STEVENS INSTITUTE OF TECHNOLOGY ACADEMIC CATALOG 2016-2017





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ABOUT

The Academic Catalog is a resource designed to help students prepare for and plan their studies. The Academic Catalog contains information about undergraduate and graduate education including information about each degree and program offered and the requirements and curricula for earning each degree. It also contains information on academic procedures and requirements, financial aid, student life, student services and university policies.

It is the personal responsibility of each student to acquire an active knowledge of all pertinent information set forth in the Academic Catalog.

The policies and requirements listed in the Catalog are in effect for the entirety of the listed academic year. The edition of the Catalog that contains a student's degree and graduation requirements is determined by their academic year of entry or reentry and academic year of acceptance to their major or program. Archived catalogs are available online or by contacting the Office of the Registrar.

Stevens Institute of Technology reserves the right to change the information, regulations, requirements, procedures and policies announced in this catalog including but not limited to: requirements for admission; graduation or degrees; scheduling; credit or content of courses; fees; and calendars.

School and departmental websites and departmental curricular and course information are maintained independently and do not necessarily reflect university-approved curricula and course information. In case of discrepancies between departmental information and the Academic Catalog, the Academic Catalog is considered definitive.

OUR HISTORY & MISSION

Founded in 1870 by "America's First Family of Inventors," the Stevens family, Stevens Institute of Technology is a premier technological research university with a legacy of leadership in fields including engineering, finance, cybersecurity and coastal resilience.

Stevens graduates co-founded both General Motors and Texas Instruments, engineered the world's first urban power plant, engineered and erected the steel frames of New York City's Empire State Building and Chrysler Building, and directed the design and preparation of spacecraft modules for NASA's Apollo moon launch missions. From Frederick Winslow Taylor, the father of scientific management, and Mark Crispin (inventor of the IMAP email protocol), to Nobel Prize-winning physicist Frederick Reines (discoverer of the neutrino, confirming the 'big bang' theory), artist Alexander Calder (inventor of the hanging art form known as the mobile), award-winning journalist and political commentator Richard Reeves and cloud-software pioneer Gregory Gianforte, Stevens has produced a long line of technical and business leaders, innovators and entrepreneurs.

Stevens laboratories and facilities continue to enable groundbreaking research. The Davidson Laboratory features the fastest wave tank complex located at a U.S. university and has played a role in virtually every major maritime and coastal engineering advance of the past century and a half, including the development of modern submarines and the re-engineering of Apollo space capsules. The Hanlon Financial Systems Lab features a state-of-the-art simulated Wall Street trading room complete with Bloomberg terminals streaming real-time market data and a full suite of leading-edge software tools for financial analysis. The Systems Engineering Research Center (SERC), a Stevens-led consortium of approximately twenty institutions, is supported by the U.S. Department of Defense (DoD), producing important insights in the creation and evolution of complex systems and the development of systems engineers. The Immersion Lab enables high-definition visualization of complex concepts and data for professional audiences and non-professional audiences and stakeholders. Stevens is home to three National Centers for Excellence, research facilities selected by the U.S. government to lead national research, development and evolution efforts to address critical global needs including port security, ship design and development and systems engineering.

The Stevens mission is clear:

To inspire, nurture and educate leaders in tomorrow's technology-centric environment while contributing to the solution of the most challenging problems of our time.

OUR HISTORY & MISSION

We believe that the solutions to many of the critical problems that face humanity can be found in the improved use and understanding of technology, and that it is our duty to produce engineers, scientists and business leaders prepared for this challenge. This vision is embodied in our Stevens curriculum, which uniquely blends hands-on innovation, entrepreneurship and marketing education with engineering and technical training with the goal of helping students learn to think outside of the box and develop real-world products, services, applications and intellectual property. Stevens' small size and multi-disciplinary environment provides students and researchers alike the opportunity to continually collaborate in projects that cut across departmental lines.

Our vision — outlined in our strategic plan, "The Future. Ours to Create." — is to become a premier, student-centric technological research university.

We will achieve this goal through five key strategic priorities:

- Student-Centricity. Stevens will place an extraordinary emphasis on the development of its students, their academic and leadership development, career preparation and personal growth.
- Excellence in All We Do. Stevens will maintain an unrelenting commitment to excellence in all that it does.
- Through Collaboration, Impact. Building on our agility and collaborative spirit, Stevens will break down internal barriers to collaborative education and research to maximize the impact of the work of our faculty and students.
- Technology at Our Core. Proud of our legacy, we will embrace the power of technology as a differentiator to offer a distinctive educational experience to our students, drive our research and scholarship programs, devise novel teaching and learning methods and enhance our administrative, outreach and communication activities.
- Strengthened Reputation, Increased Prestige. Stevens alumni, faculty and research have made a significant positive impact on the world for more than 140 years. We will continue to ensure that our graduates continue to play a critical role in solving the technology-based problems of the future.

Stevens will directly address key areas of societal and global interest including healthcare and medicine, STEM (science, technology, engineering and mathematics) education, finance, coastal resilience and systems engineering through a comprehensive research program and new course and degree offerings.

As we move forward into the future together — a future that will be defined by the nation's and the world's appropriate and ethical use of technology for societal benefit — Stevens will continue to be at the forefront of discovery and innovation, and we will continue to train designers, inventors, managers and leaders for this exciting new era.

ACCREDITATION

The Commission on Higher Education of the Middle States Association of Colleges and Schools, an institutional accrediting agency recognized by the U.S. Secretary of Education and the Commission on Recognition of Postsecondary Accreditation, accredits Stevens Institute of Technology. Stevens Institute of Technology has been continually accredited by the Middle States Commission on Higher Education since 1927. The most recent Middle States action reaffirmed Stevens' accreditation until 2018 and commended Stevens for the quality of the periodic review report and process.

The following programs at Stevens are currently accredited by the Engineering Accreditation Commission (EAC) of ABET, https://www.abet.org: biomedical engineering, chemical engineering, civil engineering, computer engineering, electrical engineering, environmental engineering, engineering management, mechanical engineering, and engineering. The computer science program is accredited by the Computing Accreditation Commission (EAC) of ABET, https://www.abet.org.

The chemistry and chemical biology program at Stevens is approved by The American Chemical Society (ACS), a congressionally chartered independent membership organization which represents professionals at all degree levels and in all fields of chemistry and sciences that involve chemistry. The Chemistry Bachelor of Science Degree is certified by ACS and the Chemical Biology Bachelor of Science Degree can also be certified if certain courses are completed.

All of Stevens' undergraduate and graduate business programs are accredited by AACSB, placing Stevens among the 5 percent of business schools globally to earn this distinction. AACSB provides internationally recognized, specialized accreditation for business and accounting programs at the bachelor's, master's and doctoral levels. Some Stevens master's degree programs in project management are accredited by the PMI Global Accreditation Center for Project Management Education Programs. This accreditation publicly confirms these programs meet comprehensive quality standards within academic degree programs related to project management, and that they can prepare students for success in project management careers.

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STUDENT LIFE

Undergraduate Student Life

The Office of Undergraduate Student Life fosters learning experiences for all students at Stevens through intellectual, personal and social development that occurs beyond the classroom. We advise and provide organizational support to more than 100 student organizations, facilitate Women's Programs, Safe Zone, and Diversity Programs, and oversee Greek Life, which includes 17 social sororities and fraternities. Additionally, our office coordinates campus-wide programs from Orientation and the annual Club Fair to Freshman Family Weekend and the Student Leader Awards Brunch.

The Stevens campus community is always brimming with activity and diverse offerings for involvement outside of the classroom. Students participate in informal get-togethers, cultural celebrations, musical performances, community service, and more. Throughout the year, there are also off-campus trips, comedy nights, recreational excursions, and other activities sponsored by the Entertainment Committee. Additionally, the Student Government Association sponsors annual events such as the Founder's Day Ball and Techfest, Stevens' fall festival.

For students interested in developing their leadership skills, the Office of Undergraduate Student Life hosts three leadership programs through Stevens LEADS (leadership education and diversity series), in addition to a yearly leadership retreat and workshops. We are also committed to preparing students to be active global citizens by engaging in meaningful service activities that enhance the quality of life for the local, national, and international communities. Students can get involved in one of our service organizations, like Engineers Without Borders or Habitat for Humanity, or take part in annual service programs such as our Global Service Initiative to Jamaica.

Student Government Association (SGA)

At Stevens, you are an important member of the community. The keystone of the undergraduate division is the SGA; it directs and funds all student activities with the assistance of the Office of Undergraduate Student Life. Other elected groups include the Co-op Student Council, Ethnic Student Council, Residence Hall Association, Interfraternity Council, Panhellenic Council and the Multicultural Greek Council, all which serve the interests of their members. Members of the administration frequently hold informal meetings with small groups of students, providing an opportunity for an exchange of ideas and opinions.

Graduate Student Affairs

The Office of Graduate Student Affairs serves to support and promote the holistic development of all graduate students by providing them with opportunities for engaging and educational co-curricular experiences. The office aims to create an environment in which all graduate students are able to find balance between their academic, extracurricular, and personal priorities and feel supported, engaged, and able to succeed academically. To that end, OGSA works closely with the Office of Graduate Academics to develop, facilitate and sponsor a wide variety of programs, services and resources that enhance the academic experience for graduate students.

There is a vibrant and diverse graduate student community that has a major presence on campus, much of which stems from graduate student clubs and organizations. Becoming involved in a student organizations is a great way to enhance your collegiate experience and acquire important skills such as team building, leadership, communication, and time management. At Stevens, graduate student clubs organize speaker series, cultural presentations, and student networking opportunities for the Stevens community. These are a variety of cultural and academic clubs comprised of students from diverse backgrounds.

STUDENT LIFE

The Office of Graduate Student Affairs offers various events, trips, and activities to help graduate students make connections and build community. The Graduate Enrichment Series is a certificate program that offers weekly opportunities for students to grow both personally and professionally. These sessions are available to all graduate students at no additional charge and are led by faculty and staff from numerous departments and offices around campus and cover a wide variety of topics. Participating in the Graduate Enrichment Series provides opportunities for individual growth and development and help ensure that the Stevens experience is well-rounded.

The Office of Graduate Student Affairs also sponsors the Ph.D. Network which was developed to support doctoral students on their unique journey. The network offers opportunities for personal and professional development as well as social and leisure activities for doctoral students and their families. The network helps to foster a supportive community of peers, regardless of academic department or year of study.

Graduate Student Council (GSC)

The purpose of this governing organization is to provide a structure through which graduate students work together to improve the quality of graduate student life. The objectives of the Graduate Student Council at Stevens are as follows:

To represent graduate students (certificate, masters, doctorate) on all matters pertaining to their general welfare as graduate students with the administration.

- ▶ To build a graduate student community via graduate student co-curricular activities.
- ▶ To approve and oversee all graduate student organizations and allocate budgets appropriately.
- ▶ To provide a formal means of communication among graduate students.

Athletics

Stevens competes at the NCAA division III level for intercollegiate sports. Men participate in baseball, basketball, crosscountry, golf, lacrosse, soccer, swimming, tennis, track and field, volleyball and wrestling. Women represent Stevens in basketball, cross-country, equestrian, fencing, field hockey, lacrosse, soccer, softball, swimming, tennis, track and field and volleyball. The majority of sports are affiliated with the Empire 8 Athletic Conference. Other conferences include MACFA for men's fencing, NIWFA for women's fencing, wrestling in the Centennial Conference, men's volleyball in the United Volleyball Conference and the equestrian squad holds membership in the IHSA. Stevens' mascot is Attila the Duck.

Stevens also offers a wide variety of intramural sports, a number of club sport teams, an outdoor recreation program and an extensive offering of informal sport/recreational opportunities including wellness classes and a well-equipped fitness center. Students enjoy a full program of athletic activities throughout the year.

Club sports teams compete in national and regional conferences and tournaments. The current club sport offerings include: archery, baseball, women's basketball, bowling, crew, cycling, ice hockey, men's lacrosse, women's lacrosse, sailing, ski and snowboard, men's soccer, women's soccer, swimming, tennis, triathlon, ultimate frisbee, men's volleyball and women's volleyball. Be sure to go to <u>www.stevensrec.com</u> for complete details.

For a closer look, visit Stevens' impressive athletic facilities which include the Charles V. Schaefer, Jr. Athletic and Recreational Center, Walker Gym, De Baun Athletic Complex, six tennis courts and beach volleyball court. Our websites, <u>www.stevensducks.com</u> and <u>www.stevensrec.com</u>, are great resources for additional information and news updates.

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Undergraduate Academics

The Office of Undergraduate Academics provides general academic advising and support services to the entire undergraduate student body, in addition to the major specific advising provided by the faculty advisor (see Faculty Advisors). Questions regarding academic policies, procedures, or advising issues can be directed to the Office located in Edwin A. Stevens Building Room 119, (201) 216-5228. Or, visit the website at http://www.stevens.edu/directory/undergraduate-academics.

All undergraduates are assigned a freshman faculty advisor. The faculty advisor may change later in a student's career based upon the major, concentration, or other considerations.

Advising in the freshmen and sophomore years generally focuses on degree requirements, course selection and the transition from high school to college. In the junior and senior years, advising generally focuses on career options and/or graduate school.

Transfer students are assigned a freshman or upperclass advisor as appropriate.

Academic Support Center (ASC)

The Academic Support Center (ASC), located in Edwin A. Stevens Room 119, provides a variety of support programs and services to assist undergraduate students in achieving academic success. These services include: Academic Tutoring, Freshman Quiz Review Sessions, Peer Mentoring and Academic Success Workshops.

Tutoring for technical courses is provided free of charge by skilled undergraduate and graduate students. The ASC offers individual assigned tutors and has a walk-in tutoring center located in the Library room 306 to assist undergraduate students with understanding course material.

Freshman Quiz Reviews for first-semester courses are also provided through the ASC. The goal of a review session is to provide the student with additional insight into material previously presented in class. Please note, these review sessions are intended solely as a review, not as a substitute for attending class or preparing on one's own.

The Peer Mentor program provides an opportunity for new first year students to connect with an undergraduate student who has completed at least one year at Stevens. Peer Mentors assist new students in their academic transition from high school to college. The mentoring process can provide new students with the information, support and encouragement they need to be successful at Stevens.

Academic Success Workshops are another component of the ASC. A variety of topics are offered throughout the semester including: Time Management, Developing Effective Study Skills and Preparing for Finals.

For more information, please visit the ASC website at: <u>http://www.stevens.edu/directory/undergraduate-academics/</u> academic-support-center

Graduate Academics

The Office of Graduate Academics strives to ensure an excellent academic experience for our diverse and talented graduate student population from inquiry to graduation. In doing so, we aim to educate and empower students with the skills and experience they need to fulfill their academic goals and reach their fullest professional potential.

The Office of Graduate Academics provides the leadership, vision, and support services necessary to ensure the quality of graduate programs, encourage interdisciplinary education and research, and provide opportunities for the holistic development of graduate students. We collaborate with the Office of Graduate Student Affairs and academic leaders across the university to advocate for graduate student academic needs and the creation of new graduate programs, provide high-quality student support services, implement student success initiatives and uphold policies related to the graduate student experience. We also provide the information that students need to enhance their academic experience and that faculty and staff need to effectively carry out their responsibilities to students.

Questions regarding graduate academic policies or procedures can be directed to the Office of Graduate Academics in person, by phone, or via email. The Office of Graduate Academics is located on the 1st floor of the Edwin A. Stevens building. You can also reach them by phone (201-216-8031), via email at gradacademics@stevens.edu or online at http://www.stevens.edu/directory/office-graduate-academics.

Writing & Communications Center

The Writing & Communications Center (WCC), in the College of Arts and Letters, empowers students by helping them develop the written and oral communication skills essential to their success in academic coursework and beyond Stevens. The goal of the WCC is to help students become autonomous and capable writers in their own right. To that end, the WCC provides one-on-one, group, and online conferences as well as workshops and seminars, specifically for the following:

- ▶ essays
- public speaking
- slide show presentations
- English conversation
- ▶ resumes
- cover letters
- ▶ interview preparation
- ▶ graduate school applications

- personal statements
- poster presentations
- journal publications
- ▶ fellowship applications
- dissertations
- collaborative work
- time management
- PhD coaching
- ▶ and more.

International Student and Scholar Services

The International Student and Scholar Services (ISSS) supports the academic mission of the university by providing specific programs and services to international students and scholars. The main role of the ISSS is to facilitate compliance with federal regulations that govern the immigration status of international students and scholars during their time at Stevens. The ISSS provides educational workshops, information, and services in support of these regulations.

The ISSS office is responsible for all international student and scholar immigration-related matters, including the issuance and/or processing of:

- Form I-20, F-1 visa
- DS-2019, J-1 visa (students and scholars)
- ▶ H-1B applications for temporary workers in specialty occupations
- University-sponsored Lawful Permanent Resident (LPR) applications
- Employment authorization documents (EADs)

The ISSS also promotes international and multicultural understanding by providing cross-cultural opportunities and events for Stevens' international population.

Registrar

The Office of the Registrar, stewards of academic records maintenance, is committed to serving the Stevens Institute of Technology community and the public in a courteous, accurate, and expeditious manner. With knowledge, integrity, and energy, we aim to improve the client experience and University reputation through coordinated, customer-centric services that exceed expectations.

The Office of the Registrar provides students with access to their academic records, enrollment, degree verifications, academic calendars and exam schedules.

Through an integrated mix of personal and online services, we have developed a system that supports Stevens students in managing all aspects of their education. Through the University's convenient myStevens portal, you can execute the following Registrar-related actions: register for classes, check your grades, view unofficial transcripts, review class schedules, search for classes, view graduation checkout status, change contact information.

In addition to online services, students may receive the personal attention that is the hallmark of Stevens Institute of Technology education by visiting the Office of the Registrar's located on the 10th Floor of the Wesley J. Howe Center.

Transcripts

Information on how to order transcripts securely on-line can be found at www.stevens.edu/registrar.

Student Service Center

The Student Service Center (SSC), located in the Wesley J. Howe Center is a valuable resource for navigating through administrative tasks with convenience and efficiency.

The SSC houses the Office of Financial Aid and the Office of Student Accounts. The counseling and support staff members are cross-trained so that the first person you meet has the knowledge to resolve the most common questions and concerns.

For more information, contact the Office of Financial Aid and the Office of Student Accounts, located in the Student Service Center, by calling 201-216-5555 or by e-mail <u>financialaid@stevens.edu</u> or <u>studentaccounts@stevens.edu</u>.

Student Health Center

The Student Health Center is an acute care facility located on the ground floor of Jacobus Hall. The Health Center's goal is to improve and maintain physical wellness and productivity for students. Health Center services are free and include health promotion and disease prevention, care during acute and chronic phases of illness, and referrals to outside providers when appropriate. Student Health Center staff members recognize the basic human rights of all patients who seek treatment and all students are treated with respect, consideration, and confidentiality.

The Student Health Center is staffed by a full-time registered nurse and clinicians. Please visit the Student Health Center website for clinical hours at: <u>http://www.stevens.edu/sit/health</u>. During off-hours, please contact Campus Police at 201-216-3911 for a medical emergency. Students needing emergency medical attention will be transported to the local hospital via ambulance. Charges for healthcare services performed outside of the Student Health Center are the individual student's responsibility.

All enrolled Stevens students are required (by NJ state law) to provide a Student Health and Immunization Record to the Student Health Center. Failure to provide immunization documentation can result in a Registrar's hold being placed on a student account. This will halt the enrollment process until immunization compliance is satisfied. For additional information and answers to specific questions, please contact the Student Health Center at 201-216-5678.

Counseling and Psychological Services

Counseling and Psychological Services (CAPS) is a comprehensive mental health resource center for the campus community. CAPS offers a variety of high quality counseling services to Stevens students in order to enhance both academic and personal achievement. The Office offers individual counseling, group therapy and psychiatric services as well as a variety of educational and consultative services designed to promote wellness at Stevens.

Our Office understands, appreciates and celebrates the differences that exist between individuals at Stevens Institute of Technology. We are committed to insuring that CAPS is a welcoming space for all and that our professional services are culturally competent and inclusive. Our primary mission is to meet the mental health demands of the vibrant and diverse Stevens community. CAPS aims to serve as a resource for students, faculty and staff at Stevens when addressing psychological and emotional concerns that may range from mild concerns to psychiatric crises.

All services provided by CAPS are confidential and free of charge. No information is released without student permission. In addition, student records with CAPS are kept separate from academic records and transcripts. To schedule an appointment, please call (201) 216-5177 or e-mail <u>stevenscounseling@stevens.edu</u>.

Disability Services

The Office of Disability Services exists to assist individuals with disabilities have opportunity for full participation and equal access to campus programs and services, in alignment with federal standards and state regulations.

Who Is Eligible for Assistance?

Services are available to any individuals with documented disabilities- students, faculty, staff, and visitors to our campus. Individuals eligible for service include, but are not limited to, those with autism spectrum or attention disorders, learning disabilities, and mobility, vision, hearing or speech impairments. Students with food allergies or other dietary restrictions may discuss these matters with the Director of Disability Services and Dining Services staff. Additionally, those with temporary disabilities, such as conditions stemming from concussion, injury or surgery, may also be eligible for accommodation services.

Accommodation Services

Individuals with disabilities have the responsibility to self-identify to the Director of Disability Services and provide relevant documentation from a qualified professional, which is required to support a request for accommodation services. The individual and the Director will discuss the appropriate and reasonable accommodations that may be beneficial in the classroom, the campus community or other areas. Given the many varieties and intricacies of disabilities, reasonable accommodations will be determined on an individual basis.

For additional information, please contact the Office of Disability Services at 201-216-3748.

Career Center

The Stevens Career Center supports all full time, on-campus students in obtaining career outcomes appropriate to their personal interests and career goals through career exploration programs, experiential education opportunities, and individualized guidance from the Career Center staff. Student programming evolves in accordance with the interests and academic studies of Stevens students and the opportunities and demands of the employment market. Students are encouraged to build their success early through experiential education opportunities that include summer internships, cooperative education assignments, and faculty-mentored research.

The Career Center is located on the 6th Floor of the Wesley J. Howe Center and provides the following services:

Career Advising and Career Exploration

Career education and programming are provided to develop the critical professional skill sets students need to present themselves to employers and to position themselves for future career success. The Career Development workshop series is offered for undergraduate students and the Career Masters workshop series is available for graduate students. One-on-one advising meetings, career planning workshops, corporate site visits, and networking events are provided throughout the academic year.

On-Campus Recruiting Program

Approximately 300 organizations visit the Stevens campus annually to recruit students for full time employment, summer internships, and cooperative education assignments. An orientation workshop is required to gain access to employment opportunities posted on CastlePointCareers, the interactive on-line system where students can post their resumes, review job descriptions, apply for positions, and schedule interviews.

Career Fairs

The Career Center hosts three career fairs annually. Career fairs serve as an information exchange between students and corporate representatives. The Fall Career Fair is targeted to graduating students. The Winter and Spring Career Fairs are open to all Stevens students and provide access to full time employment and summer internship opportunities.

Summer Internships and the Full Time Employment Job Search

Internship experience is an integral part of the student career development process that supports attainment of successful post-graduation career outcomes. The Career Center facilitates student access to summer internship opportunities. Students participate by attending an orientation workshop and meeting with a career advisor who will assist in resume creation and the internship search process. Students are encouraged to start their full time job search one year prior to graduation. Programming is provided on how to conduct a job search and interact with employer representatives. Success is best achieved through participation in the services offered by the Stevens Career Center.

Cooperative Education

Cooperative Education (Co-op) is a five-year educational program where students alternate between semesters of full time study and full time work in areas related to their academic studies and career interests. The Co-op Program assists students in clarifying their career aspirations while experiencing the connection between the theories learned in the classroom and applied in the workplace.

A student's first year is dedicated to completing freshman year academic requirements and attending Co-op meetings to understand the rotational nature of the program, to prepare for the recruitment process, and to gain an understanding of workplace expectations. Over the course of the second through fourth years, Co-op students alternate semesters of study with semesters of full time employment in accordance with the Co-op study plan that has been approved by their Co-op advisor. Senior year is devoted to full time study and completing the course requirements of the undergraduate degree.

The many benefits of participating in cooperative education include having the opportunity to work at a maximum of three different employers and the ability to gain knowledge and skills while receiving compensation on a full-time basis when on assignment.

Eligibility

The Co-op Program is available for full time undergraduate students pursuing degrees in the engineering or science disciplines. Students must commit to following a five-year alternating work/study plan and attend the required Career Development workshops. All freshman year course requirements must be completed and students must be in good academic standing with a minimum 2.20 GPA. For more information, contact <u>coop@stevens.edu</u>, or 201.216.5166, or visit the Career Center on the 6th Floor of the Wesley J. Howe Center.

Residence Life

The Office of Residence Life is committed to providing a safe, supportive and lively living and learning environment that nurtures each student and promotes their growth and development. Living at Stevens leads to some of the most exciting and rewarding times of a student's life. Most Stevens undergraduate students live in Stevens housing (both on and off campus). Students who submit their application by the deadline are guaranteed Stevens housing.

Housing contracts are a full year commitment. A housing security deposit is assessed once and returned when the student leaves Stevens. There is a cancellation fee assessed to any students who cancels their housing application.

At Stevens, all residence halls have completely furnished rooms including bed, desk, dresser and closet or wardrobe. All rooms have state-of-the-art Wi-Fi connection service to the campus network, cable TV access and complimentary laundry facilities.

New student residences are located throughout campus just steps from classrooms, laboratories, dining, and recreational facilities. We provide on campus and Stevens Leased Housing within the City of Hoboken for upper-class students.

On Campus Housing

- Davis Hall, Humphreys Hall, Hayden Hall and Castle Point Hall provide double and triple occupancy housing for new students.
- Palmer Hall houses 90 upper-class students in singles and quads.
- ▶ Jonas Hall has double and quad rooms with private bathrooms in each room
- River Terrace Apartments provides 2 to 7 person apartments with double and single rooms for upper-class students. All suites include private bath and kitchen.

Stevens Leased Housing

Our Stevens Leased Housing apartments are within walking distance of the campus. They are fully furnished, double occupancy bedrooms and 2 bathrooms (4 person apartments). They include Wi-Fi, internet and cable TV access. They house male and female upper-class students.

Special Interest Housing

- Lore-El (Women's Center) is located at 802 Castle Point Terrace. It is a beautiful Victorian-style residential house located on the Stevens campus and focuses on Women in STEM fields.
- **C.A.R.E House** (Community Awareness Residential Experience) is located at 1036 Park Avenue. It is home to a community that focuses on service learning.
- Greek Housing (Fraternities & Sororities): offers unique and valuable living opportunities. Eligibility to live in a Greek house is determined by each organization.

Graduate Student Housing

Most Stevens graduate students live in their own apartments in Hoboken, N.J., as well as other cities in the surrounding area. A small number of graduate students live in Stevens Leased Housing. Graduate students are not housed on campus.

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Applying for Admissions

Admission to Stevens is a process designed to ensure that you have an accurate picture of the opportunities and challenges offered by a Stevens education, and that the Admissions Committee has enough information to assess your potential for success. With these goals in mind, several measures are used in making Admissions decisions.

High School Transcript

The most important criterion in our decision to admit you as a freshman is your academic performance in high school. (If you are already studying at the college level and wish to apply for admission to transfer to Stevens, you must have earned at least 30 college credits and submit an official copy of all college transcripts.) We believe that the quality of your recent work is an accurate indication of your preparation for Stevens, thus your high school record should show strong performance in the following areas:

- For Engineering, Computer Science, Applied Sciences and Quantitative Finance: Four years of English; four years of mathematics (one year of algebra; one year of geometry; one year of pre-calculus; and one year of calculus); three years of science (biology, chemistry, and physics).
- For Business and Science, Technology & Society: Four years of English; four years of mathematics (two years of algebra; one year of geometry; and one year of pre-calculus); three years of science (biology, chemistry and physics).
- For Humanities: Four years of English; three years of mathematics (two years of algebra and one year of geometry); one year of science either physics, chemistry or biology. These are minimum requirements. Student planning secondary concentrations in math or science should have more extensive preparation in these fields than indicated above.
- For Accelerated Pre-Medicine Program: Four years of English; four years of college prep mathematics; three years of science (biology, chemistry, and physics). Students are encouraged to pursue AP Biology and AP Chemistry, if possible. To be considered for the Accelerated Medicine Program, students must have a combined score of at least 1400 on the SAT I (critical reading and mathematics sections), and have taken the two SAT Subject Test (Math Level I or II and Biology or Chemistry). Students may take these tests in the junior or senior year. All tests should be completed by October of the senior year so that we have time to evaluate scores.

Please have your guidance/college counselor submit an official copy of your transcript.

College Entrance Examinations

The College Entrance Examinations are a second and somewhat different test of your abilities. Stevens requires the Scholastic Aptitude Test (SAT I) or the American College Test (ACT).

If you are pursuing the Accelerated Pre-Medicine Program, you must score a minimum of 1400 on the SAT I in one sitting and take the SAT Subject Test in mathematics level I or level II, biology, and chemistry. All Accelerated Pre-Law applicants must take two SAT Subject Tests of your choice.

We encourage you to begin taking these exams in your junior year of high school. If you are not applying as an Early Decision candidate we recommend that you take all exams by December of your senior year so we can evaluate your scores in a timely manner. Please keep in mind that the Admissions Committee looks at the highest score in the Critical Reading and Math section of the SAT I to compute a total score.

For complete information and registration forms of all tests, see your guidance/college counselor or contact the Educational Testing Service (SAT), Princeton, NJ, 08540, www.sat.org, or the American College Testing Program (ACT), Iowa City, IA, 52243, www.act.org.

Personal Interview

Admissions offers an interview option to all students applying for undergraduate admission. Applicants should contact the Office of Undergraduate Admissions at (201) 216-5194 to set up an interview. If you are applying for the Accelerated Pre-Medicine program, an interview is required. Interviews can be completed by phone, Skype or on campus.

Guidance Counselor/Teacher Evaluations

We require all applicants to submit at least one teacher evaluation and once guidance counselor evaluation, so we can learn more about your academic and personal qualities, as well as your potential of becoming a successful Stevens student. You will find the appropriate evaluation forms in your application and on our website.

Written Statement

At Stevens, we give you a written opportunity to provide us with information about yourself before the Admissions Committee meets to determine an admissions decision. This may be a talent, fact, experience, or thought that you did not include on the application or in your personal interview. Please complete the essay as part of your application to Stevens.

Completing the Application

Go to <u>www.stevens.edu/sit/admissions/apply</u> to access our application instructions. Stevens uses the Common Application in addition to a private Stevens Application.

Deadlines

Applying for Freshman Admission

To be considered for admission to the fall class of first year students at Stevens, please submit your application and additional information required, by February 1. You may submit application as soon as you complete your junior year of high school, once the next cycle's application is available. Once we receive all of the additional information required the Admissions Committee will meet to review your file and make an admissions decision. Please note that students applying for accelerated programs have a deadline of January 1.

Early Admission

Applying Early Decision - ED I

If Stevens is your first choice, you may apply for admission as an Early Decision candidate by November 15. One advantage of applying Early Decision is that you will receive an admission decision, including notification of an estimated financial aid package if you have applied for it, by December 15. If you are accepted to Stevens, you must submit your tuition deposit by January 10th. We then ask you to withdraw applications from any other colleges and universities to which you have applied.

Applying Early Decision - ED II

Stevens also has an Early Decision II process. The application procedures are the same, however, the deadline for application is January 15 with a notification date of February 15. If you are accepted to Stevens, you must submit your tuition deposit by March 10th and then withdraw applications from any other colleges and universities to which you have applied.

To be considered for Early Decision, please indicate this on your application and submit it with all of the additional information required by November 15 for ED I/January 15 for ED II.

Applying Early Admission

Under very special circumstances we will accept students who have finished their high school requirements at the end of their junior year. You must adhere to the same requirements and deadlines as those applying for admission.

Advanced Placement

Stevens participates in the Advanced Placement (AP) Program of the College Entrance Examination Board. You may receive college credit toward your degree for various examinations. For a detailed list and additional information, refer to the section entitled Undergraduate Procedures and Requirements in this catalog. Be sure to list these exams and the scores received on your application.

Stevens Link Semester

The Stevens Link Semester is a one-semester, foundational program for a select group of students to be offered conditional admission to Stevens Institute of Technology for the fall term. Successful completion of the Link semester includes the achievement of a 2.5 or better GPA in the fall term with a minimum of 12 earned credits, as well as satisfactory conduct. Any students with a lower GPA will be reviewed on a case-by-case basis. Upon successful completion of the foundation semester, Link students will be fully admitted to Stevens in their second semester. It is expected that students will be able to graduate within four years depending on their academic performance. Participation in programs such as cooperative education may result in a five-year timeframe. Questions can be directed to the Office of Undergraduate Admissions at 800-STEVENS or visit: http://www.stevens.edu/sit/admissions.

International Students

Admissions requirements and procedures for international applicants are the same as those for domestic candidates. However, if your first or native language is not English, you are required take the Test of English as a Foreign Language (TOEFL) and earn a score of at least 550 on the paper version or 80 on the internet based version. We also accept the International English Language Testing System (IELTS) with a score of 6 or higher.

At Stevens, international students are not eligible for financial aid. There are limited merit-based scholarships for which you do not need to apply (all applicants for admission are automatically considered). Additional sources of money for international students include loan programs and the Stevens Cooperative Education Program; information about these programs can be found in this catalogue.

Transfer Students

Stevens considers transfer students from community colleges and four-year institutions. To earn a degree from Stevens, you must complete at least 50 percent of your degree requirement credits at Stevens and at least five courses must be technical electives taken in the junior and senior years.

A minimum grade of "C" is required for undergraduate transfer credit. Courses taken on a pass/fail basis are not acceptable. If a Stevens course includes a laboratory, then you must have also taken a laboratory. A syllabus or course description from the institution's catalog must be sent to ascertain equivalence. Since it is essential that all course prerequisites be met, you should provide complete transcripts with descriptions of the courses and all educational experience as early as possible in the application process. It is also advisable for you to visit with or write to the Office of Undergraduate Admissions, Attn: Transfer Admissions, Stevens Institute of Technology, Hoboken, NJ, 07030, (201) 216-5194. You may be asked to confer with faculty in the departments in which you seek credit for courses taken elsewhere.

The application deadline for transfer admission to Stevens for the fall semester is July 1; November 1 for the spring semester.

Part-time and Evening Study for Non-Traditional Students

Stevens does not offer the opportunity to pursue an undergraduate degree by attending part-time and/or solely in the evening. If you want to pursue an undergraduate degree, you can do so on a full-time basis only, and you must register for at least 12 credit hours per semester to be considered a full-time student.

The Campus Visit

An important step in selecting a school is visiting the campus. Not only does the admissions staff want to meet you, we very much want you to see our beautiful and historic 55-acre campus overlooking the Hudson River and exciting New York City. During your visit, you have the opportunity to explore our state-of-the-art laboratories, see our residence halls, and meet professors and current students. A visit to Stevens also gives you an opportunity to present special circumstances, qualifications, or interests that may help us determine your ability to succeed here.

Throughout the year, the Office of Undergraduate Admissions offers Information Sessions and Campus Visit Days for high school juniors and seniors. These events include an overview of the university, academic programs, applying for admission, and filing for financial aid. It also enables you to speak with current students and faculty, and take a tour of campus.

If you live far from campus, there are other options. Admissions representatives travel to a multitude of high schools participating in college fairs. During the summer, you may also visit Stevens and make it a part of your family vacation.

Please call the Office of Undergraduate Admissions at (201) 216-5194 to discuss your campus visit plans or visit our Website at <u>http://www.stevens.edu/admissions</u> for updated information.

Degree Programs

Bachelor's Degree Programs

Stevens awards three baccalaureate degrees: the Bachelor of Engineering (B.E.), the Bachelor of Science (B.S.), and the Bachelor of Arts (B.A.).

Degree Options

Degree with Honor and High Honor

The undergraduate Degree with Honor is conferred if a student achieves a grade point average of 3.2 for courses taken toward the undergraduate degree. The Degree with High Honor is conferred if a student achieve a grade point average of 3.6 for courses taken toward the undergraduate degree.

Degree with Thesis

Students may apply for candidacy for Degree with Thesis in either semester of the junior year or in the first semester of the senior year. A candidate for any Degree with Thesis must report the title of the thesis and the name of the directing professor in writing to the Office of Undergraduate Academics no later than December 15 of the senior year. In April of the senior year, the student must submit an Application for Degree With Thesis after the approved thesis has been delivered to the Library. Some points of interest about the Thesis:

- ▶ the diploma reads "with thesis"
- the thesis is not for credit and is over and above the other degree requirements

- the thesis does not affect the GPA
- ▶ the thesis is not treated as an overload for tuition calculation
- the student may begin work on the thesis before the senior year

Special Degree Programs

There are a number of special programs available to students, depending on their area of study. A student planning to enter any of the following special degree programs should discuss their plans with their Faculty Advisor and the Office of Undergraduate Academics.

Simultaneous Degree Program

The Simultaneous Degree Program permits a student to complete the requirements for two degrees, scheduling and extra credit rule permitting. A student may complete a bachelor's and master's degrees in four years. Two bachelor's degrees (any combination of B.E., B.A., and B.S.) must be completed simultaneously. A student must take at least 24 credits over and above their first bachelor's degree in order to earn a second degree.

Double B.E. Degree Program

The Double B.E. Degree Program enables a student to earn two B.E. degrees, but the students must satisfy all of the requirements in both concentrations; this includes two Junior and Senior Design sequences. In addition, the student must take at least 24 credits over and above the first B.E. degree.

4+1 Bachelor's/Master's Program

Students are selected for the program at the time of admission to Stevens. Students will be notified of their acceptance into this program prior to April 1st of the senior year of high school. Students must confirm their participation in the program. Students will be required to have a minimum 3.2 cumulative GPA at the end of their sophomore year to remain in the program.

Students in the program must complete their bachelor's degrees in four years. The students will receive their master's degrees upon completing the graduate degree requirements in the fifth year. Students in the fifth year will have graduate student status subject to the full-time graduate tuition. Students will receive a scholarship equal to 20 percent of the graduate tuition in the fifth year.

Qualified students will apply for admission to a specific master's degree program in their fifth semester. The application starts with a screening process by the Office of Undergraduate Academics. Students are recommended to take two or three graduate courses towards the master's degree before they complete the bachelor's degree.

Graduate academic advising will be done at the department level and each department will appoint a faculty member to serve in this role. All students in the program will be required to have an approved master's study plan by the end of the spring semester of their junior year.

Double Major Program (College of Arts and Letters Only)

Students studying in the College of Arts and Letters can choose to double major by combining two disciplines from within the College of Arts and Letters. In cases of double majors, just one degree will be conferred and transcripts will designate the two major areas. Students can choose to combine any two CAL majors. If the double major contains a major in Science, Technology, and Society students can choose whether the overall degree is a B.A. or B.S., by fulfilling the requirements pertaining to each type of degree.

The six classes of the common core are counted for both majors. Students then have to take eight additional classes in each major area. No upper-division course may be counted towards both majors. For example: if the first major is in philosophy and the second in history, the two additional upper-division (300/400-level) classes that count toward the major in philosophy must be in a third discipline. The same requirement holds for the combination with interdisciplinary majors, and all other requirements for the single major apply. CAL 301, Seminar in Writing and Research Methods, or a research methods class, only has to be taken in one of the major areas.

Students choose in which major to write the B.A. thesis. The second major requires an extra tutorial course in addition to all the other requirements of the major with one of the following options in place of a second thesis: 1) research paper, 2) creative project, 3) portfolio, 4) musical composition or curated exhibit, 5) performance, 6) other similar project approved and monitored by the student's faculty advisor in consultation with the student. Alternatively, students may also opt for one thesis that incorporates both majors. This work must be more extensive in length and scope than the single degree thesis, and is subject to the approval of both advisors.

Accelerated Degree Programs

Accelerated Seven-Year Program in Medicine

The Combined B.S.-M.D. Program is an opportunity to earn the B.S. degree in Chemical Biology at Stevens and the M.D. degree at Rutgers New Jersey Medical School in a total of seven years. If you are a high school senior who has demonstrated academic excellence, in the top 10% of your class, with a combined SAT score of at least 1400 and a promise for a career in medicine, you can be considered for the B.S.-M.D. program. Admission to this program is highly competitive, and an interview at both Stevens and the medical school is required. If accepted to this program, you must complete three years in the Accelerated Chemical Biology program with a GPA of at least 3.50, grades in all of the premed courses at least B (not B-) or above, and you obtain acceptable scores on the MCAT exam. Stevens awards the B.S. degree upon successful completion of the first year of medical studies.

Accelerated Law Program

The Accelerated Law program consists of three years of undergraduate study at Stevens and three years of study at either <u>New York Law School</u> or <u>Seton Hall University School of Law</u>.

Stevens awards the B.E., B.S., or B.A. degree upon completion of the first year of law school. Students then complete the remaining two years of law school, earning a J.D. degree from either New York Law School or Seton Hall University School of Law.

Admission Requirements:

- Applicants must achieve at least a 1300 on the SAT or a score of 30 on the ACT.
- Applicants must achieve a high school GPA of 3.7/4.0.
- Applicants select which law school they wish to apply to during the Stevens application process.
- Applicants are required to complete an interview at Stevens.

Additionally, students must maintain the following requirements for law school:

Applicants must maintain a 3.2 GPA at Stevens as well as complete the LSAT.

The minimum LSAT scores are determined by the law schools each year, and typically mimic the national averages.

Approaches To Learning

At Stevens, taking what is learned in the classroom and applying it in a hands-on environment is an integral part of each student's education. Therefore, we offer a variety of opportunities, such as cooperative education, internships, research, and industry-sponsored projects.

• The Freshman Experience

All incoming freshmen and transfer students participate in the Freshman Experience program by enrolling in the following courses during their first and second terms: CAL 103 – Writing and Communications Colloquium and CAL 105 – Cal Colloquium: Knowledge, Nature, Culture. There is a special provision for incoming international undergraduate students that places them in CAL 101 – English Skills during their first semester, with CAL 103 and CAL 105 being taken during their second and third semesters.

• The Pinnacle Scholars Program

The Pinnacle Scholars Program is an invitation-only program for undergraduate students who want to push the boundaries of their education even further. Students are identified and selected during the undergraduate admissions process and are notified of their selection for this highly competitive program in their admissions acceptance letters. Invited students must confirm or decline acceptance into the program. Pinnacle Scholars gain unique and extremely valuable hands-on exploration and application of their knowledge through advanced research and international experiences.

Among the many advantages, this highly regarded program gives undergraduates a distinction in the job market and/or advancement to competitive graduate and doctoral studies. Pinnacle Scholars receive the following benefits:

- An annual cultural passport (valued at \$500) for museum memberships and cultural events (e.g. Broadway and Off-Broadway plays, opera, symphony, art exhibits). This passport will allow you to experience the special cultural opportunities available only in the New York City Metropolitan area.
- The opportunity to enroll in special honors and research seminars that provide support and guidance for research activities.
- Individualized mentoring and advisement.
- ► The option to participate in the 4+1 Master's Program with a scholarship equal to 20 percent of your graduate tuition in the fifth year.
- An annual \$5,000 stipend to support participation in one of the following three options each year*:
 - Research opportunities guided by a faculty advisor
 - Innovation and Entrepreneurship Summer Research Program (application required)
 - An international experience (e.g. study abroad or internship, approved by the Office of International Programs) (*The stipend may be used for summer courses if one of the three options is unavailable due to capacity or scheduling.)

Pinnacle Scholars may remain in the program for up to eight academic semesters provided they maintain a 3.2 grade point average (GPA) and make satisfactory academic progress toward the degree. The cumulative GPA will be reviewed annually.

Courses for Pinnacle Scholars

Pinnacle Scholar Seminar I (1-1-0)

This seminar covers topics that will enhance the undergraduate experience of Pinnacle Scholars. Pinnacle Scholars will learn about and discuss subjects including, but not limited to, the transition to university life, campus resources, conducting research, engaging in entrepreneurial and innovative project development, and international learning experiences. The seminar will also explore content specific to the Pinnacle Scholars Learning Communities themes. Potential themes: Energy and Resources; Sustainability and the Environment; Bio-Innovation, Medicine, and Health; Technology, Science, and Society; and Technology and Global Security.

Pinnacle Scholar Seminar II (1-1-0)

This seminar covers topics specific to each of the Pinnacle Scholars Learning Communities and topics that will aid Pinnacle Scholars as they determine which of the three summer involvement opportunities that they will engage in. Students will learn how to prepare a research proposal, develop a plan for an entrepreneurial and innovative project and explore the steps necessary to engage in an international experience. In addition, Pinnacle Scholars will explore graduate education programs and associated entrance exams.

Stevens Technical Enrichment Program (STEP)

The Stevens Technical Enrichment Program (STEP <u>www.stevens.edu/sit/step</u>) provides support and encouragement to students of color underrepresented in the fields of science, technology, engineering, and mathematics (STEM). STEP offers an environment and space in which the students are able to freely engage and support each other, events which highlight the students' cultural and ethnic diversity, and programs which facilitate their academic, personal and professional development. STEP also coordinates the Bridge summer program for pre-freshmen, and oversees the New Jersey Educational Opportunity Fund (EOF) Program (<u>http://www.state.nj.us/highereducation/EOF/EOF_Eligibility.shtml</u>).

STEP Bridge is a challenging six-week college-level summer residential program for incoming freshmen. It helps students begin their transition from high school to college in general, and Stevens in particular. During Bridge the pre-freshmen network with upperclassmen, create friendships with classmates, and develop relationships with STEP staff and faculty members. Students either are required to attend Bridge as a condition of their admission to Stevens, or apply to attend the summer program. Any Stevens' undergraduate who did not participate in Bridge is welcome to join STEP during the academic year.

The New Jersey Educational Opportunity Fund (EOF) Program is a state-funded financial aid and support program offered to students who meet the state-mandated financial and education guidelines. EOF students receive a financial award and specific support services. All freshmen receiving an EOF grant are required to attend Bridge and are considered members of STEP.

For more information, contact step@stevens.edu, or 201-216-5387, or visit the STEP Office in the Wesley J. Howe Center.

Cooperative Education

Cooperative Education is a five-year educational program where students alternate between semesters of full time study and full time work in areas related to their academic studies and career interests. The Co-op Program assists students in clarifying their career aspirations while experiencing the connection between the theories learned in the classroom and applied in the workplace.

Students' first year is dedicated to completing freshman year academic requirements and attending Co-op meetings to understand the rotational nature of the program, to prepare for the recruitment process, and to gain an understanding of

workplace expectations. Over the course of the second through fourth years, Co-op students alternate semesters of study with semesters of full time employment in accordance with the Co-op study plan that has been approved by their Co-op advisor. Senior year is devoted to full time study and completing the course requirements of the undergraduate degree.

The many benefits of participating in cooperative education include having the opportunity to work at a maximum of three different employers and the ability to gain knowledge and skills while receiving compensation on a full-time basis when on assignment.

Eligibility

The Co-op Program is available for full time undergraduate students pursuing degrees in the engineering or science disciplines. Students must commit to following a five-year alternating work/study plan and attend the required Career Development workshops. All freshman year course requirements must be completed and students must be in good academic standing with a minimum 2.20 GPA.

For more information, contact <u>coop@stevens.edu</u>, or 201.216.5166, or visit the Career Center on the 6th Floor of the Wesley J. Howe Center.

Preparing for a Career in the Health Professions

Stevens provides advising services to students interested in pursuing a career in the health professions. To make yourself a desirable candidate for admission to such programs, you will need an education that includes a strong foundation in the sciences, highly developed communication skills, and a solid background in the social sciences and humanities.

Students who are considering a career in the health professions should begin exploring their options early in their career at Stevens. They should inquire about the requirements of specific schools and plan their studies at Stevens accordingly. Students are NOT required to choose a science major in order to apply to medical school, although majors such as Biology, Chemical Biology, or Biomedical Engineering include the courses that are typically required for application to medical school in their curricula, so choosing one of those majors may make a student's course planning a bit easier, but you can incorporate the required courses into many majors including, but not limited to, chemistry, chemical engineering, physics, humanities, arts, business, and other engineering majors.

Students who are planning to begin medical school or dental school immediately after graduation from Stevens should plan to complete all of the minimum required courses listed by the schools in which they are interested by the end of your junior year at Stevens to help ensure they are prepared to take the appropriate national exam (the Medical College Admission Test (MCAT) for medical school or the Dental Admission Test (DAT) for dental school) that same spring. Although many students choose to begin professional school immediately after graduation from undergraduate school, there is a strong national trend toward adding one or more years of experience between undergraduate school and professional school, providing more flexibility in undergraduate course scheduling and choice of undergraduate major as well as the potential to study abroad. Stevens faculty advisors will help you to decide which plan is best for you. In addition to excellent grades and excellent test scores, you will also benefit from experience in clinical settings (e.g., Emergency Medical Technician/First Aid training, hospital or medical/dental office volunteering), research laboratories where you can develop your power of inquiry and logic, leadership and service. A variety of student clubs as well as your academic advisors can help to make these connections for you.

Health Professions Advisory Committee

The Health Professions Advisory Committee (HPAC) helps students prepare to apply to medical (MD and DO) or dental school, and also provides advice for students interested in advancing toward careers such as physician's assistants, physical therapy, pharmacy, and veterinary medicine. The HPAC meets with groups of students on a periodic basis, interviews individual applicants as applications draw near, collects letters of recommendation on behalf of applicants, and writes the Committee

letter for the student's applications. HPAC also holds seminars to discuss the application requirements and procedures, and any changes in the application process. The HPAC includes faculty with expertise in science and engineering, literature and social sciences, business/healthcare management, and undergraduate academic administration.

Health Professions Student Organizations

In an effort to support those interested in the healthcare field, Stevens supports two active student organizations: the Stevens Health Professionals Club (SHPC) and Alpha Epsilon Delta (AED).

- SHPC is dedicated to providing educational and volunteer opportunities for students aspiring for a career in healthcare. Through programs offered on and off campus, students interested in an array of areas of healthcare will benefit from guest speakers representing various careers, introductions to and advice from members of professional school admissions committees, and access to volunteer opportunities at hospitals and EMS training courses. AED is a national health pre-professional honor society dedicated to recognizing and encouraging those committed to healthcare. The organization strives to organize events each semester focused on philanthropy, scholarship, and social issues to promote the awareness of healthcare on campus and within the Hoboken community.
- AED is a national health pre-professional honor society dedicated to recognizing and encouraging those committed to healthcare. The organization strives to organize events each semester focused on philanthropy, scholarship, and social issues to promote the awareness of healthcare on campus and within the Hoboken community.

Recommended Courses

Typically, the following courses are recommended for students who are interested in applying to medical or dental-school. These courses usually satisfy the admissions requirements to accredited U.S. medical and dental schools:

- Two years of chemistry with lab (CH 115, 116, 117, 118; CH 243, CH 244, CH 245, CH 246)
- The biology sequence BIO 281 and BIO 381, and then either BIO 382 or BME 482 (Please note that the lab portions of CH 381 and either CH 382 or BME 482 are used to satisfy the requirement for two biology labs)
- One year of physics with lab (PEP 111, 112, 221, 222)
- Eight credits of mathematics (MA 121, 122, 123, 124)
- One year of English, including writing and composition (any two HUM 100-level courses)

Please Note: Most U.S. medical and dental schools will NOT accept AP courses from high school, courses taken abroad, or courses taken at community colleges to satisfy the basic chemistry, biology, physics, math, and English courses.

In addition to the courses outlined above, the following are typically recommended to help students prepare for the MCAT, which was revised in 2015 and now includes a significant emphasis on psychology, sociology, and biochemistry:

- Genetics
- Biochemistry (CH 580 and CH 581)
- Immunology
- Physiology
- Biological psychology
- Bioethics
- Probability & Statistics

- ▶ English literature
- Psychology (HSS 175)
- Sociology (HSS 141)

ROTC

Stevens offers Air Force ROTC and Army ROTC through programs at New Jersey Institute of Technology (NJIT) in Newark, NJ, and Seton Hall University in South Orange, NJ.

For additional information about the Air Force ROTC program, contact the Department of Aerospace Studies at NJIT, telephone: (973) 596-3626, email: <u>afrotc490@njit.edu</u>.

For additional information about the Army ROTC program, contact the Department of Military Science at Seton Hall University, (973) 763-3078 or (973) 761-9446.

Sponsored Senior Design Program

The Sponsored Senior Design Program provides an opportunity for a team of engineering and/or computer science students to select a two-semester sponsored design project. Typically, the sponsoring organization proposes one or more project topics, primary goals and essential design requirements. The student team will collaboratively work with technical mentors from the sponsoring organization and faculty advisor(s) to develop and evaluate solutions that meet the sponsor's requirements. The students are expected to present periodic reviews on design concepts; analysis, testing and optimization results; detailed designs, and prototypes of hardware and software systems, to the sponsor. Prior to the commencement of the project, the sponsor, the students and the institute will enter into an agreement that stipulates the project expectations, fees and assignment of intellectual property rights.

Study Abroad

Studying Abroad is one of the most important activities that college students may do for their personal development, their career, and to prepare for the world they will enter after graduation. In the global society in which we live today, it is becoming increasingly essential to have an understanding of and appreciation for different people, cultures, and how others see things and address challenges, both in business and everyday life. Participating in a Study Abroad Program or other education abroad experience will add another dimension to a student's resume, help them gain a global perspective, and allow them to recognize the value of international cooperation.

Undergraduates who have completed at least one year of study at Stevens, and who have a 2.75 cumulative GPA have the option to participate in a semester long education abroad experience. They are also able to study on short term faculty led programs, primarily in the summer, engage in research, internships or enroll in courses at partner universities located around the world. Seniors may also participate in summer or other short term programs offered by Stevens or other affiliates and partners.

Short-term opportunities include Stevens Faculty Led Programs at foreign destinations, and research programs at international facilities or universities. Past destinations have included Ecuador, England, Greece, Italy, Malaysia, Spain, the Netherlands, and Norway. Some short-term programs may offer students the opportunity to earn academic credits.

Semester abroad programs are study abroad experiences in which students enroll for a semester at partner universities located around the world. Students select a university which offers courses which are then pre-approved for transfer to Stevens and which meet graduation requirements. Stevens offers several established options for study abroad experiences. Among them are exchange programs with the Universidad Pontificia Comillas in Spain, Beijing Institute of Technology in

China, KTH in Sweden and the University of Amsterdam in the Netherlands. Stevens also partners with University College Dublin in Ireland, Queen Mary: University of London, Budapest University of Technology and Economics in Hungary, and the University of Nicosia in Cyprus. Stevens also partners with several study abroad providers, including Academic Programs International (API), Global Semesters Inc., International Studies Abroad (ISA), The Education Abroad Network (TEAN), and CIS Abroad, to name a few.

The decision of when to study abroad is made after discussions with the Academic Advisor, Co-op Counselor (if appropriate) and the Director of International Programs. Students are advised to select the semester or summer which best fits their academic curriculum, and does not delay their graduation.

Stevens's students who have participated in study-abroad programs and other international education experiences report that it enriched their lives, and enhanced their opportunities for employment and/or professional studies.

For more information view <u>www.stevens.edu/studyabroad</u>, contact <u>studyabroad@stevens.edu</u>, or visit the Office of International Programs, Edward A. Stevens Building, Room 119B.

Undergraduate Procedures and Requirements

A more detailed description of undergraduate academic policies and procedures can be found at <u>https://www.stevens.edu/</u><u>about-stevens/university-policy-library/undergraduate-academics/undergraduate-academics-policies-and-procedures</u>.

Academic Standing

Academic grades are listed below and quality points per credit are indicated in parentheses:

А	(4.00)	Excellent
A-	(3.67)	
B+	- (3.33)	
В	(3.00)	Good
B-	(2.67)	
C+	(2.33)	
С	(2.00)	Fair
C-	(1.67)	
D+	- (1.33)	
D	(1.00)	Poor
F	(0.00)	Failure
Ρ	(0.00)	Indicates a successfully completed Pass/Fail course.
W		If you withdraw from a course up until one week before the last class meeting of the semester, "W" is posted.
Ex	С.	If you are excused by a physician from attending physical education classes, you receive an "Exc."

Faculty regulations concerning the abbreviations "Abs." for absent and "Inc." for incomplete can be found on the Undergraduate Academics Web site at <u>https://www.stevens.edu/about-stevens/university-policy-library/undergraduate-academics-policies-and-procedures</u>. Stevens uses the Quality Points System to determine grade

point averages (GPA). This means an "A" in a three semester-hour course is worth three times more than an "A" in a one semester-hour course. To determine the number of quality points for any course, the semester hours are multiplied by the value of the letter grade received for the course. To determine the weighted average, the sum of quality points is divided by the sum of quality hours.

Examinations

All students must take a written examination at the end of each term in all major-required core courses. Examinations in all technical, engineering, humanities, and management electives are at the option of the specific department(s).

Grade Point Averages

The Office of the Registrar calculates three different GPAs for each student:

- ▶ The semester GPA is determined from all courses taken at Stevens during a semester.
- The graduating GPA is calculated from all courses taken at Stevens that are part of the degree requirement. If a course is repeated, the new grade replaces the old grade for purposes of calculating the graduating GPA, even if the new grade is lower than previous grade(s). Please note that if a course that has been passed previously is retaken, and a grade of F or W is recorded for the retaken course, then the course is considered as having been passed and the previous grade will be used in calculating the graduating GPA. If a course is repeated outside of Stevens with a grade of C or better, then a grade of C is used to calculate the graduating GPA.
- The ranking GPA is calculated from all courses that are part of the degree requirement. In this case, all repeated courses are included and repeated courses taken outside of Stevens are calculated as a "C."

Grade Changes

A final grade in a course may be changed only if an error in grading or grade computation was made, or if an Incomplete/ Absence petition was approved and filed before the end of the semester in which the course was taken. If one of these circumstances applies, a grade may be changed within one regular (spring or fall) semester after the term in which the course was taken.

Graduation Requirements

To be eligible for graduation, you must have a "C" average (2.00 GPA) for eight terms of work and pass all required courses for your curriculum. Each course which is part of an undergraduate degree program must be passed within no more than three attempts.

Advanced Placement

Stevens participates in the Advanced Placement (AP) program of the College Entrance Examination Board. You may receive college credit toward your degree for the following examinations and corresponding scores.

AP Examination & Score	Stevens Equivalent	Credits
Art History (4,5)	HAR 180	3
Biology (4,5)	CH 281 and CH 282	4
Chemistry (4,5)	CH 115, 116, 117 and 118	8
Chinese Language and Culture (4,5)	General Elective (for engineering students), Elective (for majors other than engineering)	3
Computer Science A (4,5)	Computer Science (CS) and Cyber Security (CyS) majors and minors will receive a CS elective and will be placed in CS 181 or CS 284 for the first semester. Majors other than CS and CyS receive credit for E 115 and CS 105.	2 or 3
Economics-Macroeconomics (4,5)	BT 243	3
Economics-Microeconomics (4,5)	BT 244	3
English-Language & Composition (4,5)	100 Level Humanities	3
English-Literature & Composition (4,5)	100 Level Humanities	3
Environmental Science (4,5)	General Elective (for engineering students), Elective (for majors other than engineering)	3
French Language & Culture (4,5)	General Elective (for engineering students), Elective (for majors other than engineering)	3
German Language & Culture (4,5)	General Elective (for engineering students), Elective (for majors other than engineering)	3
Government & Politics-Comparative (4,5)	100 Level Humanities	3
Government & Politics - U.S. (4.5)	100 Level Humanities	3
History - European (4,5)	100 Level Humanities	3
History - U.S. (4,5)	100 Level Humanities	3
History - World (4,5)	100 Level Humanities	3
Italian Language and Culture (4,5)	General Elective (for engineering students), Elective (for majors other than engineering)	3
Japanese Language and Culture (4,5)	General Elective (for engineering students), Elective (for majors other than engineering)	3
Latin (4,5)	100 Level Humanities	3
Mathematics - Calculus AB (4,5)	MA 121 and MA 122 Or MA 117	4
Mathematics - Calculus BC (4,5)	MA 121, MA 122, and MA 123 Or MA 117	6 or 4
Music Theory (4,5)	HMU 201	3
Physics 1 (4,5)	PEP 123 (for Business and Humanities majors)	3
Physics 2 (4,5)	PEP 124 (for Business and Humanities majors)	3
Physics C - Mechanics (4,5)	PEP 111	3
Physics C - E & M (4,5)	PEP 112	3
Psychology (4,5)	HSS 175	3
Spanish Language & Culture (4,5)	General Elective (for engineering students), Elective (for majors other than engineering)	3
Spanish Literature & Culture (4,5)	100 Level Humanities	3

IB Placement

Stevens participates in the International Baccalaureate (IB) program of the International Baccalaureate Organization. You may receive college credit toward your degree for the following examinations and corresponding scores.

IB Examination	IB Level Stevens Equivalent	Credits
Biology w/Lab (6,7) HL	CH281 and 282	4
Chemistry w/Lab (6,7) HL	CH115,116,117, and 118	8
Classical Language (6,7) HL	General Elective (for engineering students), Elective (for majors other than engineering)	3
Computer Science (6,7) SL	Free Elective; may take courses for which CS 115 is a pre-requisite; CS majors will be placed in CS 181	3
Computer Science (6,7) HL	Free Elective; may take courses for which CS 115 and CS 284 are pre-requisites; CS majors will be placed in CS 182 second semester	3
Economics (6,7) HL	BT243 and 244	6
History (6,7) HL	HHS 123 or 124; (class for credit chosen with consultation of faculty advisor)	3
Language A1 (6,7) HL	General Elective (for engineering students), Elective (for majors other than engineering)	3
Language A2 (6,7) HL	General Elective (for engineering students), Elective (for majors other than engineering)	3
Language B (6,7) HL	General Elective (for engineering students), Elective (for majors other than engineering)	3
Music (5,6,7) SL/HL	Assessment test given that may allow the student to place out of specified topic and receive full course credit if they pass that assessment. The student can declare any required music and technology major components.	*Dependent upon Exam
Philosophy (6,7) HL	HPL 111 or 112; (class for credit chosen with consultation of faculty advisor)	3
Psychology (6,7) HL	HSS175	3
Social and Cultural Anthropology (6,7) HL	General Elective (for engineering students), Elective (for majors other than engineering)	3
Theater HL (6,7) HL	General Elective (for engineering students), Elective (for majors other than engineering)	3
World Cultures (6,7) HL	HUM 107	3
World Religions (6,7) HL	General Elective (for engineering students), Elective (for majors other than engineering)	3

Course Options

Course by Examination

Course by examination is open to students with a GPA of 3.0 or better either in the previous semester or overall, and is limited to one per semester. Permission to take a course by examination must be obtained on a Request for a Course by Examination form from the instructor, student advisor, and the Office of Undergraduate Academics.

If the examination is successfully completed, the instructor who administered the examination issues a letter grade in the course. The examination must be taken prior to the start of a semester, and if the examination is not passed, the unsuccessful

attempt is recorded as part of the student's permanent record, and the student must enroll in that course in the following semester.

A course that has already been attempted by a student cannot subsequently be taken as a Course by Examination.

Course by Application

If a particular course is not offered through the regular schedule, the course may be taken by application with the approval of the instructor, the Department Director, and the Office of Undergraduate Academics on a Request for a Course by Application form. Regular enrollment is required, and arrangements are made for the student to study the material and be tested during the semester. A letter grade is issued at the end of the semester.

Extra Courses

Freshman, during the first academic year, are not allowed to take extra classes beyond the number of courses in their major.

Taking extra courses beyond a program's normal load is a serious matter. While the Office of Undergraduate Academics does not encourage overloading, any overload consideration must be discussed and approved by that office. The following are the criteria for overloading:

After the first year, the students may enroll in an extra class with the permission of the Office of Undergraduate Academics and a GPA of 3.3 or higher in the previous full-time semester. The students with an extra course and 3.6 or higher GPA may enroll in two extra courses. The GPA requirements above can also be met by the student's cumulative GPA.

The baseline definition for the regular course load is the maximum number of credits for the student's major in any of the semesters of the program in the catalog for the student's entrance year. An additional per credit tuition fee will apply for students who overload.

Auditing Courses

To audit a course is to attend classes without receiving credit for the course. A student may do this with approval from the Office of Undergraduate Academics. This course will count as an enrolled course for purposes of computing overload charges, should any be required. In order to change from credit to audit status or audit to credit status in a class, student must file a Change of Enrollment (Add/Drop) form in the Registrar's Office before the Add/Drop deadline established by the Registrar.

Pass/Fail

If a student is on the Dean's List or has a 3.00 average, one course per semester may be selected under a pass-fail grading system, subject to the Advisor's approval. The course must be an extra undergraduate course beyond the requirements for the undergraduate degree. The course must be clearly designated on the study plan or application for candidacy as either "extra" or "outside the area of concentration." No graduate course may be taken under the pass-fail grading system regardless of its status. You have until the mid-term date of the semester to designate a course as pass-fail.

Dropping/Withdrawing from Courses

Individual courses may be dropped during the Add/Drop Period in the first two weeks of each semester (one week in summer sessions) by submitting a Change of Enrollment Form to the Office of the Registrar. When a course is dropped, no record of the student's enrollment in the course remains on the student transcript.

After the Add/Drop Period has passed, students may withdraw from a course up to one week before the last day of classes. When a student withdraws from a course, a grade of "W" is recorded on the transcript. The grade of "W" does not affect the

student's graduating GPA. International students should consult with the Office of International Student and Scholar Services before withdrawing from a course.

Dean's List

The Dean's List is prepared at the end of each academic term by the Registrar's Office. To be eligible for a given semester, you must be in good standing, earn at least 12 credits, and have a 3.5 term GPA with no failures and no more than one course withdrawal.

Reduced Load Program

The Reduced Load Program has two options:

Freshman Option

Permits freshmen to take one fewer technical course for each of the first two semesters. The courses are made up tuition free during the summer immediately following the freshman year. The deadline to sign up is the start of the second semester. To register for the tuition free courses, students must visit the Office of Undergraduate Academics during registration to complete Change of Enrollment form(s).

Reduced Load Option

Reduces the student's work load in each semester by lengthening the time from entrance to graduation from eight to ten semesters. Students who are accepted into the Reduced Load Option receive full tuition waiver in the 9th and 10th semesters. The waiver of full tuition does not extend beyond the 10th semester. The deadline to sign up is the end of the third semester for engineering students and the end of the second semester for all other students.

Students may elect to change their participation from the Freshman Option to the Reduced Load option after their first two semesters. Students who elect to make this change forfeit the free summer classes offered through the Freshman Option.

Continued participation in the Reduced Load Option is contingent upon maintenance of a curricular program that does not exceed "reduced load" status for the appropriate field of study while paying the current full semester tuition. Explicit in this condition is a forfeiture of the student's right to exercise the "extra course" provision. This forfeiture does not prohibit students from pursuing certain program enhancements such as minors following specific approval from the Office of Undergraduate Academics.

Students may, during the 9th and 10th semesters, qualify for limited financial aid. Merit scholarships are strictly limited to eight semesters. In all cases, it is the student's responsibility to complete all applicable financial aid forms. Students are strongly urged to contact the Office of Financial Aid for details.

Contact the Office of Undergraduate Academics to discuss the options above.

English Language Requirement for International Students

Undergraduate international students will be placed in CAL 101 during their first semester. After successful completion of CAL 101, international students must take CAL 103, followed by CAL 105. A diagnostic will be administered during the first week of CAL 101 and students who surpass the requirements of the diagnostic may transfer to CAL 103. CAL 101 may be used to satisfy a general or free elective requirement. Subsequently, all undergraduate international students must complete the remaining humanities courses required for their degree program.

Online Graduate Courses for Undergraduate Students

Undergraduate students may, with junior or senior standing, a 3.0 or higher GPA, and the permission of their advisor, enroll in up to two online graduate courses per semester. Students with a 3.2 or higher GPA may take a third web course. These classes are counted as part of the students' regular semester credit load for purposes of computing overload charges, if any apply. Students wishing to take more than two (or three with a GPA of 3.2 or higher) online courses require the permission of the Office of Undergraduate Academics, and will incur additional charges at the undergraduate per-credit tuition rate for these classes regardless of whether or not they exceed the credit-load limit. Undergraduates are not permitted to enroll in the winter or the Spring 2 WebCampus semesters. Online graduate courses may not include more than two 600- or higher-level courses per semester and those courses require a separate permission process.

International students in F-1 immigration status should keep in mind that immigration regulations permit them to count only one online course (3 credits) toward their full-time requirement in each regular (fall and spring) semester. Therefore, while Stevens permits them to take 2 online courses per semester at no additional cost, they must generally be enrolled in a minimum of 15 credits, at least 9 of which must be in regular on-campus courses, in order to do this and still maintain their immigration status. For additional details and questions, please contact the Office of International Student and Scholar Services. http://www.stevens.edu/directory/international-student-and-scholar-services

Non-matriculated Students

Students wishing to take a course at Stevens on a non-matriculated basis must obtain approval from the Office of Undergraduate Academics. A minimum 3.0 GPA at the student's current or previous college or university is required, in addition to completion of the equivalent of all pre-requisite courses for the desired Stevens course. Tuition is charged on a per-credit basis. For details regarding course offerings, visit the Office of the Registrar's web site at http://www.stevens.edu/directory/office-registrar

Academic Leave of Absence/Withdrawal from Stevens

Students seeking a Leave of Absence or Withdrawal should appear in person to the Office of Undergraduate Academics (OUA) located in Edwin A. Stevens Building Room 119. Withdrawing from Stevens means that the student no longer plans to continue his/her education at Stevens. Leave of Absence (LOA) means that the student plans to return to Stevens to continue his/her education. Students wishing to take a voluntary leave of absence from Stevens can do so for up to 6 months or one semester. Transcripts will be reviewed to determine readmission eligibility and conditions. Students who do not return to Stevens within 6 months or one semester will be classified as withdrawn. LOA/Withdrawal Form can be found on the OUA website. http://www.stevens.edu/directory/undergraduate-academics

Students should contact the Office of Financial Aid for questions regarding the impact a leave or withdrawal will have on loans and/or scholarships.

Note: Undergraduate students must apply for readmission within 7 years from the date of the leave of absence or withdrawal from Stevens. An undergraduate degree must be completed within 12 years of entrance to Stevens.

Administrative Leave of Absence

Students may be placed on an Administrative (involuntary) Leave of Absence for any of the below reasons:

- Financial: If a student is not able to meet his/her financial obligations for the semester or has an outstanding balance from a previous semester/year
- Medical/Mental Health: as determined by professional staff member(s)

- Disciplinary: as determined by Student Affairs or by the Honor Board
- Academic: as determined by the Academic Promotions Committee
- ▶ Not Enrolled: students who do not register for classes by the end of the drop/add period for the semester

> Physical Education (P.E.) Requirements

The Office of Physical Education conducts a structured instructional class program which provides students with knowledge and skills in a wide range of lifetime, team, dance and wellness oriented activities.

Students participate in a multitude of sport pursuits which can be enjoyed both during college and beyond. Examples of the types of classes available include: archery, basketball, boot camp, bowling, core and sculpt, CPR certification, fencing, fly fishing, golf, women's golf, indoor cycling, leadership, Olympic weight lifting, outdoor adventure, Pilates, racquetball, sailing, soccer, squash, strength and conditioning, swimming, tai chi, tennis, yoga and Zumba.

The following are the P.E. graduation requirements for all Stevens students for non-academic credit. They will appear on the student record as pass/fail. All students must complete four Physical Education (P.E.) courses.

- All four P.E. courses must be completed by the end of the sixth semester.
- Students are encouraged to enroll in more than the minimum four required P.E. courses.
- ▶ Participation in varsity sports can be used to satisfy up to three of the P.E. requirements.

The Physical Education course offerings are updated on an annual basis to meet the needs and interests of the student body. Course options may vary from semester to semester.

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Applying for Admissions

Application Requirements

Applicants to any graduate program at Stevens are required to have completed a bachelor's degree from an accredited college or university in the United States or the equivalent from a foreign institution.

A complete application includes the following:

- Online application
- ▶ \$60 non-refundable application fee
- Two letters of recommendation
- Official college transcripts from all institutions attended (both undergraduate and graduate) with proof of degree
- Statement of Purpose
- GRE/GMAT scores for all full-time masters and PhD applicants. Please note that GRE/GMAT scores are valid for 5 years from the testing date.

Additional Requirements for International Applicants

International applicants must provide proof of English language proficiency. Applicants can choose to submit scores from either the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). TOEFL and IELTS scores are valid for two years from the testing date. The minimum required scores for each test are listed below.

IELTS: 6 Paper-based TOEFL: 537 Internet-based TOEFL: 74

Additional Requirements for Doctoral Program Applicants

Applicants to doctoral programs may be required to submit additional information such as a resume, additional letters of recommendation, and/or evidence of written work, as specified by a given school, department, or program.

Current Stevens Undergraduate Students Applying for Graduate Admission

Current undergraduate SIT students applying to a graduate program must complete the online application found on the graduate admissions website.

Application Review

After all required documents are submitted to the Office of Graduate Admissions, accompanied by an application fee of \$60, representatives from the relevant academic department will review the materials. Applicants will be evaluated based on several criteria: undergraduate class standing (upper third is desirable); performance in major field; grade-point average; professional experience, where appropriate; and performance on standardized examinations.

Study Plans

Newly-admitted students must meet with their academic advisor during New Student Orientation and complete a plan of study before enrolling in courses. Courses not included in your Study Plan may not count toward your degree.

Change of Program

A student who wishes to change to a different program prior to the first day of the semester is treated as a new student applying for admission and must fill out a new application. Students wishing to change to a different program after the first day of the semester should fill out a program change form which must be submitted to the Office of Graduate Admissions, after which the student's file is then sent to the new department for a separate admission decision. The student must then complete a new Study Plan, and all previously completed coursework must be evaluated for transfer into the new program. Acceptance of such credits is entirely at the discretion of the department and must be approved by the Dean of Graduate Academics.

Deferring Admission

Newly admitted students may request to defer their acceptance for one semester. Students who have not enrolled within one year of their acceptance must reapply through the Office of Graduate Admissions. The student's file will be reviewed and a decision letter will be sent to the student.

Degree Programs

Stevens Institute of Technology offers graduate programs in engineering, science, systems engineering, management, and the liberal arts. Programs lead to one of over 50 different advanced degree designations from the Master's to the Doctor of Philosophy degree. The graduate programs are intended to enable professionals to advance in industries increasingly influenced by technology and also to enable scholars to explore the frontiers of their disciplines. Students may attend graduate courses on a full-time or part-time basis, with many students attending classes at off-campus corporate cites. Students may complete a prescribed course sequence or engage in research activity that generates new knowledge in pursuit of an advanced degree.

Master's Programs

A Master's program may be thought of as an extension or completion of the higher level of education already achieved in undergraduate studies. It may be an exploration in some depth of a particular area of science, engineering, computer science, information systems, management, or liberal arts, or it may be intended as a first step toward a doctoral degree. Since the master's degree carries with it the designation of the department in which it is earned, you must follow a Study Plan that your faculty advisor approves as satisfactory for the requirements of the degree and adequate to your particular needs. Upon request of the Dean of Graduate Academics you may arrange an interdisciplinary program designating at least two professors to supervise the major areas of study. *For more information regarding Interdisciplinary programs, please see additional information below.*

For the master's degree, you must earn no less than 30 credits, 15 of which must be in your major's department. Additional requirements may be required by the department offering the program. Interdisciplinary programs are exempt from the requirements of 15 credits in one department. Thesis requirements, if any, vary with the department. In general, a master's thesis is optional for part-time students, but required by some departments of full-time students who are supported graduate assistants or are continuing on to the doctorate. For specific program requirements, please visit your Department's section of the Academic Catalog.

Engineer Programs

The Engineers degree is a terminal professional degree beyond the master's degree. The purpose of the Engineer program is to advance the training of engineers beyond the master's level and to provide modern education for engineers whose master's degrees are not recent. A design project carrying from 8 to 15 credits is required. Five programs, each of 60 credits, beyond the bachelor's degree, are offered, leading to the degrees of:

- Chemical Engineer
- Civil Engineer
- Computer Engineer
- Computer Science Engineer
- Electrical Engineer
- Mechanical Engineer
- Physics

Doctoral Programs

Doctoral programs are specifically designed for students to ultimately lead an independent investigation of a problem within their field allowing them to make significant contributions to that particular body of knowledge. While part of this involves acquiring existing knowledge in their field, doctoral students' fundamental objective is to develop their skills and capacity to conduct original research. Therefore, the preliminary requirements for the doctorate are regarded not as ends in themselves, but rather as preparation for the dissertation in which the student demonstrates ability.

As doctoral students pursue research in a particular field of science, engineering, or management, they will develop their study plan in preliminary conferences with a faculty advisor from the relevant department and all concerned faculty members. In addition to the general admissions requirements, students must satisfy the standards for qualifications established by their department. Approval is generally only given when a student has completed work equivalent to a master's degree.

A prior master's degree may be transferred for up to 30 credits without specific course descriptions with approval of the department and the Dean of Graduate Academics. Up to one-third of additional course credits may be transferred with the approval of the thesis committee and the Dean of Graduate Academics. The grade of "B" (3.0 GPA) or better is required for such courses and such courses may not have been already used to obtain an academic degree.

The Dean of Graduate Academics, at the request of the student, may arrange an interdisciplinary program. To oversee and approve such a program, the Dean of Graduate Academics, on the advice of faculty responsible for the programs involved, will designate a professor from each of the pertinent disciplinary areas to serve on a special supervisory committee. The committee chairpersons will ordinarily be the professors who will supervise the student's research. Examination requirements for interdisciplinary programs will be tailored appropriately and administered through the Dean of Graduate Academics.

Individual departments may require proficiency in a foreign language appropriate to the area of a doctoral candidate's proposed dissertation. This proficiency will be tested by an examination set by the department at least one year before graduation. Individual departments may require an additional language.

Before a department approves a candidate for the doctorate, the candidate must have demonstrated to the Dean of Graduate Academics that the language requirements, if any, have been satisfied; that the qualifying or comprehensive and preliminary examinations in the major and minor areas of study have been passed; and that the research program for a dissertation has been approved.

Within six months of becoming a doctoral candidate, the student needs to select a Research Advisor and agree upon a research topic. The Research Advisor will request that the Department Director nominate additional members of the Advisory Committee. A dissertation committee is composed of at least four persons, one of whom must be a Stevens professor from another department or program. It is permissible and desirable to have as a committee member a highly qualified person from outside Stevens. The chair or co-chair must be a tenure track, full-time professor, professor emeritus, or a person employed in an academic capacity at Stevens who has been approved through a process determined by the particular school of his/her employment. A Dissertation Advisory Committee Appointment form is completed and submitted to the Dean of Graduate Academics for approval. Usually, the student's Research Advisor serves as Chairman of the Advisory Committee. The student and the Advisory Committee must meet at least once a year and report to the Dean of Graduate Academics that the meeting was held.

Upon appointment of the Advisory Committee the candidate will prepare and defend a research proposal. The institute requires that the candidate take the Stevens "Signature" course PRV961 which is intended to broaden the PhD educational experience. This may be done concurrently with the preparation of the proposal.

Within two weeks after the beginning of the semester in which the student expects to complete the requirements for the doctorate an application for candidacy for the degree must be filed at the Registrar's Office. A dissertation, in which the student presents the results of their research in a form worthy of publication, must be submitted to the committee at least six weeks before the date on which they expect to receive their degree. After the advisory committee accepts the student's dissertation, a date will be set for a public oral examination to defend it. The defense must take place at least two weeks before commencement. At the time of the defense, at least one manuscript based on dissertation work must be submitted for publication.

Interdisciplinary Programs

Interdisciplinary graduate programs promote intellectual growth and offer distinct challenges to conventional thinking. They address areas that are too broad or too complex to be dealt with adequately by a single academic discipline. Interdisciplinary programs are essential for the education of graduate students involved in projects concerned with the nurturing of technology from concept to realization. It is also the case that some interesting scholarly areas involve the blending of two or more academic disciplines, for example, management science juxtaposes operations research and business.

Students interested in an interdisciplinary program at either the Master's or Ph.D. level may proceed as follows:

- ▶ The student applies to Stevens Institute of Technology as an interdisciplinary student and outlines the program he or she would like to undertake.
- ▶ The Office of Graduate Admissions forwards the application to the Dean of Graduate Academics. The Dean of Graduate Academics forwards the application to the appropriate departments/programs for consideration.
- ▶ The departments/programs render their decisions and report them to the Dean of Graduate Academics.
- If all decisions are positive, the Dean of Graduate Academics informs the appropriate directors and appoints advisors for the preparation of a Study Plan and mentoring of the student.
- The Dean of Graduate Academics formally informs the Office of Graduate Admissions the status of the application. If all decisions are positive, admission is granted; else admission is not granted.
- The student must complete a Study Plan and submit to the Dean of Graduate Academics for approval. Upon approval, the Study Plan is sent to the Office of the Registrar.

Graduate Certificate Programs

Graduate Certificates are organized for practicing engineers, applied scientists, and managers to keep abreast of the newest techniques and their applications in selected disciplines. Most graduate certificates consist of four graduate courses often of an applied nature, and the information and understanding gained in the courses can be immediately applied to the solution of on-the-job problems. One course taken at another institution may be transferred to the graduate certificate with faculty approval. The grade of "B" (3.0 GPA) or better is required for such a course, and it may not have been already used to obtain an academic degree. A Graduate Certificate is awarded upon satisfactory completion (i.e. a 3.0 GPA in the courses of the program not including a transferred course) of the graduate courses required for the program. In most instances, these courses may be applied towards a graduate degree.

Online Programs

Stevens students can take courses online for graduate credit and non-credit through WebCampus. A complete listing of WebCampus courses can be found at www.stevens.edu/webcampus. Designed for those who, because of distance or other commitments, cannot attend class at either Stevens' Hoboken campus or at off-campus corporate locations, WebCampus courses are delivered worldwide by the same superior faculty who teach in conventional classroom settings. Currently, there are 45 Graduate Certificates and 19 Master's programs available online through WebCampus.

Graduate Procedures and Requirements

A more detailed description of graduate academic policies and procedures can be found in the Graduate Student Handbook.

Academic Standing

The lowest passing grade for graduate courses is "C-," and "F" is failure.

Students must maintain a "B" (3.0) grade point average to remain in satisfactory academic standing in a graduate program.

Students may be placed on probation if they a) have less than a "B" average b) have received a "C" and/or a "C-" in three or more courses c) have received an "F" in a course that has been improve by repeating it.

Grade Point Average

Academic grades are listed below and quality points per credit are indicated in parentheses:

А	(4.00)
A-	(3.67)
B+	(3.33)
В	(3.00)
B-	(2.67)
C+	(2.33)
С	(2.00)
C-	(1.67)
F	(0.00)

The Office of the Registrar calculates three different GPAs for each student:

- ▶ The semester GPA is determined from all courses taken at Stevens during a semester.
- The graduating GPA is calculated from all courses taken at Stevens that are part of the degree requirement. If a course is repeated, only the last grade is used, even if the last grade is lower than previous grade.
- The ranking GPA is calculated from all courses that are part of the degree requirement. In this case, all repeated courses are included.

Special Grades

The following grades are given under the specified conditions:

"AUD" - audit	A student who registers to audit a course, pays the full fee, but does not receive a terminal grade or credit.
"ABS" - absent	This grade indicates that the student was absent from the final examination with approval of the instructor and the Dean of Graduate Academics.
	The approval must be obtained through the use of the INC/ABS petition form available from the Student Services Center. The petition form must be filed within thirty days of the final examination date. After the student takes the examination, a Change of Grade form will be submitted by the instructor, giving a terminal grade for the course.
	Under normal circumstances, but subject to the discretion of the Dean of the Graduate Academics, a grade of F will be given for the course if the instructor does not submit a terminal grade before the agreed upon date.
"INC" - incomplete	Indicates that the student filed a petition form that is available from the Office of the Registrar. The petition must be filed no later than the last regular class meeting.
	Generally, an incomplete grade is granted to a person having been in the class for at least 10 class sessions, who is in good academic standing in the course, and has completed all the course requirements due within that time period. This grade is given at the discretion of the instructor.
	The incomplete must be made up within one year unless an extension is granted by the Dean of Graduate Academics.
"S/U" - satisfactory/ unsatisfactory	Indicate satisfactory or unsatisfactory respectively and are in progress grades, used as an interim grade for special problems courses, master's theses, engineer projects and doctoral dissertation.
"NG" - no grade	It is a temporary notation issued to students by the Registrar in the following situations:
	 a grade has not been entered on the grade sheet for a student
	 "W", "INC", or "ABS" has been entered on a grade sheet, but no petition has been filed or approved
"W" - withdrawal	Students are automatically approved to withdraw from a class if it is before the end of the tenth class session. After the tenth class session, students need the permission of the instructor and Dean of Graduate Academics to withdraw from a course.
	A "W" will appear on your transcript but does not affect your GPA.

Grade Changes

A final grade in a course may be changed only if a) an error in grading or grade computation was made, or b) an Inc./Abs. petition was approved and filed before the end of the semester in which the course was taken. If one of these circumstances applies, a grade may be changed within one regular (Spring or Fall) semester after the term in which the course was taken.

Graduation Requirements

In order to graduate a student must obtain (1) a minimum of a "B" average (3.0 GPA) average in their major and (2) an overall average of "B" (3.0 GPA) in the courses required to meet the requirements for the degree. A maximum of six years is allowed for completion of the degree, unless an extension has been requested by the student and granted by the Dean of Graduate Academics.

Transferring Credits

Up to 9 transfer credits may be accepted toward a 30 credit Master's degree or 12 transfer credits toward a 36 credit Master's degree or a 48 credit MBA degree, if these credits have not already been used to obtain an academic degree. All credits for transfer must show grades of "B" (3.0 GPA) or better, and the courses must be approved by the appropriate departments and submitted to the Registrar's Office.

Course Options

Course by Application

If a particular course is not offered through the regular schedule, the course may be taken by application with the approval of the instructor, the Department Director, the Office of Graduate Academics on a Request for Course by Application form. Regular enrollment is required, and arrangements are made for the student to study the material and be tested out during the semester. A letter grade is issued at the end of the semester.

Auditing Courses

To audit a course is to attend classes without receiving credit for the course. A student may do this with approval from the Office of Graduate Academics. Under no circumstances can you change to credit status or take the course for credit at a future time.

Dropping/Withdrawing from Courses

Individual courses may be dropped during the Add/Drop Period in the first two weeks of each semester (one week in summer sessions) by submitting a Change of Enrollment Form to the Office of the Registrar. When a course is dropped, no record of the student's enrollment in the course remains on the student transcript.

After the Add/Drop Period has passed, students may withdraw from a course up to one week before the last day of classes. When a student withdraws from a course, a grade of "W" is recorded on the transcript. The grade of "W" does not affect the student's graduating GPA. International students should consult with the Office of International Student and Scholar Services before withdrawing from a course because it could have implications on immigration status.

English Language Proficiency Requirements for International Students

The ability to communicate effectively in English — to read, write and speak the language fluently — is vital for Stevens graduate students. Therefore, every international applicant must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

Depending on TOEFL/IELTS scores, some students may be required to take an English Language Communications course during their first semester at Stevens. Those students will receive a letter from the English Language Communication (ELC) staff during orientation that informs them of their course placement. For detailed information about scores and associated

requirements, please refer to the English Language Proficiency Policy on the Office of Graduate Admissions website. If you have specific questions about the ELC policy or courses, please email Sophie Hales, ELC Coordinator at shales@stevens.edu, or Helene Beck, Assistant ELC Coordinator at hbeck@stevens.edu.

English Language Communication (ELC) Courses

ELC 71: Language and Communication in Academic Contexts (6 hours; 4 credits)

ELC 71 focuses on improving critical reading skills, developing effective listening strategies, gaining intelligibility in speaking, and acquiring familiarity with academic writing conventions. Through a variety of materials and task based activities, students will gain competence in writing well organized, coherent, and grammatically correct texts. Class discussions, text analysis, and teamwork will enhance students' analytical skills and promote confidence in social interaction in an English-speaking environment. Additional required work in the Language Laboratory will also improve informal communication, as well as the ability to give formal presentations.

ELC 81 Writing and Speaking for Academic Purposes I (4 hours; 2 credits)

ELC 81 focuses on improving academic writing skills through emphasis on specific tasks, including email, summary, and problem-solution writing, which are necessary for success at the graduate level. There is additional focus on improving speaking and listening strategies for academic, social, and professional interaction, which includes an understanding of how these two skills are related. A variety of materials and task-based activities help students gain competence and confidence in writing and speaking, both formally and informally. Additionally, required attendance in the Language Laboratory will enhance students' intelligibility in social and academic situations.

ELC 91 Writing and Speaking for Academic Purposes II (4 hours; 2 credits)

ELC 91 helps students position themselves as successful members of the graduate community by exploring the effective use of academic conventions. Resolving questions of rhetoric through text analysis, class discussions, and collaborative activities strengthens critical reading, thinking, and academic writing skills. A variety of genre-specific tasks help students improve communication of both sourced/non-sourced and verbal/non-verbal (graphs, tables, etc.) information. Additionally, refining critical elements of pronunciation through class and Language Laboratory work will improve the quality of formal and informal presentations.

Non-matriculated Students

Students wishing to take a course at Stevens on a non-matriculated basis must obtain approval from the Office of Graduate Academics. A minimum 3.0 GPA at the student's current or previous college or university is required, in addition to completion of the equivalent of all pre-requisite courses for the desired Stevens course. Tuition is charged on a per-credit basis. For details regarding course offerings, visit the Office of the Registrar's web site at http://www.stevens.edu/directory/office-registrar.

Academic Leave of Absence/Withdrawal from Stevens

Students seeking a Leave of Absence or Withdrawal should appear in person to the Office of Graduate Academics located in Edwin A. Stevens Building Room 130. Withdrawing from Stevens means that the student no longer plans to continue his/her education at Stevens. Leave of Absence (LOA) means that the student plans to return to Stevens to continue his/her education. Students wishing to take a voluntary leave of absence from Stevens can do so for up to one year or two semesters. Transcripts will be reviewed to determine readmission eligibility and conditions. Students who do not return to Stevens within one year or two semesters and have not obtained an extension of their Leave of Absence approved by the Dean of Graduate Academics will be classified as withdrawn with the exception of those in military service who have been deployed.

Administrative Leave of Absence

Students may be placed on an Administrative (involuntary) Leave of Absence for any of the below reasons:

- Financial: If a student is not able to meet his/her financial obligations for the semester or has an outstanding balance from a previous semester/year
- Medical/Mental Health: as determined by professional staff member(s)
- ▶ Disciplinary: as determined by the Dean of Graduate Academics and the Director of Graduate Student Affairs

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Tuition, Fees & Other Expenses for Undergraduate Students

For the 2016-2017 academic year, the cost of attendance is as follows:

Tuition (full time, 12 – 20 credit)	\$47,134
Freshman Room and Board (typical on-campus, double occupancy/typical meal plan; other plans vary)	\$14,350
Books and Supplies (estimated)	\$1,200
General Services Fee	\$1292
Student Activities Fee	\$412
Total	\$64,388

Full-Time Students

Students enrolled in 12 - 20 credit-hours are considered full-time academic students and tuition is \$23,567 per semester.

Part-Time Students

Students enrolled in fewer than 12 credit-hours are considered part-time. Part-time undergraduates are charged 1,571 per credit-hour. If a student enrolls in fewer than 12 credit hours, he/she is not eligible for state or Stevens financial aid and may not be eligible for federal financial aid. Students with fewer than 12 credit-hours should check with the Office of Financial Aid to see if they are eligible for any federal financial aid.

Fees

\$206	Student Activities Fee per semester, which is used by the Student Government Association (SGA) to support the many undergraduate clubs and activities
\$90	Laboratory Fee for each class taken with a lab each semester
\$50	Hanlon Lab fee for each class taken in Hanlon with a lab each semester
\$646	General Services Fee (per semester)
\$20	Fee to replace an ID card
\$100	Vehicle Registration Fee per semester (commuter)
\$300	Vehicle Registration Fee per semester (on-campus resident)
\$550	Late Payment Fee

Books & Supplies

Students can purchase all required textbooks and other supplies at the Campus Store. Purchases may be charged to the student's Duck Bills or personal credit card.

Co-op Students

Students participating in the Stevens Cooperative Education program are not charged tuition but are considered attending full-time. Co-op students are not entitled Stevens Institutional financial aid when they are on a co-op working term. Each co-op student studies full-time during one summer semester and is eligible to receive federal, state or Stevens financial aid. Students are required to pay the student activities, General Service, health insurance, and other applicable fees each year.

Health Insurance

Stevens requires all students to have health insurance. Copies of the student health insurance brochure can be viewed online by visiting <u>www.universityhealthplans.com</u>. Undergraduate students are charged annually for health insurance and may waive the charge if the student has equivalent coverage that meets Stevens' requirements for undergraduate students. Students may go to <u>www.universityhealthplans.com</u> and click on "Stevens Institute of Technology" to submit an online waiver of the Institute coverage by a specific deadline designated each semester by Stevens. If Stevens does not receive the online waiver information by the published deadlines the University cannot waive the insurance charge. The brochure and rate information is available on our **website** at <u>http://www.stevens.edu/directory/office-student-accounts/health-insurance-information</u>

Student Housing & Meal Plans

Residence Halls

Students intending to live on campus should visit the Office of Residence Life website at <u>https://www.stevens.edu/campus-life/residence-life</u> to apply view current residence hall rates and to for housing online.

Meal Plans

The meal plan options are designed to provide students with increased flexibility. With a meal plan, students are able to dine in the Pierce Dining Hall, which is all-you-care-to-eat and open seven days a week. Meal plan options are assigned by residence and are per semester. Meal plans and their prices are subject to change. Students who choose to live in Stevens Housing are required to purchase a meal plan.

Duckbills

At Stevens, we make it easy to dine and socialize with friends without having to carry cash. DuckBills are a prepaid, dollar for dollar, declining balance account housed on your Stevens ID Card that may be used to pay for purchases at participating on and off campus locations. They are convenient, safe and fun to use. Students, staff and faculty are all encouraged to use DuckBills for their purchases. Visit <u>https://www.stevens.edu/campus-life/residence-life</u> for more information.

For more information about campus housing, dining services, and meal plans, please visit <u>www.stevens.edu/housing</u>, or contact the Office of Residence Life at <u>reslife@stevens.edu</u> or by calling (201) 216-5128.

E-Billing Statements

An email notification will be sent to the student's Stevens email account to notify when a new statement is available. Students can authorize parents, guardians and employers as third-party payees. Authorize users will also receive email notifications when a new statement is available. You can access ebilling through your myStevens account or directly at www.stevens.edu/ebilling

Payment Options

Tuition, fees, and charges for room and board are due and payable by the designated due date sent in the students' e-bill. Students participating in Stevens' Study Abroad program or Co-op program have the same payment deadlines. Prompt payment of student account balances ensures students keep the classes they selected and their advance housing selections. Grade reports, transcripts, access to registration and the housing lottery will be withheld if any balance remains unpaid. Balances paid after the due date will result in a late payment fee of at least \$550.00. Amounts paid with checks returned by the bank will result in additional fees.

Check, e-Check and Credit Card

The Office of Student Accounts accepts check, online e-check and online credit card payments. Payments made by check can be mailed or brought to the Office of Student Account in the Student Service Center. If you choose to mail a check please make it payable to Stevens Institute of Technology and include your campus-wide ID number on the check. Students or their authorized third-party payees can make e-check or credit card payments online through ebilling. A non-refundable service fee of 2.75% (minimum of \$3.00) will be added to your credit card payment. Stevens does not charge a fee for e-check (ACH) payments. You can access ebilling through your myStevens account or directly at www.stevens.edu/ebilling.

Monthly Payment Plan

To assist students and their families, Stevens offers a monthly payment plan through Tuition Management Systems (TMS). This is an interest free option but there is a nominal enrollment fee. You can schedule your payments over as many as five payments each semester. Stevens allows students who have an active payment plan to attend classes, reside on campus and participate in other Institute activities while payments are being made to the provider. Enrollment deadline dates apply so contact TMS for specifics 888-356-0350 or enroll on line at www.afford.com/stevens

Should you have any questions regarding this or other payment options please visit our website <u>https://www.stevens.edu/</u> <u>studentaccounts</u> or call the Office of Student Accounts at (201) 216-5555.

Late Payment Fees

Students with unmet financial obligations are not considered to have valid registrations. They are not allowed to attend classes, receive transcripts or grades, participate in registration, or receive their diploma. If a student withdraws or graduates from Stevens with a balance due, Stevens will actively try to collect the unpaid balance. This may include referring the delinquent account to a credit reporting agency and/or collection agency. This may include, but is not limited to, late fees, collections costs, litigation/attorney's fees, and court costs.

Balances paid after the due date will result in a late payment fee of at least \$550.00 unless the student is enrolled in the monthly payment plan. Please refer all questions to the Office of Student Accounts by email <u>studentaccounts@stevens.edu</u> or by phone (201) 216-5555.

Withdrawals & Refunds

Students who enroll and decide not to attend class for any reason must officially drop from classes online through Web for Students within MyStevens or by completing the Drop section of the Change of Enrollment form. The Change of Enrollment form must be submitted to the Office of the Registrar. After the official add/drop period is over a withdrawal will occur and a"W" grade will appear on the transcript. The professors' approval and/or the Dean of Graduate or Undergraduate Academics' approval is required prior to withdrawing from a class after the add/drop period (please refer to the current Academic Calendar). The date the form is submitted to the Office of the Registrar will determine the official withdrawal date for housing and/or meal plans in writing to the Office of Residence Life. They will determine the official withdrawal date for housing and meal plans (which may be different than the date submitted to the Registrar). All tuition, fees, student housing and meal plan charges will be reversed based on the official withdrawal date of classes in accordance with the following schedules:

Regular Academic Semester Tuition Refund Schedule:

Through the first day of the semester (less deposits)	100%
After the first day of the semester through the second week	90%
After the second week of the semester through the fourth week	50%
After the fourth week of the semester through the eighth week	25%
Thereafter	0%

Summer Session Semester Tuition Refund Schedule:

Through the first day of the semester (less deposits)	100%
After the first day of the semester through the first week	90%
After the first week of the semester through the second week	50%
After the second week of the semester through the third week	25%
Thereafter	0%

Return of Title IV Funds

Federal regulations require specific refund calculations for students receiving Title IV financial aid who completely withdraw from the University. Under the Return of Title IV (R2T4) regulations, a student is considered to have withdrawn from a payment period or period of enrollment if he or she does not complete all of the days in the payment period he or she was scheduled to complete. Title IV financial aid includes the following federal student aid (FSA) programs: Federal Perkins Loan, Federal Supplemental Education Opportunity Grant (FSEOG), Pell Grant, Direct Subsidized/Unsubsidized Loans and Direct PLUS/Graduate PLUS loans.

The amount of federal aid a student earns is determined on a prorated basis and is based on the date of withdrawal. Once a student completes more than 60% of the payment period, all of the federal aid the student is scheduled to receive for the period is considered as earned. If earned funds are not received prior to the date of withdrawal the student may be due a post-withdrawal disbursement. Students eligible for post-withdrawal disbursements will be notified – Stevens Institute of Technology must receive permission from the student before it can disburse these funds. The student will have 14 days from receipt of notification to accept/decline the post withdrawal disbursement.

Calculations for Return of Title IV Funding are performed as follows:

- 1. Determine the date of withdrawal
- 2. Calculate the percentage of the enrollment period completed as of the date of withdrawal
- 3. Calculate the percentage of Title IV aid the student earned as of the date of withdrawal
- 4. Calculate the amount of Title IV aid that must be returned/repaid to the programs
- 5. Amounts returned to the Department of Education must be credited to the FSA programs in the following order:
 - a. Federal Unsubsidized Loan
 - b. Federal Subsidized Loan
 - c. Federal Perkins Loan
 - d. Federal PLUS Loan
 - e. Federal Pell Grant
 - f. FSEOG
 - g. Other Title IV Grants

Students who receive Title IV funding and who officially withdraw from the University will be subject to the Return of Title IV calculation in determining earned aid. Students who receive Title IV funding and stop attending classes without official notification to the University, whereby a last date of attendance cannot be determined, will be subject to a Return of Title IV calculation based on attendance through the midpoint of the payment period or the last date of an academically related activity in which the student participated.

Charges that were previously paid by federal aid funds which are returned per the Return of Title IV policy calculation will be the responsibility of the student.

Tuition, Fees & Other Expenses for Graduate Students

Tuition and Matriculation Maintenance

Full-Time Graduate Tuition rate of \$16,664 is charged to students enrolled in 9 - 12 credits. Overload credits will be charged at the per credit tuition rate of \$1,501. Graduate students enrolled in less than 9 credits will be charged \$1,501 per credit. Students who have completed all required credits, and who need to maintain matriculation while completing a thesis, special problem, dissertation, project, or other degree requirements, must enroll for Maintenance for Matriculation (D 999) and pay a \$479 fee per semester, in addition to any other required fees.

Other Fees

For the 2016-2017 academic year, full-time students are required to pay a \$438 General Services Fee and a \$155 Student Activity Fee for each semester they are enrolled in classes, part of which is used to support graduate activities. Part-time students are required to pay a \$283 General Service Fee. Certain classes may have additional laboratory fees and course materials fees. The amounts of those fees vary and are specific to the departments and locations. A \$115 fee for binding three copies of the thesis is required in advance of the last term of study for the Master's and Ph.D. degrees. A \$125 microfilming fee is also required for the Ph.D. degree. Stevens requires all degree-seeking graduating students to pay a \$260 graduation fee (\$80 for students seeking a graduate certificate). There is a \$50 fee for checks that are returned by the bank. There is a \$20 fee to replace student ID cards. There is a \$50 late payment fee and various deferred payment fees, depending on the option chosen.

Transcripts

Stevens will release a student's transcript upon request, provided that his/her account is not overdue and that he/she requests the transcript in writing. Students should allow approximately one week to process the transcript. The transcript is sent directly by Stevens in a sealed envelope to the requested party. Stevens will only release an official transcript directly to the student in a sealed envelope. All transcripts are sent by U.S. mail, unless other arrangements are made. If a student needs the transcripts in less than one week, he/she is required to pay for overnight, two-day, or priority mail. All transcript requests must be made in writing over the student's signature or directly from a Stevens email address. No verbal requests for transcripts will be honored under any circumstances, nor will any requests from a third party unless the student has signed a release for the transcript to that third party.

Health Insurance

Stevens requires students to have health insurance. Copies of the insurance brochure can be viewed online by visiting <u>www.universityhealthplans.com</u>. All full-time students (9 credits or more) are charged annually for health insurance unless they have equivalent coverage. Students may go to <u>www.universityhealthplans.com</u> and click on "Stevens Institute of Technology"

to submit an online waiver of the Institute coverage by a specific deadline designated each semester by Stevens. Optional Health Insurance is also available to all part-time students and to students' spouses and children. The brochure and rate information is available on our website at http://www.stevens.edu/directory/office-student-accounts/health-insurance-information.

Books and Supplies

All required textbooks may be purchased at the Campus Store or through the Campus Store web site at <u>www.stevenscampusstore.com</u>. They will ship textbooks via UPS directly to any address requested by the student, for the cost of the textbooks plus the UPS charge. The Campus Store accepts Duck Bills, American Express, MasterCard, and Visa.

Graduate Student Housing

Most Stevens graduate students live in off-campus houses and apartments in Stevens' hometown of Hoboken, N.J., as well as other cities which surround the university. Our local area is an exciting urban community with a great assortment of shops, restaurants, parks, historical sites, businesses and nightlife. Public transportation options abound, and Stevens also offers a robust shuttle program to make nearby neighborhoods extremely accessible to campus. A small number of graduate students live in Stevens Leased Housing apartments – located in Hoboken within walking distance of the campus. Additional Housing information may be found at <u>www.stevens.edu/housing</u> or contact the Office of Residence Life at (201) 216-5128 or <u>reslife@stevens.edu</u>.

Meal Plans

Graduate students, while not required, are welcome to be on any meal plan. For more information, please visit <u>https://www.stevens.edu/campus-life/residence-life</u> or contact the Office of Residence Life at (201) 216-5128 or <u>reslife@stevens.edu</u>.

Payment Options

Tuition and fees are due and payable by the designated due date sent in the students' e-bill. Prompt payment of student account balances ensures students keep the classes they selected and their advance housing selections. Grade reports, transcripts, and access to registration will be withheld if any balance remains unpaid. Balances paid after the due date will result in a late payment fee of at least \$550.00. Amounts paid with checks returned by the bank will result in additional fees.

Check, e-Check and Credit Card

The Office of Student Accounts accepts check, online e-check and online credit card payments. Payments made by check can be mailed or brought to the Office of Student Account in the Student Service Center. If you choose to mail a check please make it payable to Stevens Institute of Technology and include your campus-wide ID number on the check. Students or their authorized third-party payees can make e-check or credit card payments online through ebilling. A non-refundable service fee of 2.75% (minimum of \$3.00) will be added to your credit card payment. Stevens does not charge a fee for e-check (ACH) payments. You can access ebilling through your myStevens account or directly at www.stevens.edu/ebilling.

Deferred Payments

If a student is not able to pay his/her bill in full at the time of registration, he/she is required to meet with a representative from The Office of Student Accounts to discuss their payment options. If an employer is assuming responsibility for payment of tuition and fees following the end of the semester, students may remain registered without payment by selecting the Employer Reimbursement Bridge Plan Agreement offered in the fall and spring semesters only. There is an additional \$150 fee per semester for selecting this option.

Monthly Payment Plan

To assist students and their families, Stevens offers a monthly payment plan through Tuition Management Systems (TMS). This is an interest free option but there is a nominal enrollment fee. You can schedule your payments over as many as five payments each semester. Stevens allows students who have an active payment plan to attend classes, reside on campus and participate in other Institute activities while payments are being made to the provider. Enrollment deadline dates apply so contact TMS for specifics 888-356-0350 or enroll on line at www.afford.com/stevens

Late Payment Fees

Students with unmet financial obligations are not considered to have valid registrations. They are not allowed to attend classes, receive transcripts or grades, participate in registration, or receive their diploma. If a student withdraws or graduates from Stevens with a balance due, Stevens will actively try to collect the unpaid balance. This may include referring the delinquent account to a credit reporting agency and/or collection agency. This may include, but is not limited to, late fees, collections costs, litigation/attorney's fees, and court costs.

Balances paid after the due date will result in a late payment fee of at least \$550.00 unless the student is enrolled in the monthly payment plan or a Bridge Plan. Please refer all questions to the Office of Student Accounts by email<u>studentaccounts@stevens.edu</u> or by phone (201) 216-5555.

Withdrawals and Refunds

Students who enroll and decide not to attend class for any reason must officially drop from classes online at <u>www.stevens.edu/es/student</u> or by completing the Drop section of the Change of Enrollment form. The Change of Enrollment form must be submitted to the Office of the Registrar. After the official add/drop period is over a withdrawal will occur and a "W" grade will appear on the transcript. The professors' approval and/or the Dean of Graduate or Undergraduate Academics' approval may be required prior to withdrawing from a class after the add/drop period (please refer to the current Academic Calendar). The date the form is submitted to the Office of the Registrar will determine the official withdrawal date for tuition and fees. Students must officially withdraw from housing and/or meal plans in writing to the Office of Residence Life. They will determine the official withdrawal date for housing and meal plans (which may be different than the date submitted to the Registrar). All tuition, fees, and student housing and meal plan charges will be reversed based on the official withdrawal date and will be calculated from the official opening date of classes in accordance with the following schedules:

Regular Academic Semester Refund Schedule for Continuing Students

- Through the first day of the semester 100%
- After the first day of the semester through the second week 90%
- ▶ After the second week of the semester through the fourth week 50%
- ▶ After the fourth week of the semester through the eighth week 25%
- ▶ Thereafter 0%

Summer Session Refund Schedule for Continuing Students

- Through the first day of the semester 100%
- After the first day of the semester through the first week 90%
- ▶ After the first week of classes through the second week 50%
- After the second week of the semester through the third week 25%
- Thereafter 0%

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Financing a Stevens Education

The mission of the Financial Aid staff is to identify financial resources and to provide those resources to students who would otherwise be unable to pursue their educational and professional goals. The Financial Aid staff strives to facilitate the financial aid process by educating students and their families about the availability of aid, as well as by providing solutions and alternatives in educational financing. The staff is committed to ensuring the highest quality of service to Stevens students. This involves evaluating each student's aid application individually and the continual assessment of our application, awarding, and disbursement processes.

Stevens requires the Free Application for Federal Student Aid (FAFSA). Incoming undergraduate students must also submit the CSS PROFILE. The priority filing date for incoming students is February 15th prior to the fall semester in which a student begins at Stevens; the priority filing date for returning students is April 15 each year. For more information and to complete the FAFSA online, please visit: <u>www.fafsa.ed.gov</u>. For more information and to complete the CSS/PROFILE, please visit: <u>https://profileonline.collegeboard.com/prf/index.jsp</u>.

Stevens is committed to making education affordable and we work diligently to provide families with the resources to help. For families who qualify for financial need, we structure packages around a core of state, federal, and Stevens aid sources, all of which are considered financial aid components. Independent of need, Stevens also offers merit-based awards to new students who demonstrate a commitment to excellence through a variety of admission factors, known as "need-blind" admissions

Undergraduate Student Financial Aid Information

Institutional Financial Aid Programs

Stevens has a strong commitment to assisting and investing in talented students. We offer a wide range of need-based grants and merit-based scholarships, of which many are made available due to our generous friends and successful alumni. All institutional merit scholarships received at Stevens are renewable for four years (eight semesters), provided the recipient meets the predetermined academic requirements stated in the original award notification. Eligibility for renewal is determined after each spring semester. A student must enroll as a full-time undergraduate (12 credits per semester) in order to receive any award(s). In no case will the scholarship exceed the tuition cost. Dollar amounts range between \$1,000 and full tuition. Merit scholarships are only awarded at the time of admission after review by the Office of Undergraduate Admissions. Merit scholarships are determined by considering the strength of a student's application, including academic record and standardized test scores. Therefore, new merit awards are not available for returning students.

Stevens merit-based scholarships include the following:

The Edwin A. Stevens Scholarship

This award is named in honor of the Institute's founder. It provides awards to students who have a demonstrated record of excellence in high school as evidenced by grade point average, class rank, SAT scores and high recommendations.

Martha Bayard Stevens Scholarship (formally known as Women In Engineering Scholarship)

This award is available to outstanding young women students in all fields of study at Stevens, based on high academic achievement and leadership.

The Presidential Scholarship

The Presidential Scholarship is a prestigious award for students who have demonstrated academic excellence as evidenced by high school grade point average, class rank, SAT scores and high recommendations.

The Ann P. Neupauer Scholarship

Stevens' newest and most prestigious academic honor, named in honor of the late Mrs. Neupauer, a generous friend of the Institute. The Neupauer Scholarship is a four-year, full tuition award. This scholarship is renewable based on the student achievement of an annual GPA of 3.2 or better.

ROTC Matching Scholarship

Students who have been selected to receive ROTC Scholarships (of at least \$7,500 per semester) while studying at Stevens will receive an additional supplemental scholarship from the Institute. This additional award will be in the amount of the full difference between the ROTC Scholarship plus any merit scholarships, and grants, so that all awards combined will equal full tuition. This award is only available during semesters in which the student is eligible to receive the ROTC Scholarship.

FIRST Scholarship

Admitted students who participated on a FIRST team during their junior or senior year of high school may be eligible for the FIRST scholarship of \$6,000 per year. The scholarship application is available only to incoming freshmen and application deadlines apply.

Students may also be considered for the following need-based award:

The Stevens Grant

The Stevens Grant is a need-based award that may be offered if a student continues to demonstrate significant financial need after all other possible sources of grant and scholarship assistance (from Stevens, the U.S. Department of Education, or the State of NJ) have been applied to his/her financial aid package. The student must be a full-time undergraduate and eligibility is determined based on the data the student and his/her family supply on the FAFSA. Amounts can fluctuate from one year to the next if financial circumstances change. The Stevens Grant has no specific grade point average requirement other than the Institute's standards for satisfactory academic progress. Students must complete a FAFSA each year by April 15th to confirm their eligibility.

Federal Financial Aid Programs

The federal government offers grant, loan, and work opportunity programs to assist students and their families in meeting the cost of higher education. Eligibility consideration is determined by information from the FAFSA, a student's enrollment status and satisfactory progress toward completion of their degree program.

Federal aid programs include:

Federal Pell Grant: The Federal Pell grant program is designed to assist the neediest of undergraduate students who are earning their first baccalaureate or four-year professional degree. For 2015-2016 awards range from \$598 to \$5,815 per academic year.

Federal Supplemental Education Opportunity Grant: is designed to assist undergraduate students with exceptional financial need and gives priority to students who receive Federal Pell Grants. Eligible students must be enrolled at least half time and awards range from \$500 to \$2000 annually.

Federal Work Study: provides an opportunity to earn money while in school to help pay educational expenses. Students may work on campus or off campus at non-profit community service agencies. Awards range from \$1,000 to \$1,500 per academic year.

Federal Perkins Loan: A subsidized loan with a 5% fixed interest rate offered to students demonstrating exceptional financial need. No interest accrues on the loan while enrolled at least half time; there is a nine (9) month grace period after a student graduates, withdraws or drops below half-time, prior to repayment. Awards range from \$750 to \$4,000.

Federal Direct Loan: Eligibility for a Direct Federal Subsidized or Unsubsidized Ioan is based upon 'need' as determined by the information submitted on the FAFSA. Undergraduate borrower limits for Federal Direct Loans are as follows:

- \$3,500.00 Subsidized + \$2,000.00 Unsubsidized for Dependent Freshmen
- \$3,500.00 Subsidized + \$6,000.00 Unsubsidized for Independent Freshman
- ▶ \$4,500.00 Subsidized + \$2,000.00 for Unsubsidized for Dependent Sophomores
- ▶ \$4,500.00 Subsidized +\$6,000.00 for Unsubsidized for Independent Sophomores
- \$5,500.00 Subsidized + \$2,000.00 for Unsubsidized for Dependent Juniors & Seniors
- \$5,500.00 Subsidized +\$6,000.00 for Unsubsidized for Independent Juniors & Seniors

The cumulative aggregate Federal Direct Loan debt an undergraduate dependent student may incur is \$31,000.00 — no more than \$23,000 may be from the Direct Subsidized Loan program. The cumulative aggregate Federal Direct Loan debt an independent student may incur is \$57,500 — no more than \$23,000 from the Direct Subsidized Loan program.

Students must complete Loan Entrance Counseling and a Master Promissory Note (MPN) prior to borrowing at <u>www.studentloans.gov</u>. The Loan Entrance Counseling provides required information about a borrower's rights and responsibilities.

Subsidized Federal Direct Loans

"Interest free' while the student is enrolled at least half-time (6 credits). Students are required to begin repayment six months after leaving school or dropping below six credits. The interest rate is fixed each award year and there is a loan fee taken at the time of disbursement. Interest rates are set by Congress and are tied to financial markets. Interest rates for loans made on/after July 1, 2015 and before July 1, 2016 are 4.29%. There is a 1.068% loan fee taken at the time of disbursement. New borrowers as of July 1, 2013 may not receive Direct Subsidized Loans for more than 150 percent of the published length of their program (measured in academic years).

Unsubsidized Federal Direct Loans

Available to students who do not qualify for a Subsidized Direct loan or are eligible for loan funds in addition to their subsidized eligibility. However, students are responsible for the interest on the loan while enrolled in school. Students may

choose to have the interest capitalized. The interest rate for loans made on/after July 1, 2014 and before July 1, 2015 is fixed at 4.29% and there is a 1.068% loan fee taken at the time of disbursement.

Federal PLUS Loan Program

The Federal Direct PLUS Loan is a credit-based loan program for the parent or guardian of the undergraduate student. Parents of matriculated students enrolled at least halftime (6 credits) may borrow up to the cost of education less any other financial aid received by the student per academic year. Repayment of the PLUS Loan begins 60 days after disbursement of the funds to the University. Parents have up to 10 years to repay the loan with a minimum payment of \$50 per month.

To be eligible for a Federal Direct PLUS loan, the student must file the FAFSA and the parent (as well as the student) may not be in default on his/her federal student loans. Prequalification can be determined when parent applies via <u>www.studentloans.gov</u>. Credit decisions will expire after 180 days. In the event a parent is denied a PLUS loan, they may elect to apply with an endorser or the student may receive additional unsubsidized loan proceeds.

For Federal Direct PLUS Loans made on/after July 1, 2015and before July 1, 2016, there is a fixed interest rate of 6.84% and a loan fee of 4.272% that is taken at the time of disbursement.

State of New Jersey Financial Aid Programs

New Jersey residents attending Stevens may qualify for a variety of grants and scholarships offered by the State, mostly through the New Jersey Higher Education Student Assistance Authority (NJHESAA). To be considered for state aid, a student must file the FAFSA no later than June 1 of each year (note that Stevens recommends new students file the FAFSA by February 15 and the deadline for current students is April 15). No late applications are considered for state awards, and state awards cannot be used at out-of-state colleges or universities. In addition, they are only available if the student has resided in New Jersey for at least 12 months as of September 15 of the academic year. If one is considered a dependent student, his/her parent(s) must also meet the same residency requirement. These are estimated awards set by the state and awards will be finalized by the state.

Tuition Aid Grant (TAG): TAG is a need-based grant, available to assist low and middle income students. Annual award amounts range between \$1,958 and \$12,196. Eligibility is based on the data supplied on the FAFSA and may fluctuate with the student's or family's financial circumstances from one year to the next. TAG is available for a maximum of nine semesters of undergraduate study. Students must be enrolled full-time in a degree-granting program. However, students in their final semester who need fewer than 12 credits to fulfill their degree requirements may qualify for TAG during that term with as few as 6 credits. Students must meet the June 1st yearly TAG deadline in order to be re-awarded for the next academic year.

Educational Opportunity Fund (EOF): New Jersey residents admitted into The Stevens Technical Enrichment Program (STEP) upon entry into Stevens may also qualify for an Educational Opportunity Fund, or EOF, Grant. This need-based award is in the amount of \$2,500. In order to qualify for this grant and admission into the EOF program, a student (and/or family) must meet income guidelines established by the State of New Jersey, and the student must also be from an educationally disadvantaged background.

NJS Governor's Urban Scholars Program: provides a merit award to high-achieving students who reside in New Jersey's 14 designated high-need communities. Annual awards of up to \$1,000 are available for qualified students. Students must rank within the top five (5%) percent of their class and have a minimum 3.0 GPA at the end of their junior year of high school and meet other basic eligibility and renewal criteria.

New Jersey Student Tuition Assistance Reward Scholarship II (STARS II): allows successful NJ STARS scholars to transfer to a New Jersey four-year public or non-public college or university and earn a bachelor's degree. The NJ STARS II Scholarship is valued at \$1,250 per semester (\$2,500 per academic year – traditional fall and spring semesters only). Students must

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be NJ STARS recipients or non-funded during the semester of county college graduation and graduate with an Associate's degree and GPA of 3.25 or higher. While there is no consideration of financial need, the maximum family income (taxable and non-taxable) must be less than \$250,000. In addition, the student must be enrolled full-time, apply for all forms of state and federal need-based grants and merit scholarships and begin NJ STARS II program participation no later than the second semester immediately following county college graduation. To be considered for NJ STARS II, students must file a FAFSA each year within established New Jersey State deadlines.

Satisfactory Academic Progress (SAP)

The following guidelines apply to all undergraduate students at Stevens, including those seeking financial aid awards from federal, state, institutional, or other sources administered through Stevens, except in cases where the donor or donors establish specific requirements.

The student is subject to federal, state, and university limits on the total number of semesters of aid he/she may receive. To be eligible to receive aid for which he/she qualifies financially, a student must make satisfactory progress toward a degree as follows:

Progress is routinely monitored at the end of the spring semester after spring semester grades are submitted to the Registrar's Office.

Undergraduate Program Guidelines

There are three distinct measurements to the SAP standards:

- A. Grade Point Average (Qualitative Measure)
- B. Credit Completion Ratio/Pace (Quantitative Measure)
- C. Maximum Time Frame measurement

These standards also include an opportunity to appeal the denial of financial aid if the student has faced special circumstances, which prevented the student from attaining the minimum standards described in this policy. The Satisfactory Academic Appeals Committee will not automatically reinstate a student's aid even after a student has been readmitted to the University. Federal financial aid eligibility does not allow for reinstatement based on academic renewal policies.

A. Grade Point Average (GPA) / (Qualitative Measure)

Undergraduate students must maintain at least a 2.0 cumulative GPA after attempting 12 credits. Stevens Institute of Technology requires at least a 2.0 GPA for conferral of the bachelor's degree. Specific federal, state and institutional scholarships and grants may require a different GPA for renewal; this is a separate requirement for continued eligibility for these funds.

B. Credit Completion Ratio or Calculating Pace (Quantitative Measure)

Each year, a student's progress will be measured by comparing the number of attempted credit hours with the earned credit hours. This includes any course for which the student has remained enrolled past the add/drop period. After a student has attempted 12 credits, s/he must earn sixty seven percent (67%) of the cumulative attempted credits to maintain satisfactory academic progress.

C. Maximum Time Frame Measure

A student is eligible to receive funding up to 150% attempted credit hours toward their degree. Some programs limit funding on a semester basis. Students that attempt and earn only the minimum amount of credit hours required may run out of eligibility for certain federal and state financial aid programs prior to completing their degree.

Example of Satisfactory Academic Progress review requirements:

Attempted Credits	Required Percentage	# of Credits To Be Earned	Required Cumulative
24	67%	16.75	2.0
49	67%	32.38	2.0
73	67%	48.91	2.0
97	67%	64.99	2.0

General Information

A. Withdrawal from courses /WD (Withdrawn officially)

Credits remain in the total number of attempted hours but are not added to the earned credits. This may have a negative effect on the total number of earned credits needed per year. The GPA is not affected by these grades.

B. Incomplete courses/ INC (Incomplete)

These courses will be counted when determining the number of credits attempted. When a passing grade is received, the grade will be added to the number of credits earned.

C. Repeated courses

These courses are counted each time the course is taken and will be included in the total number of attempted credit hours. When a course is completed, the credits are added to the total number of earned credits hours.

D. Transfer credits

Transfer credits, accepted by Stevens, will be added to the attempted/earned credit hours in order to determine the number of credits a student should attempt and earn.

E. Failing Grades

These grades may have a serious negative impact on the student's academic record: F (Failing), and M (Missing, no grade submitted)

F. Expunged Grades

Expunged Grades are included in the financial aid SAP calculation. Federal regulations do not allow for Academic Amnesty; therefore Expunged grades cannot be excluded from evaluation. This means that the GPA that appears on a student's academic transcript will be different than the GPA used in the financial aid SAP calculation.

Students identified as not making SAP will receive correspondence at their campus e-mail address. Students have the right to appeal the decision by submitting a SAP Appeal Form. Generally, the SAP Appeals Committee will consider appeals that involve circumstances beyond the student's control that have had an impact upon the student's academic performance.

The appeal must include a narrative of the extenuating circumstances (e.g., the student or an immediate family member suffered a serious illness or injury, death of a close relative, separation or divorce) that prevented the student from meeting the minimum requirements, and reasonable explanation of the expectation that the event/circumstances will not re-occur. Students are required to attach pertinent documentation supporting their appeal including their Appeal Letter and at least one piece of objective documentation. Furthermore, students who do not meet SAP after their financial aid probation semester are required to submit their academic plan to succeed in their program of study as well as carefully review their academic history.

SAP Appeal Deadlines:

Fall Semester	July 15
Spring Semester	January 15

Students may submit their appeals by the deadline to the Office of Financial Aid.

SAP Appeals Committee and Decision:

The appeal will be reviewed by a committee and a response will be provided within fifteen (15) business days. All committee decisions are final. Students will be notified of the committee's decision in writing (personal email announcement at their Stevens Email account). The committee reserves the right to request additional information, including an academic plan, for consideration in the review.

Appeal Approvals and Academic Plan:

Students who successfully appeal are approved for one payment period are considered to be on probation. To gain eligibility in the subsequent semester, a student must meet the standards of SAP or meet the requirements of his or her academic plan described at the time of the appeal submission. It is highly recommended that students meet with their academic advisor or Dean before creating their academic plan to ensure it is attainable.

SAP Academic Suspension:

If the student fails to meet SAP standards or the requirements set forth in the SAP Academic Plan, the student will be placed on SAP suspension. The student is ineligible for financial aid with this status. A student with SAP suspension status will remain ineligible for financial aid until the student meets the minimum SAP Policy requirements.

Graduate Student Financial Information

Financial Aid Sources

Many sources of financial aid are available to graduate students. These include fellowships, assistantships, on-campus employment, employer tuition assistance plans, loan funds, and deferred payment plans. Fellowships and assistantships are granted on a competitive basis to outstanding full-time graduate students. Applicants should consult their department for more information regarding assistantships. Continuing students may become eligible for additional sources of aid as they progress through the program and should consult with their department at regular intervals.

Click here for more information.

Graduate Assistantships

Graduate Assistantships (teaching, research, or other) are available in every academic department and in some non-academic departments. Graduate Assistants are appointed based on recommendation by the appropriate department director or principal investigator of a grant or contract. Graduate Assistants may carry a reduced course load but still complete the master's degree in two years or less.

Stevens Institute of Technology is able to offer a select group of students funding in the form of teaching or research assistantships. The material provided and discussed in this section is for information purposes only, and is offered as a guide.

Assistantships are graduate funding opportunities that can take many forms. A student awarded a research or teaching assistantship may receive tuition and fees for up to three courses per semester during the Fall and Spring semester plus a stipend; or some combination of tuition, fees, and stipend. In exchange for the predetermined funding, the student must work up to a maximum of 20 hours per week during the semester, and maintain a satisfactory academic performance. Stevens does not provide what is commonly known as "tuition waivers"; for example, the tuition and fee costs cannot be waived. Additional support may also be available for the summer sessions.

The number of assistantships awarded each year is limited. If you do not receive an assistantship for your first year at Stevens you can pursue an assistantship within your department after you arrive. It is important to note that each department identifies and awards assistantships to students, while the Registrar's Office administers the process.

Provost Masters Fellowship Awards

The Provost Masters Fellowships are offered each year during the fall and spring semesters to exceptional students interested in pursuing a master's degree on a full-time basis. These one-time fellowships are awarded to qualified students at the time of their admission to any one of the Master's degree programs offered at Stevens. Students who are placed approximately in the top 5% of the applicant pool are considered for this award. Selection criteria for the Provost Masters Fellowship includes GRE/GMAT scores in addition to exceptional undergraduate academic performance. TOEFL/IELTS scores are also considered as a criterion for international applicants. There is no separate application for the fellowship awards as students are automatically considered when they initially apply.

Research Assistantships

Research Assistantships generally provide graduate tuition and fee support and a monthly stipend (see above) for services on sponsored research contracts. Appointments are reviewed and made by the Office of Graduate Admissions after recommendation by the academic department director or principal investigator.

Teaching Assistantships

Teaching Assistantships generally provide graduate tuition and fee support and a monthly stipend (see above) for teaching assistant services in the academic departments. Appointments are reviewed and made by the Dean of Academic Administration after recommendation by the academic department director.

Robert Crooks Stanley Graduate Fellowships

Robert Crooks Stanley Graduate Fellowships provide tuition plus living allowance for graduate students pursuing a Ph.D. degree. The fellowships are endowed through the generosity of the late Mrs. Robert C. Stanley and her children as a memorial to Dr. Stanley, Class of 1899 and former chairman of the Board of Trustees. A committee appointed by the Board of Trustees makes the selections.

Loans and Work-Study

Graduate students enrolled in a degree-granting program on at least a half-time basis (a minimum of six credits per semester) may apply for federal student loans and/or Federal Work-Study by submitting the Free Application for Federal Student Aid (FAFSA). The results of this standardized application will allow the Office of Financial Aid to determine eligibility for federal aid. Only U.S. citizens or permanent residents may file the FAFSA; international students do not qualify for federal assistance.

FAFSA

The FAFSA should be completed and submitted to the processing center at least eight weeks prior to the beginning of the semester in which the student plans to enroll. The FAFSA may be submitted online atwww.fafsa.ed.gov. Additional information about graduate financial aid, including free, online scholarship search services, as well as alternative financing sources, may also be accessed through the Office of Financial aid's home page (www.stevens.edu/finaid/).

Federal Loans

There are a number of loan opportunities for eligible graduate students. Federal Direct Unsubsidized Loans as well as Federal Direct Graduate PLUS loans may be available to qualified borrowers. The maximum amount that can be borrowed from the

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Federal Direct Unsubsidized Loan program for the academic year is \$20,500. The graduate student aggregate loan limit is \$138,500. Interest accrues on the loan beginning at disbursement (the interest rate is fixed and is 6.21% for the 2014-15 year) and there is a loan fee taken at the time of disbursement 1.073%).

The Graduate PLUS loan is a credit-based loan that is not need based. The interest rate is fixed at 7.21% for the 2014-2015 year. The Graduate PLUS Application can be completed at studentloans.gov. After submission of the PLUS Application, the student will receive a credit decision electronically. If credit approved then the student must complete their Graduate PLUS Promissory Note, on studentloans.gov. If your credit is declined by the federal government then you may appeal their credit decision, or you may wish to obtain a co-signer. A co-signer must electronically complete an Endorser Addendum on www.studentloans.gov.

Private Education Loans

Alternative Loans (Private Education Loans) are offered through private lenders and are meant to provide additional educational funding only after a student and his/her family has exhausted all other sources of funding such as federal and state aid. These loans are not guaranteed by the federal government and may carry high interest rates and origination fees. All of the loans require a credit check and most will require a cosigner if the borrower has little or negative credit history. Stevens is not permitted to recommend any specific lender/programs. Contact the lender of your choice for details about their program and application process. Make sure to understand your rights, responsibilities and benefits before you select a lender. A list of historical lenders may be found at www.stevens.edu/sit/financial-aid/student-info/afo.

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Academic Integrity

Honor System for Undergraduate Students

The Stevens Honor System is the rigorous ethical and moral standard to which undergraduate students are held, and which seeks to ensure that all academic work is bona fide. This standard was formally established in 1908 with the creation of the Stevens Honor System as well as its governing body, the Stevens Honor Board. The Honor System at Stevens fulfills two objectives. First, it seeks to ensure that work submitted by students can be trusted as their own and was performed in an atmosphere of honesty and fair play. Second, it promotes a sense of honor and integrity throughout campus and for Stevens' students in preparation for the professional world.

Enrollment into the undergraduate student body at Stevens Institute of Technology signifies a student's commitment to the Honor System and the University's ethical and moral standards. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. Specific student responsibilities include:

- Maintaining honesty and fair play in all aspects of academic life at Stevens
- Writing and signing the pledge, in full, on all submitted academic work
- ▶ Reporting any suspected violations to the Honor Board
- Cooperating with the Honor Board during investigations and hearings

Student responsibilities are further outlined in the constitution and bylaws of the Honor System, which may be reviewed online at <u>www.stevens.edu/honor</u>.

The Honor Board is the Honor System's governing body. It is comprised of undergraduate students who are elected by their peers. Members of the Honor Board investigate all suspected breaches of academic integrity, and assign penalties to students who either confess to or are found responsible for Honor System violations. When investigating a case, Honor Board members meet with the accused student, pertinent witnesses, and relevant faculty. The investigation culminates with one of three outcomes: the case is dropped due to insufficient evidence to support the suspected violation, the accused student confesses, or a hearing is held and the case is presented to a jury of the student's peers.

The Honor System also includes a two-level appeals process. Any student who is dissatisfied with the penalty assigned by the Honor Board after confessing or being found responsible by a jury may appeal to the Academic Appeals Committee for a reduced penalty. If unsuccessful, the student may submit a final appeal to the Provost or appointed designee.

Graduate Student Code of Academic Integrity

The Graduate Student Code of Academic Integrity holds that integrity is essential to the ethical pursuit of knowledge and is expected of all Stevens graduate students in all academic endeavors including coursework, research, scholarship, and creative activity.

While all members of the Stevens Community have a responsibility to uphold and maintain the highest standards of integrity in study, research, instruction, and evaluation, the Graduate Student Code of Academic Integrity is concerned specifically with the conduct of graduate students.

By enrollment at Stevens, all graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that

the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline.

Individual departments or schools within the Institute may adopt additional policies and procedures above and beyond those set forth in this code, but any and all purported violations must be reported to the Office of Graduate Academics no more than seven business days after the instructor becomes aware of the issue.

For more information on the Graduate Student Code of Academic Integrity, including types of violations, the process for handling perceived violations and the types of sanctions that can be applied, please visit <u>http://www.stevens.edu/sites/</u><u>stevens_edu/files/Graduate-Student-Code-Academic-Integrity.pdf</u>.

Conduct & Student Responsibilities

We ask that students act in a responsible and mature manner, taking the safety of oneself and others seriously. Stevens complies with government regulations for health and safety and we expect students to comply with all federal, state and local laws. The Student Handbook can be found online at: <u>http://stevens.edu/studentlife</u>.

Alcohol Policy

The legal age for consumption of alcoholic beverages in New Jersey is 21 years of age. No alcoholic beverages are permitted in residence halls where freshmen reside. Other resident students and guests may consume alcoholic beverages in private living units provided that such consumption meets the conditions listed below. Failure to adhere to the following regulations may result in the termination of the gathering and/or judicial action.

- Persons may not transport open containers of alcoholic beverages, nor may they consume alcoholic beverages in hallways, foyers, stairwells, bathrooms, in open air or public areas.
- ▶ No kegs, "beer balls" or other such containers are permitted on campus.
- ► No unauthorized distribution of alcoholic beverages or possession of alcoholic beverages for purposes of distribution on the Institute's premises or at Institute sponsored or supervised activities are permitted.
- Any event where alcoholic beverages are sold or where any charge or donation is made for admission to the event requires a special Alcoholic Beverage Commission permit, as well as registration and approval by the Institute. This permit may be obtained through the Office of Student Life.
- Drunken or disorderly behavior on property owned or controlled by the Institute or at functions sponsored or supervised by Stevens is not permitted.

Drug Policy

Stevens Institute of Technology will not condone the use, sale or possession of illicit drugs or narcotics on the property of the Institute or on the property of any affiliated organization recognized by the Institute. No warnings will be issued. An infraction will subject the student to disciplinary action by the Institute in the form of probation, suspension or dismissal. In addition, the student may be subject to prosecution under federal, state and local law. Local, state, and federal laws which apply to illegal possession, use, or distribution of drugs and alcohol are fully enforced at Stevens Institute of Technology.

If a student violates the policy, he/she may be put on probation, be required to fulfill community service and, depending on severity and/or repetition, be suspended or expelled. If a student is suspended or expelled, no refund of tuition or fees paid will be granted.

Additional information about the drug and alcohol policy, or the drug and alcohol assistance program, is available from the Office of Student Life and in the Student Handbook on the website at http://stevens.edu/studentlife.

Gender-based and Sexual Misconduct (Title IX)

Stevens is committed to maintaining a safe learning environment that is free of gender-based and sexual misconduct, including sexual violence, sexual harassment, relationship violence, and stalking. Title IX of the Education Amendments of 1972 prohibits discrimination based on sex in educational programs and activities that receive federal financial assistance. Sex discrimination under Title IX includes sexual harassment and sexual violence by employees, students or third parties. The University's Policy on Gender-based and Sexual Misconduct can be found at: http://stevens.edu/titleix.

This Policy protects and applies to all students, faculty and staff at Stevens, as well as third-parties. It applies to conduct occurring on Stevens' property or at University-sanctioned events or programs that take place off campus, including study abroad, internship programs and cooperative educational programs. The Policy also applies to off campus conduct that has an impact on a member of the Stevens' community and implicates Stevens' obligations under Title IX.

All members of the Stevens community are responsible for compliance with the Policy and are encouraged to immediately report misconduct covered by the Policy to the Title IX Coordinator or Deputy Title IX Coordinator whether it takes place on or off-campus. In addition, all faculty members and all staff members are required to immediately report allegations of misconduct to the Title IX Coordinator or Deputy Title IX Coordinator, regardless of whether the Complainant intends to make a report.

For more information or to make a report, you may contact Title IX Coordinator, Dr. Kristie Damell, Assistant Dean of Students, Phone: 201.216.5679, Email: <u>kdamell@stevens.edu</u> or Deputy Title IX Coordinator, Leslie Devine, Director of Faculty and Staff Benefits and Compliance, Phone: 201.216.5146, E-mail: <u>Leslie.Devine@stevens.edu</u>.

Hazing

Stevens Institute of Technology endorses and adheres to New Jersey Statutes 2C:10-3 et seq., establishing "hazing" as a disorderly person's offense and "aggravated hazing" as a crime of the fourth degree. Both offenses are punishable by imprisonment and/or fine under New Jersey law.

Health Insurance

All full-time Stevens students are required to have health insurance. Stevens Institute of Technology offers student health insurance and charges students for health insurance each year. The University waives the health insurance charge if an online insurance waiver process is completed. If the online waiver process is not completed by the published deadlines stated on the health insurance website, the insurance charge remains on the student's account. Information on the online waiver process can be found at www.universityhealthplans.com and then by clicking on Stevens Institute of Technology.

If a student is contemplating participation in a varsity sport, we strongly encourage him/her to enroll in the Stevens health insurance program. The base plan coordinates with other health insurance policies. Please review the current policy on-line at <u>www.universityhealthplans.com</u> by clicking on Stevens Institute of Technology. Students may obtain a copy of the athletic brochure from the Director of Athletics' office in the Schaefer Center.

Please note that benefits have limits and are paid on a Usual, Customary, and Reasonable (UCR) basis. Students are responsible for any unpaid balances. In addition, optional dental and vision plans are available. A description of these plans along with enrollment and payment procedures can be found at <u>www.universityhealthplans.com</u> by clicking on Stevens Institute of Technology.

Non-discrimination

Stevens Institute of Technology is committed to the principle of equality of opportunity and creating a campus climate that supports, nurtures, and rewards educational and career advancement on the basis of ability and performance. Accordingly, it is the policy of the university not to discriminate on the basis of race, color, religion, creed, sex, national origin, nationality, citizenship status, age, ancestry, marital or domestic partnership or civil union status, familial status, affectional or sexual orientation, gender identity or expression, atypical cellular or blood trait, genetic information, pregnancy or pregnancy-related medical conditions, disability, protected military or veteran status, or any other characteristic protected by laws in any phase of its admissions, financial aid, athletics, educational, or employment programs or activities.

Stevens is in compliance with all applicable federal and state laws and regulations relating to non-discrimination and affirmative action including Titles VI and VII of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, and Title IX of the Education Amendments of 1972. For more information about Stevens' compliance with Title IX, which addresses sex discrimination and sexual misconduct, please visit Stevens' website at: <u>www.stevens.edu/titleix</u> or direct inquiries to the Office of Undergraduate Student Life.

Right of Privacy

Stevens Institute of Technology complies with the Family, Education Rights, and Privacy Act of 1974 as amended (the Buckley Amendment), which was designed to protect the privacy of educational records, to establish the rights of students to inspect and review their educational records, to provide guidelines for the correction of inaccuracies, and to limit disclosures of information from the records. Complete information regarding student rights, responsibilities of the Institute, copies of the Act, and rules and regulations for compliance with the Act may be obtained from the Student Service Center and the Registrar's Office.

Smoke-free Environment

Stevens Institute of Technology has specified a smoke-free environment as mandatory in all areas within buildings on its campus, including the residence halls and fraternity and sorority houses. Thus, smoking in all buildings is prohibited at all times.

Student Responsibilities

Any loss occasioned by damage to University property is charged to the student or students responsible, but if we do not know the students causing the damage, the costs may be assessed equally upon all members of the student body. The University reserves the right to exclude students at any time if their conduct or academic standing is regarded as undesirable, without assigning any further reason. In such cases, fees are not refunded or remitted in whole or in part, and neither the college nor any of its officers shall be under any liability for such exclusion.

> Jeanne Clery Disclosure of Campus Security Policy and Crime Statistics Act

Stevens Institute of Technology complies with the Jeanne Clery Disclosure of Campus Security Policy and Crime Statistics Act, a federal law which requires colleges and universities to maintain and disclose annual security reports that contain policy statements and crime statistics for the school. The policy statements address Stevens' policies, procedures and programs concerning safety and security, for example, policies for responding to emergency situations and sexual offenses. The report includes three years' worth of statistics for certain types of crimes that were reported to have occurred on or near the campus or other university-owned property. This report is available on Stevens' website at http://www.stevens.edu/directory/campus-police. You may also request a paper copy from Stevens' Campus Police.

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The Charles V. Schaefer, Jr. School of Engineering and Science seeks to be globally recognized as an engineering and science school that educates students to have the breadth and depth required to lead in their chosen profession, and leads in the development of important new knowledge and new technologies and their integration into the fabric of society by the various education and innovation pathways we support.

The graduates of the Charles V. Schaefer, Jr. School of Engineering and Science shall:

- Demonstrate technical competence in engineering design and analysis consistent with the practice of a specialist and with the broad perspective of the generalist;
- Develop the hallmarks of professional conduct, including a keen cognizance of ethical choices, together with the confidence and skills to lead, to follow, and to transmit ideas effectively; and
- Inculcate learning as a lifelong activity and as a means to the creative discovery, development, and implementation of technology.

Our graduate programs prepare students to:

- Expand the scope of their professional activities in academia, industry, and government and increase the diversity of their careers;
- Create and transfer knowledge through cutting-edge research and succeed in bringing innovations to the marketplace.

Undergraduate Programs

BACHELOR OF ENGINEERING

The Stevens engineering curriculum is rooted in a tradition that has set it apart since the founding of the Institute in 1870, yet it remains responsive to the changing demands of the workplace into which one graduates. The Stevens tradition recognizes the value of a broad core curriculum that provides significant breadth in engineering, the sciences, and the humanities, combined with the necessary depth in your chosen engineering discipline.

To meet these goals, the Charles V. Schaefer, Jr. School of Engineering and Science offers a demanding curriculum. It prepares you technically and instills a work ethic that has proven of considerable value to our graduates throughout their lives. In addition to strong technical competencies in general engineering and the specific discipline, the curriculum teaches key competencies that are highly valued by employers. These include strong problem-solving skills, effective team-participation skills, and the ability to communicate effectively, in both written and oral modes.

A major vehicle for achieving these competencies in the engineering curriculum is the Design Spine. The Design Spine is a sequence of design courses each semester; initially it is integrated with science and engineering core courses and, in future semesters, the discipline-specific program. Design is at the heart of engineering. Design activities allow you to gain confidence in applying and reinforcing the knowledge learned in the classroom.

As an engineering student, you take core courses for the first three semesters. The choice of the engineering discipline in which you will concentrate is made late in the third semester. You are provided many opportunities to explore the various engineering fields.

You may choose to specialize in biomedical, chemical, civil, computer, electrical, environmental, or mechanical engineering, as well as engineering management. A program in engineering is also available which presently has a concentration in naval engineering.

A strength of the Stevens engineering curriculum is the requirement for a significant thread of humanities and general education courses throughout the four-year program. You may take advantage of this as a platform to pursue a minor or to pursue the double degree program, a B.A. degree in addition to the B.E. degree.

The following pages outline the structure of the engineering curriculum by semester, showing core course and technical elective requirements. Specific concentrations are described by the department, as are requirements for their minor programs.

Engineering Program

The B.E. in Engineering is founded on the strength of the extensive Stevens core curriculum in exposing students to a breadth of engineering topics while allowing for concentration in an engineering area. In this regard it allows for a somewhat more flexible program than is typically available in a specialized B.E. program. At present, a concentration is offered in Naval Engineering. Several technical electives within the program can be tailored to a student's interests under the guidance of the program faculty advisor.

Concentration in Naval Engineering

Naval Engineering is a broad-based engineering discipline that involves the design, construction, operation, and maintenance of surface and sub-surface ships, ocean structures, and shore facilities. Although these vessels and facilities are traditionally employed in the defense of the nation, many are also employed in the support of the civilian (commercial) Marine Transportation System. Because of the complexities of today's naval and civilian vessels and supporting infrastructure, the naval engineer must possess a strong background in the physical sciences, mathematics, and modeling, as well as the more specialized fields of naval architecture, marine engineering, systems engineering, and environmental engineering.

Mission and Objectives

The mission of the engineering program with a concentration in naval engineering program at Stevens is to develop innovative engineers capable of international leadership in the profession. The educational program emphasizes design innovation, trans-disciplinary study, a systems perspective on complex ship and infrastructure designs, lifelong learning and opportunities for international study and internships. As is the case for the other Stevens engineering programs, the naval engineering program includes a broad-based core engineering curriculum and a substantial experience in the humanities.

The program is conducted in concert with the Stevens leadership in the Office of Naval Research–sponsored Atlantic Center for the Innovative Design and Control of Small Ships and in collaboration with University College London.

The objectives of the engineering with a concentration in naval engineering program are provided in terms of our expectations for our graduates. Within several years of graduation, they will:

- ▶ Be recognized as among the most innovative designers and project managers in the world;
- Be thoroughly aware of, and knowledgeable in dealing with, environmental, social, ethical, and economic impacts of their projects; Augment their knowledge through professional and cultural continuing education; and
- ▶ Be active in leadership roles within their professional and technical societies.

Guidelines for Engineering Minor Programs

A minor represents a coherent program of study in an engineering discipline other than the student's major degree program. Successful completion of a minor program is recognized on the transcript and with a Minor Certificate at graduation. Recognition is thus provided for a significant education experience in another discipline.

General guidelines for a minor program in an engineering discipline are:

- Engineering minor programs will consist of a coherent sequence of a minimum of six courses. A minimum of two courses (minimum 6 credits) should be in addition to those courses required to complete a student's major degree program (which includes general education courses).
- The minor program must be in a discipline other than that of a student's major program of study. As such minors are distinguished from options within the major discipline or the concentration within the Engineering Program (typically referred to as the general engineering program)
- The Minor Advisor may allow courses awarded transfer credit to be used but these must constitute less than half of those applied to the minor program.
- A student may earn no more than two Engineering minors.
- A student wishing to pursue a minor program must complete a Minor Program Study Plan signed by a Minor Advisor from the discipline of the minor to ensure a coherent program is undertaken. In order to be awarded the minor at graduation the student must complete a Minor Candidacy Form signed by the Minor Advisor after all minor requirements are fulfilled.

Entry to an Engineering minor program requires the student to have a minimum GPA of 2.5. In order for a course to count towards a minor the grade of C or above must be achieved.

Minor in Entrepreneurship

The undergraduate minor in entrepreneurship provides the educational prerequisites needed to foster the successful birth and development of technology-driven new ventures.

The minor will provide the knowledge and the infrastructure needed to sustain and support the efforts of Stevens' undergraduate students in engineering and science to create economic value through innovation and entrepreneurship.

After completing the minor, students will be able to develop and write an effective business plan by systematically developing the following skills:

- Able to identify and recognize viable technical business opportunities
- Can critically evaluate these business opportunities
- Can assess and manage the intellectual property embodied in technological opportunities
- Can develop an effective business model addressing market, operating and financial requirements
- Knows how to launch a technologically-based business

Courses

- MGT 103 Introduction to Entrepreneurship
- ▶ E 355 Engineering Economy or BT 200 Financial Accounting
- MGT 372 Discovery and Commercialization of Technical Business Opportunities
- BT 447 Creativity & Innovation
- MGT 472 Assessment and Financing of Technical Business Opportunities
- MGT 419 Entrepreneurship Practicum

Minor in Green Engineering

Issues of sustainability are of increasing concern for the developed and the developing nations of the world. Engineers have to take a central role in providing the needed solutions and associated leadership to address those issues. In the design, implementation and use of products, processes and systems that impact all facets of our lives, fundamental decisions are made by engineers. Those decisions can either contribute to an exacerbation of the negative impact of human endeavors on the environment, or they can be the means to reduce that impact. Engineering decisions are not just technical; they essentially must include economic considerations as well as be influenced by the ethical, social and political dimensions that shape their context.

The application of the principles by which engineers can have a positive impact on sustainability is known as Sustainable Engineering or more colloquially as Green Engineering. The latter terminology has found resonance with the general resurgence of interest in the environmental impact of human activity and the associated "green" approaches to mitigating them. While elements of sustainable engineering are permeating the broad-based Stevens undergraduate engineering programs, the scope is relatively limited so far. It is therefore proposed that for the student who wishes to explore sustainable approaches to engineering in some depth, the appropriate vehicle is to pursue a minor program.

Objectives of the Green Engineering Minor

- Provide a holistic, systems perspective to the impact of human activity on the environment, including the role of engineering.
- Educate students in the concepts of sustainable development and industrial ecology.
- Provide insight into sustainability tools and metrics such as life cycle analysis and ecological footprint.
- Show how engineering decisions, particular with regard to design, can support sustainability goals.
- Develop awareness of the ethical, economic, social and political dimensions that influence sustainability.

Content of the Green Engineering Minor

The Green Engineering Minor consists of six courses, three of which are required. It provides a two-course foundation. This is followed by two technical electives which can also provide a sustainable engineering focus area. Two additional courses are intended to allow students to explore ethical, social, economic and political contextual issues associated with sustainability. It should be noted that some of the courses taken towards the minor might also be applicable to meet Humanities/Social Science as well as General Education course requirements where appropriate.

General requirements for engineering minors include:

- A minimum of two courses are required beyond those needed to meet the requirements of the student's BE degree (including general electives)
- A minimum course grade of C in a minor course is required for it to count
- A minimum GPA of 2.5 is required to commence the minor program

Green Engineering Minor - Core Requirements

The following three core courses are required for the minor:

- ▶ EN 301 Sustainable Engineering
- ▶ E 580 Sustainable Energy
- ▶ HPL 480 Environmental Policy: Philosophical & Economic Issues

Green Engineering Minor - Technical Electives

Two technical electives are required from the following list of current or planned courses (as they become available). The technical electives could be used to create a focus area as indicated. A technical elective can be approved by the Green Engineering Minor Coordinator that does not primarily focus on green content but is directed to a subject where green issues can be identified so that together with the other courses in the minor a coherent program is achieved. A Minor technical elective in some circumstances might also be applied to the student's degree program if it meets the requirements for the latter and should be discussed with the appropriate advisor.

Chemical/Biochemical Processes

CHE 580 Biofuels Engineering Technology

Civil Structures

- CE 304 Water Resources Engineering
- ▶ CM 560 Sustainable Design
- CM 561/580 Green Construction

Environmental Engineering

- ▶ EN 345 Modeling and Simulation of Environmental Systems
- ▶ EN 545 Environmental Impact Analysis and Planning
- ▶ EN 575 Environmental Biology
- ME 532/EN 506 Air Pollution Principles and Control

Power & Energy

- ME 511 Wind Energy- Theory & Application
- ME 421 Energy Conversion Systems
- ▶ ME 510 Power Plant Engineering
- ▶ E 518 Solar Energy: Theory & Application
- E 528 Solar Energy: System Design

NOTE: E423-424 Capstone Design, if it has a project with significant "green" content, can be used to replace one technical elective if it is approved by the Green Engineering Minor Coordinator.

Green Engineering Minor - Contextual Courses

One contextual course is the core course noted above: HPL 480. In addition, one elective is to be selected from the following listed by field:

General

- EM 385 Innovative System Design
- ▶ PEP 575 Fundamentals of Atmospheric Radiation & Climate
- EN 587 Environmental Law & Management

Philosophy

- ▶ HPL 370 Philosophy of Technology
- ▶ HPL 380 Environmental Ethics
- ▶ HPL 455 Ethical Issues in Science and Technology

History

HHS 391 History of Regional Development Policies

Social Science

HSS 380 Energy, Politics and Administration (planned for future)

Graduation Requirements

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- ▶ Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirements

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

Engineering Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
PE 200	Physical Education I	0	0	0	0
	Total	12	10	27	17

Term II					
Course #	Course Name	Lecture	Lab	Study	Credit
	Science Elective ¹	3	0	6	3
PEP 111	Mechanics	3	0	6	3
E 122	Engineering Design II	0	3	3	2
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
PE 200	Physical Education II	0	0	0	0
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	16	8	37	19

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics ²	3	0	6	3
S.E.	Science Elective ¹	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
Hum	Humanities	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
MA 227	Multivariable Calculus	3	0	6	3
	Total	17	5	37	18

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
E 342	Transport/Fluid Mechanics ²	3	3	6	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Probability and Statistics for Engineers	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
Hum	Humanities	3	0	6	3
	Total	15	6	32	18

Course #	Course Name	Lecture	Lab	Study	Credit
E 345	Modeling and Simulation ³	3	0	6	3
E 355	Engineering Economics	3	3	6	4
E 322	Engineering Design VI ³	1	3	5	2
T.E.	Technical Elective ³	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
	Total	16	6	35	18

Term VI

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ³	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
T.G. 403	Senior Innovation I	2	0	4	2
T.E.	Technical Elective ³	3	0	6	3
E 423	Engineering Design VII	1	7	4	3
	Total	15	7	32	17

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ³	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
T.G. 404	Senior Innovation II	1	0	2	1
E 424	Engineering Design VIII ³	1	7	4	3
Hum	Humanities	3	0	6	3
	Total	14	7	30	16

(1) Basic Science electives – note: engineering programs may have specific requirements: one elective must have a laboratory component; two electives from the same science field cannot be selected.

(2) Core option – specific course determined by engineering program

(3) Discipline specific course

(4) General Electives – chosen by the student can be used towards a minor or option can be applied to research or approved international studies

ENGINEERING PROGRAM

Science Elective I and II Requirements & Options

Biomedical Engineering

- Science 1: CH 116 Chemistry II and CH 118 Chemistry Lab II
- Science 2: BIO 281 Biology without BIO 282 Biology Lab

.....

Chemical Engineering

- ▶ Science 1: CH 116 and CH 118
- Science 2: BIO 281 Biology without BIO 282 Biology Lab

Civil Engineering

- Science 1: CH 116 Chemistry II with or without CH 118 Chemistry Lab II
- Science 2: BIO 281 Biology with or without BIO 282 Biology Lab as long as one lab is included in the 2 courses

Computer Engineering (science elective II deferred to term 6)

Any two of the following: BIO 281 Biology, CH 116 Chemistry II, PEP 201 Physics III for Engineers with lab, NANO 200 Intro to Nanotechnology, EN250 Quantitative Biology or PEP 151 Introduction to Astronomy, as long as one lab is included in the 2 courses

Electrical Engineering (science elective II deferred to term 6)

Any two of the following: BIO 281 Biology, CH 116 Chemistry II, PEP 201 Physics III for Engineers with lab, NANO 200 Intro to Nanotechnology, EN250 Quantitative Biology or PEP 151 Introduction to Astronomy, as long as one lab is included in the 2 courses

Engineering - concentration in Naval Engineering

Any two of the following: BIO 281 Biology, CH 116 Chemistry II, PEP 201 Physics III for Engineers with lab, NANO 200 Intro to Nanotechnology, EN250 Quantitative Biology or PEP 151 Introduction to Astronomy, as long as one lab is included in the 2 courses

Engineering Management

Any two out of the following: of BIO 281 Biology, CH 116 Chemistry II, PEP 201 Physics III for Engineers with lab, NANO 200 Intro to Nanotechnology, EN250 Quantitative Biology or PEP 151 Introduction to Astronomy, as long as one lab is included in the 2 courses

Environmental Engineering

- Science 1: CH 116 Chemistry II and CH 118 Chemistry Lab II
- Science 2: BIO 281 Biology, PEP 151 Introduction to Astronomy, NANO 200 Intro to Nanotechnology, EN250 Quantitative Biology (web course) or PEP201 Physics III for Engineers with lab, as long as one lab is included in the 2 courses

Mechanical Engineering

Mechanical Engineering students can select their two science electives according to the following criteria. While making the selection, please note to satisfy ABET requirements, at least one of the two science electives must have a laboratory component.

- Science 1: CH 116 Chemistry I (has a separate 1 credit lab, CH 118) or BIO 281 Biology and Biotechnology (has a separate 1 credit lab, BIO 282)
- Science 2 Choose the second course from above or one course from the following: EN 250 Quantitative Biology (no lab), NANO 200 Introduction to Nanotechnology (no lab), PEP 151 Introduction to Astronomy (no lab), PEP 201 Physics III for Engineers (lab component built into the course), PEP 336 Astrophysics (no lab), or PEP 351 Planetary Science (no lab)

Software Engineering

Any two of the following: BIO 281 Biology, CH 116 Chemistry II, PEP 201 Physics III for Engineers with lab, NANO 200 Intro to Nanotechnology, EN250 Quantitative Biology or PEP 151 Introduction to Astronomy, as long as one lab is included in the 2 courses

Lab Requirement

If a lab was NOT taken with the Science Elective I choice it will be required with the Science Elective II choice.

- EN 250, NANO 200 & PEP 151 do not have a laboratory associated with it. Therefore, take these courses only if you have taken a laboratory with Science Elective I.
- ▶ PEP 201 has a built in lab component which fulfills the lab requirement.

Note

Science Elective I & II cannot be in the same field.

▶ BIO 281 & EN 250 are considered science electives from the same field.

BACHELOR OF SCIENCE

The science departments—Biomedical Engineering, Chemistry & Biological Sciences, Computer Science, Mathematical Sciences and Physics & Engineering Physics—provide exciting, top-quality programs for undergraduates at Stevens. The quality of our programs derives from the quality of our world-class faculty. Undergraduate students are a welcomed part of our community. They are afforded ready access to faculty and to ongoing research activities on campus and off campus, and, as they pursue their studies, undergraduates are encouraged to participate in research and innovative and entrepreneurial activities.

The science curricula at Stevens emphasize project-based learning, encourage and reward independent study and scientific initiative, offer expanded research opportunities for undergraduates, and promote the undergraduate thesis as a capstone for a student's course of study. These elements of the curriculum are intended to enhance the undergraduate experience of the student with a serious interest in studying the natural sciences or computer science.

The undergraduate programs are separated into two categories of curricula. The programs in chemistry & chemical biology, mathematical sciences, and physics follow a unified curriculum, the Bachelor of Science in the natural sciences. The Department of Computer Science has developed distinct curricula for each of two undergraduate programs: Bachelor of Science in Computer Science, and Bachelor of Science in Natural Science Subjects.

The science program at Stevens offers a remarkable opportunity for a career in today's scientific world. It prepares you to work at the frontiers of knowledge making significant contributions to science and the well-being of mankind. Careers in biology, chemistry, medicine, physics, nanotechnology, mathematics, and statistics, are accessible through the science program.

The concepts, techniques and attitudes that are common to all sciences form the core courses of the Science program. You develop an awareness of the interactions among the various scientific disciplines and their individual contributions to the advancement of knowledge - the total picture of science. Additional courses in a chosen concentration prepare you exceptionally well with both the tools and knowledge to enter a profession immediately upon graduation, or to embark on advanced study leading to a graduate degree.

Studies during your freshman year include courses in biology, chemistry, computer science, mathematics, and physics, and a sequence of courses in humanities. Studies in the humanities continue throughout the four-year program. In the next three years you may choose a concentration in the area of chemistry, chemical biology, mathematics, computational science,

applied physics, or engineering physics. Upon successful completion of your studies, you are awarded the Bachelor of Science degree.

The minimal formal requirements for the science program are listed in the semester-by-semester schedule, including the Notes. Courses may be taken in a different order than listed. Consult the individual department schedule for more specific details.

Bachelor of Science (Computer Science)

The computer science degree emphasizes the principles of computer science and prepares students for careers in industry and/ or graduate school. Course materials focus on how to design, implement, deploy, and manage sophisticated software systems.

Bachelor of Science (Cybersecurity)

As the need for data security increases in all industries, including medicine, banking, and homeland security, the demand for professionals with knowledge in the areas of information assurance and computer security continues to grow. In 2003, as part of the National Strategy to Secure Cyberspace, the White House identified as a top priority the necessity of maintaining a pool of well-trained and certified IT security specialists through providing comprehensive training and education.

The cybersecurity major builds on a basic computer science education to also develop the deep technical skills required of a modern security professional. These skills include a deep knowledge and understanding of crytography, as well as the ability to diagnose threats and defenses for software systems. Therefore the pivot course for this major is a course in secure systems that includes a cybersecurity lab as a co-requisite. The cybersecurity major include courses in:

- Operating systems
- Concurrent programming
- Database management systems
- Cybersecurity fundamentals
- Privacy
- Cryptography
- Secure systems

This program is structured to provide students with security expertise within the context of a broad education. The curriculum not only has a strong focus in science and computer science but also incorporates aspects of engineering and technology management. Cybersecurity students in the senior design project do a project involving secure systems, under the guidance and supervision of security faculty.

Minor in Entrepreneurship

The undergraduate minor in entrepreneurship provides the educational prerequisites needed to foster the successful birth and development of technology-driven new ventures.

The minor will provide the knowledge and the infrastructure needed to sustain and support the efforts of Stevens' undergraduate students in engineering and science to create economic value through innovation and entrepreneurship.

After completing the minor, students will be able to develop and write an effective business plan by systematically developing the following skills:

- Able to identify and recognize viable technical business opportunities
- Can critically evaluate these business opportunities
- Can assess and manage the intellectual property embodied in technological opportunities

- Can develop an effective business model addressing market, operating and financial requirements
- Knows how to launch a technologically-based business

Courses

- MGT 103 Introduction to Entrepreneurship
- ▶ E 355 Engineering Economy or BT 200 Financial Accounting
- MGT 372 Discovery and Commercialization of Technical Business Opportunities
- ▶ BT 447 Creativity & Innovation
- MGT 472 Assessment and Financing of Technical Business Opportunities
- MGT 419 Entrepreneurship Practicum

Graduation Requirements

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- ▶ Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirements

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

Science Curriculum

-	
Term	
1 GT III	

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 111	Mechanics	3	0	6	3
CS 105 Or CS 115	Introduction to Scientific Computing ¹ Or Introduction to Computer Science	2	2	6	3
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103	Writing And Communications Colloquium	3	0	6	3
PE 200	Physical Education I	0	0	0	0
	Total	15	5	33	17

Term II					
Course #	Course Name	Lecture	Lab	Study	Credit
PEP 112	Electricity and Magnetism	3	0	6	3
BIO 281	Biology and Biotechnology	3	0	6	3
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
PE 200	Physical Education II	0	0	0	0
	Total	16	3	33	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 221	Physics Lab I for Scientists	0	3	1	1
BT 244 Or BT 243	Microeconomics Or Macroeconomics	3	0	6	3
T.E.	Technical Elective	3	0	6	3
	Humanities	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	13	5	27	14

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Science Elective ²	3	0	6	3
PEP 222	Physics Lab II for Scientists	0	3	1	1
	Thermodynamics ³	3	0	6	3
T.E.	Technical Elective	3	0	6	3
	Humanities	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	12	5	25	13

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities	3	0	6	3
T.E.	Technical Elective	3	0	6	3
T.E.	Technical Elective	3	0	6	3
T.E.	Technical Elective III	3	0	6	3
	Total	12	0	24	12

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Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities	3	0	6	3
MA 222	Probability and Statistics	3	0	6	3
PEP 242	Modern Physics	3	0	6	3
T.E.	Technical Elective	3	0	6	3
	Total	12	0	24	12

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities	3	0	6	3
T.E.	Technical Elective	3	0	6	3
T.E.	Technical Elective	3	0	6	3
T.E.	Technical Elective III	3	0	6	3
GE	Elective 2	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities	3	0	6	3
T.E.	Technical Elective	3	0	6	3
T.E.	Technical Elective	3	0	6	3
T.E.	Technical Elective III	3	0	6	3
GE	Elective 2	3	0	6	3
	Total	15	0	30	15

(1) Alternate course: Intro. to Computer Science

(2) The Science Elective must be chosen from: MA 227 Multivariable Calculus (3-0-3) or CH 382 Biological Systems (3-3-4)

(3) Thermodynamics can be either CH 321 or E 234.8

CORE CURRICULUM COURSES

E 101 Engineering Experiences I

This course consists of a set of engineering experiences such as lectures, small group sessions, on-line modules and visits. Students are required to complete a specified number of experiences during the semester. The goal is to introduce students to the engineering profession, engineering disciplines, college success strategies, Stevens research and other engaging activities. Course is pass/fail.

E 115 Introduction to Programming

An introduction to the use of an advanced programming language for use in engineering applications, using C++ as the basic programming language and Microsoft Visual C++ as the program development environment. Topics covered include basic syntax (data types and structures, input/output instructions, arithmetic instructions, loop constructs, functions, subroutines, etc.) needed to solve basic engineering problems as well as an introduction to advanced topics (use of files, principles of objects and classes, libraries, etc.). Algorithmic thinking for development of computational programs and control programs from mathematical and other representations of the problems will be developed. Basic concepts of computer architectures impacting the understanding of a high-level programming language will be covered.

E 120 Engineering Graphics

Engineering graphics: principles of orthographic and auxiliary projections, pictorial presentation of engineering designs, dimensioning and tolerance, sectional and detail views, assembly drawings. Descriptive geometry. Engineering figures and graphs. Solid modeling introduction to computer-aided design and manufacturing (CAD/CAM) using numerically-controlled (NC) machines.

E 121 Engineering Design I

This course introduces students to the process of design and seeks to engage their enthusiasm for engineering from the very beginning of the program. The engineering method is used in the design and manufacture of a product. Product dissection is exploited to evaluate how others have solved design problems. Development is started of competencies in professional practice topics, primarily: effective group participation, project management, cost estimation, communication skills and ethics. Engineering Design I is linked to and taught concurrently with the Engineering Graphics course. Engineering graphics are used in the design projects and the theme of "fit to form" is developed.

Corequisites: E 115, E 120

E 122 Engineering Design II

This course will continue the freshman year experience in design. The engineering method introduced in Engineering Design I will be reinforced. Further introduction of professional practice topics will be linked to their application and testing in case studies and project work.

Prerequisites: E 121

E 126 Mechanics of Solids

Fundamental concepts of particle statics, equivalent force systems, equilibrium of rigid bodies, analysis of trusses and frames, forces in beam and machine parts, stress and strain, tension, shear and bending moment, flexure, combined loading, energy methods, statically indeterminate structures.

Prerequisites: PEP 111, MA 115 or MA 122

E 231 Engineering Design III

This course continues the experiential sequence in design. Design projects are linked with Mechanics of Solids topics taught concurrently. Core design themes are further developed.

Prerequisites: E 122

Corequisites: E 126

E 232 Engineering Design IV

This course continues the experiential sequence in design. Design projects are in, and lectures address the area of Electronics and Instrumentation. Core design themes are further developed.

Prerequisites: E 231, E 245

E 234 Thermodynamics

Concepts of heat and work; First and Second Laws for closed and open systems including steady processes and cycles; thermodynamic properties of substances and interrelationships; phase change and phase equilibrium; chemical reactions and chemical equilibrium; representative applications. Introduction to energy conversion systems, including direct energy conversion in fuel-cells, photo-voltaic systems, etc.

Prerequisites: CH 115, MA 115 or MA 122, PEP 111,

E 243 Probability and Statistics for Engineers

Descriptive statistics, pictorial and tabular methods, measures of location and of variability, sample space and events, probability and independence, Bayes' formula, discrete random variables, densities and moments, normal, gamma, exponential and Weibull distributions, distribution of the sum and average of random samples, the central limit theorem, confidence intervals for the mean and the variance, hypothesis testing and p-values, applications for prediction in a regression model. A statistical computer package is used throughout the course for teaching and for project assignments.

Prerequisites: MA 116 or MA 124

E 245 Circuits and Systems

Ideal circuit elements; Kirchoff laws and nodal analysis; source transformations; Thevenin/Norton theorems; operational amplifiers; response of RL, RC and RLC circuits; sinusoidal sources and steady state analysis; analysis in frequency domain; average and RMS power; linear and ideal transformers; linear models for transistors and diodes; analysis in the s-domain; Laplace transforms; transfer functions.

Corequisites: PEP 112, MA 221

E 301 International Educational Experiences I

This course designation provides a vehicle to award general elective academic credit to approved international educational experiences that meet School of Engineering and Science/engineering program educational outcomes, but would not otherwise be transferable as equivalent to a Stevens course or courses. Multiple activities can be combined for approval if they present a coherent whole that addresses school/program outcomes. The program or activities must be approved for credit by the School of Engineering and Science Education and Assessment Committee.

E 302 International Educational Experiences II

This course designation provides a vehicle to award general elective academic credit to approved international educational experiences that meet School of Engineering and Science/engineering program educational outcomes, but would not otherwise be transferable as equivalent to a Stevens course or courses. Multiple activities can be combined for approval if they present a coherent whole that addresses school/program outcomes. The program or activities must be approved for credit by the School of Engineering and Science Education and Assessment Committee.

E 321 Engineering Design V

This course includes both experimentation and open-ended design problems that are integrated with the Materials Processing course taught concurrently. Core design themes are further developed.

Corequisites: E 344

E 322 Engineering Design VI

This course allows each discipline to address design topics specific to their discipline. Offered as a discipline specific course (e.g.: CE322, CHE322, CPE322, EE322, EM322, EN322, ME322, NE322, SSW322).

Prerequisites: E 321

Corequisites: E 345, E 355

E 342 Transport/Fluid Mechanics

Offered as a specific departmental course; see departmental listing.

E 344 Materials Processing

An introduction is provided to the important engineering properties of materials, to the scientific understanding of those properties and to the methods of controlling them. This is provided in the context of the processing of materials to produce products.

Prerequisites: CH 115

E 345 Modeling and Simulation

Development of deterministic and non-deterministic models for physical systems; engineering applications; simulation tools for deterministic and non deterministic systems; case studies and projects. Offered as a discipline specific course (e.g.: CE345, CHE345, CPE345, EE345, EM345, EN345, ME345, NE 345, SSW345).

E 355 Engineering Economics

Students learn a set of Engineering Economic techniques that serve as powerful tools to aid in the design, implementation and continued improvement of any engineering project or process. The primary goal of this course is to help students develop an ability to make sound economic decisions, thereby facilitating effective evaluation and selection of alternative technical, design, and engineering solutions. In this course students will be exposed to the analysis of financial data, the concept of interest rates, the time value of money, economic analysis using the three worths, internal rate of return and benefit cost analysis. Furthermore, the student will gain a comprehensive knowledge about advanced engineering economy topics such as depreciation, capital cost and recovery, after tax analysis, inflation, sensitivity analysis, risk analysis and simulation. Laboratory exercises include the use of spreadsheets to solve engineering economy problems and a series of labs that parallel the lecture portion of the course.

Prerequisites: E 121, and E 122, and E 231, and E 232

E 385 Special Topics in Sustainable Engineering

This is a multidisciplinary course addressing contemporary issues in sustainable engineering. The course is primarily projectbased with relevant lectures and seminars from the instructor and guest speakers. Each student or group of students will develop a plan of project activities appropriate for the assigned credits under the supervision of an advisor and may include a co-advisor from outside Stevens. The scope of the project must not duplicate any activity for which credit has been or is being obtained in another course. This course is open to engineering undergraduate students from any discipline with at least sophomore standing. This course can be used as an elective in the Green Engineering Minor.

E 400 Research in Engineering

Individual research investigation under the guidance of a faculty advisor. Hours/credits to be arranged. A final report/thesis and a formal presentation in a seminar/conference is required.

E 423 Engineering Design VII

Senior design capstone courses. For most programs a capstone project spanning two semesters is required. Environmental Engineering requires projects of one semester duration. While the focus is on the capstone disciplinary design experience, all programs will include the two-credit core module on Engineering Economic Design (E421) during the first semester

E 424 Engineering Design VIII

Senior design capstone courses include a capstone project spanning two semesters.

Prerequisites: E 423

E 580 Sustainable Energy

Assessment of current and potential energy systems, covering extraction, conversion and end use, with emphasis on meeting regional and global energy needs in the 21st century in a sustainable manner; systems engineering and economic analysis tools for sustainable energy systems; climate change; energy technologies in each fuel cycle stage for fossil (oil, gas, synthetic), nuclear (fission and fusion) and renewable (solar, biomass, wind, hydro, and geothermal) energy types; storage, transmission, and conservation; evaluation and analysis of energy technology systems in the context of engineering, economic, environmental, political and social aspects.

Department of Biomedical Engineering, Chemistry and Biological Sciences

FACULTY

PETER TOLIAS DEPARTMENT DIRECTOR (INTERIM)

Ciara Agresti, M.S. Instructor, Biology and Chemical Biology

Sesha Alluri, Ph.D. Lecturer, Chemistry

Athula Attygalle, Ph.D. Research Professor, Chemistry

Thomas Cattabiani, M.S. Senior Lecturer, Biology and Chemical Biology

Marissa Gray, Ph.D. Teaching Assistant Professor, Biomedical Engineering Associate Department Director, Graduate Programs

Vikki Hazelwood, Ph.D. Industry Professor Program Director, Biomedical Engineering

Dilhan Kalyon, Ph.D. Joint Affiliate Professor, Biomedical Engineering Director of the Highly Filled Materials Institute

Helen Kambic, Ph.D. Teaching Professor, Biomedical Engineering

Eun-Hee Kang, Ph.D. Lecturer, Chemistry and Chemical Biology

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Ramana Vinjamuri, Ph.D. Assistant Professor, Biomedical Engineering

Hongjun Wang, Ph.D. Associate Professor, Chemical Biology and Biomedical Engineering

Xiaojun Yu, Ph.D. Associate Professor, Biomedical Engineering

Yong Zhang, Ph.D. Associate Professor, Chemistry

UNDERGRADUATE PROGRAMS

Chemistry

Chemistry is a field of study which seeks to describe the properties, composition, structure and process of formation of all things that make up the universe. Chemistry, which is commonly known as the central science, bridges the gap between the life sciences and physical sciences.

The Stevens Chemistry program is based on a solid foundation in the major core areas of chemistry which includes organic chemistry, analytical chemistry, physical chemistry, inorganic chemistry and biochemistry. Additional courses in advanced chemistry are available in those areas in which Stevens has unique strengths, such as polymer chemistry, natural products, medicinal chemistry, computational chemistry, and instrumental analysis. Research is strongly encouraged due to its importance in preparing for a career in chemistry; it also helps develop independence in solving open-ended problems.

The Stevens program prepares students for career opportunities in diverse fields including pharmaceuticals, petroleum, polymers and plastics, paints and adhesives, electronic materials, waste treatment, agricultural chemistry, and foods and fragrances, in addition to many other industries. Chemists can be involved in research where they either create new knowledge or synthesize new chemicals. They can also choose fields in quality control where testing and analysis are crucial. Chemists are employed in hospitals, as well as clinical, environmental control, and criminology laboratories. Chemistry also occupies a pivotal role in the high-technology areas of bioinformatics, biotechnology, materials technology, ceramics, polymers, and electronic materials. The Stevens program also prepares students for success in graduate programs in chemistry and professional schools.

The Bachelor of Science in Chemistry is certified by the American Chemical Society (ACS).

Chemistry Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 111	Mechanics	3	0	6	3
CS 105	Introduction to Scientific Computing ¹	2	2	6	3
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	15	5	33	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 112	Electricity and Magnetism	3	0	6	3
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
BIO 281	Biology and Biotechnology	3	0	6	3
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	17	3	33	17

Term III					
Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ³	3	0	6	3
MA 221	Differential Equations	4	0	8	4
BIO 381	Cell Biology	3	3	7	4
PEP 221	Physics Lab I for Scientists	0	3	1	1
CH 243	Organic Chemistry I	3	0	6	3
CH 245	Organic Chemistry Laboratory I	0	4	0	1
PE 200	Physical Education I	0	2	0	0
	Total	13	12	28	16

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ³	3	0	6	3
MA 227	Multivariable Calculus	3	0	6	3
CH 321	Thermodynamics	3	0	6	3
CH 244	Organic Chemistry II	3	0	6	3
PEP 222	Physics Lab II for Scientists	0	3	1	1
CH 246	Organic Chemistry Laboratory II	0	4	0	1
CH 501	Professional Ethics in Chemical & Scientific Research	1	0	1	1
PE 200	Physical Education II	0	2	0	0
	Total	15	9	31	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ³	3	0	6	3
CH 580	Biochemistry I – Cellular Metabolism and Regulation	3	0	6	3
CH 362	Instrumental Analysis I - Spectroscopy and Chromatography	3	4	8	4
CH 360	Spectra and Structure	3	0	6	3
BT 244	Microeconomics ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	6	32	16

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ³	3	0	6	3
PEP 242	Modern Physics	3	0	6	3
MA 222	Probability and Statistics	3	0	6	3
CH 461	Instrumental Analysis II - Electrochemistry	3	4	8	4
CH 581	Biochemistry II – Biomolecular Structure and Function	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	6	32	16

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Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
T.E.	Technical Elective ⁵	3	0	6	3
CH 496 Or CH 498	Chemistry Project I Or Chemical Research I	0	8	4	3
CH 421	Chemical Dynamics	3	4	6	4
	Total	12	12	28	16

Term VII

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ³	3	0	6	3
CH 412	Inorganic Chemistry I	3	4	8	4
CH 582	Biophysical Chemistry	3	0	6	3
CH 497 Or CH 499	Chemistry Project II Or Chemical Research II	0	8	4	3
CH 322	Theoretical Chemistry	3	0	6	3
	Total	12	12	30	16

(1) Students may choose CS 115, Intro. to Computer Science, in place of CS 105.

(2) Students may choose BT 243, Macroeconomics, in place of BT 244.

(3) Humanities requirements can be found on pages 556-557.

(4) General Education Electives: Chosen by the student, can be any approved 3 or 4 credit course needed towards a minor, major concentration, research, independent study, language course or a course taken during an international experience.

(5) Technical elective: can be selected from available CH 4XX and CH 5XX course offerings.

Chemical Biology

Chemical Biology is the application of chemistry to the understanding and utilization of biological phenomena. Chemical biology represents an approach to understanding biology through the underlying chemical interactions of biological macromolecules and provides students with the essential tools to reveal the logic of how biological systems operate as well as engineering changes in those systems. Stevens pioneered this field with establishing the first undergraduate program in chemical biology in the late 1970s.

By developing a chemical understanding of biological systems, chemical biologists can develop quantitative descriptions of complex biological phenomena, predict outcomes of biological systems, and contribute to the new field of synthetic biology wherein the chemistry of life is expanded using existing scientific principles that nature has not yet employed.

The Stevens Program in Chemical Biology combines a complete education in chemistry with additional mathematics and physics training to ensure a solid foundation in quantitative physical sciences and a set of biology courses that introduce the key elements of cellular, molecular, and physiological biology. Thus, the chemical biology program is effective in launching students onto careers in chemistry, biochemistry, biotechnology, forensic science or biology. This program also allows students to prepare for further training at the Masters or PhD level in a wide array of programs in chemical or biological sciences as well as gain the training necessary for admission in professional schools in medicine, dentistry, veterinary medicine or other health professions.

The Bachelor of Science in Chemical Biology is certified by the American Chemical Society if the students choose to take two additional courses in the degree program which includes courses in Inorganic Chemistry, which serves a general elective, and Professional Ethics.

Beyond the traditional chemical biology curriculum, two specialized tracks have been identified within the chemical biology program: Bioanalytical Chemistry and Bioinformatics.

Chemical Biology Curriculum

Term I

	1	1	1		
Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
CS 105	Introduction to Scientific Computing ¹	2	2	6	3
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
PEP 111	Mechanics	3	0	6	3
CAL 103	Writing And Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
	Total	15	5	33	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
BIO 281	Biology and Biotechnology	3	0	6	3
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	16	3	33	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
MA 221	Differential Equations	4	0	8	4
BIO 381	Cell Biology	3	3	7	4
CH 243	Organic Chemistry I	3	0	6	3
CH 245	Organic Chemistry Laboratory I	0	4	0	1
PEP 221	Physics Lab I for Scientists	0	3	1	1
PE 200	Physical Education I	0	2	0	0
	Total	13	12	28	16

Term IV					
Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
BIO 382	Biological Systems	3	3	7	4
CH 321	Thermodynamics	3	0	6	3
CH 244	Organic Chemistry II	3	0	6	3
CH 246	Organic Chemistry Laboratory II	0	4	0	1
PEP 222	Physics Lab II for Scientists	0	3	1	1
CH 501	Professional Ethics in Chemical & Scientific Research	1	0	1	1
PE 200	Physical Education II	0	2	0	0
	Total	12	12	26	16

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
BIO 484	Introduction to Molecular Genetics	3	3	7	4
CH 580	Biochemistry I – Cellular Metabolism and Regulation	3	0	6	3
CH 362	Instrumental Analysis I - Spectroscopy and Chromatography	3	4	8	4
BT 244	Microeconomics ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	9	33	17

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
PEP 242	Modern Physics	3	0	6	3
E 243	Probability and Statistics for Engineers	3	0	6	3
CH 461	Instrumental Analysis II - Electrochemistry	3	4	8	4
CH 581	Biochemistry II – Biomolecular Structure and Function	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	6	32	16

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
BIO 583	Physiology	3	0	6	3
CH 421	Chemical Dynamics ⁶	3	4	6	4
CH 496 Or CH 498	Chemistry Project I Or Chemical Research I	0	8	4	3
G.E.	General Elective ³	3	0	6	3
	Total	12	12	28	16

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Term	VIII
101111	

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
CH 582	Biophysical Chemistry	3	0	6	3
T.E.	Technical Elective ⁴	3	0	6	3
CH 497 Or CH 499	Chemistry Project II Or Chemical Research II	0	8	4	3
G.E.	General Elective	3	0	6	3
	Total	12	8	28	15

(1) Students may choose CS 115, Intro. to Computer Science, in place of CS 105. The Bioinformatics Concentration requires CS 115 in place of CS 105.

(2) Students may choose BT 243, Macroeconomics, in place of BT 244.

(3) CH 412 required for ACS certification

(4) BIO 686 Immunology is suggested and requires Instructor's permission. Others are selected from available CH or BIO 3XX, 4XX, 5XX courses.

(5) Humanities requirements can be found on pages 556-557.

(6) CH 421 can be taken in term V instead of term VII.

Bioinformatics

New and powerful techniques have been developed for determining the structures of biological molecules and manipulating biomolecular sequences which results in large amounts of data. Bioinformatics makes use of mathematical and computer science techniques to process this data so it can be used for further scientific advances. The Stevens Bioinformatics track is built on the foundations of chemical biology. Students elect CS115 as an introduction to computing in the freshman year in place of CS105. After the first two years in the Chemical Biology Program, the Bioinformatics student begins replacing certain electives with mathematics and computer science courses. The Stevens Bioinformatics track concentrates on giving students the ability to contribute to building the software and analytical infrastructure of the field.

Bioinformatics Curriculum

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CS 135	Discrete Structures	3	2	8	4
CS 284	Data Structures ¹	2	2	8	4
Hum	Humanities ⁵	3	0	6	3
CH 580	Biochemistry I – Cellular Metabolism and Regulation	3	0	6	3
CH 362	Instrumental Analysis I - Spectroscopy and Chromatography	3	4	8	4
	Total	14	8	36	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
PEP 242	Modern Physics	3	0	6	3
MA 222	Probability and Statistics	3	0	6	3
CH 461	Instrumental Analysis II - Electrochemistry	3	4	8	4
CH 581	Biochemistry II – Biomolecular Structure and Function	3	0	6	3
	Total	15	4	32	16

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities⁵	3	0	6	3
BT 244	Microeconomics	3	0	0	3
CS 385	Algorithms	4	0	8	4
BIO 484	Introduction to Molecular Genetics	3	3	7	4
BIO 583	Physiology	3	0	6	3
CH 421	Chemical Dynamics ⁶	3	4	6	4
	Total	19	7	33	21

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
CS 442	Database Management Systems	3	0	6	3
CH 582	Biophysical Chemistry	3	0	6	3
BIO 668	Computational Biology ³	3	0	6	3
BIO 686	Immunology ²	3	0	6	3
CH 497	Chemistry Project II ⁴	0	8	4	3
	Total	15	8	34	18

(1) CS 115 must have been chosen in Freshman year

(2) Requires advisor's approval.

(3) Requires advisor's approval.

(4) Project/Research can either be a project (CH 496/497) or thesis (CH 498/499) and can be done either in the junior/senior or senior year.

(5) Humanities requirements can be found on pages 556-557.

(6) CH 421 can be taken in term V instead of term VII.

Bioanalytical Chemistry

Biological systems are characterized by presence of large, complex biological molecules arrayed as collections of genes, transcripts, proteins, carbohydrates, lipids, and associated metabolites. Whereas a comprehensive chemical definition of biological systems was once beyond the realm of possibility, we can now envision the treatment of biological cells, tissues, and even complete organisms in terms of their chemical composition and interactions. Bioanalytical chemistry comprises the techniques and instrumentation necessary to separate and analyze the chemical composition of biological systems. Bioanalytical chemists have already made tremendous contributions in the areas of genomics, gene expression analysis, and disease gene/protein identification, as well as drug discovery and forensic science. In addition to further contributions in these fields, bioanalytical chemists will be increasingly needed to improve the practice of medicine through chemically-defined diseases states, and to protect our general public through surveillance for illicit drugs, explosives, and pathogens. The track in bioanalytical chemistry is built on the foundations of chemical biology. After the first two years in the regular chemical biology program, the bioanalytical chemistry student begins concentrating on analytical techniques relevant to biological macromolecules such as mass spectrometry, magnetic resonance imaging, flow cytometry, and genome and transcriptome array analysis.

Bioanalytical Chemistry Curriculum

Term V

Course #	Course Name	Lecture	Lab	Study	Credit	
Hum	Humanities	3	0	6	3	
CH 560	Spectra and Structure	3	0	6	3	
CH 362	Instrumental Analysis I - Spectroscopy and Chromatography	3	4	8	4	
CH 580	Biochemistry I – Cellular Metabolism and Regulation	3	0	6	3	
CH 421	Chemical Dynamics ⁴	3	4	6	4	
BIO 484	Introduction to Molecular Genetics	3	3	7	4	
	Total	18	11	39	21	

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
MA 222	Probability and Statistics ³	3	0	6	3
PEP 242	Modern Physics	3	0	6	3
CH 461	Instrumental Analysis II - Electrochemistry	3	4	8	4
CH 581	Biochemistry II – Biomolecular Structure and Function	3	0	6	3
	Total	15	4	32	16

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities	3	0	6	3
BT 244	Microeconomics	3	0	0	3
CH 662	Separation Methods in Analytical and Organic Chemistry ¹	3	0	6	3
CH 666	Modern Mass Spectrometry ¹	3	4	6	4
CH 496 Or CH 498	Chemistry Project I ² Or Chemical Research I	0	8	4	3
	Total	12	12	22	16

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁵	3	0	6	3
CH 660	Advanced Instrumental Analysis ¹	3	0	0	3
CH 412	Inorganic Chemistry I	3	4	8	4
CH 582	Biophysical Chemistry	3	0	6	3
CH 497 Or CH 499	Chemistry Project II ² Or Chemical Research II	0	8	4	3
	Total	12	12	24	16

(1) Requires advisor' approval.

(2) Project/Research can be either a project (CH 496/497) or thesis (CH 498/499) and can be done either in the junior/senior year or senior year.

(3) E243 Engineering Statistics may be substituted.

(4) CH 421 can be taken in term VII instead of term V.

(5) Humanities requirements can be found on pages 556-557.

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Biology

Stevens recently instituted a new major in biology. The biology program reflects Stevens' philosophy that life sciences are best approached with a strong foundation in chemical and physical sciences. As a result, the Biology and Chemical Biology Programs share the same curriculum through three semesters. The principle difference between the programs relates to the amount of chemistry required in the advance undergraduate curriculum. In the biology major, additional upper level courses are dedicated to expanding the breadth and depth of exposure to biology topics and additional technical and general electives encourage pairing of the biology curriculum with the pursuit of minor fields of study, graduate certificates, double majors or master's degrees in other disciplines. Like the chemical biology curriculum, the biology curriculum will provide students with a strong background in chemistry, physics and mathematics that will ensure that students will have the ability to understand and engineer life science systems.

Graduates of the biology program at Stevens will be well prepared to pursue employment in biomedical science, biotechnology, or clinical research laboratories, to continue their education at the master's or doctoral level in a wide array of programs in biological sciences, to gain admission to professional training in medicine, dentistry, veterinary medicine, physician assistant, physical therapy, or other health professions, or to combine their knowledge of life sciences with employment in other areas of employment such as scientific publishing, law, business, or healthcare.

Biology Curriculum

Term I

Course #	Course Name	Looturo	Lab	Chudu	Credit
Course #		Lecture	Lab	Study	Grean
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
MA 121	Differential Calculus	4	0	8	2
and					
MA 122	Integral Calculus				2
PEP 111	Mechanics	3	0	6	3
CS 105	Introduction to Scientific Computing	2	2	6	3
CAL 103	Writing And Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
	Total	15	5	33	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
MA 123 and MA 124	Series, Vectors, Functions, and Surfaces Calculus of Two Variables	4	0	8	2
PEP 112	Electricity and Magnetism	3	0	6	3
BIO 281	Biology and Biotechnology	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	16	3	33	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
CH 243	Organic Chemistry I	3	0	6	3
CH 245	Organic Chemistry Laboratory I	0	4	0	1
MA 221	Differential Equations	4	0	8	4
BIO 381	Cell Biology	3	3	7	4
PEP 221	Physics Lab I for Scientists	0	3	1	1
Hum	Humanities ²	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	13	12	28	16

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
CH 244	Organic Chemistry II	3	0	6	3
CH 246	Organic Chemistry Laboratory II	0	4	0	1
E 243	Probability and Statistics for Engineers ¹	3	0	6	3
BIO 382	Biological Systems	3	3	7	4
PEP 222	Physics Lab II for Scientists	0	3	1	1
Hum	Humanities ²	3	0	6	3
CH 501	Professional Ethics in Chemical and Scientific Research	1	0	0	1
PE 200	Physical Education II	0	2	0	0
	Total	13	12	26	16

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CH 362	Instrumental Analysis I - Spectroscopy and Chromatography	3	4	8	4
BIO 484	Introduction to Molecular Genetics	3	3	7	4
BT 243 Or BT 244	Macroeconomics Or Microeconomics	3	0	6	3
CH 580	Biochemistry I - Cellular Metabolism and Regulation	3	0	6	3
Hum	Humanities ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	9	33	17

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit	
CH 461	Instrumental Analysis II - Electrochemistry	3	4	8	4	
Or	Or					
CH 321	Thermodynamics					
CH 581	Biochemistry II - Biomolecular Structure and Function	3	0	6	3	
T.E.	Technical Elective ³	3	0	6	3	
G.E.	General Elective ⁴	3	0	6	3	
Hum	Humanities ²	3	0	6	3	
PE 200	Physical Education IV	0	2	0	0	
	Total	15	6	32	16	

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Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 242	Modern Physics	3	0	6	3
CH 496 Or CH 498	Chemistry Project I Or Chemical Research I	0	8	4	3
T.E.	Technical Elective ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
Hum	Humanities ²	3	0	6	3
	Total	12	8	28	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ³	3	0	6	3
CH 497 Or CH 499	Chemistry Project II Or Chemical Research II	0	8	4	3
T.E.	Technical Elective ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
Hum	Humanities ²	3	0	6	3
	Total	12	8	28	15

(1) MA 222 can be taken in place of E243.

(2) Humanities requirements can be found on pages 556-557.

(3) Biology Technical Electrive can be selected from available BIO 3XX, 4XX, and 5XX course offerings.

(4) General Education Electives - Chosen by the student can be any approved 3 or 4 credit course used towards a minor, major concentration, research, independent study, language courses, or a course taken during international experience.

Accelerated Program in Medicine

If you are pursuing the special combined degree program in medicine, your undergraduate curriculum will include core courses common to both the Chemical Biology and Biology Programs. The completion of this core within three years at Stevens requires adoption of a heavy course load, and a minimum GPA and score on the Medical College Admissions Test (MCAT) to ensure matriculation to the professional training program. The first year of the medical program transfers as credit for completion of the B.S. degree, so the undergraduate degree is awarded after four years. Enrolling in the Accelerated Program in Medicine requires admission to both Stevens and the professional school at the time of the initial undergraduate application. Please see information on Undergraduate Admissions for more information.

Accelerated Program in Medicine Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
CS 105	Introduction to Scientific Computing	2	2	6	3
MA 121	Differential Calculus	4	0	8	2
and					
MA 122	Integral Calculus				2

PEP 111	Mechanics	3	0	6	3
CAL 103	Writing And Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
	Total	15	5	33	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
BIO 281	Biology and Biotechnology	3	0	6	3
MA 123 and	Series, Vectors, Functions, and Surfaces	4	0	8	2
MA 124	Calculus of Two Variables				2
PEP 112	Electricity and Magnetism	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	16	3	33	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
HUM	Humanities ⁴	3	0	6	3
MA 221	Differential Equations	4	0	8	4
BIO 381	Cell Biology	3	3	7	4
CH 243	Organic Chemistry I	3	0	6	3
CH 245	Organic Chemistry Laboratory I	0	4	0	1
PEP 221	Physics Lab I for Scientists	0	3	1	1
BT	Economics ²	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	12	34	19

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁴	3	0	6	3
BIO 382	Biological Systems	3	3	7	4
CH 321	Thermodynamics	3	0	6	3
CH 244	Organic Chemistry II	3	0	6	3
CH 246	Organic Chemistry Laboratory II	0	4	0	1
PEP 222	Physics Lab II for Scientists	0	3	1	1
PE 200	Physical Education II	0	2	0	0
	Total	12	12	26	15

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Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁴	3	0	6	3
Hum	Humanities ⁴	3	0	3	3
CH 362	Instrumental Analysis I - Spectroscopy and Chromatography	3	4	8	4
CH 580	Biochemistry I – Cellular Metabolism and Regulation	3	0	6	4
BIO 484	Introduction to Molecular Genetics	3	3	7	4
PE 200	Physical Education III	0	2	0	0
	Total	15	9	30	18

Term V

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
Hum	Humanities ⁴	3	0	6	3
Hum	Humanities ⁴	3	0	3	3
PEP 242	Modern Physics	3	0	6	3
CH 461	Instrumental Analysis II - Electrochemistry	3	4	8	4
CH 581	Biochemistry II – Biomolecular Structure and Function	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	18	6	35	19

(1) Students may choose CS 115, Intro. to Computer Science, in place of CS 105.

(2) Economics can be either BT 243 (Macro) or BT 244 (Micro).

(3) CH 686 Immunology is suggested. Requires Instructor approval.

(4) Humanities requirements can be found on pages 556-557.

Biomedical Engineering

A Biomedical Engineer works at the interface between physical and biological systems. A distinguishing feature of biomedical engineers is that they design instruments and devices that interact with or make measurements on living systems. These systems can be as small as a protein, gene, or cell, as complex as an organ such as the heart and lungs or as integrated as the heart lungs and muscles during exercise. The ultimate goal is to help improve medical diagnosis and treatment and to improve the quality of life for people who are incapacitated.

The biomedical engineering field is truly multidisciplinary. Biomedical engineers must understand not only basic engineering principles but also the biology and physiology of cells, organs and systems that work together to create a functioning human being. In addition, the biomedical engineer must have some in-depth experience in applying engineering concepts to living systems. Biomedical Engineers are engaged in designing and manufacturing prostheses (replacement hips, knees, tendons, arms, legs, etc.), total artificial hearts as well as left ventricular assist devices, pacemakers and defibrillators, Imaging devices such as CAT scans, MRI, f-MRI, ultrasound, and nuclear medicine imaging (PET,SPECT), replacement organs (artificial pancreas, ears, retina, etc.), in-patient monitoring devices (blood pressure, sleep apnea, EKG, etc.), in addition to more standard medical devices such as portable EKG and pulmonary function machines for use in physicians' offices. Biomedical Engineers also engage in cutting edge research on living systems and contribute important new knowledge to the field.

The Biomedical Engineering program at Stevens is based on a solid foundation in basic science, math, biology and engineering fundamentals. Within Biomedical Engineering, there is depth in these two areas:

Biomechanics & Biomaterials

- E344 Materials Processing
- ▶ BME 505 Biomaterials
- ▶ BME 506 Biomechanics
- BME 556 Advanced Biomechanics

Bioinstrumentation

- ▶ E232 Engineering Design IV
- ▶ E322 Engineering Design VI
- BME 460: Biomedical Digital Signal Processing Laboratory
- ▶ BME 504: Medical Instrumentation & Imaging

In addition, courses in Transport in Biosystems, Engineering Physiology, Biosystems Simulation and Control, and Bioethics are included to provide the multidisciplinary background for a modern biomedical engineer. The transport, physiology, biomaterials, imaging and simulation courses contain laboratories to provide extensive hands-on experience. Since tomorrow's biomedical devices will have to be smarter, smaller and, in many cases wireless, a course in bioinstrumentation design is included in the design sequence (Design VI). The program is design oriented and culminates in a group capstone senior design project that spans the 7th and 8th semesters. The group carries out a comprehensive design of a biomedical device which includes an economic analysis, engineering computations and drawings, a plan for manufacture and the delivery of a working prototype of the device or a major component of the device. The emphasis in the design sequence is on teamwork, presentation skills and an entrepreneurial approach to design and manufacture. The program also provides for the flexibility of applying to medical school. The courses required to take the MCAT exam are normally completed by the end of the junior year.

Biomedical Engineering Program Mission and Objectives

The Stevens biomedical engineering program produces graduates who possess a broad foundation in engineering and liberal arts, combined with a depth of disciplinary knowledge at the interface of engineering and biology. This knowledge is mandatory for success in a biomedical engineering career. Biomedical engineering is also an enabling step for a career in medicine, dentistry, business or law.

The objectives of the biomedical engineering program are to prepare students such that within several years after graduation:

- Graduates will identify biomedical engineering challenges and lead solution concepts using their knowledge of fundamental engineering principles, work experience and state-of-the-art tools and techniques.
- Graduates will be among the leaders of the fields in development of biomedical devices, implants, tissues, and systems to meet the needs of society.
- Graduates will establish themselves as leaders in their chosen career path by applying their skills in problem solving, teamwork, ethics, management, communication, and their awareness of professional and social issues.

Biomedical Engineering Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	12	10	27	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II1	0	3	1	1
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
PEP 111	Mechanics	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	8	30	18

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ⁶	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	8	37	19

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IV

Course #	Course Name	Lecture	Lab	Study	Credit
MA 227	Multivariable Calculus ²	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
BME 306	Introduction to Biomedical Engineering	3	0	6	3
BIO 281	Biology and Biotechnology	3	0	6	3
E 344	Materials Processing	3	0	6	3
E 234	Thermodynamics	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	17	5	37	18

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
BME 342	Transport in Biological Systems ²	3	3	6	4
E 321	Engineering Design V	0	3	2	2
CH 243	Organic Chemistry I	3	0	6	3
CH 245	Organic Chemistry Laboratory I	0	4	0	1
CH 381	Cell Biology	3	3	7	4
E 243	Probability and Statistics for Engineers	3	0	6	3
Hum	Humanities ⁶	3	0	6	3
	Total	15	13	33	20

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
E 355	Engineering Economics	3	3	6	4
BME 322	Engineering Design VI ³	1	3	2	2
BME 505	Biomaterials	2	3	6	3
BME 460	Biomedical Digital Signal Processing Laboratory	1	3	4	2
BME 506	Biomechanics	3	0	6	3
G.E.	General Elective ⁵	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	13	14	30	17

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
BME 482	Engineering Physiology	3	3	6	4
BME 504	Medical Instrumentation and Imaging	3	0	6	3
BME 423	Senior Design I ³	0	8	3	3
T.G. 403	Senior Innovation I	3	0	6	3
Hum	Humanities ⁶	3	0	6	3
BME 556	Advanced Biomechanics	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	13	33	19

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Course #	Course Name	Lecture	Lab	Study	Credit
BME 445	Biosystems Simulation and Control	3	3	4	4
BME 453	Bioethics	3	0	3	3
G.E.	General Elective II ⁵	3	0	6	3
BME 424	Senior Design II ³	0	8	3	3
TG 404	Senior Innovation II	1	0	2	1
Hum	Humanities ⁶	3	0	6	3
	Total	12	11	22	16

Term VIII

(1) Discipline specific course.

(2) Core option - specific course determined by engineering program

(3) Discipline specific course

(4) Core option - specific course determined by engineering program

(5) General Electives - chosen by the student - can be used towards a minor or option - can be applied to research or approved international studies

(6) Humanities requirements can be found on pages 556-557.

Graduation Requirements

Physical Education Requirements

- ➤ All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- ▶ Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirement

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

Minors

Chemistry

A minor in chemistry must include the following courses:

- CH 243, CH 245 Organic Chemistry I + Lab;
- CH 244, CH 246 Organic Chemistry II + Lab.;
- ▶ CH 421 Chemical Dynamics,
- CH 362 Instrumental Analysis I;
- ▶ CH 412 Inorganic Chemistry
- CH 580 Biochemistry I

The following are prerequisites needed to undertake the minor program:

- ▶ CH 115, CH 117 General Chemistry I + Lab;
- CH 116, CH 118 General Chemistry II + Lab;

This sequence meets the American Chemical Society guidelines for a Minor in Chemistry. NOTE: The minor in Chemistry is not available to majors in Chemical Biology.

Chemical Biology

A minor in chemical biology includes at least the following courses:

- CH 243, CH 245 Organic Chemistry I + Lab.;
- CH 244, CH 246 Organic Chemistry II + Lab.;
- ▶ CH 421 Chemical Dynamics;
- ▶ BIO 381 Cell Biology;
- BIO 382 Biological Systems;
- ▶ BIO 484 Introduction to Molecular Genetics;
- CH 580 Biochemistry I.

The following are prerequisites needed to undertake the minor program:

- ▶ CH 115, CH 117 General Chemistry I + Lab;
- CH 116, CH 118 General Chemistry II + Lab;
- BIO 281 Biology and Biotechnology;

NOTE: The minor in Chemical Biology is not available to majors in Chemistry or Biology.

Biology

A minor in biology includes at least the following courses:

- ▶ BIO 281 Biology and Biotechnology
- ▶ BIO 381 Cell Biology;
- BIO 382 Biological Systems;
- ▶ BIO 484 Introduction to Molecular Genetics;
- Two other Biology Courses at the 300 level or higher

NOTE: The minor in Biology is not available to majors in Chemical Biology.

Biomedical Engineering (for students in Engineering Curriculum)

The following are required courses:

- ▶ BIO 381 Cell Biology
- ▶ BME 306 Introduction to Biomedical Engineering
- BME 482 Engineering Physiology

- ▶ BME 504 Medical Instrumentation and Imaging
- ▶ BME 505 Biomaterials
- ▶ BME 506 Biomechanics

The following prerequisite is needed to undertake the minor program:

▶ BIO 281 Biology and Biotechnology

GRADUATE PROGRAMS

The Master of Science and Doctor of Philosophy degrees are offered in both chemistry and chemical biology. For admission to the graduate program in chemistry, applicants must have earned a B.A. or B.S. degree in Chemistry. Applicants with other degrees will be considered on a case by case basis. Admission to the chemical biology program requires either an undergraduate degree in chemistry with strong biology background or an undergraduate degree in biology with strong chemistry background.

The Master of Engineering and Doctor of Philosophy degrees are offered in biomedical engineering. Admission to these programs requires a bachelor's degree in engineering. Students without a bachelor's degree in biomedical engineering may be required to complete prerequisites during their enrollment in the program.

Our department offers two additional Masters of Science programs in bioengineering and computational and medicinal chemistry for drug discovery. For admission to the M.S. program in bioengineering, students must have earned a B.A. or B.S. in a strong science program such as biology, chemical biology, biochemistry, biotechnology, or equivalent. Students should also have taken basic Calculus and Physics courses as part of their undergraduate degree. This program is for students interested in obtaining a fundamental knowledge of bioengineering with a focus on tissue engineering, regenerative medicine, and biomaterials.

For admission to the M.S. program in computational and medicinal chemistry for drug discovery, students must have completed a B.A. or B.S. in chemistry, chemical biology, biochemistry, or equivalent. Students should also have taken basic calculus and physics courses as part of their undergraduate degree and have a familiarity with computer programming. This program is for students interested in obtaining a fundamental knowledge of drug discovery and specifically computational and medicinal chemistry.

Awareness of recent developments in one's field is an important component of professional development. The department hosts seminars by visiting faculty in each of the disciplines. Finally, a measure of the success of a student's education is the ability to carry out original research. Either a thesis or a special research problem can be part of the master's program. Furthermore, students completing a Masters' or PhD thesis are required to present their results in a departmental seminar.

Throughout both the master's and doctoral degree program, the students are exposed to various methods and techniques for research. The department maintains instrumentation enabling atomic, molecular, cellular, and small animal studies. Instrumentation includes but is not limited to confocal and wide field fluorescence microscopy, PCR, fluorometry, double-beam spectrophotometry, polarimetry, circular dichroism, Fourier-transform infrared spectroscopy, nuclear magnetic resonance spectroscopy, mass spectrometry, gas and high performance liquid chromatography, motion capture, mechanical testing, 3D printing, and nanofiber synthesis. Other facilities at Stevens enable access to scanning and electron microscopy, atomic force microscopy, microfluidics, and a Class 100 clean room for nanofabrication.

Master of Science - Chemistry; Master of Science - Chemical Biology

For the Master of Science degree thirty graduate credits in an approved plan of student that includes core courses are required. The core courses required for the chemistry and chemical biology degree are specified below. Areas of concentration available for both degrees include analytical chemistry, chemical biology, organic chemistry, physical chemistry and polymer chemistry, and others can be designed. Please refer to the elective options section below for suggested courses in each

concentration area. Research may be included in master's degree programs, either as a Special Research Problem (CH 800) or a Master's Thesis (CH 900), and is counted towards the 30 credits required for the degree. All fellows and teaching or research assistants are expected to complete a thesis.

Core Courses in Chemistry

- CH 520 Advanced Physical Chemistry
- CH 561 Instrumental Methods of Analysis
- CH 610 Advanced Inorganic Chemistry
- CH 620 Kinetics & Thermodynamics
- CH 640 Advanced Organic Chemistry
- CH 660 Advanced Instrumental Analysis

Core Courses in Chemical Biology (*Prerequisites may be required*)

- CH 581 Biochemistry II
- ▶ BIO 687 Molecular Genetics
- BIO 690 Cellular Signal Transduction
- One Advanced Chemistry Course (with recommendation of research advisor)

Elective Courses

See the elective options section below for a list of courses. Additional courses are chosen depending on the student's interests and background. The Program Director must approve all elective courses.

Master of Science - Bioengineering

The M.S. in Bioengineering is tailored for students with a strong science background who would like the skills needed to develop materials and devices at the intersect ion of life science and engineering. This interdisciplinary program focuses on tissue engineering and regenerative medicine methods to improve healthcare. Our program builds on a foundation of molecular biology and chemistry while also adding elements of bioengineering design. For the Master of Science degree, students must successfully complete thirty graduate credits including 15 credits of core courses listed below. Students may elect to choose thesis (6-9 credits) or non-thesis options, depending on their professional goals. Students pursuing a thesis should make arrangements with an advisor within the first year at Stevens. Graduates of this program will be well positioned to obtain careers in pharmaceutical, biotechnology, and medical device companies in addition to biomedical research and regulatory institutions.

Core Courses in Bioengineering -15 credits

- BIO 687: Molecular Biology
- ▶ BIO 684: Molecular Biology Laboratory
- BME 504: Biomaterials
- ▶ BME 602: Principles of Tissue Engineering
- BME/BIO 690: Cellular Signal Transduction

Technical Elective Courses - 9 credits for non-thesis option, 6-9 credits for thesis option

- BIO 583: Physiology
- ▶ BIO 689: Cellular Biology Lab Techniques
- ▶ BIO 691:Introduction to Systems Biology
- BIO 695: Organelles
- ▶ BME 503: Physiological Systems for Engineers
- BME 650: Advanced Biomaterials
- BME 665: Pathophysiology
- BME 675: Nanomedicine
- ▶ PME 530: Introduction to Pharmaceutical Manufacturing
- CAL 557: Bioethics

Unrestricted Electives - 6 credits for non-thesis option only

Additional courses are chosen with an advisor's guidance and will depend on the student's interests and background. The Program Director must approve all elective courses.

Master of Science - Computational and Medicinal Chemistry for Drug Discovery

The M.S. in Computational and Medicinal Chemistry for Drug Discovery Program is tailored for students with a strong science background who are interested in drug discovery and need the skills and knowledge in computational and medicinal chemistry. This program focuses on key areas in computational chemistry, medicinal chemistry including protein structure and property interaction, ligand and receptor interactions and modification of ligands and compounds to better-fit receptors and other targets. The program builds on a foundation of chemistry and biology and provides a complement of skills and knowledge essential for drug early preclinical discovery. For the Master of Science degree, students must successfully complete thirty graduate credits including 15 credits of core courses listed below. Students may elect to choose thesis (6-9 credits) or non-thesis options, depending on their professional goals. Students pursuing a thesis should make arrangements with an advisor within the first year at Stevens. Graduates of this program will be well positioned to obtain careers in drug discovery focusing on silico structure-based drug design and medicinal chemistry research within academic, government and national labs, pharmaceutical and biotechnology companies, as well as legal and patent offices.

Core Courses in Computational and Medicinal Chemistry for Drug Discover y - 15 credits

- ▶ CH 685: Medicinal Chemistry
- CH 664: Computational Chemistry
- CH 581: Biochemistry II Bio-molecular Structure and Function
- CH 782: Special Topics in Bioorganic Chemistry
- CH 640: Advanced Organic Chemistry

Technical Elective Courses - 9 credits for non-thesis option, 6-9 credits for thesis option

- CH 682: Biochemistry Laboratory Techniques
- CH 642: Synthetic Organic Chemistry
- ▶ CH 582: Bio-Physical Chemistry

- CH 610: Advanced Inorganic and Bioinorganic
- CH 646: Chemistry of Natural Products
- CH 666: Modern Mass Spectroscopy
- CH 550: Spectra and Structure Determination
- CH 661:Advanced Analysis Laboratory
- CH 662: Separation Methods in Analytical and Organic Chemistry

Unrestricted Electives - 6 credits for non-thesis option only

Additional courses are chosen with an advisor's guidance and will depend on the student's interests and background. The Program Director must approve all elective courses.

Master of Engineering - Biomedical

Stevens is a leader in the field of biomedical engineering, engaging in visionary research and collaboration with researchers in medical centers, the biotech industry and government. Our graduates are leaders in academia, industries related to medicine, biotechnology and in newly emerging fields based on biological technology.

The Biomedical Engineering graduate program is designed to foster independent scholarly work while providing flexibility to accommodate each student's interests and career goals. Each full time M. Eng. student is required to complete 30 credits of graduate work that includes 6 required credits of core course work. The additional 21 graduate credits of course work can be tailored to aid the students' research project or their professional development goals and may include a 9 credit thesis.

In lieu of the 9-credit thesis, students can elect to do a 6-credit research or design project, plus 3 credits of additional graduate course work in connection with their job. The project must be approved by the BME program director and have the official support of the students company. Wherever possible, research and design projects will include an outside member of the thesis committee from the medical or biotech industry.

Core Courses in Biomedical Engineering - Common Requirements for Students with BME/other Engineering background. (Prerequisites may be required)

Students may be admitted to the M.Eng. program in BME with undergraduate engineering degrees other than BME. For students admitted with a non-BME degree, prerequisite courses may be required that may not carry graduate credit. The prerequisite courses will be determined on an individual basis in consultation with the BME graduate program advisor. In any case, all graduate BME students are required to complete the following core courses:

- ▶ BME 600 Strategies and Principles of Biomedical Design
- ▶ BME 601 LA Advanced Biomedical Engineering Lab

Doctoral Programs in Chemistry and in Chemical Biology

There are two different doctoral programs, a Doctorate in Philosophy in Chemistry and a Doctorate in Philosophy in Chemical Biology. The master's degree is not a prerequisite for admission to the doctoral program. Admission to either doctoral program is based on official transcripts showing strong performance in chemistry or chemistry and biology coursework, GRE scores, letters of recommendation from at least three of more people who know the student's academic and research background and for applicants whose native language is not English, a minimum score as specified by the Office of Graduate Academics on the TOEFL. The admissions committee is looking for reasonable evidence that the student will be successful and prove capable of specialization with a broad intellectual foundation. Specifically, students will be admitted to the doctoral program only if the Admissions Committee feels that he/she is reasonably well prepared for the Qualifying Examinations in Chemistry

or Chemical Biology, which must be passed within a 15-month period after admission. Students who enter the PhD Program after a master's degree in the field should be prepared to take the Qualifying Exam within 10 months. Applicants with good academic records who lack this level of preparation may be admitted initially to the M.S. program.

Continuation in the doctoral program is contingent on passing the Qualifying Examination, Preliminary Examination, and meeting all other requirements as dictated by the Stevens Office of Graduate Academics. A student enrolled in the master's program in Chemistry or Chemical Biology who is interested in a doctorate degree must apply formally for admission to the Doctoral program. For the Ph.D. degree, a prior Masters' degree may be transferred for up to 30 credits. Up to one-third of additional course credits may be transferred with the approval of the Program Director and the Dean of the Graduate School provided they have not been used to obtain another degree.

Elective Options

The following are typical examples of specialization areas:

Analytical Chemistry

- CH 650 Spectra and Structure Determination
- CH 660 Advanced Instrumental Analysis
- CH 661 Advanced Instrumental Analysis Laboratory
- CH 662 Separation Methods in Analytical & Organic Chemistry
- CH 666 Modern Mass Spectrometry

Chemical Biology

- CH 580 Biochemistry I
- ▶ CH 581 Biochemistry II
- ▶ CH 582 Biophysical Chemistry
- ▶ BIO 583 Physiology
- BIO 668 Computational Biology
- BIO 678 Experimental Microbiology
- ▶ BIO 682 Biochemical Laboratory Techniques
- BIO 684 Molecular Biology Laboratory Techniques
- ▶ CH 685 Medicinal Chemistry
- BIO 686 Immunology
- ▶ BIO 687 Molecular Genetics
- ▶ BIO 688 Methods in Chemical Biology
- ▶ BIO 689 Cell Biology Lab Techniques
- ▶ BIO 690 Cellular Signal Transduction
- ▶ BIO 691 Introduction to Systems Biology
- ▶ BIO 692 Epigenetics
- BIO 693 Gene Therapy
- ▶ BIO 694 Advanced Computational Modeling in Biology and Biomaterials Science
- ▶ BIO 695 Organelles

- ▶ CH 780 Selected Topics in Biochemistry I
- ▶ CH 781 Selected Topics in Biochemistry II
- ▶ CH 782 Selected Topics in Bioorganic Chemistry

Organic Chemistry

- ▶ CH 640 Advanced Organic and Heterocyclic Chemistry I
- CH 641 Advanced Organic and Heterocyclic Chemistry II
- CH 642 Synthetic Organic Chemistry
- CH 646 Chemistry of Natural Products
- CH 650 Spectra and Structure Determination
- ▶ CH 685 Medicinal Chemistry
- CH 782 Selected Topics in Bio-organic Chemistry

Physical Chemistry

- CH 620 Chemical Thermodynamics and Kinetics
- ▶ CH 621 Quantum Chemistry
- ▶ CH 622 Molecular Spectroscopy
- ▶ CH 623 Chemical Kinetics
- CH 624 Statistical Mechanics
- CH 650 Spectra and Structure Determination
- CH 720 Current Topics in Chemical Physics I
- ▶ CH 721 Current Topics in Chemical Physics II
- CH 722 Selected Topics in Physical Chemistry

Polymer Science

- ▶ CH 670 Polymer Synthesis
- CH 671 Physical Chemistry of Polymers
- CH 672 Macromolecules in Modern Technology
- ▶ CH 674 Polymer Functionality

Electives

To complete the course requirements for the degree, a student may choose additional courses with the approval of the advisor. Special courses are frequently offered under the title of Special (or Selected) Topics, which can be included with the permission of the advisor. Some courses are offered as reading courses, with no designated lecture schedule.

Degree Requirements

All doctoral students in Chemistry and Chemical Biology must pass a Qualifying Examination. After successful completion of the qualifying examination, the next milestone is a preliminary examination. The preliminary examination is based on an original research proposal in an area of the student's own choice, preferably an area related to the pending dissertation area but with a topic significantly different from his or her thesis. It is submitted in written form and defended orally before the Thesis Committee. The final milestone is the doctoral dissertation and defense. Specifics on these degree requirements can be found in the Chemistry and Chemical Biology Program Graduate Student Handbook.

Language Proficiency

Students must fulfill the English proficiency requirements on page 44.

Doctoral Dissertation

The policies and regulations governing the doctoral dissertation are described in detail in the Chemistry and Chemical Biology Program Graduate Student Handbook.

Doctoral Program in Biomedical Engineering

The purpose of the doctoral program is to educate scientists and engineers who are prepared to carry out independent investigations. While courses provide the tools for independent work, a large part of the doctoral work is done through independent study. This includes preparation for the qualifying examination, the preparation of research proposals and seminars and familiarity with the current scientific literature in the area of specialization.

The master's degree is not a prerequisite for admission to the doctoral program. Admission to the doctoral program is based on 1) GRE score, and 2) reasonable evidence that the student will prove capable of specialization on a broad intellectual foundation. 84 credits of graduate work in an approved program of study are required beyond the bachelor's degree. This may include up to 30 credits obtained in a master's degree program, if the area of the master's degree is relevant to the doctoral program. Those with a master's degree who wish to transfer credits towards the Ph.D. must be aware that only one master's degree can be used toward the Ph.D. A doctoral dissertation based on the results of original research, carried out under the guidance of a faculty member and defended in public examination, is a major component of the doctoral program, and is included in the 84-credit requirement. For more details about program requirements, see our Graduate Student Handbook.

In the BME program, between 30 and 45 credits may be earned for the Ph.D. dissertation.

Graduate Certificate Programs

In addition to the degree programs, the department currently offers "mini-graduate" programs leading to the Certificate of Special Study in one of seven areas: Analytical Chemistry, Biomedical Chemistry, Biomedical Engineering, Chemical Biology, Chemical Physiology, Laboratory Methods in Chemical Biology and Polymer Chemistry. Students in these certificate programs must meet the same admission and performance standards as regular degree graduate students. Each of the certificate programs requires twelve credits (four courses), all of which are transferable to the appropriate master's degree program.

Analytical Chemistry

- CH 561 Instrumental Methods of Analysis
- CH 660 Advanced Instrumental Analysis
- CH 662 Separation Methods in Analytical and Organic Chemistry
- CH 666 Modern Mass Spectrometry

Biomedical Chemistry

- CH 642 Synthetic Organic Chemistry
- CH 646 Chemistry of Natural Products

and two of the following courses (with advisor approval):

- CH 647 Chemistry and Pharmacology of Drugs
- CH 685 Selected Topics in Medicinal Chemistry
- CH 800 Special Research Problems in Chemistry

Biomedical Engineering

- ▶ BME 506 Biomechanics
- ▶ BME 505 Biomaterials
- BME 504 Medical Instrumentation and Imaging
- ▶ BME 503 Physiological Systems

(Requires an undergraduate Engineering Degree in a discipline other than BME)

Chemical Biology

- CH 580 Biochemistry I
- CH 681 Biochemistry II
- BIO 686 Immunology
- BIO 687 Molecular Genetics

Chemical Physiology

- CH 580 Biochemistry I
- BIO 583 Physiology
- BIO 684 Molecular Biology Laboratory Techniques

and one of the following courses with the approval of your program advisor:

- BIO 686 Immunology
- BIO 690 Cellular Signal Transduction
- CH 800 Special Research Problems in Chemistry

Laboratory Methods in Chemical Biology

- CH 561 Instrumental Methods of Analysis
- ▶ CH 682 Biochemical Lab. Techniques
- ▶ BIO 684 Molecular Biology Lab Techniques
- BIO 689 Cell Biology Lab. Techniques

Polymer Chemistry

- CH 670 Synthetic Polymer Chemistry
- CH 671 Physical Chemistry of Polymers
- CH 672 Macromolecules in Modern Technology
- CH 673 Special Topics in Polymer Chemistry
- ▶ CH 674 Polymer Functionality

The above graduate certificate programs are regular graduate courses and can be part of the Master of Science program in chemistry or chemical biology.

COURSE OFFERINGS

Biology

BIO 281 Biology and Biotechnology

Biological principles and their physical and chemical aspects are explored at the cellular and molecular level. Major emphasis is placed on cell structure, the processes of energy conversion by plant and animal cells, genetics and evolution, and applications to biotechnology.

BIO 282 Introductory Biology Laboratory

An introductory laboratory illustrating basic techniques and principles of modern biology by means of laboratory experiments and simulated experiments. This laboratory does not satisfy medical school admission requirements. Prerequisites: BIO 281 or CH 281 Corequisites: BIO 281

BIO 341 Biological Chemistry

Survey of biologically important classes of compounds including fats and lipids, terepenes, steroids, acetogenins, sugars, carbohydrates, peptides, proteins, alkaloids, and other natural products. Prerequisites: CH 244

BIO 381 Cell Biology

The structure and function of the cell and its subcellular organelles is studied. Biological macromolecules, enzymes, biomembranes, biological transport, bioenergetics, DNA replication, protein synthesis and secretion, motility, and cancer are covered. Cell biology experiments and interactive computer simulation exercises are conducted in the laboratory. Prerequisites: BIO 281 or CH 281

BIO 382 Biological Systems

Physiochemical principles underlying the coordinated function in multicellular organisms are studied. Electrical properties of biological membranes, characteristics of tissues, nerve-muscle electrophysiology, circulatory, respiratory, endocrine, digestive, and excretory systems are covered. Computer simulation experiments and data acquisition methods to evaluate and monitor human physiological systems are conducted in the laboratory. Prerequisites: BIO 281 or CH 281

BIO 484 Introduction to Molecular Genetics

Introduction to the study of molecular basis of inheritance. Starts with classical Mendelian genetics and proceeds to the study and function of DNA, gene expression and regulation in prokaryotes and eukaryotes, genome dynamics and the role of genes in development, and cancer. All topics include discussions of current research advances. Accompanied by laboratory section that explores the lecture topics in standard wet laboratory experiments and in computer simulations. Prerequisites: BIO 281, BIO 381 or CH 281, CH 381

BIO 485 Developmental Biology

Introduction to developmental biology. Using concepts from cell and molecular biology, this course surveys the major concepts and mechanisms of development leading from a fertilized egg to a fully differentiated, multicellular organism based on three primary tissue layers. Key concepts include pattern formation, cell commitment, generation of anatomical axes, organogenesis, stem cells and progenitor cells, regeneration, and human diseases of development and aging. The course incorporates lectures, recitations/discussions, reading of the primary literature, and student presentations. Prerequisites: BIO 381, BIO 484 or CH 381, CH 484

BIO 583 Physiology

Fundamentals of control processes governing physiological systems analyzed at the cellular and molecular level. Biological signal transduction and negative feedback control of metabolic processes. Examples from sensory, nervous, cardiovascular, and endocrine systems. Deviations that give rise to abnormal states; their detection, and the theory behind the imaging and diagnostic techniques such as MRI, PET, SPECT; and the design and development of therapeutic drugs. The principles, uses, and applications of biomaterials and tissue engineering techniques; and problems associated with biocompatibility. Students (or groups of students) are expected to write and present a term project. Prerequisites: BIO 382 or CH 382

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321, BIO 580 or CH 321, CH 580

Computational Biology

Experimental Microbiology

Molecular Biology Laboratory Techniques

This laboratory course introduces essential techniques in molecular biology and genetic engineering in a project format. The course includes aseptic technique and the handling of microbes; isolation and purification of nucleic acids; construction, selection and analysis of recombinant DNA molecules; restriction mapping; immobilization and hybridization of nucleic acids; and labeling methods of nucleic acid probes. Prerequisites: BIO 484 or CH 484

and infectious diseases. Includes experimental laboratory instruction. Prerequisites: BIO 382 or CH 382

Topics at the interface of biology and computer technology will be discussed, including molecular sequence analysis,

BIO 686 Immunology

BIO 668

BIO 678

BIO 684

The cells and molecules of the immune system and their interaction and regulation; the cellular and genetic components of the immune response, the biochemistry of antigens and antibodies, the generation of antibody diversity, cytokines, hypersensitivities, and immunodeficiencies (i.e. AIDS); and transplants and tumors. Use of antibodies in currently emerging immunodiagnostic techniques such as ELISA, disposable kits, molecular targets, and development of vaccines utilizing molecular biological techniques, such as recombinant and subunit vaccines. Students (or groups of students) are expected to write and present a term project. Prerequisites: BIO 381 or CH 381

BIO 687 Molecular Genetics

This course is a modern approach to the study of heredity through molecular biology. Primary emphasis is on nucleic acids, the molecular biology of gene expression, molecular recognition and signal transduction, and bacterial and viral molecular biology. The course will also discuss recombinant DNA technology and its impact on science and medicine. Prerequisites: BIO 484 or CH 484

BIO 688 Methods in Chemical Biology

A discussion of the theories underlying various techniques of molecular biology which are used in the biotechnology industry. Topics include all recombinant DNA techniques; DNA isolation and analysis; library construction and screening; cloning; DNA sequencing; hybridization and other detection methods; RNA isolation and analysis; protein isolation and analysis (immunoassay, ELISA, etc.); transgenic and ES cell methods; electrophoresis (agarose, acrylamide, two dimensional, and SDS-PAGE); column chromatography; and basic cell culture including transfection and expression systems. Prerequisites: BIO 381 or CH 381

BIO 689 Cell Biology Laboratory Techniques

Laboratory practice in modern biological research will be explored. Techniques involving gene and protein cellular probes, ELISA, mammalian cell culturing, cell cycle determination, differential centrifugation, electron microscopy, and fluorescent cellular markets will be addressed. Laboratory fee \$60. Prerequisites: BIO 381 or CH 381

BIO 690 Cellular Signal Transduction

This advanced course covers the mechanism and biological role of signal transduction in mammalian cells. Topics included are extracellular regulatory signals, intracellular signal transduction pathways, role of tissue context in the function of cellular regulation, and examples of biological processes controlled by specific cellular signal transduction pathways. Cross-listed with: BME 690, NANO 690 Prerequisites: BIO 381, BIO 484 or CH 381, CH 484

BIO 691 Introduction to Systems Biology

Systems biology is a new approach to complex biological problems. It uses a combination of the most modern techniques for comprehensive measurements of cells and molecules, combined with complex computer and mathematical modeling, to build up inclusive depictions of how living systems function. This course is an integrative approach to help comprehend dynamic biological systems. True understanding of systems biology requires a cross-disciplinary approach. Topics will include both a biological and computer science perspective taught by experts in each individual discipline. The course will cover introduction to advance biological subjects in cell biology and genetics followed by introduction to computer science methods including modeling and "bio-machine" features of systems biology. In class, we will also explore critical reading of current research. Cross-listed with: CS 691

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phylogeny generation, biomolecular structure simulation, and modeling of site-directed mutagenesis. Prerequisites: BIO

(3 - 3 - 0)Discussions in medical, industrial, and environmental microbiology will include bacteriology, virology, mycology, parasitology,

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BIO 692 **Epigenetics**

Epigenetics describes the inheritance of different functional states, which may have divergent phenotypic consequences, without any change in the sequence of DNA. This course will examine the molecular mechanisms and biological processes in which epigenetic modifications play an elemental role in inheritance. It will cover different biological mechanisms of the epigenetic machinery including: DNA methylation, histone tails, chromatin structure, nucleosome occupancy, heterochromatin assembly, gene silencing, siRNAs and miRNAs. The epigenetic profile of embryonic stem cells, cell differentiation, gene imprinting and X-chromosome inactivation will be examined as well as the relationship of epigenetics to cancers and ageing. Prerequisites: Undergraduate Genetics and Undergraduate Cell Biology.

BIO 694 Advanced Computational Modeling in Biology and Biomaterials Science (3 - 3 - 0)

This course combines computational modeling with lab experience. The course is project based. Students will be able to choose from a pool of problems being actively researched at Stevens, understand how to obtain experimental data, design and implement a computational model, predict the behavior of the system being modeled, and use a second set of experimental results to validate the model. Cross-listed with: CS 694

BIO 695 Organelles

This course is designed for beginning graduate students and advanced undergraduate students with a particular enthusiasm for advanced cell biology. Overall, the course will present organelle biogenesis by first presenting past scientific strategies, theories, and findings in the field of cell biology and then relating these foundations to current investigations. Reviews of protein and lipid mediators important for organelle biogenesis are then presented followed by summaries focused on the nucleus, endoplasmic reticulum, Golgi apparatus, lysosome, mitochondria, and peroxisome. Each organelle will be extensively covered for sub-compartment biochemistry, isolation, and current research. Intensive classroom discussions focus on the experimental methods used, results obtained, interpretation of these results in the context of cell structure and function, and implications for further directions of studies in the field. Prerequisites: BIO 381 or CH 381

Biomedical Engineering

Seminar in Biomedical Engineering BME 181

Introduction to current research topics in Biomedical Engineering. The applications are chosen to demonstrate the depth, breadth, impact and future directions of the BME field. Typical topics include Biomechanics, Biomaterials and Tissue Engineering, Cardio-Respiratory Mechanics, Gait Analysis, Markerless motion capture, Bio-Robotics and Robotic Surgery, Brain-Computer Interfaces and nano-medicine. Students will learn how to critically review current research publications.

BME 306 Introduction to Biomedical Engineering

Overview of the biomedical engineering field with applications relevant to the healthcare industry such as medical instrumentation and devices. Introduction to the nervous system, propagation of the action potential, muscle contraction and introduction to the cardiovascular system. Discussion of ethical issues in biomedicine. Prerequisite: Sophomore Standing.

BME 322 Engineering Design VI

Introduction to the principles of wireless transmission and the design of biomedical devices and instrumentation with wireless capabilities.(e.g. pacemakers, defibrilators. EKG). Electrical safety (isolation, shielding), and equipment validation standards for FDA compliance are introduced. Use of LabView to provide virtual bioinstrumentation. The course culminates in group projects to design a biomedical device that runs on wireless technology. Prerequisites: E 232

BME 342 Transport in Biological Systems

A study of momentum, mass and heat transport in living systems. Rheology of blood. Basic hemodynamics. Use of the equations of continuity and motion to set up complex flow problems. Flow within distensible tubes. Shear stress and endothelial cell function. Mass transfer and metabolism in organs and tissues. Microscopic and macroscopic mass balances. Diffusion. Blood-tissue transport of solutes in the microcirculation. Compartmental models for pharmacokinetic analyses. Analysis of blood oxygenators, hemodialysis, tissue growth in porous support materials. Artificial organs. Energy balances and the use of heat to treat tumor growth (radio frequency ablation, cryogenic ablation). Laboratory exercises accompany major topics discussed in class and are conducted at the same time. Prerequisites: MA 227 Corequisites: BME 306

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BME 423 Senior Design I

Senior design courses. Senior design provides, over the course of two semesters, a collaborative design experience with a significant biomedical problem related to human health. The project will often originate with an industrial sponsor or a medical practitioner at a nearby medical facility and will contain a clear implementation objective (i.e. for a medical device). It is a capstone experience that draws extensively on the student's engineering and scientific background and requires independent judgments and actions. The project generally involves a determination of the medical need, a detailed economic analysis of the market potential, physiological considerations, biocompatibility issues, ease of patient use, an engineering analysis of the design, manufacturing considerations and experimentation and/or prototype construction of the device. The faculty advisor, industrial sponsor or biomedical practitioner works closely with the group to insure that the project meets its goals in a timely way. Leadership and entrepreneurship are nourished throughout all phases of the project. The project goals are met in a stepwise fashion, with each milestone forming a part of a final report with a common structure. Oral and written progress reports are presented to a panel of faculty at specified intervals and at the end of each semester. Prerequisites: BME 322, and BME 342, and BME 505, and BME 506 Corequisites: BME 482

BME 424 Senior Design II

Senior design courses. Senior design provides, over the course of two semesters, a collaborative design experience with a significant biomedical problem related to human health. The project will often originate with an industrial sponsor or a medical practitioner at a nearby medical facility and will contain a clear implementation objective (i.e. for a medical device). It is a capstone experience that draws extensively on the student's engineering and scientific background and requires independent judgments and actions. The project generally involves a determination of the medical need, a detailed economic analysis of the market potential, physiological considerations, biocompatibility issues, ease of patient use, an engineering analysis of the design, manufacturing considerations and experimentation and/or prototype construction of the device. The faculty advisor, industrial sponsor or biomedical practitioner works closely with the group to insure that the project meets its goals in a timely way. Leadership and entrepreneurship are nourished throughout all phases of the project. The project goals are met in a stepwise fashion, with each milestone forming a part of a final report with a common structure. Oral and written progress reports are presented to a panel of faculty at specified intervals and at the end of each semester. Prerequisites: BME 423

BME 445 Biosystems Simulation and Control

Time and frequency domain analysis of linear control systems. Proportional, derivative and integral control actions. Stability. Applications of control theory to physiological control systems: biosensors, information processors and bioactuators. Mathematical modeling and analysis of heart and blood pressure regulation, body temperature regulation, regulation of intracellular ionic concentrations, eye movement and pupil dilation controls. Use of Matlab and Simulink to model blood pressure regulation, auto regulation of blood flow, force development by muscle contraction, and integrated response of cardiac output, blood pressure and respiration to exercise. Prerequisites: BME 482

BME 453 Bioethics

This course focuses on professional ethical conduct in the biomedical field. It will enable students to understand the ethical challenges they may encounter as biomedical engineers, allow them to practice biomedical engineering in an ethical manner and conduct themselves ethically as contributing members of society. Case discussions and presentations by practitioners in the field illustrate ethical norms and dilemmas. Prerequisites: Corequisites: BME 306

BME 460 Biomedical Digital Signal Processing Laboratory

Biomedical Digital Signal Processing is an introductory course into the fascinating world of Digital Signal Processing as it applies to the clinic. Since modern medical systems employ DSP concepts to analyze biomedical signals, such as the ECG, there is a need for Biomedical Engineers to gain a more in-depth understanding of the subject. This class is designed to break the complex subject down into three fundamental areas, hardware systems, mathematical concepts, and software algorithms. Essential Signal Processing concepts are introduced and then reinforced with multiple biomedical examples and MatLab simulations, all serving to clarify the subject. Topics include: The Hardware building blocks, Signals and Systems, Euler's Equation, Nyquist's Sampling Theorem as Applied to Biomedical Applications, Convolution, Filters, Adaptive Filters, the Power Spectrum, and Discrete Fourier Transformations. Prerequisites: E 232, E 245

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BME 482 Engineering Physiology

Introduction to mammalian physiology from an engineering point of view. The quantitative aspects of normal cellular and organ functions and the regulatory processes required maintaining organ viability and homeostasis. Laboratory exercises using exercise physiology as an integration of function at the cellular, organ and systems level will be conducted at the same time. Measurements of heart activity (EKG), cardiac output (partial CO2 rebreathing), blood pressure, oxygen consumption, carbon dioxide production, muscle strength (EMG), fluid shifts and respiratory function in response to exercise stress will be measured and analyzed from an engineering point of view. Prerequisites: BME 342, CH 381 or BIO 381

BME 498 Research in Biomedical Engineering I

Individual investigation of a substantive character undertaken at an undergraduate level under the guidance of a member of the departmental faculty. A written report is required. Hours to be arranged with the faculty advisor. Prior approval required. These courses can be used as general electives for degree requirements. Cross-listed with: CM 502

BME 499 Research in Biomedical Engineering II

An individual research project of a substantive nature and relevant to the field of biomedical engineering.

BME 503 Physiological Systems (for Engineers)

A study of the physiological functions of major organ systems (Neural, Blood, Muscle, Heart, Vascular System Renal, Respiratory and Lymphatics) and how they interact to maintain homeostasis from a systems engineering point of view. Functional anatomy and physiology will be covered as well as quantitative methods for the analysis of organ function and their interactions. An analysis of changes in the major physiological variables with exercise will be used as an example of the integration of the major organs to compensate for stress. Cross-listed with: ME 528 Prerequisites: CH 381 or BIO 381

BME 504 Medical Instrumentation and Imaging

Imaging plays an important role in both clinical and research environments. This course presents both the basic physics together with the practical technology associated with such methods as X-ray computed tomography (CT), magnetic resonance imaging (MRI), functional MRI (f-MRI) and spectroscopy, ultrasonics (echocardiography, Doppler flow), nuclear medicine (Gallium, PET and SPECT scans) as well as optical methods such as bioluminescence, optical tomography, fluorescent confocal microscopy, two-photon microscopy and atomic force microscopy. Cross-listed with: CPE 585 Prerequisites: BME 306, and BME 322

BME 505 Biomaterials

Intended as an introduction to materials science for biomedical engineers, this course first reviews the materials properties relevant to the application to the human body. It goes on to discuss proteins, cells, tissues, and their reactions and interactions with foreign materials, as well as the degradation of these materials in the human body. The course then treats various implants, burn dressings, drug delivery systems, biosensors, artificial organs, and elements of tissue engineering. Laboratory exercises accompany the major topics discussed in class and are conducted at the same time. Cross-listed with: MT 505 Prerequisites: E 344 Corequisites: BME 306

BME 506 Biomechanics

This course reviews basic engineering principles governing materials and structures such as mechanics, rigid body dynamics, fluid mechanics and solid mechanics and applies these to the study of biological systems such as ligaments, tendons, bone, muscles, joints, etc. The influence of material properties on the structure and function of organisms provides an appreciation for the mechanical complexity of biological systems. Methods for both rigid body and deformational mechanics are developed in the context of bone, muscle, and connective tissue. Multiple applications of Newton's Laws of mechanical are made to human motion. Corequisites: BME 505

BME 520 Cardiopulmonary Mechancis

The heart and lungs are mechanically dynamic organs. This course will survey the principal mechanisms of mechanical cardiopulmonary function. In the lungs, topics will include pressure-volume curve analysis, surface tension effects, hypoxic pulmonary vasoconstriction and lung diseases such as neonatal respiratory distress, pulmonary edema, pulmonary hypertension and emphysema. In the cardiovascular system, topics will include the Frank-Starling mechanism, the myogenic response, the end-systolic pressure-volume response, cardiac oxygen consumption, ventricular-arterial coupling, shear stress effects on the vascular endothelium, and ventricular assist devices for Fontan and adult circulations. Prerequisites: BME 482 or BME 503, and BME 506, and CH 381 or BIO 381

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BME 556 Advanced Biomechanics

This course will provide students with a practical approach to current computational and experimental methods used in the field of biomechanics. The goal of the course will be to bridge the gap between the theoretical computations and the practical application of experimental techniques. Topics covered will include cartilage and muscle mechanics as well as the response of bone tissue to loading. The analysis of implants will also be covered. The course will conclude with analysis of human motion. Experiments will be associated with various topics to demonstrate practical applications of the theoretical concepts introduced. Students will be required to use statistical analysis software. Prerequisites: BME 506, BME 505, knowledge of, or courses in Differential Equations, Multivariable Calculus and Statistics. Prerequisites: BME 505, BME 506, knowledge of or courses in Differential Equations, Multivariable Calculus and Statistics.

BME 557 Sensory Systems I

The Sensory Systems I course will focus on speech, audition, and vision systems. Students will begin with a review of system principles including sampling, filtering, analog to digital conversion (ADC), spectral (Fourier) analysis and transfer functions. The second topic will cover the audio spectrum and properties of sound as they relate to both speech and hearing. The course will then cover basic anatomy and physiology of the larynx, ear, and eye. Students will participate in two types of Labs for each of the three topics. Sensory Labs are designed to enhance the student's knowledge of sound production, auditory response and image processing. Reverse Engineering (RE) Labs utilizing existing speech, hearing, and vision enhancement products will be conducted as well. Prerequisites: E 245, BME 306, BME 482

BME 558 Introduction to Brain-Machine Interfaces

This course aims for understanding the emerging field of Brain Machine Interfaces (BMI). After the completion of this course the students will have working knowledge of what BMIs are, how they are designed, implemented and tested. The core modules of BMI are data acquisition, decoding and application. Each of these modules will be expanded in detail. A common midterm project will be assigned to all the students. Then the students are expected to select a specialized topic, do a final project and write a term paper towards the final week. This course serves as an introduction to this emerging field of BMIs. This can serve both undergraduate seniors and graduate students.

BME 580 **Biomedical Instrumentation and Measurements** (3 - 3 - 0)

This course introduces biomedical engineering principles, techniques, design & application of medical instrumentation. This course deals with the sensors, electrodes and analog integrated circuits to process physiological signals in a way that it can be used further for various diagnostic, therapeutic and surgical applications. It also introduces matrix laboratory and LabVIEW software to measure, record and monitor physiological signals. The course includes a bioinstrumentation lab where students gain hands on experience with the use of sensors, electrodes, filters, microcontrollers and circuits to acquire, modify and display various physiological signals. Students are graded based on the performance in homework assignments, lab assignments and midterm & final exams. Prerequisites: BME 460, BME 423

BME 600 Strategies and Principles of Biomedical Design

A successful approach to product development and design in the field of medical technologies requires a highly interdisciplinary approach. This course reviews the regulations, protocols, and guidelines which must be met in each discipline, and describes how these issues are inter-related and how the affect design and product development. Marketing, Regulatory, IP and Clinical aspects are all considered in the technical aspects of design.

BME 601 Advanced Biomedical Engineering Lab

One of the distinguishing features of biomedical engineers is the ability to make and interpret measurements on living systems. One of the major objectives of advanced laboratory training is to provide experience in selecting appropriate measurement and analysis tools that will advance hypothesis driven and translational research and development. This laboratory serves these dual purposes. Students are introduced to techniques for measurements at the cellular, organ and systems levels. Students will then use these techniques to: a) formulate hypotheses, design experiments using the tools provided, make appropriate measurements, analyze the data an determine if the data do or do not support their hypotheses; b) make measurements that facilitate the design and manufacture of devices in terms of materials properties, fatigue and failure modes. Each student will keep a laboratory notebook. Prerequisites: BME 505, BME 503

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BME 602 Principles of Tissue Engineering

This course is an introduction to the field of Tissue Engineering. It is rapidly emerging as a therapeutic approach to treating damaged or diseased tissues in the biotechnology industry. In essence, new and functional living tissue can be fabricated using living cells combined with a scaffolding material to guide tissue development. Such scaffolds can be synthetic, natural, or a combination of both. This course will cover the advances in the field of cell biology, molecular biology, material science and their relationship towards developing novel 'tissue engineered' materials. Cross-listed with: NANO 602

BME 603 Topics in Biological Transport

The engineering applications of biological transport phenomena are important considerations in basic research related to molecules, organelles, cell and organ function; the design and operation of devices such as filtration units for kidney dialysis, high density cell culture and biosensors; and applications including drug and gene delivery, biological signal transduction and tissue engineering. This course develops the fundamental principles of transport processes, the mathematical expression of these principles and the solution of transport equations, along with characterization of composition, and function of living systems to which they are applied.

Intro to Clinical Research BME 640

This course will introduce students to various aspects of clinical research, i.e. research with human subjects, including clinical research methods, protocols, governance, study designs, as well as subject management and protection, bioethics, and biostatics. It is anticipated that students are familiar with biomedical design, biomaterials and biomechanics.

BME 650 Advanced Biomaterials

Upon completion of this course, students will be able to demonstrate an understanding of the major classes of engineering materials, their principle properties and design requirements that serve as both the basis for materials selection as well as for the ongoing development of new materials. This course is substantially differentiated from introductory materials courses by its very specific focus on material whose use puts them in direct contact with physiological systems. Thus the course begins with brief sections on inflammatory response, thrombosis, infection and device failure. It then concentrates on developing the fundamental material science and engineering concepts underlying the structure-property relationships in both synthetic and natural polymers, metals and alloys, and ceramics relevant to in vivo medial-device technology. Cross-listed with: NANO 650

BME 655 Principles of Multiscale Biosystems Development and Integration (3 - 3 - 0)

This course extends concepts present in tissue engineering, biotransport and biomaterial to develop design principles for generating tissue and organs in-vitro. The processes which cells integrate proteins and extracellular matrix to form functioning organ systems are developed. The principles of bioreactor design are sued to analyze and design in-vitro systems for growing functioning tissue and organs for use as prostheses. Principles of Scale-up to organs of different size are discussed. Design issues and limitations for extension of these principles to multi-organ systems are illustrated.

BME 665 Pathophysiology

Pathophysiology describes changes in physiology resulting in disease or injury. A solid understanding of normal physiology is necessary before attempting the study of abnormal situations. The course emphasizes the "mechanistic" approach to pathophysiology, i.e., A-B-C, rather that the symptom-diagnosis-treatment approach. Multiple examples, case studies and procedural videos are presented with a discussion of what they do well and where improvements can be made. Prerequisites: CH 583 or BME 482 or BME 503 or BIO 583

BME 675 Nanomedicine

This course will provide a comprehensive introduction to the rapidly developing field of nanomedicine, and discuss the application of nanoscience and nanotechnology in medicine such as in diagnosis, imaging and therapy, surgery and drug delivery. Cross-listed with: NANO 675 Prerequisites: NANO 600

BME 685 Nanobiotechnology

This course describes the application of nano- and micro-fabrication methods to build tools for exploring the mysteries of biological systems. It is a graduate-level course that will cover the basics of biology and the principles and practice of nanoand micro-fabrication techniques with a focus on applications in biomedical and biological research. Cross-listed with: NANO 685 Prerequisites: NANO 600

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BME 690Cellular Signal Transduction(3 - 3 - 0)This advanced course coves the mechanism and biological role of signal transduction in mammalian cells. Topics included
are exracellular regulatory signals, intercellular signal transduction pathways, role of tissue context in the function of cellular
regulation, and example of biological processes controlled by specific cellular signal transduction pathways. Cross-listed with:

CH 690 Prerequisites: CH 381, CH 484 or BIO 381, BIO 484

BME 700Seminar in Biomedical Engineering(0 - -)

Lectures by department faculty, guest speakers, and doctoral students on recent research.

BME 701-702Selected Topics in Biomedical Engineering I-II(3 - 3 - 0)

Selected topics of current interest in the field of biomedical engineering will be treated from an advanced point of view.

BME 702Curriculum Practical Training(1 - 0 - 0)

International graduate students may arrange an internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course provided that the course constitutes and integral part of their educational program. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/her activities during that semester, even if the activity remains ongoing. This is a one-credit course that may be repeated up to a total of three credits.

BME 800 One to three cred	Special Problems in Biomedical Engineering (ME) lits. Limit of three credits for the degree of Master of Engineering (Biomedical).	(1 to 3)
BME 801 One to three cred	Special Problems in Biomedical Engineering (PHD) lits. Limit of three credits for the doctoral degree in Biomedical Engineering.	(1 to 3)
BME 810 One to three cred	Special Topics in Biomedical Engineering lits. Limit of three credits. Must arrange with instructor.	(1 to 3)
BME 900 For the degree of	Masters Thesis in Biomedical Engineering Master of Engineering (Biomedical). Nine credits with departmental approval	(9-0-0)
BME 901 For the degree of	Biomedical Engineering Project (ME) Master of Engineering (Biomedical). One to nine credits with departmental approval.	(1 to 9)
BME 960	Research in Biomedical Engineering	()

Original research leading to the doctoral dissertation. Hours and credits to be arranged.

Chemistry and Chemical Biology

CH 115 General Chemistry I (3 - 3 - 0)

This course is an introduction to important concepts and principles of chemistry with a focus on the following topics: atomic structure and periodic properties, stoichiometry, properties of gases, thermochemistry, chemical bond types, intermolecular forces, liquids and solids and a brief introduction to chemical kinetics, organic chemistry and materials chemistry. Prerequisites: Corequisites: CH 117

CH 116 General Chemistry II (3 - 3 - 0)

This course is an introduction to important concepts and principles of chemistry with a focus on the following topics: chemical kinetics; properties of solutions; chemical equilibrium; acids and bases; acid base equilibrium, polyprotic acids, buffers, titrations, indicators, salts; solubility and complex ion equilibria; chemical thermodynamics: entropy, free energy and spontaneity; electrochemistry: balancing oxidation reduction reactions, galvanic cells, electrolysis; nuclear chemistry, nuclear energetics and radioactivity; the representative elements; transition metals and coordination chemistry. Prerequisites: CH 115

Laboratory work to accompany CH 115: experiments of atomic spectra, stoichiometric analysis, qualitative analysis, and organic and inorganic syntheses Prerequisites: Corequisites: CH 115

CH 118 General Chemistry Laboratory II

General Chemistry Laboratory I

Organic Chemistry Laboratory I

CH 117

CH 245

Laboratory work to accompany CH 116: analytical techniques properties of solutions, kinetics, chemical and phase equilibria, acid-base titrations, thermodynamic properties, electrochemical cells, and properties of chemical elements. Prerequisites: CH 117 Corequisites: CH 116

CH 189 Seminar in Chemistry and Biology

Introduction to chemistry as the "central science" and its impact on other fields, particularly biology. Areas to be explored include the interaction of radiation with matter, the effect of symmetry on chemical and physical properties of molecules, hyphenated methods of analysis, the chemistry of biological signals, biochemical cycles, the physiology of exercise, and chaotic reactions. Prerequisites: Corequisites: CH 115

CH 243 Organic Chemistry I

Principles of descriptive organic chemistry; structural theory; reactions of aliphatic compounds; and stereochemistry. Prerequisites: CH 116, CH 118

CH 244 Organic Chemistry II

Continuation of CH 243. Includes examination of functional groups and functional group interconversions, aromatic compounds, infrared and nuclear magnetic resonance spectroscopy. Prerequisites: Corequisites: CH 243

Laboratory includes introduction to organic reaction and separation techniques, reactions of functional groups, and synthesis. Prerequisites: Corequisites: CH 243

CH 246 Organic Chemistry Laboratory II (1 - 0 - 4)

Laboratory work in synthesis, spectroscopy and chromatographic separation techniques. Prerequisites: Corequisites: CH 244

CH 321 Thermodynamics

Thermodynamics is the science of the transformations of energy and provides a powerful way to discuss equilibria and the direction of natural changes in chemistry. Its concepts apply to both physical change, such as fusion and vaporization, and chemical change, including electrochemistry. This course will cover the laws of thermodynamics, thermodynamic functions (including energy, enthalpy, entropy, Gibbs energy and the chemical potential) and the application to phase equilibria, chemical reaction equilibria and solution theory for both ideal and real systems. Applications of thermodynamic principles to current scientific problems will be explored. Prerequisites: CH 116, MA 124

CH 322 Theoretical Chemistry

Quantum mechanics of molecular systems are developed. The techniques of approximation methods are employed for molecular binding and spectroscopic transitions. Examples are taken from infrared, visible, ultraviolet, microwave, and nuclear magnetic resonance spectroscopy. Prerequisites: MA 221, and CH 243

CH 362 Instrumental Analysis I - Spectroscopy and Chromatography (4 - 3 - 4)

Theoretical and experimental approach to spectroscopy and chromatography. Includes ultraviolet, visible and infrared absorption by molecules, emission spectroscopy, nuclear magnetic resonance, mass spectroscopy and gas-liquid and high-performance chromatography. Prerequisites: CH 116, CH 118

CH 412 Inorganic Chemistry I

Lecture and laboratory; ionic solids, lattice energy, and factors determining solubility; thermodynamics in inorganic synthesis and analysis; acid-base equilibria; and systematic chemistry of the halogens and other non-metals. Prerequisites: CH 362, CH 322

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CH 421 **Chemical Dynamics**

Chemical kinetics, solution theories with applications to separation processes, electrolytes, polyelectrolytes, regular solutions and phase equilibria, and laboratory practice in the measurements of physical properties and rate processes. Prerequisites: CH 321, MA 221, E 234

CH 461 Instrumental Analysis II - Electrochemistry

Theory and practice of electrochemical methods in analytical chemistry. Includes potentiometry, coulometry, amperometry, polarography, voltammetry, conductivity, etc. Prerequisites: CH 116, CH 118

CH 496 Chemistry Project I

Participation in a small group project, under the guidance of a faculty member, whose prior approval is required. Experimentation, application of chemical knowledge and developmental research leading to the implementation of a working chemical process. Individual or group written report required.

CH 497 Chemistry Project II

Participation in a small group project, under the guidance of a faculty member, whose prior approval is required. Experimentation, application of chemical knowledge and developmental research leading to the implementation of a working chemical process. Individual or group written report required.

CH 498 Chemical Research I

Individual research project under the guidance of a chemistry faculty member, whose prior approval is required. A written report in acceptable journal format and an oral presentation are required at the end of the project.

CH 499 Chemical Research II

Individual research project under the guidance of a chemistry faculty member, whose prior approval is required. A written report in acceptable journal format and an oral presentation are required at the end of the project.

CH 500 Physical Chemistry Review

Review of undergraduate physical chemistry by means of problem solving; atomic spectra; structure of atoms and molecules; thermodynamics; changes of state; solutions; chemical equilibrium; kinetic theory of gases; chemical kinetics, and electrochemistry.

CH 501 Professional Ethics in Chemical and Scientific Research

A course for advanced undergraduate and beginning graduate students in the sciences, especially chemistry and chemical biology, focusing on the ethical problems unique to the chemical profession. Special emphasis will be given to situations in which there is not a simple correct answer but only a number of imperfect alternatives. Class discussion of case studies.

CH 520 Advanced Physical Chemistry

The elements of quantum mechanics are developed and applied to chemical systems. Valence bond theory and molecular orbital theory of small molecules; introduction to group theory for molecular symmetry; fundamental aspects of chemical bonding, and molecular spectra.

CH 524 Intro to Surface Analysis

This course provides a broad introduction to common surface analysis techniques used to measure a wide range of properties of solid surfaces.

CH 525 Techniques of Surface and Nanostructure Characterization (3 - 3 - 0)

Lectures, demonstrations and laboratory experiments, selected from among the following topics, depending on student interest: vacuum technology; thin-film preparation; scanning electron microscopy; infrared spectroscopy, ellipsometry: electron spectroscopies-Auger, photoelectron, LEED; ion spectroscopies SIMS, IBS, field emission; surface properties-area, roughness, and surface tension. Alternate years. Cross-listed with: MT 525, NANO 525, PEP 525

CH 540 Advanced Organic Laboratory I

Your needs and interests will be considered in the assignment of typical advanced preparations, small research problems and special operations. Fall and Spring semesters, by request.

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CH 541 Advanced Organic Laboratory II

Your needs and interests will be considered in the assignment of typical advanced preparations, small research problems and special operations. Fall and Spring semesters, by request. Prerequisites: CH 540

CH 550 Spectra and Structure

An intensive course on the interpretation of spectroscopic data; emphasis is on the use of modern spectroscopic techniques, such as NMR (13C, D, 15N, and H), mass (including CI), laser-Raman, ESCA, ORD, CD, IR, and UV for structure elucidation. Special attention is given to the application of computer technology in spectral work. A course designed for practicing chemists in analytical, organic, physical, and biomedical areas. Extensive problem solving. No laboratory.

CH 555 Catalysis and Characterization of Nanoparticles

Most processes in petroleum and chemical industries utilize catalytic reactions. Moreover, many emerging technologies in the energy sector and in green chemistry for sustainability rely on catalysis. This course provides the fundamentals of synthesis, characterization and testing of catalytic materials with an emphasis on metal and metal oxide nanoparticles, the most widely used class of catalysts. Methodologies for development of molecular-level reaction mechanisms, material structure-activity relations and kinetic models are described. The course is essential for anyone planning a career in the chemical industry. It is recommended for all professionals working with nanoparticles and also with diverse applications where the solid-gas interface is important. Cross-listed with: CHE 555, MT 555, NANO 555, EN 555

CH 561 Instrumental Methods of Analysis

Primarily a laboratory course, with some lecture presenting the principles and applications of contemporary instrumental analytical methods, with a focus on spectroscopy and separations. Laboratory practice explores ultraviolet, visible and infrared spectrophotometry, atomic absorption spectroscopy, nuclear magnetic resonance spectrometry, gas-liquid and highperformance liquid chromatography, and capillary electrophoresis. These instrumental techniques are utilized for quantitative and qualitative analyses of organic, inorganic, biological and environmntal samples.

CH 580 Biochemistry I - Cellular Metabolism and Regulation (3 - 3 - 0)

Discussions include metabolic pathways in biosynthesis and catabolism of biomolecules, including carbohydrates, proteins, lipids, and nucleic acids. The hormonal regulation of metabolism, as well as vitamin metabolism, is presented. Prerequisites: CH 242

CH 581 Biochemistry II - Biomolecular Structure and Function (3 - 3 - 0)

Discusses the physical and structural chemistry of proteins and nucleotides, as well as the functional role these molecules play in biochemistry. Extensive use of known X-ray structural information will be used to visualize the three-dimensional structure of these biomolecules. This structural information will be used to relate the molecules to known functional information. Prerequisites: CH 244

CH 582 **Biophysical Chemistry**

The relationship of the chemical and physical structure of biological macromolecules to their biological functions as derived from osmotic pressure, viscosity, light and X-ray scatting, diffusion, ultracentrifugation, and electrophoresis. The course is subdivided into: 1) properties, functions, and interrelations of biological macromolecules, e.g., polysaccharides, proteins, and nucleic acids; 2) correlation of physical properties of macromolecules in solution; 3) conformational properties of proteins and nucleic acids; and 4) aspects of metal ions in biological systems. Prerequisites: CH 421

CH 610 Advanced Inorganic and Bioinorganic Chemistry

A systematic treatment of the bonding and reactivity of inorganic substances; molecular shape and electron charge distribution of main-group and coordination compounds, including valence-bond theory and a group theoretical approach to molecular orbital theory; organometallic chemistry; the solid state; and the role of inorganic compounds in biological processes and the environment.

CH 620 Chemical Thermodynamics and Kinetics

Applications of the laws of thermodynamics to solutions, electrolytes and polyelectrolytes, binding, and biological systems; statistical thermodynamics is developed and applied to spectroscopy and transition state theory; and chemical kinetics of simple and complex reactions, enzyme and heterogeneous catalysis, and theories of reaction rates.

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CH 621 Quantum Chemistry

Theorems and postulates of quantum mechanics; operator relationships; solutions of the Schrödinger equation for model systems; variation and perturbation methods; pure spin states; Hartree-Fock self-consistent field theory; and applications to many-electron atoms and molecules. Prerequisites: CH 520, PEP 554

CH 622 Molecular Spectroscopy

Theoretical foundations of spectroscopic methods and their application to the study of atomic and molecular structure and properties; theory of absorption and emission of radiation; line spectra of complex atoms: group theory; rotational, vibrational, and electronic spectroscopy of diatomic and polyatomic molecules; infrared, Raman, uv-vis spectroscopy; laser spectroscopy and applications; photoelectron spectroscopy; multi-photon processes. Also offered as PEP 722. By request. Prerequisites: CH 520, PEP 554

CH 623 **Chemical Kinetics**

A detailed discussion of the kinetics and mechanism of complex reactions in the gaseous and liquid phases; topics include: stationary and nonstationary conditions; chain reactions, photo and radiation-induced reactions, and reaction rate theories. By request.

CH 624 Statistical Mechanics

Classical and quantum mechanical preliminaries; derivation of the laws of thermodynamics; applications to monoatomic and polyatomic gases and to gaseous mixtures; systems of dependent particles with applications to the crystalline solid, the imperfect gas, and the cooperative phenomena; electric and magnetic fields; and degenerate gases. By request. Prerequisites: CH 620

CH 640 Advanced Organic and Heterocyclic Chemistry I (3 - 3 - 0)An advanced course in the chemistry of carbon compounds, with special reference to polyfunctional compounds, heterocycles, techniques of literature survey, stereochemical concepts, and physical tools for organic chemists. Fall semester. Prerequisites: CH 244

Advanced Organic and Heterocyclic Chemistry II CH 641

An advanced course in the chemistry of carbon compounds, with special reference to polyfunctional compounds, heterocycles, techniques of literature survey, stereochemical concepts, and physical tools for organic chemists. Spring semester.

CH 642 Synthetic Organic Chemistry

A survey of important synthetic methods with emphasis on stereochemistry and reaction mechanism. Prerequisites: CH 244

CH 646 Chemistry of Natural Products (3 - 3 - 0)

Structure, synthesis, and biogenesis of antibiotics, alkaloids, hormones, and other natural products. Prerequisites: CH 244

CH 647 Chemistry and Pharmacology of Drugs

Discussion at the molecular level of drug receptor interaction, influence of stereochemistry and physiochemical properties on drug action, pharmacological effects of structural features, mechanism of drug action, metabolic rate of drugs in animals and man, and drug design. The application of newer physical tools and recent advances in methods for pharmacological studies will be emphasized. Prerequisites: CH 244

CH 660 Advanced Instrumental Analysis (3 - 3 - 0)

Advanced treatment of the theory and practice of spectrometric methods (mass spectrometry, nuclear magnetic resonance, etc.) and electroanalytical methods with emphasis on Fourier Transform techniques (FTIR, FTNMR, etc.) and hyphenated methods (gc-ms, etc.), the instrument-sample interaction, and signal sampling. A survey of computational methods, such as factor analysis and other chemometric methods is also included. Prerequisites: CH 362

CH 661 Advanced Instrumental Analysis Laboratory

Your needs and interests are considered in the assignment of work on one or more of the following: NMR spectrometry, mass spectrometry, electrochemical methods, infrared, ultraviolet, and visible spectrophotometry.

SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

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CH 662 Separation Methods in Analytical and Organic Chemistry

An advanced course applying principles and theory to problems in chemical analysis. Theory of separations, including distillation, chromatography, and ultracentrifugation; heterogeneity and surface effects; and sampling and its problems.

CH 663 **Design of Chemical Instrumentation**

A practical treatment of the mechanical, electronic, and optical devices used in the construction of instruments for research and chemical analysis and control; motors, light sources and detectors, servomechanisms, electronic components and test equipment, vacuum and pressure measuring devices, and overall design concepts are among the topics treated.

CH 664 **Computer Methods in Chemistry**

Discusses computational chemistry topics, including energy minimization, molecular dynamics, solvation mechanics, and electronic structure calculations. Applications in drug design and receptors will be discussed. Prerequisites: CH 321

CH 665 Chemometrics I

Application of chemometric techniques to problems in analytical, physical and organic chemistry, with emphasis on spectroscopic measurements. Includes optimization, analysis of variance, pattern recognition, factor analysis, experimental design, etc.

CH 666 Modern Mass Spectrometry

A comprehensive hands-on course covering both fundamentals and modern aspects of mass spectrometry, with emphasis on biological and biochemical applications. Topics include: contemporary methods of gas phase ion formation [electron ionization (EI), chemical ionization (CI), inductively coupled plasma (ICP), fast atom bombardment (FAB), plasma desorption (PD), electrospray (ESI), atmospheric pressure chemical ionization (APCI), matrix assisted laser desorption ionization (MALDI), detection (electron and photomultipliers, and array detectors), and mass analysis [magnetic deflection, quadrupole, ion trap, time of flight (TOF), and Fourier-transform (FTMS)]. Detailed interpretation of organic mass spectra for structural information, with special emphasis on even-electron-ion fragmentation. Qualitative and quantitative applications in environmental, biological, pharmacological, forensic, and geochemical sciences.

Synthetic Polymer Chemistry CH 670

Mechanisms and kinetics of organic and inorganic polymerization reactions; condensation, free radical and ionic addition, and stereoregular polymerizations; copolymerizations; and the nature of chemical bonds and the resulting physical properties of high polymers.

CH 671 Physical Chemistry of Polymers

Physio-chemical aspects of polymers, molecular weight distributions, solution characterization and theories, polymer chain configuration, thermodynamics of polymer solutions, the amorphous state, and the crystalline state.

CH 672 Macromolecules in Modern Technology

The course covers recent advances in macromolecular science, including polyelectrolytes and water-solubl synthetic and biological macromolecules at surfaces, self-assembly of synthetic and biological macromolecules, and polymers for biomedical applications. Cross-listed with: NANO 672

CH 673 Special Topics in Polymer Chemistry

Recent developments in polymer science will be discussed, e.g., physical measurements, polymer characterization, polymerization kinetics, and morphology. Topics will vary from year to year and specialists will participate.

CH 674 Polymer Functionality

Topics at the interface of polymer chemistry and biomedical sciences, focusing on areas where polymers have made a particularly strong contribution, such as in biomedical sciences and pharmaceuticals. Synthesis and properties of biopolymers; biomaterials; nanotechnology smart polymers; functional applications in biotechnology, tissue and cell engineering; and biosensors and drug delivery. Cross-listed with: NANO 674 Prerequisites: CH 244

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CH 682 Biochemical Laboratory Techniques

Students will work actively in small collaborative groups to solve a unique research project that encompasses the purification, analysis of purity, kinetics, and structure-function analysis of a novel recombinant protein. Techniques in protein purification, gel electrophoresis, peptide digest separation, ligand binding, steady-state and stopped-flow kinetics, and molecular simulation will be explored.

CH 685 Medicinal Chemistry

A few topics of timely interest will be treated in depth,; recent chemical developments will be surveyed in fields such as antibiotics, cancer chemotherapy, CNS agents, chemical control of fertility, steroids and prostaglandins in therapy, etc. Prerequisites: CH 244

CH 700 Seminar in Chemistry

Lectures by department faculty, guest speakers, and doctoral students on recent research.

CH 701 Curricular Practical Training

International graduate students may arrange an educationally relevant internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. The project must be educationally relevant; i.e., it must help the student develop skills consistent with the goals of the educational program. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/her activities during that semester, even if the activity remains ongoing. The student must also present his/her activities in an accompanying oral presentation that is also graded. This is a one-credit course that may be repeated up to a total of three credits.

CH 720	Selected Topics in Chemical Physics I	(3-3-0)
Topics of current	interest selected by you are to be investigated from an advanced point of view.	
CH 721	Selected Topics in Chemical Physics II	(3-3-0)
Topics of current	interest selected by you are to be investigated from an advanced point of view.	
CH 722	Selected Topics in Physical Chemistry	(3-3-0)

Topics selected to coincide with research interests current in the department.

CH 740 Selected Topics in Organic Chemistry (3 - 3 - 0)

Selected topics of current interest in the field of organic chemistry will be treated from an advanced point of view; recent developments will be surveyed in fields such as reaction mechanisms, physical methods in organic chemistry, natural products chemistry, biogenesis, etc.

CH 760 Chemoinformatics

This advanced course in computational chemistry builds on the methods developed in CH 664. Students will analyze and design combinatorial libraries, develop SAR models, and generate calculated molecular properties. The hands-on course will use both PC and Silicon Graphics computers. Software, such as that from Oxford Molecular, Tripos, and Oracle will be used, as will MSI software, such as INSIGHT/DISCOVER, Catalyst, and Cerius 2. Prerequisites: CH 664

CH 780 Selected Topics in Biochemistry I

Topics of current interest in biochemical research are discussed, such as: enzyme chemistry, biochemical genetics and development, cellular control mechanism, biochemistry of cell membranes, bioenergetics, and microbiology.

CH 781 Selected Topics in Biochemistry II

Topics of current interest in biochemical research are discussed, such as: enzyme chemistry, biochemical genetics and development, cellular control mechanism, biochemistry of cell membranes, bioenergetics, and microbiology.

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CH 782	Selected Topics in Bioorganic Chemistry	(3-3-0)
	nterest will be treated in an interdisciplinary fashion; recent developments will be surv radioactive and stable isotope techniques, genesis of life chemicals, nucleic acids and abolic errors.	
CH 800	Special Research Problems in Chemistry	(1 to 6)
One to six credits	. Limit of six credits for the degree of Master of Science.	
CH 801	Special Problems in Chemistry	(1 to 6)
One to six credits	. Limit of six credits for the degree of Doctor of Philosophy.	
CH 900	Masters Thesis in Chemistry/Chemical Biology	(1-1-0)
For the degree of	Master of Science, five to ten credits with departmental approval.	
CH 960	Dissertation in Chemistry/Chemical Biology	(1-1-0)

Original experimental or theoretical research that may serve as the basis for the dissertation required for the degree of Doctor of Philosophy. The work will be carried out under the guidance of a faculty member. Hours and credits to be arranged.

Department of Chemical Engineering & Materials Science

FACULTY

RONALD BESSER DEPARTMENT DIRECTOR

Pinar Akcora, Ph.D. Associate Professor

Ronald Besser, Ph.D. Professor and Director

Henry Du, Ph.D. Professor & Program Director

Richard Eitel, Ph.D. Teaching Associate Professor

Dilhan Kalyon, Ph.D. Institute Professor & Director of Highly Filled Materials Institute

Suphan Kovenklioglu, Ph.D. Professor and Program Director

Adeniyi Lawal, Ph.D. Professor

EMERITUS FACULTY

George DeLancey, Ph.D. Professor Emeritus

Costas Gogos, Ph.D. Professor Emeritus Stephanie Lee, Ph.D. Assistant Professor

Woo Lee, Ph.D. George Meade Bond Professor Director of the Center for Microchemical Systems

Matthew Libera, Ph.D. Professor & Associate Dean of Engineering & Science

Simon Podkolzin, Ph.D. Associate Professor

Keith Sheppard, Ph.D. Professor & Interim Dean

Fei Tian, Ph.D. Research Assistant Professor

Yujun Zhao, Ph.D. Teaching Associate Professor

Richard Grisky, Ph.D. Professor Emeritus

Milton Ohring, Ph.D. Professor Emeritus

UNDERGRADUATE PROGRAMS

Chemical Engineering

A distinguishing responsibility of chemical engineers is that they create, design, and improve processes and products that are vital to our society. Today's high technology areas of biomedicine, electronic device processing, ceramics, plastics, and other high-performance materials are generating opportunities for innovative solutions that may be provided by the unique background chemical engineers possess.

Generally considered to be one of the most diverse fields of engineering, the opportunities afforded chemical engineers are equally diverse: research and development, design, manufacturing, marketing and management. A variety of industries are served by chemical engineers, including: energy, petrochemical, pharmaceutical, food, agricultural products, polymers and

plastics, materials, semiconductor processing, waste treatment, environmental monitoring and improvement, and many others. There are career opportunities in traditional chemical engineering fields like energy and petrochemicals, but also in biochemical, pharmaceutical, biomedical, electrochemical, materials, and environmental engineering.

The chemical engineering program at Stevens is based on the fundamental areas of chemical engineering science that are common to all of its branches. Courses in organic and physical chemistry, biochemical engineering and process control are offered in addition to chemical engineering core courses in thermodynamics, fluid mechanics, heat and mass transfer, separations, process analysis, reactor design, and process design. Thus, the chemical engineering graduate is equipped for the many challenges facing modern engineering professionals. Chemical engineering courses include significant use of modern computational tools and computer simulation programs. Qualified undergraduates may also work with faculty on research projects. Many of our graduates pursue advanced study in chemical engineering, bioengineering or biomedical engineering, medicine, law, and many other fields.

Mission and Objectives

The following mission statement lays out our primary goal in the education of future chemical engineers:

"The chemical engineering program educates technological leaders by preparing them for the conception, synthesis, design, testing, scale-up, operation, control and optimization of industrial chemical processes that impact our well-being."

The Program Educational Objectives (PEOs) of the Chemical Engineering Program indicate expectations from our graduates a few years after graduation. The program faculty in collaboration with the School of Engineering's Education and Assessment Committee (SEAC), the CEMS department's External Advisory Board, and alumni developed these objectives. The objectives follow:

Graduates of the Stevens Bachelor of Engineering in Chemical Engineering are expected to:

- Apply mathematics, science and maturity of experience to lead in the solution of complex problems in chemical engineering.
- Demonstrate broad-based skills and understanding of problem solving, ethics, social awareness, safety, communication, teamwork and leadership to excel as recognized leaders in their profession.

In addition, a statement of the specific **Chemical Engineering Program Outcomes** that we aim to see demonstrated in the students we are preparing for the profession follow.

Graduates of the Bachelor of Engineering Chemical Engineering Program from Stevens Institute of Technology will:

- Be able to use basic knowledge in physics, mathematics, physical chemistry, organic chemistry, and biological sciences to address chemical engineering problems (Scientific Foundations).
- Be able to analyze chemical engineering systems using principles of material and energy balances, heat, mass and momentum transfer, kinetics and thermodynamics, process control and mathematical modeling (Engineering Foundations).
- Be able to design and conduct experiments involving reaction and separation of chemicals, transfer of heat, mass and momentum and the interpretation of results (Experimentation).

- Be able to use the basic concepts, tools and methods of material and energy balances, kinetics, thermodynamics, separations, reactions, heat, mass and momentum transfer and process control to design chemical engineering units and systems (Technical Design).
- Be able to develop and assess alternative designs for chemical engineering systems incorporating considerations such as feasibility, cost, safety, legal/regulatory issues and societal impacts (Design Assessment).
- Be able to use basic analytical instrumentation, process sensors, process simulators and other computer software for applications in process analysis and design as well as in oral presentations and reports (Tools).
- Be able to recognize and achieve high levels of professionalism in chemical engineering practice (Professionalism).
- ▶ Be able to assume leadership roles (Leadership).
- Be able to function on teams (Teamwork).
- ▶ Be able to prepare professional reports and deliver effective presentations (Communication).
- Be cognizant of ethical and moral issues and codes relating to chemical engineering and general engineering practice (Ethics and Morals).
- Have an understanding of diversity, pluralism, and the impact of chemical engineering practice on society (Social Issues).
- Participate in chemical engineering professional societies and in learning activities to pursue knowledge that goes beyond classroom experience (Lifelong Learning).
- Be able to apply fundamental knowledge in chemical engineering to nurture new technologies from concept to commercialization (Entrepreneurship).

Chemical	Engine	ering	Си	rricul	'um
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Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	12	12	27	17

Term II					
Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
PEP 111	Mechanics	3	0	6	3
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
PE 200	Physical Education II	0	2	0	0
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	10	30	18

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ¹	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	16	8	37	19

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
E 232	Engineering Design IV	2	3	7	3
CHE 234	Chemical Engineering Thermodynamics	4	0	8	4
CHE 210	Process Analysis	3	0	3	3
Hum	Humanities ¹	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
E 344	Materials Processing	3	0	6	3
MA 227	Multivariable Calculus	3	0	6	3
	Total	18	5	36	19

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CHE 342	Heat and Mass Transfer	3	0	6	3
E 321	Engineering Design V	0	3	2	2
CHE 332	Separation Operations	3	0	6	3
CHE 336	Fluid Mechanics	3	0	6	3
Hum	Humanities ¹	3	0	6	3
CH 243	Organic Chemistry I	3	0	6	3
	Total	15	3	32	17

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Course #	Course Name	Lecture	Lab	Study	Credit
E 355	Engineering Economics	3	3	6	4
CHE 322	Engineering Design VI	1	4	5	3
CHE 351	Reactor Design	3	0	6	3
E 243	Probability and Statistics for Engineers	3	0	6	3
CHE 345	Process Control, Modeling and Simulation	3	0	3	3
BIO 281	Biology and Biotechnology	3	0	6	3
	Total	16	7	32	19

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
CH 245	Organic Chemistry Laboratory I	0	4	0	1
CHE 423	Engineering Design VII	0	8	4	3
CHE 432	Chemical Engineering Laboratory	1	4	6	2
TG 403	Senior Innovation I	2	0	4	2
G.E.	General Elective ²	3	0	6	3
T.E.	Chemistry Elective ³	3	4	6	4
	Total	9	20	26	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Chemistry Elective ³	3	4	6	4
G.E.	General Elective ²	3	0	6	3
CHE 424	Engineering Design VIII ¹	0	8	4	3
TG 404	Senior Innovation II	1	0	2	1
Hum	Humanities ¹	3	0	6	3
G.E.	General Elective ²	3	0	6	3
	Total	13	12	30	17

(1) Humanities requirements can be found on pages 556-557.

(2) General Electives - chosen by the student - can be used towards a minor or option - can be applied to research or approved international studies

(3)Technical Elective

Graduation Requirements

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Term VI

Humanities Requirements

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

Minors

Students may qualify for a minor in biochemical, biomedical, or chemical engineering by taking the required courses indicated. Completion of a minor indicates proficiency beyond that provided by the Stevens curriculum in the basic material of the selected area. Student must meet the Institute requirements for enrolling into a minor program. At least two courses in the minor must be overload courses, beyond the credit requirements for all other programs being pursued by the student. Moreover these courses cannot be used for graduate credits. In addition, the grade in any course credited for a minor must be "C" or better.

Requirements for a Minor in Biochemical Engineering for students enrolled in the Chemical Engineering curriculum

- CHE 243: Organic Chemistry I
- CH 244: Organic Chemistry II
- CH 281: Biology and Biotechnology
- ▶ CH 381: Cell Biology

Requirements for a Minor in Chemical Engineering for students enrolled in the Engineering curriculum

- CHE 210: Process Analysis
- ▶ CHE 234: Chemical Engineering Thermodynamics
- ▶ CHE 332: Separation Operations
- CHE 336: Fluid Mechanics
- CHE 342: Heat and Mass Transfer
- CHE 351: Reactor Design
- * CHE 234 and 336 may be waived if appropriate substitutes have been taken in other programs.

GRADUATE PROGRAMS

The department offers programs of study leading to the Master of Engineering, Master of Science and the Doctor of Philosophy degrees. Courses are offered in chemical, biochemical, polymer engineering and materials science and engineering. The programs are designed to prepare graduates for a wide range of professional opportunities in manufacturing, design, research, or in development. Special emphasis is given to the relationship between basic science and its applications in modern technology. Chemical, and materials engineers create, design, and improve processes and products that are vital to our society. Our programs produce broad-based graduates who are prepared for careers in many fields and who have a solid foundation in research and development methodology. We strive to create a vibrant intellectual setting for our students and faculty anchored by pedagogical innovations and interdisciplinary research excellence. Active and well-equipped research laboratories in polymer processing, biopolymers, highly filled materials, microchemical systems, catalysis, high-performance coatings, photonic devices and systems, and nanotechnology are available for Ph.D. dissertations and master's theses.

Admission to the degree programs requires an undergraduate education in chemical engineering, materials science and, or related disciplines.

Master's Programs

The Master of Engineering or Master of Science requires 30 graduate credits in an approved plan of study. 6 to 9 credits can be obtained by performing research in the form of a master's thesis. The curriculum must include the following core courses:

Master of Engineering - Chemical

Chemical Engineering Concentration (10 Courses)

- MA 530: Applied Mathematics for Engineers and Scientists II
- CHE 620: Chemical Engineering Thermodynamics
- CHE 630: Theory of Transport Processes
- CHE 650: Reactor Design

Plus six courses or thesis work in combination with three to four courses.

Polymer Engineering Concentration (10 Courses)

- CHE 630: Theory of Transport Processes
- CHE 560: Fundamentals of Polymer Science
- ▶ CHE 671: Polymer Rheology
- CHE 672: Processing of Polymers for Biomedical Applications

Plus six courses or thesis work in combination with three to four courses.

Master of Engineering or Science – Materials Science and Engineering

The degree in Master of Engineering or Master of Science requires a total of 10 courses, 4 of which must be from the core with balance in electives and research. Candidates may choose either a special topic or thesis research with any member of the faculty in the department to satisfy the research requirement. A minimum GPA of 3.0 is required for the Master degree.

Core Courses

Any three of the following courses:

- MT 521 Thermodynamics of Materials
- MT 601 Structure and Diffraction
- MT 602 Principles of Inorganic Materials
- MT 665 Soft Matter Physics

Plus:

MT 650 Innovation and Entrepreneurship in Materials Science and Engineering

Microelectronics and Photonics Science and Technology - Interdisciplinary

The master's degree is also available in the concentration of Microelectronics and Photonics Science and Technology (MPST), which is an interdisciplinary area of study jointly administrated with several other Departments in the School of Engineering and Science.

Core Courses

- MT 507 Introduction to Microelectronics and Photonics
- ▶ Four additional courses from the Materials core (listed above).
- Five electives are required from the courses offered below by Materials Science and Engineering, Physics and Engineering Physics, and Electrical Engineering. Three of these courses must be from Materials Science and Engineering and one must be from each of the other two departments. Ten courses are required for the degree.

Required Concentration Electives

- ▶ PEP 503 Introduction to Solid State Physics
- ▶ PEP 515 Photonics I
- ▶ PEP 516 Photonics II
- ▶ PEP 561 Solid State Electronics I
- MT 562 Solid State Electronics II
- MT 595 Reliability and Failure of Solid State Devices
- MT 596 Microfabrication Techniques
- ▶ EE 585 Physical Design of Wireless Systems
- ▶ EE 626 Optical Communication Systems
- CPE 690 Introduction to VLSI Design

Doctoral Programs

Doctoral Program in Chemical Engineering or Materials Science and Engineering

Admission to the Chemical Engineering or Materials Science and Engineering doctoral program is based on evidence that a student will prove capable of scholarly specialization in a broad intellectual foundation of a related discipline. The master's degree is strongly recommended for students entering the doctoral program. Applicants without the master's degree will normally be enrolled in the master's program.

Eighty-four credits of graduate work in an approved program of study are required beyond the bachelor's degree; this may include up to 30 credits obtained in a master's degree program, if the area of the master's degree is relevant to the doctoral program. A doctoral dissertation for a minimum of 30 credits and based on the results of the student's original research, carried out under the guidance of a faculty member and defended in a public examination, is a major component of the doctoral program. The Ph.D. qualifying exam consists of a written and an oral exam. Students are strongly encouraged to take the qualifying exam within two semesters of enrollment in the graduate program. A minimum of 3.5 GPA must be satisfied in order to take the exam. A time limit of six years is set for completion of the doctoral program.

Interdisciplinary

An interdisciplinary Ph.D. program is jointly offered with the Department of Physics and Engineering Physics and the Department of Chemistry, Chemical Biology, and Biomedical Engineering. This program aims to address the increasingly cross-cutting nature of doctoral research in these disciplines. The interdisciplinary Ph.D. program aims to take advantage of the complementary educational offerings and research opportunities in these areas. Any student who wishes to enter this interdisciplinary program needs to obtain the consent of the two departments involved and the subsequent approval of the Dean of Academic Administration. The student will follow a study plan designed by his/her faculty advisor(s). The student will be granted official candidacy in the program upon successful completion of a qualifying exam that will be administered

according to the applicable guidelines of the Office of Graduate Admissions. All policies of the Office of Graduate Admissions that govern the credit and thesis requirements apply to students enrolled in this interdisciplinary program. Interested students should follow the normal graduate application procedures through the Dean of Academic Administration.

Research

A thesis for the master's or doctoral program can be completed by participating in one of the following research programs of the department.

- Biologically Active Material Professor Matthew Libera
- Crystallization Professor Dilhan Kalyon
- ▶ Electron Microscopy and Polymer Interfaces Professor Matthew Libera
- Heterogeneous catalysis, infrared spectroscopy, density-functional theory (DFT) calculations Professor Simon Podkolzin
- Mathematical Modeling and Simulation of Transport Processes Professor Adeniyi Lawal
- Micro/nano Approaches for Alternative Energy Systems Professors Woo Lee, Adeniyi Lawal and Ronald Besser
- Nanoparticle Self-Assembly, Self-Healing Polymers, and Drug Delivery Professor Pinar Akcora
- Organic Semiconductor Thin Films for Device Applications Professor Stephanie Lee
- Polymer Characterization and Processing Professor Dilhan Kalyon
- Rheology Modeling Processability and Microstructure of Filled Materials Professor Dilhan Kalyon
- Surface Modification at Multiple Length Scales, Plasmonic Nanoparticles for Sensing and Imaging, Novel Fiber Optic Sensors - Professor Henry Du

Graduate Certificate Programs

In addition to the degree programs, the department also offers graduate certificate programs. In most cases, the courses may be used toward the master's degree. Each graduate certificate program is a self-contained and highly focused collection of courses carrying nine or more graduate credits. The selection of courses is adapted to the professional interests of the student.

The Graduate Certificate in Pharmaceutical Manufacturing Practices is an interdisciplinary School of Engineering certificate developed by the Department of Mechanical Engineering and the Department of Chemical Engineering and Materials Science. This certificate is intended to provide professionals with skills required to work in the pharmaceutical industry. The focus is on engineering aspects of manufacturing and the design of facilities for pharmaceutical manufacturing, within the framework of the regulatory requirements in the pharmaceutical industry.

The certificate is designed for technologists in primary manufacturers, including pharmaceutical, biotechnology, medical device, diagnostic, and cosmetic companies, as well as in related companies and organizations, including architect/engineer/ construction firms, equipment manufacturers and suppliers, government agencies, and universities.

Pharmaceutical Manufacturing Practices

- ▶ PME 530 Introduction to Pharmaceutical Manufacturing
- ▶ PME 535 Good Manufacturing Practice in Pharmaceutical Facilities Design
- ▶ PME 540 Validation and Regulatory Affairs in Pharmaceutical Manufacturing

and one of the following electives:

- ▶ PME 628 Pharmaceutical Finishing and Packaging Systems
- ▶ PME 538 Chemical Technology Processes in API Manufacturing
- PME 649 Design of Water, Steam, and CIP Utility Systems for Pharmaceutical Manufacturing (M.E. Graduate Course)
- ▶ PME 531 Process Safety Management (CHE Graduate Course)

(Full course descriptions can be found in the Interdisciplinary Programs section.)

Photonics

- ▶ EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- ▶ EE/MT/PEP 515 Photonics I
- ▶ EE/MT/PEP 516 Photonics II
- ▶ EE/MT/PEP 626 Optical Communication Systems

Microelectronics

- EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- ▶ EE/MT/PEP 561 Solid State Electronics I
- ▶ EE/MT/PEP 562 Solid State Electronics II
- CpE/MT/PEP 690 Introduction to VLSI Design

Microdevices and Microsystems

- ▶ EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- ▶ EE/MT/PEP 595 Reliability and Failure of Solid State Devices
- ▶ EE/MT/PEP 596 Micro-Fabrication Techniques
- ► EE/MT/PEP 685 Physical Design of Wireless Systems

Any one elective in the three certificates above may be replaced with another within the Microelectronics and Photonics (MP) curriculum upon approval from the MP Program Director.

COURSE OFFERINGS

Chemical Engineering

CHE 210 Process Analysis

An introduction to the most important processes employed by the chemical industries, such as plastics, pharmaceutical, chemical, petrochemical, and biochemical. The major emphasis is on formulating and solving material and energy balances for simple and complex systems. Equilibrium concepts for chemical process systems will be developed and applied. Computer courseware will be utilized extensively. Prerequisites: E 115, CH 116, MA 221

CHE 234 Chemical Engineering Thermodynamics

Thermodynamic laws and functions with particular emphasis on systems of variable composition and chemically reacting systems. Chemical potential, fugacity and activity, excess function properties, standard states, phase and reaction equilibria, reaction coordinate, chemical-to-electrical energy conversion. Prerequisites: E 115, CH 116, MA 221

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CHE 322 Engineering Design VI

The objectives of this course are to learn modern systematic design strategies for steady state chemical processing systems and at the same time to gain a functional facility with a process simulator (Aspen) for design, analysis, and economic evaluation. A process is constructed stepwise, with continuing discussion of heuristics, recycle, purge streams, and other process conditions. Aspen is used for design and analysis of the process units. From the viewpoint of the process simulations, the course is divided into four categories: Component, property and data management; Unit operations; System simulation; and Process economic evaluation. The equations used by the simulator are discussed as well as convergence methods, loops and tear streams and scrutiny of default settings in the simulator. The factored cost method and profitability measures are reviewed and compared to simulator results. Work on a capstone design project is begun in the last section of the course. Prerequisites: CHE 332, E 321 Corequisites: CHE 351

CHE 332 Separation Operations

The design of industrial separation equipment using both analytical and graphical methods is studied. Equilibrium based design techniques for single and multiple stages in distillation, absorption/stripping, and liquid-liquid extraction are employed. An introduction to gas-solid and solid-liquid systems is presented as well. Mass transfer considerations are included in efficiency calculations and design procedures for packed absorption towers, membrane separations, and adsorption. Ion exchange and chromatography are discussed. The role of solution thermodynamics and the methods of estimating or calculating thermodynamic properties are also studied. Degrees of freedom analyses are threaded throughout the course as well as the appropriate use of software. Iterative rigorous solutions are discussed as bases for Aspen simulation models used in Design VI. Prerequisites: CHE 210

CHE 336 Fluid Mechanics

Fluid categories, balances of mass, energy, and momentum in the context of fluid components. Hydrostatics and the fluids in laminar, turbulent, and transitional flows. Particular attention is given to flow inside pipes including the concepts of friction and pressure drop, and the effects of changes in height and pumping energy. Fluid moving equipment and flow in porous media. Use of computational tools to solve complex and/or repetitive fluid flow problems.

CHE 342 Heat and Mass Transfer

Heat conduction, convection and radiation. General differential equations for energy transfer. Conductive and convective heat transfer. Molecular, convective and interface mass transfer. The differential equation for mass transfer. Steady state molecular diffusion and film theory. Convective mass transfer correlations. Mass transfer equipment. Prerequisites: CHE 234, MA 221

CHE 345 Process Control, Modeling and Simulation

Development of deterministic and non-deterministic models for physical systems, engineering applications, and simulation tools for case studies and projects. Prerequisites: CHE 332 Corequisites: CHE 351

CHE 351 Reactor Design

Chemical equilibria and kinetics of single and multiple reactions are analyzed. Conversion, yield, selectivity, and temperature and concentration history are studied in ideal plug flow, continuous stirred tank and batch reactors. The bases of reactor selection are developed. Rate expressions for catalytic reactors are developed using L-H approach and applied to the design of fixed bed catalytic reactors. Prerequisites: CHE 210, CHE 342, CHE 336

CHE 423 Engineering Design VII

Senior Design provides, over the course of two semesters, collaborative design experiences with a problems of industrial or societal significance. Projects can originate with an industrial sponsor, from an engineering project on campus, or from other industrial or academic sources. In all cases, a project is a capstone experience that draws extensively from the student's engineering and scientific background and requires independent judgments and actions. Advice from the faculty and industrial sponsors is made readily available. The projects generally involve a number of unit operations, a detailed economic analysis, simulation, use of industrial economic and process software packages, and experimentation and/or prototype construction. The economic thread initiated in Design VI is continued in the first semester of Senior Design by close interaction on a project basis with TG 403. Leadership and entrepreneurship are nourished throughout all phases of the project. The project goals are met stepwise, with each milestone forming a part of a final report with a common structure. Prerequisites: CHE 322, CHE 351, CHE 345

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of industrial or societal significance. Projects can originate with an industrial sponsor, from an engineering project on campus, or from other industrial or academic sources. In all cases, a project is a capstone experience that draws extensively from the student's engineering and scientific background and requires independent judgments and actions. Advice from the faculty and industrial sponsors is made readily available. The projects generally involve a number of unit operations, a detailed economic analysis, simulation, use of industrial economic and process software packages, and experimentation and/or prototype construction. The economic thread initiated in Design VI is continued in the first semester of Senior Design (ChE 423) by close interaction on a project basis with TG 404. Leadership and entrepreneurship are nourished throughout all phases of the project. The project goals are met stepwise, with each milestone forming a part of a final report with a common structure. Prerequisites: CHE 423

Senior Design (ChE 423, ChE 424) provides, over the course of two semesters, collaborative design experiences with problems

CHE 432 Chemical Engineering Laboratory

Engineering Design VIII

A laboratory course designed to illustrate and apply chemical engineering fundamentals. The course covers a range of experiments involving mass, momentum, and energy transport processes and basic unit operations such as distillation, stripping and multi-phase catalytic reactions. Prerequisites: CHE 332, CHE 351

CHE 480 **Biochemical Engineering**

Integration of the principles of biochemistry and microbiology into chemical engineering processes; microbial kinetic models; transport in bioprocess systems; single & mixed culture fermentation technology; enzyme synthesis, purification & kinetics; bioreactor analysis, design and control; product recovery and downstream processing. Prerequisites: CHE 351

CHF 498 Research in CHE I

CHE 424

Individual investigation of a substantive character undertaken at an undergraduate level under the guidance of a member of the Departmental faculty on a Course by Application basis. A written report is required. Hours to be arranged with the faculty advisor.

CHE 499 Research in Chemical Engineering II

Individual investigation of a substantive character undertaken at an undergraduate level under the guidance of a member of the departmental faculty on a Course by Application basis. A written report is required. Hours to be arranged with the fa

CHE 504 Safety of Pilot Plants and Research Operations (3 - 3 - 0)

This course is intended to teach the basis of safety in pilot plants, laboratory and similar research operations. It will focus on the practical concerns faced in industry and highlight specifics not readily available elsewhere.

CHE 521 Chemical and Materials Thermodynamics

The principal areas of concentration include a review of the first and second laws of thermodynamics for closed and open systems; the calculus of thermodynamics; equilibrium criteria and stability criteria; properties of pure materials and unary systems; elementary applications of statistical thermodynamics to determine specific heats; chemical potentials and equilibria in heterogeneous systems, fugacity and activity functions; solution thermodynamics; vapor-liquid, liquid-liquid, vapor-liquidliquid and solid-liquid equilibria and phase diagrams; chemical equilibria; surfaces and surface tension.

CHE 530 Introduction to Pharmaceutical Manufacturing

Pharmaceutical manufacturing is vital to the success of the technical operations of a pharmaceutical company. This course is approached from the need to balance company economic considerations with the regulatory compliance requirements of safety, effectiveness, identity, strength, quality, and purity of the products manufactured for distribution and sale by the company. Overview of chemical and biotech process technology and equipment, dosage forms and finishing systems, facility engineering, health, safety, & environment concepts, and regulatory issues.

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CHE 531 Process Safety Management

This course reviews the 12 elements of the Process Safety Management (PSM) model created by the Center for Chemical Process Safety of the American Institute of Chemical Engineers. PSM systems were developed as an expectation/demand of the public, customers, in-plant personnel, stockholders and regulatory agencies because reliance on chemical process technologies were not enough to control, reduce and prevent hazardous materials incidents. PSM systems are comprehensive sets of policies, procedures and practices designed to ensure that barriers to major incidents are in place, in use and effective. The objectives of this course are to: define PSM and why it is important, describe each of the 12 elements and their applicability, identify process safety responsibilities, give real examples and practical applications to help better understand each element, share experiences and lessons learned of all participants, and assess the quality and identify enhancements to student's site PSM program. Cross-listed with: PME 531

CHE 535 Good Manufacturing Practice in Pharmaceutical Facilities Design (3 - 3 - 0)

Current Good Manufacturing Practice compliance issues in design of pharmaceutical and biopharmaceutical facilities. Issues related to process flow, material flow, and people flow, and A&E mechanical, industrial, HVAC, automation, electrical, and computer. Bio-safety levels. Developing effective written procedures, so that proper documentation can be provided, and then documenting through validation that processes with a high degree of assurance do what they are intended to do. Levels I, II, and III policies. Clinical phases I, II, III and their effect on plant design. Defending products against contamination. Building quality into products.

CHE 539 Manufacturing of Biopharmaceutical Products

This course provides a broad overview of topics related to the design and operations of modern biopharmaceutical facilities. It covers process, utilities and facility design issues, and encompasses all major manufacturing areas, such as fermentation, harvest, primary and final purification, media and buffer preparation, equipment cleaning and sterilization, and critical process utilities. Unit operations include cell culture, centrifugation, conventional and tangential flow filtration, chromatography, solution preparation, and bulk filling. Application of current Good Manufacturing Practices and Bioprocessing Equipment Standards (BPE-2002) will be discussed. Cross-listed with: PME 539, ME 539

CHE 540 Validation in Pharmaceutical Manufacturing

Validation of a pharmaceutical manufacturing process is an essential requirement with respect to compliance with Good Manufacturing Practices (GMP). Course covers: validation concepts for process, equipment, facility, cleaning, sterilization, filtration, analytical methods and computer systems; validation Master Plans, IQ, OQ, and PPQ protocols; and validation for medical devices. Cross-listed with: PME 540, ME 540 Prerequisites: CHE 530 or ME 530

CHE 541 Validation of Computerized Systems

Computers and computerized systems are ubiquitous in pharmaceutical manufacturing. Validation of these systems is essential to assure public safety and compliance with appropriate regulatory issues regarding validation: GMP, GCP, 21CFR Part 11, etc. This course covers validation concepts for various classes of computerized systems and applications used in the pharmaceutical industry; importance of requirements engineering in validation; test protocols and design; organizational maturity considerations. Prerequisites: CHE 540

CHE 555 Catalysis and Characterization of Nanoparticles

Most processes in petroleum and chemical industries utilize catalytic reactions. Moreover, many emerging technologies in the energy sector and in green chemistry for sustainability rely on catalysis. This course provides the fundamentals of synthesis, characterization and testing of catalytic materials with an emphasis on metal and metal oxide nanoparticles, the most widely used class of catalysts. Methodologies for development of molecular-level reaction mechanisms, material structure-activity relations and kinetic models are described. The course is essential for anyone planning a career in the chemical industry. It is recommended for all professionals working with nanoparticles and also with diverse applications where the solid-gas interface is important. Cross-listed with: MT 555, NANO 555, EN 555, CH 555

CHE 560 Fundamentals of Polymer Science

This course will be an introductory level graduate course in polymers. Methods in polymer formation and structural characterization of polymers will be introduced as they determine their applications in bio and nanotechnology. Polymer blends, block copolymers, networks and gelation and scattering techniques will be also covered. Examples on nanotechnology applications of self-assembled polymers and nanocomposites will be emphasized.

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CHE 580 Biofuels Engineering Technology

This course is designed for both science and engineering students who want to contribute to the development and implementation of processes for production of important renewable energy sources. In this course, students will learn the fundamental concepts of important biofuels and the current state-of -the-art technology for their production along with economics, environmental impact, and policy issues. Benefiting from this course, students would be able to evaluate ways for converting feedstocks to biofuels by both biochemical and thermochemical methods and integrate conceptual design of a biofuel process. As a fundamental cross-discipline course, topics are comprehensive yet introductory and require the minimal prerequisite learning in chemistry and thermodynamics. Prerequisites: CH 321 or CHE 234

CHE 612 Stagewise Operations

The ultimate goal of this course is to prepare students to undertake the analysis of the most difficult problems in equilibrium stage operations. The problems typically involve one or more process columns with components exhibiting highly non-ideal behavior. This class of problems includes azeotropic distillation, extractive distillation, columns with more than one liquid phase, and a variety of other anomalies. Lack of complete equilibrium data is not uncommon. Extensive use is made of commercial software in the solution of problems. The course concludes with the assignment of an industrial problem as a substantial project requiring that the students exercise virtually all techniques studied.

CHE 620 Chemical Engineering Thermodynamics

This course supplements the clasical undergraduate thermodynamics course by focusing on physical and thermodynamic properties, and phase equilibria. A variety of equations of state and their applicability are introduced as are all of the important liquid activity coefficient equations. Customization of both vapor and liquid equations is introduced by appropriate methods of applied mathematics. Vapor-liquid, liquid-liquid, vapor-liquid-liquid and solid-liquid equilibria are considered with rigor. Industrial applications are employed. A variety of methods for estimating physical and thermodynamic properties are introduced. Students are encouraged to use commercial software in applications. The course concludes with an introduction to statistical thermodynamics.

CHE 628 Manufacturing and Packaging of Pharmaceutical Oral Solid Dosage Products (3 - 3 - 0)

The course covers oral solid dosage (OSD) manufacturing and packaging in the pharmaceutical industry. Production unit operations include blending, granulation, size reduction, drying, compressing, and coating for tablets, as well as capsule filling. Packaging aspects reviewed include requirements for primary and secondary containers and labeling, package testing. The course emphasizes design, scale-up, trouble-shooting, validation, and operation of typical OSD manufacturing and packaging facilities, including equipment, material flow, utilities, and quality assurance. Topics related to cGMP, process validation, manufacturing and packaging documentation, QA and QC in OSD manufacturing will be presented. The term project required for this course involves conceptual design of a contract manufacturing and packaging facility for OSD products, including equipment selection, development of the process flow diagrams, room layouts and other design elements, as well as preparation of Standard Operating Procedures for various unit operations.

CHE 630 Theory of Transport Processes

(3 - 3 - 0) balances: constitutive material equations; momentum and energy

Generalized approach to differential and macroscopic balances: constitutive material equations; momentum and energy transport in laminar and turbulent flow; interphase and intraphase transport; dimensionless correlations.

CHE 638 Chemical Technology Processes in API Manufacturing (3 - 3 - 0)

A high-level exposure to bulk active pharmaceutical ingredient manufacturing and their relevant unit operations.

CHE 639 Modeling and Simulation of Pharmaceutical Manufacturing Systems (3 - 3 - 0)

This course will introduce students to the modeling and simulation applications in the pharmaceutical manufacturing. Learn the basics of discrete event simulation and use commercially available software to develop models of various manufacturing and service systems. Approaches to the development of conceptual and computer models, data collection and analysis, model verification and validation, simulation output analysis are discussed. Learn how to model chemical, biochemical and separation processes in pharmaceutical manufacturing using process simulation software. Develop material balances, stream reports, operations and equipment Gantt charts, conduct process debottlenecking and cost analysis. Cross-listed with: PME 639, ME 639

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CHE 646 Biopharmaceuticals Facilities Design

Proven techniques and creative tools presented for design, development, and delivery of biopharmaceutical manufacturing facilities. Includes skills and knowledge in bioprocessing requirements, equipment and facility requirements, project management as well as regulatory guidelines and big-picture drug development. Also corporate capital management processes to functionally meet corporate requirements from pre-clinical to commercial scale of operations, qualifications to pass regulatory inspections, achieving faster time-to-market, but not breaking the corporate treasury bank. Course also explores trends in new equipment technology such as disposables or single-use product, new design concepts in aseptic manufacturing, barrier and isolation technologies, new FDA thinking in risk-based compliance approach, process analytical technology, capital project planning and management. Cross-listed with: PME 646 Prerequisites: CHE 535, CHE 530, CHE 539, PME 609

CHE 649 Design of Water, Steam, and CIP Utility Systems for Pharmaceutical Manufacturing (3 - 3 - 0) Water & steam systems: water used as excipient, cleaning agent, or product diluent; water quality selection criteria; generation, storage and treatment.

CHE 650 Reactor Design

A graduate-level reaction engineering course that builds on previous student experience in undergraduate reactor design. Review of design equations based on the mole balances of ideal reactor types. Review of algorithms for isothermal reactor design. Theory of reaction rates and the measurement and assessment of rate data. Basis and approach to using the steady-state approximation for catalytic and biological reactions. Residence time distributions, their experimental determination and implementation for the prediction of conversion. Modeling reactors with fundamental equations of transport as the basis. Modeling reactors in three dimensions with computational tools.

CHE 653 Design of PAT Systems for Pharmaceutical Manufacturing (3 - 3 - 0)

The objective of this course is to provide the student with the engineering tools and knowledge required to design and deploy Procesa Analytical Technology (PAT) solutions in pharmaceutical drug substance and drug product manufacturing. This course provides in-depth coverage of current PAT technologies. At the conclusion of this course, students will understand the engineering theory, principles, and mathematics required to design and deploy these technologies in a pharmaceutical manufacturing environment in compliance with FDA and international regulations. Topics covered include: analyzer types and principals of operation, chemometric techniques for multivariate analysis, multivariate process models, dynamic process control, and advanced pattern recognition techniques. In addition, the course will cover the technical aspects of real-time data management and 21 CFR Part 11 compliance. Cross-listed with: PME 653 Prerequisites: CHE 530

CHE 660 Advanced Process Control

Mathematical modeling and identification of chemical processes. State-space process representation and analysis: stability, observability, controllability and reach-ability. Analysis and design of advanced control systems: internal model control, dynamic matrix control and model predictive control. Synthesis of multivariable control systems: interaction analysis, singular value decomposition, decoupler design. Continuous and sampled-data systems, on-line process identification. State and parameter estimation techniques: Luenberger observer and Kalman filter. Knowledge of Laplace transforms, material and energy balances, computer programming and matrix algebra is required.

CHE 661/ Design of Control Systems ME 623

This course focuses on the application of advanced process control techniques in pharmaceutical and petrochemical industries. Among the topics considered are bioreactor and polymerization reactor modeling, biosensors, state and parameter estimation techniques, optimization of reactor productivity for batch, fed-batch and continuous operations, and expert systems approaches to monitoring and control. An overview of a complete automation project - from design to startup - of a pharmaceutical plant will be discussed. Included: process control issues and coordination of interdisciplinary requirements and regulations. Guest speakers from local industry will present current technological trends. A background in differential equations, biochemical engineering, and basic process control is required.

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CHE 662 **Chemical Process Simulation**

The course comprises a series of workshops, employing an industrial process simulator, Aspen Plus, which explore the primary components required to simulate a chemical process. Most workshops have embedded irregularities designed to heighten the student awareness of the types of errors that could arise when using simulation software. The workshops include facilities to exercise and customize a wide variety of physical and thermodynamic properties as the students develop process models. Heavy concentration is on the equations describing the models used. As the experience level of the students rises, workshops designed to introduce complicated industrial flowsheets are employed.

CHE 670 Polymer Properties and Structure

Stress-strain relationships, theory of linear viscoelasticity and relaxation spectra, temperature dependence of viscoelastic behavior, dielectric properties, dynamic mechanical and electrical testing, molecular theories of flexible chains, statistical mechanics and thermodynamics of rubber-like undiluted systems, morphology of high polymers. Cross-listed with: MT 670

CHE 671 Polymer Rheology

Processing of Polymers for Biomedical Applications CHE 672

Descriptions of various polymer processing operations and processing requirements of biomedical products, principles of processing of polymers covering melting, pressurization, mixing, devolatilization, shaping using extrusion, spinning, blowing, coating, calendering and molding technologies, surface treatment and sterilization, applications in the areas of prostheses and artificial organs and packaging of various biomedical devices. Prerequisites: CHE 630

polymer melts: solution of isothermal and nonisothermal flow problems with non-Newtonian fluids which are encountered in

polymer processing; development of design equations for extruder dies and molds. Prerequisites: CHE 630

CHE 673 Polymerization Engineering

Analysis and design of experimental and industrial polymerization reactors for various polymerization mechanisms: relationship between design parameters and polymer structure, yield and average molecular weight: kinetic and statistical methods; batch and continuous, addition and condensation polymerization in bulk, solution, suspension and emulsion.

CHE 674 Design of Polymer Processing Machinery

A treatment of polymer processing machinery with emphasis on the design of components to implement the various elementary steps involved, and subsequent assembly of these components into processing machines. Use is made of computational models. Principles of control systems are applied to processing machinery. The primary objective is to stimulate creative approaches to the design of processing machinery rather than to familiarize the student with the details of existing machinery. Prerequisites: CHE 672

CHE 675 Polymer Blends and Composites

Recent advances in polymer blend and composite formation; the role of melt rheology in component selection and the resulting morphology; melt mixing processes and equipment; models for predicting processing and performance characteristics; morphology generation and control in manufacturing processes; sample calculations and case histories for polyblends used in film blowing, blow molding and injection molding.

CHE 676 Polymer Mold and Die Design

Principal manufacturing methods utilizing molds and dies; mold and die design characteristics dictated by functional requirements; interaction between molds/dies and processing machinery; mathematical models of forming processes including: flow through dies and into molds, solidification, heat transfer and reaction (in reactive processing); end-product properties (morphology, bulk properties, tolerances, appearance) and operating conditions in alternative manufacturing methods; materials and manufacturing methods for molds and dies; case studies.

CHE 677 Polymer Product Design

Design of polymeric products; design criteria based upon product functions and geometry; material selection by property assessment; selection of molds, dies, and special manufacturing devices (e.g., mold inserts); selection of appropriate forming process (injection, rotational or blow-molding, extrusion, etc.), and determination of optimum operating conditions (such as temperature, pressure, cycle or residence time). Case histories of failure.

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Molecular and continuum mechanical constitutive equations for viscoelastic fluids; analysis of viscometric experiments to evaluate the viscosity and normal stress functions: dependence of these functions on the macromolecular structure of

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Discussion of models for flow and deformation in polymers, and a treatment of measurable rheological properties. Analysis of thermoplastic and thermosetting resins for processability. Use of experimental data to determine parameters of the constitutive equations. Laboratory includes use of state-of-art equipment in elongational, rotational, and capillary viscometry.

Experimental Methods in Polymer Melt Rheology

CHE 682 Colloids and Interfacial Phenomena

A survey course covering the chemical, biological and material science aspects of interfacial phenomena. Applications to adhesion, biomembranes, colloidal stability, detergency, lubrication, coating, fibers, and powders - were surface properties play an important role. Prerequisites: Physical Chemistry and Thermodynamics. Prerequisites: E 321, CH 321, CH 421

CHE 695 **Bio/Nano Photonics**

CHE 678

This course deals with the principles of light interactions with biological and biomedical-relevant systems. The enabling aspects of nanotechnology for advanced biosensing, medical diagnosis, and therapeutically treatment will be discussed. Cross-listed with: BME 695, NANO 695, NANO 695

CHE 700 Lectures by depar	Seminar in Chemical Engineering rtment faculty, guest speakers, and doctoral students on recent research. Cross-liste	(3 - 0 - 0) d with: BME 700, MT 700
	Selected Topics in Chemical Engineering III-IV f current interest in the field of chemical engineering will be treated from an adva	(3-3-0) nced point of view.
	Selected Topics in Polymer Science and Engineering III-IV of current theories and experimental aspects of polymer science and engineering.	(3 to 6 - 3 to 6 - 0) (Three to Six credits.)
CHE 800 One to six credits	Special Problems in Chemical Engineering . Limit of six credits for the degree of Master of Engineering (Chemical).	(1 to 6)
CHE 801 One to six credits	Special Problem in Chemical Engineering . Limit of six credits for the degree of Doctor of Philosophy.	(1 to 6)
CHE 810 A participating se	Special Topics in Chemical Engineering eminar on topics of current interest and importance in Chemical Engineering.	(3)
CHE 900 For the degree of	Thesis in Chemical Engineering Master of Engineering (Chemical). Credits to be arranged.	(1 to 10)
CHE 960	Research in Chemical Engineering	()

Original research leading to the doctoral dissertation. Hours and credits to be arranged.

Materials Science and Engineering

MT 501 Introduction to Materials Science and Engineering (3 - 3 - 0)

An introduction to the structures/properties relationships of materials principally intended for students with a limited background in the field of materials science. Topics include: structure and bonding, thermodynamics of solids, alloys and phase diagrams, mechanical behavior, electrical properties and the kinetics of solid state reactions. The emphasis of this subject is the relationship between structure and composition, processing (and synthesis), properties and performance of materials.

(3 - 3 - 0)MT 502 **Processing of Electronic Materials**

This course deals with aspects of the technology of processing procedures involved in the fabrication of semiconductor devices. Topics include crystal growth, epitaxy, silicon oxide growth, impurity doping, ion implantation, photo and electron beam lithography, etching, sputtering, thin film metallization, assivation and packaging. A description of these fabrication techniques used for discrete devices (e.g., bi-polar transistor, field effect transistor, light-emitting diode and solar cell), as well as large-scale integrated thin film circuits, will be presented. Prerequisites: MT 501, E 344

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MT 503 Introduction to Solid State Physics

Description of simple physical models which account for electrical conductivity and thermal properties of solids. Basic crystal lattice structures, X-ray diffraction, and dispersion curves for phonons and electrons in reciprocal space. Energy bands, Fermi surfaces, metals, insulators, semiconductors, superconductivity, and ferromagnetism. Fall semester. Cross-listed with: EE 503, PEP 503 Prerequisites: PEP 242, PEP 331

MT 505 Introduction to Biomaterials

Intended as an introduction for the student who is familiar with materials science, this course first reviews the properties of materials that are relevant to their application in the human body. It then introduces proteins, cells, tissues, and their reactions to foreign materials, and the degradation of these materials in the human body. The course then treats the various implants, burn dressings, drug delivery systems, biosensors, artificial organs, and elements of tissue engineering. Cross-listed with: BME 505 Prerequisites: MT 501

MT 506 Mechanical Behavior of Solids

Theory and practical means for predicting the behavior of materials under stress. Elastic and plastic deformation, fracture and high-temperature deformation (creep).

MT 507 Introduction to Microelectronics and Photonics (3 - 3 - 0)

An overview of microelectronics and photonics science and technology. It provides the student who wishes to specialize in their application, physics or fabrication with the necessary knowledge of how the different aspects are interrelated. It is taught in three modules: design and applications, taught by EE faculty; operation of electronic and photonic devices, taught by physics faculty; fabrication and reliability, taught by materials faculty. Cross-listed with: EE 507, PEP 507

MT 515 Photonics I

This course will cover topics encompassing the fundamental subject matter for the design of optical systems. Topics will include optical system analysis, optical instrument analysis, applications of thin film coatings and opto-mechanical system design in the first term. The second term will cover the subjects of photometry and radiometry, spectrographic and spectrophotometric systems infrared radiation measurement and instrumentation, lasers in optical systems, and photon-electron conversion. Cross-listed with: PEP 515, EE 515 Prerequisites: PEP 209 or PEP 509 or EE 509

MT 516 Photonics II

This course will cover topics encompassing the fundamental subject matter for the design of optical systems. Topics will include optical system analysis, optical instrument analysis, applications of thin film coatings and opto-mechanical system design in the first term. The second term will cover the subjects of photometry and radiometry, spectrographic and spectrophotometric systems infrared radiation measurement and instrumentation, lasers in optical systems, and photon-electron conversion. Cross-listed with: PEP 516, EE 516 Prerequisites: PEP 209 or PEP 509 or EE 509

MT 518 Solar Energy: Theory & Application

This course is an in depth treatment of the principles and practice associated with using solar radiation as an alternate energy source. It examines the science of solar radiation, technologies for its capture and the design principles that are used to apply solar energy in building design. Cross-listed with: ME 518 Prerequisites: MT 518

MT 520 Composite Materials

Composite material characterization; composite mechanics of plates, panels, beams, columns, and rods integrated with design procedures; analysis and design of composite structures; joining methods and procedures; introduction to manufacturing processes of filament winding, braiding, injection, compression and resin transfer molding, machining and drilling; and industrial applications. Cross-listed with: ME 520

MT 521 Chemical and Materials Thermodynamics

The principal areas of concentration include a review of the first and second laws of thermodynamics for closed and open systems; the calculus of thermodynamics; equilibrium criteria and stability criteria; properties of pure materials and unary systems; elementary applications of statistical thermodynamics to determine specific heats; chemical potentials and equilibria in heterogeneous systems, fugacity and activity functions; solution thermodynamics; vapor-liquid, liquid-liquid, vapor-liquid-liquid and solid-liquid equilibria and phase diagrams; chemical equilibria; surfaces and surface tension.

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MT 525 Techniques of Surface and Nanostructure Characterization

Lectures, demonstrations and laboratory experiments, selected from among the following topics, depending on student interest: vacuum technology; thin-film preparation; scanning electron microscopy; LEED; infrared spectroscopy, ellipsometry; electron spectroscopies (Auger, photoelectron, field emission); ion spectroscopies (SIMS, IBS; surface properties-area), roughness and surface tension. Cross-listed with: NANO 525, CH 525, PEP 525

MT 528 Solar Energy: System Designs

This course provides an in-depth treatment of how to transfer the latest solar thermal technology available to real world applications. It takes the student through the various phases of development of a solar space heating and photovoltaic integrated building; review occupant's requirements, site analysis, design concept, solar system design, cost estimates, building design, performance predictions and construction. The emphasis of the class is on solar system design methods, economic optimization of solar systems and installation. Cross-listed with: ME 519

MT 544 Introduction to Electron Microscopy

A lecture and laboratory course that introduces basic concepts in the design and operation of transmission electron microscopes and scanning electron microscopes as well as the fundamental aspects of image interpretation and diffraction analysis. Topics include: electron sources, electron optics, kinematic and dynamic theory of electron diffraction, and spectroscopic analysis.

MT 555 Catalysis and Characterization of Nanoparticles

Most processes in petroleum and chemical industries utilize catalytic reactions. Moreover, many emerging technologies in the energy sector and in green chemistry for sustainability rely on catalysis. This course provides the fundamentals of synthesis, characterization and testing of catalytic materials with an emphasis on metal and metal oxide nanoparticles, the most widely used class of catalysts. Methodologies for development of molecular-level reaction mechanisms, material structure-activity relations and kinetic models are described. The course is essential for anyone planning a career in the chemical industry. It is recommended for all professionals working with nanoparticles and also with diverse applications where the solid-gas interface is important. Cross-listed with: CHE 555, NANO 555, EN 555, CH 555

MT 561 Solid State Electronics for Engineering I

This course introduces fundamentals of semiconductors and basic building blocks of semiconductor devices that are necessary for understanding semiconductor device operations. It is for first-year graduate students and upper-class undergraduate students in electrical engineering, applied physics, engineering physics, optical engineering and materials engineering who have no previous exposure to solid state physics and semiconductor devices. Topics covered will include description of crystal structures and bonding; introduction to statistical description of electron gas; free-electron theory of metals; motion of electrons in periodic lattices-energy bands; Fermi levels; semiconductors and insulators; electrons and holes in semiconductors; impurity effects; generation and recombination; mobility and other electrical properties of semiconductors; thermal and optical properties; p-n junctions; metal-semiconductor contacts. Cross-listed with: PEP 561. EE 561

MT 562 Solid State Electronics for Engineeing II

This course introduces operating principles and develops models of modern semiconductor devices that are useful in the analysis and design of integrated circuits. Topics covered include: charge carrier transport in semiconductors; diffusion and drift, injection and lifetime of carriers; p-n junction devices; bipolar junction transistors; metal-oxide-semiconductor field effect transistors; metal-semiconductor field effect transistors and high electron mobility transistors; microwave devices; light emitting diodes, semiconductor lasers and photodetectors; integrated devices. Cross-listed with: EE 562, PEP 562

MT 570 **Electronic Materials and Devices**

Electronic, optical and magnetic properties of materials. Cross-listed with: PEP 580

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SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

MT 585 Physical Design of Wireless Systems

Physical design of wireless communication systems, emphasizing present and next generation architectures. Impact of non-linear components on performance; noise sources and effects; interference; optimization of receiver and transmitter architectures; individual components (LNAs, power amplifiers, mixers, filters, VCOs, phase-locked loops, frequency synthesizers, etc.); digital signal processing for adaptable architectures; analog-digital converters; new component technologies (SiGe, MEMS, etc.); specifications of component performance; reconfigurability and the role of digital signal processing in future generation architectures; direct conversion; RF packaging; minimization of power dissipation in receivers. Cross-listed with: EE 585, PEP 585

MT 595 Reliability and Failure of Solid State Devices

This course deals with the electrical, chemical, environmental and mechanical driving forces that compromise the integrity and lead to the failure of electronic materials and devices. Both chip and packaging level failures will be modeled physically and quantified statistically in terms of standard reliability mathematics. On the packaging level, thermal stresses, solder creep, fatigue and fracture, contact relaxation, corrosion and environmental degradation will be treated. Cross-listed with: EE 595, PEP 595

MT 596 **Microfabrication Techniques**

Deals with aspects of the technology of processing involved in the fabrication of microelectronic devices and microelectromechanical systems (MEMS). Students will become familiar with various fabrication techniques used for discrete devices and large-scale integrated circuits. Students will also be exposed to MEMS sensor and actuator applications originating from the different engineering disciplines. Cross-listed with: EE 596, PEP 596

MT 601 Structure and Diffraction

Crystal structures, point defects, dislocations, slip systems, grain boundaries and microstructures. Scattering of X-rays and electrons; diffraction by single and polycrystalline materials and its application to material identification, crystal orientation, texture determination, strain measurement and crystal structure analysis.

MT 602 Principles of Inorganic Materials Synthesis

The goal of this course is to learn the basic concepts commonly utilized in the processing of advanced materials with specific compositions and microstructures. Solid state diffusion mechanisms are described with emphasis on the role of point defects, the mobility of diffusing atoms and their interactions. Macroscopic diffusion phenomena are analyzed by formulating partial differential equations and presenting their solutions. The relationships between processing and microstructure are developed on the basis of the rate of nucleation and growth processes that occur during condensation, solidification and precipitation. Diffusionless phase transformations observed in certain metallic and ceramic materials are discussed. Cross-listed with: NANO 602 Prerequisites: MT 603 or MT 521

(3 - 3 - 0)MT 603 Thermodynamics and Reaction Kinetics of Solids

The principal areas of concentration include a review of thermodynamic laws applying to closed systems, chemical potentials and equilibria in heterogeneous systems, fugacity and activity functions, solution thermodynamics, multicomponent metallic solutions, the thermodynamics of phase diagrams and phase transformations.

MT 626 **Optical Communication Systems**

Components for and design of optical communication systems; propagation of optical signals in single mode and multimode optical fibers; optical sources and photodetectors; optical modulators and multiplexers; optical communication systems: coherent modulators, optical fiber amplifiers and repeaters, transcontinental and transoceanic optical telecommunication system design; optical fiber local area networks. Cross-listed with: EE 626, NIS 626, PEP 626

MT 650 Special Topics in Materials Science and Engineering

This course will serve to broaden exposure the recent advances in materials engineering and provide training in key skill sets required to succeed in the engineering profession. Students will lead investigations of innovative materials science approaches and solutions required to address the significant technical and societal challenges for a sustainable future. Students will also attend departmental seminars, discuss engineering ethics, intellectual property, and the critical evaluation of technical literature.

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MT 665/ Soft Matter Physics CHE 665

The course will cover soft matter systems, including colloids, gels, polymers, liquid crystals, micelles and biological membranes. Phenomena occurring in these systems, such as crystallization and phase transitions, will be explored at molecular and microscopic levels. Quantitative characterization of the mechanical, electrical, and optical properties of soft matter systems will also be developed. Seminal papers in each of the fields will be assigned as readings and discussed in lectures.

MT 670 Polymer Properties and Structure

Stress-strain relationships, theory of linear viscoelasticity and relaxation spectra, temperature dependence of viscoelastic behavior, dielectric properties, dynamic mechanical and electrical testing, molecular theories of flexible chains, statistical mechanics and thermodynamics of rubber-like undiluted systems, and morphology of high polymers. Cross-listed with: CHE 670

MT 685 Physical Design of Wireless Systems

Physical design of wireless communication systems, emphasizing present and next generation architectures. Impact of non-linear components on performance; noise sources and effects; interference; optimization of receiver and transmitter architectures; indi Cross-listed with: PEP 685

MT 690 Introduction to VLSI Design

This course introduces students to the principles and design techniques of very large scale integrated circuits (VLSI). Topics include: MOS transistor characteristics, DC analysis, resistance, capacitance models, transient analysis, propagation delay, power dissipation, CMOS logic design, transistor sizing, layout methodologies, clocking schemes, case studies. Students will use VLSI CAD tools for layout and simulation. Selected class projects may be sent for fabrication. Cross-listed with: CPE 690, PEP 690, EE 690

MT 700 Seminar in Materials Science and Engineering Lectures by department faculty, guest speakers, and doctoral students on recent research. Enrollment during the entire period of study is required of all full-time students. No credit. Must be taken every semester.

MT 707 **Curriculum Practical Training**

A faculty-directed research project involving work in industry or other enterprise external to Stevens. Originates with ongoing collaborations with which Stevens faculty are active engaged. Student must satisfy specific immigration policies to be eligible to participate.

MT 800	Special Problems in Materials	(1 to 6)	
One to six credits.	Limit of six credits for the degree of Master of Engineering.		
MT 801	Special Problems in Materials	(1 to 6)	
One to six credits.	Limit of six credits for the degree of Doctor of Philosophy.		
MT 810	Special Topics in Materials	(3)	
A participating ser	minar on topics of current interest in materials research.		
MT 900	Thesis in Materials	(1 to 6)	
Research for the o	begree of Master of Science or Master of Engineering. Hours and credits to be arranged.		
MT 960	Research in Materials	()	

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Original research leading to the doctoral dissertation. Hours and credits to be arranged.

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Nanotechnology

NANO 200 Introduction to Nanotechnology

The course addresses the science underpinnings of nanotechnology to provide an understanding of the fundamental challenges and limitations involved in designing and demonstrating nanodevices and systems. The role of solid state physics, chemistry and some biology will be emphasized together with some basic engineering science ideas applied at the nanoscale. By the end of the course, students will understand principles of the fabrication, characterization and manipulation of nanoscale materials, systems, and devices. Prerequisites: CH 115, PEP 111

NANO 325 Introduction to Nanofabrication and Characterization (3 - 3 - 0)

The course addresses the science underpinnings of nanotechnology to provide a hands-on experience for undergraduate students in nanofabrication and characterization. It will discuss the grand challenges of nanofabrication and will showcase examples of specific applications in electronics, photonics, chemistry, biology, medicine, defense, and energy. NANO 200 would be a pre-requisite for this course. This course will offer hands-on experiments to fabricate prototype devices/systems (e.g. relatively simple sensors or actuators) in order for students to understand the full sequence/spectrum of development of nanodevices and systems, e.g. from concept design, fabrication and characterization. Prerequisites: NANO 200

NANO 503 Introduction to Solid State Physics

Description of simple physical models which account for electrical conductivity and thermal properties of solids. Basic crystal lattice structures, X-ray diffraction and dispersion curves for phonons and electrons in reciprocal space. Energy bands, Fermi surfaces, metals, insulators, semiconductors, superconductivity and ferromagnetism. Fall semester. Typical text: Kittel, Introduction to Solid State Physics. Cross-listed with: PEP 503 Prerequisites: PEP 242, PEP 542

NANO 525 Techniques of Surface and Nanostructure Characterization (3 - 3 - 0)Lectures, demonstrations and laboratory experiments, selected from among the following topics, depending on student

interest: vacuum technology; thin-film preparation; scanning electron microscopy; infrared spectroscopy, ellipsometry: electron spectroscopies-Auger, photoelectron, LEED; ion spectroscopies SIMS, IBS, field emission; surface properties-area, roughness, and surface tension. Alternate years. Cross-listed with: MT 525, CH 525, PEP 525

NANO 553 Introduction to Quantum Mechanics

This course is an introduction to quantum mechanics for students in physics and engineering. Techniques discussed include solutions of the Schrodinger equation in one and three dimensions, and operator and matrix methods. Applications include infinite and finite quantum wells, barrier penetration and scattering in one dimension, the harmonic oscillator, angular momentum, central force problems, including the hydrogen atom, and spin. Fall semester. Typical text: Quantum Physics by Gasiorowicz. Cross-listed with: PEP 553 Prerequisites: MA 221, PEP 242

NANO 554 Quantum Mechanics I

This course is meant as the first in a two-course sequence on non-relativistic quantum mechanics for physics graduate students, with an emphasis on applications to atomic, molecular, and solid state physics. Undergraduate students may take this course as a Technical Elective. Topics covered include: review of Schrödinger wave mechanics; operator algebra, theory of representation, and matrix mechanics; symmetries in quantum mechanics; spin and formal theory of angular momentum, including addition of angular momentum; and approximation methods for stationary problems, including time independent perturbation theory, WKB approximation, and variational methods. Typical text: Quantum Mechanics by E. Merzbacher. Cross-listed with: PEP 554 Prerequisites: PEP 532, PEP 538, PEP 553

NANO 555 Catalysis and Characterization of Nanoparticles

Most processes in petroleum and chemical industries utilize catalytic reactions. Moreover, many emerging technologies in the energy sector and in green chemistry for sustainability rely on catalysis. This course provides the fundamentals of synthesis, characterization and testing of catalytic materials with an emphasis on metal and metal oxide nanoparticles, the most widely used class of catalysts. Methodologies for development of molecular-level reaction mechanisms, material structure-activity relations and kinetic models are described. The course is essential for anyone planning a career in the chemical industry. It is recommended for all professionals working with nanoparticles and also with diverse applications where the solid-gas interface is important. Cross-listed with: CHE 555, MT 555, EN 555, CH 555

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NANO 570 Environmental Chemistry

Principles of environmental reactions with emphasis on aquatic chemistry; reaction and phase equilibria; acid-base and carbonate systems; oxidation-reduction; colloids; organic contaminants classes, sources, and fates; groundwater chemistry; and atmospheric chemistry. Cross-listed with: EN 570

NANO 571 Physicochemical Processes for Environmental Control

A study of the chemical and physical operation involved in treatment of potable water, industrial process water, and wastewater effluent; topics include chemical precipitation, coagulation, flocculation, sedimentation, filtration, disinfection, ion exchange, oxidation, adsorption, flotation, and membrane processes. A physical-chemical treatment plant design project is an integral part of the course. The approach of unit operations and unit processes is stressed. Cross-listed with: EN 571

NANO 596 Fabrication Techniques for Micro and Nano Devices (3 - 3 - 0)

Deals with aspects of the technology of processing procedures involved in the fabrication of microelectronic devices and microelectromechanical systems (MEMS). Students will become familiar with various fabrication techniques used for discrete devices as well as large-scale integrated thin-film circuits. Students will also learn that MEMS are sensors and actuators that are designed using different areas of engineering disciplines and they are constructed using a microlithographically-based manufacturing process in conjunction with both semiconductor and micromachining microfabrication technologies. Cross-listed with: MT 596, EE 596, PEP 596 Prerequisites: PEP 507

NANO 600 Nanoscale Science and Technology

This course deals with the fundamentals and applications of nanoscience and nanotechnology. Size-dependent phenomena, ways and means of designing and synthesizing nanostructures, and cutting-edging applications will be presented in an integrated and interdisciplinary manner.

NANO 602 Principles of Inorganic Materials Synthesis

The goal of this course is to learn the basic concepts commonly utilized in the processing of advanced materials with specific compositions and microstructures. Solid state diffusion mechanisms are described with emphasis on the role of point defects, the mobility of diffusing atoms, and their interactions. Macroscopic diffusion phenomena are analyzed by formulating partial differential equations and presenting their solutions. The relationships between processing and microstructure are developed on the basis of the rate of nucleation and growth processes that occur during condensation, solidification, and precipitation. Diffusionless phase transformations observed in certain metallic and ceramic materials are discussed. Cross-listed with: MT 602

NANO 610 Health and Environmental Impact of Nanotechnology

This course covers the environmental and health aspects of nanotechnology. It presents an overview of nanotechnology along with characterization and properties of nanomaterials. The course material covers the biotoxicity and ecotoxicity of nanomaterials. A sizable part of the course is devoted to discussions about the application of nanotechnology for environmental remediation along with discussions about fate and transport of nanomaterials. Special emphasis is given to risk assessment and risk management of nanomaterials, ethical and legal aspects of nanotechnology, and nano-industry and nano-entrepreneurship. Cross-listed with: EN 610

NANO 615 Crystallization of Biological Molecules

This course provides an overview and industrial perspectives regarding downstream separation in drug substance development and manufacturing. Basic principles and practical applications of unit operations most commonly employed in the pharmaceutical industry will be discussed, including extraction, absorption, membrane, distillation, crystallization, filtration, and drying. Examples will be discussed to illustrate the intrinsic relationship between process development, equipment selection, and scale-up success. Cross-listed with: CHE 615

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NANO 650 Advanced Biomaterials

Upon completion of this course, students will be able to demonstrate an understanding of the major classes of engineering materials, their principal properties, and design requirements that serve as both the basis for materials selection, as well as for the ongoing development of new materials. This course is substantially differentiated from introductory materials courses by its very specific focus on materials whose use puts them in direct contact with physiological systems. Thus, the course begins with brief sections on inflammatory response, thrombosis, infection, and device failure. It then concentrates on developing the fundamental materials science and engineering concepts underlying the structure-property relationships in both synthetic and natural polymers, metals and alloys, and ceramics relevant to in vivo medical device technology. Crosslisted with: BME 650

NANO 652 Design and Fabrication of Micro and Nano Electromechanical Systems (3 - 3 - 0)

This course follows the introductory course and covers advanced topics in the design, modeling, and fabrication of micro and nano electromechanical systems. The materials will be broad and multidisciplinary including: review of micro and nano electromechanical systems, dimensional analysis and scaling, thermal, transport, fluids, microelectronics, feedback control, noise, and electromagnetism at the micro and nanoscales; the modeling of a variety of new MEMS/NEMS devices; and alternative approaches to the continuum mechanics theory. The goal will be achieved through a combination of lectures, case studies, individual homework assignments, and design projects carried out in teams. Cross-listed with: ME 653

NANO 672 Polymers at Solid-Liquid Interfaces

The course covers recent advances in macromolecular science, including polyelectrolytes and water-soluble polymers, synthetic and biological macromolecules at surfaces, self-assembly of synthetic and biological macromolecules, and polymers for biomedical applications. Cross-listed with: CH 672

NANO 674 **Polymer Functionality**

Topics at the interface of polymer chemistry and biomedical sciences, focusing on areas where polymers have made a particularly strong contribution, such as in biomedical sciences and pharmaceuticals. Synthesis and properties of biopolymers; biomaterials; nanotechnology smart polymers; functional applications in biotechnology, tissue and cell engineering; and biosensors and drug delivery. Cross-listed with: CH 674 Prerequisites: CH 244

NANO 675 Nanomedicine

This course will provide a comprehensive introduction to the rapidly developing field of nanomedicine and discuss the application of nanoscience and nanotechnology in medicine such as, in diagnosis, imaging and therapy, surgery, and drug delivery. Cross-listed with: BME 675 Prerequisites: NANO 600

NANO 680 Fundamentals of Micro/Nano Fluidics

As an introduction to micro/nano fluidics, course topics include basic fluid mechanical theories, experimental techniques, fabrication techniques and applications of micro/nano fluidics. The theory part will cover continuum fluid mechanics at micro/ nano scales, molecular approaches, capillary effects, electrokinetic flows, acoustofluidics and optofluidics. The experimental part will cover micro/nano rheology and particle image velocimetry. The fabrication part will cover materials and machining techniques for micro/nano fluidic devices. The application part will cover micro/nano fluidic devices for flow control, life sciences and chemistry. As a term project, individual students are required to perform a case study for their own selected topic in micro/nano fluidics, to conduct a literature survey/summary and to propose/analyze their own new design idea of a micro/nano fluidic devices by utilizing the knowledge obtained throughout the course. Cross-listed with: ME 680

NANO 682 Colloids and Interfacial Phenomena at the Nanoscale

A survey course covering the chemical, biological and material science aspects of interfacial phenomena. Applications to adhesion, biomembranes, colloidal stability, detergency, lubrication, coatings, fibers and powders - where surface properties play an important role. Cross-listed with: CHE 682

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NANO 685 Nanobiotechnology

This course describes the application of nano- and micro-fabrication methods to build tools for exploring the mysteries of biological systems. It is a graduate-level course that will cover the basics of biology and the principles and practice of nanoand microfabrication techniques, with a focus on applications in biomedical and biological research. Cross-listed with: BME 685 Prerequisites: NANO 600

NANO 690 Cellular Signal Transduction

This advanced course covers the mechanism and biological role of signal transduction in mammalian cells. Topics included are extracellular regulatory signals, intracellular signal transduction pathways, role of tissue context in the function of cellular regulation, and examples of biological processes controlled by specific cellular signal transduction pathways. Cross-listed with: CH 690 Prerequisites: CH 381, CH 484 or BIO 381, BIO 484

NANO 691 Physics and Applications of Semiconductor Nanostructures (3 - 3 - 0)

This course is intended to introduce the concept of electronic energy band engineering for device applications. Topics to be covered are electronic energy bands, optical properties, electrical transport properties of multiple quantum wells, superlattices, quantum wires, and quantum dots; mesoscopic systems, applications of such structures in various solid state devices, such as high electron mobility, resonant tunneling diodes, and other negative differential conductance devices, double-heterojunction injection lasers, superlattice-based infrared detectors, electron-wave devices (wave guides, couplers, switching devices), and other novel concepts and ideas made possible by nano-fabrication technology. Fall semester. Typical text: M. Jaros, Physics and Applications of Semiconductor Microstructures; G. Bastard, Wave Mechanics Applied to Semiconductor Heterostructures. Cross-listed with: PEP 691 Prerequisites: PEP 503, PEP 553

NANO 695 **Bio/Nano Photonics**

This course deals with the principles of light interactions with biological and biomedical-relevant systems. The enabling aspects of nanotechnology for advanced biosensing, medical diagnosis, and therapeutic treatment will be discussed. Crosslisted with: CHE 695, BME 695 Prerequisites: NANO 600

NANO 700 Seminar in Nanotechnology

Lectures by department faculty, guest speakers and doctoral students on recent research.

NANO 701 Multiscale Mechanics and Computational Methods

This graduate course will introduce the applications of multiscale theory and computational techniques in the fields of materials and mechanics. Students will obtain fundamental knowledge on homogenization and heterogeneous materials, and be exposed to various sequential and concurrent multiscale techniques. The first half of the course will be focused on the homogenization theory and its applications in heterogeneous materials. In the second half multiscale computational techniques will be addressed through multiscale finite element methods and atomistic/continuum computing. Students are expected to develop their own course projects based on their research interests and the relevant topics learned from the course. Cross-listed with: CE 702

NANO 740 The Physics of Nanostructures

Progress in the technology of nanostructure growth; space and time scales; quantum confined systems; quantum wells, coupled wells, and superlattices; quantum wires and quantum dots; electronic states; magnetic field effects; electron-phonon interaction; and quantum transport in nanostructures: Kubo formalism and Butikker-Landau formalism; spectroscopy of quantum dots; Coulomb blockade, coupled dots, and artificial molecules; weal localization; universal conductance fluctuations; phase-breaking time; theory of open quantum systems: fluctuation-dissipation theorem; and applications to quantum transport in nanostructures. Cross-listed with: PEP 740 Prerequisites: PEP 554, PEP 662

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NANO 810 Special Topics in Nanotechnology

A participating seminar on topics of current interest and importance in Nanotechnology.

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Department of Civil, Environmental, & Ocean Engineering

FACULTY

DAVID A. VACCARI DEPARTMENT DIRECTOR

Khondokar Billah, Ph.D. Distinguished Service Professor

Alan Blumberg, Ph.D. George Meade Bond Professor & Director of Davidson Laboratory

Leslie Brunell, Ph.D., P.E. Associate Teaching Professor

Barry Bunin, Ph.D. Chief Architect - Maritime Security Laboratory; Research Professor

Christos Christodoulatos, Ph.D. Professor & Director of the Center for Environmental Systems

Raju Datla, Ph.D. Research Associate Professor

Dimitri Donskoy, Ph.D. Associate Professor

John Dzielski, Ph.D. Research Professor

Elizabeth Fassman-Beck, Ph.D. Associate Professor

Mirjam Furth, Ph.D. Assistant Professor

Nickitas Georgas, Ph.D. Research Assistant Professor

Sophia Hassiotis, Ph.D. Associate Professor

Thomas Herrington, Ph.D. Research Associate Professor

Len Imas, Ph.D. Research Associate Professor George Korfiatis, Ph.D. McLean Chair Professor

Sarath Jagupilla, Ph.D., P.E. Teaching Assistant Professor

Xiaoguang Meng, Ph.D., P.E. Professor

Jon Miller, Ph.D. Research Assistant Professor

Philip Orton, Ph.D. Research Assistant Professor

Valentina Prigiobbe, Ph.D. Assistant Professor

Julie Pullen, Ph.D. Associate Professor

Marcus Rutner, Ph.D. Associate Professor

Dibyendu (Dibs) Sarkar, Ph.D. Professor

Tsan-Liang Su, Ph.D. Research Associate Professor

Alexander Sutin, Ph.D. Research Professor

Linda Thomas-Mobley, Ph.D., J.D. Industry Professor

David A. Vaccari, Ph.D., P.E. Professor and Department Director

Thomas Wakeman III, Ph.D. Research Professor, Associate Department Director

Alex Washburn, Ph.D. Industry Professor for Design

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EMERITUS FACULTY

Richard Hires, Ph.D Professor Emeritus Daniel Savitsky, Ph.D Professor Emeritus/Consultant

The Civil, Environmental and Ocean Engineering Department promotes the use of engineering approaches to create solutions for societal needs concerning the built and natural environment by

- providing a high quality, broad-based undergraduate education that emphasizes both fundamental knowledge and design experiences for its students;
- developing new knowledge through cutting-edge and applied research; providing services and leadership to the public and the profession;
- integrating research knowledge and professional service experience into innovative undergraduate and graduate instruction;
- ▶ and by fostering in our students a culture of lifelong personal and professional growth.

UNDERGRADUATE PROGRAMS

The department has three programs towards the degree of bachelor of engineering (B.E.): civil engineering, environmental engineering, and engineering (with a concentration in naval engineering). In addition, there are several minors offered to engineering students in other majors. The individual B.E. programs are described below.

B.E. in Civil Engineering

Civil engineering is concerned with the design and construction of infrastructure, including structures, foundations, environmental and transportation systems, waterways, ports, irrigation, storm water and green infrastructure, and water supply and treatment. The civil engineer's vital role is to plan, design, and supervise the construction of these facilities. Civil engineering is one of the most publicly visible technical fields. It has the distinction of being one of the earliest of the engineering disciplines, yet continues to generate new technology. The basic principles of structural analysis, which are the concern of civil engineers, are expressed in every machine and aircraft, and in buildings and other constructed facilities. The study of mechanics is basic to the field of civil engineering. Water is fundamental to all life. Civil engineers design water systems with applications ranging from urban water supply to aquatic ecosystem protection. A thorough foundation in science and mathematics is necessary for the application of basic scientific principles to the design of structures and fluid systems. Computer methods are integrated throughout the civil engineering elective offerings. Graduates of the Stevens program meet the demands for positions of responsibility in various sub-disciplines of civil engineering and contribute to the advancement of the civil engineering practice. Prospective employers include industrial firms, consulting engineering firms, and construction contractors, as well as various government agencies. Our undergraduate offerings include subjects basic to all civil engineering.

Civil Engineering Program Mission and Objectives

The mission of the civil engineering program at Stevens is to educate a new generation of civil engineers who are leaders in the profession. The educational program emphasizes technical competence, professional practice, leadership, lifelong learning, civic contribution and entrepreneurship.

The program of study combines a broad-based core engineering curriculum, and a substantial experience in the humanities and in business engineering management, with specialization in civil engineering. Within the sequence of civil engineering courses, students have the flexibility to concentrate in structural, transportation, geotechnical, water resources, environmental engineering, and construction management.

The objectives of the civil engineering program are provided in terms of our expectations for our graduates. Within several years of graduation:

- Our graduates apply mathematics and science to solve complex problems in civil engineering.
- Our graduates apply skills in problem solving, teamwork, ethics, management, communication, and awareness of professional and social issues to establish leadership in their chosen career paths.

Civil Engineering Curriculum

Term I					
Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	12	10	27	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II ¹	3	0	6	3
PEP 111	Mechanics	3	0	6	3
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

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Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ²	3	0	6	3
PE 200	Physical Education	0	2	0	0
	Total	16	8	37	19

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
MA 227	Multivariable Calculus	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics	3	0	6	3
CE 373	Structural Analysis	3	0	3	3
Hum	Humanities ²	3	0	6	3
BIO 281	Biology and Biotechnology ¹	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	17	5	34	18

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CE 342	Fluid Mechanics	3	3	6	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Probability and Statistics for Engineers	3	0	6	3
CE 486	Structural Steel Design	3	0	3	3
Hum	Humanities ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	8	29	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
E 355	Engineering Economics	3	3	6	4
CE 322	Engineering Design VI	1	3	2	2
CE 304	Water Resources Engineering	3	0	3	3
CE 483	Geotechnical Engineering	2	3	6	3
G.E.	General Elective ³	3	0	6	3
T.E.	Technical Elective ⁴	3	0	3	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	11	26	18

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Course #	Course Name	Lecture	Lab	Study	Credit
CE 381	Civil Engineering Measurements Lab	2	3	3	3
T.E.	Technical Elective ⁴	3	0	6	3
G.E.	General Elective ³	3	0	6	3
CE 423	Engineering Design VII	0	8	3	3
TG 403	Senior Innovation I	2	0	4	2
CE 484	Reinforced Concrete Design	3	0	3	3
	Total	13	12	25	17

Term VII

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ⁴	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
G.E.	General Elective ³	3	0	6	3
CE 424	Engineering Design VIII	0	8	3	3
Hum	Humanities ²	3	0	6	3
CE 345	Modeling and Simulation	3	0	3	3
	Total	13	8	26	16

(1) Science electives – one elective must have a laboratory component

(2) Humanities requirements can be found on pages 556-557.

- (3) General electives chosen by the student can be used towards a minor or option- can be applied to research or approved international studies
- (4) Technical Electives: Any 500 and 600-level course in Civil, Environmental, Ocean, or Mechanical Engineering is acceptable. At least one of the Technical Electives should be chosen from EN 377, CE 410 or CE 541.

B.E. in Environmental Engineering

Environmental engineering has traditionally been taught as a branch of civil engineering concerned with the supply of safe drinking water and the sanitary disposal of municipal wastes. The field has expanded in recent years to include many new areas, such as the treatment of industrial and hazardous wastes, the prediction of the fate and transport of pollutants in the environment, and the design of systems for remediation of sites contaminated with hazardous wastes. Furthermore, the field continues to grow into new directions such as sustainability and green engineering. These changes have placed new demands on engineers to understand the fundamental environmental transformation processes that describe natural and engineered systems for which this program is designed to prepare our students.

Environmental Engineering Program Mission and Objectives

The mission of the environmental engineering program is to provide a broad-based education that prepares students in the technical and social fundamentals that will enable them to have a wide impact in the improvement of interactions between humans and their environment.

The objectives of the program are aligned with these expectations for our graduates

Graduates of our program will be recognized as being among "the best in the business" by their peers by leveraging their strong technical basis to continuously increase their skills and knowledge in their area of expertise, and will develop the qualifications for licensure.

- Graduates of our program will have a positive impact on their workplace through multidisciplinary collaboration, teamwork and leadership.
- Graduates of our program effectively navigate important contextual factors in their careers, including the historical, regulatory, political, policy, economic, ethical and public relations aspects of environmental problems.

Environmental Engineering Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 101	Engineering Experiences I	1	0	0	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	12	10	27	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
PEP 111	Mechanics	3	0	6	3
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	8	30	18

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ²	3	0	6	3
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
PE 200	Physical Education	0	2	0	0
	Total	16	8	37	19

Term IV					
Course #	Course Name	Lecture	Lab	Study	Credit
MA 227	Multivariable Calculus	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
Hum	Humanities ²	3	0	6	3
S.E.	Science Elective II ¹	3	0	6	3
EN 377	Introduction to Environmental Engineering Systems	3	0	0	3
EN 379	Environmental Engineering Laboratory	0	3	0	1
CHE 234	Chemical Engineering Thermodynamics	4	0	8	4
PE 200	Physical Education II	0	2	0	0
	Total	18	8	33	20

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CE 342	Fluid Mechanics	3	3	6	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
CHE 210	Process Analysis	3	0	3	3
EN 541	Fate and Transport of Environmental Contaminants	3	0	6	3
Hum	Humanities ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	8	29	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
EN 345	Modeling and Simulation of Environmental Systems	3	0	6	3
E 355	Engineering Economics	3	3	6	4
EN 322	Engineering Design VI	1	3	5	2
EN 570	Environmental Chemistry	3	0	6	3
EN 571	Physicochemical Processes for Environmental Control	3	0	6	3
G.E.	General Elective ³	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	16	8	35	18

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
EN 573	Biological Processes for Environmental Control	3	0	6	3
EN 575	Environmental Biology	3	0	6	3
EN 423	Engineering Design VII	1	7	4	3
E 243	Probability and Statistics for Engineers	3	0	6	3
TG 403	Senior Innovation I	2	0	4	2
G.E.	General Elective ³	3	0	6	3
	Total	16	7	34	17

Course #	Course Name	Lecture	Lab	Study	Credit
EN 506	Air Pollution Principles and Control	3	0	6	3
EN 551	Environmental Chemistry of Soils and Natural Surfaces	3	0	6	3
EN 424	Engineering Design VIII	1	7	4	3
Hum	Humanities ²	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
G.E.	General Elective ³	3	0	6	3
	Total	14	7	32	16

Term VIII

 Science elective – Science II can be one of the following: CH 281 Biology, PEP 151 Introduction to Astronomy, NANO 200 Intro to Nanotechnology, EN250 Quantitative Biology or PEP201 Physics III for Engineers – one elective must have a laboratory component
 Humanities requirements can be found on pages 556-557.

(3) General electives – chosen by the student – can be used towards a minor or option – can be applied to research or approved international studies

(4) Technical Electives: Any 500 and 600-level course in Civil, Environmental, Ocean, or Mechanical Engineering is acceptable. At least one of the Technical Electives should be chosen from EN 377, CE 410 or CE 541.

B.E. in Engineering (Concentration in Naval Engineering)

The naval engineering concentration within the engineering program is a broad-based discipline that involves the design, construction, operation, and maintenance of surface and subsurface ships, ocean structures, and shore facilities. Although these vessels and facilities are traditionally employed in the defense of the nation, many are also employed in the support of the civilian (commercial) Marine Transportation System. Because of the complexities of today's naval and civilian vessels and supporting infrastructure, the naval engineer must possess a strong background in the physical sciences, mathematics, and modeling, as well as the more specialized fields of naval architecture, marine engineering, systems engineering, and environmental engineering.

Engineering Program Mission and Objectives

The mission of the engineering program with a concentration in naval engineering at Stevens is to develop innovative engineers capable of international leadership in the profession. The educational program emphasizes design innovation, trans-disciplinary study, a systems perspective on complex ship and infrastructure designs, lifelong learning, and opportunities for international study and internships. As is the case for the other Stevens engineering programs, the engineering program includes a broad-based core engineering curriculum and a substantial experience in the humanities.

The program is conducted in concert with the Stevens leadership in the Office of Naval Research-sponsored Atlantic Center for the Innovative Design and Control of Small Ships and in collaboration with University College London.

The objectives of the engineering program are provided in terms of our expectations for our graduates. Within several years of graduation, they will

- Graduates of the engineering program will be recognized as being among "the best in the business" by their peers in technical disciplines that engineering graduates are engaged in. They will leverage their broad engineering background to continuously expand their areas of expertise.
- Graduates of our program will professionally enhance their workplace through multidisciplinary collaboration, teamwork and leadership.
- Graduates of our program will maintain exemplary sensitivity to social factors including the environmental, historical, legal, political, policy, economic, ethical and public relations aspects of problems in various engineering disciplines.

Engineering (with a concentration in Naval Engineering) Curriculum

Term I					
Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	12	10	27	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
	Science Elective I ¹	3	0	6	3
PEP 111	Mechanics	3	0	6	3
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ²	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	8	37	19

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Course #	Course Name	Lecture	Lab	Study	Credit
MA 227	Multivariable Calculus	3	0	6	3
E 234	Thermodynamics	3	0	6	3
	Science Elective II ¹	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
Hum	Humanities ²	3	0	6	3
OE 524	Introduction to Ship Design and Ship Building	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	17	5	37	18

Term IV

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CE 342	Fluid Mechanics	3	3	6	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Probability and Statistics for Engineers	3	0	6	3
Hum	Humanities ²	3	0	6	3
OE 525	Principles of Naval Architecture	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	8	32	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
OE 528	Computer-Aided Ship Design	3	0	6	3
E 355	Engineering Economics	3	3	6	4
NE 322	Engineering Design VI	1	3	5	2
OE 520	Design of Marine Structures	3	0	6	3
G.E.	General Elective ³	3	0	6	3
CE 373	Structural Analysis	3	0	3	3
PE 200	Physical Education IV	0	2	0	0
	Total	16	8	32	18

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ⁴	3	0	6	3
OE 527	Laboratory in Naval Architecture	0	3	0	3
G.E.	General Elective ³	3	0	6	3
NE 423	Engineering Design VII	1	7	4	3
TG 403	Senior Innovation I	2	0	4	2
OE 531	Total Ship Design I	3	0	6	3
	Total	13	10	28	18

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Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ⁴	3	0	6	3
OE 532	Total Ship Design II	3	0	6	3
NE 424	Engineering Design VIII	1	7	4	3
TG 404	Senior Innovation II	1	0	2	1
G.E.	General Elective ³	3	0	6	3
Hum	Humanities ²	3	0	6	3
	Total	14	7	30	16

(1) Science electives can be found on pages 78-80.

(1) Humanities requirements can be found on pages 556-557.

(3) General Electives are chosen by the student and can be used towards a minor or option or can be applied to research or approved international studies.

(4) Technical Electives: discipline specific course

Graduation Requirements

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- ▶ Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirement

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

Minors

Students may qualify for minors in structural engineering, coastal engineering, water resources, or environmental engineering by taking the required courses indicated below. Completion of a minor indicates proficiency beyond that provided by the Stevens engineering curriculum in the basic material of the selected area. The minor program must be in a discipline other than that of a student's major program of study, and at least two courses in the minor must be overload courses, beyond the credit requirements for all other programs being pursued by the student.

Structural Engineering

A minimum of six of courses must be selected from the following:

- ▶ CE 345 Modeling and Simulation
- ► CE 373 Structural Analysis

Two of the following courses:

- CE 484 Concrete Structures or CE 486 Structural Steel Design
- ▶ CE 519 Advanced Structures
- ▶ CE 681 Finite Elements

And one or two of the following:

- CE 579 Advanced Reinforced Concrete Structures
- ► CE 623 Structural Dynamics
- ▶ CE 660 Advanced Steel Structures

Water Resources

- CE 304 Water Resources Engineering
- ▶ CE 342 Fluid Mechanics
- CE 535 Stormwater Management
- CE 578 Coastal and Floodplain Engineering or CE 537 Introduction to GIS
- CE 685 Advanced Hydraulics or CE 652 Hydrologic Modeling
- ▶ EN 686 Groundwater Hydrology and Pollution

Coastal Engineering

- CE 304 Water Resources Engineering
- CE 342 Fluid Mechanics
- ▶ OE 501 Oceanography
- ▶ OE 589 Coastal Engineering
- OE 535 Ocean Measurements and Analysis
- CE 578 Coastal and Floodplain Engineering

Environmental Engineering

- ▶ CHE 210 Process Analysis
- ▶ CE 342 Fluid Mechanics
- ▶ EN 375 Environmental Systems

And any three of the following courses:

- ▶ EN 570 Environmental Chemistry
- ▶ EN 541 Fate and Transport of Environmental Contaminants
- ▶ EN 571 Physicochemical Processes for Environmental Control
- ▶ EN 573 Biological Processes for Environmental Control

GRADUATE PROGRAMS

The goal of the graduate programs is to prepare students to be technical leaders in their field, including the ability to do original research. The department offers master of engineering, master of science, doctoral degrees, and the degree of civil engineer. The master's degrees may be with or without thesis. Major areas of current research in civil engineering include wind engineering, multi-scale modeling and stochastic mechanics, nondestructive evaluation and damage identification, bridge and infrastructure evaluation and design, soil-structure interactions, soil mechanics, deep foundation systems, and green infrastructure for urban stormwater management. In environmental engineering we have been studying advanced

oxidation of hazardous wastes, statistical process control of wastewater treatment, stabilization/solidification of contaminated soil, and physicochemical treatment of heavy metal contaminated wastes. Our ocean engineering group conducts research on hydrodynamic modeling of currents and the dispersion of effluents in the coastal zone, experimental and computational marine hydrodynamics, coastal sediment transport, climate change, port security, coastal hazards, inland and coastal flooding, storm surges, maritime transportation, and analysis of current and wave observations in the coastal ocean.

An undergraduate degree in engineering or related disciplines with a "B" average from an accredited college or university is generally required for graduate study in civil, environmental, and ocean engineering. It is required that any applicants requesting assistantship appointments, and applicants to the Ph.D. program, provide GRE scores as well as evidence of ability to carry out independent work. Examples of such evidence include a description of master's degree thesis work and/or completed work-related projects. GRE scores are not otherwise required, but may be submitted in support of the application. International students must demonstrate their proficiency in the English language prior to admission by scoring at least 550 (79 computer-based) on the TOEFL examination. Applications for admission from qualified students are accepted at any time.

Master's Programs

Master's degree programs build on baccalaureate degrees to provide the student with added depth and specialization. The Master of Engineering (M.E.) degree is offered with programs in civil, environmental, and ocean engineering, and the Master of Science (M.S.) is offered in Construction Management. The programs require 30 credit-hours of course work. A thesis is optional and may be substituted for five to ten credit hours of course work. The thesis option is strongly recommended for full-time students, those receiving financial support, or those planning to pursue doctoral studies.

Master of Engineering - Civil Engineering

Concentrations are available in the areas of structural, transportation, geotechnical, and water resources engineering. The student must complete core courses depending on the areas of concentration as follows:

Civil Engineering Concentrations

Structural Engineering

- CE 519 Advanced Structural Analysis
- CE 579 Advanced Reinforced Concrete Structures
- ▶ CE 595 Geotechnical Design
- CE 660 Advanced Steel Structures
- CE 681 Finite Element Methods

Transportation Engineering

- CM 508 Transportation Engineering
- CE/ES 5xx Transportation Systems Planning and Operations
- CE/ES 6xx Traffic Flow Modeling and Operations
- ▶ EN 5xx Sustainable Transportation Systems

In addition, at least four courses must be selected in one of the transportation subspecialty areas (contact an advisor for details).

Geotechnical/Geoenvironmental Engineering

- ▶ CE 595 Geotechnical Design
- EN 520 Soil Behavior and its Role in Environmental Applications
- ▶ EN 654 Environmental Geotechnology
- ▶ EN 686 Groundwater Hydrology and Pollution

Water Resources Engineering

- CE 525 Engineering Hydrology or CE 504 Water Resources Engineering
- CE 535 Stormwater Management
- ▶ CE 652 Hydrologic Modeling
- CE 565 Numerical Methods in Civil and Environmental Engineering
- ▶ EN 686 Ground Water Hydrology and Pollution

Substitutions for core courses may be considered on a case-by-case basis in consultation with your advisor.

Master of Engineering - Environmental Engineering

The Environmental Engineering graduate program is divided into three areas of concentration: Environmental Control Processes, Groundwater and Soil Pollution Control, and Environmental System Modeling.

The Environmental Processes concentration addresses the treatment of industrial and domestic water and wastewater, and hazardous wastes. Process fundamentals are integrated with a design-based approach to meeting treatment objectives. Students will be prepared for careers in both design and operation of facilities for pollution control. Graduates of this program are best qualified for design and operation work in public and private treatment facilities such as for drinking water, wastewater, and industrial wastes.

The Groundwater and Soil Pollution Control concentration emphasizes the transport and fate of contaminants in the subsurface environment and on engineering processes to mitigate their adverse environmental impact. Some specific areas of study in this option are the modeling of contaminant transport in local or regional geohydrologic systems, the impact of contamination in the subsurface environment, the management of municipal and industrial waste disposal, and the remediation of groundwater and soil. Many of our graduates in this option work in remediation of contaminated properties or of groundwater resources.

The Modeling of Environmental Systems concentration addresses the circulation and mixing processes in surface waters and the effect of such processes on the fate and transport of contaminants. Deterministic, stochastic, and experimental techniques are emphasized. Major areas of current faculty research include groundwater hydrology and pollution, water and wastewater treatment processes, design of waste disposal management, and environmental processes in coastal and estuarine waters. This option is appropriate for those interested in a more analytical approach to environmental processes in nature, and has career interests in conducting studies of pollutant fate and transport in the environment, or who have an interest in a research or academic career.

Master's candidates without a previous engineering degree may, on a case-by-case basis, be allowed to enroll for the Master of Engineering in Environmental Engineering if they have a bachelor's degree in a relevant science discipline. These students may be required to take additional engineering courses, including undergraduate courses, not for credit towards a degree. All applicants must have at least two years of calculus and one year of chemistry.

Core Courses

- ▶ CE 565 Numerical Methods for Civil and Environmental Engineering
- EN 541 Fate and Transport of Environmental Contaminants
- ▶ EN 570 Environmental Chemistry

Environmental Engineering Concentrations

Environmental Control Processes

- ▶ EN 570 Environmental Chemistry
- ▶ EN 571 Physicochemical Processes for Environmental Control
- ▶ EN 573 Biological Processes for Environmental Control
- ▶ EN 575 Environmental Biology
- ▶ EN 637 Environmental Control Laboratory
- ▶ EN 751 Design of Wastewater Facilities

Groundwater and Soil Pollution Control

- ▶ EN 520 Soil Behavior and its Role in Environmental Applications
- ▶ EN 551 Environmental Chemistry of Soils
- ▶ EN 553 Groundwater Engineering
- ▶ EN 654 Environmental Geotechnology
- ▶ EN 686 Groundwater Hydrology and Pollution
- ▶ EN 690 Soil and Groundwater Remediation Technologies

Modeling of Environmental Systems

- CE 679 Regression and Stochastic Methods
- CE 684 Mixing Processes in Inland and Coastal Waters
- ▶ EN 680 Modeling of Environmental Systems
- ▶ EN 780 Nonlinear Correlation and System Identification

The remaining courses are electives, which are selected in consultation with the academic advisor. Electives may be concentrated in specific areas, such as:

Inland and Coastal Environmental Hydrodynamics

- ▶ CE 525 Engineering Hydrology
- ▶ OE 501 Oceanography
- ▶ OE 616 Sediment Transport

Water Resources

- ▶ CE 525 Engineering Hydrology
- ▶ CE 535 Stormwater Management

Air Pollution Control

- ▶ EN 505 Air Pollution Principles and Control
- ▶ EN 550 Environmental Chemistry of Atmospheric Processes
- ▶ OE 591 Introduction to Dynamic Meteorology

Environmental Sustainability

- ▶ EN 545 Environmental Impact Analysis and Planning
- ▶ EN 547 Project Life Cycle Analysis
- ▶ EN 548 Environmental Compatibility in Design and Manufacturing

Master of Engineering - Ocean Engineering

The Ocean Engineering graduate program has six areas of concentration that are rooted in traditional and emerging topics in ocean engineering. Concentrations are offered in Coastal Engineering, Naval Engineering, Maritime Systems Engineering, Maritime Structures, Global Change & Urban Coastal Resilience, and Earth Systems. The program requires the completion of three core courses that can be combined with other courses in the program to create degrees focused on any number of ocean engineering topics, including: ocean and atmospheric modeling, sediment transport, green infrastructure design, mixing processes in coastal and estuarine waters, environmental fluid mechanics, estuarine and coastal ocean modeling, motion of vessels in waves, underwater acoustics, renewable energy, and urban coastal resilience. The master's degree program requires one graduate-level applied mathematics courses, one time series analysis course and satisfaction of the following additional requirements by concentration:

Core Courses

- OE 501 Oceanography or OE 511 Urban Oceanography
- ▶ OE 630 Hydrodynamics
- MA 530 Applied Mathematics for Engineers & Scientists II or PEP 527 Mathematical Methods of Engineering and Science I

One or more of the required core courses may be waived with the approval of your academic advisor.

Ocean Engineering Concentrations

Coastal Engineering Concentration

- OE 535 Ocean Measurements and Analysis
- CE 578 Coastal and Floodplain Engineering
- ▶ OE 585 Littoral Processes
- OE 589 Coastal Engineering

The remaining courses in the Coastal Engineering Concentration are electives, which are selected in consultation with the academic advisor.

Naval Engineering Concentration

- OE 524 Introduction to Ship Design and Ship Building
- OE 525 Principles of Naval Architecture

- CE 527Laboratory in Naval Architecture
- ▶ OE 528 Computer Aided Ship Design

The remaining courses in the Naval Engineering Concentration are electives, which are selected in consultation with the academic advisor.

Maritime Systems Engineering Concentration

This concentration provides the participant with a fundamental working knowledge of the principles of systems engineering and systems architecture and applies these to the key issues facing the evolving maritime transportation system. The courses for this concentration are:

- ▶ OE 505 Maritime Systems Engineering
- ▶ SYS 605 Systems Integration
- ▶ SYS 625 Fundamentals of Systems Engineering
- SYS 650 System Architecture and Design
- OE 626 Port Planning and Development

The remaining courses in the Maritime Systems Engineering Concentration are electives, which are selected in consultation with the academic advisor.

Maritime Structures Concentration

This concentration provides knowledge of the specific structure types and design analyses associated with port and maritime systems. Students are given instruction in the various design and maintenance considerations unique to the marine and inland waterway environments. In addition, students will gain skills in using state-of-the-art design tools, including computer and physical models of maritime structures for consideration in construction and maintenance applications. The courses for this concentration are:

- OE 520 Designs of Marine Structures
- ▶ CE 530 Nondestructive Evaluation
- ▶ OE 589 Coastal Engineering
- OE 622 Design of Port Structures I
- CE 649 Earth Supported Structures Or
- CE 687 Design of Hydraulic Structures

The remaining courses in the Maritime Structures Concentration are electives, which are selected in consultation with the academic advisor.

Global Change & Urban Coastal Resilience Concentration

This concentration provides a background in Urban Ocean and Meteorology with a particular focus on the coastal zone. It also prepares students to address challenges faced by cities in a changing climate.

- OE 578 Coastal and Floodplain Engineering
- ▶ OE 593 Urban Meteorology
- ▶ OE 592 Global Warming: Weather, Climate and Society
- ES 520 The Nature of Urban Design

The remaining courses in the Global & Urban Resilience Concentration are electives, which are selected in consultation with the academic advisor.

Earth Systems Concentration

This concentration gives a foundation in aspects of the earth system through the components (oceanography, meteorology, and hydrology) and as a whole (climate).

- ▶ OE 591 Introduction to Dynamic Meteorology
- OE 633 Dynamic Oceanography
- ▶ CE 652 Hydrologic Modeling
- OE 592 Global Warming: Weather, Climate and Society

The remaining courses in the Earth Systems Concentration are electives, which are selected in consultation with the academic advisor from the following list:

- ▶ OE 511 Urban Oceanography
- OE 535 Ocean Measurements and Analysis
- ▶ OE 593 Urban Meteorology
- OE 634 Air-Sea Interactions: Theory and Measurement
- ▶ OE 637 Estuarine Oceanography
- CE 648 Numerical Hydrodynamics
- CE 681 Introduction to Finite Element Methods
- CE 684 Mixing Processes in Inland and Coastal Waters
- OE 688 Coastal Ocean Dynamics I

Master of Engineering- Construction Engineering and Management

The Stevens Institute of Technology degree in Construction Engineering and Management prepares engineers to lead efforts in designing, planning, constructing, and managing society's buildings, green infrastructure, and utility projects in addition to endeavors yet-to-be-envisioned such as implementing construction of facilities for alternative energy distribution and global megaprojects.

Our students will lead the teams and manage the resources that are crucial to global human health and other demands of developing nations. The classes build upon the student's engineering undergraduate degree to develop technical, managerial and leadership expertise through advanced areas of study and initiatives including experiential learning and engagement with industry. Both full and part-time graduate students can take advantage of the flexible curriculum designed to fit into the busy schedule as some classes are offered online.

The Master of Construction Engineering and Management is for students with an undergraduate degree in civil engineering wishing to obtain specialized knowledge in construction engineering, project controls and management. Students with other engineering backgrounds may have to take additional prerequisites which will be determined on a case by case basis at time of admission.

The master's degree requires completion of a total of 30 hours of credit. Each student must complete six core courses (18 credit hours). Students choosing to complete a master's thesis shall take CM900 for six credits and choose six additional credits from approved electives. Students not choosing to complete a thesis will take a practicum class for three credits and choose nine additional credits from approved electives. The elective classes must be chosen from among the Civil

Environmental and Ocean Engineering graduate courses in this catalog. Elective courses not in the CM program or the CEOE department are available upon the approval of the student's academic advisor.

Core Courses

- CM 501 Construction Engineering I
- CM 601 Construction Engineering II
- CM 605 Construction Safety Management
- CE 649 Earth Supporting Structures
- CE 541 Project Management for Construction
- CM 581 Temporary Structures in Heavy Construction

One of the following:

- CM 900 Construction Management Master's Thesis, or
- CM 671 Construction Management Practicum

One or more of the required core courses may be waived with the approval of your academic advisor.

Master of Science - Construction Management

The construction industry today challenges the world economy with a huge volume of infrastructure-related mega projects annually. These projects become more and more complex as advancing technology demands. The future construction project will typically not only involve implementing a complex design, but also leading a diverse and technically competent labor pool, coordinating teams of Architecture and Engineering experts and reacting to changing geopolitical influences.

As a professional, the Construction Manager has evolved as the leader responsible for coordinating the resources necessary for successful completion of a high quality project, on-time and within budget expectations. The Construction Manager must master the skills of leadership, project controls, and digital-proficiency beyond estimating and scheduling software. The industry also demands inquiry into this age-old profession so that mega projects, infrastructure renewal, and urban resiliency can be planned and delivered with confidence.

The program is designed to focus on the complex mega project and allows students to select courses from the Schools of Systems and Enterprises, Technology Management and Arts and Letters. An undergraduate degree in Architecture, Construction Management, Engineering or related disciplines from a recognized school is a prerequisite for graduate study in construction management. Applicants not meeting this prerequisite will be reviewed on a case-by-case basis and may be required to enroll in CM 510 (Construction Management Fundamentals) course if accepted.

Stevens offers a Master of Science degree and several Graduate Certificates in Construction Management. The successful degree graduate will complete five core courses for 15 credits and an additional 15 credits from graduate-level courses within Construction Management or pre-approved courses offered institute-wide.

Core Courses

- ▶ CM 506 Computer Application in the Construction Process
- CM 592 Avanced Project Controls for the Built Envirnment
- CM 605 Construction Safety Management

Master of Science - Sustainability Management

The M.S. in Sustainability Management is for students in science, engineering, architecture, planning, business, social science, communications, law and policy fields who want to be a part of the relatively new, but rapidly-growing cadre of trained sustainability experts and managers. The program intends to turn their passion for sustainability into impactful careers by devising a dynamic, mission-driven curriculum that focuses on application of sustainability principles in all spheres of life – environmental, economic, social - for protection of the environment and earth's natural resources, in promoting economic development without impacting the environment, and in implementing practical solutions based on principles of social inclusion, thus ensuring a better quality of life for all members of the society. Students benefit from close interaction with an internationally recognized faculty with diverse educational and professional backgrounds; hybrid format of many classes that are offered in the evenings; and networking opportunities with industry and academic experts via participation in the weekly Sustainability Seminar Series. Graduates of the program will be well positioned to lead the workforce in devising and implementing sustainable strategies for development in business, non-profit organizations, and in the public sector (municipal government to federal).

Admission into the MS degree program in Sustainability Management is available to students with an undergraduate degree in science, engineering, architecture, planning, business, social science, communications, law, policy or any other relevant discipline with a grade point average of "B" or better from an accredited college or university. The degree program caters to the interests of new graduates, early- to mid-career professionals in sustainability related fields who can use formal training in sustainability for career advancement, and those wishing to make a career change from any other field to the exciting area of sustainability management.

The following are required courses for the M.S. in Sustainability Management (courses with numbers listed with xx are under development):

- SM 5xx /EN 5xx Perspectives in Environmental Management⁽¹⁾
- SM 5xx /EN 5xx Statistical Methods in Sustainability⁽¹⁾
- CAL 581 Environmental Policy
- ► MGT 609 Project Management
- SM 5xx Environmental Assessment⁽¹⁾
- ► SM 5xx Sustainable Business Strategies⁽¹⁾
- SM 6xx /EN 5xx Project in Sustainability Management⁽¹⁾
- SM 5xx /EN 5xx Seminar in Sustainability Management^{(1),(2)}
 - (1) New courses proposed for this new degree program.
 - (2) 1 credit course required for 3 semesters

In addition, two elective courses will be selected in consultation with the advisor based on factors such as whether the student has a background in science or engineering or in social science or in business.

Graduate Certificate Programs

The department offers the following programs leading to graduate certificates. Students need to meet regular admissions requirements for the master's program and complete the courses listed below. The courses may also be used toward corresponding Master of Engineering or Master of Science within the department with approval of your academic advisor.

Applied Coastal Oceanography

Required:

- ▶ OE 501 Oceanography
- ▶ OE 589 Coastal Engineering

Choose two from the following list:

- ▶ OE 620 Marine Structures
- ▶ OE 630 Hydrodynamics
- OE 635 Stochastic Analysis of Ocean Waves
- ▶ OE 641 Dynamics of Ocean Waves
- OE 647 Advanced Hydrodynamics Laboratory

Atmospheric and Environmental Science and Engineering (Interdisciplinary)

- ▶ PEP 575 Fundamentals of Atmospheric Radiation and Climate
- ▶ CE 591 Introduction to Dynamic Meteorology
- ME 532/EN 506 Air Pollution Principles and Control
- ▶ EN 550 Environmental Chemistry of Atmospheric Processes

Construction Professional Certificate

- CM 605 Construction Safety Management
- CM 50 Computer Applications in Construction Projects
- CM Elective I
- CM Elective II

Construction/Quality Management

- CM 541 Project Management for Construction
- CM 542 Quality Management and Construction Performance
- CM 580 Construction Management I
- CM 590 Construction Management II

Construction Accounting/Estimating

- CM 509 Construction Cost Analysis and Estimating
- ▶ CM 511 Construction Accounting
- CM 580 Construction Management I
- CM 590 Construction Management II

Construction Law/Disputes

- CM 522 Labor Relations
- CM 550 Construction Contract Law I
- CM 551 Construction Contract Law II
- CM 587 Environmental Law and Management

Environmental Compatibility in Engineering

- ▶ EN 505 Environmental Engineering
- ▶ EN 541 Fate and Transport of Environmental Contaminants
- ▶ EN 545 Environmental Impact Analysis and Planning
- ▶ EN 547 Project Life Cycle Management
- ▶ EN 548 Environmental Compatibility in Design and Manufacturing

Environmental Processes

- ▶ EN 541 Fate and Transport of Environmental Contaminants
- ▶ EN 570 Environmental Chemistry
- ▶ EN 571 Physiochemical Processes for Environmental Control
- ▶ EN 573 Biological Processes for Environmental Control

Geotechnical Engineering

- CE 520 Soil Behavior and its Role in Environmental Applications
- ▶ CE 560 Advanced Soil Testing
- ▶ CE 595 Geotechnical Design
- CE 649 Earth Supporting Structures

Inland and Coastal Environmental Hydrodynamics

- ▶ OE 501 Oceanography
- EN 541 Fate and Transport of Environmental Contaminants
- CE 684 Mixing Processes in Inland and Coastal Waters

Ocean Engineering

Required:

- ▶ OE 501 Oceanography
- ▶ OE 589 Coastal Engineering

Choose two from the following list:

- ▶ OE 620 Marine Structures
- ▶ OE 630 Hydrodynamics

- OE 635 Stochastic Analysis of Ocean Waves
- ▶ OE 641 Dynamics of Ocean Waves
- OE 647 Advanced Hydrodynamics Laboratory

Ship Hydrodynamics

Required:

- OE 525 Principles of Naval Architecture
- ▶ OE 620 Marine Structures

Choose two from the following list:

- ▶ OE 530 Yacht Design
- OE 526 Computer Aided Aspects of Naval Architecture
- ▶ OE 642 Motion of Vessels in Waves
- OE 645 Hydrodynamics of High Speed Craft
- ▶ OE 647 Advanced Hydrodynamics Laboratory

Soil and Groundwater Pollution Control

- ▶ EN 520 Soil Behavior and its Role in Environmental Applications
- ▶ EN 553 Groundwater Engineering
- ▶ EN 686 Groundwater Hydrology and Pollution
- ▶ EN 690 Soil and Groundwater Remediation Technologies

Structural Engineering

- CE 613 Matrix Analysis of Structures
- CE 519 Advanced Structural Analysis
- ▶ CE 623 Structural Dynamics
- ▶ CE 681 Introduction to Finite Element Methods

Water Resources Engineering

- ▶ CE 525 Engineering Hydrology
- CE 535 Stormwater Management or CE 537 Introduction to GIS
- CE 652 Hydrologic Modeling or CE 685 Advanced Hydraulics
- EN 686 Ground Water Hydrology and Pollution

Maritime Security

The objectives of this program are to provide the student with the operational and technological skills to deal with the international safety and security issues facing the Maritime Transportation System. The student's perspective may be that of a vessel or port operator, Port Authority, or military or governmental security agency. Risk-based analyses are performed to assess concerns related to vessel and shore labor practices, navigational security and safety including cargo (e.g., oil spills)

and vessel traffic (e.g., collisions). Acoustic and electromagnetic sensor and security technologies are studied, with a focus on their application to various security threat scenarios, including terrorism, piracy, and crime.

- ▶ OE 529 Maritime Safety and Security
- ▶ OE 560 Fundamentals of Remote Sensing
- ▶ OE 628 Technologies for Maritime Security
- OE 629 Advanced Maritime Security

Maritime Structures

The objectives of this certificate are: to better enable the student to understand the unique factors which must be considered when designing structures for the marine environments such as waves, storm surges, and high winds, and to provide them with the knowledge to apply this understanding to structural design. Upon completion of this certificate, the student will be able to determine relevant design parameters, such as wave height, water level, run up, and overtopping through an analysis of the site conditions, and to apply these parameters to design coastal, marine and port structures. In addition, the student will have the skills necessary to evaluate the integrity of existing structures using non-destructive techniques, which combined with a knowledge of the marine environment, will allow them to determine the adequacy or inadequacy of the structure.

- ▶ OE 520 Designs of Marine Structures
- ▶ OE 589 Coastal Engineering
- OE 622 Design of Port Structures
- CE 530 Nondestructive Evaluation

Maritime Systems Engineering

The complex issues facing the maritime industry as an end-to-end supply chain are addressed through the discipline of systems engineering. The objectives of this certificate are to provide the student with the basic knowledge of the systems engineering discipline and the ability to apply that discipline to the actual problems and projects the student will face on the job. Upon completion, the student will be able to decompose complex problems into manageable subsystems, understand the requirements that must be met by solutions to these problems, and construct end-to-end solutions that meet these requirements. The intended audience includes industry and government practitioners and students who wish to acquire the skills to address complex issues in the Maritime Transportation System.

- SYS 625 Fundamentals of Systems Engineering
- SYS 650 Systems Architecture and Design
- ▶ OE 610 Maritime Transportation
- OE 626 Port Planning and Development

Maritime Systems Management

This certificate program is designed to provide basic management skills applied to the maritime industry. The objectives of this certificate are: to better enable industry practitioners to meet today's maritime industry management requirements; to assist them in recognizing current business trends and opportunities in their technical and operational undertakings; and to complement the skill set of those experienced in marine operations to enable them to move into managerial positions of increased responsibility. Student will gain the skills necessary to organize and manage large scale, complex projects, or structure new organizations in a changing business environment. The intended audience includes industry practitioners wishing to complement operational experience with management skills, and students wishing to pursue management positions in the maritime industry.

- ▶ OE 610 Marine Transportation
- MGT 607 Managerial Economics
- MGT 641 Marketing Management
- MGT 609 Project Management Or
- MGT 680 Organizational Behavior and Theory

Maritime Transportation

The program objective is to enable the student to meet modern naval architecture and marine engineering challenges including the design of vessels and related port structures taking into account requirements such as short sea shipping, shallow water navigation, and multi-hull design. The intended audience includes engineering students and practitioners from the commercial, operational, and governmental arenas. The student will be able to assume positions of management and leadership by virtue of the combination of advanced technology, professional managerial practices, and legal and regulatory requirements acquired.

- ▶ OE 525 Principles of Naval Architecture
- OE 626 Port Planning and Development
- ▶ OE 642 Motion of Vessels in Waves
- OE 643 Stability and Control of Marine Craft

Doctoral Program

The program leading to the Doctor of Philosophy degree is designed to develop the student's capability to perform research or high-level design in civil, environmental, or ocean engineering. Admission to the doctoral program is made through the departmental graduate admissions committee, based on review of the applicant's scholastic record. A master's degree is required before a student is admitted to the doctoral program. One's master's level academic performance must reflect your capability to pursue advanced studies and perform independent research.

Eighty-four credits of graduate work in an approved program of study beyond the bachelor's degree are required for completion of the doctoral program. Up to 30 credits obtained in a master's program can be included in this program. Of the remaining 54 credits, 15 to 30 credit hours of course work, as well as 30 to 45 credit hours of dissertation work, are required. Within two years from the time of admission, a student must take a qualifying examination that tests his/her basic knowledge and ability to critically analyze the research literature. Upon satisfactory performance in the qualifying examination, and completion of the required course work, (s)he must take an oral preliminary examination. This examination is primarily intended to evaluate the student's aptitude for advanced research and examine his/her understanding of the subjects associated specifically with the dissertation topics. Upon satisfactory completion of the preliminary examination and all course work, a student will become a doctoral candidate and start his/her dissertation research. Doctoral research work must be based on an original investigation and the results must make a significant, state-of-the-art contribution to the field, and must be worthy of publication in current professional literature. At the completion of the research, a student must defend his/her thesis in a public presentation.

Civil Engineer Degree

The Civil Engineer Degree is an advanced graduate program with an emphasis on design. To be qualified to enter the civil engineer degree program, a student must have completed a master's degree in engineering. The degree candidate must also demonstrate professional competence by having at least two years of responsible industrial experience in one of the areas of civil engineering. The industrial experience is to be completed prior to entering the program or in the process of being satisfied upon entering the program. Thirty credits beyond the master's degree are required for the degree of civil

engineer. Eight to 15 of those credits must be on a design project. A student will be assigned an advisor who will help him/ her develop a study plan and who will supervise his/her design project. The study plan, which should include details of the professional experience and of the design project, must be submitted to the departmental committee on the civil engineer degree for approval. Upon completion of the design project, (s)he will submit a written report to the departmental committee for approval, and the student will be required to take an oral examination on the substance of the design project.

COURSE OFFERINGS

Civil Engineering

CF 304 Water Resources Engineering

Principles of engineering hydrology, the hydrologic cycle, rainfall-runoff relationships, hydrologicand hydraulic routing; groundwater resources; planning and management of water resources; probabilistic methods in water resources, reservoir design, water distribution systems. Prerequisites: E 243

CE 322 Engineering Design VI

Introduction to AutoCAD and computer graphics. Introduction to SAP2000 finite element code. Application of software and design codes to analyze and design full structure. Case studies and projects taken from architectural drawings of real structures. Prerequisites: E 321 Corequisites: CE 486

CE 342 Fluid Mechanics

Fluid properties: fluid statics, stability of floating bodies, conservation of mass, Euler and Bernoulli equations, impulsemomentum principle, laminar and turbulent flow, dimensional analysis and model testing, analysis of flow in pipes, open channel flow, hydrodynamic lift and drag. Practical civil engineering applications are stressed. Prerequisites: E 126

CE 345 Modeling and Simulation

Introduction to linear systems and eigenvalue problems. Matrix analysis of trusses and frames, stress analysis, free and forced vibrations of structures. Introduction to nonlinear ODEs and PDEs with applications to civil engineering problems. Use of MATLAB or equivalent to simulate solutions.

CE 373 Structural Analysis

Shear and bending moment diagrams for beams and frames. Statically determinate trusses influence lines and moving loads, deflection of beams using moment-area and conjugate-beam methods, introduction to energy methods, deflection of beams and frames using unit-load method, introduction to statically indeterminate structures, approximal methods, momentdistribution and slope-deflection methods. Prerequisites: E 126

CE 377 The Art of Structural Engineering

At its best, creativity in structural engineering leads to forms that are notable for their sculptural and aesthetic quality as much as for their structural intelligence. Structures that express this behavior clearly and elegantly achieve the highest levels of artistic creation, and become cultural symbols that exceed historical and cultural boundaries. This course explores Art in Structural Engineering as it evolves in modern history, beginning with the Cast Iron bridges of the Industrial Revolution. It progresses through the works of Eiffel, Roebling, Freyssinet, and Maillart to modern day innovators like Menn, Khan, and Calatrava. Students learn engineering concepts through technical presentations on structural landmarks like the Eiffel Tower, Guggenheim Museum, George Washington Bridge, and the Hearst Tower. The course studies beautiful works of structural art and takes site visits in the metropolitan area to supplement the classroom material. These trips will include the Brooklyn Bridge, Skyscraper Museum, Cast Iron District, Flatiron Building, Guggenheim Museum, and Hearst Building. The course converges engineering, architecture, design, and art into one distinguished field. It teaches the concepts and designs behind structural engineering, so high a quality in imaginative conception and execution, that the engineering itself takes on the aspects of art. Prerequisites: E 126

CE 381 **Civil Engineering Measurements Lab**

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This course explores testing and measurement methods in Civil Engineering including: land surveying, the experimental analysis to explore the engineering properties of metals and concrete and on destructive evaluation techniques. Students will gain a basic knowledge of drawing in the digital environment using AutoCAD Civil 3-D, the engineering industry design standard.

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CE 410 Transportation Engineering Design

Description of design elements of system components of transportation, including the driver, vehicle, and roadway. Traffic flow design elements including volume, density, and speed. Intersection design elements including delay, capacity and accident counter-measures. Terminal design elements.

CE 423 Engineering Design VII

Senior Design courses. Complete design sequence with a required capstone project spanning two semesters. While the focus is on the capstone disciplinary design experience, it includes the two-credit core module on Engineering Economic Design (E421) during the first semester. Cross-listed with: EN 423

CE 424 Engineering Design VIII

Senior Design courses. Complete design sequence with a required capstone project spanning two semesters. While the focus is on the capstone disciplinary design experience, it includes the two-credit core module on Engineering Economic Design (E421) during the first semester. Cross-listed with: EN 424 Prerequisites: CE 423

CE 483 Geotechnical Engineering

Principles of engineering geology and solid mechanics covering: properties and classification of soils, seepage analysis, theory of soil strength, stress distribution theory and settlement prediction, consolidation theory, introduction to the stability of slopes and the design of shallow foundations. The course is accompanied by concurrent weekly laboratory sessions where students are introduced to geotechnical laboratory tests in a hands-on fashion. Prerequisites: E 126

CE 484 **Reinforced Concrete Design**

Ultimate strength design for bending and shear of rectangular sections, slabs, "T" sections and continuous beams, girders, columns, retaining walls and footings. Code requirements. Prerequisites: CE 373

CE 486 Structural Steel Design

ASD and LRFD design for tension members, beams and columns. Design of steel frame systems. Code requirements. Prerequisites: CE 373

CE 503 **Engineering Hydraulics**

Properties of fluids, fluid statics, mass, energy and momentum conservation principles, flow in pipes, major and minor energy losses, water pumps. Principles of flow in open channels, uniform flow computations, gradually varied flows, design of hydraulic structures, dimensional analyses and similitude principles.

CE 504 Water Resources Engineering

Principles of engineering hydrology, the hydrologic cycle, rainfall - runoff relationships, hydrographs, hydrologic and hydraulic routing. Ground water resources. Planning and management of water resources. Probabilistic methods in water resources, reservoir design, water distribution systems.

CE 510 Structural Health Monitoring

The course provides a broad overview of structure health monitoring technologies, sensing and data acquisition, life-cycle analysis, structure rating and risk assessment as well as signal processing. A strong emphasis is given to Smart Materials for use as sensors and actuators. The students taking this course will learn about the strength and importance of structure health monitoring which is expected to significantly change structures into smart structures with built-in autonomous diagnostics and prognosis. Prerequisites: CE 373

CE 515 Long-Term Structural Integrity

This course introduces the fundamental mechanisms of mechanically and environmentally induced aging of metal and composite infrastructure. Efficient analytical and numerical approaches are discussed to assess aging-induced damage on the material level affecting the load-carrying performance of structural components and the global system, which enables lifecycle assessment of structures. Further contents of the course are repair and rehabilitation methods of aged infrastructure, and technology to mitigate or even prevent aging. Thorough understanding of the impact of aging to our metal and composite infrastructure enables future engineers to respond effectively to the infrastructure crisis and exploding maintenance costs the world is facing, and contribute to sustainable design of infrastructure. Prerequisites: CE 373

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CE 518 Advanced Mechanics of Materials

A second course in Mechanics of Materials that will introduce failure criteria, energy methods, beams on elastic foundation, curved beams, unsymmetric bending, buckling and theory of elasticity. The emphasis is on classical problems and solutions without numerical procedures. Prerequisites: E 126

CE 519 Advanced Structural Analysis

Analysis of structures using methods of work, slope deflection and moment distribution; force acceleration and energy methods; variable moments of inertia; continuous beams, trusses and frames; arch analysis; plasticity and limit design; slab and shell structures. Prerequisites: CE 373

CE 520 Soil Behavior and its Role in Environmental Applications (3 - 3 - 0)

An overview of soil mineralogy, soil formation, chemistry, and composition. Influence of the above factors in environmental engineering properties; study of colloidal phenomena; fate and transport of trace metals in sediments, soil fabric, and structure; conduction phenomena; and compressibility, strength, deformation properties, and stress-strain-time effects, as they pertain to environmental geotechnology applications (i.e., contaminated soil remediation, soil/solid waste stabilization, waste containment alternatives, soil-water-contaminant interactions, and contaminant transport). Cross-listed with: EN 520 Prerequisites: EN 520

CE 522 Parametric Modeling in the Urban Environment

Parametric modeling links mathematical modeling with spatial modeling. The course provides a practical introduction to the concepts and application of parametric modeling, using examples from the built environment to apply those techniques at a number of scales ranging from a city-scale urban grid to the individual building elements within it. The course will be structured around the practical, hands-on application of the techniques addressed, using Grasshopper 3d as the primary parametric programming platform. The history, theory, and broader applications of computational parametric modeling and design will be periodically addressed where needed and more in-depth reading swill be provided as supplementary texts. Cross-listed with: ES 522

CE 525 Engineering Hydrology

Principles of hydrology and their application to engineering projects, including the hydrologic cycle, measurement and interpretation of hydrologic variables, stochastic hydrology, flood routing and computer simulations in hydrology.

CE 526 Watershed Modeling

This course is intended to provide graduate students with the tools necessary to simulate the water quality of a complex watershed. The course will focus on the development of models for examining the water quality and water quantity issues that are associated with watershed management. Students will learn various modeling technologies from simplistic mass balance models to more complex dynamic models. The models required for fully understanding the effects of both point and nonpoint sources of pollution on a natural waterway will be examined. The students will also develop an understanding of how to design a monitoring program to collect the data that are appropriate for simulating a natural system. Current state and federal guidelines and regulations will be discussed including the development of a wasteload allocation for a point source, a load allocation for a nonpoint source and a Total Maximum Daily Load (TMDL) for an impaired waterway. This course will not only provide the student with the tools necessary to simulate a watershed but also provide a keen insight into the watershed management process. The final project will require the students to work in teams to analyze a specific watershed.

CE 527 Wetland Hydrology

Over the past two decades, there has been a rise in wetland mitigation projects across the country. The success of a wetland depends mainly on it hydrology. Central to the course will be the principle of water budgeting. This course will outline the hydrologic principles involved in freshwater and coastal wetland engineering. Dynamic and steady state mathematical modeling will be presented as techniques to estimate wetland hydrology.

CE 530 Nondestructive Evaluation

This course will introduce principles and applications of Nondestructive Evaluation (NDE) techniques, which are important in design, manufacturing, and maintenance. Most commonly used methods such as ultrasonic, magnetic, radiography, penetrates, and eddy currents will be discussed. Physical concepts behind each of these methods as well as practical examples of their applications will be emphasized. Cross-listed with: ME 521

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CE 535 Stormwater Management

The management of stormwater must be addressed for any modern development or construction project. The interdisciplinary nature of stormwater is relevant to protecting environmental resources and water supplies, preventing combined sewer overflows and local flooding, minimizing pollutant discharges to water bodies, and planning for livable cities. This course will focus on technical design for urban stormwater control, including Green Infrastructure technologies such as living/ green roofs, bio-retention, permeable pavement, and conventional solutions such as detention and retention ponds and constructed wetlands. The course will emphasize engineering solutions for practical applications, in the context of regulations imposed by both state and federal agencies. Prerequisites: CE 304 or CE 525

CE 541 **Project Management for Construction**

This course deals with the problems of managing a project. A project is defined as a temporary organization of human and nonhuman resources, within a permanent organization, for the purpose of achieving a specific objective. Both operational and conceptual issues will be considered. Operational issues include definition, planning, implementation, control and evaluation of the project; conceptual issues include project management vs. hierarchical management, matrix organization, project authority, motivation and morale. Cases will include construction management, chemical plant construction and other examples. Cross-listed with: CM 541 Prerequisites: CM 511

CE 555 Introductory Railroad Engineering

This course will discuss both technical and practical aspects of the design of railroad track. Topics include the individual track components, differing track types, and the understanding of uses and behavior of the entire track structure. Further topics include horizontal and vertical geometry, including turnouts. This course will have a practical emphasis, with reference to current design standards and case studies.

CE 560 Advanced Soil Testing

An advanced treatment of methods and techniques of soil testing. It entails the execution of tests, data presentation and data interpretation associated with soil mechanics practice and research. Tests include soil classification, compaction, shear strength, permeability soil-moisture extraction and soil compressibility. Use of microcomputers in data reduction and presentation.

CE 561 Fundamentals of Remote Sensing

This course exposes the student to the physical principles underlying remote sensing of ocean, atmosphere, and land by electromagnetic and acoustic passive and active sensors: radars, lidars, infrared and microwaves thermal sensors, sonars, sodars, infrasound/seismic detectors. Topics include fundamental concepts of electromagnetic and acoustic wave interactions with oceanic, atmospheric, and land environment, as well as with natural and man-made objects. Examples from selected sensors will be used to illustrate the information extraction process, and applications of the data for environmental monitoring, oceanography, meteorology, and security/military objectives. Cross-listed with: OE 560, EN 560, EE 560, CE 561, PEP 560 Prerequisites: PEP 201, PEP 112, E 246

CE 565 Numerical Methods for Civil and Environmental Engineering (3 - 3 - 0)

An introduction to numerical and methods applied to civil and environmental engineering. Methods for solution of nonlinear equations, systems of linear equations, interpolation, regression, and solution of ordinary and partial differential equations. Applications include trusses, beams, river oxygen balances and adsorption isotherms. Several computer projects are required.

CE 576 Multi-Hazard Engineering

Identification and assessment of wind, flood, earthquake, surge, wave, tsunami, erosion, subsidence, and landslide hazards and their associated loading on the built environment, and comprehensive engineering and planning techniques presented to mitigate extreme loads generated by individual and multi-hazards in the natural environment. Prerequisites: CE 342, and CE 373

CE 578 Coastal and Flood Plain Engineering

Identification, assessment, and risk analysis of river and coastal flood hazards. Introduction to flood plain analysis, surge, and overland wave propagation. Development of flood, surge, and wave load analysis. Presentation of flood hazard mitigation techniques and engineering design of flood proofing techniques. Prerequisites: CE 342, and CE 373

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CE 579 Advanced Reinforced Concrete Structures

Ultimate Strength Design of beams, deep beams, slender columns, walls, two-way and plate slabs. Study of bending, shear, torsion, deflections, shrinkage, creep and temperature effects. Code Requirements. Prerequisites: CE 484

CE 591 Introduction to Dynamic Meteorology

Introduction to meteorology presents a cogent explanation of the fundamentals of atmospheric dynamics. The course begins with a discussion of the Earth's atmospheric system includingglobal circulation, climate, and the greenhouse effect. The basic conservation laws and the applications of the basic equations of motion are discussed in the context of synoptic scale meteorology. The thermodynamics of the atmosphere are derived based on the equation of state of the atmosphere with specific emphasison adiabatic and pseudo-adiabatic motions. The concept of atmospheric stability is presented in terms of the moist and dry lapse rate. The influence of the planetary boundary layer on atmospheric motions is presented with emphasis on topographic and open ocean frictional effects, temperature discontinuity between land and sea, and the generation of sea breezes. The mesocale dynamics of tornadoes and hurricanes are discussed as well as the cyclogenesis of extratropical coast allows. The course makes use of a multitude of web-based prducts including interactive learning sites, weather forecasts from the National Weather Service (NWS), tropical predictions from the National Hurrican Center and NWS model outputs (AVN, NGM, ETA, and WAM). Cross-listed with: OE 591 Prerequisites: CE 342

CE 595 Geotechnical Design

A design oriented course in which geotechnical engineering principles are applied to the computer-aided design of shallow and pile foundations, bulkheads and retaining walls. The course also deals with advanced soil mechanics concepts as applied to the determination of lateral earth pressures needed for the design of retaining walls.

CE 596 Trans Systems Planning & Operation

This course in Transportation Systems Planning provides the engineering student with an introduction to traditional planning processes and exposure to new planning approaches being adopted in public and private sectors. Specific transportation engineering materials and case studies will be used to increase the students' breath of knowledge and familiarity with the state of the practice in the discipline. Upon completion of the course the student will be prepared to become involved in activities requiring project evaluation of context, assessment of facility siting issues, and preliminary design of transportation facilities in urban and suburban areas (e.g., highways, transit systems, bike lanes and footpaths).

CE 601 Theory of Elasticity

Review of matrix algebra; the strain tensor, including higher order terms; the stress tensor; derivation of the linear form of Hooke's law and the higher order form of Hooke's law; equilibrium equations, boundary conditions and compatibility conditions; applications to the bending and torsion problems; variational and approximate methods of solving the Dirichlet type boundary value problems with particular application to the torsion problem. Fall semester.

CE 607 Theory of Elastic Stability

Buckling failure of beams, columns, plates and shells in the elastic and plastic range; postbuckling strength of plates; application of variational principles.

CE 608 Theory of Plates and Shells

Bending of laterally loaded plates of various shapes and edge conditions; large deflection of plates; membrane stresses in shells; bending of cylindrical shells; energy solutions. Spring semester

CE 613 Matrix Analysis of Structures

Formulation of structural theory based on matrix algebra; discussion of force method and displacement method; use of matrix transformation chain in structural analysis; application to indeterminate structures, space frames, vibration and buckling of structures; computer application. Spring semester.

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CE 621 Bridge Design for Structural Engineers

This course will concentrate on the typical highway bridge design and analysis. The design will be based on the current AASHTO specifications and other applicable codes. Major topics will include detailing and seismic design considerations. In addition, emphasis will be placed on inspection procedures and the development of contract plans, specifications and construction cost estimating. Grading for the course will be based on a midterm exam and a comprehensive design project. Included in the scope of the project will be the design of the superstructure and substructure, the development of influence lines and a construction cost estimate. Prerequisites: CE 486, CE 483, CE 484, CE 519

CE 623 Structural Dynamics

Introduction to theory of structural dynamics with emphasis on civil engineering problems. One-degree systems; lumped parameter and multi-degree systems; approximate methods; analysis and design applications using computers.

CE 626 Earthquake Engineering Design

A new approach to the overall earthquake-engineering problem is presented in a form that may be utilized by engineering design offices. New earthquake invariants are obtained. The emphasis is placed on the two major topics (1) damage assessment and (2) structural design, but some consideration is also given to the development of a new "mechanism" theory consistent with deep-foci earthquakes. The fundamental data bases the sources for the basic hypotheses and the resultant theories are the accelerograms and the isoseismal maps. These lead to temporal and spacewise energy variations that are the key elements in the theoretical approach.

CE 628 Wind Effects on Structures

Wind characteristics; deterministic and stochastic response; static wind effects and building code; effects of lateral forces; dynamic effects; self-excited motion, flutter, galloping and vortex-induced vibration; tornado and hurricane effects; case studies on tall buildings, long-span bridges, etc.

CE 640 Prestressed Concrete

Basic concepts of prestressing, partial loss of prestress, flexural design, shear, torsion, camber, deflection, indeterminate prestressed structures, connections, and prestressed circular tanks.

CE 648 Numerical Hydrodynamics

Potential flows around bodies: Panel singularities methods and conformal mapping methods. Finite-difference and spectral methods for Poisson equations: numerical inversion of matrices, potential flows in or around irregular domains. Consistency, stability and convergence of numerical methods: linear stability analysis. Numerical methods for diffusion equations: methods for ordinary differential equations. One-dimensional Burgers equation: nonlinear problems, Newton iteration, error analysis. Numerical methods for stream function vorticity equations: flows in or around irregular domains. Current research in computational fluid dynamics: discussions. Four (4) exercise projects and one (1) examination project will be assigned to each student. Cross-listed with: OE 648

CE 649 Earth Supporting Structures

A course of lectures dealing with the design, performance and quality control of earth supporting structures. It includes an outline of the available methods of evaluating slope stability by field studies, numerical computer analysis and hand calculations. Finally, the last portion of the course covers the principles involved in the design and construction of earth and rockfill dams including such topics as soil compaction, hydraulic fill dams, design criteria, seepage control, slope stability analyses, seismic design and case history studies.

CE 650 Water Distribution Systems Analysis

The design of an effective and proper system for the distribution of potable water for domestic, institutional, commercial, and industrial use, requires an understanding of the principles of planning, design and construction of pipe networks. This course will focus on the critical elements of planning, design, and modeling of a water distribution systems.

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CE 651 Drainage Design and Modeling

Drainage design includes watershed analysis combined with hydrologic and hydraulic computations. The basic laws of drainage design will be discussed including the environmental and economic implications. Regulations pertinent to the area will also be addressed. Concepts of open channel, pressure and gravity flow will be discussed. Mathematical and computer models will be used to educate the engineer in the techniques available in industry. These models combined with the mathematical principals presented will aid the engineer in developing the best possible design for a particular region.

CE 652 Hydrologic Modeling

Water is probably the most used, the most abused, and the most taken for granted natural resource. Few people realize what is involved in the planning and building of urban water-distribution and management systems. Environmental costs must also be considered when analyzing any water resources project. Efforts continue toward conservation and environmental protection, which increases the need for engineers to be educated in the behavior of water as it moves through the water cycle. This course will address the modern day hydrologic processes, the mathematical and scientific processes for hydrology and introduce several models commonly used in industry. These models will aid the engineer in analyzing the hydrologic processes of a particular region and help provide the best solution for a very sensitive issue.

CE 654 Environmental Geotechnology

The objective of the course is to provide the students with exposure to the geotechnical nature of environmental problems. The topics covered include: principles of geochemistry, contaminant transport and hydrogeology; an overview of landfill liners and other disposal facilities and their design, construction, safe operation, performance monitoring, structural and physicochemical stability; an overview of the general principles governing the design, implementation and monitoring of existing remediation technologies with special emphasis on stabilization/solidification, vapor extraction, bioremediation, soil washing, pump and treat, cover systems and alternative containment systems such as slurry walls. A concurrent laboratory section introduces the student to the chemical analyses, absorption behavior, mineralogical and crystallographical identification and characterization of various waste forms as they pertain to surface chemistry considerations. The main emphasis of the course consists of providing hands-on experience with analyses involving the use of spectrometric, X-ray diffraction and scanning electron microscope equipment. Cross-listed with: EN 654 Prerequisites: EN 520

CE 660 Advanced Steel Structures

Ultimate Strength Design, deep beams, torsion, deflections, shrinkage, creep and temperature effects, biaxially loaded columns, slender columns, walls, two-way and plate slabs. Prerequisites: CE 486

CE 679 Regression and Stochastic Methods

An introduction to the applied nonlinear regression, multiple regression and time-series methods for modeling civil and environmental engineering processes. Topics include: coefficient estimation of linear and nonlinear models; construction of multivariate transfer function models; modeling of linear and nonlinear systems; forecast and prediction using multiple regression and time series models; statistical quality control techniques; ANOVA tables and analysis of model residuals. Applications include monitoring and control of wastewater treatment plants, hydrologic-climatic histories of watercourses, and curve-fitting of experimental and field data.

CE 681 Introduction to Finite Element Methods

A concise introduction for advanced undergraduate and graduate engineering students. Includes numerical discretization, finite-differences, variational principle, weighted residual method, Galerkin approximations, continuous and piecewise-defined basis functions, finite-element methods, computer coding of one-dimensional problems, triangular elements - coding of two-dimensional problems, time-dependent problems.

CE 682 Design of Hydraulic Equipment

This course will provide an understanding of the hydraulic equipment design associated with integrated water and wastewater facilities. Topics include manifold pipe flow, sludge flow, multiport diffusers, open channel flow, flow measurement, hydraulic control points, chemical feed hydraulics, pump and valve selection and hydraulics, and use of computer tools for pump selection and sizing.

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CE 684 Mixing Processes in Inland and Coastal Waters

Development of advective-diffusion equations for conservative and non-conservative substances. Fickian diffusion, turbulent diffusion, shear flow dispersion. Description and specification of mixing processes in rivers, reservoirs and estuaries. Methods and analyses of conservative dye tracer studies. Monte Carlo simulations of diffusion processes, and numerical models for simulation of advection diffusion processes in rivers and estuaries.

CE 685 Advanced Hydraulics

Fundamentals of open channel flows; types of open channels and their properties; velocity distribution in open channels. Specific energy, momentum and specific force principles; critical flows; principles of uniform flow and its computation. Gradually varied flow; channel transitions and controls. Rapidly varied flow; hydraulic jump and energy dissipaters. Unsteady flows; waves and wave propagation; flood routing. Applications of numerical methods in hydraulic engineering.

Design of Hydraulic Structures CE 687

Design of small canal and small dam structures including sharp and broad crested weirs, stilling basins, energy dissipaters, spillways, gates, flumes, sluice gates, erosion control structures and transmission pipe lines.

CE 695 Traffic Flow Modeling & Operations

An introduction course for machine learning theory, algorithms and applications. This course aims to provide students with the knowledge in understanding key elements of how to design algorithms/systems that automatically learn, improve, and accumulate knowledge with experience. Topics covered in this course include decision tree learning, neural networks, Bayesian learning, reinforcement learning, ensembling multiple learning algorithms, and various application problems. The students will have a chance to simulate their algorithms in programming language and apply them to solve real-world problems. Prerequisites: EE 605 or equivalent

CE 702 Multiscale Mechanics and Computational Methods (3 - 3 - 0)

This graduate course will introduce the applications of multiscale theory and computational techniques in the fields of materials and mechanics. Students will obtain fundamental knowledge on homogenization and heterogeneous materials, and be exposed to various sequential and concurrent multiscale techniques. The first half of the course will be focused on the homogenization theory and its applications in heterogeneous materials. In the second half multiscale computational techniques will be addressed through multiscale finite element methods and atomistic/continuum computing. Students are expected to develop their own course projects based on their research interests and the relevant topics learned from the course. Cross-listed with: NANO 701 Prerequisites: CE 681, E 234, CE 518

CE 710 Multiscale Mechanics and Computational Methods

This graduate course will introduce the applications of multiscale theory and computational techniques in the fields of materials and mechanics. Students will obtain fundamental knowledge on homogenization and heterogeneous materials, and be exposed to various sequential and concurrent multiscale techniques. The first half of the course will be focused on the homogenization theory and its applications in heterogeneous materials. In the second half multiscale computational techniques will be addressed through multiscale finite element methods and atomistic/continuum computing. Students are expected to develop their own course projects based on their research interests and the relevant topics learned from the course.

CE 741 Hydraulic Structures

This course will focus on the design of hydraulic structures including small dams, spillways, weirs and culverts. These are complex structures, the design of which must account for the water forces, which act upon them as well as their impacts upstream and downstream. Structural topics will be covered along with backwater curves and downstream effects. Models such as the US Army HEC II and HEC RAS will be used to model the associated hydraulic impacts of these structures. Structural models will also be used were appropriate to assist in the design of the structures. Environmental and economic implications of hydraulic structures will also be addressed. Prerequisites: CE 525, CE 685

CE 746 Advanced Soil Mechanics

Advanced topics in soil mechanics and geotechnology. Application of theory of elasticity to geotechnical problems; two and three dimensional consolidation theories; settlement analysis, strength of soils. Prerequisites: CE 595

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in Structures, Geo	Special Topics in Civil and Environmental Engineering I-II inar course concerned with recent research developments in civil engineering. Are btechnical, Earthquake, or Environmental Engineering. The topics are subject to o dent must have completed certain prerequisite courses and can enroll only with th	current faculty and student
CE 800 One to six credits	Special Problems in Civil Engineering . Limit of six credits for the degree of Master of Engineering (Civil).	(1 to 6)
CE 801 A thorough invest	Special Problems in Civil Engineering (PHD) igation of an advanced research topic under the direction of a faculty member.	(3)
CE 802 One to six credits	Special Problems in Civil Engineering (Deg CE) . Limit of six credits for the degree of Civil Engineer.	(1 to 6)
CE 900 For the degree of	Thesis in Civil Engineering (ME) Master of Engineering (Civil). Credits to be arranged.	(1 to 10)
CE 950 Design project for	Civil Engineering Project (Deg CE) the degree of Civil Engineer.	(8 - 0 - 0)
	Research in Civil Engineering (PHD) of advanced level in Civil Engineering, which may serve as the topics for the diss phy. Hours and credits to be arranged.	() sertations for the degree of
Doctor of Philoso	bry. Hours and credits to be arranged.	
Construction	priy. Hours and credits to be arranged.	
Construction CM 501 This course is a	Construction Engineering I study of construction industry customs, practices and methods from project , construction estimating, scheduling, and management techniques are woven in	
Construction CM 501 This course is a Equipment usage CM 502 This course provi facility. Case stud	Construction Engineering I study of construction industry customs, practices and methods from project	to the fabric of this course. (3 - 3 - 0) the completed construction ements of possible failure
Construction CM 501 This course is a Equipment usage CM 502 This course provi facility. Case stud within the complet CM 506 Today's construct that various elem- course gives the	Construction Engineering I study of construction industry customs, practices and methods from project , construction estimating, scheduling, and management techniques are woven in Construction Engineering II des the student in the construction field with a practical analysis and study of the lies are discussed along with the performance of the constructed facility and el	t conception to close-out. to the fabric of this course. (3 - 3 - 0) ne completed construction ements of possible failure (3 - 0 - 0) chnology and methods so n an efficient manner. The
Construction CM 501 This course is a Equipment usage CM 502 This course provi facility. Case stud within the complet CM 506 Today's construct that various element course gives the cost reports, and CM 508 A description of a with roadways, stu land use, energy,	Construction Engineering I study of construction industry customs, practices and methods from project , construction estimating, scheduling, and management techniques are woven in Construction Engineering II des the student in the construction field with a practical analysis and study of the lies are discussed along with the performance of the constructed facility and effect eted facility. Alternate solutions are discussed along with their economic feasibility Computer Application in the Construction Process ion manager and engineer should have a thorough knowledge of the latest ter- ents within the construction process can be produced, analyzed, and reviewed in construction executive the tools to provide proper planning and scheduling, es	t conception to close-out. to the fabric of this course. (3 - 3 - 0) ne completed construction ements of possible failure (3 - 0 - 0) chnology and methods so n an efficient manner. The timating, cost accounting, (3 - 0 - 0) management which deals opics of discussion include

This course introduces the student to the construction industry, built environment history, development and current theories.

CM 511 **Construction Accounting**

This course presents the principles of accounting for construction projects. Topics include elements of cost accounting, project accounting, and financial analysis used by the construction manager.

The general superintendent, engineering staff and construction manager, in order to manage, schedule and complete the heavy construction project, must be aware of problems associated with the completion of the complex project. Problems associated with pile driving & shoring, excavation methods, tunneling, trenchless technology, and rock excavation are reviewed. Examples and case studies are discussed with alternate solutions reviewed based on site conditions and economic considerations. Prerequisites: CM 609

CM 521 **Construction Organizations**

This course provides the student with an understanding of human behavior including individual and group performance, motivation, leadership, and industrial relations. Next, the student will examine various theories of management and the basic functions of planning, organizing, leading, and controlling. This body of knowledge will be applied to the management of construction companies and projects.

CM 522 Labor Relations

CM 512

This course provides the student with a basic understanding of the practices involved in construction labor relations. Topics include the discussion of union and open shop contractors, job site agreements, collective bargaining and local union negotiations, double-breasted construction operations and termination of the labor agreement, along with case studies in selected areas.

CM 530 Strategic Responses to Cyclical Environments

Problems in Heavy Construction

In this graduate-level course students will develop an understanding of strategic planning and its place in successfully guiding built environment organizations and the careers of the industry's professionals. Via case studies, the class will analyze specific real world situations, consider various alternatives and produce successful outcomes.

CM 531 **Construction Materials**

This lecture course covers civil engineering materials, their properties, and their construction use. Specifics to be discussed include physical and mechanical properties of steel, concrete, asphalt, wood, plastic, timber, and soil. Coverage of ASTM standard tests covering these properties is also presented.

CM 541 Project Management for Construction

This course deals with the problems of managing a project. A project is defined as a temporary organization of human and nonhuman resources, within a permanent organization, for the purpose of achieving a specific objective. Both operational and conceptual issues will be considered. Operational issues include definition, planning, implementation, control and evaluation of the project; conceptual issues include project management vs. hierarchical management, matrix organization, project authority, motivation and morale. Cases will include construction management, chemical plant construction and other examples. Cross-listed with: CE 541 Prerequisites: CM 511

CM 542 **Quality Management & Construction Performance** (3 - 3 - 0)

This course presents the principles and techniques of total quality management (TQM), with emphasis on its application to construction projects and firms. Students will form teams to apply TQM concepts and techniques to construction projects/firms.

CM 543 **Construction Contract Management**

This course deals with and discusses in detail the complex set of relationships that are involved when a construction project is undertaken. The course also reviews these relationships and how they interact with the planning, administration, start-up, and completion of the project. Risk in the construction project is discussed as it relates to the management and successful completion of the project, while also reviewing the legal relationships that can evolve during the project duration. Prerequisites: CM 541, CM 580, CM 511

CM 545 Environmental Impact Analysis and Planning

The impact of engineering projects on the physical, cultural, and socioeconomic environment, preparation of environmental impact statements, regulatory framework, and compliance procedures will be discussed. Topics include: major federal and state environmental regulations, environmental impact analysis and assessment, risk assessment and risk management, and regulatory compliance.

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CM 550 Construction Contract Law I

This course introduces the principle areas of construction law and contracts. Areas of discussion include contract formulation, scope of work, changes, delays, no damage for delays, insurance and sureties, completion, termination, and claims and dispute resolutions. Case studies are presented with class presentations and discussions.

CM 551 Construction Contract Law II: Claims and Disputes

This course presents a review and analysis of the methods used in presenting and solving construction contract disputes. Topics of discussion include the origins of the construction dispute, the contract documents, the design deficiency, the construction schedule, construction of the project and resolving the dispute. Prerequisites: CM 550

CM 560 Sustainable Design

A study of sustainable design principles and techniques. The course is designed to make the construction manager familiar with the procedures used by designers to achieve sustainable projects. Students will study the role of government mandates for sustainable design, the selection of materials and systems that meet sustainable requirements, the ecolabeling of buildings, and the economic and environmental impact of sustainable designs. Prerequisites: CM 580

CM 561 Green Construction

A study of green construction principles and techniques. The course is designed to make the manager familiar with the procedures required to achieve green construction. Students will study the role of government regulations requiring contractors to produce green construction projects, green building commissioning and the economic and environmental impact of green construction. Cross-listed with: CM 580

CM 580 Construction Management I

This course provides a survey and study of the management process for domestic and international contracting business enterprises. Topics of discussion include the roles of the construction manager, bonds and insurance elements of the estimating process, finance and cost control, labor relations, and work culture. Cross-listed with: CM 561

CM 581 Temporary Structures in Heavy Construction

This course is a study of the elements and concepts of temporary supportive structures involved with heavy construction process. Topics of discussion will include codes, construction, cofferdams, temporary sheeting and bracing, falsework and shoring, and concrete form design.

CM 587 Environmental Law and Management

This class addresses a survey of legal and regulatory approaches to environmental protection. Topics include: environmental ethics, National Environmental Policy Act, state and federal environmental agencies; Clean Water Act, Safe Drinking Water Act, Superfund, Resource Recovery and Conservation Act, Right-to-know, Environmental Cleanup Responsibility Act, and wetlands protection. Cross-listed with: EN 587

CM 590 Construction Management II

This course discusses the principles of construction marketing and strategic planning. Marketing engineering and construction company services and products are discussed with an eye towards the most economical and competitive sales techniques. Case studies and practical applications are presented for class analysis and discussion.

(3 - 3 - 0)CM 592 Advanced Project Controls in the Built Environment

This class introduces students to procedures for balancing key project constraints in the face of adversarial contractual arrangements, multiple prime, and single source contracting as well as externalities.

CM 605 **Construction Safety Management**

Various aspects of construction and safety techniques are discussed along with strategies for building a corporate culture of zero accidents, planning for high project safety performance, establishing accountability for safety, and maintaining a safety communication network.

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CM 609 Large-Scale Project Cost Analysis

This course provides the construction-orientated professional with the analysis tools and methodology to organize and prepare an accurate construction estimate. Topics include development of productivity data, analysis, and applications of historical data, break-even and cost-to-complete analysis and the study and analysis of job cost reporting systems as they relate to the construction estimate. Estimating methods and systems will be discussed, along with field trips and practical case studies.

CM 671 Practicum in Construction Management

This will be a capstone course taken at the end of a student's program of studies. The students will be organized into construction management groups.

CM 699 Research Methods in Construction Management (3 - 3 - 0)

This course is designed to support graduate students in developing their research project and to assist them in defining their research methodology. The course has been constructed to guide students through a range of issues and deliberations which should inform their general approach to research. It will give students a general introduction to research in the Construction Management field, its methodologies, its challenges and its organization. Students will be introduced to a range of research reports , data analysis so that they will be equipped to plan and organize their research, conduct a literature review, as well as to communicate their findings in writing and verbally.

CM 800	Special Problems in Construction Management (MS)	(1 to 6)
One to six credits	s. Limit of six credits for the degree of Master of Science.	
CM 810 A participating se	Special Topics in Construction Management eminar on topics of current interest and importance in Construction Management.	(3)
CM 900 Credits to be arra	Thesis in Construction Management	(1 to 10)

Credits to be arranged.

Environmental

EN 250 Quantitative Biology

Topics in biology are discussed from a quantitative point of view to develop an appreciation for biology and mathematics and the connections between them. Living systems are viewed through an engineering perspective as open systems using descriptive and quantitative models. Mathematical approaches are taken to heredity and genetics, cellular organization, transport and metabolism, human physiology, ecology, and toxicology. These are presented as applications of probability, linear algebra, ordinary differential equations, and other methods. The relevant mathematical principles are introduced as needed in each module. Prerequisites: MA 116 or MA 124 Corequisites: MA 116

EN 301 Sustainable Engineering

This course examines the global environmental and resource issues that we face as a result of human actions, in particular those to which engineering has been a contributor and also for which it can offer the potential for solutions that move us along the path to a sustainable future. A variety of techniques and paradigms will be studied that can make production, use and disposal of our engineered products sustainable. These include industrial ecology, life cycle analysis, green engineering, and design for the environment. Prerequisites: CH 115, and MA 116 or MA 124

EN 322 Engineering Design VI

Introduction to AutoCAD and computer graphics. Introduction to SAP2000 finite element code. Application of software and design codes to analyze and design full structure. Case studies and projects taken from architectural drawings of real structures. Prerequisites: E 321

EN 345Modeling and Simulation of Environmental Systems(3 - 3 - 0)

Incorporation of fundamental phenomena into mass balances to describe the fate and transport of contaminants in lakes, rivers, estuaries, groundwater, the atmosphere, and in pollution control processes. Several computer projects involving numerical solutions of models are required. Prerequisites: CHE 210 or EN 541

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EN 375 **Environmental Systems**

An introduction to environmental engineering, including: environmental legislation; water usage and conservation; water chemistry including pH and alkalinity relationships; solubility and phase equilibria; environmental biology; fate and transport of contaminants in lakes, streams and groundwater; and design and analysis of mechanical, physicochemical, and biochemical water and wastewater treatment processes.

EN 377 Introduction to Environmental Engineering Systems (3 - 3 - 0)

An introduction to environmental engineering, including: environmental legislation; water chemistry including pH and alkalinity relationships, solubility and phase equilibria; environmental biology; fate and transport of contaminants in lakes, streams and groundwater; design and analysis of mechanical, physicochemical and biochemical treatment processes. Prerequisites: CH 115 or CH 116

EN 379 Environmental Engineering Laboratory

An introduction to environmental engineering through laboratory experiments, including: principles of laboratory methods, including common instrumental methods of analysis; application of experimental results to the design of environmental treatment processes. Prerequisites: Corequisites: EN 377

EN 423 Engineering Design VII

Senior design courses. Complete design sequence with a required capstone project spanning two semesters. While the focus is on the capstone disciplinary design experience, it includes the two-credit core module on E 421 Engineering Economic Design during the first semester. Cross-listed with: CE 423

EN 424 Engineering Design VIII

Senior design courses. Complete design sequence with a required capstone project spanning two semesters. While the focus is on the capstone disciplinary design experience, it includes the two-credit core module on E 421 Engineering Economic Design during the first semester. Cross-listed with: CE 424 Prerequisites: EN 423

EN 504 Basics of Air Pollution Assessment

This course will focus on the relationship and impact that international relations, international business, and foreign policy have on world trade, commerce, and finance. The course will provide the student with a better understanding of how the complexity of international differences affects political, economic, and cultural behaviors. Among the topics for discussion: the content and scope of international politics, the international struggle for power, the role and impact of non-governmental organizations, foreign policy as a tool for promoting international commerce, the role of international law and world public opinion, the rise of regionalism, the political economy of international trade.

EN 505 **Environmental Engineering**

An introduction to environmental engineering, including: environmental legislation; water usage and conservation; water chemistry including pH and alkalinity relationships, solubility and phase equilibria; environmental biology; fate and transport of contaminants in lakes, streams and groundwater; design and analysis of mechanical, physicochemical and biochemical water and wastewater treatment processes.

EN 506 Air Pollution Principles and Control

An introduction to the principles and control of air pollution, including: types and measurement of air pollution; air pollution chemistry; atmospheric dispersion modeling; compressible fluid flow; particle dynamics; ventilation systems; inertial devices; electrostatic precipitators; scrubbers; filters; absorption and adsorption; combustion; and condensation. Cross-listed with: ME 532 Prerequisites: EN 377

EN 520 Soil Behavior and its Role in Environmental Applications

An overview of soil mineralogy, soil formation, chemistry, and composition. Influence of the above factors in environmental engineering properties; study of colloidal phenomena; fate and transport of trace metals in sediments, soil fabric, and structure; conduction phenomena; and compressibility, strength, deformation properties, and stress-strain-time effects, as they pertain to environmental geotechnology applications (i.e., contaminated soil remediation, soil/solid waste stabilization, waste containment alternatives, soil-water-contaminant interactions, and contaminant transport). Cross-listed with: CE 520

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EN 530 Introduction to Sustainable Engineering

This course assesses current and potential future energy systems, covers resources, extraction, conversion, and end-use, and emphasizes meeting regional and global energy needs in the 21st century in a sustainable manner. Topics relevant to renewable and conventional energy technologies will be presented including fossil fuels, combustion, environmental effects, carbon sequestration, nuclear power, wind power, solar energy, hydrogen, and fuel cells. Key attributes will be described within a framework that aids in evaluation and analysis of energy technology systems in the context of political, social, economic, and environmental goals.

EN 541 Fate and Transport of Environmental Contaminants

Description of fundamental processes in natural and engineered systems, including intermedia transport of contaminants between environmental compartments (air, water, soil, and biota) and chemical and biochemical transformations within these compartments. Prerequisites: EN 377

EN 545 Environmental Impact Analysis and Planning (3 - 3 - 0)

The impact of engineering projects on the physical, cultural, and socioeconomic environment, and preparation of environmental impact statements, regulatory framework, and compliance procedures. Topics include: major federal and state environmental regulations, environmental permitting processes, environmental impact analysis and assessment, risk assessment and risk management, and regulatory compliance.

EN 547 Project Life Cycle Management

This course addresses the environmental management of engineering projects from the research through the development, operation, maintenance, and ultimate disposal phases. Topics include: impacts of exploitation of raw materials and energy resources and transportation; pollution from use and ultimate disposal of products; and economics of environmental resources.

EN 548 Environmental Compatibility in Design and Manufacturing (3 - 3 - 0)

The purpose of this course is to teach engineers how to incorporate environmental principles in the design and manufacturing of various products and engineering systems. Topics include: economics and cost-benefit analysis, pollution prevention, recycling, concurrent design, facility citing, risk perception, and case studies.

EN 549 Environmental Risk Assessment and Management (3 - 3 - 0)

There is little doubt that the different types of risk assessment - health, safety, and ecological - are playing an increasingly important role in environmental decision-making and risk management. Guided by several examples and case studies, participants in this course learn to understand the basic concepts of environmental hazards and the different types of risk assessment. The student will conduct human health risk assessments and appreciate the wide array of applications, as well as the advantages and limitations of risk assessments; interpret and present the results of risk assessments to provide linkages with risk management; and apply the principles of integrated risk management.

EN 550 Environmental Chemistry of Atmospheric Processes (3 - 3 - 0)

An introduction to the science underlying the description of atmospheric processes and air pollution control, including: composition of atmosphere; sources, transport, and fate of pollutants; chemical and photochemical reactions; properties of aerosols and effects of air pollution on climate and water; and adsorption, absorption, filtration, and chemical destruction pollutants in air pollution control systems.

EN 551 Environmental Chemistry of Soils and Natural Surfaces (3 - 3 - 0)

Soil is a mixture of inorganic and organic solids, air, water, and microorganisms. Soil affects the environmental chemistry through the interactions at solution-solid and air-solid interfaces, and the soil in turn is affected by the environmental and human activities. Soil science is not only important to agriculture, but also to diverse fields, such as environmental engineering, biogeochemistry, and hydrology. This course will enable students to understand the chemical properties of soil, soil minerals, natural surfaces, and mechanisms regulating solute chemistry in soil solutions. The fate and transport of inorganic and organic pollutants in soil and soil remediation technologies are discussed. One year of introductory chemistry is required for students who want to take this course.

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EN 553 Groundwater Engineering

Fundamental and advanced topics in groundwater engineering analysis and design. Aquifers and well aquifer relationships; aquifer tests by well methods; in situ permeability determination; and flow nets. Seepage principles and seepage control measures; filter and drain design; and computer methods in groundwater engineering.

EN 555 Catalysis and Characterization of Nanoparticles

Most processes in petroleum and chemical industries utilize catalytic reactions. Moreover, many emerging technologies in the energy sector and in green chemistry for sustainability rely on catalysis. This course provides the fundamentals of synthesis, characterization and testing of catalytic materials with an emphasis on metal and metal oxide nanoparticles, the most widely used class of catalysts. Methodologies for development of molecular-level reaction mechanisms, material structure-activity relations and kinetic models are described. The course is essential for anyone planning a career in the chemical industry. It is recommended for all professionals working with nanoparticles and also with diverse applications where the solid-gas interface is important. Cross-listed with: CHE 555, MT 555, NANO 555, CH 555

EN 560 Fundamentals of Remote Sensing

This course exposes the student to the physical principles underlying remote sensing of ocean, atmosphere, and land by electromagnetic and acoustic passive and active sensors: radars, lidars, infrared and microwaves thermal sensors, sonars, sodars, infrasound/seismic detectors. Topics include fundamental concepts of electromagnetic and acoustic wave interactions with oceanic, atmospheric, and land environment, as well as with natural and man-made objects. Examples from selected sensors will be used to illustrate the information extraction process, and applications of the data for environmental monitoring, oceanography, meteorology, and security/military objectives. Cross-listed with: OE 560, EE 560, CE 561, PEP 560 Prerequisites: PEP 201, PEP 112, E 246

EN 570 **Environmental Chemistry**

Principles of environmental reactions with emphasis on aquatic chemistry; reaction and phase equilibria; acid-base and carbonate systems; oxidation-reduction; colloids; organic contaminants classes, sources, and fates; groundwater chemistry; and atmospheric chemistry. Cross-listed with: NANO 570 Prerequisites: EN 377

EN 571 Physicochemical Processes for Environmental Control

A study of the chemical and physical operation involved in treatment of potable water, industrial process water, and wastewater effluent; topics include chemical precipitation, coagulation, flocculation, sedimentation, filtration, disinfection, ion exchange, oxidation, adsorption, flotation, and membrane processes. A physical-chemical treatment plant design project is an integral part of the course. The approach of unit operations and unit processes is stressed. Cross-listed with: NANO 571 Prerequisites: EN 377

EN 573 **Biological Processes for Environmental Control** (3 - 3 - 0)

Biological basis of wastewater treatment; river systems and wastewater treatment works analogy; population dynamics; food sources; aerobic and anaerobic systems; reaction kinetics and parameters affecting waste removal; fundamentals of mass transfer and gas transfer; trickling filter, and activated sludge process; aerated lagoons; stabilization ponds; nitrification; denitrification; sludge concentration; aerobic sludge digestion; anaerobic sludge digestio and sludge conditioning; sludge drying, vacuum filtration; and incineration and ocean disposal. A biological treatment plant design project is an integral part of the course. Prerequisites: EN 377

EN 575 **Environmental Biology**

A survey of biological topics concerning the environment: ecology, population dynamics, pollution microbiology, aquatic biology, bioconcentration, limnology, stream sanitation, nutrient cycles, and toxicology.

EN 586 Hazardous Waste Management

A comprehensive introduction to hazardous waste management, including laws and regulations, identification and analysis, risk assessment, and techniques and technologies for control and treatment.

EN 587 Environmental Law and Management

A survey of legal and regulatory approaches to environmental protection. Topics include: environmental ethics, National Environmental Policy Act, State and Federal environmental agencies; and the Clean Water Act, Safe Drinking Water Act, Superfund, Resource Recovery and Conservation Act, Right-to-Know, Environmental Cleanup Responsibility Act, and wetlands protection. Cross-listed with: CM 587

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EN 590 Risk-Based Compliance in the Pharmaceutical Industry

Course presents Quality Risk Management, including Risk-Based Compliance for Cross Contamination, Occupational Safety, and Environmental Protection. Addresses the issues of occupational exposure to high hazard pharmaceutical compounds, and product-to-product cross contamination in multipurpose facilities. Explores issues that a pharmaceutical professional needs to understand regarding projects that put the workforce or product at risk and, in the case of product exposure, impact product quality and regulatory scrutiny. Included are emission sources and essentials, routes of exposure, toxicology, safety and regulatory limits of exposure, exposure control for facilities and processes, quantitative risk assessment, and mitigation techniques. Cross-listed with: PME 590

EN 591 Sustainable Trans Systems

Transportation infrastructure has a strong impact on urban land use patterns and congestion, both of which result in profound environmental economic and social impacts. Hence, the development of a sustainable transportation infrastructure requires the integration of social, environmental and economic considerations into transportation engineering design activities addressing macroscopic considerations, including transportation systems (from the subcomponents to the supporting infrastructure) and their integrations with other urban systems. This course introduces the students to the tools and methodologies to achieve such integration.

EN 610 Health and Environmental Impact of Nanotechnology (3 - 0 - 0)

This course covers the environmental and health aspects of nanotechnology. It presents an overview of nanotechnology along with characterization and properties of nanomaterials. The course material covers the biotoxicity and ecotoxicity of nanomaterials. A sizable part of the course is devoted to discussions about the application of nanotechnology for environmental remediation along with discussions about fate and transport of nanomaterials. Special emphasis is given to risk assessment and risk management of nanomaterials, ethical and legal aspects of nanotechnology, and nano-industry and nano-entrepreneurship. Cross-listed with: NANO 610, EN 610

EN 618 HAZMAT Spill Response Planning

This course is designed to introduce students to the state-of-the-art techniques in spill response planning. Numerical and analytical techniques for the prediction of fate and effects of in-water spills are discussed. Spill cleanup technologies are introduced, including mechanical (e.g., booms and skimmers), chemical (e.g., dispersants), and biological. Students are instructed in the essential steps toward developing an effective spill response plan. Special attention is paid to the influence of spill characteristics and environmental factors - waves, currents, shoreline geometry, sensitive ecological areas, etc. - in the selection of an appropriate planning strategy. Examples are given of existing spill response plans in the New York/New Jersey region, and case studies of actual spills are discussed as a means of providing students with an understanding of the complexities of operational spill response planning. Cross-listed with: OE 618

EN 637 Environmental Control Laboratory

Laboratory verification of theoretical concepts involved in design and analysis of unit operations and unit processes for environmental pollution control and conservation. Laboratory investigations include mixing, coagulation, flocculation, sedimentation, filtration, vacuum operations, flotation, disinfection, corrosion control, chemical precipitation, adsorption, ion exchange, membrane processes, biological oxidation and anaerobic digestion.

EN 651 Environmental Chemistry of Soils and Natural Surfaces (3 - 3 - 0)

Soil is a mixture of inorganic and organic solids, air, water, and microorganisms. Soil affects the environmental chemistry through the interactions at solution-solid and air-solid interfaces, and the soil in turn is affected by the environmental and human activities. Soil science is not only important to agriculture, but also to diverse fields, such as environmental engineering, biogeochemistry, and hydrology. This course will enable students to understand the chemical properties of soil, soil minerals, natural of surfaces, and mechanisms regulating solute chemistry in soil solutions. The fate and transport of inorganic and organic pollutants in soil, and soil remediation technologies are discussed.

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Modeling of Environmental Systems EN 680

EN 654

Incorporation of fundamental reaction and transport phenomena into mass balances to describe the fate and transport of contaminants in lakes, rivers, estuaries, groundwater, the atmosphere, and in pollution-control processes. Several computer projects involving numerical solutions of models are required. Prerequisites: EN 541, CE 565

The objective of the course is to provide the students with exposure to the geotechnical nature of environmental problems. The topics covered include: principles of geochemistry, contaminant transport, and hydrogeology; an overview of landfill liners and other disposal facilities and their design, construction, safe operation, performance monitoring, structural, and physicochemical stability; an overview of the general principles governing the design, implementation, and monitoring of existing remediation technologies with special emphasis on stabilization/solidification, vapor extraction, bioremediation, soil washing, pump and treat, cover systems, and alternative containment systems such as slurry walls. A concurrent laboratory section introduces the student to the chemical analyses, absorption behavior, mineralogical, and crystallographical identification and characterization of various waste forms as they pertain to surface chemistry considerations. The main emphasis of the course consists of providing hands-on experience with analyses involving the use of spectrometric, X-ray

EN 683 Coastal Oceanography for Environmental Engineers

diffraction, and scanning electron microscope equipment. Cross-listed with: CE 654 Prerequisites: EN 520

This course deals with processes in the coastal ocean and in estuaries that affect the transport and dispersion of materials floating on the surface, dissolved in the water or in suspension. Topics include: fundamentals of surface wave mechanics, wind-generated surface waves, wind-generated currents, Ekman transport and upwelling, estuarine characteristics and buoyancy-driven circulation, and estuarine-coastal ocean exchange processes.

EN 686 Groundwater Hydrology and Pollution

Environmental Geotechnology

Fundamental concepts in groundwater hydrology and pollution, occurrence, and movement of groundwater; flow nets; well hydraulics; and numerical methods in groundwater hydraulics. Chemical properties of groundwater, sources, and effects of contamination; principles of mathematical modeling of containment transport in groundwater; and numerical methods in groundwater pollution.

EN 690 Soil and Groundwater Remediation Technologies

This course will provide the student with a thorough understanding of soil and groundwater remediation technologies including fundamental principles, site applicability, remedial alternatives, and selection, planning and design of remedial systems, field implementation and economics. Prerequisites: EN 686

EN 702 **Curricular Practical Training**

International graduate students may arrange an internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course provided that the course constitutes and integral part of their educational program. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the project plus a statement from the employer that he/she intends to employ the student. This information must be provided to the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/her activities during that semester, even if the activity remains ongoing. This is a one-credit course that may be repeated up to a total of three credits.

EN 723 Flow & Mass Transport in Porous Media

An advanced treatment of flow and mass transport in porous media; fluid and porous matrix properties; mathematical description of flow and mass transport in fully and partially saturated soils; diffusion and hydrodynamic dispersion processes; analytical-numerical and conformal mapping techniques for the solution of the governing equations; development of computer models for prediction of flow and contaminant transport in variably saturated soils.

SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

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EN 751 **Design of Wastewater Facilities**

Principles of process design and economics are integrated through open-ended problem-solving situations. Topics include process selection, feasibility studies, equipment design and scale-up, costing and economics, optimization, process identification and control, operation and maintenance, and permitting and other regulatory issues. Prerequisites: EN 573, EN 571

EN 771 Advanced Environmental Separation Processes (3 - 0 - 0)

Advanced topics in separation processes for environmental applications in the mass and energy transfer areas. Topics include distillation, absorption, stripping, membrane-based separation processes, thermal destruction of hazardous wastes, supercritical fluid extraction for soils and solid wastes, utilization and development of computer models for process plant design, optimization, and simulation.

EN 780 Nonlinear Correlation and System Identification (3 - 3 - 0)

An investigation of tools to identify nonlinear processes and relationships. Mathematical tools covered include nonlinear regression, artificial neural networks, and multivariate polynomial regression. Applications include mass transfer correlations, prediction of drinking water quality, and modeling of wastewater treatment processes. Prerequisites: CE 679 or equivalent, and permission of instructor. Prerequisites: CE 679

EN 800 Special Problems in Environmental Engineering (1 to 6 - -)

One to six credits. Limit of six credits for the degree of Master of Engineering (Environmental).

EN 801 Special Problems in Environmental Engineering (1 to 6 - -)

A thorough investigation of an advanced research topic under the direction of a faculty member. The course is open to students who are or plan to be doctoral candidates. One to six credits for the degree of Doctor of Philosophy.

EN 900 Thesis in Environmental Engineering (5 to 10 - -)

For the degree of Master of Engineering (Environmental). Hours and credits to be arranged.

EN 960 Research in Environmental Engineering

Original research of advanced level in Environmental Engineering which may serve as the topic for the dissertation for the degree of Doctor of Philosophy. Credits to be arranged.

Nanotechnology

NANO 570 (3 - 3 - 0)**Environmental Chemistry** Principles of environmental reactions with emphasis on aquatic chemistry; reaction and phase equilibria; acid-base and carbonate systems; oxidation-reduction; colloids; organic contaminants classes, sources, and fates; groundwater chemistry; and atmospheric chemistry. Cross-listed with: EN 570

NANO 571 Physicochemical Processes for Environmental Control

A study of the chemical and physical operation involved in treatment of potable water, industrial process water, and wastewater effluent; topics include chemical precipitation, coagulation, flocculation, sedimentation, filtration, disinfection, ion exchange, oxidation, adsorption, flotation, and membrane processes. A physical-chemical treatment plant design project is an integral part of the course. The approach of unit operations and unit processes is stressed. Cross-listed with: EN 571

Naval Engineering

NE 322 Engineering Design VI

This course is intended to teach modern systematic design techniques used in the practice of naval engineering. The emphasis is placed on usage of CAD tools for ship hullform design and development. Methodology for the development of design objective(s), literature surveys, base case designs, and design alternatives are given. Students are encouraged to select their senior capstone design project near the end of the course, form teams, and commence preliminary work. Prerequisites: Corequisites: OE 528

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Senior design courses. Complete design sequence with a required capstone project spanning two semesters. The capstone design project will use the entire range of knowledge and skills acquired in earlier courses. The project will include extensive instruction in, and incorporation of, engineering standards, professional ethics, environmental impacts, and economics. These aims will be accomplished by providing students with realistic ship design performance requirements, and instruction and advice from practicing ship design professionals. Prerequisites: NE 322

NE 424 Engineering Design VIII

Engineering Design VII

Senior design course. Complete design sequence with a required capstone project spanning two semesters. The capstone design project will use the entire range of knowledge and skills acquired in earlier courses. The project will include extensive instruction in, and incorporation of, engineering standards, professional ethics, environmental impacts, and economics. These aims will be accomplished by providing students with realistic ship design performance requirements, and instruction and advice from practicing ship design professionals. Prerequisites: NE 423

NE 453 Advanced Fluid Dynamics

Review of basic concepts of fluid flow, Navier-Stokes equations, introduction to fluid turbulence, inviscid incompressible flow, introduction to airfoil theory, compressible fluid flow and applications. Cross-listed with: ME 453

Ocean Engineering

NE 423

OE 501 Oceanography

Geophysical description of the earth; the extent, shape. and structure of ocean basins; relief of the sea floor; chemistry of sea water; geochemical balances; physical properties of water and sea water; solar and terrestrial radiation; evaporation and precipitation over the oceans; dissolved gases in sea water; distribution of variables; and general oceanic circulation.

OE 503 Seminar in Ocean Engineering

Seminar course in which you report on selected topics in ocean engineering. Emphasis is on the problems encountered in performing engineering tasks in the ocean and methods employed to surmount them. Students are encouraged to devise alternate methods to improve existing techniques.

OE 505 Introduction to Maritime Systems

An introductory course intended to acquaint students with the various components of maritime systems, including shorefront and inland infrastructure and waterborne (vessel) transportation technologies. Students are introduced to the concepts of port and marine terminal design, cargo handling equipment and optimization, and intermodal transportation networks. The course emphasizes the application of new and emerging technologies to enhance port productivity, drawing on developments within an array of fields, including naval architecture, civil and ocean engineering, and systems engineering. Students are provided with practical examples of the application of these concepts in actual port design projects.

OE 511 Urban Oceanography

This course introduces the fundamental principles of urban oceanography by providing a broad overview of all the interacting processes that shape urban ocean ecosystems. The course investigates the geologic history of many urban area waters, in addition to the physics, chemistry, and biology of the waters, while emphasizing how man has significantly influenced how these systems behave. The course includes studying the local waters that surround us, such as the New York-New Jersey Estuary, the Hudson River and the East River. Via field expeditions on an Institute research vessel, students will experience first hand field sampling, data reduction and analysis of field data, and interpretation of processes. Their investigation results will be prepared as a cooperative class report.

OE 520 **Design of Marine Structures**

This course is intended to provide a basic understanding of the ocean environment, hydrodynamic loads and the design of marine and coastal structures. Basic hydrodynamics and linear wave theory will be introduced. Essential elements of coastal structure design will be covered including: the determination of design parameters, hydraulic performance, and structural stability. Interaction between floating and fixed marine structures such as vessels and off-shore platform components will be introduced through the following topics: hydrodynamic loads based on linear wave theory; breaking wave loads; application of Morison's equation in load predictions; fluid-induced vibration phenomena such as vortex-induced vibration and flutter; and motion response of floating structures to wave excitation. The discussion of these topics will emphasize application for engineering analysis.

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Introduction to Ship Design and Ship Building

and New Jersey. Special topics will be addressed through guest lectures and field trips.

Ocean Engineering

Overview of maritime industry; types and purposes of commercial and naval ships; introduction to various disciplines of naval engineering; concepts of hydrostatics, resistance, and propulsion; overview of ship systems and general arrangements; introduction to towing tanks and model testing methodology; overview of preliminary ship design with brief group design project; and basics of ship building, operation, repair, and maintenance.

"Living Shorelines" refers to an innovative approach to stabilizing eroding shorelines that integrates traditional coastal engineering concepts, with elements of bioengineering and coastal ecology. The goal is to create a stable, resilient shoreline that enhances the natural ecosystem. This course is designed to fit an industry need for engineers that are familiar with traditional coastal engineering concepts as well as ecology and/or bioengineering. This will be accomplished through lectures focused on the characteristics of natural organisms (flora and fauna) that contribute to the stability and ecological enhancement of traditional coastal structures. Some of the topics to be presented in this class include evaluating site conditions, integrating ecological considerations with engineering requirements, determining representative costs and understanding project regulations. A significant portion of the class will be dedicated to developing designs for living shorelines projects in New York

OE 525 Principles of Naval Architecture

OE 522

OE 524

Basic principles and design calculations in naval architecture; terminology, delineation of hull form, loading and stability, trim, and effects of flooding; freeboard and tonnage regulations; introduction to design of hull structure; nature of resistance and its variation with hull form and proportions; and introduction to propellers and propulsion. Basic theories in maneuvering and sea-keeping characteristics, computer application in naval architecture, and ship design.

OE 526 Computer-Aided Aspect of Naval Architecture

Basic principles and design calculations in naval architecture as an extension of OE 525 PNA course with emphasis placed on the application of computers. Computer-aided studies of hull-forms, intact stability, damaged stability, resistance and propulsion characteristics, course-keeping analysis, and ship motion predictions. Problems in the area of naval architecture will be considered on computers through time-sharing systems.

OE 527 Laboratory in Naval Architecture

Solution of problems in naval architecture through model testing, actually conducting a wide variety of model tests at Davidson Laboratory, and prediction of prototype performance.

Computer-Aided Ship Design OE 528

Computer-aided design procedures to achieve mission requirements for various ship types through design spirals. Determination of major dimension and performance analysis during preliminary design stage. Computer graphics on mainframe and microcomputers as design tools. Pertinent design procedures are covered in a computer-aided manner.

OE 529 Maritime Safety and Security

This course introduces students to international and national safety and security issues of importance to officials in the maritime industry, including the UN International Maritime Organization, U.S. Coast Guard, vessel owners and operators, marine facility management, and Port Authorities. Risk-based analyses are performed to assess safety and security concerns related to vessel and shore labor practices, navigational safety including cargo (e.g., oil spills) and vessel traffic (e.g., collisions) movements, Maritime Domain Awareness, sensor technology, and potential terrorist activities. Students receive instruction in the procedures required for the identification, analysis, prevention, and mitigation of safety and security problems associated with the various threats to human safety, vessels, critical infrastructure, and sensitive marine environments. Students are introduced to the concepts of risk assessment and management, vessel traffic management systems, ship and port security planning, facility contingency planning, and event response planning. State, Federal, and international regulations and guidelines related to maritime safety and security are discussed. Case studies from the New York/New Jersey region and other port regions are employed in the delivery of this instruction.

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OE 530 Yacht Design

Calculation of hydrostatic curves to determine trim and sinkage of sailing yachts, static and dynamic stability, calculation of resistance and side force by expansion of tank test results, sail force coefficients, prediction of comparative performance based on tank test results, application of lifting surface theory to the design of keel and rudder, and consideration of structural strength and stiffness. Prerequisites: OE 525

OE 531 Total Ship Design I

This course is the first one of a two-course sequence and the focus will be on marine engineerign aspects and machinery considerations. Topics covered in this course include: Diesel engines, steam turbines and gas turbines as marine prime movers. Thermodynamic cycles, ratings, matching to loads. Engine-propeller matching. Mechanical transmission of power to marine loads. Ship Design Process, Mission and Owner's Requirements, Regulatory and Classification Requirements, Design/Production Integration and Ship Building Process.

OE 532 Total Ship Design II

This is the second part of a two-course sequence where the focus is on shipboard electrical power systems and other components of ship design that are not covered in the first part. Topics covered in this course include: Electric Power Generation and Electric Propulsion, Integrated marine electrical plants, electric load calculations, auxiliary systems, combat systems, ship systems integration, human factors in ship design, general arrangement design, contracts and specifications, cost estimating and ship preservation.

OE 533 Nuclear Terrorism and Security

Study of the underlying physical realities of a possible terrorist attack consisting of an explosion and release of radioactive materials comparable to that experienced at Hiroshima; other catastrophic nuclear events including radiological weapons and destruction of a nuclear power plant are considered; the basic science and technology needed to understand these threats; an historical perspective is taken. Given that the most likely delivery, by terrorists, of a nuclear device would be waterborne, and given that many nuclear reactors are positioned on the coast or on the banks of large rivers, the course has a maritime security orientation. While focused on helping prepare students to work in fields that would prevent these events, attention is also devoted to the responses to and recovery from such events, with particular attention to analysis of radioactivity dispersal and strategies for limiting the impact of radiation and fallout.

OE 535 Ocean Measurements and Analysis

Basic ocean measurements and instrumentation, sampling requirements, data processing, analysis, and presentation. Prerequisite: Completion of an undergraduate probability and statistics course.

OE 539 Introduction to Underwater Acoustics

The course is intended to acquaint students with environmental acoustics and the application of acoustic waves to remote environmental monitoring. Students will learn how to measure and suppress environmental noise and how underwater acoustic systems are used for remote measurements of various ocean and river parameters, including: bottom profile, surface waves, current, bubble and fish density, etc. The course also surveys recent developments in acoustic tomography, including global warming control. Students will be asked to write a research paper on the application of acquired methods to remote acoustic measurements conducted at Stevens. Prerequisites: OE 539

OE 550 Environmental Acoustics and Acoustical Remote Environmental Monitoring (3 - 0 - 0)

The course is intended to acquaint students with environmental acoustics and the application of acoustic waves to remote environmental monitoring. Students will learn how to measure and suppress environmental noise and how underwater acoustic systems are used for remote measurements of various ocean and river parameters, including: bottom profile, surface waves, current, bubble and fish density, etc. The course also surveys recent developments in acoustic tomography, including global warming control. Students will be asked to write a research paper on the application of acquired methods to remote acoustic measurements conducted at Stevens. Prerequisites: OE 539

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OE 560 Fundamentals of Remote Sensing

This course exposes the student to the physical principles underlying remote sensing of ocean, atmosphere, and land by electromagnetic and acoustic passive and active sensors: radars, lidars, infrared and microwaves thermal sensors, sonars, sodars, infrasound/seismic detectors. Topics include fundamental concepts of electromagnetic and acoustic wave interactions with oceanic, atmospheric, and land environment, as well as with natural and man-made objects. Examples from selected sensors will be used to illustrate the information extraction process, and applications of the data for environmental monitoring, oceanography, meteorology, and security/military objectives. Cross-listed with: EN 560, EE 560, CE 561, PEP 560 Prerequisites: PEP 201, PEP 112, E 246

OE 580 Surfzone Hydrodynamics

This course focuses on the identification of the physical principles and environmental phenomena responsible for driving nearshore circulation on open ocean coasts. The equations governing the hydrodynamics of the surfzone (shoreward of the break point) will be studied in detail and the various types of models used to predict nearshore circulation will be discussed. Real world examples, based on current research projects being conducted at the Stevens Coastal Engineering Research Lab will form an integral part of the curriculum. Topics covered will include: basic hydrodynamics, linear wave theory, wave transformation, wave boundary layers, surfzone currents, and nearshore circulation.

OE 585 Littoral Processes

This course focuses on the physical processes impacting engineered systems in the coastal environment and the resulting impact of these built systems on the coast. The importance of characteristics such as beach composition, shoreline configuration, and both present and past hydrodynamic conditions will be emphasized. Modern approaches for predicting large scale or bulk coastal change based on observed and/or modeled environmental conditions will be presented. The course complements and will feature examples extracted from current research projects being conducted at the Stevens Coastal Engineering Research Laboratory (CERL). Topics covered in this course will include: coastal geomorphology, hydrodynamics, coastal sediment transport, inlet processes, and shore protection methods.

OE 589 Coastal Engineering

An introductory course covering the fundamental principles of coastal engineering. The initial stages of the course are intended to provide an understanding of the physics of the coastal environment. Topics will include basic wave theory (wave generation, refraction, diffraction, and shoaling), wave prediction techniques, tides and coastal circulatio, and sediment transport. The latter stages of the course will be devoted to the application of these basic principles, such as stabilization and harbor development. The course will culminate in a substantial design project, which will incorporate all aspects of the course material, ranging from the estimation of design wave conditions to the actual design of a shore protection structure. Prerequisite: MA 227 or the equivalent and Fluid Mechanics.

OE 591 Introduction to Dynamic Meteorology

Introduction to meteorology presents a cogent explanation of the fundamentals of atmospheric dynamics. The course begins with a discussion of the Earth's atmospheric system, including global circulation, climate, and the greenhouse effect. The basic conservation laws and the applications of the basic equations of motion are discussed in the context of synoptic scale meteorology. The thermodynamics of the atmosphere are derived based on the equation of state of the atmosphere, with specific emphasis on adiabatic and pseudo-adiabatic motions. The concept of atmospheric stability is presented, in terms of the moist and dry lapse rate. The influence of the planetary boundary layer on atmospheric motions is presented with emphasis on topographic and open ocean frictional effects, temperature discontinuity between land and sea, and the generation of sea breezes. The mesoscale dynamics of tornadoes and hurricanes are discussed, as well as the cyclogenesis of extratropical coastal storms. The course makes use of a multitude of web-based products, including interactive learning sites, weather forecasts from the National Weather Service (NWS), tropical predictions from the National Hurricane Center, and NWS model outputs (AVN, NGM, ETA, and WAM). Cross-listed with: CE 591

OE 610 Marine Transportation

This course introduces students to the history and technical description of the cargo-carrying vessel. Students are given instruction in the basic principles of vessel design, and the various types of ocean-going and inland waterway cargo vessels. Issues related to the introduction of new vessel types are discussed, particularly as these new designs affect port infrastructure and capacity, harbor dredging requirements, and the intermodal transportation network.

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OE 612 Environmental Issues in Maritime Systems

An introductory course intended to familiarize students with the array of environmental issues related to inland, estuarine, and oceanfront port facilities. Particular attention is paid to water quality and bottom sediment contamination problems associated with the construction and operation of port facilities. Students are introduced to the various types of analysis tools, including field measurements and computer models, employed in the examination of port and harbor environmental problems. Practical examples of their use are provided from actual projects in the New York/New Jersey region. Students are also instructed in the use of emerging technologies in the prevention/remediation of identified pollution problems. Relevant state, federal, and international regulations are also discussed.

OE 614 Economic Issues in Maritime Systems

This course introduces students to the unique economic issues facing today's port developers and operators. The economic considerations essential to the efficient movement of cargo from vessels to inland transportation systems are discussed. Students are introduced to concepts related to the optimization of port manpower, energy, and infrastructure as a means of assuring competitiveness in the global marketplace. Students are also introduced to the principles of port financial strategies, with examples given from port authorities in the United States and abroad.

OE 616 Sediment Transport

Theory of sediment transport in open channel flow, including applications to riverine, ocean, and coastal environments. Topics covered include boundary layer dynamics, the initiation of motion, sediment characteristics, suspended load, and bed load. Applications include the estimation of transport rates in waves and currents, and the influence of hydraulic structures.

OE 618 HAZMAT Spill Response Planning

This course is designed to introduce students to the state-of-the-art techniques in spill response planning. Numerical and analytical techniques for the prediction of fate and effects of in-water spills are discussed. Spill cleanup technologies are introduced, including mechanical (e.g., booms and skimmers), chemical (e.g., dispersants), and biological. Students are instructed in the essential steps toward developing an effective spill response plan. Special attention is paid to the influence of spill characteristics and environmental factors - waves, currents, shoreline geometry, sensitive ecological areas, etc. - in the selection of an appropriate planning strategy. Examples are given of existing spill response plans in the New York/New Jersey region, and case studies of actual spills are discussed as a means of providing students with an understanding of the complexities of operational spill response planning. Cross-listed with: EN 618

OE 622 Design of Port Structures I

This course introduces students to the fundamentals of port structures design, including design codes, guidelines, and functional requirements. Students are instructed in optimization procedures for port and marine terminal layout, including issues related to navigation channels and dredging, shore infrastructure and utilities, land reclamation, and environmental and economic considerations. Structural, geotechnical, and materials considerations are discussed for a variety of environmental conditions, including extreme wave and current environments, ice, and seismic loading. Examples and case studies from actual port design projects are utilized to a great extent in the delivery of the course material.

OE 623 Design of Port Structures II

This course instructs students in the functional design of the various components of ports and marine terminals, including steel, concrete, timber, and stone structures. Students are introduced to the detailed design procedures for a variety of structure types, including bulkheads and piers, fender and mooring systems, and breakwaters and revetments. Special considerations such as sedimentation/dredging, structure inspection and rehabilitation, vessel motions, and port downtime are discussed. Students receive instruction in the use of computer and physical model studies in support of structure design. Environmental and permitting issues are discussed.

OE 626 Port Planning and Development

This course introduces students to the evaluation and optimization of port and harbor layout from the standpoint of safe and efficient vessel navigation and cargo loading and unloading. Students receive instruction in the analysis tools and procedures used in the assessment of vessel motions, while underway in open water and in navigation channels, and while at dock. The evaluation of long wave motions and harbor resonance problems are discussed, as is risk-based analysis of port and harbor protection (e.g., breakwaters). Students will be introduced to computer models used in the evaluation of these issues, and will make extensive use of the models in the conduct of in-class case studies of port and harbor layouts.

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The course is intended to acquaint students with the underlying technologies pertaining to Maritime Safety and Security. Students will understand current technologies applicable to threat mitigation including threats from criminal activities, illegal immigration, piracy, and terrorism. The considered technologies will include: X-Ray scanning, Gamma Ray and neutron scanning, biometrics, radiation detection, Radio Frequency Identification Tags, underwater acoustic surveillance, wireless sensor networks, and infrared technologies will be introduced to student. The course also surveys recent developments in port protection conducted by Stevens scientists. Prerequisites: OE 560

OE 629 Advanced Maritime Security

Technologies for Maritime Security

This course provides broad knowledge of security systems and protocols applied in the Maritime Transportation System (MTS), consistent with international and national laws and regulations. Security policies, processes and procedures are presented and illustrated by case studies. All requirements for certification for those who may be designated to perform the duties and responsibilities of a Company Security Officer (CSO) or a Vessel Security Officer (VSO), as defined in the International Ship and Port Security Code (ISPS) and the Maritime Transportation Security Act of 2002 as part of their vessel or port responsibilities, are covered. Prerequisites: OE 529

OE 630 Hydrodynamics

0E 628

Development of the kinematic and dynamic equations for incompressible fluid flow, the Navier-Stokes equation, velocity potential and stream function, Bernoulli's equation, conformal mapping, free surface flows, wave theory, flow in porous media, and turbulence. Prerequisites: CE 342, MA 227

OE 631 Fluid Dynamics for Ocean Engineering

Cavitation, two-dimensional flows, complex velocity and complex potential; and concentrated and distributed singularities, lift-drag Kutta condition, D'Alembert paradox, Blasius theorem, and Karman vortex street. Conformal mapping, Möbius transformation, Schwartz-Christoffel transformation. Applications, added mass and virtual mass, Taylor's added mass theorem, Lagally's theorem, the Navier-Stokes equation, exact solutions for parallel flow, Couette flow, and Poiseuille flow. Unsteady problems: boundary layer Reynold's number, flat plate boundary layer, Von Karman integral method, and Pohlhausen solution. Prerequisites: OE 630

OE 633 Dynamic Oceanography

Gravity and rotation of earth, continuity considerations, dynamic equations of motion, gradient currents, stationary accelerated currents, turbulence, analysis of temperature-salinity diagrams, internal friction and modification of geostrophic currents, wind-driven currents, and horizontal circulation of wind-driven current.

OE 634 Air-Sea Interactions: Theory and Measurement

Momentum, heat and water flux across the air-sea interface, shear stress and the neutral wind profile, adiabatic lapse rate in the lower atmosphere, static and dynamic stability of a stratified fluid, effects of stability on transfer processes in the lower atmosphere and ocean surface layer, direct measurement of eddy flux, and indirect determination of eddy flux from routine shipboard meteorological observations. Prerequisites: OE 633

OE 635 Stochastic Analysis of Ocean Waves

Introduction to probability theory; statistical techniques for characterizing random variables and evaluation of data; statistical techniques for analyzing stochastic processes; and application of power spectral density techniques to the representation of the sea surface and other stochastic marine processes.

OE 636 Topics in the Application of Stochastic Process Theory in Ocean Engineering (3 - 0 - 0)

An expansion upon three important topics introduced in OE 205. The first topic is random data reduction and interpretation in ocean engineering; and basic methods of auto- and cross-spectral analysis, statistical errors, design of experiments, and directional-wave spectra estimation. The second deals with the application of probabilistic design methods in ocean engineering; and the third is a survey of the state-of-the-art marine applications of nonlinear random process theory. Prerequisites: OE 635

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OE 637 Estuarine Oceanography

Classification of estuaries; salt balance equation, forms of the salt balance equation for major types of estuaries, equations of motion, estuarine circulation, diffusion and dispersion in estuaries.

OE 641 Dynamics of Ocean Waves

Description and formulation of wave problems in the ocean, development of classical wave theory, free waves and forced waves induced by pulsating and uniformly translating pressures and sources in steady and unsteady states, diffraction, refraction and reflection of waves, application to floating breakwaters, and harbor oscillations.

OE 642 Motion of Vessels in Waves

Dynamic response of a ship in regular and irregular seas, the equation of motion with six degrees of freedom, added mass and damping coefficient of an oscillating ship on the free surface, coupled equation of motion of a ship in waves, and description of ship motion in the irregular sea with the discussion leading to nonlinear equations of motion. Prerequisites: OE 641

0E 643 Stability and Control of Marine Craft

Basic concepts of stability and automatic control, equations of motion of marine craft, representation of hydrodynamic forces and moments, equilibrium conditions and perturbation equations, stability criteria, Routh-Hurwitz method, directional stability and maneuvering control, effects of wind, waves and restricted waters, stability of towed bodies, anti-rolling and antipitching control systems, and dynamic simulations of marine systems.

0E 644 Design of Ship Propellers

Fundamentals of two-dimensional flow about hydrofoils, including design of camber lines for specified pressure distributions and the inverse problem, characteristics of thickness distribution, predictions of cavitation inception as a function of thickness, camber, and departure from ideal angle of attack. Three-dimensional flows about lifting signs of large and small aspect ratios. Momentum theory applied to propellers to determine ideal efficiency, lifting line, and lifting surface models of propellers. The use of openwater design charts for the determination of optimum pitch, diameter, and revolutions. Exercise of computer program for preliminary design. Introduction to concepts leading to assessment of vibratory forces and hull forces. Prerequisites: OE 525, OE 530

OE 645 Hydrodynamics of High-Speed Marine Craft

Planing craft, life, drag, wetted area of hull, appendage drag, direct and indirect propeller effect, spray formation, impact loads in smooth water and waves, porpoising, rough water behavior, and tank test procedures.

OE 647 Advanced Hydrodynamic Laboratory (3 - 3 - 0)

Several of the important theories germane to ocean engineering are reviewed or developed and used to predict body or fluid behavior. These predictions are then compared with results obtained by the student using the Davidson Laboratory research facilities. Prerequisites: OE 641, OE 630, OE 525, OE 527

0E 648 Numerical Hydrodynamics

Potential flows around bodies: panel singularities methods and conformal mapping methods. Finite-difference and spectral methods for Poisson equations: numerical inversion of matrices, and potential flows in or around irregular domains. Consistency, stability, and convergence of numerical methods: linear stability analysis. Numerical methods for diffusion equations and methods for ordinary differential equations. One-dimensional Burger's equation and nonlinear problems, Newton iteration, error analysis. Numerical methods for stream function vorticity equations: flows in or around irregular domains. Discussions of current research in computational fluid dynamics. Four exercise projects and one examination project will be assigned to each student. Prerequisite: Computer Programming. Cross-listed with: CE 648

OE 660 Naval Ship Acquisition Process

This course familiarizes the student with naval ship acquisition programs. Focusing on the current process in place by the U.S. Navy, but with a review of methods use in the past, projected to be used in the future, and in use by major world powers today. Topics include the system acquisition life cycle, requirements analysis, contract management, and program planning. Students must have basic naval architecture course work or experience, as determined by advisor.

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OE 661 Principle of Naval Ship Systems

This course will provide the student with a broad overview of the many systems and design considerations specific to naval ships. Topics include navigation, surveillance and combat systems for a wide variety of common naval ships. Design considerations, such as underway replenishment, aircraft take-off and landing, launching of boats, port and shore operations, and the effects of ship motions on the limitations of the crew will be covered in the context of developing a systems-based approach to naval ship design. Prerequisites: Students must have basic naval architecture course work or experience, as determined by advisor.

OE 683 Coastal Oceanography for Environmental Engineers

This course deals with processes in the coastal ocean and in estuaries that affect the transport and dispersion of materials floating on the surface, dissolved in the water or in suspension. Topics include: fundamentals of surface wave mechanics, wind-generated surface waves, wind-generated currents, Ekman transport and upwelling, estuarine characteristics and buoyancy-driven circulation, and estuarine-coastal ocean exchange processes.

OE 684 Mixing Processes in Inland and Coastal Waters (3 - 3 - 0)

Development of advective-diffusion equations for conservative and non-conservative substances. Fickian diffusion, turbulent diffusion, and shear flow dispersion. Description and specification of mixing processes in rivers, reservoirs, and estuaries. Methods and analyses of conservative dye tracer studies. Monte Carlo simulations of diffusion processes and numerical models for simulation of advection diffusion processes in rivers and estuaries.

OE 688 Coastal Ocean Dynamics I

Mechanics of rotating flow; inviscid shallow-water theory: topographic Rossby Waves; effects of friction: the Ekman theory; and wind-driven ocean circulation: coastal ocean modeling, supercomputing applications, dispersion, and mixing in coastal waters. Prerequisites: OE 501, MA 529

OE 690-691 Special Topics in Ocean Engineering I,II

An advanced seminar course concerned with recent research developments in ocean engineering. Special emphasis will be placed on developments in theoretical and applied hydrodynamics. Topics are subject to the currents interest of the faculty and students.

OE 702 Curricular Practical Training

International graduate students may arrange an internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course provided that the course constitutes and integral part of their educational program. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/her activities during that semester, even if the activity remains ongoing. This is a one-credit course that may be repeated up to a total of three credits.

OE 800 One to six credits.	Special Problems in Ocean Engineering (ME) . Limit of six credits for the degree of Master of Engineering (Ocean).	(1 to 6)
OE 801 One to six credits.	Special Problems in Ocean Engineering (PhD) . Limit of six credits for the degree of Doctor of Philosophy.	(1 to 6)
OE 810 A participating se	Special Topics in Ocean Engineering minar on topics of current interest and importance in Ocean Engineering.	(3)
OE 900 For the degree of	Thesis in Ocean Engineering Master of Engineering (Ocean). Hours and credits to be arranged.	(1 to 10)
0	Research in Ocean Engineering (PhD) earch of high level design in ocean engineering which may serve as the basis for the d of Philosophy. Hours and credits to be arranged.	() issertation for the

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Department of Computer Science

FACULTY

GIUSEPPE ATENIESE DEPARTMENT DIRECTOR

Giuseppe Ateniese, Ph.D. The David and GG Farber Endowed Chair in Computer Science, Professor and Director

Eduardo Bonelli, Ph.D. Teaching Associate Professor

Brian Borowski, Ph.D. Teaching Assistant Professor

Adriana Compagnoni, Ph.D. Associate Professor

Dimitrios Damopoulos, Ph.D. Teaching Assistant Professor

Daniel Duchamp, Ph.D. Research Professor

Dominic Duggan, Ph.D. Associate Professor

Enrique Dunn, Ph.D. Associate Professor

Michael Engling, Ph.D. Lecturer

David Farber, Ph.D. Visiting Distinguished Professor

EMERITUS FACULTY

A Satyanarayana, Ph.D. Emeritus Professor David Klappholz, Ph.D. Associate Professor

Samantha Kleinberg, Ph.D. Assistant Professor

Philippos Mordohai, Ph.D. Associate Professor

David Naumann, Ph.D. Professor

Antonio Nicolosi, Ph.D. Associate Professor

Fernando Perez-Cruz, Ph.D. Associate Professor

Georgios Portokalidis, Ph.D. Assistant Professor

Sridharan Srinivas, Ph.D. Teaching Assistant Professor

Nikolaos Triandopoulos, Ph.D. Associate Professor

Iraklis Tsekourakis, Ph.D. Teaching Assistant Professor

Wendy Wang, Ph.D. Associate Professor

Susanne Wetzel, Ph.D. Associate Professor

UNDERGRADUATE PROGRAMS

Stevens offers undergraduate majors in Computer Science and Cybersecurity. Each is specifically designed to train the highend IT professionals who can take advantage of trends in the IT industry and gain entry into a challenging and rewarding career path in software development and systems analysis.

Science Requirement

All majors must take one of these science sequences, each consisting of two science courses and a science laboratory:

	Science I	Science II	Science Lab
Physics	PEP 111 Mechanics	PEP 112 Electricity and Magnetism	PEP 221
Chemistry	CH 115 General Chemistry I	CH 116 General Chemistry II	CH 117
Chemistry & Biology	CH 115 General Chemistry I	BIO 281 Biology & Biotechnology	CH 117
Chemistry & Biology	CH 115 General Chemistry I	BIO 281 Biology & Biotechnology	CH 282
Physics & Biology	PEP 111 Mechanics	BIO 281 Biology & Biotechnology	CH 282
Physics & Biology	PEP 111 Mechanics	BIO 281 Biology & Biotechnology	PEP 221
Physics & Chemistry	PEP 111 Mechanics	CH 115 General Chemistry I	CH 117
Physics & Chemistry	PEP 111 Mechanics	CH 115 General Chemistry I	PEP 221

Humanities Requirement

One humanities course must be HSS 371 Computers and Society or HPL 455 Ethical Issues in Science and Technology. In addition, students must follow the requirements of the College of Arts and Letters:

- All freshmen must take CAL 103 Writing and Communication and CAL 105 CAL Colloquium.
- At least one humanities course must be at the 100 or 200 level and at least one course must be at the 300 or 400 level.
- Courses must be taken in at least two of the four disciplines of Literature, Philosophy, History, and Social Science.

Physical Education Requirement

- All students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team, and wellness areas.
- All PE courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- ▶ Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

GETTING STARTED

Study begins with a three-course sequence (CS 115, CS 284, and CS 385) that teaches the fundamentals of computer programming. Most students will take these courses in sequence in their first three semesters. Students who enter with a limited background in computer programming or who want reinforcement of fundamental concepts should take CS 110 in the first semester followed by the sequence 115-284-385 in semesters II though IV. Students who take the Honors sequence of 181-182 will skip the 115-284-385 sequence; the two Honors courses are equivalent to the standard three-course sequence.

ADVANCED PLACEMENT

Students who receive a score of 4 or 5 on the computer science advanced placement exam receive credit for one technical elective and are encouraged to take CS 181 in semester I. Students who receive a score of 6 or 7 on the International Baccalaureate (IB) computer science exam, Standard Level, are treated similarly. Students who receive a score of 6 or 7 on the IB computer science exam, High Level, receive credit for one free elective course, are exempted from CS 115, CS 284, and CS 181, and start in CS 182.

BACHELOR OF SCIENCE IN COMPUTER SCIENCE

Besides its technical rigor, the Computer Science major is distinguished by its flexibility. In the senior year, a student can choose from a large number of elective courses.

The Computer Science Department is also the home to world-class research in areas such as computer security, vision and visualization, and data mining. The quality of this research is demonstrated by the publication and funding records of the faculty of the department. Undergraduate students are encouraged to get involved with faculty in their research. Indeed, while graduate students come from all over the world to be involved with research, some undergraduates choose to stay at Stevens for their graduate work, pursuing Ph.D. research with the faculty they came to know during their undergraduate studies.

Computer Science Requirements

The program requires the following courses:

Mathematics

- MA 121 Differential Calculus
- MA 122 Integral Calculus
- MA 123 Series, Vectors, Functions, and Surfaces
- MA 124 Calculus for Functions of Two Variables
- CS 135 Discrete Structures
- MA 222 Probability and Statistics
- MA 331 Intermediate Statistics
- CS 334 Automata and Computation

Computer Science

- CS 115 Introduction to Computer Science
- CS 146 Introduction to Web Programming and Project Development
- CS 284 Data Structures
- CS 306 Introduction to IT Security
- CS 347 Software Development Process
- CS 383 Computer Organization and Programming
- CS 385 Algorithms
- CS 392 Systems Programming
- CS 423 Senior Design I

- CS 424 Senior Design II
- CS 442 Database Management Systems
- CS 443 Database Practicum
- CS 485 Societal Impact of Information Technologies
- CS 492 Operating Systems
- CS 496 Principles of Programming Languages
- CS 511 Concurrent Programming

Choose one course from list of software development electives below. (For consistency with study plans below.)

Management

▶ BT 353 Project Management

Electives

Electives fall into four categories: science/math, software development, technical, and free. Students must take at least two science/math electives and one software development elective. The number of required technical and free electives is determined by how the student starts his/her program. Students who start with CS 115 must take two technical electives and two free electives. Students who start with CS 110 must use CS 110 as a technical elective, leaving one more technical elective and two free electives. Students who start with CS 181 must take three technical electives and two free electives.

Not every science or math course may be counted as a science/math elective. Students should consult their advisor or the department web site to learn of any restrictions.

The software development elective must be chosen from the following list of courses that involve substantial programming assignments:

- CS 537 Interactive Computer Graphics
- CS 541 Artificial Intelligence
- CS 558 Computer Vision
- CS 546 Web Programming
- CS 516 Compiler Design
- CS 521 TCP/IP Networking
- CS 522 Mobile Systems and Applications
- CS 526 Enterprise and Cloud Computing
- CS 548 Enterprise Software Architecture and Design
- CS 549 Distributed Systems and Cloud Computing

Please consult the department web site for the rules that define technical electives.

Despite the description "free elective," not every course may be counted as a free elective; in particular, courses that are similar to required courses may not be taken as free electives. Students should consult their advisor or the department web site to learn of any restrictions. In particular, courses that are similar to required courses may not be taken as free electives. Students should consult their advisor or the department web site to learn of any restrictions.

Term I					
Course #	Course Name	Lecture	Lab	Study	Credit
CS 115	Introduction to Computer Science	3	2	8	4
	Science I ¹	3	0	6	3
CS 146	Introduction to Web Programming and Project Development	3	0	6	3
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	4	34	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CS 284	Data Structures	2	2	8	4
CS 135	Discrete Structures	3	2	8	4
	Science II ¹	3	0	6	3
	Science Lab ¹	0	3	0	1
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	15	9	36	19

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
CS 383	Computer Organization and Programming	3	0	6	3
CS 385	Algorithms	4	0	8	4
CS 334	Automata and Computation	3	0	6	3
BT 353	Project Management	3	0	6	3
HUM	Humanities ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	16	2	32	16

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
CS 392	Systems Programming	3	0	6	3
CS 496	Principles of Programming Languages	3	0	6	3
CS 347	Software Development Process	3	0	6	3
MA 222	Probability and Statistics	3	0	6	3
HUM	Humanities ²	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	2	30	15

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Course #	Course Name	Lecture	Lab	Study	Credit
CS 442	Database Management Systems	3	0	6	3
CS 511	Concurrent Programming	3	0	6	3
MA 331	Intermediate Statistics	3	0	6	3
CS 443	Database Practicum	3	0	6	3
HSS 371 Or HPL 455	Computers and Society Or Ethical Issues in Science and Technology ²	3	0	6	3
	Total	15	0	30	15

Term VI

Term V

Course #	Course Name	Lecture	Lab	Study	Credit	
CS 492	Operating Systems	3	0	6	3	
	Science/Math Elective	3	0	6	3	
T.E.	Technical Elective	3	0	6	3	
	Humanities ²	3	0	6	3	
CS	SD Elective	3	0	6	3	
	Total	15	0	30	15	

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
CS 423	Senior Design I	3	0	6	3
CS 306	Intro to IT Security	3	1	8	4
	Science/Math Elective	3	0	6	3
CS	SD Elective	3	0	6	3
	Humanities ²	3	0	6	3
CS 485	Societal Impact of Information Technologies	1	0	2	1
TG 403	Senior Innovation I	2	0	4	2
	Total	18	1	38	19

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
CS 424	Senior Design II	3	0	6	3
	General Elective ³	3	0	6	3
	General Elective ³	3	0	6	3
	Humanities ²	3	0	6	3
T.E.	Technical Elective	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
	Total	16	0	32	16

(1) Science Electives: see pages 78-80 for details.

(2) Humanities requirements can be found on pages 556-557.

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(3) General elective is any 3 credit course.

MINOR IN COMPUTER SCIENCE

You may qualify for a minor in computer science by taking the courses indicated below. Enrollment in a minor means you must meet the Institute's requirements for minor programs. As many as four of the six courses may be double-counted toward both your minor and your major, assuming that your major accepts those four courses. Only courses completed with grade of C or better are accepted towards a student's minor.

The minor includes these four courses:

- CS 115 Introduction to Computer Science
- CS 135 Discrete Structures or MA 134 Discrete Mathematics
- CS 284 Data Structures
- CS 385 Algorithms

plus any two CS courses numbered 300 or higher; these courses must each be 3 or more credits. No course may duplicate another; specifically, students may not count toward the minor CS 501, CS 570, or CS 590; also, students may not count toward the minor both courses in each of the following pairs: CS 383 and CS 550, CS 492 and CS 520, CS 496 and CS 510, CS 442 and CS 561.

The Computer Science minor is available to Cybersecurity majors. Cybersecurity students minoring in computer science must take two CS courses numbered 300 or higher that are not already applied toward the requirements of the Cybersecurity degree.

BACHELOR OF SCIENCE IN CYBERSECURITY

The Bachelor of Science in Cybersecurity program is structured to provide students with security expertise within the context of a broad education. A solid education in security requires not only a strong focus in science and computer science in particular (e.g., need for robust implementation and software validation), but must also incorporate some aspects of engineering and technology management. While cryptographers strive to develop the best security solution possible, actual implementations of theoretical concepts often fail due to technological limitations, cost restraints, and human factors that were not part of the initial design process. For a solution to gain practical relevance, the end user must be able and willing to use it. From an economical point of view, a solution must provide a substantial monetary benefit to the customer. In order to allow for these complex issues to be better addressed, an education in cybersecurity must integrate science, technology, and management.

Cybersecurity Requirements

The program requires the following courses:

Mathematics

- MA 121 Differential Calculus
- MA 122 Integral Calculus
- MA 123 Series, Vectors, Functions, and Surfaces
- MA 124 Calculus for Functions of Two Variables
- CS 135 Discrete Structures
- MA 222 Probability and Statistics
- CS 334 Automata and Computation

Computer Science

- CS 115 Introduction to Computer Science
- CS 284 Data Structures
- ▶ CS 146 Introduction to Web Programming and Project Development
- CS 347 Software Development Process
- CS 383 Computer Organization and Programming
- CS 385 Algorithms
- CS 392 Systems Programming
- CS 442 Database Management Systems
- CS 443 Database Practicum
- CS 485 Societal Impact of Information Technologies
- CS 488 Computer Architecture
- CS 492 Operating Systems
- CS 496 Principles of Programming Languages
- CS 511 Concurrent Programming
- CS 521 TCP/IP Networking
- CS 595 Information Security and the Law

Cybersecurity

- CS/MA 503 Discrete Mathematics for Cryptography
- CS 306 Introduction to IT Security
- CS 425 Cybersecurity Capstone I
- CS 426 Cybersecurity Capstone II
- ▶ CS 576 Systems Security
- CS 577 Reverse Engineering and Application Analysis
- CS 578 Privacy in a Networked World
- CS 579 Foundations of Cryptography

Electives

The program includes one CS elective, two Cybersecurity electives, and one free elective. Please consult the department website for the rules that define a CS or free elective. Students must obtain their advisor's approval before enrolling in a course to count as CS or free elective. The following courses are approved as Cybersecurity electives. Note that undergraduate students must meet a minimum GPA requirement in order to be allowed to enroll in 600-level courses.

- CS 594 Enterprise Security and Information Assurance
- CS 665 Forensic Analysis
- CS 675 Threats, Exploits, and Countermeasures

- ▶ CS 693 Cryptographic Protocols
- CS676 Advanced Topics in Systems Security
- CS 695 Host Forensics
- CPE 592 Multimedia Network Security
- ▶ EE 584 Wireless Network Security
- SSE 623 Systems Security Architecture and Design

Other Cybersecurity electives may be approved at the discretion of the program director.

BACHELOR OF SCIENCE IN CYBERSECURITY

Term I

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Course #	Course Name	Lecture	Lab	Study	Credit
CS 115	Introduction to Computer Science	3	2	8	4
	Science I ¹	3	0	6	3
CS 146	Introduction to Web Programming and Project Development	3	0	6	3
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	4	34	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CS 284	Data Structures	2	2	8	4
	Science II ¹	3	0	6	3
	Science Lab ¹	0	3	0	1
CS 135	Discrete Structures	3	2	8	4
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	15	9	36	19

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Course #	Course Name	Lecture	Lab	Study	Credit
CS 334	Automata and Computation	3	0	6	3
CS 383	Computer Organization and Programming	3	0	6	3
CS 385	Algorithms	4	0	8	4
CS 306	Intro to IT Security	3	1	8	4
HSS 371 Or HPL 455	Computers and Society Or Ethical Issues in Science and Technology ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	16	3	34	17

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit		
CS 392	Systems Programming	3	0	6	3		
CS 496	Principles of Programming Languages	3	0	6	3		
CS 347	Software Development Process	3	0	6	3		
MA 222	Probability and Statistics	3	0	6	3		
HUM	Humanities ²	3	0	6	3		
PE 200	Physical Education IV	0	2	0	0		
	Total	15	2	30	15		

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CS 503	Discrete Mathematics for Cryptography	3	0	6	3
CS 442	Database Management Systems	3	0	6	3
CS 443	Database Practicum	3	0	6	3
CS 576	Systems Security	3	1	8	4
HUM	Humanities ²	3	0	6	3
	Total	15	1	32	16

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
CS 488	Computer Architecture	3	0	6	3
CS 492	Operating Systems	3	0	6	3
CS 578	Privacy in a Networked World	3	0	6	3
CS 579	Foundations of Cryptography	3	0	6	3
CS 577	Reverse Eng. and Application Analysis	3	1	8	4
	Total	15	1	32	16

Term III

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Course #	Course Name	Lecture	Lab	Study	Credit
CS 425	Cybersecurity Capstone I	3	0	6	3
CS 595	Information Security and the Law	3	0	6	3
CS	Security Elective	3	0	6	3
CS	CS Elective	3	0	6	3
CS 511	Concurrent Programming	3	0	6	3
CS 485	Societal Impact of Information Technologies	1	0	2	1
TG 403	Senior Innovation I	2	0	4	2
	Total	18	0	36	18

Term VII

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
CS 426	Cybersecurity Capstone II	3	0	6	3
CS	Security Elective	3	0	6	3
	General Elective	3	0	6	3
CS 521	TCP/IP Networking	3	0	6	3
	Humanities ²	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
	Total	16	0	32	16

(1) Science Electives: see pages 78-80 for details.

(2) Humanities electives: see pages 556-557 for details

(3) General elective is any 3 credit course.

(4) Humanities electives must be taken in at least two different disciplines within CAL.

MINOR IN CYBERSECURITY

You may qualify for a minor in cybersecurity by taking the courses indicated below. Enrollment in a minor means you must meet the Institute's requirements for minor programs. As many as five of the seven courses may be double-counted toward both the minor and your major, assuming that your major accepts those five courses. Only courses completed with grade of "C" or better are accepted towards a student's minor.

The minor includes these seven courses:

- CS 115 Introduction to Computer Science
- CS 135 Discrete Structures
- CS 284 Data Structures
- CS 385 Algorithms

Plus one of the following tracks:

- CS 503 Discrete Mathematics for Cryptography
- CS 578 Privacy in a Networked World
- CS 579 Foundations of Cryptography

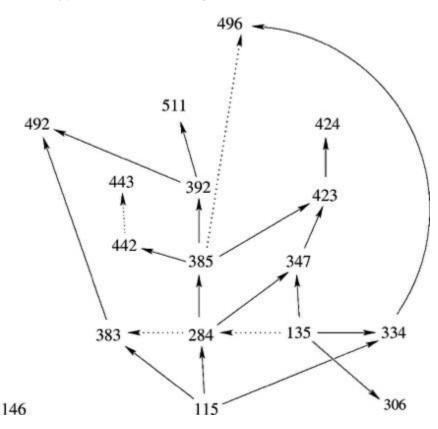
Or:

- CS 306 Introduction to IT Security
- CS 392 Systems Programming
- CS 576 Systems Security

The Cybersecurity minor is available to Computer Science majors who take the CS 503/CS 578/CS 579 option.

PREREQUISITE DIAGRAMS

The figure below shows prerequisite and corequisite relationships among required undergraduate courses. A dashed line indicates a corequisite. For example, the dashed line from CS 135 to CS 284 means that a student taking CS 284 must either have already passed CS 135 or be taking it at the same time as CS 284. (All numbers refer to CS courses.)



Graduate Programs

The Computer Science Department offers four master's degrees, several graduate certificates, an engineer degree, and a doctoral degree.

Master of Science in Computer Science: The MS/CS is the flagship graduate program. It is designed to be flexible in allowing students to combine several areas of concentration, such as software engineering, cybersecurity, and databases and service-oriented architecture. Ph.D. students who do not already have a M.S. degree should consider pursuing a M.S. in Computer Science to develop breadth before their Ph.D. studies.

- Master of Science in Enterprise and Cloud Computing: The MS/ECC is intended to educate high-end IT professionals with an interest in enterprise computing. Students learn about distributed computing from both the reliability and security points of view, including service-oriented architecture (SOA). This program has a particular emphasis on systems administration and governance. A typical back-end setup will involve several virtualized servers, running heterogeneous guest operating systems on top of hypervisors, organized in a highly available cluster. Data processing and Web service applications will have service level agreements (SLAs) that must be honored. This program develops the skills sets for the professionals who administer such operations.
- Master of Science in Cybersecurity: The MS/CyS is a rigorous program in the art and practice of cybersecurity, including fundamentals of cryptography, and threats and defenses for secure systems. The emphasis in this program is on deep technical skills that may be complemented with courses in security management, in addition to the security courses suggested for the MS/CS which emphasize broad principles and security administration.
- Master of Engineering in Media and Broadcast Engineering: Media and broadcast engineering lies at the intersection of audio/video processing, networking, software design, and complex system integration. The Master of Science in Media and Broadcast Engineering provides students with a comprehensive foundation in all aspects of media production, delivery, and management, and prepares them for relevant careers as media and broadcast engineers, network managers and developers, streaming media developers, and project managers for broadcast networks. It provides similar education and opportunities to professionals in the field who wish to enhance their skillsets. It also covers media engineering in emerging media publishing channels such as through the Internet and mobile applications.
- Graduate Certificate: A graduate certificate typically consists of four graduate courses in a targeted area of study. The courses for a graduate certificate also may be used towards another graduate degree, such as a master's degree.
- Engineer in Computer Science: The degree of Engineer in Computer Science is for students who already have a Master degree in computer science or a closely related field and who wish to continue to study computer science deeply at an advanced level, but who do not wish to or cannot make the time commitment necessary for the PhD degree. The degree requires 30 credits of computer science beyond the MS degree. Nine to twelve of these credits must be for a single long-term project on an advanced computer science topic (course CS 950).
- Ph.D. in Computer Science: The doctoral degree is a program of full time on-campus study only, aimed at preparing the student for a career in computer science research.

Master of Science - Computer Science

Degree Requirements

- 1. Completion of at least thirty credits at the graduate level (500 level and above), with a minimum grade of C and a minimum GPA of 3.00.
- 2. At least twenty-one credits must be from computer science courses, identified by the CS prefix.
- 3. At least three of the courses must be drawn from this set:
 - CS 510 Principles of Programming Languages
 - CS 511 Concurrent Programming
 - CS 513 Data Mining and Knowledge Management
 - CS 520 Introduction to Operating Systems

- CS 521 TCP/IP Networking
- CS 522 Mobile Systems and Applications
- CS 524 Introduction to Cloud Computing
- CS 526 Enterprise and Cloud Computing
- CS 537 Interactive Computer Graphics
- CS 541 Artificial Intelligence
- CS 545 Human Computer Interaction
- CS 546 Web Programming
- CS 548 Enterprise Software Architecture and Design
- CS 549 Distributed and Cloud Computing
- CS 561 Database Management Systems I
- CS 573 Fundamentals of Cybersecurity
- CS 578 Privacy in a Networked World
- CS 600 Advanced Algorithm Design and Implementation
- CS 677 Parallel Programming for Many-core Processors
- CS 694 Advanced Computational Modeling in Biology and Biomaterials
- 4. The remaining nine credits can be from computer science or any other disciplines.

Some students may seek to take electives that form a focused area of study. Accordingly, several suggested focus areas of logically related electives are defined including:

- Cloud Computing
- Databases
- Gaming and Simulation
- Mobile Systems
- Modeling, Simulation, and Visualization
- Network and Systems Administration
- Secure Systems
- Software Development
- Visual Computing and Information Extraction
- Web Application Development

See the Computer Science Department web site for definition of these focus areas.

Master of Engineering – Media and Broadcast Engineering

Degree Requirements

- 1. Completion of at least thirty credits at the graduate level (500 level and above), with a minimum grade of C and a minimum GPA of 3.00.
- 2. Three core courses that are mandatory in all tracks.

- 3. Three courses from a chosen track.
- 4. Two technical electives from any track.
- 5. Two general electives that can be any Stevens course at the 500 level or above, including a relevant M.S. thesis in one of the program's home departments.

Core courses

- EE612 Principles of Multimedia Compression
- ▶ CS521 TCP/IP Networking
- ▶ SYS625 Fundamentals of Systems Engineering

Track I: Signal Processing and Data Communication

As a traditional branch of Electrical and Computer Engineering, this track provides fundamental knowledge and skills related to audio and video processing, information compression, data communication and networking, which are enabling technologies in the media and broadcasting industry.

Track courses

- CPE 645 Image Processing and Computer Vision
- CPE 548 Digital Signal Processing
- CPE 591 Introduction to Multimedia Networking
- ▶ EE 585 Physical Design of Wireless Systems
- ▶ EE 626 Optical Communication Systems
- ▶ EE 670 Information Theory and Coding

Elective courses

- ▶ CS 537 Interactive Computer Graphics
- CS 558 Computer Vision

Track II: Software Infrastructure for Media and Broadcast Engineering

This track covers aspects of software design and development that are critical for media and broadcast engineering, including networking, distributed and cloud computing, web programming, programming for mobile systems, databases, and algorithms/

Track courses

- CS 522 Mobile Systems and Applications
- CS 524 Introduction to Cloud Computing
- CS 526 Enterprise and Cloud Computing
- ▶ CS 546 Web Programming
- CS 548 Enterprise Software Architecture & Design
- ▶ CS 554 Web Programming II

Elective courses

- CS 520 Introduction to Operating Systems
- CS 561 Database Management Systems I
- CS 570 Introduction to Programming, Data Structures, and Algorithms
- CS 590 Algorithms
- CS 600 Advanced Algorithm Design and Implementation
- CS 615 Systems Administration

Master of Science - Enterprise and Cloud Computing

The MS/ECC program is intended to educate high-end IT professionals with an interest in enterprise and cloud computing. Cloud computing has revolutionized the management of information technology (IT) resources by businesses and enterprises, providing greater scalability and manageability over traditional approaches, but introducing serious challenges with respect to security and privacy. Cloud computing typically involves software applications deployed as software-as-a-service (SaaS) over utility computing services such as Infrastructure-as-a-Service (IaaS) and platform-as-a-service (PaaS). The program covers enterprise software architectures and applications, such as service-oriented architecture and REST, as well as other application architectures such as server push, streaming, and peer-to-peer. Cloud-based computing platforms such as Hadoop, and NoSQL data stores such as Amazon Dynamo and Cassandra, are also considered. Theoretical underpinnings such as eventual consistency and distributed agreement, and tools such as vector time and Paxos, as also considered, Security and privacy aspects of cloud computing are covered from first principles, such as the use of public key infrastructures for secure Web services. The program also considers the integration of cloud computing services with mobile applications, where the cloud provides a ubiquitous compute and storage infrastructure for resource-constrained mobile devices.

Students of this program will gain hands-on experience with managing resources and deploying applications on cloud computing platforms such as Amazon Web Services (AWS) and Windows Azure. They will develop Web applications using frameworks such as ASP.NET MVC and Java Server Faces, as well as Web services using Java and C#, and enterprise-level mobile applications using Android. Graduates of the program will be able to take a lead role in their organization in decision-making regarding moving applications into the cloud, and integrating with the existing enterprise infrastructure. They will also, by benefit of their hands-on experience with the program, be in a position to lead development efforts with respect to cloud-based, Web and mobile applications.

Degree Requirements

- 1. Completion of at least thirty credit-hours of study at the graduate level (500-level and above), with a minimum grade of C and a minimum GPA of 3.00.
- 2. All of the core courses must be completed. The remaining elective courses can be taken from Computer Science and free electives from other disciplines, up to a maximum of three courses outside Computer Science.

Core Courses

- ▶ CS 522 Mobile Systems and Applications or CS 526 Enterprise and Cloud Computing
- CS 548 Enterprise Software Architecture and Design
- CS 549 Distributed Systems and Cloud Computing
- CS 594 Enterprise Security and Information Assurance

Elective Courses

Up to three electives courses (beyond the core courses) can be free electives from other disciplines, including Computer Science, Software Engineering, or Management and Information Systems, with the approval of the program director. The remaining electives must be Computer Science courses, i.e., with the CS prefix. Below are some **suggested** electives.

- CS 503 Discrete Mathematics for Cryptography
- ▶ CS 506 Introduction to IT Security*
- CS 513 Knowledge Discovery and Data Mining
- CS 520 Operating Systems
- CS 521 TCP/IP Networking
- CS 522 Mobile Systems and Applications
- CS 524 Introduction to Cloud Computing
- CS 544 Health Informatics
- CS 546 Web Programming
- CS 561 Database Management Systems I
- CS 562 Database Management Systems II
- CS 578 Privacy in a Networked World*
- CS 579 Foundations of Cryptography
- CS 609 Data Management and Exploration on the Web
- ▶ CS 615 Systems Administration
- CS 629 Advanced Internet Protocols
- CS 665 Network Forensics
- CS 675 Threats, Exploits, and Countermeasures
- * Students who take CS 506 and CS 578 will be eligible for a graduate certificate in Enterprise Security and Information Assurance

Some suggested free electives include:

- MGT 600 Financial and Managerial Accounting
- MGT 606 Managerial Economics
- MGT 623 Financial Management
- MIS 662 Legal Issues for the IT Professional
- MIS 675 Analyzing Technology Risks
- SSW 533 Software Cost Estimation and Metrics
- SSW 540 Fundamentals of Software Engineering
- SSW 565 Software Architecture and Component-Based Design
- SSW 567 Software Testing, Quality Assurance, and Maintenance

Master of Science - Cybersecurity

Reports of cybersecurity breaches have become a fixed presence in news headlines. The theft of customer account data from large retailers such as Target (2013), Staples (2014), Michaels (2014), The Home Depot (2014), and of information about government employees and contractors from the computer systems of federal offices (2015), continues to inconvenience millions of people every year. Internet pandemics such as those caused by the Code Red (2001), Sobig.F (2003), MyDoom (2004) and Conficker (2008) worms have cost several billion dollars to the global economy in recent years. Conservative estimates by security experts are that millions of residential computers are *"zombies"* (or "bots") taken over by attackers unbeknownst to their owners, organized into *"bot-nets,"* and used routinely for spamming everyone that uses the Internet. Denial of service attacks have been staged against major corporations that rely on network access, such as eBay (2000) and PayPal (2010), as well as against the root servers for the internet Domain Naming System (DNS), using bot-nets whose "services" can be purchased on the black market for just a few hundred dollars. Criminal gangs are hiring expert programmers to break into law enforcement databases to learn the names of informants. Consumers are becoming more and more reliant on computer systems, even for sensitive activities like home banking, while companies and governments are exposing themselves to potential attacks due to the need to establish and maintain a *"Web presence."* On the legislative level, increasing privacy concerns are giving rise to legislation of which companies must be aware and to which they must be able to adapt.

In response to these trends, Stevens has developed a graduate program in cybersecurity that provides deep and rigorous training in cybersecurity to IT professionals who already have a background in computer science, computer engineering, or other closely related discipline in the information sciences. The program aims to provide a nationally recognized credential for cybersecurity professionals. Academically inclined graduates of this program will also be well poised to pursue Ph.D. study in cybersecurity, should they so choose. The program provides a rigorous education in the foundations of security and privacy, including cryptography and secure systems.

Degree Requirements

Completion of at least thirty credit-hours of study at the graduate level (500-level and above), with a minimum grade of C and a minimum cumulative GPA of 3.00. The seven core courses listed below must be completed.

Beyond the core courses listed below, students may choose from a list of approved electives posted on the department web site.

Core Courses

- CS 520 Introduction to Operating Systems
- CS/MA 503 Discrete Mathematics for Cryptography
- CS 573 Fundamentals of Cybersecurity
- CS 578 Privacy in a Networked World
- CS 579 Foundations of Cryptography
- CS 600 Advanced Algorithm Design and Implementation
- CS 675 Threats, Exploits, and Countermeasures
- ▶ or CS 665 Network Forensics

CS 520 and CS 600 may be replaced by electives if the student already has taken these courses as an undergraduate.

Graduate Certificate Programs

The Computer Science department offers graduate certificate programs to students meeting the regular admission requirements for the master's program. Each certificate program is self-contained and highly focused, comprising 12 or more credits. Courses taken for a Graduate Certificate may also be used toward a master's degree.

Databases

This program provides a firm grounding in enterprise architecture, particularly as supported by modern database management systems and platforms such as Web services. Students may also focus on data mining, including both algorithms and applications of existing data mining tools.

- CS 561 Database Management Systems I
- CS 562 Database Management Systems II
- CS 546 Web Programming
- CS 574 Object-Oriented Analysis and Design or CS 513 Knowledge Discovery and Data Mining

Cybersecurity

Students will obtain a deep technical background in security and privacy, particularly in the cryptographic foundations of the tools that the security specialist will need to use. They will know that cryptographic tools require a deep understanding of their properties to be deployed properly, rather than simply treated as black boxes. They will obtain a background in algorithm design and implementation, and discrete mathematics for cryptography, prior to learning about the most popular cryptographic algorithms and protocols. They will also learn about both the technical and the social aspects of privacy, where legislation is still grappling with how to resolve individuals' privacy rights with the immense benefits to be gained from vast on-line information resources, and where technical solutions can inform the legal and social debate.

- CS/MA 503 Discrete Mathematics for Cryptography
- CS 578 Privacy in a Networked World
- CS 579 Foundations of Cryptography
- CS 600 Advanced Algorithm Design and Implementation

Enterprise Security and Information Assurance

This program is for students interested in security and privacy, particularly as it pertains to businesses, governments, and other forms of enterprises. They will get a basic grounding in security concepts, including the various forms of threats and defenses. Students will learn how enterprises can protect against attacks and exploits both from inside and outside the organization, including ensuring that critical data survives such attacks. Security governance is an important part of such mechanisms. They will learn how to recover from a security attack, determining the cause and sometimes the source of the exploit. Finally, students will also learn about both the technical and the social aspects of privacy, where legislation is still grappling with how to resolve individuals' privacy rights with the immense benefits to be gained from vast on-line information resources, and where technical solutions can inform the legal and social debate.

- CS 548 Enterprise Software Architecture and Design
- CS 578 Privacy in a Networked World
- CS 594 Enterprise Security and Information Assurance
- CS 573 Fundamentals of Cybersecurity or CS 506 Introduction to IT Security

Service-Oriented Computing

This program is for students who are working in an existing domain where they see the growing use of and need for IT skills. The program provides an accelerated professional education program that provides them with the skill sets that they need in order to use and manage the IT that is being deployed globally today. Students may have little or no background in software development, but they want to be a professional in a particular field with IT skills. This program will provide students with very focused training in the skill sets that are required to make them technically capable of taking existing frameworks and using them to develop new client-specific applications. The focus of the program is very much on front-end skills:

- Requirements acquisition and analysis
- Human-computer interaction
- Web design and information architecture
- Ethical and privacy issues

The kinds of tasks that students will pursue will range all the way from designing and implementing web pages, to developing distributed collaborative applications with sophisticated database back-ends using frameworks, such as Websphere and .NET.

- ▶ SOC 510/CS 545 Human-Computer Interaction
- SOC 542/CS 548 Enterprise Software Architecture and Design
- SOC 611 Fundamentals of Service Oriented Computing/CS 561 Database Management Systems I
- SOC 606 Introduction to Developing Internet Applications or CS 546 Web Programming or CS 549 Distributed Systems and Cloud Computing or CS 526 Enterprise and Cloud Computing

Enterprise and Cloud Computing

This program is for students who want to become high-end IT professionals with an interest in enterprise computing. Students will learn about distributed computing from both the reliability and the security points of view. They will learn about distributed computing "in the large," including enterprise application integration and service-oriented architectures (SOA). They will build on skills learned in courses in operating systems, databases, and systems programming for enterprise computing, to learn how to administer server back-ends that are the crux of modern SOA. This will involve ensuring that applications meet their goals in terms of performance, reliability, security, and privacy. A typical backend setup will involve several virtualized servers, running heterogeneous guest operating systems on top of hypervisors, organized in a highly available cluster. Data processing and Web service applications will have service level agreements (SLAs) that must be honored. The administrator must be able to respond to performance issues by dynamically reallocating resources between applications, while at the same time responding to component failures, and potentially also security attacks.

- CS 522 Mobile Systems and Applications or CS 526 Enterprise and Cloud Computing
- CS 548 Enterprise Software Architecture and Design
- CS 549 Distributed Systems and Cloud Computing
- CS 561 Database Management Systems I or CS 594 Enterprise Security and Information Assurance

Health Informatics

Students of this program will learn to use data mining methods to derive, in an exploratory manner, valuable healthcare knowledge in terms of associations, sequential patterns, classifications, predictions and symbolic rules. They will be able to describe and use tools for preserving the privacy of confidential data, as well as explain some of the social and legal aspects of privacy. Students will be able to explain health care IT standards such as UDEF and HL7, explain health care terminology, and perform system selection and evaluation in the areas of telemedicine, dental informatics, consumer health informatics,

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and hospital/clinical informatics. Special attention is given to web services and mobile computing as they relate to the health care industry.

- CS 513/SOC 550 Knowledge Discovery and Data Mining
- CS 544/SOC 552 Health Informatics
- ▶ CS 548/SOC 542 Enterprise Software Architecture and Design
- CS 578/SOC 551 Privacy in a Networked World

Distributed Systems

Required courses:

- ▶ CS 521 TCP/IP Networking
- CS 549 Distributed Systems and Cloud Computing

and any two of the following courses:

- ▶ CS 511 Concurrent Programming
- CS 520 Introduction to Operating Systems
- CS 522 Mobile Systems and Applications
- CS 546 Web Programming

Computer Systems

Required courses:

- CS 514 Computer Architecture
- CS 520 Introduction to Operating Systems

plus any two of the following courses:

- CS 511 Concurrent Programming
- CS 516 Compiler Design
- ▶ CS 521 TCP/IP Networking
- CS 522 Mobile Systems and Applications
- CS 549 Distributed Systems and Cloud Computing

Computer Graphics

Required courses:

- CS 600 Advanced Algorithm Design and Implementation
- CS 537 Interactive Computer Graphics
- CS 638 Advanced Computer Graphics or CS 539 Real time Rendering, Gaming, and Simulation Programming
- CS 558 Computer Vision or CS 539 Real time Rendering, Gaming, and Simulation Programming

Multimedia Experience and Management

Required courses:

- CS 537 Interactive Computer Graphics
- SSW 540 Fundamentals of Software Engineering
- CS 545 Human Computer Interaction
- CS 538 Visual Analytics or CS 539 Real time Rendering Gaming, and Simulation Programming or CS 638 Advanced Computer Graphics

Engineer Degree

The degree of Engineer in Computer Science is for students who already have a Masters degree in computer science or a closely related field and who wish to continue to study computer science deeply at an advanced level, but who do not wish to or cannot make the time commitment necessary for the PhD degree. The degree requires 30 credits of computer science beyond the MS degree. Nine to 12 of these credits must be for a single long term project on an advanced computer science topic (course CS 950). For part time students, the project topic cannot be drawn from the student's activity. The project must be work beyond the student's job activity, so as to expand the student's sphere of expertise. The student must be advised at all times by a full time Computer Science department faculty member. The advisor must approve and supervise the project. The project must be described in a substantial document that is reviewed by a committee of faculty, presented in a public defense, and submitted to the library for archival publication.

Doctoral Program

The purpose of the Ph.D. program is to educate students for a career in computer science research. The goal is for the quality of Stevens graduates to be on par with those produced by the best Computer Science departments in the country.

Full-time study

To make progress on leading-edge subjects in a fast moving field like computer science requires full-time study. It is nearly impossible to do work that is important, timely, and novel at the pace afforded by part-time effort-either one's result will be "scooped" or conditions will change within the field, rendering the work no longer current. Accordingly, Ph.D. students will be admitted only for full-time on-campus study.

Advised study

Each doctoral student must at all times have a single advisor who is a tenured or tenure-track Stevens faculty member. The relationship between advisor and student is not merely an administrative one. Starting early in his/her career, the student will work on research projects to be determined by the advisor and student. Through this day-to-day interaction, the student will learn the form and content of high quality research. The student's advisor will also guide the student through the program, e.g., advising on such matters as which courses to take, when to attempt the qualifying exam, what dissertation topic to pursue, etc.

Advisor-advisee relationship

The department aims to admit only students whose background and interests match those of the faculty. Each admitted student will be assigned an advisor whose expertise is well matched to the student. It is hoped that most students will remain with their initial advisors throughout their career, performing research with him/her. However, the advisor-advisee relationship is a voluntary one. If either the student or the faculty member becomes dissatisfied with the relationship, then the student

must seek another advisor among the faculty. A student can change advisors at any time provided that the student's new advisor is willing to accept the student.

Requirements

The Ph.D. degree requires 84 credits beyond the bachelor's degree. Students who already possess a master's degree may be granted up to 30 credits. The 84 credits may be fulfilled by some combination of: prior MS degree, enrollment in classroom courses, and enrollment in research participation (course CS 960). The division of a student's effort between classroom courses and research participation will vary from case to case, and is a decision that should be made by the student in consultation with and with the approval of the student's advisor. There is no minimum number of classroom courses for the doctorate.

Progress review

Each student's progress is reviewed by the entire computer science faculty near the end of the fall and spring semesters. Preparatory to this review, the student must submit a brief progress report describing the student's progress since the last review, as well as his/her plans for the time up to the next review. After drafting the report, the student must submit it to his/ her advisor for approval. Once approved, the report must be submitted to the Computer Science department office.

Students who are doctoral "candidates" must also submit a second, separate, report to the Dean of Graduate Academics' office. The definition of the term "candidate" is left to each department, and the Computer Science department defines candidates to be students who have passed the qualifying exam, both written and oral parts. The report for the graduate dean must be submitted on a special form-the "Doctoral Activity Report," (DAR). It is acceptable to write a single report and submit the DAR to the department, as well as to the graduate office.

The outcome of the progress review meeting is that a student is placed into one of three categories: good standing, probation, or terminated. A student in good standing is making satisfactory progress toward his/her degree, and is expected to follow through on the plans outlined in his/her progress report. A student on probation is making inadequate progress toward his/ her degree. A student on probation will receive a letter from the faculty that explains what remedial actions he/she must take to return to good standing, and by what time each action must be taken. No student will be terminated without spending at least the preceding semester on probation.

Qualifying Exam

Each student must pass the qualifying exam early in his/her career. The exam has two purposes: to certify that the student is broadly educated in key areas of computer science and to demonstrate that the student has become acquainted with the process of performing original research.

Accordingly, the qualifying exam has two parts, written and oral. The written portion of the qualifying exam tests the student's knowledge of fundamental computer science at an elementary level, akin to that achieved in a bachelor's program. The written exam tests three subjects: algorithms, programming languages, and operating systems. A student must pass all three subjects in order to pass the written exam. The exam is offered near the end of fall and spring semesters, timed so that grades are available at the progress review meeting. A student may take the written exam at most twice. Any subjects passed the first time need not be taken the second time. The written exam should be taken during the student's first two semesters in the program. The written exam must be completely passed during the student's first four semesters in the program.

The purpose of the oral portion of the qualifying exam is for the student to demonstrate promise in doing independent original research. The student will perform some work as specified by, and under the supervision of, his/her advisor. Ideally, this work would consist of the actual production of publishable research results; however, depending on circumstances, it may be more appropriate for the student to perform some type of pre-research work. The student will write a report detailing his/her effort and accomplishments. The student will give a public, announced talk detailing his/her effort and accomplishments. The paper will be read, and the talk attended, by the student's advisor and two other pre-selected regular Stevens faculty

members. These three faculty will decide whether the student has passed the oral exam. In style, the report and the talk must be similar to research presentations given by experienced researchers. If either the report or the talk is judged to be inadequate in either content or presentation, this fact will be taken into account during the faculty's evaluation of the student that semester. The student may be terminated, placed on probation, required to prepare a new report or talk, perform further research, or some other remedial action(s).

The oral qualifying exam must be passed no more than 12 months after passage of the written qualifying exam, or by the end of student's 5th semester in the program, whichever is earlier.

Thesis proposal

To demonstrate that he/she is ready to undertake dissertation research, the student must write and present a thesis proposal. The written document must describe the proposed research so that an appropriately informed computer scientist-although not necessarily someone who is an expert in the topic-can understand the proposal. The written proposal should contain an explanation of the problem and why it is important, a sketch of the proposed solution, and background information that serves to indicate that the problem is unsolved and what prior or related approaches to this or similar problems have already been investigated. After writing the document, the student must make a public presentation of the proposed work. The document must be read-and the presentation should be attended-by the persons who are expected to form the student's dissertation defense committee. The presentation committee will decide whether the student's proposal indicates that he/ she is ready to do the proposed work successfully.

If the proposal is judged to be inadequate in either content or presentation, this fact will be taken into account during the faculty's evaluation of the student that semester. The student may be terminated, placed on probation, required to prepare a new talk, perform further research, or some other remedial action(s).

Dissertation defense

The department follows the Stevens-wide procedures for the dissertation defense, including committee composition.

Required rate of progress

Stevens imposes certain deadlines on the student:

- Students who have a master's degree must complete the doctoral degree within six years.
- The thesis proposal must be presented at least 12 months before the degree is awarded.
- It is "recommended" that the qualifying exam be attempted no more than one year after entry to the program or after receipt of the master's degree, whichever comes first.
- In addition, a certain rate of progress through the program is typical and expected:
 - The written qualifying exam should be attempted in the first two semesters.
 - The written qualifying exam must be passed by the end of the fourth semester.
 - The oral qualifying exam must be passed by the end of the fifth semester (or no more than 12 months after passage of the written exam, whichever is earlier).
 - The thesis proposal should be presented by the end of the sixth semester.
 - These are only guidelines: meeting all these targets does not necessarily constitute satisfactory progress, nor does failing to meet any necessarily constitute unsatisfactory progress.

Leave

It is expected that students, once enrolled in the doctoral program, will remain enrolled full-time without interruption until graduation. However, sometimes it is necessary for a student to take a leave for a reason, such as personal difficulty, health, etc. If such a situation arises, the student must petition the faculty in writing for a leave, which, if granted, will last for one semester. To extend the leave, a new petition must be filed. Neither indefinite leave nor excessive repetition of leave is permitted. While the student is on leave, any time limit he/she faces (e.g., completing the qualifying exam within two years) is suspended for the length of the leave.

Exceptions

The faculty reserve the right to make exceptions to any of the rules and procedures described above in order to promote and preserve the health of the doctoral program and to ensure each student's prompt and effective progress through the program.

COURSE OFFERINGS

Computer Science

CS 105 Introduction to Scientific Computing

This is a first course in computer programming for students with no prior experience. Students will learn the core process of programming: given a problem statement, how does one design an algorithm to solve that particular problem and then implement the algorithm in a computer program? The course will also introduce elementary programming concepts like basic control concepts (such as conditional statements and loops) and a few essential data types (e.g., integers and doubles). Exposure to programming will be through a self-contained user-friendly programming environment, widely used by the scientific and engineering communities, such as Matlab. The course will cover problems from all fields of science, engineering, and business.

CS 110 Creative Problem Solving in Computing

This course is an introduction to problem solving using computers. It is specially tailored for student with no prior programming experience. CS110 offers an alternative to CS105, and prepares students for CS115. The entire course is problem driven. Programming concepts are introduced and develop as tools for creative problem solving.

CS 115 Introduction to Computer Science

This is an introduction to computer science with an emphasis on programming. The topics include: design; algorithmic thinking; recursion; object-oriented programming; ethics in computer science; and some basics about computer systems: machine language, interpreters, compilers, and data representation.

CS 135 Discrete Structures

The aim of this course is to integrate knowledge of basic mathematics with the problems involving specification, design, and computation. By the end of the course, the student should be able to: use sets, functions, lists, and relations in the specification and design of problems; use properties of arithmetic, modular arithmetic (sum, product, exponentiation), prime numbers, greatest common divisor, factoring, Fermat's Little Theorem; use binary, decimal, and base-b notation systems and translation methods; use induction to design and verify recursive programs; and implement in Scheme all algorithms considered during the course.

CS 146 Introduction to Web Programming and Project Development (3 - 3 - 0)

This course introduces students to the infrastructure underlying the Web, including protocols and markup languages. It also addresses the question of how one presents large volumes of information to people who need to find out what they are looking for quickly. The scope of the course ranges from mechanics to aesthetics. Social and ethical issues are also discussed, including the concept of information ecologies for social acceptance. Networks and protocols; pervasive computing; Web protocols; markup languages and XML; defining information architecture; understanding information needs and information-seeking behaviors; organizing Web sites and intranets; navigation systems; search systems; thesauri; from research to design: strategies for information architecture; enterprise information architecture; ethics on the Web; and information ecologies.

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CS 181 Introduction to Computer Science Honors I

Getting acquainted with C++: data types, input and output, functions, writing simple C++ programs, flow control, Boolean expressions, decision statements, if/then, and switch/case. Loop operations, while, do/while, and for loops. Arrays and pointers. Defining structs and classes, constructors and destructors, and operator overloading using an example String class. Templates. Abstract data types: vectors, lists, stacks, queues, and priority trees with applications. Trees and simple sorting with searching algorithms. By invitation only. Students who complete this class are exempt from CS 115 and CS 284.

CS 182 Introduction to Computer Science Honors II

Advanced programming concepts covering classical data structures and object-oriented programming. Emphasis will be on building a collection of re-usable software components that will form the basis of future programming efforts. The data structures covered include lists, stacks, queues, trees, binary search trees, and balanced search trees. The object-oriented features of Java covered include classes, templates, inheritance, polymorphism and run-time binding. Also included is a discussion of the analysis of asymptotic running times of algorithms. Prerequisites: CS 181 Corequisites: CS 135

CS 188 Seminar in Computer Science

Selected topics in Computer Science. Substantial student participation is required. May be repeated for credit.

CS 284 Data Structures

This is a course on standard data structures, including sorting and searching and using the Java language. The topics include: stages of software development; testing; UML diagrams; elementary data structures (lists, stacks, queues, and maps); use of elementary data structures in application frameworks; searching; sorting; and introduction to asymptotic complexity analysis. Prerequisites: CS 115 Corequisites: CS 135

CS 306 Introduction to IT Security

This course provides a basic introduction to the key concepts in security. It covers basic concepts such as authentication, confidentiality, integrity, and nonrepudiation as well as important techniques and applications. Topics include access control, security economics, ethics, privacy, software/operating system security, and security policies. Prerequisites: CS 135 or MA 134

CS 334 Automata and Computation

Introduction to recursive functional programming and equational reasoning; lists as inductive types and list induction; introduction to formal languages, automata, and the theory of computation; regular expressions, finite state machines, and pumping lemma; context free grammars and push down automata; turing machines, recursive enumerability, and unsolvable problems; and complexity and intractability. A number of models of computation are considered, as well as their relation to various problem classes (e.g. solvable problems and polynomial time solvable problems). Some experiments are performed that involve writing small Scheme programs. Prerequisites: CS 115, and CS 135

CS 347 Software Development Process

This course provides a general introduction to the essentials of the software development process, that series of activities that facilitate developing better software in less time. The course introduces software development and deployment life cycles, requirements acquisition and analysis, software architecture and design, and resource management and scheduling in the implementation phase. Students gain experience with tools and methodologies for configuration management and project management. Security engineering is considered as an essential part of the software development process, particularly from the standpoint of applied risk management. Prerequisites: CS 181 or CS 284, CS 135

CS 370 Creative Problem Solving and Team Programming

Gives students practice in solving challenging problems by applying algorithmic problem solving techniques learned in prior courses. Students will develop their problem-solving, algorithm-creation, and programming abilities. Problems will be complex and will require invention of an algorithm, not simply straightforward application of standard techniques. Students will work in teams. To provide a focus point and to help make the course fun, students will program their solutions in a style similar to that employed by programming competitions such as the national ACM programming contest. May be repeated for credit. Prerequisites: CS 182 or CS 385

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Digital systems; number systems and codes; Boolean algebra; application of Boolean algebra to switching circuits; minimization Boolean functions using algebraic, Karnaugh map, and tabular methods; design of combinational circuits; programmable logic devices; sequential circuit components; design and analysis of synchronous and asynchronous sequential circuits. Cross-listed with: CPE 358 Prerequisites: CS 115, CS 181

CS 383 Computer Organization and Programming

Switching Theory & Logical Design

The main aspects of computers: data (data types and formats, number bases), hardware (stored program computer concept, addressing methods and program sequencing, instruction sets and their implementation, the CPU and microprogrammed control, input/output organization, peripherals and interfacing, and main memory), communication (network protocols), software (operating systems, dispatching algorithms), and assembly language programming. Prerequisites: CS 115 Corequisites: CS 181 or CS 284

CS 385 Algorithms

CS 381

This is a course on more complex data structures, and algorithm design and analysis, using the C++ language. Topics include: advanced and/or balanced search trees; hashing; further asymptotic complexity analysis; standard algorithm design techniques; graph algorithms; complex sort algorithms; and other "classic" algorithms that serve as examples of design techniques. Prerequisites: CS 181 or CS 284

CS 392 Systems Programming

Introduction to systems programming in C on UNIX. Students will be introduced to tools for compilation, dynamic linking, debugging, editing, automatic rebuilding, and version control. Some aspects of the UNIX system call interface will be studied, drawn from this list: process creation, signals, terminal I/O, file I/O, inter-process communication, threads, network protocol stacks, programming with sockets, and introduction to RPC. Style issues to be covered include: naming, layout, commenting, portability, design for robustness and debugability, and language pitfalls. X programming and GUI design will be covered, if time allows. Prerequisites: CS 182 or CS 385

CS 397 Outreach Participation

Under the guidance of a faculty member, students will prepare for, participate in, then evaluate an experience in which the students represent Stevens in an off campus team outreach activity. Examples of such activities include, but are not limited to, technical competitions, cross-discipline design contests, and Ambassador programs. Course may be repeated as a free elective up to a maximum of 3 credits. Prerequisites: CS 182 or CS 284

CS 423 Senior Design I

Students in this course work in teams to develop real software for real clients. Topics in software engineering additional to, or more advanced than those taught in CS 347 are introduced "just in time," as needed. Prerequisites: CS 347, and CS 385 or CS 182 or CS 590

CS 424	Senior Design II	(3-3-0)
This course is a continuation of CS423. Prerequisites: CS 423		

CS 425 Cybersecurity Capstone I

Under the guidance of a cybersecurity faculty member of the department, students will participate in a year-long cybersecurity project. The project may be conducted in a number of ways, including as a cybersecurity-only project, as a project where the cybersecurity student is integrated into the senior capstone project of another discipline like CS, QF, ECE, or as a project where the cybersecurity student interacts in a consultant role with one or more senior capstone teams of another discipline. Prerequisites: CS 576, and CS 577

CS 426 Cybersecurity Capstone II Continuation of CS425. Prerequisites: CS 425

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CS 442 Database Management Systems

Introduction to the design and querying of relational databases. Topics include: relational schemas; keys and foreign key references; relational algebra (as an introduction to SQL); SQL in depth; Entity-Relationship (ER) database design; translating from ER models to relational schemas and from relational schemas to ER models; functional dependencies; and normalization. Cross-listed with: CPE 442 Prerequisites: CS 182 or CS 385

CS 443 Database Practicum

In this course students use skills developed in earlier courses to work in teams with clients on the development of software to be used by the clients or by the organizations for which they work. Potential clients include Stevens faculty, Stevens departments that provide services to students, not-for-profit organizations, government agencies, and, on occasion, for-profit companies. Teams work with clients to iteratively develop GUI-based prototypes of software that will satisfy the clients' needs (requirements engineering); they perform the analysis and design required before implementation begins, and, finally, they implement the software, and deploy it to the client's site together with documentation required by the software's users and maintainers. Prerequisites: CS 385, and CS 442

CS 465 Selected Topics in Computer Science

A participating seminar on topics of current interest and importance in computer science. Open only to undergraduates.

CS 485 Societal Impact of Information Technologies

Students explore tradeoffs posed by modern information technologies such as the Internet, mining of personal data, web tracking, and surveillance systems. Also covered are major debates about how IT technologies should be harnessed to serve the greater good, such as: Internet governance, privacy vs. openness, and laws regarding intellectual property. Students will learn how actions undertaken in their daily lives as IT professionals may have broad consequences, both planned and unplanned. Students will learn how to identify and analyze these consequences and who may be affected by them.

CS 488 Computer Architecture

An introduction to the functional level structure of modern pipelined processors and the empirical and analytic evaluation of their performance. Topics include: empirical and analytic techniques for measuring performance (use of various means, Amdahl's Law, and benchmarks); tradeoff analysis; principles of instruction set design and evaluation (memory addressing, operations, types and sizes of operands, instruction set encoding, CISC vs. RISC, and related compilation issues); pipelining (basics, data hazards, and control hazards); and memory systems. Cross-listed with: CPE 488 Prerequisites: CS 383 Corequisites: MA 222

CS 492 Operating Systems

The use and internals of modern operating systems. Lectures focus on internals whereas programming assignments focus on use of the operating system interface. Major topics include: the process concept; concurrency and how to program with threads; memory management techniques, including virtual memory and shared libraries; file system data structures; and I/O. Prerequisites: CS 383, CS 392

CS 496 Principles of Programming Languages

An introduction to programming language design and implementation, with an emphasis on the abstractions provided by programming languages. Assignments involve problem-solving issues in principles of programming languages such as Scheme and ML; recursive types and recursive functions; structural induction; abstract data types; abstract syntax; implementing languages with interpreters; static vs. dynamic scoping, closures, state; exceptions; types: type-checking, type inference, static vs. dynamic typing; object-oriented languages: classes and interfaces, inheritance and subtyping; polymorphism and genericity; and design patterns and the visitor pattern. Prerequisites: CS 334 Corequisites: CS 182 or CS 385

CS 497 Independent Study

Independent study under the guidance of a full time computer science faculty member, whose prior approval is required. Independent study allows the student to participate in research, explore a topic not covered by existing courses, or continue to study in greater depth a topic introduced by a course. Scope and details of the participation must be agreed upon between student and professor before the beginning of the project. One to three credits for any BS degree offered by the computer science department. May be repeated for credit.

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CS 498 Senior Research I

Individual research project under the guidance of a faculty member of the department, whose prior approval is required. Either a written report in acceptable journal format or the completion of a senior thesis, as well as an oral presentation, is required at the end of the project. Senior students only. CS 498 and CS 499 cannot be taken simultaneously.

CS 499 Senior Research II

Individual research project under the guidance of a faculty member of the department, whose prior approval is required. Either a written report in acceptable journal format or the completion of a senior thesis, as well as an oral presentation, is required at the end of the project. Senior students only. CS 498 and CS 499 cannot be taken simultaneously.

CS 501 Introduction to JAVA Programming

An introduction to the Java programming language for those students who have little or no programming background. It is intended as an elective for the Master of Science in Information Systems to be taken near the end of the program. Basic topics considered will be programs and program structure in general and Java syntax, data types, flow of control, classes, methods and objects, arrays, exception handling, and recursion. In addition, the use of Java in enterprise-wide computing and distributed systems will be introduced by considering APIs in general, and the ones specific to JDBC and the Java security features in particular. Not for credit for Computer Science department undergraduate majors. Cross-listed with: SOC 501

CS 503 **Discrete Mathematics for Cryptography**

Topics include basic discrete probability, including urn models and random mappings; a brief introduction to information theory; elements of number theory, including the prime number theorem, the Euler phi function, the Euclidean algorithm, and the Chinese remainder theorem; and elements of abstract algebra and finite fields including basic fundamentals of groups, rings, polynomial rings, vector spaces, and finite fields. Carries credit toward the Applied Mathematics degree only when followed by CS 579. Recommended for high-level undergraduate students. Cross-listed with: MA 503 Prerequisites: MA 502 or CS 135

CS 505 Probability and Stochastic Processes I

Axioms of probability; discrete and continuous random vectors; functions of random variables; expectations, moments, characteristic functions, and momentgenerating functions; inequalities, convergence concepts, and limit theorems; central limit theorem; and characterization of simple stochastic processes: widesense stationality and ergodicity. Cross-listed with: EE 605, CS 655

CS 506 Introduction to IT Security

This course provides a basic introduction to the key concepts in security. It covers basic concepts such as authentication, confidentiality, integrity, and non-repudiation as well as important techniques and applications. Topics include access control, security economics, ethics, privacy, software/operating system security, and security policies.

CS 510 Principles of Programming Languages

An introduction to programming language design and implementation, with an emphasis on the abstractions provided by programming languages. Assignments involve problem-solving issues in principles of programming languages such as Scheme and ML. Recursive types and recursive functions; structural induction; abstract data types; abstract syntax; implementing languages with interpreters; static vs. dynamic scoping, closures, and state; exceptions; types: type-checking, type inference, static vs. dynamic typing; object-oriented languages: classes and interfaces, inheritance, and subtyping; polymorphism and genericity; and design patterns and the visitor pattern. Prerequisites: MA 502, and CS 590

CS 511 **Concurrent Programming**

The study of concurrency as it appears at all levels and in different types of computing systems. Topics include: models of concurrency; languages for expressing concurrency; formal systems for reasoning about concurrency; the challenges of concurrent programming; race conditions; deadlock; livelock and nondeterministic behavior; prototypical synchronization problems, such as readers-writers and dining philosophers; mechanisms for solution of these problems, such as semaphores, monitors, and conditional critical regions; important libraries for concurrent programming; message passing, both synchronous and asynchronous; and applications of multithreaded concurrent programming and parallel algorithms. Substantial programming required. Prerequisites: CS 590 or CS 385

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CS 521 **TCP/IP** Networking

I/O. Prerequisites: CS 550, and CS 570 or CS 590

Introduction to Operating Systems

Introduction to IP networking. Examination of all layers of the OSI stack. Detailed examination of the IP, ICMP, UDP, and TCP protocols. Basic concepts of network design: end-to-end principle, routing, encapsulation, flow control, congestion control, and security. Detailed coverage of TCP. Some treatment of important Internet applications and services. Emphasis on network layer and above. Assignments focus on protocols and software. Prerequisites: CS 520 or CS 492

The use and internals of modern operating systems. Lectures focus on internals, whereas programming assignments focus

CS 522 Mobile Systems and Applications

This course introduces the field of mobile computing and the closely related field of pervasive computing. Topics covered include: mobile hardware, wireless communication, ubiquitous data access, resource scarcity, sensing and actuation, location and context awareness, security and privacy, design methodologies and infrastructure, and end-to-end application considerations. Prerequisites: CS 182 or CS 385 or CS 570 or CS 590

associated protocols are described, and various B2C and B2B applications are presented. Also, policy and regulatory issues in ecommerce are discussed. Cross-listed with: SOC 519

CS 520

(3 - 3 - 0)The course provides an understanding of electronic commerce and related architectures, protocols, and technologies. It describes the e-commerce concept, objectives, and market drivers, as well as its requirements and underpinning techniques and technologies, including the Internet, WWW, multimedia, intelligent agents, client-server, and data mining. Security in e-commerce is addressed, including types of security attacks, security mechanisms, Virtual Private Networks (VPNs), firewalls, Intranets, and extranets. Implementation issues in e-commerce, including the design and management of its infrastructure and applications (ERP, CRM, and SCM), are discussed. M-commerce is addressed, electronic payment systems with their

CS 519 Introduction to E-commerce

CS 516 Compiler Design

This course is an introduction to the structure and design of compilers. Topics include lexical analysis; syntax analysis; symbol table construction; semantic analysis; syntax-directed translation; and if time permits dataflow analysis, liveness analysis; and register allocation. The emphasis in this course is on the integration of the various parts of a compiler. Each student writes a complete compiler for a small, but substantial, language. Prerequisites: CS 590 or CS 385 or CS 182 or CS 570

CS 513 Knowledge Discovery and Data Mining

This course introduces fundamental and practical tools, techniques, and algorithms for Knowledge Discovery and Data Mining (KD&DM). It provides a balanced approach between methods and practice. On the methodological side, it covers several techniques for transforming corporate data into business intelligence. These include: online Analytical Processing (OLAP) Systems, Artificial Neural Networks (ANN), Rule-Based Systems (RBS), Fuzzy Logic (FL), Machine Learning (ML), Classification Trees (C4.5 Algorithm), and Classification and Regression Trees (CART Algorithm). To illustrate the practical significance of the various techniques, half of the course is devoted to case studies. The case studies, drawn from real-world applications, demonstrate application of techniques to real-world problems. Cross-listed with: SOC 550 Prerequisites: MA 331 or MA 541

CS 514 **Computer Architecture**

Measures of cost, performance, and speedup; instruction set design; processor design; hard-wired and microprogrammed control; memory hierarchies; pipelining; input/output systems; and additional topics as time permits. The emphasis in this course is on quantitative analysis of design alternatives. Cross-listed with: CPE 514, NIS 514 Prerequisites: CS 550, and CS 590 or CS 570

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on use of the operating system interface. Major topics include: the process concept; concurrency and how to program with threads; memory management techniques, including virtual memory and shared libraries; file system data structures; and

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CS 524 Introduction to Cloud Computing

This course introduces the concepts of cloud computing, using the frameworks of software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS). Fundamental concepts from each framework are introduced and related to the structure of the modern cloud. Cloud computing: economics of outsourcing. SaaS: The Web as a client-server system. Web stack: HTML and HTTP. Web data: XML and JSON. Web services and example APIs. PaaS: Introduction to databases and middleware. Data storage in the cloud. Privacy issues. IaaS: Design of server farms. Virtualization and green computing. Service discovery: DNS and content distribution networks. Batch processing in the cloud. Assignments include quizzes, examinations, and a presentation and term paper on a cloud-related topic. Cross-listed with: SOC 524

CS 526 Enterprise and Cloud Computing

This course is an introduction to programming and administration of mainframe computers, which are the backbone of modern enterprise computing. Introduction to z/OS and z/VM; protection and virtualization; total cost of ownership (TCO); conversational Monitoring System (CMS); initial program load (IPL) and launching new virtual machines; writing scripts in REXX; interactive z/OS facilities: TSO/E, ISPF and Unix; Unix system services; JCL and SDSF; transaction management using the Java CICS API; and network programming concepts: virtual LANs, open service adapters, and hipersockets. Prerequisites: CS 590 or CS 385 or CS 182 or CS 570

CS 532 3D Computer Vision

Computer vision addresses the image understanding problem; in other words, it aims to infer what was depicted in still images or video based on pixel intensity or color values. Never is the relationship between the depicted scene and images more explicit than in 3D computer vision that aims to extract 3D information from image and video data, as well as other modalities. This course will introduce students to concepts relating 2D images and 3D scenes including single and multiple-view geometry, structure from motion and 3D reconstruction. It will also cover processing of 3D data regardless of its origin starting from point sets and progressing to lines, polygons, Delaunay triangulations and Voronoi diagrams. Students will acquire in depth knowledge of 3D computer vision topics that have moved to the forefront for a broad range of applications in geospatial information systems (Google and Bing maps), robotics and driver assistance, 3D user interfaces (Microsoft Kinect), augmented reality and visual aids for people with impaired sight.

CS 533 Cost Estimation and Metrics

An objective cost model is necessary for planning and executing software projects. A cost model provides a framework for communicating business decisions among the stakeholders of a software effort; it supports contract negotiations, process improvement analysis, tool purchases, architecture changes, component make/buy tradeoffs, and several other return-on-investment decisions. This course provides the student with a through introduction to software estimation and to industry standard tools, like COCOMOII, used in cost estimation. Cross-listed with CpE533.

CS 535 Financial Computing

This is a course in modeling the values of assets and financial derivatives and the software implementation of these models for pricing, simulations, and scenario analysis. The course includes an introduction to markets and financial derivatives, and a development of the necessary tools from the theories of stochastic processes and parabolic differential equations. An integral part of the course is the use of financial information sources and software packages available on the Internet for modeling and analysis.

CS 536 Integrated Services - Multimedia

Types of multimedia information: voice, data video facsimile, graphics, and their characterization; modeling techniques to represent multimedia information; analysis and comparative performances of different models; detection techniques for multimedia signals; specification of multimedia representation based on service requirements; and evaluation of different multimedia representations to satisfy user applications and for generating test scenarios for standardization. Cross-listed with: CPE 536, CPE 536, NIS 536

CS 537 Interactive Computer Graphics

This is an introductory-level course to computer graphics. No previous knowledge on the subject is assumed. The objective of the course is to provide a comprehensive introduction to the field of computer graphics, focusing on the underlying theory, and thus providing strong foundations for both designers and users of graphical systems. The course will study the conceptual framework for interactive computer graphics, introduce the use of OpenGL as an application programming interface (API), and cover algorithmic and computer architecture issues. Cross-listed with: CPE 537 Prerequisites: CS 590 or CS 385 or CS 182 or CS 570

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Visual analytics is the combination of data filtering, statistical algorithms, and visual presentation in an interactive visual

Visual Analytics

interface. This course provides an introduction to both information and scientific visualization. Topics include: perception (color, space/order, and depth/occlusion), interaction (navigation, zooming, focus, and context), design studies and evaluation, and data representation (graphs, trees, volumes, and time series). Applications include: software, scientific, financial, and cartographic visualization. Junior, senior, or graduate standing is required. Prerequisites: CS 590 or CS 385 or CS 182 or CS 570

CS 539 Real-Time Rendering, Gaming, and Simulations Programming (3 - 3 - 0)

The course is an introduction to the techniques for designing and building computer games and real-time graphics-oriented simulations. The topics include: 3-D game engine architecture, design, and implementation; simulation, modeling, and object control; character behavior and behaviorbased animation; human-computer interaction; and event-driven simulations. Prerequisites: CS 537

CS 541 Artificial Intelligence

CS 538

An introduction to the large and diverse field of artificial intelligence. Topics include: problem-solving by search and constraint satisfaction; alpha-beta search for two-player games; and logic and knowledge representation, planning, learning, decision theory, statistical learning, and computer vision. Prerequisites: CS 590 or CS 182 or CS 385 or CS 570

CS 543 Principles of Computer Mediated Entertainment

This course provides an introduction to entertainment-based user interface design and development from a computer science perspective. The course includes: a survey and classification of the types of computer-mediated entertainment (CME); challenges in developing such interfaces; software architectures to support CME; design principles for sketching CME; and software tools to create CME and provide the technical infrastructure necessary to sustain it. Prerequisites: CS 347, and CS 545 or SSW 540

CS 544 Health Informatics

From medical centers and individual physicians adopting electronic medical records, to patients keeping track of chronic diseases through websites and apps, we live in an era of unprecedented access to health data. These data enable inference of drug side effects, causes of disease, and new treatments, but the new terminologies, policies, and challenges in understanding the data itself can make it difficult for computational researchers to apply their techniques to this new area and for health professionals to begin using informatics to solve practical problems. This course will give both groups the foundation needed to propose, evaluate and develop projects such as secondary analysis of health data and will enable them to begin effective interdisciplinary collaborations. Students will learn how health data is collected (in both hospital and nonhospital settings), how the structure of record systems impacts the research process and interpretation of results, and how to design and evaluate studies involving secondary use of health data (while complying with HIPAA and IRB regulations) in order to gain new medical knowledge and improve healthcare delivery. Cross-listed with: SOC 552

CS 545 Human-Computer Interaction

This is an introduction to Human Computer Interaction (HCI). It covers basic concepts, principles, and frameworks in HCI; models of interaction; and design guidelines and methodologies. The course includes extensive readings and reports, as well as work on projects involving interface design and development. Cross-listed with: SOC 510 Prerequisites: CS 590 or CS 385 or CS 182 or CS 570

CS 546 Web Programming

This course will provide students with a first strong approach of internet programming. It will give the basic knowledge on how the Internet works and how to create advanced web sites by the use of script languages, after learning the basics of HTML. The course will teach the students how to create a complex global site through the creation of individual working modules, giving them the skills required in any business such as proper team work and coordination between groups. Prerequisites: CS 561 or CS 442, and CS 146 or SOC 611

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CS 548 Enterprise Software Architecture and Design

This course addresses the important engineering issues in building largescale enterprise software systems. The course emphasizes service-oriented architectures (SOA) and best practices for building service-oriented enterprises in a vendorneutral fashion. Introduction to SOA; BPM; project management, and configuration management; Web services; mainframe services, virtualization, and data integration; application integration; legacy integration; enterprise integration; federal enterprise architecture (FEA); and case studies. Cross-listed with: SOC 542 Prerequisites: CS 590 or CS 385 or CS 182 or CS 570 or SOC 605

CS 549 Distributed Systems and Cloud Computing

Developing robust applications in distributed environments. Coursework includes developing a fault-tolerant distributed application. RPC and RMI; Web Services; application servers (e.g., JEE and Websphere). Transactions: concurrency control and recovery, distributed transactions, nested transactions, and business transactions. Models of distributed systems, impossibility results, and Byzantine failures. Protocol design and examples (2PC and 3PC). Distributed snapshots. Logical time and vector clocks. Replication for fault tolerance: primary-backup and state machine approaches, quorum consensus, and process groups. Peer-to-peer networks. Prerequisites: CS 590 or CS 385 or CS 182 or CS 570

CS 550 Computer Organization and Programming

This course provides an intensive introduction to material on computer organization and assembly language programming required for entrance into the graduate program in Computer Science or Computer Engineering. The topics covered are: structure of stored program computers; linking and loading; assembly language programming, with an emphasis on translation of high-level language constructs; data representation and arithmetic algorithms; basics of logic design; processor design: data path, hardwired control and microprogrammed control. Students will be given assembly language programming assignments on a regular basis. Prerequisites: Undergraduates need permission of advisor. Cross-listed with: CPE 550

CS 553 Introduction to Text Mining and Statistical Natural Language Processing (3 - 0 - 0)

This course will introduce statistical processing of natural language texts, particularly counting words and phrases in and of themselves as well as associations between them using correlations and other measures. Goals of text mining include document classification, information retrieval, source authentication, and stylistic categorization. Typical document sources are newspaper stories, email captures, and Internet pages, as well as collections of non-fiction and fiction such as Federalist Papers and Edgar Allan Poe short stories. Cross-listed with: SOC 553

CS 554 Web Programming II

This course focuses on teaching students the newest technologies available in Web Programming. Topics include advanced client side programming, responsive design, NoSQL databases, JQuery, AJAX, Web Site security, and the latest Frameworks. Students will be given the opportunity to suggest topics they would like to discover at the end of the semester. The course is a very hands-on course where everything taught will be practiced through in-class exercises. Prerequisites: CS 546

CS 554 Web Programming II

This course focuses on teaching students the newest technologies available in Web Programming. Topics include advanced client side programming, responsive design, NoSQL databases, JQuery, AJAX, Web Site security, and the latest Frameworks. Students will be given the opportunity to suggest topics they would like to discover at the end of the semester. The course is a very hands-on course where everything taught will be practiced through in-class exercises. Prerequisites: CS 546

CS 555 Agile Methods for Software Development

In software problem areas that require exploratory development efforts, those with complex requirements and high levels of change, agile software development practices are highly effective when deployed in a collaborative, people-centered organizational culture. This course examines agile methods, including Extreme Programming (XP), Scrum, Lean, Crystal, Dynamic Systems Development Method and Feature-Driven Development to understand how rapid realization of software occurs most effectively. The ability of agile development teams to rapidly develop high quality, customer-valued software is examined and contrasted with teams following more traditional methodologies that emphasize planning and documentation. Students will learn agile development, testing and deployment, and will be able to effectively participate in and manage agile software developments as a result of their successfully completing this course. Case studies and software development projects are used throughout. Cross-listed with: SSW 555

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Machine Learning: Fundamentals and Applications

In many fields (e.g., computer vision, speech recognition, data mining, and bioinformatics), machine learning has become a crucial ingredient in translating research into applications. The course is intended to provide an in-depth overview of recent advances in machine learning, with applications in fields such as computer vision, data mining, natural language processing. Fundamental topics that will be covered include supervised (Bayesian) and unsupervised learning, non-parametric methods, graphical models (Bayes Nets and Markov Random Fields) and dimensionality reduction. The course will also cover several of the most important recent developments in learning algorithms, including boosting, Support Vector Machines and kernel methods, and outline the fundamental concepts behind these approaches. Prerequisites: MA 222

An introduction to the field of Computer Vision, focusing on the underlying algorithmic, geometric, and optic issues. The course starts with a brief overview of basic image processing topics (convolution, smoothing, and edge detection). It then proceeds on various image analysis topics: binary images, moments-based shape analysis, Hough transform, image formation, depth and shape recovery, photometry, motion, classification, and special topics. Cross-listed with: CPE 558 Prerequisites: MA 232,

CS 561 Database Management Systems I

Computer Vision

and CS 182 or CS 385 or CS 570 or CS 590

CS 558

CS 559

Introduction to the design and querying of relational databases. Topics include: relational schemas; keys and foreign key references; relational algebra (as an introduction to SQL); SQL in depth; Entity-Relationship (ER) database design; translating from ER models to relational schemas and from relational schemas to ER models; functional dependencies; and normalization. Prerequisites: CS 590 or CS 570

CS 562 Database Management Systems II

Continuation of CS 561. Topics include UML modeling of relational databases; indexing, both static and dynamic; B-trees and B+-trees; guery optimization; concurrency control; and recovery control. Prerequisites: CS 561

CS 564 Software Requirements Aquisition and Analysis

Requirements Acquisition is one of the least understood and hardest phases in the development of software products, especially because requirements are often unclear in the minds of many or most stakeholders. This course deals with the identification of stakeholders, the elicitation and verification, with their participation, of the requirements for a new or to-beextended software product. It deals further with the analysis and modeling of requirements, the first steps in the direction of software design. Finally, it deals with the quality assurance aspects of the software requirements phase of the software development process. This course is case-history and project-oriented, and uses industry-standard software tools.

CS 568 Software Development Project I

This course provides a conceptual framework and practical experience in a full range of software development and assessment activities from a software systems engineering approach. By examining real-world examples and employing professionally accepted techniques, students will understand issues confronting software practitioners and the wider public. Undergraduate students whose program requires CS 423 and CS 424 may not take this course for credit.

CS 569 Software Development Project II

Students will work in teams on a software development project that was begun in CS568. In this course they will re-baseline the following documents: operational concept, requirements, architecture, life cycle plan, and feasibility argument and will execute its implementation and deployment. Undergraduate students in the computer science department, and graduate students who have taken CS 551 and/or CS 552 may not take this course for credit.

CS 570 Introduction to Programming, Data Structures, and Algorithms

Introduction to programming, data structures, and algorithm design, using one or more modern imperative language9s), as chosen by the instructor. Students will learn: basic programming constructs, data types, advanced and/or balanced search trees; hashing; asymptotic complexity analysis; standard algorithm design techniques; graph algorithms; sort algorithms; and other "classic' algorithms that serve as examples of design techniques. Students will be given regular programming assignments.

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CS 571 Java

"The course consists of an in-depth discussion of Java language and programming techniques. Comparison of Java to other languages, such as C/C++, is made throughout the course to emphasize various shortcomings of the language and their implications on design paradigms. Some aspects of GUI libraries, multithreading support, and Java native interface are also discussed. Not for undergraduate credit in Computer Science, Computer Engineering, Cybersecurity, and Information Systems degree programs."

CS 573 Fundamentals of CyberSecurity

"This course studies the mathematical models for computer security (Bell- LaPadula, Clark-Wilson, Biba, and Gligor models). It analyzes and compares, with respect to formal and pragmatic criteria, the properties of various models for hardware, software, and database security. Topics also include: formal specification and verification of security properties, operating system security, trust management, multi-level security, security labeling, security auditing and intrusion detection, security policy, safeguards and countermeasures, risk mitigation, covert channels, identification and authentication, password schemes, access control lists, and data fusion techniques. The course includes a project. Prerequisites: CS 590 or CS 385 or CS 182 or CS 570 Corequisites:

CS 574 Object-Oriented Analysis and Design

"Theory of object-oriented design, classes, interfaces, inheritance hierarchy, and correctness; abstract data types, encapsulation, formal specification with preconditions, postconditions and invariants, and proofs of correctness; object-oriented software, objects and classes, genericity, inheritance, polymorphism, and overloading; single and multiple inheritance, programming by contract, subclassing as subcontract, specification, and verification; programming language examples include C+ +, Java, Smalltalk, and Eiffel." Prerequisites: CS 590 or CS 385 or CS 182 or CS 570

CS 576 Secure Systems

This course will cover a wide range of topics in the area of Systems Security. A computer system is composed by software, hardware, policies, and practices. Systems security involves both designing and building secure systems, as well as improving and evaluating the security of exiting systems. This course is giving a particular emphasis into providing hands-on experience to students through building, attacking, and securing systems. The class is programming intensive. Those who take the class should be skill programmers and should have some experience with the C programming language and programming on a Linux environment. It is recommended that students are also familiar with the assembly language and with network and operating system basics. Prerequisites: (CS 392 and CS 306) or CS 631

CS 577 Reverse Engineering and Application Analysis

Software in binary form reveals very little about its design, inner workings, and purpose. There are many reasons for obtaining such information, such as recovering information about the software's development when it is lost, enabling interoperability, recovering data stored in obsolete encodings, analyzing software of unknown provenance, retrofitting software with additional functionality, etc. This course introduces students to the techniques involved in software reverse engineering and analysis. The course goes over multiple architectures, but mostly focuses on x86 and x86_64, and students are exposed to both static and dynamic analyses. This course is giving a particular emphasis into providing hands-on experience to students through disassembling, reverse engineering software, and programming custom analyses. Those who take the class should be skilled programmers and should not be afraid to dive deep into low-level code. Prerequisites: (CS 392 and CS 306) or CS 631

CS 578 Privacy in a Networked World

Increasing use of computers and networks in business, government, recreation, and almost all aspects of daily life has led to a proliferation of online sensitive data that, if used improperly, can harm the data subjects. As a result, concern about the ownership, control, privacy, and accuracy of these data has become a top priority. This course focuses on both the technical challenges of handling sensitive data and the policy and legal issues facing data subjects, data owners, and data users. This course is suitable for advanced undergraduate computer science majors, graduate students in computer science, and students in technology management or other majors with some computer science background. Course readings draw on a variety of sources, including both technical materials and the popular press. Cross-listed with: SOC 551 Prerequisites: CS 579 or CS 594 or CS 306 or CS 506

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CS 579 Foundations of Cryptography

This course provides a broad introduction to cornerstones of security (authenticity, confidentiality, message integrity, and non-repudiation) and the mechanisms to achieve them as well as the underlying mathematical basics. Topics include: block and stream ciphers, public-key systems, key management, certificates, public-key infrastructure (PKI), digital signature, nonrepudiation, and message authentication. Various security standards and protocols such as DES, AES, PGP, and Kerberos, are studied. Cross-listed with: CPE 579 Prerequisites: CS 503, and CS 182 or CS 385 or CS 570 or CS 590

CS 581 **Online Social Networks**

The technical issues involved in modern internet and online social networks. Basic social network terminology; properties of social networks: connectivity, long tail, network effects; and how these properties affect real life software systems, e.g.: blogs, wikis, social bookmarks and tagging, folksonomy, and online social networks. Students will learn programming with online social networking APIs: OpenSocial, Facebook, and Twitter. They shall also develop an appreciation of ethical, legal, and technical issues like privacy, anonymity, and authentication inherent in online social network applications. Course includes a term project resulting in a social networking application that uses the social networking APIs to operate on one of the popular social software platforms. Prerequisites: CS 392, and CS 182 or CS 385 or CS 570 or CS 590

CS 582 Causal Inference

This course covers what causality is, how we can infer it using automated methods, and how to use causes to predict future events, explain past occurrences and intervene on systems. Students will learn both the theory behind causal inference methods as well as how to apply them to real-world datasets such as from finance, biology, and politics. In addition to Bayesian networks, we will cover methods for causal inference in time series including dynamic Bayesian networks, Granger causality, and logic-based methods. Cross-listed with: SOC 582

CS 585 Introduction to Game Development

The course will provide the students with: (i) A theoretical understanding of the principles, concepts, and structures underlying game designs; (ii) An analysis of game specific engineering frameworks and architectures including software and hardware architectures, game play mechanics, design documentation, and production methodology; (iii) An introduction to the innovation processes and skills needed to formulate a viable design and take it from the idea stage to a published game. Cross-listed with: SOC 585 Prerequisites: CS 385 or CS 182 or CS 590 or CS 570

CS 586 Machine Learning for Game Design

This course examines the use of machine learning techniques in all stages of game design. Topics covered include environment and character modeling, motion synthesis, behavior learning, evolution and competition. The emphasis will be on cutting edge technology that utilizes the vast amounts of recorded game data as a basis for learning more realistic or more effective game design strategies. Advanced topics that will also be covered are gamebot identification in online games, as well as integration and evaluation of learning in games. Students will participate in groups to develop a game using principles learned in class. To complete the project, they will be required to implement and observe a representative set of the techniques covered in class. Prerequisites: MA 222, and CS 585, and CS 539 or CS 587

CS 587 Game Engine Design

In this course we will study the science and concrete programming tools underlying the design and implementation of game engines. The course will cover the principal components and techniques of a modern game engine: physics simulation engines, 3D graphics engines, artificial intelligence engines, scripting languages, network gaming for massively multiplayer games. Prerequisites: CS 537, and CS 539, and CS 541

CS 590 Algorithms

This is a course on more complex data structures, and algorithm design and analysis, using one or more modern imperative language(s), as chosen by the instructor. Topics include: advanced and/or balanced search trees; hashing; further asymptotic complexity analysis; standard algorithm design techniques; graph algorithms; complex sort algorithms; and other "classic" algorithms that serve as examples of design techniques. Cross-listed with: CPE 590 Prerequisites: CS 570 or CS 501

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Data Mining II: Advanced Algorithms for Mining Big Data

The recently introduced terminology of Big Data refers to data sets whose volume (amount of data collected, number of data sources), velocity (rate at which data is collected) and variety (heterogeneity of data and data sources) are so extreme that advanced data mining algorithms are needed to process and discover useful patterns in data for actionable intelligent decisions, in a reasonable amount of time. Cross-listed with: SOC 593

CS 594 Enterprise Security and Information Assurance

This course addresses the security of e-business and cyber environments from an end-to-end perspective, including data center security and access security. The information security phases of inspection, protection, detection, reaction, and reflection are emphasized. Topics also include: server and application security, virtual local area networks (VLANs), secure access and financial transaction techniques, and backup and disaster recovery techniques. The course also reviews financial Electronic Data Interchange (EDI) and smart card security in banking applications, and describes how the business and financial risks associated with security are estimated and managed. The course includes a project and related lab experiments. Cross-listed with: SOC 594 Prerequisites: CS 548 or SOC 542

CS 596 Introduction to Windows Programming

CS 593

This course covers programming for the Windows system environment using current Microsoft tools and technologies. The course emphasizes inter-process communication and synchronization techniques as well as explaining advanced memory management, file handling and asynchronous I/O, multi-threaded processes, and techniques applicable to high-performance and large-scale software systems. Prerequisites: CS 392 or CS 631

CS 597 User Exp Design & Programming

This course targets how to create, design, code and evaluate effective, efficient and enjoyable user experiences using both standard and emerging techniques. It explores psychological and computational foundations, fundamental concepts, task analysis and requirements analysis. The course emphasizes design, implementation and evaluation and encourages extensive use of design patterns in the design and construction of user experiences. This is truly an interactive course in all ways with demonstrations and exercises drawn from real and virtual worlds. At the end of the course the student should have a heightened appreciation of coding and evaluating user experiences in the real and virtual worlds.

CS 598 Visual Information Retrieval

Visual information retrieval studies the processing, indexing, querying, organization, classification, search, and browsing of visual information from images, videos, and other new emerging visual media. This course will cover traditional techniques as well as recent advances in visual information retrieval, especially under the context of web-scale image and video search. Students will acquire in-depth knowledge on state-of-the-art algorithms and technologies to transform unstructured visual data into structured representation for indexing and retrieval. These algorithms and technologies have empowered a broad range of applications in internet image and video search engine mobile augmented reality, location recognition, and online shopping, etc. Prerequisites: CS 182 or CS 385 or CS 570 or CS 590

CS 600 Advanced Algorithm Design and Implementation (3 - 3 - 0)

Design, implementation, and asymptotic time and space analysis of advanced algorithms, as well as analyzing worst-case and average-case complexity of algorithms. Students will be expected to run experiments to test the actual performance of the algorithms on sample inputs. Introduction to NP-complete problems and approximation algorithms. Cross-listed with: CPE 600 Prerequisites: CS 135 or MA 502, and CS 182 or CS 385 or CS 570 or CS 590

CS 601 Algorithmic Complexity

Analysis of algorithms: resource-bounded computation and time and space complexity. Various models of computation will be studied. Complexity classes and reducibilities, hardness, and completeness. Randomized algorithms and approximation algorithms. Prerequisites: CS 600

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CS 609 Data Management and Exploration on the Web

This course is an advanced graduate course on database systems and data exploration on Web. It covers a few key current research topics in database systems and Web data exploration including: (1) information retrieval (IR) from Web, (2) semistructured XML databases from the perspective of theory (thus accompanies the application-centric software engineering courses that uses XML), and (3) Web information integration. This course is suitable for advanced undergraduate computer science majors, graduate students in computer science, and students in technology management or other majors with some computer science background. Course readings are drawn from the recent top-tier international database conferences and journals. Prerequisites: CS 561 or CS 442

CS 615 Systems Administration

This course covers some of the most essential aspects of systems administration, giving students the opportunity to develop the skills necessary to analyze and troubleshoot problems arising in every day usage of networked computer systems, applying equally to single-user systems, as well as to large-scale installations. Some of the topics covered include: hardware configuration, operating system installation, shell programming, security policies, back-up deployment and disaster recovery, network design, software installation and maintenance, operating system tuning, and best practices for problem determination. Security topics including packet sniffers and spoofers, buffer overflow attacks and stack protection, and firewalls and intrusion detection are also covered, with an emphasis on their implementation. Students are expected to be comfortable in a Unix-like environment on a user level and have a solid understanding of TCP/IP networking and operating system concepts. Prerequisites: CS 520 or CS 492

CS 625 Foundations of Distributed Computing

Design and analysis of distributed algorithms, and impossibility results showing when some problems are unsolvable. Models of synchronous and asynchronous distributed computing. Fault models, including crash failures and malicious failures, and communication models, including message passing and shared memory systems. Distributed algorithms and impossibility results for problems, such as consensus, Byzantine agreement, clock synchronization, mutual exclusion, and secure multiparty computation. Prerequisites: CS 600

CS 629 Advanced Internet Protocols

A second course in computer networking that explores protocols underlying the modern Internet. Topics covered include IPv6, IPSec, mobility, quality of service, traffic engineering, multicase, transport protocols for streaming media, BGP decision algorithms, router techniques (address lookup, packet classification, switch fabric design), and mathematical techniques for describing properties of flows and flow interaction. The course uses free and/or open source tools and testbeds to conduct quantitative measurements of live traffic and to construct simulations of the operation of advanced protocols. Example tools and testbeds are: tcpdump, Wireshark, ns, Click, C-BGP, ntop, PlanetLab, and Emulab. Not all such tools and testbeds will be used in any individual offering of the course. Prerequisites: CS 521

CS 630 Models of Computation and Formal Languages (3 - 3 - 0)

Analysis of finite automata and regular sets. Formal languages and grammars, and Chomsky-hierarchy. Context-free languages and PDAs. Applications to parsing. Prerequisites: MA 502

CS 631 Advanced Programming in the UNIX Environment

In this course, students will learn to develop complex system-level software in the C programming language while gaining an intimate understanding of the UNIX family of operating systems and their programming environment. Topics covered will include the user/kernel interface, fundamental concepts of UNIX, user authentication, basic and advanced I/O, file systems, signals, process relationships, and interprocess communication. Fundamental concepts of software development and maintenance on UNIX systems (development and debugging tools such as "make" and "gdb") will also be covered. Prerequisites: CS 520

CS 634 Decidability and Computability

Computable functions and Turing machines. Primitive recursive functions, recursive functions, loop-programs, and whileprograms. Decidability, solvability, and unsolvable problems. High complexity classes and reducibilities, hardness, and completeness. The arithmetical hierarchy and definability. The connection to complexity theory is emphasized throughout the course. Prerequisites: MA 502

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CS 638 Advanced Computer Graphics

Mathematical foundations and algorithms for advanced computer graphics. Topics include 3-D modeling, texture mapping, curves and surfaces, physics-based modeling, and visualization. Special attention will be paid to surfaces and shapes. The class will consist of lectures and discussion on research papers assigned for reading. In class, we will study the theoretical foundations and algorithmic issues. In programming assignments, we will use OpenGL as the particular API for writing graphics programs. C/C++ programming skills are essential for this course. Cross-listed with: CPE 638 Prerequisites: CS 537

CS 643 Formal Verification of Software

Formal systems for specification and verification of software; review of the first-order predicate calculus; abstract data types, formal specification, preconditions, postconditions, invariants, predicate transformers, proofs of correctness, and partial and total correctness; correctness for assignments, alternatives, iterations, and procedure calls. Tools for deductive verification, model checking, and analysis of specifications and models. Prerequisites: CS 600

(3 - 3 - 0)CS 651 Introduction to Network and Graph Theory

Introduction to the theory and applications of networks and graphs. Topics include paths, connectivity, trees, cycles, planarity, network flows, matchings, colorings, and some extremal problems. Prerequisites: MA 502

CS 655 Queuing Systems With Computer Applications I (3 - 3 - 0)

Queuing models will be developed and applied to current problems in telecommunication networks and performance analysis of computer systems. Topics include elementary queuing theory, birth-death processes, open and closed networks of queues, priority queues, conservation laws, models for time-shared computer systems and computer communication networks. Cross-listed with: CPE 655, CS 505 Prerequisites: EE 605, CS 505

CS 656 Queuing Systems with Computer Applications II (3 - 3 - 0)

Queuing models will be developed and applied to current problems in telecommunication networks and performance analysis of computer systems. Topics include elementary queuing theory, birth-death processes, open and closed networks of queues, priority queues, conservation laws, models for time-shared computer systems and computer communication networks.

CS 660 Graph Algorithms

Basic graph-theoretic notions; data structures for graph representation; running time analysis; review of depth-first search, breadth-first search, and minimum spanning trees; network flow problems; graph connectivity; matchings; Eulerian graphs and digraphs; de Bruijn graphs; Hamiltonian graphs; traveling salesman problem; planar graphs; planarity testing; vertex and edge colorings; chromatic polynomials; five-coloring algorithm; and the Four-color problem. Prerequisites: MA 502, CS 600

CS 665 Forensic Analysis

Forensics involves the identification, preservation, and analysis of evidence of attacks in order to identify attackers and document their activity with sufficient reliability to justify appropriate technological, business, and legal responses. This course focuses on the technological and not on the legal components of the topic. The technical aspects will focus on analyzing both network and host data. This includes review of network traffic logs (pcap, flow records) and profiles and their types, identification of attack signatures and fingerprints, study of various traceback methods, application of data mining techniques, and the extraction of information (e.g., from malware, including botnet traffic) acquired through the use of network analysis tools and techniques, recovering evidence left behind, and technologies that can be used to assist in the analysis of obtained data or in obtaining more data. We will look into methodologies for recovering data from persistent storage and memory. Investigate the use of virtual machines in providing auditing capabilities to analysts and in setting traps for attackers. The class will not only cover the subjects in theory but instead also provide the students with an extensive hands-on experience. The class will involve a fair amount of programming. Prerequisites: (CS 392 and CS 306) or CS 631

CS 669 Network Management

Hierarchical network management for LAN and distributed discrete and integrated services networks; network management concepts; administrative and operational management; performance management; fault management; maintenance management; and security management and architectural management of different ownerships. Concept of managed objects, manager-agent relationship, and applications of network management protocols. Standard management protocols: SNMP and CMIP. Prerequisites: CS 521

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CS 675 Threats, Exploits, and Countermeasures

The class will cover advanced network and host security concepts and mechanisms. The class will cover the subjects in theory and provide the students with an extensive hands-on experience: assessing vulnerabilities, writing real working exploits for existing systems in a closed and controlled environment, and developing countermeasures to these perceived and real threats, also in the form of projects. The class will involve a fair amount of programming. Those who take the class are expected to be able to program in C/C++, have some a solid knowledge of assembly language, and be familiar with network basics and programming, as well as modern operating systems (Windows, MacOS, Unix). Prerequisites: CS 576, and CS 577, and CS 579

CS 676 Advanced Topics in Systems Security (3 - 3 - 0)

This course covers a wide range of advanced topics in the area of Systems Security. A computer system is composed by software, hardware, policies, and practices. Systems security involves both designing and building secure systems, as well as improving and evaluating the security of existing systems. During this course, students will study and present in the classroom recent papers in the area of systems security, write a literature survey on a particular topic, and work on a semester-long project, which will involve designing, implementing, and evaluating a system. Those who take the class should be skilled programmers and should already have some knowledge in the area of systems security. Prerequisites: CS 576

CS 677 Multicore Platforms for Cognitive Gaming and Simulation (3 - 3 - 0)

The course covers advanced architectures and programming techniques for visual computing and machine learning and their applications in gaming, simulation, data analysis and visualization. This class covers the architecture and programming of multicore processors and graphical processing units and associated programming frameworks and languages, for example, CUDA and OpenCL. The course will cover a wide range of applications including real-time rendering of populations and scenario developments in large scale dynamic environments, machine learning and computer vision algorithms for recognition and tracking, large scale dynamic scientific visualizations. Prerequisites: CS 537

Engineering of Large Software Systems CS 687

Students will learn how to deal with issues impacting industrial software developments. A broad range of topics will be covered emphasizing large [project issues. Large software projects are those employing 50 or more software developers for three years or more. Throughout the course, emphasis will be placed on quantitative evaluation of alternatives. Specific examples and case histories from real projects in the telephone industry are provided. Students will learn how to create architectures for large systems based on the '4+1' model; how to use modern software connector technology; module decomposition; scaling of agile methods to large projects, the use of work flows to drive software process and database designs, test plans and implementation; configuration control and software manufacturing. The special issues of database conversion data consistency, database maintenance and performance tuning will be addresses for large databases. The physical environment of the computer systems including multi-site deployment; software releases and special management report generation are examined.

CS 688 Software Testing, Quality Assurance & Maintenance

To introduce students to systematic testing of software systems, software verificaton, symbolic execution, software debugging, quality assurance, measurement and prediction of software reliability, project management software maintenance, software reuse and reverse engineering.

CS 689 Software Reliability Engineering

Students will learn how to analyze, predict, design, and engineer the required and expected reliability of software systems. Case studies will be used throughout, including studies of systems that worked well and of systems that failed in some crucial aspect. Examples of the types of systems which will be studied are the London Ambulance Dispatch System, the Lucent Telephone Switching Systems and the Mars and Voyager missions.

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CS 691 Introduction to Systems Biology

Systems biology is a new approach to complex biological problems. It uses a combination of the most modern techniques for comprehensive measurements of cells and molecules, combined with complex computer and mathematical modeling, to build up inclusive depictions of how living systems function. This course is an integrative approach to help comprehend dynamic biological systems. True understanding of systems biology requires a cross-disciplinary approach. Topics will include both a biological and computer science perspective taught by experts in each individual discipline. The course will cover introduction to advance biological subjects in cell biology and genetics followed by introduction to computer science methods including modeling and "bio-machine" features of systems biology. In class, we will also explore critical reading of current research. Cross-listed with: CH 691

CS 693 Cryptographic Protocols

This course covers the design and analysis of security protocols, and studies different attacks and defenses against them. Topics include: signature and authentication protocols, privacy, digital rights management, security protocols for wired, wireless and distributed networks, electronic voting, payment and micropayment protocols, anonymity, broadcast encryption and traitor tracing, quantum cryptography, and visual cryptography. The course includes a project. Cross-listed with: CPE 693 Prerequisites: CS 579

CS 694 Advanced Computational Modeling in Biology and Biomaterials Science (3 - 3 - 0)This course combines computational modeling with lab experience. The course is project based. Students will be able to choose from a pool of problems being actively researched at Stevens, understand how to obtain experimental data, design and implement a computational model, predict the behavior of the system being modeled, and use a second set of experimental results to validate the model. Cross-listed with: CH 694

CS 695 Host Forensics

Host forensics involves the identification, preservation, and analysis of evidence of attacks in order to identify the attackers and document their activity with sufficient reliability to justify appropriate technological, business, and legal responses. This course focuses on the technological and not on the legal components of the topic. The emphasis is on the host aspect, not on the network aspect. The technical aspect addresses analysis of intruder types and the intrusion process, review of attacks and their types, identification of attack signatures and fingerprints, application of data mining techniques, study of varied discovery methods including reverse engineering, and the extraction of information from hard disks and devices. The class will not only cover the subjects in theory but instead also provide the students with an extensive hands-on experience. The class will involve a fair amount of programming. Prerequisites: CS 392 or CS 631, and CS 306

CS 696 **Database Security**

This course is an advanced graduate course that provides an up-to-date overview of data security models, techniques, and architectures in a variety of data management applications and settings. It will cover some of the most comprehensive work on database security, with the covered topics as: (1) access control policies and mechanisms for both relational and structured databases, (2) database integrity auditing techniques, (3) database watermarking, and (4) security in distributed database management systems.

CS 700 Formal Semantics of Programming Language

Methods for giving meaning to programming language constructs; Operational, Denotational, and Axiomatic semantics. Introduction to algebraic tools; recursive definitions and fixed-point semantics; proving program correctness; and program equivalence. Prerequisites: CS 630

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This course is for CS students who are on a Co-Op assignment.

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CS 703 Curricular Practical Training

International graduate students may arrange an educationally relevant internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the project plus a statement from the employer that he/she intends to employ the student. This information must be provided to the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. The project must be educationally relevant; i.e., it must help the student develop skills consistent with the goals of the educational program. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/her activities during that semester, even if the activity remains ongoing. The student must also present his/her activities in an accompanying oral presentation that is also graded. This is a one-credit course that may be repeated for up to a total of three credits. At the discretion of the CPT director, the course may be taken for two credits. Cross-listed with: SOC 703

CS 777 Introduction to Expert Systems

This course will include the essential elements of artificial intelligence (AI); knowledge representation, search techniques, heuristic, typical problems and solution methodologies which constitute the less-than-precise definition of AI which exists today. Current practical uses of AI in information management and decision-support systems (such as intelligent agents, neural networks, and search engines) will be discussed and their relative merits/success rates evaluated. A potential application will be proposed and presented by the students. Cross-listed with: MGT 777

CS 800 Special Problems in Computer Science (M.S.)

An investigation of a current research topic at the pre-master's level, under the direction of a faculty member. A written report is required, which should have the substance of a publishable article. Students with no practical experience who do not write a master's thesis are invited to take advantage of this experience. One to six credits for the degree of Master of Science (Computer Science).

CS 801 Special Problems in Computer Science (Ph.D.) (1 to 6 - -)

An investigation of a current research topic beyond that of CS 800 level, under the direction of a faculty member. A written report is required, which should have importance in Computer Science and should have the substance of a publishable article. This course is open to students who intend to be doctoral candidates and wish to explore an area that is different from the doctoral research topic. One to six credits for the degree of Doctor of Philosophy.

CS 802 Software Engineering Examination

This will test the software engineering knowledge of students who have completed Stevens Institute of Technology-approved training programs in software engineering. Upon successful completion (graded pass/fail), students will be awarded six credits towards the Master of Quantitative Software Engineering on their study plan and three on the approval form for the certificate of Quantitative Software Engineering. To obtain a pass in this course, the student is required to demonstrate proficiency equivalent to a grade of 'B' (i.e. 3.0 out of 4.0) or higher. These credits are not transferable to other institutions.

CS 803 Special Problems in Computer Science (Engineer Degree)

An investigation of a current research topic under the direction of a faculty member. One to six credits to fulfil the Engineer Degree requirements only.

CS 810 Special Topics in Computer Science

A participating seminar on topics of current interest and importance in computer science. Open to both undergraduates and graduate students.

CS 900 Thesis in Computer Science (M.S.)

Original research of a significant character carried out under the guidance of a member of the departmental faculty, which may serve as the basis for the dissertation, is required for the degree of Doctor of Philosophy. Credits to be arranged.

CS 950 Design Project

Design project required for the degree of Engineer in Computer Science. One to 12 credits. Course may be repeated for credit up to a total of 12 credits.

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CS 960 Research in Computer Science(Ph.D.)

Original research of a significant character carried out under the guidance of a member of the departmental faculty, which may serve as the basis for the dissertation, is required for the degree of Doctor of Philosophy. Hours and credits to be arranged.

CS 595 Information Security and the Law

This course examines every major aspect of the relationship between information security and the law, at a level suitable for information security specialists and senior managers who supervise information security operations. In the first phase, the course explores substantive legal principles relating to information security, with regard to both private and government interests. The second phase of the course explores information security operations as the repository of information that may be at issue in legal proceedings. Finally, the course concludes with a discussion of the balancing process required to promote information security in a system of ordered liberties, that is, with due respect for civil rights.

Service Oriented

Introduction to JAVA Programming SOC 501

An introduction to the Java programming language for those students who have little or no programming background. It is intended as an elective for the Master of Science in Information Systems to be taken near the end of the program. Basic topics considered will be programs and program structure in general and Java syntax, data types, flow of control, classes, methods and objects, arrays, exception handling, and recursion. In addition, the use of Java in enterprise-wide computing and distributed systems will be introduced by considering APIs in general, and the ones specific to JDBC and the Java security features in particular. Not for credit for Computer Science department undergraduate majors. Cross-listed with: CS 501

SOC 510 Human- Computer Interaction

This is an introduction to Human Computer Interaction (HCI). It covers basic concepts, principles, and frameworks in HCI; models of interaction; and design guidelines and methodologies. The course includes extensive readings and reports, as well as work on projects involving interface design and development. Cross-listed with: CS 545 Prerequisites: CS 590 or CS 385

SOC 512 Online Social Networks for Service Oriented Computing

The objective of this course is to educate students in the design, implementation, and analysis of on-line social networks, from the viewpoint of software as a service. This course introduces basic concepts and results in graph theory and game theory, and demonstrates their application in reasoning about social networks. Privacy and security aspects of social networks are also considered. Course work includes developing a social network application and analyzing data harvested from social networks. Prerequisites: SOC 605 or permission of instructor.

SOC 519 Introduction to E-commerce

The course provides an understanding of electronic commerce and related architectures, protocols, and technologies. It describes the e-commerce concept, objectives, and market drivers, as well as its requirements and underpinning techniques and technologies, including the Internet, WWW, multimedia, intelligent agents, client-server, and data mining. Security in e-commerce is addressed, including types of security attacks, security mechanisms, Virtual Private Networks (VPNs), firewalls, Intranets, and extranets. Implementation issues in e-commerce, including the design and management of its infrastructure and applications (ERP, CRM, and SCM), are discussed. M-commerce is addressed, electronic payment systems with their associated protocols are described, and various B2C and B2B applications are presented. Also, policy and regulatory issues in ecommerce are discussed. Cross-listed with: CS 519

SOC 521 Software Requirements Acquisition and Analysis (3 - 3 - 0)

Requirements acquisition is one of the least understood and hardest phases in the development of software products, especially because requirements are often unclear in the minds of many or most stakeholders. This course deals with the identification of stakeholders, and the elicitation and verification, with their participation, of the requirements for a new or tobe-extended software product. It deals further with the analysis and modeling of requirements, the first steps in the direction of software design. Finally, it deals with the quality assurance aspects of the software requirements phase of the software development process. This course is case-history and project-oriented, and uses industry-standard software tools. Crosslisted with: CS 564 Prerequisites: SOC 606

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SOC 524 Introduction to Cloud Computing

This course introduces the concepts of cloud computing, using the frameworks of software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS). Fundamental concepts from each framework are introduced and related to the structure of the modern cloud. Cloud computing: economics of outsourcing. SaaS: The Web as a client-server system. Web stack: HTML and HTTP. Web data: XML and JSON. Web services and example APIs. PaaS: Introduction to databases and middleware. Data storage in the cloud. Privacy issues. IaaS: Design of server farms. Virtualization and green computing. Service discovery: DNS and content distribution networks. Batch processing in the cloud. Assignments include quizzes, examinations, and a presentation and term paper on a cloud-related topic. Cross-listed with: CS 524

SOC 542 Enterprise Software Architecture and Design

This course addresses the important engineering issues in building largescale enterprise software systems. The course emphasizes service-oriented architectures (SOA) and best practices for building service-oriented enterprises in a vendorneutral fashion. Introduction to SOA; BPM; project management, and configuration management; Web services; mainframe services, virtualization, and data integration; application integration; legacy integration; enterprise integration; federal enterprise architecture (FEA); and case studies. Cross-listed with: CS 548 Prerequisites: CS 590, CS 385

SOC 550 Knowledge Discovery and Data Mining

This course introduces fundamental and practical tools, techniques, and algorithms for Knowledge Discovery and Data Mining (KD&DM). It provides a balanced approach between methods and practice. On the methodological side, it covers several techniques for transforming corporate data into business intelligence. These include: online Analytical Processing (OLAP) Systems, Artificial Neural Networks (ANN), Rule-Based Systems (RBS), Fuzzy Logic (FL), Machine Learning (ML), Classification Trees (C4.5 Algorithm), and Classification and Regression Trees (CART Algorithm). To illustrate the practical significance of the various techniques, half of the course is devoted to case studies. The case studies, drawn from real-world applications, demonstrate application of techniques to real-world problems. Cross-listed with: CS 513 Prerequisites: MA 331 or MA 501

SOC 551 Privacy in a Networked World

Increasing use of computers and networks in business, government, recreation, and almost all aspects of daily life has led to a proliferation of online sensitive data that, if used improperly, can harm the data subjects. As a result, concern about the ownership, control, privacy, and accuracy of these data has become a top priority. This course focuses on both the technical challenges of handling sensitive data and the policy and legal issues facing data subjects, data owners, and data users. This course is suitable for advanced undergraduate computer science majors, graduate students in computer science, and students in technology management or other majors with some computer science background. Course readings draw on a variety of sources, including both technical materials and the popular press. Cross-listed with: CS 578 Prerequisites: CS 579 or CS 594 or CS 306

SOC 552 Health Informatics

This course integrates computer science and health informatics. It is the capstone course for students in the serviceoriented computing program who choose the health informatics application domain. The course covers the history of health informatics, including discussions of protocols and standards, such as OSI, UDEF, and HL7; review of information access and evaluation, health care terminology and health care economics, and looks at system selection and evaluation in the areas of telemedicine, dental informatics, consumer health informatics, and hospital/clinical informatics. Special attention is given to Web services and mobile computing as they relate to the health care industry. The course includes extensive readings. Cross-listed with: CS 544 Prerequisites: CS 548, SOC 542

SOC 553 Introduction to Text Mining and Statistical Natural Language Processing (3 - 3 - 0)

This course will introduce statistical processing of natural language texts, particularly counting words and phrases in and of themselves as well as associations between them using correlations and other measures. Goals of text mining include document classification, information retrieval, source authentication, and stylistic categorization. Typical document sources are newspaper stories, email captures, and Internet pages, as well as collections of non-fiction and fiction such as Federalist Papers and Edgar Allan Poe short stories. Cross-listed with: CS 553 Prerequisites: SOC 605

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SOC 593 Data Mining II: Advanced Algorithms for Big Data (3 - 3 - 0) The recently introduced terminology of Big Data refers to data sets whose volume (amount of data collected, number of data sources), velocity (rate at which data is collected) and variety (heterogeneity of data and data sources) are so extreme that advanced data mining algorithms are needed to process and discover useful patterns in data for actionable intelligent decisions, in a reasonable amount of time. Cross-listed with: CS 593

SOC 594Enterprise Security and Information Assurance(3 - 3 - 0)

This course addresses the security of e-business and cyber environments from an end-to-end perspective, including data center security and access security. The information security phases of inspection, protection, detection, reaction, and reflection are emphasized. Topics also include: server and application security, virtual local area networks (VLANs), secure access and financial transaction techniques, and backup and disaster recovery techniques. The course also reviews financial Electronic Data Interchange (EDI) and smart card security in banking applications, and describes how the business and financial risks associated with security are estimated and managed. The course includes a project and related lab experiments. Cross-listed with: CS 594 Prerequisites: CS 548 or SOC 542

SOC 605 Introduction to Service -Oriented Computing

This is an introduction to the field of service-oriented computing, in the context of a first course in computer programming, for students with no prior experience. Students will learn the core process of programming: given a problem statement, how does one design an algorithm to solve that particular problem and then implement the algorithm in a computer program? The course will also introduce elementary programming concepts like basic control concepts (such as conditional statements and loops) and a few essential data types. The notions of objects and object creation will also be introduced. The course will involve programming assignments using a self-contained user-friendly programming environment.

SOC 606 Introduction to Developing Internet Applications

This is a survey course of techniques and technologies for developing Internet applications, particularly for the Web. Web servers and security; three-tier client server architectures; database design and administration; and server- and client-side scripting in Web applications. The course also introduces basic software engineering principles and practices, including project management, requirements acquisition, design, testing and configuration management, reliability, security, and risk management. Prerequisites: SOC 605 Corequisites: SOC 611

SOC 611 Fundamentals of Service Oriented Computing

This course introduces students to the infrastructure underlying the Web, including protocols and mark-up languages. It also addresses the question of how one presents large volumes of information to people who need to find out what they are looking for quickly. The scope of the course ranges from mechanics to aesthetics. Social and ethical issues are also discussed, including the concept of information ecologies for social acceptance. Networks and protocols; pervasive computing; Web protocols; markup languages and XML; defining information architecture; understanding information needs and information-seeking behaviors; organizing Web sites and intranets; navigation systems; search systems; thesauri; from research to design: strategies for information architecture; ethics on the Web; and information ecologies.

This course covers what causality is, how we can infer it using automated methods, and how to use causes to predict future events, explain past occurrences and intervene on systems. Students will learn both the theory behind causal inference methods as well as how to apply them to real-world datasets such as from finance, biology, and politics. In addition to Bayesian networks, we will cover methods for causal inference in time series including dynamic Bayesian networks, Granger causality, and logic-based methods. Cross-listed with: CS 582

SOC 585 Introduction to Game Development

The course will provide the students with: (i) A theoretical understanding of the principles, concepts, and structures underlying game designs; (ii) An analysis of game specific engineering frameworks and architectures including software and hardware architectures, game play mechanics, design documentation, and production methodology; (iii) An introduction to the innovation processes and skills neeed to formulate a viable design and take it from the idea stage to a published game. Cross-listed with: CS 585 Prerequisites: CS 385 or CS 182 or CS 590

SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

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SOC 641 Distributed Application Development

This course is a survey of advanced techniques for developing distributed applications. Blocking and unblocking messagepassing; RPC and middleware; Web services; concurrency control; recoverability and availability; transactions and distributed databases; centralized and distributed transactions; load balancing; mobile computing; and distributed systems security. Discussion of architectures, such as representational state transfer (REST) and technologies such as AJAX and SOAP. Prerequisites: SOC 606

SOC 703 Curricular Practical Training

International graduate students may arrange an educationally relevant internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the project plus a statement from the employer that he/she intends to employ the student. This information must be provided to the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. The project must be educationally relevant; i.e., it must help the student develop skills consistent with the goals of the educational program. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/ her activities during that semester, even if the activity remains ongoing. The student must also present his/her activities in an accompanying oral presentation that is also graded. This is a one-credit course that may be repeated for up to a total of three credits. At the discretion of the CPT director, the course may be taken for two credits. Cross-listed with: CS 703

SOC 810 Special Topics in Service Oriented Computing

A participating seminar on topics of current interest and importance in Service Oriented Computing.

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Department of Electrical & Computer Engineering

FACULTY

YU-DONG YAO DEPARTMENT DIRECTOR

Bryan Ackland, Ph.D. Distinguished Service Professor, IEEE Fellow

Rajarathnam Chandramouli, Ph.D. Hattrick Chair Professor

Yingying Chen, Ph.D. Professor & NIS Graduate Program Director

Cristina Comaniciu, Ph.D. Associate Professor & EE Graduate Program Director

Nariman Farvardin, Ph.D. University President, Professor, IEEE Fellow

Narayan Ganesan, Ph.D. Assistant Professor

Yi Guo, Ph.D. Associate Professor

Harry Heffes, Ph.D. Professor, IEEE Fellow

Mukundan V. Iyengar, Ph.D. Teaching Assistant Professor

Dov Kruger, Ph.D. Teaching Assistant Professor

EMERITUS FACULTY

Paul Chirlian, Sc.D. Professor Emeritus

Gerald Herskowitz, Sc.D. Professor Emeritus

Emil Neu, Sc.D. Professor Emeritus Victor Lawrence, Ph.D. Distinguished Research Professor, IEEE Fellow, NAE member

Hongbin Li, Ph.D. Professor & EE Undergraduate Program Director

Hong Man, Ph.D. Professor & CPE Undergraduate Program Director

Bruce McNair, Ph.D. Distinguished Service Professor, Computer Engineering Graduate Program Director

Serban Sabau, Ph.D. Assistant Professor

Hady Salloum, Ph.D. Associate Dean for Research and Outreach

Koduvayur P. Subbalakshmi, Ph.D. Professor

Negar Tavassolian, Ph.D. Assistant Professor

Yu-Dong Yao, Ph.D. Professor & Department Director, IEEE Fellow

Dr. Harrison Rowe, Sc.D. Professor Emeritus

Dr. Stanley Smith, Ph.D. Professor Emeritus

UNDERGRADUATE PROGRAMS

Electrical Engineering

Today's technological world is driven by the electronics and electronic systems, developed and advanced by electrical engineers that are found embedded in a large portion of today's commercial and consumer products. The electronic systems and subsystems (including both hardware and software components) are increasing exponentially in complexity and sophistication each year. The familiar expectation that next year's computer and communications products will be far more powerful than today's is common to all products incorporating electronics. The high (and increasing) complexity and sophistication of these electronic products may not be seen by the casual user, but they are understood, delivered, and advanced by electrical engineers. The field of electrical engineering encompasses areas such as telecommunications, data networks, signal processing, digital systems, embedded computing, intelligent systems, electronics, optoelectronics, solid state devices, and many others. The Department's program is designed to provide our electrical engineering graduates with the tools and skills necessary to understand and apply today's technologies and to become leaders in developing tomorrow's technologies and applications.

The principles and practices of electrical engineering rest upon the broad base of fundamental science and mathematics that defines the School of Engineering and Science's core program. A sequence of electrical engineering courses provides students with an understanding of the major themes defining contemporary electronic systems, as well as depth in the mathematics and principles of today's complex electronic systems. Students select elective courses to develop depth in areas of personal interest. In addition to electrical engineering elective courses, students can draw upon computer engineering and other Stevens courses to develop the skills appropriate for their career objectives. In the senior year, students complete a significant, team-based engineering design project through which they further develop their skills.

Mission and Objectives

The mission of the undergraduate electrical engineering program in the Department of Electrical and Computer Engineering (ECE) is to provide a balanced education in fundamental principles, design methodologies, and practical experiences in electrical engineering and in general engineering topics through which graduates can enter into and sustain lifelong professional careers of innovation and creativity.

The overriding objective of the electrical engineering program is to provide graduates with the skills and understanding needed to design and build innovative new products and services which balance the rival requirements of competitive performance/cost and practical constraints imposed by available technologies.

Graduates of the Electrical Engineering program will:

- Understand the evolving electronic devices and systems from their underlying physical principles and properties.
- Design electronic devices, circuits, and systems by applying underlying mathematical principles, software principles, and engineering models.
- ▶ Perform effectively in team-based electronic engineering practice.
- ▶ Be proficient in the systematic explorations of alternatives for electronic systems design.
- Demonstrate compliance with professional ethics, for example, as stipulated in the IEEE Code of Ethics.
- Be proficient in the use of communications (oral presentations and written reports) to articulate their ideas effectively.
- Participate in continuing learning and self-improvement necessary for a productive career in computer engineering.
- ▶ Play leadership roles in their professions.

Electrical Engineering Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
		Lecluie	Lau	Study	oreun
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
0/12 100	Total	12	10	27	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
	Science Elective I ¹	3	0	6	3
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
PEP 111	Mechanics	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ⁵	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	8	37	19

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Course #	Course Name	Lecture	Lab	Study	Credit
EE 250	Mathematics for Electrical Engineers ²	3	0	3	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics	3	0	6	3
CPE 390	Microprocessor Systems	3	3	4	4
Hum	Humanities ⁵	3	0	6	3
EE 359	Electronic Circuits	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	17	8	32	19

Term IV

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
EE 471	Transport Phenomena in Solid State Devices ²	4	0	4	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Probability and Statistics for Engineers	3	0	6	3
EE 348	Signals and Systems	3	0	3	3
Hum	Humanities ⁵	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	16	5	27	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
EE 345	Modeling and Simulation ³	3	0	6	3
E 355	Engineering Economics	3	3	6	4
EE 322	Engineering Design VI ³	1	3	2	2
S.E.	Science Elective II ¹	3	0	6	3
EE 448	Digital Signal Processing	3	0	3	3
G.E.	General Elective ⁴	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	16	8	29	18

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ³	3	0	6	3
EE 465	Introduction to Communication Systems	3	0	3	3
G.E.	General Elective ⁴	3	0	6	3
EE 423	Engineering Design VII ³	1	7	4	3
T.E.	Technical Elective ³	3	0	6	3
TG 403	Senior Innovation I	2	0	4	2
	Total	15	7	29	17

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Term	VIII
1 GT III	* * * * *

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ³	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
EE 424	Engineering Design VIII ³	1	7	4	3
Hum	Humanities ⁵	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
	Total	14	7	30	16

(1) Science electives - note: engineering programs have specific requirements. See pages 78-80 for details.

(2) Core option – specific course determined by engineering program

(3) Discipline specific courses

(4) General Electives – chosen by the student – can be used towards a minor or option – can be applied to research or approved international studies

(5) Humanities requirements can be found on pages 556-557.

Computer Engineering

One of the most rapidly growing fields today is computer engineering. This includes the design, development, and application of digital and computer-based systems for the solution of modern engineering problems, as well as computer software development, data structures and algorithms, and computer communications and graphics. The department provides our computer engineering students with the tools and skills necessary to understand and apply today's technologies and to become leaders in developing tomorrow's technologies. The program prepares students to pursue professional careers in industry and government, and to continue their education in graduate school, if they choose.

Students in the computer engineering program begin by studying the scientific foundations that are the basis for all engineering. Specialized electrical engineering, computer engineering, and computer science courses follow, providing depth in the many issues related to computers, data networks, information systems, and related topics used in contemporary commercial and industrial applications. Students may direct their interests into areas such as computer and information systems, software/software engineering, and computer architectures and digital systems. In addition to computer engineering courses, students can draw upon electrical engineering and computer science courses to develop the skills appropriate for their career objectives. In the senior year, students have the opportunity to participate in an actual engineering design project which is taken directly from a current industrial or commercial application.

Mission and Objectives

The mission of the undergraduate computer engineering program in the Department of Electrical and Computer Engineering is to provide a balanced education in fundamental principles, design methodologies, and practical experiences in computer engineering, general engineering, and physical and mathematical sciences topics through which graduates can enter into and sustain lifelong professional careers of engineering innovation and creativity.

The overriding objective of the computer engineering program is to provide graduates with the skills and understanding needed to design and build innovative new products and services. They balance the rival requirements of competitive performance/cost and practical constraints imposed by available technologies.

Graduates of the computer engineering program will:

- ► Apply the underlying principles and practices of digital circuits and systems, including design techniques, engineering design tools, mathematical methods, and physical technologies.
- ▶ Participate effectively in team-based approaches to design, verification, and realization tasks.
- ▶ Be proficient in the systematic exploration of the design space to achieve optimized designs.

- Demonstrate compliance with professional ethics (for example, as stipulated in the IEEE Code of Ethics).
- Be proficient in the use of communications (oral presentations and written reports) to articulate their ideas effectively.
- Participate in continuing learning and self-improvement necessary for productive careers in computer engineering.
- ▶ Play leadership roles in their professions.

Computer Engineering Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	12	10	27	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
	Science Elective I ¹	3	0	6	3
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
PEP 111	Mechanics	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ⁵	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	8	37	19

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Course #	Course Name	Lecture	Lab	Study	Credit
MA 134	Discrete Mathematics ²	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics	3	0	6	3
CPE 360	Computational Data Structures and Algorithms	3	0	6	3
CPE 390	Microprocessor Systems	3	3	4	4
Hum	Humanities ⁵	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	17	8	35	19

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
EE 471	Transport Phenomena in Solid State Devices ²	4	0	4	4
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Probability and Statistics for Engineers	3	0	6	3
CPE 487	Digital System Design	3	0	3	3
Hum	Humanities ⁵	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	16	5	27	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
CPE 345	Modeling and Simulation ³	3	0	6	3
E 355	Engineering Economics	3	3	6	4
CPE 322	Engineering Design VI ³	1	3	2	2
CPE 462	Introduction to Image Processing and Coding	3	0	3	3
S.E.	Science Elective II ¹	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	16	8	29	18

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ³	3	0	6	3
CPE 490	Information System Engineering ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
CPE 423	Engineering Design VII ³	1	7	4	3
T.E.	Technical Elective ³	3	0	6	3
TG 403	Senior Innovation I	2	0	4	2
	Total	15	7	29	17

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Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
T.E.	Technical Elective ³	3	0	6	3
T.E.	Technical Elective ³	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
CPE 424	Engineering Design VIII ³	1	7	4	3
Hum	Humanities ⁵	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
	Total	14	7	30	16

(1) Science electives – note: engineering programs have specific requirements - one elective must have a laboratory component - two electives from the same science field cannot be selected

(2) Core option – specific course determined by engineering program

(3) Discipline specific courses

(4) General Electives – chosen by the student – can be used towards a minor or option - can be applied to research or approved international studies

(5) Humanities requirements can be found on pages 556-557.

Areas of Concentration for Electrical Engineering and Computer Engineering

Electrical and computer engineering students can select their elective courses among four technical electives and three general electives in various ways. Some of them may wish to cluster those electives in ways that would help them gain expertise in an area of specialization within electrical and computer engineering. The following groupings are possible specialty (concentration) areas that students can select from within the electrical and computer engineering program:

Computer Architectures

- CPE 517 Digital and Computer Systems Architecture
- CPE/CS 550 Computer Organization and Programming

Electronics and Embedded Systems

- ▶ EE 359 Electronic Circuits
- CPE 487 Digital System Design
- ▶ CPE 555 Real-Time and Embedded Systems
- CPE 556 Computing Principles of Embedded Systems

Software Engineering and Design

- CPE 360 Computational Data Structures and Algorithms
- CPE/CS 442 Database Management Systems
- ▶ CPE 492 Computer and Operating Systems
- ▶ EE 545 Communication Software and Middleware
- CPE 593 Applied Data Structure and Algorithm

Networks and Security

- CPE 490 Information Systems Engineering I
- ▶ CPE 579 Foundations of Cryptography

- ▶ EE 584 Wireless Systems Security
- ▶ EE 586 Wireless Networking: Architectures, Protocols, and Standards
- ▶ CPE 592 Computer and Multimedia Network Security

Power Engineering

- ▶ EE 589 Introduction to Power Engineering
- ▶ EE 590 Smart Grid

Robotics and Control

- ▶ EE 478 Control Systems
- CPE 521 Introduction to Autonomous Robots
- ▶ EE 575 Introduction to Control Theory

Image Processing and Multimedia

- CPE 462 Introduction to Image Processing and Coding
- CPE 536 Integrated Services Multimedia
- CPE 537 Interactive Computer Graphics I
- ▶ CPE 558 Computer Vision
- CPE 591 Introduction to Multimedia Networking
- CPE 592 Computer and Multimedia Network Security

Wireless Communications

- ▶ EE 441 Introduction to Wireless Systems
- ▶ EE 568 Software Defined Radio
- ▶ EE 583 Wireless Communications
- ▶ EE 584 Wireless Systems Security
- ▶ EE 585 Physical Design of Wireless Systems
- ▶ EE 586 Wireless Networking: Architectures, Protocols, and Standards

Graduate Requirements for Electrical Engineering and Computer Engineering

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirement

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

English Language Proficiency

All students must satisfy an English Language proficiency requirement.

Electives

"Technical electives" are generally selected from among the courses (EE or CPE) listed among the ECE course descriptions. Under special circumstances, students may be allowed to use courses from other departments to satisfy the technical elective requirement. Approval by the course instructor, the student's advisor, and the ECE Director is required.

"General Electives" are free electives, and can be selected from among any courses (including ECE courses) at Stevens Institute of Technology. Students can use 500-level ECE courses to satisfy an elective requirement, with the permission of the course instructor and the students' advisor. If a student satisfies the conditions established by the Stevens Graduate School for admission into 600-level graduate courses, ECE 600-level courses may also be used as electives or technical electives. Students interested in using a 500-level or 600-level course from other departments as a free elective must satisfy the conditions for admission into the course by the offering department.

Engineering with a Concentration in Information Systems Engineering

The SSE and Department of Electrical and Computer Engineering (ECE) of the Charles V. Schaefer, Jr. School of Engineering and Science jointly offer an Information Systems Engineering (ISE) concentration under the Engineering Program in the undergraduate curriculum.

The goal of the ISE concentration is to produce graduates with a broad engineering foundation who can be effective in the analysis, design, construction, implementation, and management of information systems. A student can choose either a focus area in information systems management or networked information systems (NIS). Students taking the NIS focus will, in general, take their senior design sequence with students in the Bachelor of Engineering in Computer Engineering (CPE) program. Whereas, those students taking the ISM focus will take their senior design sequence with students of Engineering in Engineering Management (BEEM) program. The following lists typical electives within each focus. Other appropriate electives can be chosen with the approval of a faculty advisor.

Network Information Systems (NIS)

Electives for the NIS focus can be selected from any ECE undergraduate or 500-level courses consistent with the themes of networks, information, and networked information systems. When appropriate, courses from other academic programs can also be used, with a maximum of 2 courses from other academic programs. The Director of the ECE Department serves as advisor to students in this focus area and electives must be approved by the ECE Director.

Information Systems Management (ISM)

Rapid advancements in technology and dynamic markets and the changing business environment have created increased demand for professionals who can manage and deliver information systems. This demand has been accelerated by new competition, shorter product life cycles, and more complex and specialized markets.

- EM 301 Accounting and Business Analysis (Fall of junior year)
- ▶ EM 385 Innovative System Design (Spring of junior year)
- EM 360 Total Quality Management (Spring of senior year)

The mission of the Bachelor of Engineering in ISE (BEISE) Program is to provide an education based on a strong engineering core, complemented by studies in business, computer engineering, systems, and management, to provide systems professionals who can develop, lead, and evolve information resources partnering with corporate management. ISE graduates are prepared to work at the interface between engineering and management to design and build innovative new products and services which balance the rival requirements of competitive performance/cost and practical constraints imposed by available technologies.

The objectives of the BEISE program can be summarized as follows:

- ISE graduates have a strong general engineering foundation and are able to use modern technological tools while working on complex multidisciplinary problems.
- ► ISE graduates will have assumed leadership positions in their chosen areas of work using knowledge gained from their information systems education.
- ISE graduates effectively work in teams on projects to solve real-world problems. This effort can involve information research, the use of project management tools and techniques, and the economic justification of the solution that is effectively communicated in a written or oral project report/business proposal that is presented to the client.
- ▶ ISE graduates will be proficient in the systematic exploration of the design space to achieve optimized designs.
- ▶ ISE graduates possess the ethics, knowledge, skills, and attributes to define, design, develop, and manage resources, processes, and complex systems needed to work in a multidisciplinary team environment.
- ▶ ISE graduates will apply engineering and management skills and the tools to continue sustained intellectual growth in the corporate or academic world.

Minors

A student may qualify for a minor in Electrical Engineering or Computer Engineering by taking the required courses indicated below. Completion of a minor indicates proficiency beyond that provided by the Stevens curriculum in the basic material of the selected area. Enrollment in a minor program means that the student must also meet Stevens' requirements for minor programs.

Electrical Engineering

- CPE 390 Microprocessor Systems
- E 250 Math for Electrical Engineers
- EE 348 Systems Theory
- EE 448 Digital Signal Processing
- ▶ EE 465 Introduction to Communications
- ▶ EE 359 Electronic Circuits

Requirements for a Minor in Computer Engineering

- CPE 360 Computational Data Structures and Algorithms
- CPE 390 Microprocessor Systems

- CPE 462 Image Processing and Coding
- CPE 487 Digital Systems Design
- CPE 490 Information Systems Eng. I
- MA 134 Discrete Math

Requirements for a Minor in Media Engineering (for EE and CPE students)

- CPE462 Introduction to Image Processing and Coding
- CPE591 Introduction to Multimedia Networking
- Cloud computing, choose one of the following
 - CS524 Introduction to Cloud Computing
 - CS526 Enterprise & Cloud Computing
- CS546 Web Programming
- EM357 Elements of Operations Research
- SYS625 Fundamentals of Systems Engineering
- In addition to these six courses, students taking this Media Engineering minor are required to complete their senior design EE/CPE423-424 on a media engineering related topic.

GRADUATE PROGRAMS

The mission of the Department of Electrical and Computer Engineering is to provide students with the tools and skills necessary to understand and apply today's technologies and to become leaders in developing tomorrow's technologies and applications. To this end, programs have been developed to ensure that students receive both fundamental knowledge in basic concepts and an understanding of current and emerging/future technologies and applications.

The Electrical and Computer Engineering department offers the degrees of Master of Engineering - Electrical Engineering, Master of Science - Electrical Engineering, Master of Engineering - Computer Engineering, Master of Science - Computer Engineering, Master of Engineering - Information and Data Engineering, Master of Science - Information and Data Engineering, the degree of Electrical Engineer, and the degree of Computer Engineer. In addition, the degree of Doctor of Philosophy is offered in Electrical Engineering and in Computer Engineering.

The faculty engage in a variety of research efforts, such as telecommunications; data networks; information systems; wireless networks; including architectures and principles; signal processing; including communications applications; channel/signal estimation and detection; image processing and coding for images and video; multimedia systems and environments; computational system architectures, reconfigurable systems; secure data communications; network analysis and modeling; optical communication systems; and low-power mobile systems.

Master of Engineering- Electrical Engineering

In general, a bachelor's degree in electrical engineering or computer engineering with a minimum grade point average of 3.0 on a 4.0 scale is required for graduate study in electrical engineering. Outstanding applicants with degrees in other engineering disciplines, physics, or mathematics may be conditionally admitted subject to the completion of appropriate ramp courses or their equivalents with a grade of "B" or better. The specific requirements will be determined on an individual basis depending on the student's background. Submission of GRE scores is recommended, but not required.

The master's degree requires completion of a total of 30 hours of credit. Each student must complete the three core courses and must complete the course requirements for one of the electrical engineering concentrations. Elective courses are to be chosen from among the EE, CPE, and NIS numbered graduate courses in this catalog. An elective course not in the CPE, EE, or NIS numbered courses may be taken, with the approval of the student's academic advisor. A maximum of two elective courses not listed in the ECE program may be taken with the approval of the academic advisor.

Master of Science - Electrical Engineering

The Master of Science degree requires completion of a master's thesis. In the Master of Engineering degree, the completion of a master's thesis is optional. All other requirements are the same for the Master of Science and Master of Engineering degrees.

Electrical Engineering Core Courses

- ▶ EE 602 Analytical Methods in Electrical Engineering
- ▶ EE 603 Linear Systems Theory
- ▶ EE 605 Probability and Stochastic Processes I

Electrical Engineering Concentrations

Those students selecting one of the departmental concentration areas must complete a three-course concentration sequence appropriate for any one of the following concentration areas. Recommended courses are listed with each concentration. (Approval by the student's advisor is required to substitute another course for a listed course.)

Autonomous Robotics

Required:

- CPE 521 Autonomous Mobile Robotic Systems
- ▶ EE 631 Cooperating Autonomous Mobile Robots

Choose two from the following list with approval from an ECE advisor:

- CPE 555 Real-Time and Embedded Systems
- CPE 645 Image Processing and Computer Vision
- ▶ EE 583 Wireless Communications
- ▶ EE 621 Nonlinear Control

Computer Architectures and Digital Systems

- ▶ CPE 514 Computer Architecture
- CPE 643 Logic Design of Digital Systems I
- CPE 690 Introduction to VLSI Design

Embedded Systems

- CPE 555 Real-Time and Embedded Systems
- CPE 621 Analysis and Design of Real-Time Systems
- CPE 690 Introduction to VLSI Design
- EE 627 Data Acquisition and Processing I
- ▶ EE 623 Applied Machine Learning

Microelectronic Devices and Systems

- CPE 690 Introduction to VLSI Design
- ▶ EE 503 Introduction to Solid State Physics
- ▶ EE 619 Solid State Devices

Signal Processing for Communications

- ▶ EE 613 Digital Signal Processing for Communications
- ▶ EE 615 Multicarrier Communications
- ▶ EE 616 Signal Detection and Estimation for Communications
- EE 663 Digital Signal Processing I
- ▶ EE 664 Digital Signal Processing II

Telecommunications Systems Engineering

- CPE 655 Queuing Systems with Computer Applications I
- ▶ EE 606 Probability and Stochastic Processes II
- ▶ EE 609 Communication Theory
- ▶ EE 610 Error Control Coding for Networks
- ▶ EE 670 Information Theory and Coding

Wireless Communications

- ▶ EE 583 Wireless Communications
- ▶ EE 584 Wireless Systems Security
- ▶ EE 585 Physical Design of Wireless Systems
- ▶ EE 586 Wireless Networking: Architectures, Protocols, and Standards
- ▶ EE 651 Spread Spectrum and CDMA
- ▶ EE 653 Cross-Layer Design for Wireless Networks

Interdepartmental Concentration in Microelectronics and Photonics Science and Technology

Students selecting this concentration must complete the core course and three of the concentration's allowed elective courses listed below (see asterisk note).

Concentration Core Course

▶ EE 507 Introduction to Microelectronics and Photonics

Allowed Concentration Electives

- ▶ CPE 690 Introduction to VLSI Design*
- ▶ EE 585 Physical Design of Wireless Systems*
- ▶ EE 626 Optical Communication Systems*
- MT 562 Solid State Electronics II
- MT 595 Reliability and Failure of Solid State Devices

- MT 596 Microfabrication Techniques
- ▶ PEP 503 Introduction to Solid State Physics
- ▶ PEP 515 Photonics I
- ▶ PEP 516 Photonics II
- ▶ PEP 561 Solid State Electronics I
- * These courses do not count towards the Microelectronics and Photonics concentration for ECE students (they do count as electives for the full master's program).

For further information on recommended elective courses under each concentration, refer to the Computer Engineering graduate program brochure, the ECE Web page, or consult with an academic advisor.

Master of Engineering - Computer Engineering

In general, a bachelor's degree in electrical engineering or computer engineering with a minimum grade point average of 3.0 on a 4.0 scale is required for graduate study in computer engineering. Outstanding applicants in other areas may be conditionally admitted subject to the completion of appropriate ramp courses or their equivalents with a grade of "B" or better. The specific requirements will be determined on an individual basis depending upon the student's background. Submission of GRE scores is recommended, but not required.

The master's degree requires completion of a total of 30 hours of credit. Each student must complete the three core courses and must complete the course requirements for one of the computer engineering concentrations. Elective courses are to be chosen from among the CPE, EE, and NIS numbered graduate courses in this catalog. An elective course not in the CPE, EE, or NIS numbered courses may be taken, with the approval of the student's academic advisor. A maximum of two elective courses not listed in the ECE program may be taken with the approval of the academic advisor.

Master of Science - Computer Engineering

The Master of Science degree requires completion of a master's thesis. In the Master of Engineering degree, the completion of a master's thesis is optional. All other requirements are the same for the Master of Science and Master of Engineering degrees.

Computer Engineering Core Courses

- CPE 517 Computer and Digital Systems Architecture
- CPE 593 Applied Data Structures and Algorithms
- ▶ CPE 602 Applied Discrete Mathematics

Computer Engineering Concentrations

Each student must complete a three-course concentration sequence appropriate for any one of the following concentration areas. Recommended courses are listed with each concentration. A course used as a core course cannot be used also to satisfy the requirement for three courses in a concentration. (Approval by the student's advisor is required to substitute another course for a listed course.)

Computer Systems

- CPE 540 Fundamentals of Quantitative Software Engineering I
- CPE 644 Logical Design of Digital Systems II

- CPE 654 Design and Analysis of Network Systems
- ▶ EE 653 Cross-Layer Design for Wireless Networks

Data Communications and Networks

- CPE 565 Management of Local Area Networks
- CPE 654 Design and Analysis of Network Systems
- CPE 678 Information Networks I
- CPE 655 Queuing Systems with Computer Applications I
- ▶ EE 653 Cross-Layer Design for Wireless Networks
- ▶ NIS 584 Wireless Systems Security

Digital Systems Design

- CPE 621 Analysis and Design of Real-Time Systems
- CPE 644 Logical Design of Digital Systems II
- CPE 690 Introduction to VLSI Systems Design

Image Processing and Multimedia

- CPE 536 Integrated Services Multimedia
- ▶ CPE 558 Computer Vision
- CPE 591 Introduction to Multimedia Networking
- ▶ CPE 645 Image Processing and Computer Vision
- ▶ EE 612 Principles of Multimedia Compression

Information Systems

- CPE 536 Integrated Services Multimedia
- CPE 563 Networked Applications Engineering
- CPE 591 Introduction to Multimedia Networking
- ▶ CPE 645 Image Processing and Computer Vision
- NIS 584 Wireless Systems Security

Information Systems Security

- CPE 591 Introduction to Multimedia Networking
- CPE 668 Foundations of Cryptography
- CPE 678 Information Networks I
- ▶ CPE 691 Information Systems Security
- ▶ EE 584 Wireless Systems Security

Intelligent Systems

- ▶ CPE 645 Image Processing and Computer Vision
- CPE 646 Pattern Recognition and Classification

- ▶ EE 568 Software Defined Radio
- ▶ EE 647 Analog and Digital Control Theory
- CPE 623 Applied Machine Learning

Real-Time and Embedded Systems

Required:

- CPE 555 Real-Time and Embedded Systems
- CPE 690 Introduction to VLSI Design

Choose two from the following list:

- CPE 621 Analysis and Design of Real-Time Systems
- CPE 623 Applied Machine Learning
- CPE 643 Logical Design of Digital Systems
- ▶ CPE 645 Image Processing and Computer Vision

For further information on recommended elective courses under each concentration, refer to the Computer Engineering graduate program brochure, the ECE Web page, or consult with an academic advisor.

Master of Engineering - Information Data Engineering

In general, a bachelor's degree in electrical engineering or computer engineering (or a closely related discipline) with a minimum grade point average of 3.0 on a 4.0 scale is required for graduate study in Networked Information Systems. Outstanding applicants with degrees in other disciplines such as computer science, management, or mathematics may be admitted subject to demonstration of the technical background expected (perhaps with the requirement for completion of appropriate ramp courses or their equivalents with a grade of "B" or better). Such applicants, as well as applicants with significant career experiences but not satisfying the primary requirements, will be admitted on an individual basis depending on the student's background. Submission of GRE scores is recommended, but not required.

The master's degree requires completion of a total of 30 hours of credit. Each student must complete NIS 560 and two of the other five listed core courses and must complete the course requirements for one of the networked information systems concentrations. Elective courses are to be chosen from among the NIS, CPE, and EE numbered graduate courses in this catalog. Under special circumstances, an elective course not in the CPE, EE, or NIS numbered courses may be taken, with the approval of the student's academic advisor. A maximum of two elective courses not listed in the ECE program may be used for the master's degree with approval of the academic advisor.

Master of Science - Information Data Engineering

The Master of Science degree requires completion of a master's thesis. In the Master of Engineering degree, the completion of a master's thesis is optional. All other requirements are the same for the Master of Science and Master of Engineering degrees.

Information and Data Engineering Core Courses

- ▶ NIS 560 Introduction to Networked Information Systems
- NIS 565 Management of Local Area Networks
- ▶ NIS 604 Analytical Methods for Networks

Information and Data Engineering Concentrations

Each student must complete a three-course concentration sequence appropriate for any one of the following concentration areas. Recommended courses are listed with each concentration. A course used as a core course cannot be used also to satisfy the requirement for three courses in a concentration. (Approval by the student's advisor is required to substitute another course for a listed course.)

Data Communications and Networks

- NIS 611 Digital Communications Engineering I
- ▶ NIS 653 Cross-Layer Design for Wireless Networks
- ▶ NIS 654 Design and Analysis of Network Systems
- ▶ NIS 655 Queuing Systems with Communications Applications I
- NIS 678 Information Networks I

Information Networks

- ▶ NIS 654 Design and Analysis of Network Systems
- NIS 563 Networked Applications Engineering
- NIS 678 Information Networks I
- ▶ NIS 679 Information Networks II
- ▶ NIS 584 Wireless Systems Security

Multimedia Information Systems

- NIS 536 Integrated Services Multimedia
- NIS 561 Database Management Systems I
- ▶ NIS 583 Wireless Communications
- ▶ NIS 591 Introduction to Multimedia Networking
- ▶ NIS 645 Image Processing and Computer Vision

Multimedia Technologies

- ▶ NIS 536 Integrated Services Multimedia
- ▶ NIS 582 Multimedia Network Security
- ▶ NIS 612 Principles of Multimedia Compression
- ▶ NIS 645 Image Processing and Computer Vision

Networked Information Systems: Business Practices

- NIS 630 Enterprise Systems Management
- ▶ NIS 631 Management of Information Technology Organizations
- ▶ NIS 632 Strategic Management of Information Technology
- NIS 633 Integrating IS Technologies

Network Systems Technologies

- ▶ NIS 586 Wireless Communications: Architectures, Protocols, and Standards
- ▶ NIS 626 Optical Communication Systems
- ▶ NIS 674 Satellite Communications

Secure Network Systems Design

- ▶ NIS 560 Introduction to Networked Information Systems
- ▶ NIS 584 Wireless Systems Security
- NIS 592 Multimedia Network Security
- ▶ NIS 654 Design and Analysis of Network Systems
- ▶ NIS 691 Information Systems Security

For further information on recommended elective courses under each concentration, refer to the Networked Information Systems graduate program brochure, the ECE Web page, or consult with an academic advisor.

Interdisciplinary Programs

Integrated Product Development

The Integrated Product Development degree is an integrated Master of Engineering degree program. The core courses emphasize the design, manufacture, implementation, and life-cycle issues of engineering systems. The remaining courses provide a disciplinary focus. The program embraces and balances qualitative, as well as quantitative, aspects and utilizes state-of-the-art tools and methodologies. It aims to educate students in problem-solving methodologies, modeling, analysis, simulation, and technical management. The program trains engineers in relevant software applications and their productive deployment and integration in the workplace. For a detailed description of this program, please see the Interdisciplinary Programs section of this catalog.

Electrical and Computer Engineering Track

The track in Electrical and Computer Engineering emphasizes the major themes intrinsic to design, manufacture, and implementation of electronic systems, as well as the transmission of signals and information in a digital format, emergent hardware principles, software integration, and data manipulation algorithms. Mathematical principles underlie all aspects of engineered systems, and a solid background in such principles is emphasized. Today's systems also reflect an integration of several means of manipulating signals, ranging from traditional analog filters to advanced digital signal processing techniques. The three courses that are common to Electrical and Computer Engineering emphasize the above. The remaining three courses can be either in Electrical Engineering, which emphasizes core principles guiding the design, manufacture, and implementation of today's diverse set of electronic systems, or in Computer Engineering, which provides a background in the principles and practices related to data/information systems design and implementation.

- CPE 514 Computer Architectures
- CPE 643 Logical Design of Digital Systems I
- ▶ EE 585 Physical Design of Wireless Systems
- ▶ EE 605 Probability and Stochastic Processes I
- ▶ EE 602 Analytical Methods in Electrical Engineering
- ▶ EE 603 Linear Systems Theory

Doctoral Programs

Admission requirements to the Ph.D. program are naturally more stringent than those for the lesser degrees. More attention is paid to the student's background and potential to perform independent research. All applications are considered individually. In general, admissions are granted to students with a master's degree in electrical engineering or computer engineering who have achieved a minimum GPA of 3.5 on a 4.0 scale. Exceptional students may be accepted after receiving the bachelor's degree. Submission of GRE scores is recommended, but not required.

The Ph.D. degree requires 84 credits. A maximum of 30 credits can be applied toward the 84-credit requirement of the Ph.D. from a previous master's degree or from any other graduate courses subject to the approval of the advisor. All Ph.D. candidates must take at least 30 credits of thesis work and at least 20 credits of course work at Stevens beyond the master's degree. Courses counting towards the Ph.D. degree are expected to be taken from the ECE catalog courses (approval by the student's advisor is required to apply courses outside the ECE program to the Ph.D. degree).

All Ph.D. candidates must pass the written Ph.D. qualifying examination. Students may take the qualifying examination only twice. Failure to pass the qualifying examination in the second attempt will result in dismissal from the Ph.D. program.

After the student has successfully completed the qualifying examination, (s)he must arrange for an advisor to assist in the development of a thesis proposal. The advisor must be a full-time ECE professor or professor emeritus. Once a suitable topic has been found and agreed upon with the advisor, the student must prepare a thesis proposal. This thesis proposal should be completed and defended within one year of passing the Ph.D. qualifying examination. The proposal must indicate the direction that the thesis will take and procedures that will be used to initiate the research. Ordinarily, some preliminary results are included in the proposal. In addition, the proposal must indicate that the student is familiar with the research literature in his/her area. To this end, the proposal must include the results of a thorough literature search. A committee of at least three faculty members must accept the written thesis proposal. The committee chairperson is the thesis advisor. The other two members should be ECE department faculty. After the written proposal has been accepted, the examination committee conducts an oral defense. At this defense, the student presents his/her proposal.

All Ph.D. candidates who are working on a thesis must have a thesis committee chaired by the thesis advisor and consisting of at least four members. The thesis advisor and at least two other members must be full-time faculty members or professors emeritus of the ECE department. In addition, there must be one member who is a regular faculty member within another department at Stevens. It is permissible and desirable to have as a committee member a highly-qualified person from outside of Stevens. The committee must approve the completed thesis unanimously. After the thesis has been completed, it must be publicly defended.

Degree of Electrical Engineer and Degree of Computer Engineer

These programs provide opportunities for the student to proceed with professional development beyond the master's level. The course work may be directed toward depth in the area of the master's degree or toward depth in a new area related to that of the master's degree. A design project of significance is required.

To be admitted to the Electrical Engineer or Computer Engineer program, the student must have a master's degree in electrical engineering or computer engineering with a minimum grade point average of 3.0 on a 4.0 scale and the agreement of at least one regular faculty member in the department who expresses a willingness to serve as project advisor. Outstanding applicants with degrees in other disciplines may be admitted subject to demonstration of the technical background expected (perhaps with the requirement for completion of appropriate ramp courses or their equivalents with a grade of "B" or better). Such applicants, as well as applicants with significant career experiences but not satisfying the primary requirements, will be determined on an individual basis depending on the student's background.

At least 30 credits beyond the master's degree are required for the Engineer Degree. At least eight, but not more than fifteen, credits must be in the design project. The project courses for EE and CPE are EE 950 and CPE 950, respectively. An ECE

faculty advisor and at least two faculty members must supervise the project; one must be a regular member of the faculty in the ECE department. A written report and oral presentation are required.

Graduate Certificate Programs

The Department of Electrical and Computer Engineering offers several graduate certificate programs to students meeting the regular admission requirements for the master's program. Each graduate certificate is self-contained and highly focused, carrying 12 or more graduate credits. All of the courses may be used toward the master's degree, as well as for the graduate certificate.

Autonomous Robotics

Required:

- CPE 521 Autonomous Mobile Robotic Systems
- ▶ EE 631 Cooperating Autonomous Mobile Robots

Choose two from the following list with approval from an ECE advisor:

- CPE 555 Real-Time and Embedded Systems
- CPE 645 Image Processing and Computer Vision
- ▶ EE 583 Wireless Communications
- EE 621 Nonlinear Control

Digital Signal Processing

- EE 613 Digital Signal Processing for Communications
- ▶ EE 616 Signal Detection and Estimation for Communications
- EE 663 Digital Signal Processing I
- ▶ EE 666 Multidimensional Signal Processing

Digital Systems and VLSI Design

- ▶ CPE 514 Computer Architecture
- CPE 621 Analysis and Design of Real-Time Systems
- CPE 643 Logical Design of Digital Systems I
- CPE 644 Logical Design of Digital Systems II
- CPE 690 Introduction to VLSI Systems Design

Microelectronics

- ▶ EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- ▶ EE/MT/PEP 561 Solid State Electronics I
- EE/MT/PEP 562 Solid State Electronics II
- CPE/MT/PEP 690 Introduction to VLSI Design

Photonics

- ▶ EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- ▶ EE/MT/PEP 515 Photonics I
- ▶ EE/MT/PEP 516 Photonics II
- ▶ EE/MT/PEP 626 Optical Communication Systems

Multimedia Technology

- CPE 536 Integrated Services Multimedia
- CPE 592 Multimedia Network Security
- CPE 612 Principles of Multimedia Compression
- CPE 645 Image Processing and Computer Vision

Networked Information Systems

Required:

▶ NIS 560 Introduction to Networked Information Systems

Select three of the following courses:

- CPE 563 Networked Applications Engineering
- ▶ EE 584 Wireless Systems Security
- NIS 565 Management of Local Area Networks
- ▶ NIS 591 Introduction to Multimedia Networking
- NIS 678 Information Networks I
- ▶ NIS 691 Information Systems Security

Real-Time and Embedded Systems

Required:

- CPE 555 Real-Time and Embedded Systems
- ▶ CPE 690 Introduction to VLSI Design

Choose two from the following list:

- CPE 621 Analysis and Design of Real-Time Systems
- CPE 623 Applied Machine Learning
- CPE 643 Logical Design of Digital Systems
- ▶ CPE 645 Image Processing and Computer Vision

Secure Network Systems Design

Select four of the following courses:

- CPE 560 Introduction to Networked Information
- CPE 592 Multimedia Network Security
- CPE 654 Design and Analysis of Network Systems
- CPE 691 Information Systems Security
- ▶ EE 584 Wireless Systems Security

Software Design for Embedded and Information Systems

- CPE 545 Communication Software and Middleware
- CPE 555 Real-Time and Embedded Systems
- ▶ CPE 556 Computing Principles for Mobile and Embedded Systems
- ▶ NIS 593 Applied Data Structures & Algorithms
- ▶ CPE 640 Software Engineering I

Wireless Communications

▶ EE 583 Wireless Communications (required)

(Select 3 of the following courses)

- ▶ EE 584 Wireless Systems Security
- ▶ EE 585 Physical Design of Wireless Systems
- ▶ EE 586 Wireless Networking: Architectures, Protocols and Standards
- ▶ EE 651 CDMA and Spread Spectrum
- ▶ EE 653 Cross-Layer Design for Wireless Networks

COURSE OFFERINGS

Electrical Engineering

EE 321 Engineering Design V

This course will include both experimentation and open-ended design problems that are integrated with the Materials Processing course taught concurrently. Core design themes will be further developed.

EE 181 Seminar in Electrical Engineering

Introduction to electrical and computer engineering, addressing theoretical foundation, systems, and applications. Topics include information theory, control theory, power systems, wireless systems, information networks, sensor networks, and internet of things. Cross-listed with: CPE 181

EE 250 Mathematics for Electrical Engineers

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Introduction to logic, methods of proof, proof by induction and the pigeonhole principle with applications to logic design. Analytic functions of a complex variable, Cauchy-Riemann equations, Taylor series. Integration in the complex plane, Cauchy Integral formula, Liouville's theorem, maximum modulus theorem. Laurent series, residues, the residue theorem. Applications to system theory, Laplace transforms, and transmission lines. Prerequisites: MA 221

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EE 291 Supplemental Topics in Circuits and Systems I

Additional work for transfer students to cover topics omitted from Circuits and Systems courses taken elsewhere. This additional work is usually specified as completion of particular PSI modules.

EE 322 Engineering Design VI

This course addresses the general topic of selection, evaluation and design of a project concept, emphasizing the principles of team-based projects and the stages of project development. Techniques to acquire information related to the state-of-theart concepts and components impacting the project, evaluation of alternative approaches and selection of viable solutions based on appropriate cost factors, presentation of proposed projects at initial, intermediate and final stages of development and related design topics. Students are encouraged to use this experience to prepare for the senior design project courses. Prerequisites: E 321 Corequisites: EE 345

EE 333 Electronics & Instrumentation Lab

Experimental investigations of the characteristics of networks, and integrated electronics with application to analog and digital instrumentation and control. Students are required to design, breadboard and test their circuits.

EE 345 Modeling and Simulation

Development of deterministic and non-deterministic models for physical systems, engineering applications and simulation tools for deterministic and non-deterministic systems. Case studies and projects.

EE 348 Signals and Systems

An introduction to the mathematical methods used in the study of communications systems with practical applications. Discrete and fast Fourier transforms. Functions of a complex variable. Laplace and Z transforms. Prerequisites: E 245, and EE 250

EE 359 **Electronic Circuits**

Design of differential amplifiers using BJTs or FETs, design of output stages (class B and class AB), output and input impedance of differential amplifiers, frequency response. Feedback amplifiers, Nyquist criteria, Nyquist plots and root loci, bode plots, gain/phase margins and application in compensation for operational amplifiers, oscillators, tuned amplifiers and filters (passive and active). A suitable circuit analysis package is used for solving many of the problems. Prerequisites: Corequisites: E 232, and EE 250

EE 423 Engineering Design VII

Senior design course. The development of design skills and engineering judgment, based upon previous and current course and laboratory experience, is accomplished by participation in a design project. Projects are selected in areas of current interest such as communication and control systems, signal processing and hardware and software design for computerbased systems. To be taken during the student's last fall semester as an undergraduate student. Prerequisites: EE 322

EE 424 Engineering Design VIII

A continuation of EE 423 in which the design is implemented and demonstrated. This includes the completion of a prototype (hardware and/or software), testing and demonstrating performance and evaluating the results. To be taken during the student's last spring semester as an undergraduate student. Prerequisites: EE 423

EE 440 Current Topics in Electrical and Computer Engineering

This course consists of lectures designed to explore a topic of contemporary interest from the perspective of current research and development. In addition to lectures by the instructors and discussions led by students, the course includes talks by professionals working in the topic being studied. When appropriate, team-based design projects are included. Cross-listed with: CPE 440

EE 441 Introduction to Wireless Systems

Review of history, concepts, and technologies of wireless communications; explanations and mathematical models for analyzing and designing wireless systems; description of various wireless systems, including cellular systems, wireless local area networks, and satellite-based communication systems; and wireless design projects using Matlab, LabView, and software-defined radio. Cross-listed with: CPE 441

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EE 448 **Digital Signal Processing**

Introduction to the theory and design of digital signal processing systems. Include sampling, linear convolution, impulse response, and difference equations; discrete-time Fourier transform, DFT/FFT, circular convolution, and Z-transform; frequency response, magnitude, phase and group delays; ideal filters, linear-phase FIR filters, all-pass filters, minimumphase and inverse systems; digital processing of continuous-time signals. Prerequisites: EE 348

EE 465 Introduction to Communication Systems

Review of probability, random processes, signals and systems; continuous-wave modulation including AM, DSB-SC, SSB, FM and PM; superheterodyne receiver; noise analysis; pulse modulation including PAM, PPM, PDM and PCM; quantization and coding; delta modulation, linear prediction and DPCM; baseband digital transmission, matched filter and error rate analysis; passband digital transmission including ASK, PSK and FSK. Prerequisites: E 243, EE 348

Transport Phenomena in Solid State Devices EE 471

Introduction to the underlying phenomena and operation of solid state electronic, magnetic and optical devices essential in the functioning of computers, communications and other systems currently being designed by engineers and scientists. Charge carrier concentrations and their transport are analyzed from both microscopic and macroscopic viewpoints, carrier drift due to electric and magnetic fields in solid state devices is formulated and optical energy absorption and emission are related to the energy levels in solid-state materials. Diffusion, generation and recombination of charge carriers are combined with carrier drift to produce a continuity equation for the analysis of solid state devices. Explanations and models of the operation of PN, metal-oxide, metal-oxide-semiconductor and heterostructure junctions are used to describe diode, transistor, photodiode, laser, integrated circuit and other device operation. Prerequisites: E 232

EE 473 **Electromagnetic Fields**

Introduction to electromagnetic fields and applications. Vector calculus: orthogonal coordinates, gradient, divergence, curl, and Stokes' and divergence theorems. Electrostatics: charge, Coulomb's and Gauss' laws, potential, conductors and dielectrics, dipole fields, stored energy and power dissipation, resistance and capacitance, polarization, boundary conditions, and LaPlace's and Poisson's equations. Magnetostatics: Biot-Savart's and Ampere's laws, scalar and vector potentials, polarization, magnetic materials, stored energy, boundary conditions, inductance, magnetic circuits, and force. Time-dependent Maxwell's equations: displacement current, constitutive relations, isotropic and anisotropic media, force, boundary conditions, and the time-dependent Poynting vector and power. Circuit theory of transmission lines, transient response, and multiple reflections. Prerequisites: EE 250

EE 474 **Microwave Systems**

Complex scalars and vectors, sinusoidal steady-state, complex Maxwell's equations, and complex Poynting's theorem. Propagation of plane waves: complex vector wave equation, loss-less transmission line analogy, sinusoidal steady-state, frequency, wavelength and velocity, polarity, lossy media, radiation pressure, group velocity, and reflection and refraction. Snell's law, Brewster angle, field theory of transmission lines, TEM waves, sinusoidal steady-state transmission line theory, traveling and standing waves, Smith Chart, matching power flow, lossy lines, and circuit and field theory. Waveguides: TE and TM modes in general guides, propagation constant and wave impedance, separation of variables, rectangular and cylindrical guides, representation of wavelength fields by plane wave components, propagation and cutoff (evanescent) modes, the Poynting vector, dielectric guides, and losses. Waveguide resonators. Antennas: scalar and vector potentials, wave equations, spherical coordinates, electric and magnetic dipole antennas, and aperture antennas. Microwave electronics and traveling wave tubes. Prerequisites: EE 473

Advanced Communication Systems EE 475

Information theory and coding. Error control coding: CRCs, trellis codes, convolutional codes, and Viterbi decoding. Quantization and digitization of speech: PCM, ADPCM, DM, LPC, and VSELP algorithms. Carrier recovery and synchronization. Multiplexers: TDM and FDM hierarchies. Echo cancelers, equalizers, and scrambler/unscramblers. Spread spectrum communication systems. Mobile communications: digital cellular communication systems and PCS Encryption techniques. Introduction to computer communications networks. Prerequisites: EE 465

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observability and stability via state space methods, and pole placement and elements of state variable design for single-input single-output systems. Prerequisites: EE 348

EE 478

EE 480 **Optical Fiber Communication Systems**

Control Systems

Relevant characteristics of optical fibers, sources (LED and laser diodes), and photodetectors (PIN, APD) are introduced to provide the background for optical fiber communication system design. Subsystems design deals with optical transmitters, optical receivers, and optical components (switches, couplers, multiplexers, and demultiplexers). Optical fiber systems design and applications include long-haul optical transmission systems, local area networks, coherent optical communication, and future trends.

z-transform and Laplace transforms, time domain performance error of feedback systems, PID controller, frequency domain stability, including Nyquist stability in both analog and digital form, frequency domain performance criteria and design, such as via the gain and phase plots, state variable analysis of linear dynamical systems, elementary concepts of controllability,

EE 485 Research in Electrical Engineering I

Individual investigation of a substantive character taken at the undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. The student's thesis committee consists of the faculty advisor and one or more readers. Prior approval from the faculty advisor and the Department Director is required. Hours to be arranged with the faculty advisor. For information regarding a Degree with Thesis, see the "Academic Procedures, Requirements, and Advanced Degrees" section of this catalog.

EE 486 Research in Electrical Engineering II

Individual investigation of a substantive character taken at the undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. The student's thesis committee consists of the faculty advisor and one or more readers. Prior approval from the faculty advisor and the Department Director is required. Hours to be arranged with the faculty advisor. For information regarding a Degree with Thesis, see the "Academic Procedures, Requirements, and Advanced Degrees" section of this catalog.

EE 493 Data and Computer Communications

Introduction to information networks, data transmission and encoding; digital communication techniques, circuit switching and packet switching, OSI protocols, switched networks and LANs, introduction to ISDN and ATM/SONET networks, system architectures.

EE 503 Introduction to Solid State Physics

Description of simple physical models which account for electrical conductivity and thermal properties of solids. Basic crystal lattice structure, X-ray diffraction and dispersion curves for phonons and electrons in reciprocal space. Energy bands, Fermi surfaces, metals, insulators and semiconductors, superconductivity and ferromagnetism. Cross-listed with: PEP 503, MT 503, PEP 501

EE 507 Introduction to Microelectronics and Photonics

An overview of microelectronics and photonics science and technology. It provides the student who wishes to specialize in their application, physics or fabrication with the necessary knowledge of how the different aspects are interrelated. It is taught in three modules: design and applications, taught by EE faculty; operation of electronic and photonic devices, taught by Physics faculty; fabrication and reliability, taught by the materials faculty. Cross-listed with: MT 507, PEP 507

EE 509 Intermediate Waves and Optics

The general study of field phenomena; scattering and vector fields and waves; dispersion, phase, and group velocity; interference, diffraction, and polarization; coherence and correlation; and geometric and physical optics. Cross-listed with: PEP 509

EE 510 Introduction to Radar Systems

The radar equation for pulses, signal to noise ratio, target cross section, and antenna parameters; Doppler radar, CW radar, multifrequency CW radar, FM radar, and chirp radar; tracking and acquisition radar, radar wave propagation; transmitter and receiver design: and interference considerations.

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SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

(3 - 3 - 0)Introduction to the theory and design of linear feedback and control systems in both digital and analog form, review of

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media; magnetostatics; multipole expansion, electromagnetic energy, electromagnetic induction, Maxwell's equations, electromagnetic waves, waves in bounded regions, wave equations and retarded solutions, simple dipole antenna radiation theory, and transformation law of electromagnetic fields. Spring semester. Typical text: Reitz, Milford and Christy, Foundation of Electromagnetic Theory. Cross-listed with: PEP 542

Digital Signal Processing EE 548

Review of mathematics of signals and systems including sampling theorem, Fourier transform, z-transform, Hilbert transform; algorithms for fast computation: DFT, DCT computation, convolution; filter design techniques: FIR and IIR filter design, time and frequency domain methods, window method and other approximation theory based methods; structures for realization of discrete time systems: direct form, parallel form, lattice structure and other state-space canonical forms (e.g., orthogonal filters and related structures); roundoff and quantization effects in digital filters: analysis of sensitivity to coefficient quantization, limit cycle in IIR filters, scaling to prevent overflow, role of special structures. Cross-listed with: CPE 548

EE 556 Computing Principles for Mobile and Embedded Systems

Embedded systems have emerged as a primary application area, highlighting the co-integration of application-specific hardware components with programmable, flexible, adaptable, and versatile software components. Such systems have been one of the drivers of important new computing principles that play an important role in achieving optimal performance of the overall system. This course will provide the student with a background in these new computing principles and their application to embedded systems. Representative topics include emerging computing paradigms in the areas of contextaware pervasive systems, spatio-temporal access control with distributed software agents, vehicular computing, information systems cryptography, trust and privacy in mobile environments, location-aware services, RFID systems, wireless medical networks, and urban sensing. Cross-listed with: CPE 556

SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

This course will cover topics encompassing the fundamental subject matter for the design of optical systems. Topics will include optical system analysis, optical instrument analysis, applications of thin-film coatings and opto-mechanical system design in the first term. The second term will cover the subjects of photometry and radiometry, spectrographic and spectrophotometric systems, infrared radiation measurement and instrumentation, lasers in optical systems and photonelectron conversion. Cross-listed with: PEP 515, MT 515 Prerequisites: EE 509

EE 516 Photonics II

Photonics I

EE 515

This course will cover topics encompassing the fundamental subject matter for the design of optical systems. Topics will include optical system analysis, optical instrument analysis, applications of thin-film coatings and opto-mechanical system design in the first term. The second term will cover the subjects of photometry and radiometry, spectrographic and spectrophotometric systems, infrared radiation measurement and instrumentation, lasers in optical systems and photonelectron conversion. Cross-listed with: PEP 516, MT 516 Prerequisites: EE 509 or PEP 509 or PEP 209

EE 517 **Digital and Computer Systems Architecture**

This course covers the design and architecture of computer and digital systems in the system design region starting from the transistor/logic gate level to below the device driver level/system monitor level. The systems considered in the course will go beyond the computer chips or CPUs discussed in a typical computer architecture course, but will include complex logic devices such as application specific integrated circuits (ASICs), the core-designs for field programmable gate arrays (FPGAs), system-on-a-chip (SoC) designs, ARM, and other application-specific architectures. Printed circuit board-level architectural considerations for multiple complex digital circuits will also be discussed. Cross-listed with: CPE 517

EE 541 Physics of Gas Discharges

Charged particle motion in electric and magnetic fields; electron and ion emission; ion-surface interaction; electrical breakdown in gases; dark discharges and DC glow discharges; confined discharge; AC, RF, and microwave discharges; arc discharges, sparks, and corona discharges; non-thermal gas discharges at atmospheric pressure; and discharge and lowtemperature plasma generation. Typical texts: J.R. Roth, Industrial Plasma Engineering: Principles, Vol. 1 and Y.P. Raizer, Gas discharge Physics. Cross-listed with: PEP 541

EE 542 Electromagnetism

Electrostatics; Coulomb-Gauss law; Poisson-Laplace equations; boundary value problems; image techniques, and dielectric

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EE 560 Fundamentals of Remote Sensing

This course exposes the student to the physical principles underlying remote sensing of ocean, atmosphere, and land by electromagnetic and acoustic passive and active sensors: radars, lidars, infrared and microwaves thermal sensors, sonars, sodars, infrasound/seismic detectors. Topics include fundamental concepts of electromagnetic and acoustic wave interactions with oceanic, atmospheric, and land environment, as well as with natural and man-made objects. Examples from selected sensors will be used to illustrate the information extraction process, and applications of the data for environmental monitoring, oceanography, meteorology, and security/military objectives. Cross-listed with: OE 560, EN 560, CE 561, PEP 560 Prerequisites: PEP 201, PEP 112, E 246

EE 561Solid State Electronics for Engineering I(3 - 3 - 0)

This course introduces fundamentals of semiconductors and basic building blocks of semiconductor devices that are necessary for understanding semiconductor device operations. It is for first-year graduate students and upper-class undergraduate students in electrical engineering, applied physics, engineering physics, optical engineering and materials engineering who have no previous exposure to solid state physics and semiconductor devices. Topics covered will include description of crystal structures and bonding; introduction to statistical description of electron gas; free-electron theory of metals; motion of electrons in periodic lattice-energy bands; Fermi levels; semiconductors and insulators; electrons and holes in semiconductors; impurity effects; generation and recombination; mobility and other electrical properties of semiconductors; thermal and optical properties; p-n junctions; metal-semiconductor contacts. Cross-listed with: PEP 561, MT 561

EE 562 Solid State Electronics for Engineering II

This course introduces operating principles and develops models of modern semiconductor devices that are useful in the analysis and design of integrated circuits. Topics covered include: charge carrier transport in semiconductors; diffusion and drift; injection and lifetime; p-n junction devices; bipolar junction transistors; metal-oxide-semiconductor field effect transistors and high electron mobility transistors; microwave devices; light-emitting diodes, semiconductor lasers, and photodetectors; and integrated devices. Cross-listed with: MT 562, PEP 562

EE 568 Software-Defined Radio

This course offers an introduction to software-defined radios, devices that can be programmed to work with a variety of different radios. The course covers the following topics: software radio architectures, existing software radio efforts, a review of basic receiver design principles, and application to software radios. Basic questions, design tradeoffs, and architectural issues are also discussed. Several case studies of software radios will be discussed throughout the course.

EE 575 Introduction to Control Theory

An introduction to classic and modern feedback control that does not presume an undergraduate background in control. Transfer function and state space modeling of linear dynamic systems, closed-loop response, root locus, proportional, integral, and derivative control, compensators, controllability, observability, pole placement, linear–quadratic cost controllers, and Lyapunov stability. MATLAB simulations in control system design.

EE 583 Wireless Communications

This courses serves as a broad introduction to the several technologies and applications of wireless communications systems. The emphasis is on providing a reasonable mixture of information leading to a broad understanding of the technical issues involved, with modest depth in each of the topics. As an integrating course, the topics range from the physics of wave generation/propagation/reception through the circuit/component issues, to the signal processing concepts, to the techniques used to impress the information (voice or data) on a wireless channel, to overviews of representative applications including current generation systems and next generation systems. Upon completion of this course, the student shall understand the manner in which the more detailed information in the other three courses is integrated to create a complete system. Cross-listed with: NIS 583

EE 584 Wireless Systems Security

Wireless systems and their unique vulnerabilities to attack; system security issues in the context of wireless systems, including satellite, terrestrial microwave, military tactical communications, public safety, cellular and wireless LAN networks; security topics: confidentiality/privacy, integrity, availability and control of fraudulent usage of networks. Issues addressed include jamming, interception and means to avoid them. Case studies and student projects are important components of the course. Cross-listed with: NIS 584, TM 584



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EE 585 Physical Design of Wireless Systems

Physical design of wireless communication systems, emphasizing present and next generation architectures. Impact of non-linear components on performance; noise sources and effects; interference; optimization of receiver and transmitter architectures; individual components (LNAs, power amplifiers, mixers, filters, VCOs, phase-locked loops, frequency synthesizers, etc.); digital signal processing for adaptable architectures; analog-digital converters; new component technologies (SiGe, MEMS, etc.); specifications of component performance; reconfigurability and the role of digital signal processing in future generation architectures; direct conversion; RF packaging; minimization of power dissipation in receivers. Cross-listed with: MT 585, PEP 585, PEP 685

EE 586Wireless Networking: Architecture, Protocols and Standards(3 - 0 - 0)

This course addresses the fundamentals of wireless networking, including architectures, protocols and standards. It describes concepts, technology and applications of wireless networking as used in current and next-generation wireless networks. It explains the engineering aspects of network functions and designs. Issues such as mobility management, wireless enterprise networks, GSM, network signaling, WAP, mobile IP and 3G systems are covered. Cross-listed with: NIS 586, TM 586

EE 587 Microwave Engineering I

A study of microwave techniques at both the component and system level. Topics include wave propagation and transmission, uniform and non-uniform transmission lines, rectangular and circular waveguide, losses, microstrip, waveguide excitation, modal expansion of waveguide fields, perturbation theory, ferrites, scattering parameters for lumped and distributed systems, general theory of microwave junctions waveguide components including tee's, circulators, isolators, phase shifters, splitters, and directional couplers.

EE 588 Microwave Engineering II

A more advanced treatment of microwave systems. Topics include coupled mode theory, periodic structures, cavities, cavity excitation and perturbation, circuit representations, broadband matching, microwave filter theory, antenna theory, including various types of wire antennas, horns, dishes, antenna arrays, phased arrays, sources, detectors, modulators, limiters, optical-microwave interaction, and microwave signal processing. Topics may vary to accommodate specific interests.

EE 589 Introduction to Power Engineering

Electric power systems provide the essential infrastructure upon which the modern industrial society is built. This course deals with the fundamental concepts in Power Systems. Topics covered will describe how electrical power is created, transmitted, and effectively used, including generators, transmission lines, transformers, and protection devices.

EE 590 Smart Grid

The course will cover the evolution of the smart grid, overview of energy production, the role of telecommunication technologies in efficient transmission, self healing networks that can withstand a failure in its transmission paths, flow of electricity in the system through intelligent metering and sensors networks, which are the true enablers of smart grid. The course will also explain risks to smart grid and protective measures to ensure system integrity while supplying energy at greater reliability and economy.

EE 595 Reliability and Failure of Solid State Devices

This course deals with the electrical, chemical, environmental and mechanical driving forces that compromise the integrity and lead to the failure of electronic materials and devices. Both chip and packaging level failures will be modeled physically and quantified statistically in terms of standard reliability mathematics. On the packaging level, thermal stresses, solder creep, fatigue and fracture, contact relaxation, corrosion and environmental degradation will be treated. Cross-listed with: MT 595, PEP 595 Prerequisites: EE 507, PEP 507 MT 507

EE 596 Micro-Fabrication Techniques

Deals with aspects of the technology of processing procedures involved in the fabrication of microelectronic devices and microelectromechanical systems (MEMS). Students will become familiar with various fabrication techniques used for discrete devices as well as large-scale integrated thin-film circuits. Students will also learn that MEMS are sensors and actuators that are designed using different areas of engineering disciplines and they are constructed using a microlithographically-based manufacturing process in conjunction with both semiconductor and micromachining microfabrication technologies. Cross-listed with: MT 596, PEP 596, NANO 596 Prerequisites: PEP 507, PEP 501, MT 501, EE 507 Corequisites: EE 507, MT 507, PEP 507, PEP 501, MT 501

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EE 599 Curricular Practical Training

This course involves an educationally relevant practical industry project experience that augments the academic content of the student's program. Students engage in a project in industry that is relevant to the focus of their academic program. This project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit a final written report, and present a summary of his/her activities by means of a powerpoint presentation that will both be graded. This is a one-credit course that may be repeated up to a total of three credits.

EE 602 Analytical Methods in Electrical Engineering

The theory of linear algebra with application to state space analysis. Topics include Cauchy-Binet and Laplace determinant theorems, system of linear equations; linear transformations, basis and rank; Gaussian elimination; LU and congruent transformations; Gramm-Schmidt; eigenvalues, eigenvectors and similarity transformations; canonical forms; functions of matrices; singular value decomposition; generalized inverses; norm of a matrix; polynomial matrices; matrix differential equations; state space; controllability and observability.

EE 603 Linear System Theory

Fourier transforms; distribution theory; Gibbs phenomena; Shannon sampling; Poisson sums; discrete and fast Fourier transforms; Laplace transforms; z-transforms; the uncertainty principle; Hilbert transforms; computation of inverse transforms by contour integration; stability and realization theory of linear, time invariant, continuous and discrete systems.

EE 605 Probability and Stochastic Processes I

Axioms of probability; discrete and continuous random vectors; functions of random variables; expectations, moments, characteristic functions, and momentgenerating functions; inequalities, convergence concepts, and limit theorems; central limit theorem; and characterization of simple stochastic processes: widesense stationality and ergodicity. Cross-listed with: NIS 605, CS 505

EE 606 Probability and Stochastic Processes II

Introduction and review of probability as a measure, measure theoretic notions of random variables and stochastic processes, discrete time and continuous time Markov chains, renewal processes, delayed renewal processes, convergence of random sequences, martingale processes, stationarity and ergodicity. Applications of these topics with examples from networked communications, wireless communications, statistical signal processing and game theory.

EE 608 Applied Modeling and Optimization

Engineering, computational science and business students tackle various kinds of real-life optimization problems occurring in areas such as information theory, wireless communications, VLSI design, design and analysis of networks, optimal decision making etc. This course will provide a comprehensive coverage of several aspects of applied modeling and optimization. Complexity issues and numerical techniques (classical and non-classical techniques) to solve optimization problems will be the main thrust. Example problems arising in electrical engineering, computer engineering and business will be extensively used to illustrate the different optimization algorithms. This course will be computer projects based. Software packages such as MAPLE, MATLAB, CPLEX etc. will be used. Cross-listed with: NIS 608

EE 609 Communication Theory

Review of probability theory with applications to digital communications, digital modulation techniques, receiver design, bit error rate calculations, bandwidth efficiency calculations, convolutional encoding, bandwidth efficient coded modulation, wireless fading channel models, and shannon capacity, software simulation of communication systems. Cross-listed with: NIS 609

EE 610 Error Control Coding for Networks

Error-control mechanisms; Elements of algebra; Linear block codes; Linear cyclic codes; fundamentals of convolutional codes; Viterbi decoding codes in mobile communications; Trellis-coded modulation; concatenated coding systems and turbo codes; BCH codes; Reed-Solomon codes; implementation architectures and applications of RS codes; ARQ and interleaving techniques. Cross-listed with: NIS 610

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EE 611 Digital Communications Engineering

Waveform characterization and modeling of speech/image sources; quantization of signals; uniform, nonuniform and adaptive quantizing; Pulse Code Modulation (PCM) systems; Differential PCM (DPCM); linear prediction theory, adaptive prediction; Deltamodulation and sigma-delta modulation systems; subband coding with emphasis on speech coding; data compression methods like Huffman coding, Ziv-Lempel coding and run length coding. Cross-listed with: NIS 611

EE 612 Principles of Multimedia Compression

Brief introduction to Information Theory; entropy and rate; Kraft-McMillan inequality; entropy codes - Huffman and arithmetic codes; scalar quantization-quantizer design issues, the Lloyd quantizer and the Lloyd-Max quantizer; vector quantization - LBG algorithm, other quantizer design algorithms; structured VQs; entropy constrained quantization; bit allocation techniques: generalized BFOS algorithm; brief overview of linear algebra; transform coding: KLT, DCT, LOT; subband coding; wavelets; wavelet based compression algorithms (third generation image compression schemes)- EZW algorithm, the SPIHT algorithm and the EBCOT algorithm; video compression: motion estimation and compensation; image and video coding standards: JPEG/ JPEG 2000, MPEG, H.263, H.263+; Source coding and error resilience. Cross-listed with: NIS 612

EE 613 Digital Signal Processing for Communications

This course teaches digital signal processing techniques for wireless communications. It consists of two parts. Part 1 covers basic DSP fundamentals, such as DFT, FFT, IIR and FIR filters and DSP algorithms (ZF, ML, MMSE). Part 2 covers DSP applications in wireless communications. Various physical layer issues in wireless communications are addressed, including channel estimation, adaptive equalization, synchronization, interference cancellation, OFDM, multi-user detection and rake receiver in CDMA, space-time coding and smart antennae.

EE 615OFDM and Multicarrier Communications(3 - 0 - 0)

This course reviews multicarrier modulation (MCM) methods which offer several advantages over conventional single carrier systems for broadband data transmission. Topics include fundamentals of MCM, where the data stream is divided into several parallel bit streams, each of which has a much lower bit rate, to exploit multipath diversity and practical applications. It will cover new advances, as well as the present core technology. Hands-on learning with computer-based approaches will include simulation in MATLAB and state-of-the-art high level software packages to design and implement modulation, filtering, synchronization, and demodulation.

EE 616Signal Detection and Estimation for Communications(3 - 3 - 0)

Introduction to signal detection and estimation principles with applications in wireless communication systems. Topics include optimum signal detection rules for simple and composite hypothesis tests, Chernoff bound and asymptotic relative efficiency, sequential detection and nonparametric detection; optimum estimation including Bayesian estimation and maximum likelihood, Fisher information and Cramer-Rao bound, linear estimation, least squares and weight least squares.

EE 617 Statistical Signal Processing

Mathematical modeling of signal processing; Wiener-Kalman filters, LP, and LMS methods; estimation and detection covering minimum-variance-unbiased (MVUB) and maximum likelihood (ML) estimators, Cramer-Rao bound, Bayes and Neyman-Pearson detectors, and CFAR detectors; methods of least squares (LS): batch mode, weighted LS, total LS (TLS), and recursive LS (RLS); SVD and high resolution spectral estimation methods including MUSIC, modified FBLP, and Min-Norm; higher order spectral analysis (HOSA) with applications of current interest; PDA and JPDA data association trackers with MultiDATTM; and applied computer projects on major topics.

EE 619 Solid State Devices

Operating principle, modeling and fabrication of solid state devices for modern optical and electronic system implementation; recent developments in solid state devices and integrated circuits; devices covered include bipolar and MOS diodes and transistors, MESFET, MOSFET transistors, tunnel, IMPATT and BARITT diodes, transferred electron devices, light emitting diodes, semiconductor injection and quantum-well lasers, PIN and avalanche photodetectors. Cross-listed with: PEP 619 Prerequisites: EE 503, MT 503 PEP 503

EE 620 Reliability Engineering

Combinatorial reliability including series, parallel, cascade, and multistage networks; Markov, Weibull, and exponential failure models; redundancy; repairability; marginal and catastrophic failures; and parameter estimation.

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EE 621 Nonlinear Control

Methods for analysis and design of nonlinear control systems emphasizing Lyapunov theory. Second order systems, phase plane descriptions of ononlinerar phenomena, limit cycles, stability, direct and indirect method of Lyapunov, linearization, feedback linearization, Lyapunov-based design, and backstepping.

EE 626 **Optical Communication Systems**

Components for and design of optical communication systems; propagation of optical signals in single mode and multimode optical fibers; optical sources and photodetectors; optical modulators and multiplexers; optical communication systems: coherent modulators, optical fiber amplifiers and repeaters; transcontinental and transoceanic optical telecommunication system design; optical fiber LANs. Cross-listed with: NIS 626, MT 626, PEP 626

EE 627 Data Acquisition and Processing III

The application of electronic principles and analog and digital integrated circuits to the design of industrial and scientific instrumentation, process control, and robotics and automation. Topics include sensors and transducers, analog and digital signal conditioning and processing, data conversion, data transmission and interface standards, machine vision, control, and display. Microcomputers, microprocessors, and their support components are applied as system elements.

EE 628 Data Acquisition and Processing II

The application of electronic principles and analog and digital integrated circuits to the design of industrial and scientific instrumentation, process control, and robotics and automation. Topics include sensors and transducers, analog and digital signal conditioning and processing, data conversion, data transmission and interface standards, machine vision, control, and display. Microcomputers, microprocessors, and their support components are applied as system elements.

EE 631 Cooperating Autonomous Mobile Robots

Advanced topics in autonomous and intelligent mobile robots, with emphasis on planning algorithms and cooperative control. Robot kinematics, path and motion planning, formation strategies, cooperative rules, and behaviors. The application of cooperative control spans from natural phenomena of groupings, such as fish schools, bird flocks, and deer herds, to engineering systems such as mobile sensing networks and vehicle platoon. Cross-listed with: NIS 651

EE 647 Analog and Digital Control Theory

State space description of linear dynamical systems; canonical forms; solutions of state equations; controllability, observability, and minimality; Lyapunov stability; pole placement; asymptotic observer and compensator design and quadratic regulator theory; extensions to multivariable systems; matrix fraction description approach; and elements of time-varying systems.

EE 651 Spread Spectrum and CDMA

Basic concepts, models and techniques; direct sequence frequency hopping, time hopping, chirp and hybrid systems, jamming game, anti-jam systems, analysis of coherent and non-coherent systems; synchronization and demodulation; multiple access systems; ranging and tracking; pseudo-noise generators. Cross-listed with: NIS 651

EE 653 Cross-Layer Design for Wireless Networks

Introduction to wireless networks and layered architecture, principles of cross-layer design, impact of cross-layer interactions for different architectures: cellular and ad hoc networks, model abstractions for layers in cross-layer design for different architectures (cellular and ad hoc networks), quality of service (QoS) provisioning at different layers of the protocol stack with emphasis on physical layer, medium access control (MAC) and network layers, examples of cross-layer design in the literature: joint optimizations involving beamforming, interference cancellation techniques, MAC protocols, admission control, power control, routing and adaptive modulation. Cross-listed with: NIS 653

EE 663 Digital Signal Processing I

Review of mathematics of signals and systems including sampling theorem, Fourier transform, z-transform, Hilbert transform; algorithms for fast computation: DFT, DCT computation, convolution; filter design techniques: FIR and IIR filter design, time and frequency domain methods, window method and other approximation theory based methods; structures for realization of discrete time systems: direct form, parallel form, lattice structure and other state-space canonical forms (e.g., orthogonal filters and related structures); roundoff and quantization effects in digital filters: analysis of sensitivity to coefficient quantization, limit cycle in IIR filters, scaling to prevent overflow, role of special structures.

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Advanced Digital Signal Processing

Implementation of digital filters in high speed architectures; multirate signal processing: Linear periodically time varying systems, decimators and expanders, filter banks, interfacing digital systems operating at multiple rates, elements of subband coding and wavelet transforms; signal recovery from partial data: from zero crossing, level crossing, phase only, magnitude only data; elements of spectral estimation: MA, R & ARMA models. lattice, Burg methods, MEM.

EE 666 Multidimensional Signal Processing

EE 664

Mathematics of multidimensional (MD) signals and systems; frequency and state space description of MD systems; multidimensional FFT; MD recursive and nonrecursive filters, velocity and isotropic filters, their stability and design; MD spectral estimation with applications in array processing; MD signal recovery from partial information such as magnitude, phase, level crossing etc.; MD subband coding for image compression; selected topics from computer aided tomography and synthetic aperture radar.

EE 670 Information Theory and Coding

An introduction to information theory methods used in the analysis and design of communication systems. Typical topics include: entropy, relative entropy and mutual information; the asymptotic equipartition property; entropy rates of stochastic process; data compression; Kolmogorov complexity; channel capacity; differential entropy; the Gaussian channel; maximum entropy and mutual information; rate distortion theory; network information theory; algebraic codes.

EE 672 Game Theory for Wireless Networks

Part I: Introduction to game theory: games in strategic form and Nash equilibrium, Existence and properties of Nash equilibrium, Pareto efficiency, Extensive form games, repeated games, Bayesian games and Bayesian equilibrium, types of games and equilibrium properties, learning in games. Part II: Applications for wireless networks: resource allocation, enforcing cooperation in ad hoc networks, cognitive radios. Cross-listed with: NIS 672

EE 673 Wireless Communications

Introduction to wireless communication systems; the concept of frequency reuse; basic planning of a cellular system, elements of cellular radio design system; propagation characteristics of cellular radio channels; frequency management, channel allocation and handoff mechanisms; specifications of digital cellular systems in USA and Europe; Spread spectrum cellular communications; elements of cordless communication systems.

EE 674 Satellite Communications

Overview of communication theory, modulation techniques, conventional multiple access schemes, and SS/TDMA; satellite and frequency allocation, analysis of satellite link, and identification of the parameters necessary for the link calculation; modulation and coding; digital modulation methods and their comparison; error correction coding for the satellite channel, including Viterbi decoding and system performance; synchronization methods and carrier recovery; and effects of impairment on the channel.

EE 681 Fourier Optics

An introduction to two-dimensional linear systems, scalar diffraction theory, and Fresnel and Fraunhofer diffraction. Applications of diffraction theory to thin lenses, optical imaging systems, spatial filtering, optical information processing, and holography.

EE 683 Wireless Systems Overview

This courses serves as a broad introduction to the several technologies and applications of wireless communications systems. The emphasis is on providing a reasonable mixture of information leading to a broad understanding of the technical issues involved, with modest depth in each of the topics. As an integrating course, the topics range from the physics of wave generation/propagation/reception through the circuit/component issues, to the signal processing concepts, to the techniques used to impress the information (voice or data) on a wireless channel, to overviews of representative applications including current generation systems and next generation systems. Upon completion of this course, the student shall understand the manner in which the more detailed information in the other three courses is integrated to create a complete system.

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EE 684 Spread Spectrum and CDMA

Provides depth in the several topics related to signal processing and data processing that appear within wireless communications systems. The treatment is mathematical, providing depth in the analytic formulations and analysis techniques. Digital signal processing techniques will be given particular emphasis, recognizing their considerable influence on present and emerging designs. However, these digital signal processing techniques will be supplemented by analog signal processing techniques will be supplemented by analog signal processing techniques, which continue to be important for front-ends of receivers (and will remain important as carrier frequencies continue to migrate to higher frequencies). In addition to covering the mathematical principles of digital and analog signal processing, the course will cover contemporary digital signal processors. The data processing issue arises in the coding of data for improved communications performance. Compression algorithms, reducing the amount of data that must be transmitted, coding techniques to provide error detection/protection, and encryption techniques to improve security are representative examples of data processing.

EE 685 Physical Design of Wireless Systems

The emphasis will be on the design of the transmitter and receiver sections of a wireless system, but antenna design will also be covered to provide an understanding of the techniques used to achieve directional and steerable antennas when appropriate for the given wireless system. The wide range of carrier frequencies seen in wireless systems leads to a variety of semiconductor and other technologies being required at different carrier frequencies. In addition, the bandwidth of the signal leads to substantially different issues arising in the packaging used for the transmitter and receiver ends. For lower carrier frequencies, advanced silicon IC technologies are preferred, given the maturity of the technology and the considerable density of both analog and digital circuitry that can be integrated on a single IC. At higher frequencies, the limits of contemporary silicon technologies are encountered, leading to use of specialized semiconductor technologies such as GaAs and SiGe circuits. In addition, the difficulty of realizing high accuracy analog/digital conversions at multi-GHz frequencies leads to a preference, at this time, for analog for analog circuitry at the higher frequencies. On the other hand, analog/digital conversions are becoming possible at sufficiently high sampling rates that digital processing is being strongly pursued directly at the front end of a receiver, allowing a variety of new techniques to be considered for the overall receiver design. In cases where front-end digital signal processing cannot be achieved, such digital processing is increasingly used at intermediate frequencies (i.e., the IF section). In the case of data communications, digital techniques are almost certainly used at baseband, for example to separate the data signal from the received analog signal, to perform data decoding, etc. The course will include material related to contemporary digital signal processor technologies, supplementing the discussions in Course 2 by considering in greater depth the physical design and performance limitations of technologies and architectures.

EE 686High-Level Operation, Performance, Standards, and
Control of Wireless Communications Systems(3 - 3 - 0)

Provides the student with depth in the overall understanding of the high-level definition and operation of a contemporary wireless system. Since many wireless systems involve connections among hardware developed by different commercial manufacturers, national and international standards play a major role in the evolution of wireless systems. Earlier first generation systems evolved to today's second generation systems, with third generation systems expected shortly. One component of this course relates to these important standards. There are several fundamentally different wireless systems applications simultaneously evolving. Some relate to personal communications services (e.g., cellular telephony, wireless modems, etc.). Others relate to LANs, implemented in wireless rather than wired technologies to allow mobility or ease of access but providing data rates competitive with wired systems. Satellite communications systems (e.g., the Iridium system) are emerging and promise to provide a particularly interesting means of extending communication services. GPS systems provide an important means of determining one's position to high accuracy. Digital and software radios exploit the familiar concept of radio transmissions to provide digital information (and draw upon channel assignment schemes related to the radio metaphor). In addition to the commercial development of separate (and non-integrated) wireless systems of the various types above, there are important military applications. Upon completion of this course, the student will have depth of understanding in the high-level, systems-oriented view of wireless systems.

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SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

EE 689 Applied Antenna Theory

Brief review of electromagnetic theory; Maxwell's equations; the wave equations; plane waves and spherical waves; explanation of phenomenon of radiation; the incremental dipole antenna; dipole antennas including half-wave dipole and grounded monopole. Linear-antenna arrays such as Yagi-Uda array and log-periodic array. Radiation from an aperture such as rectangular and circular apertures. Prime-focus fed paraboloidal reflector antennas; far-field patterns, directivity, effects of scanning and effects of random surface imperfections. Shaped-reflector paraboloidal reflector antennas, Cassegrain and Gregorian paraboloidal antennas. Offset para-boloidal reflectors, spherical reflectors. Tracking antennas, types of monopulse patterns, antenna noise, concept of G/T.

EE 690 Introduction to VLSI Design

This course introduces students to the principles and design techniques of Very Large Scale Integrated Circuits (VLSI). Topics include: MOS transistor characteristics, DC analysis, resistance, capacitance models, transient analysis, propagation delay, power dissipation, CMOS logic design, transistor sizing, layout methodologies, clocking schemes, case studies. Students will use VLSI CAD tools for layout, and simulation. Selected class projects may be sent for fabrication. Cross-listed with: MT 690, **PEP 690**

EE 693 Heterogeneous Computing Architecture and Hardware (3 - 3 - 0)

This course presents tools, techniques and algorithms to accelerate compute intensive applications, via a combination of computing devices such as the GPU, FPGA and multi-core CPU on a heterogeneous platform. Computationally intensive problems present various challenges in terms of tasks with different characteristics and features. With the exponential growth of data from sensors, biological sequencing, financial transactions, multimedia and user generated content; there is a strong need to accelerate the processing involved at various levels. Such applications benefit highly from heterogeneous computing architecture. The basics of GPU architecture, programming tools, such as CUDA and OpenCL, real-world applications that benefit from GPU computing will be presented. This is followed by the techniques for multi-core CPU programming, hardware design via Verilog as well as advantages of FPGA for various low latency applications and a combination of the two architectures to accelerate scientific applications.

EE 695 Applied Machine Learning

An introduction course for machine learning theory, algorithms and applications. This course aims to provide students with the knowledge in understanding key elements of how to design algorithms/systems that automatically learn, improve and accumulate knowledge with experience. Topics covered in this course include decision tree learning, neural networks, Bayesian learning, reinforcement learning, ensembling multiple learning algorithms, and various application problems. The students will have chances to simulate their algorithms in a programming language and apply them to solve real-world problems. Cross-listed with: CPE 695

EE 700	Seminar in Electrical Engineering	(0)

An ECE seminar on topics of current interest.

EE 701 **EE Co-Op Education Project** (0 - 0 - 0)

This course is for EE graduate students who are on Co-Op assignment.

EE 710 Selected Topics in Multicarrier Communications (3 - 3 - 0)

This course reviews multicarrier modulcation (MCM) methods that offer several advantages over conventional single carrier systems for broadband data transmission. Topics include fundamentals of MCM, where the data stream is divided up into several parallel bit streams, each of which has a much lower bit rate, to exploit multipath diversity and the practical applications. It will cover new advances as well as the core technology. Hands on learning with computer based learning approaches will include simulation in MATLAB and state of the art high level software packages to design and implement modulation, filtering, synchronization and demodulation.

EE 740 Selected Topics in Communication Theory (3 - 3 - 0)

A participating seminar in the area of modern communications. Typical topics include high-resolution spectral estimation, nonparametric and robust signal processing, CFAR radars, diversity techniques for fading multipath channels, and adaptive nonlinear equalizers of optical communications.

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EE 775 Selected Topics in Information Theory and Coding

Current topics in information theory and coding. Typical topics include: basic theorems of information theory, entropy, channel capacity, and error bounds. Rate distortion theory: discrete source with a fidelity criterion, minimum distortion quantization, bounds on rate-distortion functions, error control codes: review of prerequisite linear algebra and field theory, linear block codes, cyclic algebraic codes, convolutional codes, and sequential decoding.

Special Problems in Electrical Engineering EE 800

An investigation of a current research topic at the pre-master's level, under the direction of a faculty member. A written report is required, which should have the substance of a publishable article. Students with no practical experience who do not write a master's thesis are invited to take advantage of this experience.

EE 801 Special Problems in Electrical Engineering (3--)

An investigation of a current research topic beyond that of EE 800 level, under the direction of a faculty member. A written report, which should have the substance of a publishable article, is required. It should have importance in modern electrical engineering. This course is open to students who intend to be doctoral candidates and wish to explore an area that is different from the doctoral research topic.

EE 810 Special Topics in Electrical Engineering (3--)

A participating seminar on topics of current interest and importance in Electrical Engineering.

EE 900 Thesis in Electrical Engineering (ME) (1 to 10 - -)

A thesis of significance to be filed in libraries, demonstrating competence in a research area of electrical engineering. For the degree of Master of Engineering (Electrical Engineering). Credits to be arranged.

FF 950 Electrical Engineering Design Project (Deg EE) (3 - 0 - 0)

An investigation of a current engineering topic or design. A written report is required.

EE 960 Research in Electrical Engineering

Original research of a significant character, undertaken under the guidance of a member of the departmental faculty, which may serve as the basis for the dissertation required for the degree of Doctor of Philosophy. Hours and credits to be arranged.

Computer Engineering

CPE 181 Seminar in Computer Engineering (1 - 1 - 0)Introduction to electrical and computer engineering, addressing theoretical foundation, systems, and applications. Topics include information theory, control theory, power systems, wireless systems, information networks, sensor networks, and internet of things. Cross-listed with: EE 181

CPE 322 Engineering Design VI

This course addresses the general topic of selection, evaluation, and design of a project concept, emphasizing the principles of team-based projects and the stages of project development. Techniques to acquire information related to the state-of-theart concepts and components impacting the project, evaluation of alternative approaches and selection of viable solutions based on appropriate cost factors, presentation of proposed projects at initial, intermediate and final stages of development, and related design topics. Students are encouraged to use this experience to prepare for the senior design project courses. Prerequisites: E 321 Corequisites: CPE 345

CPE 345 Modeling and Simulation

Development of deterministic and non-deterministic models for physical systems, engineering applications, and simulation tools for deterministic and non-deterministic systems. Case studies and projects.

CPE 358 Switching Theory and Logical Design

Digital systems, number systems and codes, Boolean algebra, application of Boolean algebra to switching circuits, minimization of Boolean functions using algebraic, Karnaugh map and tabular methods, design of combinational circuits, programmable logic devices, sequential circuit components, design and analysis of synchronous and asynchronous sequential circuits. Cross-listed with: CS 381, CS 381

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CPE 360 **Computational Data Structures and Algorithms**

The role of data structures and algorithms in the real world; principles of programming including the topics of control flow, recursion and I/O; principles of computational intelligence; topics from elementary data structures including arrays, lists, stacks, queues, pointers, strings; searching and sorting; data structures for concurrent execution; topics from elementary algorithms including analysis of algorithms and efficiency, computational complexity, empirical measurements of computational complexity of algorithms, proof techniques including induction; selected topics from advanced algorithms including distributed algorithms; programming laboratory exercises and projects. Prerequisites: E 115

CPE 384 Data Structures and Algorithms I

An introduction to basic data structures and algorithms. Emphasis will be placed on programming in C++ and debugging skills. Topics include: control flow, loops, recursion, elementary data structures (lists, stacks, queues) and their implementation via arrays and pointers, primitive sorting algorithms, binary trees and searching. Prerequisites: CS 115, CS 181

CPE 385 Data Structures and Algorithms II

A continuation of CS384/CPE360, this course focuses on algorithm development including running time analysis and correctness arguments. Topics include: asymptotic notation and running time analysis, program verification using loop invariants, advanced sorting algorithms, linear sorting algorithms, lower bounds, general trees, priority queues and heaps, set implementations, elementary graph algorithms. Prerequisites: CPE 360 or CS 384 Corequisites: MA 334

CPE 390 Microprocessor Systems

A study of the implementation of digital systems using microprocessors. The architecture and operation of microprocessors is examined in detail along with I/O interfacing, interrupts, DMA and software design techniques. Specialized controller chips for interrupts, DMA, arithmetic processing, graphics and communications are discussed. The laboratory component introduces hardware and software design of digital systems using microprocessors. Design experiments include topics such as bus interfacing, memory decoding, serial communications and programmable ports. Cross-listed with: E 115 Prerequisites: E 115

CPE 423 Engineering Design VII

Senior Design course. The development of design skills and engineering judgment, based upon previous and current course and laboratory experience, is accomplished by participation in a design project. Projects are selected in areas of current interest such as communication and control systems, signal processing, and hardware and software design for computerbased systems. To be taken during the student's last fall semester as an undergraduate student. Prerequisites: CPE 322

CPE 424 Engineering Design VIII

A continuation of CPE423 in which the design is implemented and demonstrated. This includes the completion of a prototype (hardware or software), testing and demonstrating the performance, and the evaluation of results. To be taken during the student's last spring semester as an undergraduate student. Prerequisites: CPE 423

CPE 437 Interactive Computer Graphics

Introduction to computer graphics. Designing a complete 2-D graphics package with an interface. Graphics hardware overview. Drawing of 2-D primitives (polylines, polygons, and ellipses). Character generation. Attribute primitives (line styles, color and intensity, area filling, and character attributes). 2D transformations (translation, general scaling, general rotation, shear, reflection). Windowing and clipping. 3-D concepts (3-D transformations, 3-D viewing, and 3-D modeling). Selected topics. Cross-listed with: CS 437

CPE 440 Current Topics in Electrical Engineering & Computer Engineering (3 - 3 - 0)

This course consists of lectures designed to explore a topic of contemporary interest from the perspective of current research and development. In addition to lectures by the instructors and discussions led by students, the course includes talks by professionals working in the topic being studied. When appropriate, team-based design projects are included. Cross-listed with: EE 440

CPE 441 Introduction to Wireless Systems

Review of history, concepts and technologies of wireless communications; Explanations and mathematical models for analyzing and designing wireless systems; Description of various wireless systems, including cellular systems, wireless local area networks and satellite-based communication systems; Wireless design projects using Matlab, LabView and software defined radio. Cross-listed with: EE 441

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CPE 442 Database Management Systems

Introduction to the design and querying of relational databases. Topics include: relational schemas; keys and foreign key references; relational algebra (as an introduction to SQL); SQL in depth; Entity-Relationship (ER) database design; translating from ER models to relational schemas and from relational schemas to ER models; functional dependencies; and normalization. Cross-listed with: CS 442 Prerequisites: CPE 385

CPE 450 Real-Time Embedded Systems

Unlike typical software-based systems, real-time systems must complete their tasks within specified timeframes. Unlike general purpose computing platforms, embedded systems must perform their tasks while minimizing tightresource constraints. This course addresses the considerations in designing real-time embedded systems, both from a hardware and software perspective. The primary emphasis is on real-time processing for communications and signal processing systems, but applications to seismic and environmental monitoring, process control, and biomedical systems will be addressed. Programming projects in a high level language like C/C++ will be an essential component of the course, as well as hardware design with modern design tools.

CPE 460 Software Design and Development

Theory of software design, with emphasis on large systems. Models of the software process, specifications development, designing, coding and testing. Program abstraction with functional abstraction and with abstract data types. Top-down and bottom-up development methods. Common software architecture models. Specification Validation, design verification, testing strategies, test coverage issues. Prerequisites: CPE 385

CPE 462 Introduction to Image Processing and Coding (3 - 3 - 0)

Image acquisition, storage, image formation, sampling, basic relationship between pixels, imaging geometry, segmentation: edge detection, edge linking and boundary detection, Hough transform, region growing, thresholding, split and merge, histogram matching, representation: chain code, polygonal approximation and skeletonization, thinning algorithms, texture, image compression: elementary discussion of motion vectors for compression, discussion of industry standards such as JEPG and MPEG. Prerequisites: E 245

CPE 470 Parallel Processing

Learn how multiple computational threads may be detected in ordinary code, and how such threads may be tailored for execution on parallel and superscalar architectures. Topics include: introduction to the architecture of parallel and superscalar machines, lexical and syntax analysis, data dependence analysis, control dependence anlysis, generation of code for parallel and superscalar architecture. Students are required to complete a significant programming project. Prerequisites: CPE 390, CPE 385

CPE 485 Research in Computer Engineering I

Individual investigation of a substantive character taken at the undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. The student's thesis committee consists of the faculty advisor and one or more readers. Prior approval from the faculty advisor, a faculty member who has agreed to supervise the research, and the Department Director is required. Hours to be arranged with the faculty advisor. For information regarding a Degree with Thesis, see the "Academic Procedures, Requirements, and Advanced Degrees" section of this catalog. The thesis option is a two-semester program requiring completion of CPE 485 and CPE 486. Continuation into CPE 486 is contingent on demonstrating adequate progress in CPE 485.

CPE 486 Research in Computer Engineering IV

Individual investigation of a substantive character taken at the undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. The student's thesis committee consists of the faculty advisor and one or more readers. Prior approval from the faculty advisor, a faculty member who has agreed to supervise the research, and the Department Director is required. Hours to be arranged with the faculty advisor. For information regarding a Degree with Thesis, see the "Academic Procedures, Requirements, and Advanced Degrees" section of this catalog. The thesis option is a two-semester program requiring completion of CPE 485 and CPE 486. Continuation into CPE 486 is contingent on demonstrating adequate progress in CPE 485. Prerequisites: CPE 485

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Design of complex digital CMOS/VLSI circuits. Introduction to MOS transistor characteristics and fabrication, digital circuit design and layout for integrated circuits, major categories of VLSI circuit functions, design methodologies including use of Hardware Description Languages (HDL), FPGA, verification, simulation, testability. The course includes a project using VHDL for the design of a significant system function. Prerequisites: E 245

SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

CPE 488 **Computer Architecture**

CPE 487

An introduction to the functional level structure of modern pipelined processors and the empirical and analytic evaluation of their performance. Topics include: empirical and analytic techniques for measuring performance (use of various means, Amdahl's Law, and benchmarks); tradeoff analysis; principles of instruction set design and evaluation (memory addressing, operations, types and sizes of operands, instruction set encoding, CISC vs. RISC, and related compilation issues); pipelining (basics, data hazards, and control hazards); and memory systems. Cross-listed with: CS 488 Prerequisites: CS 383

CPE 490 Information Systems Engineering I

Digital System Design

The focus of the course is on data networks and end-user software environments for information systems. Topics include the TCP/IP protocols, organization of large-scale data networks, end-to-end operation over heterogeneous networks and the software foundation of client-server application programs. The students complete a project using TCP/IP protocols to create a basic client-server application. Prerequisites: MA 134

CPE 491 Information Systems Engineering II

This course emphasizes a major component of contemporary networked information systems, namely visually rich information, including multimedia, virtual reality, human-machine interactions and related topics. The students complete a project in which they demonstrate competency in creating and manipulating the information and the resources used to store, transfer and present the information.

CPE 493 Data and Computer Communications

Introduction to information networks, data transmission and encoding, digital communication techniques, circuit switching and packet switching, OSI protocols, switched networks and LANs, introduction to ISDN and ATM/SONET networks, system architectures. Prerequisites: E 234

CPE 494 Networked Systems Design: Principles and Practices (3 - 3 - 0)

Basic elements in local and wide-area network infrastructures, architecture and protocols at all layers; client-server systems programming using sockets and remote procedure cells; concurrency and coordination issues and techniques; concepts and tools for fault tolerance, failure detection, checkpointing, disaster recovery and rejuvenation in networked applications; overview of network systems middleware facilities such as .NET and Weblogic to illustrate the above principles and techniques.

CPE 498 Interactive Computer Graphics

An introduction to computer graphics. Designing a complete 2D graphics package with an interface. Graphics hardware overview. Drawing of 2D primitives (polylines, polygons, ellipses). Character generation. Attribute primitives (line styples, color and intensity, area filling, character attributes). 2D transformations (translation, general scaling, general rotation, shear, reflection). Windowing and clipping. 3D concepts (3D transformations, 3D viewing, 3D modeling). Selected topics. Prerequisites: CS 385

CPE 514 **Computer Architecture**

Measures of cost, performance, and speedup; instruction set design; processor design; hard-wired and microprogrammed control; memory hierarchies; pipelining; input/output systems; and additional topics as time permits. The emphasis in this course is on quantitative analysis of design alternatives. Cross-listed with: NIS 514, CS 514 Prerequisites: CPE 550

CPE 517 Digital and Computer Systems Architecture

This course covers the design and architecture of computer and digital systems in the system design region starting from the transistor/logic gate level to below the device driver level/system monitor level. The systems considered in the course will go beyond the computer chips or CPUs discussed in a typical computer architecture course, but will include complex logic devices such as application specific integrated circuits (ASICs), the core-designs for field programmable gate arrays (FPGAs), system-on-a-chip (SoC) designs, ARM, and other application-specific architectures. Printed circuit board-level architectural considerations for multiple complex digital circuits will also be discussed. Cross-listed with: EE 517

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CPE 521 Autonomous Mobile Robotic Systems

This course will offer the students an overview of the technology of autonomous mobile robotic systems the mechanisms that allow a mobile robot to move through a real-world environment to perform its tasks. Since the design of any successful mobile robot involves the integration of many different disciplines -- among them kinematics, signal analysis, information theory, artificial intelligence, and probability theory -- the course will discuss all facets of mobile robotic system, including hardware design, wheel design, kinematics analysis, sensors and perception, localization, mapping, motionplanning, navigation, and robot control architectures. Multi-robot systems will also be introduced due to their broader applications, such as search and rescue tasks, and exploring tasks.

CPE 533 Cost Estimation and Metrics

An objective cost model is necessary for planning and executing software projects. A cost model provides a framework for communicating business decisions among the stakeholders of a software effort; it supports contract negotiations, process improvement analysis, tool purchases, architecture changes, component make/buy tradeoffs, and several other return-oninvestment decisions. This course provides the student with a through introduction to software estimation and to industry standard tools, like COCOMOII, used in cost estimation. Cross-listed with CS533 .

CPE 536 Integrated Services - Multimedia

Types of multimedia information: voice, data video facsimile, graphics, and their characterization; modeling techniques to represent multimedia information; analysis and comparative performances of different models; detection techniques for multimedia signals; specification of multimedia representation based on service requirements; and evaluation of different multimedia representations to satisfy user applications and for generating test scenarios for standardization. Cross-listed with: NIS 536, CS 536

CPE 537 **Interactive Computer Graphics**

This is an introductory-level course to computer graphics. No previous knowledge on the subject is assumed. The objective of the course is to provide a comprehensive introduction to the field of computer graphics, focusing on the underlying theory, and thus providing strong foundations for both designers and users of graphical systems. The course will study the conceptual framework for interactive computer graphics, introduce the use of OpenGL as an application programming interface (API), and cover algorithmic and computer architecture issues. Cross-listed with: CS 537 Prerequisites: CPE 590

CPE 540 Fundamentals of Quantitative Software Engineering I

This course introduces the subject of software engineering, also known as software development process or software development best practice from a quantitative, analytic- and metrics-based point of view. Topics include introductions to: software life-cycle process models from the heaviest weight, used on very large projects, to the lightest weight, such as, extreme programming; industry-standard software engineering tools; teamwork; project planning and management; objectoriented analysis and design. The course is case-history and project oriented. Cross-listed with: CS 540, SSW 540

CPE 542 Fundamentals of Quantitative Software Engineering II

This course is a project-oriented continuation of CS540. It is intended for computer science majors interested in learning software development process, but not interested in the full MS program in QSE or the Graduate Certificate in QSE. Prerequisites: CS540

CPE 545 Communication Software and Middleware

Communications in computer networks are not only enabled by physical links and hardware, but are also enabled by software and middleware. This course provides an understanding of software techniques in communications. It explores development models that address a broad range of issues in the design of communication software, including hardware and software partitioning, layering, and protocol stacks. Other topics are configuration techniques, buffer and timer management, task and table managements, and multi-board communications software design. Communication middleware and agent technologies as enabling technology in networking will also be covered.

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CPE 548 Digital Signal Processing

Review of mathematics of signals and systems including sampling theorem, Fourier transform, z-transform, Hilbert transform; algorithms for fast computation: DFT, DCT computation, convolution; filter design techniques: FIR and IIR filter design, time and frequency domain methods, window method and other approximation theory based methods; structures for realization of discrete time systems: direct form, parallel form, lattice structure and other state-space canonical forms (e.g., orthogonal filters and related structures); roundoff and quantization effects in digital filters: analysis of sensitivity to coefficient quantization, limit cycle in IIR filters, scaling to prevent overflow, role of special structures. Cross-listed with: EE 548

CPE 550 Computer Organization and Programming

This course provides an intensive introduction to material on computer organization and assembly language programming required for entrance into the graduate program in Computer Science or Computer Engineering. The topics covered are: structure of stored program computers; linking and loading; assembly language programming, with an emphasis on translation of high-level language constructs; data representation and arithmetic algorithms; basics of logic design; processor design: data path, hardwired control and microprogrammed control. Students will be given assembly language programming assignments on a regular basis. Cross-listed with: CS 550 Prerequisites: CS 580

CPE 555 Real-Time and Embedded Systems

The miniaturization of electronics and increasingly sophisticated software environments has enabled the realization of systems that embed intelligence within a wide variety of systems interacting in real time with the environment. Such systems are characterized by hardware/software integration along with integration of both analog and digital electronics. Representative topics include specification of the overall system, real-time operating system, embedded network protocols, tradeoffs between hardware and software, etc. The lectures will be complemented by projects related to design of such systems.

CPE 556 Computing Principles for Mobile and Embedded Systems (3 - 0 -

Embedded systems have emerged as a primary application area, highlighting the co-integration of application-specific hardware components with programmable, flexible, adaptable, and versatile software components. Such systems have been one of the drivers of important new computing principles that play an important role in achieving optimal performance of the overall system. This course will provide the student with a background in these new computing principles and their application to embedded systems. Representative topics include emerging computing paradigms in the areas of context-aware pervasive systems, spatio-temporal access control with distributed software agents, vehicular computing, information systems cryptography, trust and privacy in mobile environments, location-aware services, RFID systems, wireless medical networks, and urban sensing. Cross-listed with: EE 556

CPE 558 Computer Vision

An introduction to the field of Computer Vision, focusing on the underlying algorithmic, geometric, and optic issues. The course starts with a brief overview of basic image processing topics (convolution, smoothing, and edge detection). It then proceeds on various image analysis topics: binary images, moments-based shape analysis, Hough transform, image formation, depth and shape recovery, photometry, motion, classification, and special topics. Cross-listed with: CS 558 Prerequisites: CS 590, CS 385 Corequisites: MA 115, Ma 112

CPE 560 Introduction to Networked Information Systems

An overview of the technical and application topics encountered in contemporary networked information systems including the overall architecture of such systems, data networked architectures, secure transmission of information, data representations including visual representations, information coding/compression for storage and transmission, management of complex heterogeneous networks, and integration of next-generation systems with legacy systems. Cross-listed with: NIS 560

CPE 563 Networked Applications Engineering

Introduction to the engineering principles and practices to build networked applications, such as e-mail and www; programming networked applications using Web Services; coordinating the execution of application components on different computers on the network; ensuring consistency of data among the components in online banking-like applications; monitoring, recovery, and rejuvenation capabilities to handle component failures; authentication among components for eCommerce-like applications; application quality of service; middleware platforms that address these issues in practice; and large-scale networked application examples. Cross-listed with: NIS 563

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CPE 565 Management of Local Area Networks

Principles and practices of managing local area networks are presented from the perspective of a network systems engineer, including hands-on projects working with a real local area network (Cisco routers, switches, firewalls, etc.). The SNMP protocols and network management using SNMP are presented in terms of the general organization of information regarding network components and from the perspective of creating basic network management functions using SNMP. Techniques for troubleshooting practical networks, along with setting up and maintaining an IP network are covered. The course includes a project-based learning experience. Cross-listed with: NIS 565

CPE 579 Foundations of Cryptography

This course provides a broad introduction to cornerstones of security (authenticity, confidentiality, message integrity and nonrepudiation) and the mechanisms to achieve them as well as the underlying mathematical basics. Topics include: block and stream ciphers, public-key systems, key management, certificates, public-key infrastructure (PKI), digital signature, nonrepudiation, and message authentication. Various security standards and protocols such as DES, AES, PGP and Kerberos, are studied. Cross-listed with: CS 579 Prerequisites: CS 590 or CS 385, CS 503

CPE 580 The Logic of Program Design

Introduction to the rigorous design of functional and procedural programs in modern language (C++). The main theme is that programs can be reliably designed, proven and refined if one pays careful attention to their underlying logic, and the emphasis of this course is on the logical evolution of programs from specifications. Programs are developed in the UNIX environment. The necessary background in logic, program syntax and UNIX is developed as needed, though at a fast pace. Cross-listed with: CS 580 Prerequisites: Corequisites: MA 502

CPE 585 Medical Instrumentation and Imaging

Imaging plays an important role in both clinical and research environments. This course presents both the basic physics together with the practical technology associated with such methods as X-ray computed tomography (CT), magnetic resonance imaging (MRI), functional MRI (f-MRI) and spectroscopy, ultrasonics (echocardiography, Doppler flow), nuclear medicine (Gallium, PET and SPECT scans) as well as optical methods such as bioluminescence, optical tomography, fluorescent confocal microscopy, two-photon microscopy and atomic force microscopy. Cross-listed with: BME 504

CPE 590 Algorithms

This is a course on more complex data structures, and algorithm design and analysis, using one or more modern imperative language(s), as chosen by the instructor. Topics include: advanced and/or balanced search trees; hashing; further asymptotic complexity analysis; standard algorithm design techniques; graph algorithms; complex sort algorithms; and other "classic" algorithms that serve as examples of design techniques. Cross-listed with: CS 590 Prerequisites: MA 502, and CS 570

CPE 591 Introduction to Multimedia Networking

The objective of this course is to introduce current techniques in multimedia communications especially as applied to wireless networks. The course will introduce the basic issues in multimedia communications and networking. Topics covered include: multimedia information representation - text, images, audio, video; introduction to information theory - information of a source, average information of a discrete memoryless source, source coding for memoryless sources; multimedia compression - text, image, audio, video; standards for multimedia communications; transmissions and protocols; circuit switched networks; the Internet; broadband ATM networks; packet video in the network environment; transport protocols -TCP/IP; TCP; UDP; RTP and RTCP; wireless networks - models, characteristics; error resilience for wireless networks. Crosslisted with: NIS 591

CPE 592 Computer and Multimedia Network Security

The objective of this course is to introduce current techniques in securing IP and multimedia networks. Topics under IP security will include classic cryptography, Diffie-Hellman, RSA, end-to-end authentication, Kerberos, viruses, worms and intrusion detection. Topics from multimedia will include steganography, digital watermarking, covert channels, hacking, jamming, security features in MPEG-4, secure media streaming, wireless multimedia, copy control and other mechanisms for secure storage and transfer of audio, image and video data. Cross-listed with: NIS 592

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CPE 593 Applied Data Structures & Algorithms

The course provides the student with an integrated presentation of (i) the formalisms of data structures, graphs and algorithms, (ii) the development of efficient and reliable software using these formalisms, and (iii) theapplications of the data structures, graphs and algorithms topics (including appropriate elements of graph theory) within representative computing, information, and communications engineering applications. Principles will be applied through programming projects solving representative problems drawn from data networking and other applications. Cross-listed with: NIS 593

CPE 599 Curricular Practical Training

This course involves an educationally relevant practical industry project experience that augments the academic content of the student's program. Students engage in a project in industry that is relevant to the focus of their academic program. This project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit a final written report, and present a summary of his/her activities by means of a powerpoint presentation that will both be graded. This is a one-credit course that may be repeated up to a total of three credits.

CPE 600 Advanced Algorithm Design and Implementation (3 - 3 - 0)

Design, implementation, and asymptotic time and space analysis of advanced algorithms, as well as analyzing worst-case and average-case complexity of algorithms. Students will be expected to run experiments to test the actual performance of the algorithms on sample inputs. Introduction to NP-complete problems and approximation algorithms. Cross-listed with: CS 600 Prerequisites: CPE 590, CS 385

CPE 602 Applied Discrete Mathematics

This is an introductory course for engineers. Topics that will be covered include principles of counting, set theory, mathematical induction, analysis of algorithms and complexity, relations, recurrent relations, graph algorithms, combinatorial design, software tools, applications to coding theory, network optimization, data compression, security, etc. Cross-listed with: NIS 602

CPE 604 Analytical Methods for Networks

This course is an introduction on modern information networks with an emphasis on providing the student with the mathematical background and required analytical skills for performance analysis of information networks protocols. The material concentrates mostly on the bottom three layers of the protocol stack, focusing on delay and throughput analysis. Topics covered include an overview of the OSI layering model, data link layer issues, medium access control, queueing analysis, mathematical models for routing in broadcast and point-to-point networks, and flow and congestion control. Cross-listed with: NIS 604

CPE 608 Applied Modeling and Optimization

This course will deal with the main aspects of applied modeling and optimization suitable for engineering, science, and business students. Sample applications to be used as case studies include channel capacity computation (information theory), statistical detection and estimation (signal processing), sequential decision making/revenue maximization (business), and others. Topics will include introduction to convex and non-linear optimization and modeling; linear, quadratic, and geometric program models and applications; stochastic modeling; combinatorial issues; gradient techniques; machine learning algorithms; stochastic approximation; genetic algorithms; and ant colony optimization. Cross-listed with: NIS 608

CPE 610 Introduction to Bioinformatics Engineering

This is an introductory course. Topics that will be covered in this course include an introduction to the basic concepts in biology such as DNA and RNA, biological data in digital symbol sequences, genomes—diversity, size and structure, genome, proteome, protein function, alignment versus prediction, consensus sequences and sequence logos, graphical models, secondary encoding and output interpretation, prediction of protein secondary structure, phylogenetic trees, Shannon model of a biological system and its implications, data analysis using BLAST tool, and probabilistic evolutionary models.

CPE 612 Principles of Multimedia Compression

Modeling of image signals; 2D prediction theory and application to DPCM/ADM coding of images; subband coding of images; filters for subband coding; transform coding of images; comparison of various transforms like KLT, DCT, LOT; vector quantizing theory, vector quantizing algorithms like the LBG algorithm; VQ for image coding.

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CPE 619 E-Commerce Technologies

The course provides an understanding of electronic commerce and related architectures, protocols and technologies. The course introduces the E-commerce concept, objectives, and market drivers, and identifies its requirements, underpinning techniques, and technologies. These include Internet techniques like tunneling and Telnet and WWW techniques like Forms, and Common Gateway Interface (CGI). Other related topics such as multimedia, intelligent agents and their applications in E-commerce, the client/server model, and Commitment, Concurrency and Recovery (CCR) are also presented. Network, service, and application management, which are important aspects of E-commerce, are discussed. Quality of Service (QoS) management, Service Level Agreement (SLA) management, Application Programming Interface (APIs), and the role of Application Service Providers (ASPs) are discussed. There will be strong emphasis on the important topic of security management. Topics here include security concepts and technologies, types of security attacks, encryption techniques, public key systems, Data Encryption Standard (DES), and authentication techniques. Virtual Private Networks (VPNs), secure tunneling techniques, firewalls, Intranets, extranets, and VPN management are covered. The policy and regulatory issues in E-commerce are discussed. Finally, various E-commerce applications in the areas of finance, securities, trading, auctions, and travel are described. The course includes some E-commerce case studies and demonstrations. Cross-listed with: NIS 619, CS 619, TM 619, CS 619

CPE 625 Systems Operational Effectiveness and Life-Cycle Analysis

This course presents the fundamental principles and process for designing effective and reliable, supportable, and maintainable systems. The participants will also understand the concept of system operational effectiveness, and the inherent "cause and effect" relationship between design decisions and system operation, maintenance and logistics. Furthermore, the course will also discuss system life cycle cost modeling as a strategic design decision making methodology and present illustrative case studies.

CPE 631 Cooperating Autonomous Mobile Robots

Advanced topics in autonomous and intelligent mobile robots, with emphasis on planning algorithms and cooperative control. Robot kinematics, path and motion planning, formation strategies, cooperative rules and behaviors. The application of cooperative control spans from natural phenomena of groupings such as fish schools, bird flocks, deer herds, to engineering systems such as mobile sensing networks, vehicle platoon.

CPE 636 Integrated Services - Multimedia

Types of multimedia information: voice, data video facsimile, graphics and their characterization; modeling techniques to represent multimedia information; analysis and comparative performances of different models; detection techniques for multimedia signals; specification of multimedia representation based on service requirements; evaluation of different multimedia representations to satisfy user applications and for generating test scenarios for standardization. Cross-listed with: CS 636

CPE 638 Advanced Computer Graphics

Mathematical foundations and algorithms for advanced computer graphics. Topics include 3-D modeling, texture mapping, curves and surfaces, physics-based modeling, and visualization. Special attention will be paid to surfaces and shapes. The class will consist of lectures and discussion on research papers assigned for reading. In class, we will study the theoretical foundations and algorithmic issues. In programming assignments, we will use OpenGL as the particular API for writing graphics programs. C/C++ programming skills are essential for this course. Cross-listed with: CS 638 Prerequisites: CPE 537

CPE 640 Software Engineering I

This course covers the principles and theory of programming-in-the-large. The phases of software development, requirements development, software design software coding, and module testing, and software verification will be discussed in detail. Documents, rapid phototyping, top down, bottom up, successive refinement, functional and data abstraction will be discussed. Black and white box testing methods will be covered. Hierarchical and democratic term organization structures and the effects of personalizing and group dynamics will be discussed.

CPE 642 Software Engineering II

Types of multimedia information: voice, data video facsimile, graphics and their characterization; modeling techniques to represent multimedia information; analysis and comparative performances of different models; detection techniques for multimedia signals; specification of multimedia representation based on service requirements; evaluation of different multimedia representations to satisfy user applications and for generating test scenarios for standardization. Cross-listed with: CS 642

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CPE 643 Logical Design of Digital Systems I

Design concepts for combinational and sequential (synchronous and asynchronous) logic systems; the design processes are described algorithmically and are applied to complex function design at the gate and register level; the designs are also implemented using software development tools, logic compilers for programmable logic devices and gate arrays. Cross-listed with: CS 527

CPE 644 Logical Design of Digital Systems II

The design of complex digital logic systems using processor architectures. The architectures are implemented for reduced instruction set computers (RISC) and extended to complex instruction set computers (CISC). The emphasis in the course is the design of high-speed digital systems and includes processors, sequencer/controllers, memory systems and input/output.

CPE 645 Image Processing and Computer Vision

The goal is to acquaint the students with the fundamental techniques of image processing. Specific topics include: Digital imaging fundamentals; neighborhood operators; clustering, region growing; split and merge, segmentation; edge and line linking; degradation model, restoration, inverse filtering; zero-crossing methods, gradient edge detectors; gray level cooccurrence, texture analysis; morphological operations; image registration and enhancement; scale space filtering; motion estimation; 3D image recognition and estimation. Cross-listed with: NIS 645

CPE 646 Pattern Recognition and Classification

Introduction and general pattern recognition concerns and statistical pattern recognition: introduction to statistical pattern recognition, supervised learning (training) using parametric and nonparametric approaches, parametric estimation and supervised learning, maximum likelihood (ML) estimation, the Bayesian parameter estimation approach, supervised learning using nonparametric approaches, Parzen windows, nonparametric estimation, unsupervised learning and clustering, and formulation of unsupervised learning problems; syntactic pattern recognition: quantifying structure in pattern description and recognition, grammar-based approach and applications, elements of formal grammars, syntactic recognition via parsing and other grammars, graphical approaches, and learning via grammatical inference; neural pattern recognition: the artificial neural network model, introduction to neural pattern associators and matrix approaches, multilayer, feed-forward network structure, and content addressable memory approaches. The Hopfield approach to pattern recognition, unsupervised learning, and self-organizing networks.

CPE 654 Design and Analysis of Network Systems

Analysis of current networks including classic telephone, ISDN, IP and ATM. Attributes and characteristics of highspeed networks. Principles of network design including user-network interface, traffic modeling, buffer architectures, buffer management techniques, call processing, routing algorithms, switching fabric, distributed resource management, computational intelligence, distributed network management, measures of network performance, quality of service, selfhealing algorithms, hardware and software issues in future network design. Cross-listed with: NIS 654

CPE 655 Queuing Systems with Computer Applications I

Queuing models will be developed and applied to current problems in telecommunication networks and performance analysis of networked computer systems. Topics include elementary queuing theory, birth-death processes, open and closed networks of queues, priority queues, conservation laws, models for time-shared computer systems and computer communication networks. Cross-listed with: NIS 655, CS 655, CS 655

CPE 656 Queuing Systems with Computer Applications II (3 - 0 - 0)

This course is a continuation of CPE 655. Cross-listed with: NIS 656, CS 656 Prerequisites: CPE 655, CS 655 NIS 655

CPE 658 Image Analysis and Wavelets

The course emphasizes two main themes. The first is the study of wavelets as a newly emerging tool in signal analysis. The second is its applications in image processing and computer vision. In the first category, the following topics will be covered: time-frequency localization, windowed Fourier transform, continuous and discrete wavelet transforms, orthogonal and biorthogonal families of wavelets, and multiresolution analysis and its relation to subband coding schemes and use of wavelets in analysis of singularities. In the second category, applications of wavelets in problems of compact coding of images, edge and boundary detection, zero-crossing based representation, motion estimation, and other problems relevant to image processing and transmission will be considered.

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CPE 664 Advanced Digital Signal Processing

Implementation of digital filters in high speed architectures; multirate signal processing: linear periodically time varying systems, decimators and expanders, filter banks, interfacing digital systems operating at multiple rates, elements of subband coding and wavelet transforms; signal recovery from partial data: from zero crossing, level crossing, phase only, magnitude only data; elements of spectral estimation: MA, AR and ARMA models. Lattice, Burg methods, MEM. Prerequisites: EE 548, CPE 548

CPE 668 Foundations of Cryptography

This course provides a broad introduction to cornerstones of security (authenticity, confidentiality, message integrity and non-repudiation) and the mechanisms to achieve them. Topics include: block and stream ciphers, secret-key and public-key systems, key management, public-key infrastructure (PKI), digital envelope, integrity and message authentication, digital signature and non-repudiation, trusted third party and certificates. Various security standards and protocols such as DES, PGP and Kerberos will be studied. The course includes a project and some lab experiments related to running, analyzing and comparing various security algorithms. Cross-listed with: CS 669

CPE 671 High-Speed Signal and Image Processing with VLSI (3 - 0 - 0)

The design of ASCA (Application Specific Computer Architectures) for signal and image processing; topics include an overview of VLSI architectural design principles, signal and image processing algorithms, mapping algorithms onto array structures, parallel architectures and implementation, and systolic design for neural network processing.

CPE 678 Information Networks I

The first of a two-course sequence on modern computer networks. Focus is on the physical and data link levels of the OSI layers. Trace the evolution of client/server computing to the Internet. Topics covered include OSI layering, TCP/IP overview, the application of Shannon's and Nyquist's bandwidth theorems, Discrete Wave Division Multiplexing, wireless transmission, local loops, QAM, TDM, SONET/SDH, circuit switching, ATM switching, knockout switch, ISDN, STM, framing, error detection and correction, CRC, ARQ protocol, sliding window protocols, finite state machines, Universal Modeling Language, PPP, ALOHA, CSMA, LANs, fast and gigabit Ethernet, bridges and FDDI. A significant amount of time is spend on designing 802.3 LANs. Cross-listed with: NIS 678

CPE 679 Computer and Information Networks

Learn the technologies that make the Internet work. You will understand the TCP and IP protocols and their interaction. You will study the TCP slow start in low noise and high noise environments, the use of proxy servers, web caching, and gain understanding of the technologies used to make routers perform well under load. These include shortest path routing, new routing protocols, TCP congestion control, leaky bucket and token bucket admission control, weighted fair queueing and random early detection of congestion. Networks are described in terms of their architecture, transport, routing and management. Quality of Service (QoS) models are integrated with communication models. The course requires problem solving and extensive reading on network technology. After an introduction to bridges, gigabit ethernet, routing and the Internet Protocol, a fundamental understanding of shortest path and distance vector routing is taught. A "problem/solution" approach is used to develop how and why the technology evolved to keep engineering tradeoffs in focus. Continuation of Information Networks I with a focus on the network and transport layers of the OSI layers. Protocol definitions for distributed networks and performance analysis of various routing protocols including Bellman-Ford, BGP and OSPF. TCP over IP is discussed. Other topics include pipelining, broadcast routing, congestion control and reservations, Leaky and Token Bucket algorithms, weighted fair queuing, tunneling, firewalls, Ipv4 and IPv6. Network layers in SAN including the different service categories are discussed. The TCP and UDP transport protocols are discussed in depth along with network security, DNS, SAN, SLIP, firewalls and naming. Cross-listed with: NIS 679

CPE 680 Ad Hoc Networks

Ad hoc networking relates to a collection of network components that can self-organize and manage communications in a manner largely transparent to the user. Such networks have grown in importance as wireless network technologies have advanced, leading to dynamically changing network topologies. Representative topics, presented from the perspective of ad hoc networks, include routing protocols, performance metrics, implementations, applications such as sensor and peer-topeer networks, and security are presented from the perspective of ad hoc networks.

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CPE 695

n introduction course for machine learning theory, algorithms and applications. This course aims to provide students with the knowledge in understanding key elements of how to design algorithms/systems that automatically learn, improve and accumulate knowledge with experience. Topics covered in this course include decision tree learning, neural networks, Bayesian learning, reinforcement learning, ensembling multiple learning algorithms, and various application problems. The students will have chances to simulate their algorithms in a programming language and apply them to solve real-world problems. Cross-listed with: EE 695

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An ECE Departme	ent seminar on topics of current interest.		
CPE 700	Seminar in Computer Engineering (ECE Seminar)	(0))

CPE 701	CPE Co-Op Education Project	(0-0-0)

This course is for CPE students who are on a Co-Op assignment.

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SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

CPE 682 Fuzzy Logic Systems

The geometry of fuzzy sets; the universe as a fuzzy set; fuzzy relational algebra; fuzzy systems; the fuzzy entropy theorem; the subsethood theorem; the fuzzy approximation theorem (FAT); fuzzy associative memories (FAM); adaptive FAMs (AFAM); fuzzy learning methods; approximate reasoning (linguistic modeling); different integration of neural networks and fuzzy systems; neuro-fuzzy controller and their applications; expert systems: knowledge acquisition, knowledge representation, and inference engines; hybrid expert systems (soft computing): knowledge-based systems, fuzzy systems, and neural networks; and applications: image processing, data compression, pattern recognition, computer vision, qualitative modeling, retrieval from fuzzy database, process control, robotics, and some industrial applications.

CPE 685 **Computational Systems Biology**

This is an introductory course on computational modeling of biological systems. Topics that will be covered include biological modeling, representing biochemical networks, chemical and biochemical kinetics, case studies, Bayes inference and Monte Carlo methods, stochastic simulation of biological networks. Prerequisites: EE 606

CPE 686 Software Tools in Bioinformatics

This is an introductory course on computational software tools and methods used in bioinformatics and computational genomics. Software tools, websites, databases, hardware and programming languages used in the analysis of biological information will be introduced. Prerequisites: CPE 610

CPE 690 Introduction to VLSI Design

This course introduces students to the principles and design techniques of very large scale integrated circuits (VLSI). Topics include: MOS transistor characteristics, DC analysis, resistance, capacitance models, transient analysis, propagation delay, power dissipation, CMOS logic design, transistor sizing, layout methodologies, clocking schemes, case studies. Students will use VLSI CAD tools for layout and simulation. Selected class projects may be sent for fabrication. Cross-listed with: MT 690, **PEP 690**

Information Systems Security CPE 691

History of network security; classical information security; cryptosecurity; kerberos for IP networks; private and public keys; nature of network security; fundamental framework for network security; analysis and performance impact of network topology; vulnerabilities and security attack models in ATM, IP, and mobile wireless networks; security services, policies, and models; trustworthy systems; intrusion detection techniques - centralized and distributed; emulation of attack models and performance assessment through behavior modeling and asynchronous distributed simulation; principles of secure network design in the future; and projects in network security and student seminar presentations. Cross-listed with: NIS 691

CPE 693 **Cryptographic Protocols**

This course covers the design and analysis of security protocols, and studies different attacks and defenses against them. Topics include: signature and authentication protocols, privacy, digital rights management, security protocols for wired, wireless and distributed networks, electronic voting, payment and micropayment protocols, anonymity, broadcast encryption and traitor training, quantum cryptography and visual cryptography. The course includes a project and some related lab experiments. Cross-listed with: CS 693 Prerequisites: CPE 668

Applied Machine Learning

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CPE 702 Selected Topics in Imaging and Pattern Recognition

Current topics in image processing and pattern recognition. Topics may include Bayes decision theroy, parameter estimation, feature selection, non-parametric techniques, linear discriminate functions, unsupervised learning, clustering, applications of pattern recognition, and biomedical problems. Cross-listed with: CS 702

CPE 732 Selected Topics VLSI Design and Simulation

Current topics in VLSI, VHSIC, and ASIC design, simulation, and verification. Electronic design automation (EDA) tools. Design physics and processing and basic CMOS and bipolar circuit structures. Top-down design methods; formal specifications of circuits; simulation as an aid to circuit design and verification; and principles of functional and logical simulation before layout. Bottom-up circuit construction; hierarchical layout circuits; floor plan organization and routing of subcircuit interconnections; extraction of circuit from layout; critical path analysis. Class project and design, simulation, and layout of medium size circuit.

CPE 765 Selected Topics in Computer Engineering (3 - 3 - 0)

A participating seminar on topics of current interest and importance in computer engineering.

CPE 800 Special Problems in Computer Engineering (M.Eng.) (3--)

An investigation of current research topic at the pre-master's level, under the direction of a faculty member. A written report is required, which should have the substance of a publishable article. Students with no practical experience who do not write a master's thesis are invited to take advantage of this experience.

CPE 801 Special Problems in Computer Engineering (Ph.D.) (3--)

An investigation of a current research topic beyond that of CPE 800 level, under the direction of a faculty member. A written report is required, which should have importance in modern computer engineering and have the substance of a publishable article. This course is open to students who intend to be doctoral candidates and wish to explore an area that is different from the doctoral research topic.

CPE 810 Special Topics in Computer Engineering (3--)

A participating seminar on topics of current interest and importance in Computer Engineering.

CPE 900 Thesis in Computer Engineering (M.Eng.)

A thesis of significance to be filed in libraries, demonstrating competence in a research area of computer engineering. Credits to be arranged.

CPE 950 Computer Engineer Design Project (1 - 1 - 0)

An investigation of current a engineering topic or design. A written report is required.

CPE 960 Research in Computer Engineering (Ph.D.)

Original research of a significant character undertaken under the guidance of a member of the departmental faculty that may serve as the basis for the dissertation required for the degree of Doctor of Philosophy. Hours and credits to be arranged.

Information and Data Engineering

NIS 505 Probability for Telecommunications Managers

This course provides a background in probability and stochastic processes necessary for the analysis of telecommunications systems. Topics include axioms of probability, combinatorial methods, discrete and continuous random variables, expectation, Poisson processes, birth-death processes, and Markov processes. Cross-listed with: TM 605

NIS 514 Computer Architecture

Measures of cost, performance, and speedup; instruction set design; processor design; hard-wired and microprogrammed control; memory hierarchies; pipelining; input/output systems; and additional topics as time permits. The emphasis in this course is on quantitative analysis of design alternatives. Cross-listed with: CPE 514, CS 514

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NIS 521 Communication Software and Middleware

Communications in computer networks are not only enabled by physical links and hardware, but are also enabled by software and middleware. This course provides an understanding of software techniques in communications. It explores development models that address a broad range of issues in the design of communication software, including hardware and software partitioning, layering, and protocol stacks. Other topics are configuration techniques, buffer and timer management, task and table managements, and multi-board communications software design. Communication middleware and agent technologies as enabling technology in networking will also be covered.

NIS 536 Integrated Services - Multimedia

Types of multimedia information: voice, data video facsimile, graphics, and their characterization; modeling techniques to represent multimedia information; analysis and comparative performances of different models; detection techniques for multimedia signals; specification of multimedia representation based on service requirements; and evaluation of different multimedia representations to satisfy user applications and for generating test scenarios for standardization. Cross-listed with: CPE 536, CS 536

NIS 545 Communication Software and Middleware

Communications in computer networks are not only enabled by physical links and hardware, but are also enabled by software and middleware. This course provides an understanding of software techniques in communications. It explores development models that address a broad range of issues in the design of communication software, including hardware and software partitioning, layering, and protocol stacks. Other topics are configuration techniques, buffer and timer management, task and table managements, and multi-board communications software design. Communication middleware and agent technologies as enabling technology in networking will also be covered.

NIS 560 Introduction to Networked Information Systems

An overview of the technical and application topics encountered in contemporary networked information systems including the overall architecture of such systems, data network architectures, secure transmission of information, data representations including visual representations, information coding/compression for storage and transmission, management of complex heterogeneous networks and integration of next-generation systems with legacy systems. Cross-listed with: CPE 560

NIS 561 Database Management Systems I

Introduction to the use of relational database systems; the relational model; the entity-relationship model; translation of entityrelationship diagrams into relational schemes; relational algebra; SQL; normalization of relational schemes. Students who have had a previous course in database systems must obtain permission of the instructor to enroll in this course.

NIS 563 Networked Applications Engineering

Introduction to the engineering principles and practices to build networked applications, such as e-mail and www; programming networked applications using Web Services; coordinating the execution of application components on different computers on the network; ensuring consistency of data among the components in online banking-like applications; monitoring, recovery, and rejuvenation capabilities to handle component failures; authentication among components for eCommerce-like applications; application quality of service; middleware platforms that address these issues in practice; and large-scale networked application examples. Cross-listed with: CPE 563

NIS 564 Design & Analysis of Network Systems

Analysis of current networks including classic telephone, ISDN, IP and ATM. Attributes and characteristics of highspeed networks. Principles of network design including user-network interface, traffic modeling, buffer architectures, buffer management techniques, call processing, routing algorithms, switching fabric, distributed resource management, computational intelligence, distributed network management, measures of network performance, quality of service, selfhealing algorithms, hardware and software issues in future network design.

NIS 565 Management of Local Area Networks

Principles and practices of managing local area networks are presented from the perspective of a network systems engineer, including hands-on projects working with a real local area network (Cisco routers, switches, firewalls, etc.). The SNMP protocols and network management using SNMP are presented in terms of the general organization of information regarding network components and from the perspective of creating basic network management functions using SNMP. Techniques for troubleshooting practical networks, along with setting up and maintaining an IP network are covered. The course includes a project-based learning experience. Cross-listed with: CPE 565

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NIS 583 Wireless Communications

This courses serves as a broad introduction to the several technologies and applications of wireless communications systems. The emphasis is on providing a reasonable mixture of information leading to a broad understanding of the technical issues involved, with modest depth in each of the topics. As an integrating course, the topics range from the physics of wave generation/propagation/reception through the circuit/component issues, to the signal processing concepts, to the techniques used to impress the information (voice or data) on a wireless channel, to overviews of representative applications including current generation systems and next generation systems. Upon completion of this course, the student shall understand the manner in which the more detailed information in the other three courses is integrated to create a complete system. Crosslisted with: EE 583

NIS 584 Wireless Systems Security

Wireless systems and their unique vulnerabilities to attack; system security issues in the context of wireless systems, including satellite, terrestrial microwave, military tactical communications, public safety, cellular and wireless LAN networks; security topics: confidentiality/privacy, integrity, availability, and control of fraudulent usage of networks. Issues addressed include jamming, interception and means to avoid them. Case studies and student projects are an important component of the course. Cross-listed with: EE 584, TM 584

NIS 586 Wireless Networking: Architecture, Protocols and Standards (3 - 0 - 0)

This course addresses the fundamentals of wireless networking, including architectures, protocols and standards. It describes concepts, technology and applications of wireless networking as used in current and next-generation wireless networks. It explains the engineering aspects of network functions and designs. Issues such as mobility management, wireless enterprise networks, GSM, network signaling, WAP, mobile IP and 3G systems are covered. Cross-listed with: EE 586, TM 586

NIS 591 Introduction to Multimedia Networking

The objective of this course is to introduce current techniques in multimedia communications especially as applied to wireless networks. The course will introduce the basic issues in multimedia communications and networking. Topics to be covered include: multimedia information representation - text, images, audio, video; iIntroduction to information theory - information of a source, average information of a discrete memoryless source, source coding for memoryless sources; multimedia compression - text, image, audio, video; standards for multimedia communications; transmissions and protocols; circuit switched networks; the Internet; broadband ATM networks; packet video in the network environment; transport protocols - TCP/IP; TCP; UDP; RTP and RTCP; wireless networks - models, characteristics; error resilience for wireless networks. Cross-listed with: CPE 591

NIS 592 Multimedia Network Security

The objective of this course is to introduce current techniques in securing IP and multimedia networks. Topics under IP security will include classic cryptography, Diffie-Hellman, RSA, end-to-end authentication, Kerberos, viruses, worms and intrusion detection. Topics from multimedia will include steganography, digital watermarking, covert channels, hacking, jamming, security features in MPEG-4, secure media streaming, wireless multimedia, copy control and other mechanisms for secure storage and transfer of audio, image and video data. Cross-listed with: CPE 592

NIS 593 Applied Data Structures & Algorithms

The course provides the student with an integrated presentation of (i) the formalisms of data structures, graphs and algorithms, (ii) the development of efficient and reliable software using these formalisms, and (iii) the applications of the data structures, graphs and algorithms topics (including appropriate elements of graph theory) within representative computing, information, and communications engineering applications. Principles will be applied through programming projects solving representative problems drawn from data networking and other applications. Cross-listed with: CPE 593

NIS 599 Curricular Practical Training

This course involves an educationally relevant practical industry project experience that augments the academic content of the student's program. Students engage in a project in industry that is relevant to the focus of their academic program. This project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit a final written report, and present a summary of his/her activities by means of a powerpoint presentation that will both be graded. This is a one-credit course that may be repeated up to a total of three credits.

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NIS 602 Applied Discrete Mathematics for Engineers

This is an introductory course for engineers. Topics that will be covered include principles of counting, set theory, mathematical induction, analysis of algorithms and complexity, relations, recurrent relations, graph algorithms, combinatorial design, software tools, applications to coding theory, network optimization, data compression, security, etc. Cross-listed with: CPE 602

NIS 604 Analytical Methods for Networks

This course is an introduction on modern information networks with an emphasis on providing the student with the mathematical background and required analytical skills for performance analysis of information networks protocols. The material concentrates mostly on the bottom three layers of the protocol stack, focusing on delay and throughput analysis. Topics covered include an overview of the OSI layering model, data link layer issues, medium access control, queueing analysis, mathematical models for routing in broadcast and point-to-point networks, and flow and congestion control. Crosslisted with: CPE 604

NIS 605 Probability and Stochastic Processes I

Axioms of probability; discrete and continuous random vectors; functions of random variables; expectations, moments, characteristic functions, and momentgenerating functions; inequalities, convergence concepts, and limit theorems; central limit theorem; and characterization of simple stochastic processes: widesense stationality and ergodicity. Cross-listed with: EE 605

NIS 608 Applied Modeling and Optimization

Engineering, computational science and business students tackle various kinds of real-life optimization problems occurring in areas such as information theory, wireless communications, VLSI design, design and analysis of networks, optimal decision making etc. This course will provide a comprehensive coverage of several aspects of applied modeling and optimization. Complexity issues and numerical techniques (classical and non-classical techniques) to solve optimization problems will be the main thrust. Example problems arising in electrical engineering, computer engineering and business will be extensively used to illustrate the different optimization algorithms. This course will be computer projects based. Software packages such as MAPLE, MATLAB, CPLEX etc. will be used. Cross-listed with: CPE 608, EE 608

NIS 609 **Communications Theory**

Review of probability theory with applications to digital communications, digital modulation techniques, receiver design, bit error rate calculations, bandwidth efficiency calculations, convolutional encoding, bandwidth efficient coded modulation, wireless fading channel models, and shannon capacity, software simulation of communication systems. Cross-listed with: EE 609

NIS 610 Error Control Coding for Networks

Error-control mechanisms; elements of algebra; linear block codes; linear cyclic codes; fundamentals of convolutional codes; Viterbi decoding codes in mobile communications; Trellis-coded modulation; concatenated coding systems and turbo codes; BCH codes; Reed-Solomon codes; implementation architectures and applications of RS codes; and ARQ and interleaving techniques. Cross-listed with: EE 610

NIS 611 **Digital Communications Engineering**

Waveform characterization and modeling of speech/image sources; quantization of signals; uniform, nonuniform and adaptive quantizing; pulse code modulation (PCM) systems; differential PCM (DPCM); linear prediction theory, adaptive prediction; delta modulation and sigma-delta modulation systems; subband coding with emphasis on speech coding; data compression methods like Huffman coding, Ziv-Lempel coding and run length coding. Cross-listed with: EE 611

NIS 612 Principles of Multimedia Compression

Brief introduction to nformation theory; entropy and rate; Kraft-McMillan inequality; entropy codes - Huffman and arithmetic codes; scalar quantization- quantizer design issues, the Lloyd quantizer and the Lloyd-Max quantizer; vector quantization -LBG algorithm, other quantizer design algorithms; structured VQs; entropy constrained quantization; bit allocation techniques: generalized BFOS algorithm; brief overview of linear Algebra; transform coding: KLT, DCT, LOT; subband coding; wavelets; wavelet based compression algorithms (third generation image compression schemes)- EZW algorithm, the SPIHT algorithm and the EBCOT algorithm; video compression: motion estimation and compensation; image and video coding standards: JPEG/ JPEG 2000, MPEG, H.263, H.263+; Source coding and error resilience. Cross-listed with: EE 612

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NIS 619 **E-Commerce Technologies**

This course provides an understanding of electronic commerce and related architectures, protocols, and technologies. It describes the e-commerce concept, objectives, and market drivers, as well as its requirements and underpinning techniques and technologies, including the Internet, WWW, multimedia, intelligent agents, client-server relations, and data mining. Security in e-commerce is addressed, including types of security attacks, security mechanisms, Virtual Private Networks (VPNs), firewalls, intranets, and extranets. Implementation issues in e-commerce, including the design and management of its infrastructure and applications (ERP, CRM, and SCM), are discussed. M-commerce is addressed, electronic payment systems with their associated protocols are described, and various B2C and B2B applications are presented. Also, policy and regulatory issues in e-commerce are discussed. Cross-listed with: CPE 619, CS 619, TM 619, CS 619

NIS 626 **Optical Communication Systems**

Components for and design of optical communication systems; propagation of optical signals in single mode and multimode optical fibers; optical sources and photodetectors; optical modulators and multiplexers; optical communication systems: coherent modulators, optical fiber amplifiers and repeaters, transcontinental and transoceanic optical telecommunication system design; optical fiber LANs. Cross-listed with: EE 626, MT 626, PEP 626

NIS 630 Enterprise Systems Management

This course focuses on the role of information technology (IT) in reengineering and enhancing key business processes. The implications for organizational structures and processes, as the result of increased opportunities to deploy information and streamlining business systems are covered. Cross-listed with: MIS 710

(3 - 3 - 0)NIS 631 Management of Information Technology Organizations

The objective of this course is to investigate and understand the organizational infrastructure and governance considerations for information technology. It concentrates on developing students' competency in current/emerging issues in creating and coordinating the key activities necessary to manage the day-to-day IT functions of a company. Topics include: ITs key business processes, IT governance, organizational structure, value of IT, role of the CIO, outsourcing, systems integration, managing emerging technologies and change and human resource considerations.

NIS 632 Strategic Management of Information Technology

The objective of this course is to address the important question, "How to improve the alignment of business and information technology strategies?" The course is designed for advanced graduate students. It provides the student with the most current approaches to deriving business and information technology strategies, while ensuring harmony among the organizations. Topics include business strategy, business infrastructure, IT strategy, IT infrastructure, strategic alignment, methods/metrics for building strategies and achieving alignment. Cross-listed with: MIS 760

NIS 633 Integrating IS Technologies

This course focuses on the issues surrounding the design of an overall information technology architecture. The traditional approach in organizations is to segment the problem into four areas - network, hardware, data and applications. This course will focus on the interdependencies among these architectures. In addition, this course will utilize management research on organizational integration and coordination science. The student will learn how to design in the large, make appropriate choices about architecture in relationship to overall organization goals, understand the different mechanisms available for coordination and create a process for establishing and maintaining an enterprise architecture. Cross-listed with: MIS 730, MGT 784 Prerequisites: MIS 620, MIS 630 MIS 640

NIS 645 Image Processing and Computer Vision

The goal is to acquaint the students with the fundamental techniques of image processing. Specific topics include: Digital imaging fundamentals; neighborhood operators; clustering, region growing; split and merge, segmentation; edge and line linking; degradation model, restoration, inverse filtering; zero-crossing methods, gradient edge detectors; gray level cooccurrence, texture analysis; morphological operations; image registration and enhancement; scale space filtering; motion estimation;3D image recognition and estimation. Cross-listed with: CPE 645

Spread Spectrum and CDMA NIS 651

Basic concepts, models, and techniques; direct sequence frequency hopping, time hopping, chirp and hybrid systems, jamming game, anti-jam systems, and analysis of coherent and non-coherent systems; synchronization and demodulation; multiple access systems; ranging and tracking; and pseudo-noise generators. Cross-listed with: EE 651, EE 631

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NIS 653 Cross-Layer Design for Wireless Networks

Introduction to wireless networks and layered architecture, principles of cross-layer design, impact of cross-layer interactions for different architectures: cellular and ad hoc networks, model abstractions for layers in cross-layer design for different architectures (cellular and ad hoc networks), quality of service (QoS) provisioning at different layers of the protocol stack with emphasis on physical layer, medium access control (MAC) and network layers, examples of cross-layer design in the literature: joint optimizations involving beamforming, interference cancellation techniques, MAC protocols, admission control, power control, routing and adaptive modulation. Cross-listed with: EE 653

NIS 654 Design and Analysis of Network Systems

Analysis of current networks, including classic telephone, ISDN, IP, and ATM. Attributes and characteristics of highspeed networks. Principles of network design, including user-network interface, traffic modeling, buffer architectures, buffer management techniques, call processing, routing algorithms, switching fabric, distributed resource management, computational intelligence, distributed network management, measures of network performance, quality of service, selfhealing algorithms, and hardware and software issues in future network design. Cross-listed with: CPE 654

NIS 655 Queuing Systems with Communications Applications I (3 - 0 - 0)

Queuing models will be developed and applied to current problems in telecommunication networks and performance analysis of networked computer systems. Topics include elementary queuing theory, birth-death processes, open and closed networks of queues, priority queues, conservation laws, models for time-shared computer systems and computer communication networks. Cross-listed with: CPE 655, CS 655

NIS 656Queuing Systems with Computer Applications II(3 - 0 - 0)

This course is a continuation of NIS 655. Cross-listed with: CPE 656, CS 656 Prerequisites: NIS 655

NIS 672 Game Theory for Wireless Networks

Part I: Introduction to game theory: games in strategic form and Nash equilibrium, existence and properties of Nash equilibrium, Pareto efficiency, extensive form games, repeated games, Bayesian games and Bayesian equilibrium, types of games and equilibrium properties, learning in games. Part II: Applications for wireless networks: resource allocation, enforcing cooperation in ad hoc networks, cognitive radios. Cross-listed with: EE 672

NIS 674 Satellite Communications

Overview of communication theory, modulation techniques, conventional multiple access schemes and SS/TDMA; satellite and frequency allocation, analysis of satellite link, identification of the parameters necessary for the link calculation; modulation and coding; digital modulation methods and their comparison; error correction coding for the satellite channel including Viterbi decoding and system performance; synchronization methods, carrier recovery; effects of impairment on the channel.

NIS 678 Information Networks I

CpE 678 Information Networks I is the first of two courses on modern computer networks. Its focus is the physical and data link levels of the OSI layers. It traces the evolution of client/server computing to the Internet. Topics covered include OSI layering, TCP/IP overview, the application of Shannon's and Nyquist's bandwidth theorem's, Discrete Wave Division Multiplexing, wireless transmission, local loops, QAM, TDM, SONET/SDH, circuit switching, ATM switching, knockout switch, ISDN, ATM, framing, error detection and correction, CRC, ARQ protocol, sliding window protocols, finite state machines, Universal Modeling Language, PPP, ALOHA, CSMA, LANs, fast and gigabit Ethernet, Bridges and FDDI. A significant amount of time is spent on designing 802.3 LANs. Cross-listed with: CPE 678

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NIS 679 Computer and Information Networks

Learn the technologies that make the Internet work. You will understand the IP and TCP protocols and their interaction. You will study TCP slow start in low noise and high noise environments, the use of proxy servers, web caching and gain understanding of the technologies used to make routers perform well under load. These include shortest path routing, new routing algorithms, TCP congestion control, leaky bucket and token bucket admission Control, weighted fair queuing and random early detection of congestion. Networks are described in terms of their architecture, transport, routing, and their management. Quality of Service issues (QoS) are integrated with communication models. The course requires problem solving and extensive reading on network technology. After an introduction to bridges, gigabit Ethernet, routing and the Internet Protocol, a fundamental understanding of shortest path and distance vector routing is taught. A 'problem/solution' approach is used to develop how and why the technology evolved to keep engineering tradeoffs in focus. Continuation of Information Networks I with a focus on the network and transport layers of the OSI layers. Protocol definitions for distributed networks and performance analysis of various routing protocols including Bellman-Ford, BGP, and OSPF. TCP over IP is discussed Other topics include pipelining, broadcast routing, congestion control and reservations, Leaky and Token Bucket algorithms, weighted fair queuing, tunneling, firewalls, Ipv4 and IPv6. Network layers in SAN including the different service categories are discussed. The TCP and UDP transport protocols are discussed in depth along with network security, DNS, SAN, SLIP, firewalls and naming. Cross-listed with: CPE 679

NIS 691 Information Systems Security

History of network security; classical infosec; cryptosecurity; Kerberos for IP networks; private and public keys; nature of network security; fundamental framework for network security; security on demand in ATM networks; analysis and performance impact of ATM network topology; security in IVCC; vulnerabilities and security attack models in ATM, IP and mobile wireless networks; intrusion detection techniques - centralized and distributed; emulation of attack models and performance assessment through behavior modeling and asynchronous distributed simulation; principles of secure network design in the future; projects in network security and invited guest lecturers. Cross-listed with: CPE 691

NIS 700 Seminar in Networked Information Systems (0 - -)

An ECE seminar on topics of current interest.

NIS 765 Selected Topics in Networked Information Systems (3 - 3 - 0)

A participating seminar on topics of current interest and importance in Networked Information Systems.

NIS 770 Economics of Networks

This course analyzes the economics of networks and communications services. Theoretical and practical aspects of the subject will be covered based on three pillars: Technologies, Economics/Pricing, and Special Topics (auctions, trading bandwidth, and regulation). Communications technologies are reviewed, e.g., Internet, ATM, Wireless. The course then provides in depth analysis of the economics of monopoly, oligopoly and perfectly competitive markets, as applied to the telecom markets. Pricing alternatives are formalized using simple mathematical models. Students learn how network control and performance of networks relate to the costs of service delivery and the economic analysis of consumer decision making. Special topics related to game theory, risk management of telecom operations, trading of bandwidth as well as auctions of bandwidth and spectrum are covered towards the end of the course. Cross-listed with: TM 770 Prerequisites: TM 605, TM 610

NIS 800Special Problems in Networked Information Systems(1 - -)

An investigation of a current research topic at the pre-master's level, under the direction of a faculty member. A written report, which should have the substance of a publishable article, is required. Students with no practical experience who do not write a master's thesis are invited to take advantage of this experience.

NIS 810 Special Topics in Networked Information Systems (3 - -)

A participating seminar on topics of current interest and importance in Networked Information Systems.

NIS 900 Thesis in Networked Information Systems (M.Eng.) (1 to 6 - -)

A thesis of significance to be filed in libraries, demonstrating competence in a research area of electrical engineering. Hours and credits to be arranged.

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Department of Mathematical Sciences

FACULTY

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Alexander Ushakov, Ph.D. Assistant Professor

Michael Zabarankin, Ph.D. Associate Professor

UNDERGRADUATE PROGRAMS

Bachelor of Science in Mathematics

The Bachelor of Science in Mathematics offers a broad background appropriate for students planning to pursue a job in industry, while also offering students the depth and rigor required for graduate studies in mathematics or related fields.

The curriculum satisfies the core Bachelor of Science curriculum that includes certain breadth requirements in mathematics, physics, chemistry, biology, computer science, the humanities and social sciences. In addition to this science core, the student completes twelve upper-level mathematics courses (called technical electives). Some of these technical courses are prescribed by the program as being foundational to an undergraduate degree in mathematics. The remaining technical electives are chosen by the student in consultation with his/her academic advisor. In some cases courses from other departments can be substituted as technical electives with the approval of the undergraduate advisor. The program also includes two general electives which can be applied toward a minor or a second major in another discipline. Entering freshmen mathematics majors are expected to enroll in the seminar course MA 188 once they have completed the Calculus I requirement. Students interested in taking computer science courses beyond the minimum requirement should plan to take Discrete Mathematics, MA 134, no later than Term 3. Writing a senior thesis is strongly recommended, especially for students interested in pursuing graduate studies. As early as possible, students should discuss with the academic advisor how best to use the electives to focus the program on a particular area of mathematics.

The link to the mathematics curriculum takes you to a recommended study plan. The courses do not need to be taken in exactly the order listed. See the Department of Mathematics Web page for information on when particular courses are offered. There are additional notes at the end of the study plan regarding recommended electives and possible course substitutions. Mathematics majors are required to submit an approved study plan in Term 2.

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 111	Mechanics	3	0	6	3
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CS 105	Introduction to Scientific Computing ¹	2	2	6	3
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	15	5	33	17

Mathematics Curriculum

Term I

Term II					
Course #	Course Name	Lecture	Lab	Study	Credit
PEP 112	Electricity and Magnetism	3	0	6	3
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
BIO 281	Biology and Biotechnology	3	0	6	3
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	16	3	33	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
MA 221	Differential Equations	4	0	8	4
PEP 221	Physics Lab I for Scientists	0	3	1	1
BT	Economics ³	3	0	6	3
G.E.	General Elective ⁵	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	13	5	27	14

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
MA 222	Probability and Statistics	3	0	6	3
PEP 222	Physics Lab II for Scientists	0	3	1	1
E 234	Thermodynamics (or CH 321)	3	0	6	3
MA 227	Multivariable Calculus	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	12	5	25	13

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
MA 331	Intermediate Statistics	3	0	6	3
MA 232	Linear Algebra	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	12	2	24	12

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Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
PEP 242	Modern Physics	3	0	6	3
MA 336	Modern Algebra	3	0	6	3
MA 346	Numerical Methods	3	0	6	3
MA 234	Complex Variables with Applications	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	2	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
MA 441	Introduction to Mathematical Analysis	3	0	6	3
MA 410	Differential Geometry	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
	Total	12	0	24	12

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
G.E. 2	General Elective ⁵	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
	Total	15	0	30	15

(1) Students may choose CS 115, Intro. to Computer Science, in place of CS 105.

(2) Technical Elective. Preapproved choices (Fall: MA 360, 410, 450, 498), (Spring: MA 230, 335, 361, 442, 499), MA 134, MA 463, 503.

(3) Economics: Either BT 243 (Macro) or BT 244 (Micro). The second economics course can be used as 200-level Humanities elective.(4) Humanities electives can be found on pages 556-557.

(5) General elective: Chosen by the student. Any approved 3 credit course. Typical examples: courses used to fulfill minor requirements, language courses, course taken during an international experience.

Minor in Mathematics

A minor in mathematics can be a valuable qualification for students concentrating in other areas. A student wishing to pursue a minor in mathematics must complete a Minor Program Study Plan signed by the department advisor for mathematics, and meet the School of Engineering and Science requirements for minor programs.

Required courses for a Minor in Mathematics:

- MA 221 Differential Equations
- MA 227 Multivariable Calculus
- MA 222 Probability and Statistics
- MA 232 Linear Algebra

- MA 234 Complex Variables with Applications
- One elective at 300 or above chosen with the consent of the Department advisor.

Course substitutions are possible with the approval of the department advisor. Typical substitutions are Multivariable Calculus & Optimization, MA 230, in place of MA 227 and the Probability & Statistics course used in the engineering curriculum, E-243, in place of MA 222.

Completion of Calculus II (MA-124 or MA-116) is a prerequisite for undertaking the minor program:

Interdisciplinary Program in Computational Science

Computational Science is an emerging field which emphasizes the use of sophisticated computational techniques and algorithms for solving complex and difficult problems related to science and engineering. At Stevens, undergraduates may study computational science through an interdisciplinary program leading to a Bachelor of Science in Computational Science with a specialization in an area of science or engineering. The program combines theory and techniques from mathematics, mathematical modeling, computer science and coding with knowledge and experience in a particular application area of science or engineering. It complements existing theoretical and experimental approaches and may be thought of as a new mode of scientific inquiry.

The program consists of the same science curriculum core courses as the mathematics program along with the twelve technical electives. Computational Science majors will take CS 115 as the computer science requirement since this course is a prerequisite for additional CS courses required in the program. The technical electives are divided between foundation courses in mathematics and computer science, and at least five application courses in the student's area of specialization. An important part of the program is a project or research problem to be done in the senior year so the five application area prior to preparing his/her study plan. Each student's study plan reflects his/her interests and aspirations, and is made up by the student, working with an advisor from the application area. Interested students should consult with the undergraduate program director in the Department of Mathematical Sciences for further information.

The link to the computational science curriculum shows a recommended study plan including the core and foundation courses. Courses need not be taken in exactly the order shown in the curriculum. Specific choices for the application area are made in consultation with the student's academic advisor from Mathematical Sciences and a co-advisor from another department with expertise in the application area.

Typical areas of specializations include:

- Computational Chemistry
- Computational Mechanics
- Computational Oceanography
- Computational Physics
- Computer Vision and Computer Graphics
- ▶ Cybersecurity
- Environmental Systems

Interdisciplinary Program in Computational Science Curriculum

Term I					
Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CS 115	Introduction to Computer Science	3	2	8	4
PEP 111	Mechanics	3	0	6	3
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	16	5	35	18

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
BIO 281	Biology and Biotechnology	3	0	6	3
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	16	3	33	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
MA 134	Discrete Mathematics (or CS 135)	3	0	6	3
PEP 221	Physics Lab I for Scientists	0	3	1	1
	Humanities ³	3	0	6	3
CS 284	Data Structures	2	2	8	4
PE 200	Physical Education I	0	2	0	0
	Total	12	7	29	15

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
MA 227	Multivariable Calculus	3	0	6	3
E 234	Thermodynamics (or CH 321)	3	0	6	3
PEP 222	Physics Lab II for Scientists	0	3	1	1
	Humanities ³	3	0	6	3
MA 222	Probability and Statistics	3	0	6	3
CS 385	Algorithms	4	0	8	4
PE 200	Physical Education II	0	2	0	0
	Total	16	5	33	17

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
MA 232	Linear Algebra	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
	Humanities ³	3	0	6	3
BT	Economics ¹	3	0	6	3
MA 331	Intermediate Statistics	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	2	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 242	Modern Physics	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
	Humanities ³	3	0	6	3
MA 346	Numerical Methods	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	12	2	24	12

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
MA 498	Senior Research Project I	0	8	4	3
T.E.	Technical Elective ²	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
	Humanities ³	3	0	6	3
	Total	9	8	22	12

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
MA 499	Senior Research Project II	0	8	4	3
T.E.	Technical Elective ²	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
	Humanities ³	3	0	6	3
	Total	9	8	22	12

(1) Economics: Either BT 243 (Macro) or BT 244 (Micro). The second economics course can be used as 200-level Humanities elective Technical Elective.

(2) Technical Electives. These courses will be in the student's area of specialization and are selected in consultation with the academic advisors.

(3) Humanities electives can be found on pages 556-557.

(4) General elective - Any approved 3 credit course. Typical examples: courses used to fulfill minor requirements, language courses, courses taken during an international experience.

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Graduation Requirements

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirements

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

GRADUATE PROGRAMS

Admission Criteria and Application Requirements

Applications to all graduate programs, degree and certificate, must be prepared and submitted according to the Stevens Office of Graduate Admissions regulations. Instructions and forms may be found on the Graduate Admissions web site. Notice that the procedure is different for domestic and international applicants. The following sections describe requirements specific to graduate programs in the Department of Mathematical Sciences.

Master Degree and Certificate Programs

Adequate undergraduate preparation for admission to any master degree or certificate program includes analytic geometry and calculus, elementary differential equations, one semester of linear algebra, and one semester of probability or probability and statistics. It is possible to be admitted with the requirement that you make up a deficiency in preparation. Applications to any master degree or certificate program should include

- ▶ Two letters of recommendation
- Official transcripts and diplomas. For non-English speaking institutions, these documents must be accompanied by a certified English translation
- GRE General Test scores
- ▶ TOEFL score for international students

Master of Science - Applied Mathematics

This program provides a background in mathematical techniques which are useful in solving practical problems in science and engineering. There are six core courses which provide a foundation in analysis and differential equations, linear algebra, probability and numerical techniques. The elective courses should be chosen to provide a particular concentration or specialization to the program. Students are encouraged to consider courses from other departments that are relevant to the particular concentration.

The program requires 30 credits (10 courses) of coursework. You may transfer up to one-third of this amount from outside Stevens. If you know the material in one of the required courses, you may substitute another course. Requests for transfer credit or course substitution will need approval from the department and must be accompanied by evidence of the course content. Courses from other departments can also be applied to your program. All elective courses must be chosen with the consent of a department academic advisor.

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Core Courses

- MA 547 Advanced Calculus I or MA 635 Real Variable I
- MA 552 Linear Algebra
- MA 611 Probability
- MA 615 Numerical Analysis I
- MA 649 Intermediate Differential Equations or MA 650 Partial Differential Equations
- MA 681 Functions of a Complex Variable I

Typical Electives

- MA 548 Advanced Calculus II
- MA 612 Mathematical Statistics
- MA 620 Intro to Network & Graph Theory
- MA 623 Stochastic Processes
- MA 627 Combinatorial Analysis
- MA 629 Nonlinear Optimization
- MA 631 Calculus of Variations
- MA 635 Real Variables I
- MA 641 Time Series Analysis I
- MA 649 Intermediate Differential Equations
- MA 650 Intermediate Partial Differential Equations
- MA 651 Topology I
- MA 653 Numerical Solutions of Partial Diff. Eqs
- MA 661 Dynamic Programming & Stochastic Optimal Control
- MA 711 Inverse Problems in Science & Engineering
- MA 712 Mathematical Models of Risk
- MA 800 Special Problems in Mathematics (MS)
- MA 810 Special Topics in Mathematics

Master of Science - Mathematics

A master's degree in mathematics requires 30 credits of coursework, including the following core courses:

Core Courses

- MA 552 Linear Algebra
- MA 605 Foundations of Algebra I
- MA 611 Probability
- MA 635 Real Variables I

- MA 651 Topology I
- MA 681 Functions of a Complex Variable I

Typical Electives

- MA 606 Foundations of Algebra II
- MA 620 Intro to Networks & Graph Theory
- MA 623 Stochastic Processes
- MA 627 Combinatorial Analysis
- MA 629 Nonlinear Optimization
- MA 631 Calculus of Variations
- MA 636 Real Variables II
- MA 649 Intermediate Differential Equations
- MA 650 Intermediate Partial Differential Equations
- MA 717 Algebraic Topology
- MA 800 Special Problems in Mathematics (MS)
- MA 810 Special Topics in Mathematics

Master of Science - Stochastic Systems

This program focuses on analysis and optimal decision-making for complex systems involving uncertain data and risk. The program includes courses in statistics, stochastic processes, stochastic optimization, and stochastic optimal control theory. Applications to financial systems, network design and routing, telecommunication systems, medicine, actuarial mathematics, and other areas are discussed. Students are encouraged to apply the techniques they learn to problems derived from their professional work and interests.

Ten courses are required for the degree; six are core courses. Elective courses are chosen with the consent of the student's academic advisor.

Core Courses

- MA 547 Advanced Calculus or MA 635 Real Variables I
- MA 611 Probability
- MA 612 Mathematical Statistics
- MA 623 Stochastic Processes
- MA 629 Nonlinear Optimization
- MA 661 Stochastic Optimal Control & Dynamic Programming

Typical Electives

- MA 615 Numerical Analysis I
- MA 630 Advanced Optimization Methods
- MA 631 Calculus of Variations

- MA 632 Game Theory
- MA 635 Real Variables I
- MA 641 Time Series Analysis I
- MA 655 Optimal Control
- MA 662 Stochastic Optimization
- MA 711 Inverse Problems in Science & Engineering
- MA 720 Multivariate Statistics
- MA 711 Inverse Problems in Science & Engineering
- MA 712 Mathematical Models of Risk
- MA 800 Special Problems in Mathematics (MS)
- MA 810 Special Topics in Mathematics

Doctoral Program

Admission Requirements

Admission to the doctoral program requires the preparation specified above. If your goal is a Ph.D., you should apply directly to the doctoral program and not to a master's program. In order to receive full consideration, applications to the doctoral program should be received by February 15 for admission in the Fall Semester, and October 15 for admission in the spring semester. Because of constraints due to course scheduling, admission for the spring semester is not always feasible and may depend on the student's preparation. In addition, financial aid is usually not available for students admitted in the spring semester. Applicants requesting financial aid should apply by February 15 and clearly state that such aid is being requested.

Applications to the doctoral program should include the following items, all of which enter into the Graduate Program Committee's evaluation of applicants:

- A personal statement that, in a succinct manner, describes the student's reasons for pursuing a Ph.D., prior classroom and research experience in mathematics, and current mathematical interests. This should not exceed two pages.
- Official transcripts and diplomas. For non-English-speaking institutions, these documents must be accompanied by a certified English translation.
- Letters of recommendation: at least two; at most, four.
- GRE General Test scores (Math Subject Test recommended).

Financial Aid

The department supports a limited number of Ph.D. students through teaching assistantships which entitle the recipients to a salary and a waiver of their tuition costs. Teaching assistants are considered for renewal each year, depending on the student's progress towards graduation and performance evaluations as a teaching assistant. Save for exceptional cases, financial support from Stevens is limited to four years beyond the Master's degree. Assistantships are usually available only for students entering in the fall.

Students who wish to be considered for a teaching assistantship beginning their first year should mention this in their Personal Statement. Students with prior teaching experience are encouraged to submit additional documentation that addresses their teaching skills, such as letters of recommendation, evaluation forms, teaching awards, etc. However, no teaching experience is required for an incoming student to be considered for a teaching assistantship.

Degree Requirements

The primary requirement for a doctoral degree in mathematics is that you produce a dissertation containing an original and significant result in mathematics. You will work under the guidance of a faculty advisor who is an expert in your area of research.

Preparation for dissertation work includes both courses in mathematical fundamentals and practice in communicating mathematics orally and in writing. The courses you take will not necessarily include everything you will need to know. As a doctoral student you will be expected to learn some mathematics on your own outside of class. Seminars afford a means to that end. They can be organized informally among students or more formally with a faculty advisor. Seminars of the latter type may be taken for academic credit. Students are encouraged to identify subjects they would like to study and to seek out faculty advisors.

Coursework and Credits

The doctoral program requires 84 credits beyond the bachelor's degree (54 credits beyond the master's) of which at least 30 credits must be approved doctoral research credits (MA 960). This credit total includes the three-credit "Signature" course, PRV961. A prior master's degree may be transferred for up to 30 credits without specific course descriptions and with approval of the department and the Dean of Graduate Academics. Up to one-third of additional course credits may be transferred with the approval of the thesis committee and the Dean of Graduate Academics. The grade of "B" (3.0 GPA) or better is required for such courses and such courses may not have been already used to obtain an academic degree.

General Exam

This is a written exam covering three subject areas, one of which must be real analysis. The elective subjects consists of two-semester sequences such as probability and statistics, algebra I and algebra II, nonlinear optimization and advanced methods of optimization, complex analysis and differential equations. Other subject choices are possible with the approval of the Graduate Program Committee. The exam is offered once each semester. The General Exam should be attempted within the first year of completing the masters degree or within the first year of study for students entering with a prior masters degree. One failure of the General Exam is allowed. A second failure will result in the student being dropped from the Ph.D. program. After passing the General Exam a student is officially recognized as a Ph.D. candidate.

Dissertation Advisory Committee

Within six months of becoming a doctoral candidate, the student needs to select a Research Advisor and agree upon a research topic. The Research Advisor assists with recommending additional members for the student's Dissertation Advisory Committee.

Refer to the Graduate Student Handbook for further details on the requirements and process for approving the Advisory Committee.

Dissertation

The final and most important step of the Ph.D. program is writing a dissertation of publishable quality. This will embody the results of the student's original research in mathematics, and the dissertation will be presented by the student at a public defense. If the suitably appointed Dissertation Committee approves the defense, the student will be recommended to the Office of Graduate Academics for the Ph.D. degree.

Graduate Certificates

The Mathematical Science department offers graduate certificates in Applied Statistics and Stochastic Systems. Each program consists of four courses, including one elective chosen with the consent of the departmental advisor. Most courses may be used toward a master's degree, as well as for the certificate.

The admissions requirements for certificate programs are the same as for the master degree as described above. The course requirements are listed below.

Applied Statistics

- MA 552 Linear Algebra
- MA 611 Probability
- MA 612 Mathematical Statistics

Typical Electives

- MA 623 Stochastic Process
- MA 641 Time Series Analysis I
- MA 712 Mathematical Models of Risk

Stochastic Systems

- MA 611 Probability
- MA 612 Mathematical Statistics
- MA 629 Nonlinear Optimization

Typical Electives

- MA 623 Stochastic Process
- MA 630 Advanced Optimization Methods
- MA 632 Game Theory
- MA 661 Stochastic Optimal Control & Dynamical Programming
- MA 662 Stochastic Optimization
- MA 712 Mathematical Models of Risk

COURSE OFFERINGS

Mathematics

MA 090 Pre-Calculus

Partial fractions, polynomials, Remainder Theorem, Fundamental Theorem of Algebra, Descartes' Rule, exponential and log functions, trigonometric functions, trigonometry of triangles, right triangles, laws of sines and cosines, and conic sections.

MA 115 Calculus I

An introduction to differential and integral calculus for functions of one variable. Begins with limits and continuity, and ends with integration techniques and applications of the definite integral. As of Fall 2012, MA 115 is replaced by the sequence MA 121 and MA 122.

MA 116 Calculus II

Improper integrals, infinite series. Taylor series, vector operations in 3D, calculus for functions of two and three variables including graphical representations, partial derivatives, the gradient, optimization, iterated integrals in rectangular and polar coordinates and applications of double integrals. As of Spring 2013 MA116 is replaced by the sequence MA123 and MA124.

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Limits, the derivatives of functions of one variable, differentiation rules, and applications of the derivative. Definite integrals for functions of one variable, antiderivatives, the Fundamental Theorem, integration techniques, and applications of the integral.

MA 119 Multivariable Calculus & Finite Mathematics

Calculus for Business and Liberal Arts

The first third of this course introduces students to calculus for functions of several variables and requires that students are familiar with the main results and techniques from one-variable calculus. The applied problems emphasize optimization problems for functions of two and three variables. The second part of the course reviews the use of matrices in representing systems of linear equations and then returns to the theme of optimization with an introduction to Linear Programming. The final third of the course teaches set notation and theory, basic counting principles, and an introduction to discrete probability. Throughout the course, motivating examples are drawn from applications in business, engineering, and the social sciences. Prerequisites: MA 117 or MA 122 or MA 115

MA 120 Introduction to Calculus

The first part of the course reviews algebra and precalculus skills. The second part of the course introduces students to topics from differential calculus, including limits, rates of change and differentiation rules. This is a seven week course.

MA 121 Differential Calculus

MA 117

Limits, the derivatives of functions of one variable, differentiation rules, applications of the derivative. This is a seven week course. Prerequisites: MA 120

MA 122 Integral Calculus

Definite integrals of functions of one variable, antiderivatives, the Fundamental Theorem, integration techniques, improper integrals, applications. This is a seven week course. Prerequisites: MA 121

(2 - 4 - 0)MA 123 Series, Vectors, Functions, and Surfaces Taylor polynomials and series, functions of two and three variables, linear functions, implicit functions, vectors in two and

three dimensions. This is a seven week course. Prerequisites: MA 122 or MA 115

MA 124 Calculus of Two Variables

Partial derivatives, the tangent plane and linear approximation, the gradient and directional derivatives, the chain rule, implicit differentiation, extreme values, application to optimization, double integrals in rectangular coordinates. This is a seven week course. Prerequisites: MA 123

MA 134 **Discrete Mathematics**

This course provides the background necessary for advanced study of mathematics or computer science. Topics include propositional calculus, predicates and quantifiers, elementary set theory, countability, functions, relations, proof by induction, elementary combinatorics, elements of graph theory, mends, and elements of complexity theory.

MA 188 Seminar in Mathematical Sciences

Selected topics in the Mathematical Sciences and applications of mathematics. Topics typically reflect the research interests of the department faculty. The course may be repeated for credit. Pass/Fail.

MA 221 **Differential Equations**

Ordinary differential equations of first and second order, homogeneous and non-homogeneous equations; improper integrals, Laplace transforms; review of infinite series, series solutions of ordinary differential equations near an ordinary point; boundary-value problems; orthogonal functions; Fourier series; separation of variables for partial differential equations. Prerequisites: MA 124 or MA 116

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MA 222 **Probability and Statistics**

Introduces the essentials of probability theory and elementary statistics. Lectures and assignments greatly stress the manifold applications of probability and statistics to computer science, production management, quality control, and reliability. Contents include: descriptive statistics, pictorial and tabular methods, and measures of location and of variability; sample space and events, probability axioms, and counting techniques; conditional probability and independence, and Bayes' formula; discrete random variables, distribution functions and moments, and binomial and Poisson distributions; continuous random variables, densities and moments, normal, gamma, and exponential and Weibull distributions unions; distribution of the sum and average of random samples; the Central Limit Theorem; confidence intervals for the mean and the variance; hypothesis testing and p-values, and applications for the mean; simple linear regression, and estimation of and inference about the parameters; and correlation and prediction in a regression model. Prerequisites: MA 124 or MA 116

MA 227 Multivariable Calculus

Review of matrix operations, Cramer's rule, row reduction of matrices; inverse of a matrix, eigenvalues and eigenvectors; systems of linear algebraic equations; matrix methods for linear systems of differential equations, normal form, homogeneous constant coefficient systems, complex eigenvalues, nonhomogeneous systems, the matrix exponential; double and triple integrals; polar, cylindrical and spherical coordinates; surface and line integrals; integral theorems of Green, Gauss and Stokes. Prerequisites: MA 124 or MA 116 Corequisites: MA 221

MA 230 Multivariable Calculus and Optimization

This course starts with some fundamental notions in multivariate analysis and geometry as well as basic notions and results of convex analysis: (gradient, Jacobian and Hessian, closed and open sets, convex sets, convex hulls, convex cones, polyhedral sets, convex functions, and convexity criteria). These notions are used to present the theory and methods of nonlinear optimization: necessary and sufficient conditions of optimality for nonlinear optimization problems with and without constraints, and duality theory. Numerical methods for unconstrained and constrained problems with differentiable functions include, gradient methods, Newton method, conjugate gradients, gradient projection, reduced gradient, simplex method, penalty methods, dual methods. Optimization problems from statistics, engineering, and business will serve as examples. Prerequisites: MA 124 or MA 116

MA 232 Linear Algebra

This course introduces basic concepts of linear algebra from a geometric point of view. Topics include the method of Gaussian elimination to solve systems of linear equations; linear spaces and dimension; independent and dependent vectors; norms, inner product, and bases in vector spaces; determinants, eigenvalues and eigenvectors of matrices; symmetric, unitary, and normal matrices; matrix representations of linear transformations and orthogonal projections; the fundamental theorems of linear algebra; and the least-squares method and LU-decomposition. Prerequisites: Sophomore or higher class standing.

MA 234 **Complex Variables with Applications**

An introduction to functions of a complex variable. The topics covered include complex numbers, analytic and harmonic functions, complex integration, Taylor and Laurent series, residue theory, and improper and trigonometric integrals. Prerequisites: Corequisites: MA 227

MA 236 Introduction to Mathematical Reasoning

This course introduces students to first order logic and to fundamental discoveries about the nature and limits of mathematics which have emerged in the last hundred years. The course begins with a concrete treatment of first order logic and culminates with the unsolvability of the halting problem and the Church-Turing Theorem on the undecidability of first order logic.

Honors Mathematical Analysis III MA 281

Covers the same material as that dealt with in MA 221, but with more breadth and depth. Prerequisites: MA 182

MA 282 Honors Mathematical Analysis IV

Covers the same material as that dealt with in MA 227, but with more breadth and depth. By invitation only.

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MA 293 Supplementary Topics of Differential Equations

This course is designed for the completion of transferring credits for MA 221 Differential Equations. The transfer students, who need to learn some topics of MA 221 not included in the courses taken elsewhere, may enroll in this course only once with permission of an undergraduate adviser in the Math Department, and are required to complete this course under the guidance of the MA 221 course coordinator. The students who pass this course will receive the full transfer credits for MA 221. The students who fail will then be required to enroll in the full course of MA 221 at Stevens. Pass/Fail.

MA 294 Supplementary Topics of Calculus IV

This course is designed for the completion of transferring credits for MA 227 Multivariable Calculus. The transfer students, who need to learn some topics of MA 227 not included in the courses taken elsewhere, may enroll in this course only once with permission of an undergraduate adviser in the Math Department. The students are required to complete this course under the guidance of the MA 227 course coordinator. The students who pass this course will receive the full transfer credits for MA 227. The students who fail will then be required to enroll in the full course of MA 227 at Stevens. Pass/Fail.

MA 331 Intermediate Statistics

An introduction to statistical inference and to the use of basic statistical tools. Topics include descriptive and inferential statistics; review of point estimation, method of moments, and maximum likelihood; interval estimation and hypothesis testing; simple and multiple linear regression; analysis of variance and design of experiments; and nonparametric methods. Selected topics, such as quality control and time series analysis, may also be included. Statistical software is used throughout the course for exploratory data analysis and statistical inference based in examples and in real data relevant for applications. Prerequisites: MA 222 or E 243

MA 335 Introduction to Number Theory

This is an introductory course to number theory. Topics include divisibility, prime numbers and modular arithmetic, arithmetic functions, the sum of divisors and the number of divisors, rational approximation, linear Diophantine equations, congruences, the Chinese Remainder Theorem, guadratic residues, and continued fractions.

MA 336 Modern Algebra

A rigorous introduction to group theory and related areas with applications as time permits. Topics include proof by induction, greatest common divisor, and prime factorization; sets, functions, and relations; definition of groups and examples of other algebraic structures; and permutation groups, Lagrange's Theorem, and Sylow's Theorems. Typical application: error correcting group codes.

MA 346 Numerical Methods

This course begins with a brief introduction to writing programs in a higher level language, such as Matlab. Students are taught fundamental principles regarding machine representation of numbers, types of computational errors, and propagation of errors. The numerical methods include finding zeros of functions, solving systems of linear equations, interpolation and approximation of functions, numerical integration and differentiation, and solving initial value problems of ordinary differential equations. Prerequisites: MA 124 or MA 116

Intermediate Differential Equations MA 360

This course offers more in-depth coverage of differential equations. Topics include ordinary differential equations as finitedimensional dynamical systems; vector fields and flows in phase space; existence/uniqueness theorems; invariant manifolds; stability of equilibrium points; bifurcation theory; Poincaré-Bendixson Theorem and chaos in both continuous and discrete dynamical systems; and applications to physics, biology, economics, and engineering. Prerequisites: MA 221

MA 361 Intermediate Partial Differential Equations

This course offers a rigorous approach to classical partial differential equations. It begins with definitions, properties, and derivations of some basic equations of mathematical physics followed by the topics: solving of first order equations with the method of characteristics; classification of second order equations; the heat equation and wave equation; Fourier series and separation of variables; Green's functions and elliptic theory; examples of the first and second order nonlinear partial differential equations. Prerequisites: MA 221

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MA 410 **Differential Geometry**

This course is an introduction to the geometry of curves and surfaces. Topics include tangent vectors, tangent bundles, directional derivatives, differential forms, Euclidean geometry and calculus on surfaces, Gaussian curvatures, Riemannian geometry, and geodesics. Prerequisites: MA 227

MA 441 Introduction to Mathematical Analysis

This course introduces students to the fundamentals of mathematical analysis at an adequate level of rigor. Topics include fundamental mathematical logic and set theory, the real number systems, sequences, limits and completeness, elements of topology, continuity, derivatives and related theorems, Taylor expansions, the Riemann integral, and the Fundamental Theorem of Calculus. Prerequisites: MA 227

MA 442 **Real Variables**

This course introduces principles of real analysis and the modern treatment of functions of one and several variables. Topics include metric spaces, the Heine-Borel theorem in R-n, Lebesgue measure, measurable functions, Lebesgue and Stieltjes integrals, Fubini's theorem, abstract integration, L-p classes, metric and Banach space properties, and Hilbert space. Prerequisites: MA 232, MA 441

MA 450 Optimization models in finance

This course introduces the students to mathematical models and computational methods for static and dynamic optimization problems occurring in finance. The models involve knowledge of probability, optimality conditions, duality, and basic numerical methods. Special attention will be paid to portfolio optimization and to risk management problems. Prerequisites: MA 222, MA 230

MA 460 Chaotic Dynamics, with Computations and Applications (3 - 3 - 0)

This course introduces students to the concepts behind the modern theory of dynamical systems, particularly chaotic systems. Although the course is mathematical in nature, the emphasis is on the underpinning ideas and applications, rather than a systematic exposition of results. Topics include: standard examples and definitions, solutions of ODEs as dynamical systems, flows, and maps; fixed points of linear maps, periodic orbits, limit cycles, and asymptotic stability; rudiments of hyperbolicity; and symbolic dynamics and the Horse Shoe. Further topics may include: fundamentals of topological dynamics, fundamentals of ergodic theory, attractors, and fractals. A good part of the assigned work involves computer experimentation and computations. Prerequisites: MA 221, MA 232

MA 461	Special Problems I	(2)
Individual proi	acts in pure and applied mathematics	

Individual projects in pure and applied mathematics.

MA 462 Special Problems II

Individual projects in pure and applied mathematics.

MA 463 Seminar in Mathematics I (3 - 3 - 0)

Seminar in selected topics, such as: combinatorial topology, differential geometry, finite groups, number theory, or statistical techniques.

Seminar in Mathematics II MA 464

Seminar in selected topics such as: combinatorial topology, differential geometry, finite groups, number theory, or statistical techniques.

MA 498 Senior Research Project I

Students will do a research project under the guidance of a faculty advisor. Senior standing and prior approval are required. Topics may be selected from any area of mathematics with the instructor's approval. Each student will be required to present results in both a written and oral report. The written report may be in the form of a senior thesis.

MA 499 Senior Research Project II

Students will do a research project under the guidance of a faculty advisor. Senior standing and prior approval are required. Topics may be selected from any area of mathematics with the instructor's approval. Each student will be required to present results in both a written and oral report. The written report may be in the form of a senior thesis.

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natural logarithm; and probability density functions and integration by parts.

MA 502 Mathematical Foundations of Computer Science

Introduction to Mathematical Analysis

This course provides the necessary mathematical prerequisites for the computer science master's program and also serves as a foundation for further study in mathematics. The topics covered include prepositional calculus: predicates and quantifiers; elementary number theory and methods of proof; mathematical induction; elementary set theory; combinatorics; functions and relations; countability; recursion and O-notation. Applications to computer science are stressed.

This course is an introduction to the basic ideas of pre-calculus and calculus for the people who need preparation or review before taking more advanced courses. The exact content depends upon the particular needs of those enrolled and the requirements of degree programs they are pursuing. Topics covered will be selected from the following: algebra, functions,

MA 503 Discrete Mathematics for Cryptography

MA 501

Topics include basic discrete probability, including urn models and random mappings; a brief introduction to information theory; elements of number theory, including the prime number theorem, the Euler phi function, the Euclidean algorithm, and the Chinese remainder theorem; and elements of abstract algebra and finite fields including basic fundamentals of groups, rings, polynomial rings, vector spaces, and finite fields. Carries credit toward the Applied Mathematics degree only when followed by CS 668. Recommended for high-level undergraduate students. Cross-listed with: CS 503 Prerequisites: MA 502

MA 505 Introduction to Mathematical Methods (3 - 3 - 0)

Elementary mathematical techniques important to applied mathematics. Topics covered include review of functions and continuity; ordinary and partial derivatives; integration; ordinary and partial differential equations; infinite series and numerical techniques for solving differential equations; and multiple integration and surface integrals. Applications to problems of applied mathematics are given where feasible.

MA 525 Introduction to Computational Science (3 - 3 - 0)

This course is primarily for students interested in using numerical methods to solve problems in mathematics, science, engineering, and management. Computational projects will be a significant part of this course and it is expected that students already have experience programming in at least one high level language. Standard topics include numerical solutions of ordinary and partial differential equations, techniques in numerical linear algebra, the Fast Fourier Transform, optimization methods, and an introduction to parallel programming. Additional topics will depend on the interests of the instructor and students. Prerequisites: MA 232, MA 346

MA 529 Applied Mathematics for Engineers and Scientists I (3 - 3 - 0)

Review of limits, continuity, partial differentiation, Leibnitz's rule; implicit functions and Jacobians; gradients, divergence, curl, line and surface integrals; theorems of Stokes, Gauss and Green; complex numbers, elementary functions, analytic functions, complex integration, power series, residue theorem, evaluation of real definite integrals; systems of linear equations, rank, eigenvalues and eigenvectors. Prerequisites: MA 227

MA 530 Applied Mathematics for Engineers and Scientists II (3 - 3 - 0)

Review of first order and second order constant coefficient differential equations, nonhomogeneous equations; series solutions, Bessel and Legendre functions; boundary value problems, Fourier-Bessel series and separation of variables for partial differential equations; classification of partial differential equations; Laplace transform methods; calculus of variations; introduction to finite-difference methods. Prerequisites: MA 227

MA 534 Methods of Applied Mathematics

Difference equations; calculus of variations; integral equations; and applications to engineering and science. Prerequisites: MA 227

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and graphs; slopes and secant lines; derivatives; chain rule; optimization; curve sketching; integration; the exponential and

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MA 540 Introduction to Probability Theory

Sample space, events, and probability; basic counting techniques and combinatorial probability; random variables, discrete and continuous; probability mass, probability density, and cumulative distribution functions; expectation and moments; some common distributions; jointly distributed random variables, conditional distributions and independence, bivariate normal, and transformations of variables; and Central Limit Theorem. Some additional topics may include an introduction to confidence intervals and hypothesis testing.

MA 541 Statistical Methods

This course offers an introduction to exploratory data analysis and the use of basic statistical tools. Topics will include: data collection; descriptive statistics, and graphical and tabular treatment of quantitative, qualitative, and count data; detecting relations between variables; confidence intervals and hypothesis testing for one and two samples; simple and multiple linear regression; analysis of variance; design of experiments; and nonparametric methods. Selected topics, such as quality control and time series analysis, may also be included. Statistical software will be used throughout the course and statistical inference will be based on examples using real data. Students will participate in group projects of data analysis. They will be trained in the different phases of the professional statistician's work, namely: data collection, description, analysis, testing, and presentation of the conclusions. Prerequisites: MA 540

MA 547 Advanced Calculus I

Elementary topology of Euclidean spaces; differential calculus of functions of several variables; inverse and implicit function theorems; integration; differential forms; and theorems of Gauss, Green, and Stokes. Prerequisites: MA 227

MA 548 Advanced Calculus II

A continuation of MA 547, but with greater emphasis on mathematical rigor. Topics covered may include convergence of series, Riemann-Stieltjes integration, functions of bounded variation, metric spaces, introduction to measure theory, and functional analysis. Prerequisites: MA 547

MA 552 Axiomatic Linear Algebra

Fields and vector spaces; subspaces and quotient spaces; basis and dimension; linear transformations and matrices; determinants; and the theory of a single linear transformation.

MA 560 Special Topics in Mathematics

Special topics in mathematics not covered in regularly scheduled courses and suitable for both graduates and advanced undergraduates. May be taken more than once.

MA 570 **Calculus Review**

A review of calculus for students who have successfully completed two or more semesters of calculus but feel a bit rusty. Emphasis is placed on problem solving and on an intuitive understanding of basic concepts. This module is offered in various formats, all of which include substantial online content.

MA 571 **Differential Equations Review**

A review of differential equations for students who have completed an undergraduate course in differential equations. The course reviews the general theory of linear ODEs and analytical methods for deriving explicit solutions; use of numerical ODE solvers; two-point boundary value problems; separation of variables for linear partial differential equations (PDEs); eigenvalues, eigenfuctions and Fourier Series expansions.

MA 573 Linear Algebra Review

A review of linear algebra concepts and results for students who have successfully completed an undergraduate course in linear algebra or have been introduce to linear algebra concepts as a part of another undergraduate class.

Methods of Mathematical Physics I MA 603

A unified development of mathematical tools for treating a variety of problems in physics and engineering. Linear algebra, normed and inner product spaces, and spectral theory of operators; integral equations; boundary value problems for ordinary and partial differential equations; Green's functions; calculus of variations; and other related topics as time permits. Problem solving is stressed.

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MA 604 Methods of Mathematical Physics II

A unified development of mathematical tools for treating a variety of problems in physics and engineering; linear algebra, normed and inner product spaces, spectral theory of operators; integral equations; boundary value problems for ordinary and partial differential equations; Green's functions; calculus of variations; other related topics as time permits; problem solving is stressed.

MA 605 Foundations of Algebra I

Topics covered in the sequence MA 605-606 include: elementary number theory, basic group theory, Lagrange's theorem, isomorphism theorems, solvability, direct products, Jordan-Holder theorem, Sylow theorems, basic properties of rings, quotient rings, field of quotients of an integral domain, polynomial rings, factorization, elementary properties of fields, field extensions, and Galois theory.

Foundations of Algebra II MA 606

Topics covered in the sequence MA 605-606 include: elementary number theory, basic group theory, Lagrange's theorem, isomorphism theorems, solvability, direct products, Jordan-Holder theorem, Sylow theorems, basic properties of rings, quotient rings, field of quotients of an integral domain, polynomial rings, factorization, elementary properties of fields, field extensions, and Galois theory. Prerequisites: MA 605

MA 611 Probability

Foundations of probability, random variables and their distributions, discrete and continuous random variables, independence, expectation and conditioning, generating functions, multivariate distributions, convergence of random variables, and classical limit theorems.

MA 612 Mathematical Statistics

Point estimation, method of moments, maximum likelihood, and properties of point estimators; confidence intervals and hypothesis testing; sufficiency; Neyman-Pearson theorem, uniformly most powerful tests, and likelihood ratio tests; and Fisher information and the Cramer-Rao inequality. Additional topics may include nonparametric statistics, decision theory, and linear models. Prerequisites: MA 611

MA 615 Numerical Analysis I

The MA 615-616 sequence covers topics in numerical analysis and numerical methods including: errors and accuracy; polynomial approximation; interpolation; numerical differentiation and integration; numerical solution of differential equations; least square and minimum-maximum error approximations; nonlinear equations; simultaneous linear equations; summing series, Fourier series, filter design, the frequency approach, design of numerical tools, and statistics of error analysis; eigenvalues and eigenvectors of matrices; and the orientation throughout is toward computers.

MA 616 Numerical Analysis II

The MA 615-616 sequence covers topics in numerical analysis and numerical methods including: errors and accuracy; polynomial approximation; interpolation; numerical differentiation and integration; numerical solution of differential equations; least square and minimum-maximum error approximations; nonlinear equations; simultaneous linear equations; summing series, Fourier series, filter design, the frequency approach, design of numerical tools, and statistics of error analysis; eigenvalues and eigenvectors of matrices; and the orientation throughout is toward computers. Prerequisites: MA 615

MA 619 Introductory Sampling

This course covers basic ideas in sampling theory and uses only elementary mathematics. Topics include multistage sampling, stratified sampling, systematic sampling, self-weighting samples, and optimum allocation.

Random walks and Markov chains; Brownian motions and Markov processes; and applications, stationary (wide sense)

MA 623 Stochastic Processes

MA 625 Fundamentals of Geometry

processes, infinite divisibility, and spectral decomposition. Prerequisites: MA 611

Absolute geometry as founded on axioms of incidence, order, congruence, and continuity; models of absolute geometry and problems of consistency; independence and categoricity of an axiom system; Euclidean and non-Euclidean geometry; brief description of the Erlangen program; and classical differential geometry of surfaces.

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Real Variables I

The real number system. Introduction to metric spaces and their applications. Lebesque measure and integral from a classical and/or modern approach. Prerequisites: MA 547

MA 636 Real Variables II

L-p spaces and applications to Fourier series and Lebesque-Stieltjes integral. Prerequisites: MA 635

MA 637 Mathematical Logic I

Prepositional calculus; syntax and semantics of first order theories; completeness theorem; elementary model theory: axiomatic development of Zermelo-Fraenkel or Bernays-Gödel set theory; and ordinals, cardinals, the axiom of choice, and several equivalent axioms.

MA 638 Mathematical Logic II

First order number theory; primitive and general recursive functions; arithmetization; Gödel's incompleteness theorems; Tarski's theorems; and syntax and semantics of second order theories. Prerequisites: MA 637

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MA 627 **Combinatorial Analysis**

Fundamental laws of counting, permutations, combinations, recurrence relations, Mšbius inversion, probleme des menages, probleme des recontres, partitions, trees, generating functions, Ramsey theory, transversal theory, and matroid theory.

MA 629 Nonlinear Optimization

This course introduces the students to the foundation of optimization. The first part of the class focuses on basic results of convex analysis and their application to the development of necessary and sufficient conditions of optimality and Lagrangian duality theory. The main numerical methods of optimization and their convergence constitute the second portion of the class. Along with the theoretical results and methods, examples of optimization models in probability, statistics, and approximation theory will be discussed as well as some basic models from management, finance, and other practical situations will be introduced in order to illustrate the discussed notions and phenomena, and to demonstrate the scope of applications. Linear optimization techniques will be treated as a special case. Some attention will be paid to using optimization software such as AMPL and CPLEX in the numerical assignments.

MA 630 Advanced Optimization Methods

This course introduces the students to the several advanced topics in the theory and methods of optimization. The first portion of the class focuses on subgradient calculus for non-smooth convex functions, optimality conditions for non-smooth optimization problems, conjugate and Lagrangian convex duality. The second part of the class discusses numerical methods for non-smooth optimization as well as approaches to large-scale optimization problems. The latter include decomposition methods, design of distributed and parallel methods of optimization, as well as stochastic approximation methods. Along with the theoretical results and methods, examples of optimization models in statistical learning and data mining, compressed sensing and image reconstruction will be discussed in order to illustrate the challenges and the phenomena, and to demonstrate the scope of applications. Some attention will be paid to using optimization software such as AMPL, CPLEX and SNOPT in the numerical assignments. Prerequisites: MA 629

MA 632 Theory of Games

Strategic games and Nash equilibrium, strictly competitive (zero-sum) games and max-minimization, sStrategic games with imperfect information (Bayesian games), extensive games with perfect information (bargaining and repeated games), extensive games with imperfect information and signaling games, coalitional games (the core, stable sets, and bargaining sets), and auctions.

MA 633 Generalized Functions and Other Operational Methods (3 - 3 - 0)

Modern theory of the delta function and other generalized functions: Fourier and Laplace transforms and applications to ordinary and partial differential equations. Prerequisites: MA 547

MA 634 Methods of Operations Research (3 - 3 - 0)

Queuing theory, transportation problem, traffic theory, inventory control, search theory, and methods of optimization. Prerequisites: MA 540

MA 635

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MA 641 Time Series Analysis I

Scope and applications of time series analysis: process control, financial data analysis and forecasting, and signal processing. Exploratory data analysis: graphical analysis, trend and seasonality detection and removal, and moving-average filtering. Review of basic statistical concepts related to the characterization of stationary processes. ARMA models and prediction of stationary processes. Estimation of ARMA models and model building and forecasting with ARMA models. Spectral analysis: periodogram testing for seasonality and periodicities and the maximum entropy and maximum-likelihood estimators. Asymptotic convergence. Selected topics, such as multivariate time series, nonlinear models, Kalman filtering, econometric forecasting, and long-memory processes. Selected applications, such as the unit-root problem in economics, forecasting and testing for market efficiency in financial time series, process control, and quality control.

MA 642 Time Series Analysis II

Scope and applications of time series analysis: process control, financial data analysis and forecasting, signal processing. Exploratory data analysis: graphical analysis, trend and seasonality detection and removal, moving-average filtering. Review of basic statistical concepts related to the characterization of stationary processes. ARMA models, prediction of stationary processes. Estimation of ARMA models, model building and forecasting with ARMA models. Spectral analysis: periodogram testing for seasonality and periodicities, the maximum entropy and maximum-likelihood estimators. A symptotic convergence. Selected topics such as multivariate time series, nonlinear models, Kalman filtering, econometric forecasting, and longmemory processes. Selected applications such as the unit-root problem in economics, forecasting and testing for market efficiency in financial time series, process control and quality control. Prerequisites: MA 641

MA 649 Intermediate Differential Equations

Theory and application of ordinary differential equations (ODEs) with an emphasis on ODEs as continuous dynamical systems on a finite-dimensional phase space. Standard topics include existence and uniqueness theorems, general theory for linear equations, the exponential of linear map, stability of equilibrium points, hyperbolicity and structural stability, Lyapunov's method, invariant manifolds, Floquet theory for periodic orbits, and Poincare-Bendixon theorem. Prerequisites: Corequisites: MA 547

MA 650 Intermediate Partial Differential Equations

This course discusses the classical theory and applications of partial differential equations and introduces the student to the modern theory. Classification of second order equations; well-posedness; existence and uniqueness for the Cauchy problem; Riemann function; Dirichlet and Neumann problems; Green's functions; perturbation theory; elliptic operators; variational formulation for the Laplace equation; weak solutions; and Sobolev spaces. Prerequisites: Corequisites: MA 547

MA 651 Topology I

Metric spaces and topological spaces, bases and sub-bases, connectivity, local (path) connectivity, separation axioms, compactness and local compactness, concepts of convergence, Tychonoff's theorem, Urysohn's lemma, Tietze extension theorem, and selected topics as time permits.

MA 652 Topology II

Metric spaces and topological spaces, bases and sub-bases, connectivity, local (path) connectivity, separation axioms, compactness and local compactness, concepts of convergence, Tychonoff's theorem, Ury-sohn's lemma, Tietze extension theorem; homotopy type, fundamental group, covering spaces; topology of Euclidean space and manifold; selected topics as time permits.

Numerical Solutions of Partial Differential Equations MA 653

This course is an introduction to methods and theory in numerical solutions of partial differential equations. The finite difference and pseudo-spectral methods will be used as examples to solve partial differential equations, including parabolic, hyperbolic, and elliptic equations in one or higher dimensional space. The theory on consistency, convergence, and Von Neumann stability analysis of numerical schemes will be emphasized for a basic understanding about how to control numerical errors and to achieve higher order accuracy for numerical solutions. Students will also be assigned projects to obtain the first-hand experience in numerical computations. Prerequisites: MA 650

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This course introduces students to modeling and numerical techniques for optimization under uncertainty and risk. Topics include: generalized concavity of measures, optimization problems with probabilistic constraints (convexity, differentiability, optimality, and duality), numerical methods for solving problems with probabilistic constraints, two-stage and multi-stage models (structure, optimality, duality), decomposition methods for two-stage and multi-stage models, risk averse optimization models, Prerequisites: MA 547, MA 629

MA 681 Functions of a Complex Variable I

Complex numbers; elementary functions; Möbius transformations; analytic functions; power series; integration; Cauchy-Goursat theorems; Cauchy integral formula; Taylor and Laurent series; singularities; residue theory; and meromorphic and entire functions. Prerequisites: MA 548

MA 682 Functions of a Complex Variable II

Analytic continuation; Riemann surfaces; elliptic functions; gamma function; conformal mapping. Prerequisites: MA 681

Dynamical Systems MA 691

Theory and methods in continuous and discrete dynamical systems. Topics may vary, but will typically include local bifurcation theory for vector fields and maps, center manifold reductions, normal forms, periodic orbits and Poincaré maps, averaging methods, Melnikov methods, chaotic dynamics, the Smale horseshoe map, and symbolic dynamics. Prerequisites: MA 649

MA 707 Integral Transforms

Study of the classical transforms, the Laplace, Fourier, Hilbert, and other transforms; inversion and application to solution of differential, difference, and integral equations; and Abelian and Tauberian theorems, including Wiener's theory. Prerequisites: MA 635, MA 681

MA 708 Hilbert Space Theory

Geometry of Hilbert space; spectral theory of self-adjoint and normal operators; applications to differential operators; multiplicity theory; and families of operators, Stone's theorem, and introduction to rings of operators. Prerequisites: MA 635, MA 681

MA 711 Inverse Problems in Science and Engineering

This course introduces basic concepts and techniques to solve inverse problems for both integral and differential equations. Topics include: Ill-posed problems, Tikhonov regularization, collocation methods, Galerkin methods, inverse eigenvalue problems, inverse boundary value problems, conditions on dense solvability. Computational projects may be assigned. Prerequisites: MA 547

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MA 655 **Optimal Control Theory**

The main purpose of this course is to present the foundations of the optimal control theory, some applications, and their solutions. The students will be introduced to the core concepts and results of control and system theory. The foundational and basic results will be derived for discrete and continuous time scales, and state variables. Topics to be covered: proportionalderivative control; state-space and spectrum assignment; outputs and dynamic feedback; reachability; controllability; feedback and stability; Lyapunov theory; linearization principle of observability; dynamic programming algorithm; multipliers for unconstrained and constrained controls; and Pontryagin maximum principle. Prerequisites: MA 547, MA 649

Dynamic Programming & Stochastic Optimal Control MA 661

The main purpose of this course is to present the foundations of the stochastic control theory, the corresponding numerical methods, and some applications. The focus will be on the idea of dynamic programming which will be developed starting from deterministic models, through finite-horizon stochastic problems, to infinite-horizon stochastic problems of various types. Applications to queuing systems, network design, and routing; supply-chain management and others will be discussed in detail. Topics to be covered: basic concepts of control theory for stochastic dynamic systems; controlled Markov chains; dynamic programming for finite horizon problems; infinite horizon discounted problems; numerical methods for infinite horizon problems; linear stochastic dynamic systems in discrete time; tracking and Kalman filtering; linear quadratic models; controlled Markov processes in continuous time; and elements of stochastic control theory in continuous time and state space. Prerequisites: MA 547, MA 623

MA 662 Stochastic Programming

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Notion of simplicial complex, absolute, and relative homology groups of a space; exact sequences; cohomology; axioms for homology theory; introduction to homological algebra; and homotopy and the fundamental group. Prerequisites: MA 651, MA 605

Linear topological spaces, local convexity, and spaces of distribution; Banach spaces; three fundamental theorems and applications to classical analysis; operators, operational calculus, compact operators, and applications to integral equations;

Klein-Milman theorems; and fixed point theorems with applications to nonlinear problems. Prerequisites: MA 635

The course will introduce the students to the fundamental mathematical models of risk and approaches to decision-making under uncertainty and risk-aversion. The mathematical models will range from classical models as Expected Utility Theory, Prospect Theory, Dual Utility Theory, to state-of-the-art work on stochastic dominance, the theory of coherent risk measures, and general deviation measures. The course also surveys recent developments in particular applied areas as portfolio

MA 719 Advanced Probability

MA 712

MA 715

MA 717

Martingales; generalized weak and strong laws; infinitely divisible distribution; stable distributions, limiting distributions for triangular arrays; semigroup theory applications; bilateral Laplace transforms; renewal equation; random walks;. Markov processes. Prerequisites: MA 611

MA 720 **Advanced Statistics**

Selected topics may include: distribution theory; theory of inference; foundations of probability; spectral analysis; multivariant analysis.

MA 721 Advanced Ordinary Differential Equations

Mathematical Models of Risk

optimization, asset pricing, nuclear safety, reliability, etc.

Functional Analysis

Algebraic Topology

Existence and uniqueness of solutions; dependence on parameters; periodic solutions; nonlinear autonomous systems; Poincare-Bendixon theory; continuous transformation groups; linear systems; Floquet theory; linear systems in complex domain; regular and irregular singularities; asymptotic expansions; Stokes' phenomenon; boundary value problems. Prerequisites: MA 649

MA 723 Advanced Partial Differential Equations

Characteristics and classification of equations; Cauchy-Kowalewski theorem; linear and quasilinear systems; elliptic equations and potential theory; Green's function; mean value theorems; a priori estimates; functions space methods; hyperbolic equations; Riemann's solution of the Cauchy problem; discontinuities and shocks; Huyghen's principle; method of spherical means; parabolic equations. Prerequisites: MA 650

MA 725 Advanced Numerical Analysis

Selected topics in numerical analysis not treated in MA615-616; topics may include: numerical solution of partial differential equations, boundary value problems, approximation theory; Monte Carlo methods, power spectral methods as they apply to numerical analysis, optimal search problems.

Theory of Algebraic Numbers MA 727

Algebraic number fields; rings of algebraic integers and integral basis of field discriminant; unique factorication for ideals; splitting and ramifications of primes; Kummer's theorem with applications to quadratic and roots of unity fields; padic numbers; Hensel's lemMA; geometry of numbers; units in an algebraic extension; finiteness of class numbers of a field; and computation of class numbers in special cases. Prerequisites: MA 605, MA 606

MA 751 Advanced Topics in Analysis

Selected topics in advanced analysis not treated in other courses; topics may include: integral transforms, general convolution transform, approximation theory, theorems of Jackson and Bernstein, functions of exponential type, Nevalinna's theory of meromoporhic functions, asymptotic development, perturbation theory.

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Hintikka, Gödel	ropositional calculus and quantification theory, including references to the works of is completeness for theorem for the first order and predicate calculus, recursive fur ödel's incompleteness theorem for arithmetic, axiomatic set theory, model theory.	nction theory, decidable
MA 754 Selected topics topology to alge	Advanced Topics in Topology in topology; topics may include: K theory, infinite dimensional analysis, knot theory, a braic geometry.	(3-3-0) applications of algebraic
MA 758 This course will	Special Topics in Graph Theory focus on one or more topics of current interest in graph	(3)
and engineering	Nonlinear Analysis niqueness of solutions to nonlinear partial differential equations with applications to g. Topics covered will include Degree Theory, The Mountain Pass Lemma, Variational ration Schemes. The course will also include a review of Hilbert space methods.	
MA 800 One to six credi	Special Problems in Mathematics (MS) ts. Limit of six credits for the degree of Master of Science.	(1 to 6)
MA 801 One to six credi	Special Problems in Mathematics ts. Limit of six credits for the degree of Doctor of Philosophy.	(1 to 6)
	Special Topics in Mathematics n mathematics not covered in regularly scheduled courses and suitable for both gr . May be taken more than once.	(3) aduates and advanced
MA 900 For the degree of	Thesis in Mathematics of Master of Science. Hours and credits to be arranged.	(1 to 10)
-	Research in Mathematics h carried out under the guidance of a member of the faculty which may serve as the b degree of Dector of Philosophy. Hours and credits to be arranged	() basis for the dissertation

MA 752 Advanced Topics in Algebra

Selected topics in algebra not treated in other courses; topics may include: group representations, Lie algebra, structure of rings, valuation theory, algebraic curves, Galois theory of non-commutative fields, polynomial ideals, elimination theory.

MA 753 Advanced Topics in Mathematical Logic

Selected topics in mathematical logic; topics may include: a study of the connection between the semantical and syntactical treatments of propositional calculus and quantification theory including references to the works of Harbrand. Dreben and +

required for the degree of Doctor of Philosophy. Hours and credits to be arranged.

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Department of Mechanical Engineering

FACULTY

FRANK FISHER DEPARTMENT DIRECTOR (INTERIM)

Robert Chang, Ph.D. Assistant Professor

Constantin Chassapis, Ph.D. Professor & Vice Provost for Academics

Chang-Hwan Choi, Ph.D. Associate Professor

Kevin Connington, Ph.D. Teaching Assistant Professor

Alexander De Rosa, Ph.D. Teaching Assistant Professor

Brendan Englot, Ph.D. Assistant Professor

Sven Esche, Ph.D. Associate Professor, Associate Department Director, and Director of Graduate Programs

Frank Fisher, Ph.D. Associate Professor & Interim Department Director

Maxine Fontaine, Ph.D. Teaching Assistant Professor

Hamid Hadim, Ph.D. Professor & Undergraduate Program Director

Yazan Manna, Ph.D. Teaching Assistant Professor

Manu Mannoor, Ph.D. Assistant Professor

Souran Manoochehri, Ph.D. Professor

EMERITUS FACULTY

Richard Cole, Ph.D. Professor Emeritus John Nastasi, M.Des.S. Industry Professor & Director of Product-Architecture and Engineering Program

Nick Parziale, Ph.D. Assistant Professor

Christophe Pierre, Ph.D. Professor & Provost and Vice President for Academic Affairs

Kishore Pochiraju, Ph.D. Professor & Director of the Design and Manufacturing Institute

Marehalli Prasad, Ph.D. Professor

Elaine Pratt, M.B.A. Industry Professor

Mishah Salman, Ph.D. Teaching Assistant Professor

Yong Shi, Ph.D. Associate Professor

Leonid Shnayder, Ph.D. Industry Professor

Siva Thangam, Ph.D. Professor & Dean of Academic Administration

Eric Williams, Ph.D. Teaching Assistant Professor

Eui-Hyeok (EH) Yang, Ph.D. Professor

Damiano Zanotto, Ph.D. Assistant Professor

Fernando Sisto, Ph.D. Professor Emeritus

UNDERGRADUATE PROGRAMS

The range and scope of mechanical engineering has undergone radical changes over the past decade, while retaining and expanding traditional areas of endeavor. Some of the changes have been due to the improvements in auxiliary fields, such as materials, or the introduction of new fields, such as microelectromechanical systems (MEMS), information technology, nanotechnology, and bioengineering.

Traditionally, the design and production of machines have been major concerns of the mechanical engineer, working to the basic criteria of cost, efficiency, and delivery date. Safety and environmental considerations have added new dimensions to the mechanical engineer's problem. This is most apparent for example, in the design of new automobiles, where improved mileage and cleaner engines have been coupled with a reduction in weight and size, and greater emphasis on highway safety.

In all areas, increasing emphasis has been placed on synthesis, looking to the performance of complete systems as opposed to that of single components. Career opportunities are traditionally found in such diverse areas as power generation, design of machinery, manufacturing, research and development, guidance systems, product design and development, robotics, propulsion engineering, system analysis and design, and many others.

Our graduates wishing to further their education have been successful in gaining admission to the graduate schools of their choice.

Reflecting the wide diversity of subject matter to be found in the present-day practice of mechanical engineering, the department offers a multitude of opportunities for study and research. Major areas of interest include: bio-mechanical systems and biomedical devices, energy conversion, design and manufacturing, HVAC, solid mechanics, automatic controls, dynamics, fluid mechanics, machine design, heat transfer, turbomachinery, combustion, robotics, and noise control. If you have particular interests or highly-specific objectives, we can generally satisfy your individual goals through elective courses and appropriate project work. Furthermore, the available pool of electives allows the student to specialize in one of the following concentration areas:

- ► Aerospace Engineering
- Automotive Engineering
- Biomedical Engineering
- Mechatronics (Electro-mechanical Systems)
- Nuclear Power Engineering
- Pharmaceutical Manufacturing
- Power Generation
- Product Design and Manufacturing
- Robotics and Automation
- Sustainable Energy
- Product Engineering Architecture

Program Mission, Program Educational Objectives, and Student Outcomes

The mission of the mechanical engineering program is to produce graduates with a broad-based foundation in fundamental engineering principles and liberal arts, together with the depth of disciplinary knowledge needed to succeed in a career in mechanical engineering or a related field, including a wide variety of advanced technological and management careers.

To achieve its mission, the Department of Mechanical Engineering, with input from its constituents, has established the following Program Educational Objectives:

- 1. Graduates identify and solve problems in mechanical engineering and related fields using their broad-based knowledge of fundamental engineering concepts and state-of-the-art tools and techniques.
- 2. Graduates develop mechanical and thermal devices and systems to meet the needs of society.
- 3. Graduates excel in working within and leading multi-disciplinary teams.
- 4. Graduates conduct themselves in a socially responsible manner and adapt to technological change.

Student Outcomes - By the time of graduation, mechanical engineering students will have:

- 1. (Scientific Foundations) the ability to use applied scientific knowledge to solve problems in mechanical engineering and related fields (ABET Criterion 3a).
- 2. (Engineering Foundations) the ability to use fundamental engineering knowledge to solve problems in mechanical engineering and related fields (ABET Criterion 3a).
- 3. *(Experimentation)* the ability to design and conduct experiments, as well as to analyze and interpret experimental data for mechanical engineering and related applications (*ABET Criterion 3b*).
- 4. (*Technical Design*) the technical ability to design mechanical and thermal engineering devices or systems to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (*ABET Criterion 3c*).
- 5. (*Design Assessment*) the ability to develop and assess alternative designs of both mechanical and thermal engineering systems based on technical and non-technical criteria including their impact in a global, economic, environmental, and societal context (*ABET Criterion 3h*).
- 6. (*Tools*) the ability to use the relevant tools necessary for practice in mechanical engineering and related fields (*ABET Criterion 3k*).
- 7. (*Professionalism*) the ability to recognize and achieve high levels of professionalism in their work (*ABET Criterion 3f*).
- 8. (Leadership) the ability to assume leadership roles (ABET Criterion 3d).
- 9. (Teamwork) the ability to function on multidisciplinary teams (ABET Criterion 3d).
- 10. (Communication) the ability to communicate effectively and persuasively (ABET Criterion 3g).
- 11. (Ethics) a critical understanding of ethical responsibility (ABET Criterion 3f).
- 12. (Contemporary Issues) a knowledge of contemporary issues (ABET Criterion 3j)
- 13. (*Lifelong Learning*) a recognition of the need for an ability to engage in lifelong learning and development (ABET Criterion 3i).
- 14. (*Entrepreneurship*) fundamental knowledge and an appreciation of the technology and business processes necessary to nurture new technologies from concept to commercialization.

Areas of Concentration

Mechanical engineering students can select their elective courses among two ME technical electives and three general electives in various ways. Some of them may wish to cluster those electives in ways that would help them gain expertise in an area of specialization within mechanical engineering. The following groupings are possible specialty (concentration) areas that students can select from within the mechanical engineering program:

Aerospace Engineering

- ME 545 Introduction to Aerospace Engineering
- and two courses from the following:
- ME 423/424 Senior Design Project
- ME 453 Advanced Fluid Mechanics
- ME 520 Analysis and Design of Composites
- ME 546 Introduction to Turbomachinery

Automotive Engineering

- ME 423/424 Senior Design Project
- ▶ ME 515 Automotive Engineering
- ME 529 Modern and Advanced Combustion Engines

Biomedical Engineering

Choose any three courses from the following:

- ME 525 Biomechanics
- ME 526 Biofluid Mechanics
- ME 527 Mechanics of Human Movement
- ME 580 Medical Device Design and Technology
- ME 587 Human Factors Engineering

Mechatronics (Electro-mechanical Systems)

- ME 522 Mechatronics I
- ME 523 Mechatronics II
- ME 573 Introduction to Micro-Elecromechanical Systems

Nuclear Power Engineering

- ME 513 Introduction to Nuclear Engineering
- ME 516 Nuclear Reactor, Safety & Waste Disposal
- ME 517 Nuclear Power Plant Design & Operations

Pharmaceutical Manufacturing

- ME 530 Introduction to Pharmaceutical Manufacturing
- ME 535 Good Manufacturing Practice in Pharmaceutical Facilities Design
- ME 540 Validation and Regulatory Affairs in Pharmaceutical Manufacturing

Power Generation

- ▶ ME 510 Power Plant Engineering
- ME 529 Modern & Advanced Combustion Engines

and one course from the following:

- ME 546 Intro. to Turbomachinery
- ME 595 Heat Exchanger Design

Product Design and Manufacturing

- ME 554 Introduction to Computer-Aided Design
- ME 564 Principles of Optimum Design and Manufacture
- ME 566 Design for Manufacturability

Product Engineering Architecture

- ▶ PAE 610 The Creative Form and the Digital Environment
- ▶ PAE 630 Introduction to Interactive digital Media
- ▶ PAE 640 Performative Environments

Robotics and Automation

- ME 522 Mechatronics I
- ME 551 Microprocessor Applications in Mechanical Engineering
- ME 598 Introduction to Robotics

Sustainable Energy

Choose from any three courses from the following:

- ME511 Wind Energy Theory & Applications
- ME513 Introduction to Nuclear Engineering
- ▶ ME514 Sustainable Energy
- ME518 Solar Energy Theory & Application
- ME519 Solar Energy System Designs

Mechanical Engineering Curriculum

Term I

• "					
Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 118	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 121	Engineering Design I	0	3	2	2
E 120	Engineering Graphics	0	2	1	1
E 115	Introduction to Programming	1	2	3	2
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	12	10	27	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
	Science Elective ¹	3	0	6	3
E 122	Engineering Design II	0	3	3	2
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
PEP 111	Mechanics	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
E 231	Engineering Design III	0	3	2	2
Hum	Humanities ³	3	0	6	3
PE 200	Physical Education I	0	2	0	0
	Total	16	8	37	19

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Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
MA 227	Multivariable Calculus	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
ME 234	Mechanical Engineering Thermodynamics	3	0	6	3
	Science Elective ¹	3	0	6	3
ME 225	Dynamics	3	0	6	3
Hum	Humanities ³	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	17	5	37	18

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
ME 342	Fluid Mechanics	3	0	6	3
E 344	Materials Processing	3	0	6	3
E 321	Engineering Design V	0	3	2	2
E 243	Probability and Statistics for Engineers	3	0	6	3
ME 361	Design of Machine Components	3	0	6	3
Hum	Humanities ³	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	Total	15	5	32	17

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
ME 345	Modeling and Simulation	2	2	4	3
E 355	Engineering Economics	3	3	6	4
ME 322	Engineering Design VI	2	2	4	2
ME 335	Thermal Engineering	3	0	6	3
ME 358	Machine Dynamics and Mechanisms	3	1	6	3
G.E.	General Elective ²	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	16	10	32	18

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
ME 354	Heat Transfer	3	0	6	3
ME 483	Control Systems	3	0	6	3
G.E.	General Elective ²	3	0	6	3
ME 423	Engineering Design VII	1	6	4	3
T.G. 403	Senior Innovation I	2	0	4	2
T.E.	Technical Elective ⁴	3	0	6	3
	Total	15	6	32	17

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Course #	Course Name	Lecture	Lab	Study	Credit
ME 491	Manufacturing Processes and Systems	3	0	6	3
T.E.	Technical Elective ⁴	3	0	6	3
G.E.	General Elective ²	3	0	6	3
ME 424	Engineering Design VIII	1	6	4	3
ME 470	Mechanical Engineering Systems Laboratory	0	3	2	2
Hum	Humanities ³	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
	Total	14	9	32	18

(1) Science Electives Engineering programs have specific requirements. See page 79 for details.

(2) General Elective can be: a) a Mech Eng 400 or 500 course; b) an upper level SES, SSE, or SOB course; c) an upper level HUM course (with advisor approval).

(3) Humanities electives can be found on pages 556-557.

(4) Mechanical Engineering Technical Elective (to be selected from available ME 400 and ME 500 course offerings), can be used towards ME concentration area (with advisor approval).

Graduation Requirements

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirement

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

Minors

Students from other engineering programs may pursue a minor in mechatronics by taking the required courses indicated below. Enrollment in a minor program means that you must also meet Stevens School of Engineering and Science requirements for minor programs. Only courses completed with a grade of "C" or better are accepted towards the minor.

Requirements for a Minor in Mechatronics

- ME 225 Dynamics
- ME 358 Machine Dynamics and Mechanics
- ME 483 Control Systems
- ME 522 Mechatronics I
- ▶ ME 551 Microprocessor Applications in ME or ME 523 Mechatronics II or ME 573 Introduction to Micro-Electromechanical Systems (MEMS)

GRADUATE PROGRAMS

The Department of Mechanical Engineering provides three graduate programs in mechanical engineering leading to the following degrees: (i) the "Master of Engineering - Mechanical" degree, (ii) the professional "Mechanical Engineer" degree, and (iii) the "Doctor of Philosophy" degree with a concentration in mechanical engineering. A major objective of the graduate program is to encourage research work at all levels so that individuals can progressively solve more challenging problems with a wider research scope as they gain confidence and competence.

In addition to the above-mentioned three graduate degree programs, the Department of Mechanical Engineering also offers the following other graduate programs: (i) "Master of Engineering in Product Architecture and Engineering" degree program, (ii) "Master of Engineering in Integrated Product Development" degree program, (iii) Master of Science in Pharmaceutical Manufacturing" degree program, and (iv) various graduate certificate programs.

The Department of Mechanical Engineering has active research interests in the following areas: biomedical devices, biosensors and cell/tissue-based physiological platforms, composites and structured materials, computational and experimental fluid dynamics and heat transfer, computer-aided design and manufacturing, integrated product and process design, control theory, design of thermal systems, knowledge-based engineering systems, noise control and vibration, robotics and automation, nano/micro system modeling, design and fabrication, sustainable energy and pharmaceutical manufacturing.

Master's Program in Mechanical Engineering

The Master of Engineering - Mechanical degree program is intended to extend and broaden the undergraduate preparation. It can be considered as a terminal degree or as preparation for the Ph.D. program. A bachelor's degree in mechanical engineering is needed for acceptance to the master's program. Applicants with undergraduate degrees in other engineering disciplines may be required to take appropriate undergraduate courses before being formally admitted into the program.

The Master of Engineering - Mechanical degree requires 30 credits, approved by the student's academic advisor. The program structure is as follows:

- Two required core courses
- At least four courses from any one of the seven concentrations below
- ▶ Four elective courses must be chosen as described below.

Core Courses

- ME 635 Modeling and Simulation
- ME 641 Engineering Analysis I

Concentration Courses

At least four courses from any one of the seven concentrations:

Product Design

- ▶ ME 520 Analysis and Design of Composites
- ME 615 Thermal Systems Design
- ME 658 Advanced Mechanics of Solids
- ME 659 Advanced Structural Design
- ME 663 Finite Element Method
- ME 665 Advanced Product Development

Manufacturing

- ME 565 Introduction to Additive Manufacturing
- ME 566 Design for Manufacturability
- ▶ ME 644 Computer Integrated Design and Manufacturing
- ME 645 Design of Production Systems
- ME 652 Advanced Additive Manufacturing
- ME 653 Design for Additive Manufacturing

Thermal, Fluids, Energy

- ▶ ME 510 Power Plant Engineering
- ▶ ME 601 Engineering Thermodynamics
- ME 604 Advanced Heat Transfer
- ME 615 Thermal Systems Design
- ▶ ME 674 Fluid Dynamics
- ME 675 Computational Fluid Dynamics and Heat Transfer

Pharmaceutical Manufacturing

- ME 530 Introduction to Pharmaceutical Manufacturing
- ME 535 Good Manufacturing Practice in Pharmaceutical Facilities Design
- ME 540 Validation and Regulatory Affairs in Pharmaceutical Manufacturing
- ME 628 Manufacturing and Packaging of Pharmaceutical Oral Solid Dosage Products
- ME 629 Manufacturing of Sterile Pharmaceuticals
- ME 647 Environmental Systems (HVAC) in Healthcare Manufacturing

Medical Devices

- ▶ ME 525 Biomechanics
- ▶ ME 526 Biofluid Mechanics
- ME 580 Medical Device Design and Technology
- ME 658 Advanced Mechanics of Solids
- ME 660 Medical Devices Manufacturing
- ▶ ME 674 Fluid Dynamics

Robotics & Control

- ME 598 Introduction to Robotics
- ME 621 Introduction to Modern Control Engineering
- ME 622 Optimal Control and Estimation of Dynamical Systems
- ME 631 Mechanical Vibrations I
- ME 651 Analytic Dynamics
- ME 654 Advanced Robotics

Micro/Nano Systems

- ▶ ME 573 Introduction to MEMS
- ▶ ME 581 Introduction to BioMEMS
- ME 680 Fundamentals of Micro/Nano Fluidics
- ME 681 Applications of Advanced Micro/Nano Materials, Structures, and Devices
- NANO 525 Techniques of Surface and Nanostructure Characterization
- ▶ NANO 600 Nanoscale Science and Technology

Elective Courses

Four elective courses must be chosen. Of these four courses, a maximum of two courses may be non-ME courses, and of the non-ME courses, a maximum of one may be a non-SES course (i.e. any Stevens graduate course). A student may substitute a Project (**ME 800** Special Problems in Mechanical Engineering, 3 credits) or a Master's Thesis (**ME 900** Thesis in Mechanical Engineering, 6 credits) for the appropriate number of courses.

In order to graduate with a Master of Engineering - Mechanical degree, a student must obtain a minimum of "B" average in the major field, as well as an overall average of "B" in all the courses needed to meet the 30-credit requirement for the degree. Please see the Office of Graduate Admissions section on Student Status.

Master's Program in Product Architecture and Engineering

The Master of Engineering in Product-Architecture and Engineering degree program is intended to integrate the study of Architecture, Sustainable Engineering and Computational Analysis with production methodologies and emerging materials. All students in the program must complete 10 courses (30 credits), comprised of six core courses and four elective courses. Two of the four electives must be taken from the recommended list (see below) of relevant graduate courses offered by the Mechanical Engineering Department. The remaining two courses (6 credits) constitute the student's elective field and will consist of at least one course of 600-level or higher offered within the Product-Architecture and Engineering program. Students may elect to complete a thesis (PAE 900 Thesis in Product-Architecture and Engineering) in lieu of completing the two open electives.

A Bachelor of Science degree in Engineering, a B.I.D. (B.F.A., B.A., or B.S.) in Industrial Design, or a B.Arch. (Bachelor in Architecture) is needed for acceptance to the program. Applicants with undergraduate degrees in other engineering or design disciplines may be required to take appropriate undergraduate courses before being formally admitted into the program.

Core Courses

- ▶ PAE 610 The Creative Form and the Digital Environment
- ▶ PAE 620 The Creative Form and the Production Environment
- ▶ PAE 630 Introduction to Interactive Digital Media
- ▶ PAE 640 Performative Environments
- ▶ PAE 800 Product Architecture and Engineering Design Project
- ▶ PAE 810 Special Topics in Product Architecture and Engineering

To complete the degree requirements, students can choose from the following list of courses:

- ME 502 Introduction to Engineering Analysis
- ME 520 Analysis and Design of Composites
- ME 564 Principles of Optimum Design and Manufacture
- ME 566 Design for Manufacturability
- ME 635 Simulation and Modeling

In order to graduate with a Master of Engineering in Product-Architecture and Engineering, a student must obtain a minimum of "B" average in the major field, as well as an overall average of "B" in all the courses needed to meet the 30-credit requirement for the degree. Please see the Office of Graduate Admissions section on Student Status.

Master's Program in Integrated Product Development

The Integrated Product Development program is an integrated Master' of Engineering degree program. The core courses emphasize the design, manufacture, implementation, and life-cycle issues of engineering systems. The remaining courses provide a disciplinary focus. The program embraces and balances qualitative, as well as quantitative, aspects and utilizes state-of-the-art tools and methodologies. It aims to educate students in problem-solving methodologies, modeling, analysis, simulation, and technical management. The program trains engineers in relevant software applications and in productive deployment and integration in the workplace.

All students in this program must complete ten courses (30 credits), comprised of four core courses and up to six elective courses selected from one of the four engineering tracks listed below. The student, with the approval of the graduate program director, may design customized tracks. Up to six elective credits may be taken in lieu of the course credits toward a project relevant to the selected track.

Core Courses

- ▶ IPD 601 Integrated Product Development I
- ▶ IPD 602 Integrated Product Development II
- ▶ IPD 611 Simulation and Modeling
- ▶ IPD 612 Project Management and Organizational Design

Tracks

Students then choose from one of the following four engineering tracks:

- Armament Engineering
- Electrical and Computer Engineering
- Manufacturing Technologies
- Systems Reliability and Design

Armament Engineering Track

This technology track provides an interdisciplinary graduate education in Armament Engineering. The program emphasizes systems engineering of military weapons from concept through development and field use. Technical disciplines in the design and manufacture of explosives, modeling and simulation of the interior and exterior ballistics, rocket and missile design, guidance and control, modern research instrumentation, and testing procedures are emphasized.

- ME 504 Interior Ballistics and Design for Projection
- ME 505 Theory and Performance of Propellants and Explosives I
- ME 506 Theory and Performance of Propellants and Explosives II
- ME 507 Exterior Ballistics
- ME 508 Terminal Ballistics
- ▶ plus one free elective.

Manufacturing Technologies Track

This track integrates product design, materials processing, and manufacturing expertise with modern computer software technology. The program is specifically concerned with product design for manufacturing, manufacturing systems analysis and development, robotics and control, and the integration of the various phases and activities associated with turning a concept into a deliverable product. Different manufacturing processes are introduced, and the design and control of these processes are discussed. Of particular interest are the development and implementation of models to predict the effects of design and manufacturing choices on system performance, producibility, and economics.

- ME 560 Total Quality Control
- ME 564 Principles of Optimal Design and Manufacture
- ME 598 Introduction to Robotics
- ME 621 Introduction to Modern Control Engineering
- ▶ ME 644 Computer-Integrated Design and Manufacturing or ME 520 Analysis and Design of Composites
- ME 645 Design of Production Systems

The complete description of the IPD program can be found in the Interdisciplinary Programs section of the catalog.

Master's Program in Pharmaceutical Manufacturing

The Pharmaceutical Manufacturing (PME) master's degree program is intended to integrate the study of pharmaceutical manufacturing concepts with more advanced engineering design and scientific methodologies to satisfy specialty needs within the industry. The Master of Science (M.S.) in Pharmaceutical Manufacturing is a 30-credit degree program that concentrates primarily on industry areas related to commercial manufacturing, such as GMP, manufacturing technologies, facilities design, validation, compliance, and quality. All students are required to take the five required core courses below:

Required Core Courses

- ▶ PME 530 Introduction to Pharmaceutical Manufacturing
- ▶ PME 535 Good Manufacturing Practices in Pharmaceutical Facilities Design
- ▶ PME 540 Validation in Pharmaceutical Manufacturing
- ▶ PME 560 Quality in Pharmaceutical Manufacturing
- ▶ PME 602 Statistical Methods in Pharmaceutical Manufacturing

Many electives are available to students for the remaining five courses. At least two electives must be 600-level PME technology courses (e.g. PME 626, 628, 629).

Primary Elective Courses (recommended)

- ▶ PME 541 Validation of Computerized Systems
- ▶ PME 542 Global Regulation and Compliance in the Pharmaceutical Industry
- ▶ PME 626 Manufacturing of Biopharmaceutical Products
- ▶ PME 628 Manufacturing and Packaging of Pharmaceutical Oral Solid Dosage Products
- ▶ PME 629 Manufacturing of Sterile Pharmaceuticals

Additional Elective Courses

- ▶ PME 531 Process Safety Management in Pharmaceutical Manufacturing
- PME 555 Lean Six Sigma
- ▶ PME 580 Medical Device Design and Technology
- ▶ PME 600 Engineering Economics and Cost Analysis
- ▶ PME 609 Project Management Fundamentals
- ▶ PME 639 Modeling and Simulation of Pharmaceutical Manufacturing Systems
- ▶ PME 647 Environmental Systems (HVAC) in Healthcare Manufacturing
- ▶ PME 660 Medical Devices Manufacturing
- ▶ PME 701 PME Co-op Education
- ▶ PME 800 Special Problems in Pharmaceutical Manufacturing and Engineering
- ▶ PME 900 Thesis in Pharmaceutical Manufacturing and Engineering

In addition to the master's degree-level offerings, the program currently offers two Graduate Certificates (GCs), each of which requires four courses and is described below.

Pharmaceutical Manufacturing (PM) provides an introductory overview of the pharmaceutical, touching on all basic manufacturing processes, facility design issues, validation, compliance, and quality assurance concepts, and pharmaceutical technologies

Courses: PME 530, 535, 540 and 1 of the following – PME 626, 628 or 629.

Validation, Compliance & Quality (VCQ) is designed for individuals who work or aspire to work in validation, compliance, or quality functions in industries driven by Good Manufacturing Practices (GMP). Students learn approaches to process validation, qualification of equipment, utilities, facilities, analytical methods, cleaning validation, etc., as well as quality-related concepts and methods, and regulatory compliance issues in the global environment.

Courses: PME 540, 560, 602 and 1 of the following – PME 541 or 542

Doctoral Program in Mechanical Engineering

Admission to the doctoral program will be made through the Department Director in conjunction with the Graduate Committee, and it will be based on an assessment of the applicant's academic background, competence and aptitude for advanced study and research. Normally, an appropriate Master of Engineering degree or its equivalent is required, but exceptionally well qualified applicants will be considered for admission even without a completed master's degree. If deemed acceptable, the student will be assigned an Advisor. Then, the student, in conjunction with the Advisor, will select a thesis topic and complete a study plan within three months in the program.

Courses are selected to develop skills in a particular area of interest. While this coursework is necessary to develop the tools and skills of the student's profession, the most important aspect of the doctoral program is the student's original research topic.

The subject of the doctoral dissertation (ME 960) is open to a wide range of particular choices. The selection of a topic by the doctoral aspirant provides for a sub-specialization within the broad range of mechanical engineering disciplines. The courses selected for the study plan should complement the student's dissertation subject.

Upon submission of an approved study plan by the student and no later than after one year of enrollment in the program, a Doctoral Committee is appointed for each student by the Department Director in conjunction with the Graduate Committee, with the Advisor as the chairperson. All doctoral students are required to take a qualifying examination (consisting of a Core Competency Test (CCT) and a Research Competency Test (RCT)) at the first offering after one year in the program. Upon failing the qualifying examination, the student may take the examination for a second time at the next offering. Upon failing the examination for the second time, the student will be asked to leave the program. In addition to the qualifying examination, all doctoral students are required to present a research proposal (including a written report and an oral presentation) to the Doctoral Committee for its approval. The candidate must present the proposal within 24 months of enrollment into the program. The Doctoral Committee, at its discretion, may decide on additional oral/written examinations before accepting the proposed dissertation plan. In the case where the committee rejects the research proposal, the candidate may submit a request for a second and final chance for presenting a revised research proposal during the following academic semester.

Upon satisfactory completion of the research proposal and all coursework, the student will be considered a **doctoral candidate** and continue the research which will form the basis of the student's dissertation. The dissertation must be based upon original investigation in the field of mechanical engineering, approved by the Department Director and Graduate Committee, and must be a contribution worthy of publication in the current professional literature. Before receiving the doctoral degree, the student must also satisfy the requirements for residence and publication of the dissertation.

Nanotechnology Concentration

The mechanical engineering doctoral program is an integral part of the institute-wide nanotechnology graduate program. A Ph.D. degree option in mechanical engineering with concentration on nanotechnology is available to students who satisfy the conditions and requirements of the nanotechnology area which are outlined in a separate section of the catalog.

Ph.D. Requirements

Applicants with a GPA of 3.5 or better in a master's program in mechanical engineering or a related field as well as with excellent TOEFL and GRE scores are encouraged to apply for the Ph.D. program in mechanical engineering. Exceptionally well qualified applicants who obtained only a bachelor's degree in mechanical engineering or a related field will also be considered for direct admission into the Ph.D. program in mechanical engineering. The Ph.D. Qualifying Examination consists of a Core Competency Test and a Research Competency Test to be taken after one year in the Ph.D. program.

The Ph.D. program in mechanical engineering requires a total of 84 credits beyond the bachelor's degree in an approved program of study. Up to 30 credits previously obtained in a master's degree program in mechanical engineering or a related field may be applied towards this requirement. In addition, the Ph.D. program in mechanical engineering culminates in a Ph.D. dissertation based on the results of original research carried out under the guidance of a faculty member and defended in a public examination.

Graduate Certificate Programs

The Mechanical Engineering Department offers several graduate certificate programs to students meeting the regular admission requirements for the master's program. Each graduate certificate program is self-contained and highly focused, carrying 12 or more graduate credits. All of the courses may be used toward the Master of Engineering degree, as well as for the graduate certificate. Current graduate programs include:

Additive Manufacturing

- ME 565 Introduction to Additive Manufacturing
- ME 652 Advanced Additive Manufacturing
- ME 653 Design for Additive Manufacturing
- ME 691 Additive Manufacturing for Biological Systems
 or -
- ME 692 Advanced Topics in Additive Manufacturing

Advanced Manufacturing

- ME 566 Design for Manufacturability
- ME 621 Introduction to Modern Control Engineering
- ME 652 Advanced Additive Manufacturing
- ME 560 Total Quality Control

- or -

ME 564 Principles of Optimum Design and Manufacture

Air Pollution Technology

- ME 532 Air Pollution Principles and Control
- ME 534 Industrial and Environmental Catalytic Processes
- ME 590 Environmental Law for Practicing Engineers
- ME 612 Selected Topics in Air Pollution Technology

Computational Fluid Mechanics and Heat Transfer

- ME 594 Computer Methods in Mechanical Engineering
- ME 604 Advanced Heat Transfer or ME 609 Convective Heat Transfer
- ME 674 Fluid Dynamics
- ME 675 Computational Fluid Dynamics and Heat Transfer

Design and Production Management

- ME 566 Design for Manufacturability
- ME 636 Project Management and Organizational Design
- ME 644 Computer-Integrated Design and Manufacturing
- ME 645 Design of Production Systems

Medical Devices

- ME 525 Biomechanics
- ME 580 Medical Device Design and Technology
- ME 660 Medical Devices Manufacturing

and one of the following courses:

- ▶ ME 581 Introduction to BioMEMS
- ME 691 Additive Manufacturing for Biological Systems
- ME 692 Biomaterials Processing and Integration
- ME 693 Bioelectronics and Instrumentation

Nuclear Power Engineering

- ▶ ME 513 Introduction to Nuclear Engineering
- ME 517 Nuclear Power Plant Design and Operation

and two of the following:

- ME 516 Nuclear Reactor Safety and Waste Disposal
- ME 614 Nuclear Reactor Theory and Design
- ME 616 Thermal-Hydraulics Design of Nuclear Power Reactors

Ordnance Engineering

- ME 505 Theory and Performance of Propellants and Explosives I
- ME 507 Exterior Ballistics

and any two of the following courses:

- ME 504 Interior Ballistics and Design for Projection
- ▶ ME 506 Theory of Performance of Propellants and Explosives II
- ME 508 Terminal Ballistics

Power Generation

- ME 510 Power Plant Engineering
- ME 595 Heat Exchanger Design

and two of the following:

- ME 529 Modern and Advanced Combustion Engines
- ME 546 Introduction to Turbomachinery
- ME 625 Gas Turbines

Robotics and Control

- ME 598 Introduction to Robotics
- ME 621 Introduction to Modern Control Engineering
- ME 654 Advanced Robotics

and one of the following:

- ME 622 Optimal Control and Estimation of Dynamical Systems
- ▶ ME 623 Design of Control Systems

Structural Analysis and Design

- ME 658 Advanced Mechanics of Solids
- ME 659 Advanced Structural Design
- ME 661 Advanced Stress Analysis
- ME 663 Finite-Element Methods

Sustainable Energy Systems

- ME 514 Sustainable Energy
- ME 615 Thermal Systems Design

and two of the following five courses

- ME 510 Power Plant Engineering
- ME 511 Wind Energy Theory and Application
- ME 513 Introduction to Nuclear Engineering
- ME 518 Solar Energy Theory and Application
- ME 519 Solar Energy System Designs

Vibration and Noise Control

- ME 584 Vibration and Acoustics in Product Design
- ▶ ME 611 Engineering Acoustics
- ME 631 Mechanical Vibrations I
- ME 651 Analytic Dynamics

COURSE OFFERINGS

Mechanical Engineering

124, PEP 112, and E 126

ME 181 Seminar in Mechanical Engineering

Introduction to current research topics in Mechanical Engineering and the academic research enterprise. The applications chosen demonstrate the breadth, impact, and future of Mechanical Engineering. Typical topics include additive manufacturing, biomechanics and biomedical applications of Mechanical Engineering, energy, advanced materials, robotics, and nanotechnology.

ME 225 **D**vnamics Particle kinematics and kinetics, systems of particles, work-energy, impulse and momentum, rigid-body kinematics, relative motion, Coriolis acceleration, rigid-body kinetics, direct and oblique impact, eccentric impact. Prerequisites: MA 116 or MA

ME 234 Mechanical Engineering Thermodynamics (3 - 3 - 0)Concepts of energy, heat and work; thermodynamic properties of substances and property relationships, phase change; First and Second Laws for closed and open systems including steady and transient processes and cycles; using entropy; representative applications including vapor and gas power and refrigeration cycles. Prerequisites: MA 116 or MA 124, CH 115, PEP 111

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ME 322 Engineering Design VI

This course is intended to teach modern systematic design techniques used in the practice of mechanical engineering. Methodology for the development of design objective(s), literature surveys, base case designs, and design alternatives are given. Economic analyses with an emphasis on capital investment and operating costs are introduced. Integrated product and process design concepts are emphasized with case studies. Students are encouraged to select their senior capstone design project near the end of the course, form teams, and commence preliminary work. A number of design projects are required of all students. Prerequisites: E 321 Corequisites: ME 345

Thermal Engineering ME 335

Applications of First and Second Laws to thermal systems including gas turbine, and internal and external combustion engines. Vapor cycles, including supercritical binary and combined cycles, regeneration and recuperation, gas compression, refrigeration and gas liquefaction. Analysis of thermal processes, including available energy and availability, irreversibility, effectiveness. Laboratory work in air compressors, internal combustion engines, furnaces, heat pumps, and gas turbines. Prerequisites: MA 221 and ME 234

ME 342 Fluid Mechanics

Properties of a fluid, basic flow analysis techniques, fluid kinematics, hydrostatics, manometry, pressure distribution in rigid body motion of a fluid, control volume analysis, conservation of mass, linear and angular momentum, Bernoulli and energy equations, dimensional analysis, viscous flow in pipes, flow metering devices, external flows, estimation of lift and drag, turbo-machinery, open channel flow. Prerequisites: E 126, MA 221, ME 225, PEP 112

ME 345 Modeling and Simulation

Modeling and simulation methodologies including model-block building, logical and data modeling, validation, simulation and trade-off analysis, decision-making, and optimization. Product and assembly modeling; visual simulation; process modeling; production modeling; process plans and resource modeling, entity flow modeling including conveyors, transporters, and guided vehicles; Input and output statistical analysis. Several CAD/CAE simulation software are used. Prerequisites: MA 221, ME 225, and ME 234

ME 354 Heat Transfer

Basic modes of heat transfer, steady heat conduction, extended surface heat transfer, transient heat conduction, computational methods, forced and free convection, boiling and condensation, thermal radiation, heat exchangers. Design projects. Prerequisites: MA 227, ME 234, and ME 342

ME 358 Machine Dynamics and Mechanisms

The principles of dynamics as applied to the analysis of the accelerations and dynamic forces in machines such as linkages, cam systems, gears trains, belts, chains and couplings. The effect these dynamic forces have on the dynamic balance and operation of the machines and the attending stresses in the individual components of the machines. Some synthesis techniques. Students also work in teams on a semester long project associated with the design of a mechanical system from recognizing the need through a detailed conceptual design. Prerequisites: E 126, E 232, MA 227, and ME 225

Design of Machine Components ME 361

Application of the principles of strength of materials to the analysis and design of machine parts. Stress and deflection analysis. Curved bars, multi-support shafts, torsion, cylinders under pressure, thermal stresses, creep, and relaxation, rotating disks, fasteners, springs, bearings, gears, brakes and other machine elements are considered. Failure of structural materials under cyclic stress. Prerequisites: MA 221, E 126

ME 401 Special Problem in ME

Individual investigation in a subject area of current interest in Mechanical Engineering undertaken at an undergraduate level under the guidance of a faculty advisor. The type of project undertaken must be consistent with the student's academic level. To register for this course, the student and faculty advisor jointly submit a detailed proposal.

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ME 421 Energy Conversion Systems

Technology and economics of energy sources, storage and utilization, overview of fundamental concepts of mechanical, thermal, chemical, nuclear, electrical energy conversion (practical and visionary), thermo chemical conversion, including combustion in power plants, propulsion systems, thermo mechanical conversion in nozzles and turbomachinery, "direct" energy conversion in fuel cells, etc., nuclear energy conversion. Prerequisites: ME 335, ME 342 Corequisites: ME 354

ME 423 Engineering Design VII

Senior design courses. Complete design sequence with a required capstone project spanning two semesters. Prerequisites: ME 322

ME 424 Engineering Design VIII

Senior design courses. Complete design sequence with a required capstone project spanning two semesters. Prerequisites: ME 423

ME 453 Advanced Fluid Mechanics (3 - 3 - 0) Differential equations of fluid flow, Navier-Stokes equations, introduction to fluid turbulence, inviscid incompressible flow, introduction to airfoil theory, compressible fluid flow and applications nozzles, ducts and airfoils. Cross-listed with: NE 453 Prerequisites: MA 227, ME 342

ME 463 Research in Mechanical Engineering I

Individual investigation of a substantive character undertaken at an undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. Thesis committee will consist of the faculty advisor and one or more reader.

ME 464 Research in Mechanical Engineering II

Individual investigation of a substantive character undertaken at an undergraduate level under the guidance of a faculty advisor leading to a thesis with a public defense. Thesis committee will consist of the faculty advisor and one or more reader.

ME 470 Mechanical Engineering Systems Laboratory

Experiments in selected mechanical engineering systems areas, including principles and applications of experimentation, data-acquisition, design of experiments, and written and oral reporting on experimental hardware and results. Prerequisites: ME 335, ME 342, and ME 361

ME 471 Mechanics of Materials

Multidimensional stress, strain and transformation equations, yield conditions and theories of failure, constitutive laws including linear elasticity, viscoelasticity and temperature influences, equations of elasticity, simple applications to uniaxial stress and symmetric bending, unsymmetrical bending and shear center of beams, torsions, combined stresses with applications to beams, thin-walled cylinders and pressure tanks, shrink fits, bending beyond the elastic limit, instability and energy methods. Prerequisites: ME 361

ME 473 Design of Mechanical Systems

Static and dynamic force analysis of mechanisms, dynamics of reciprocating and rotating machinery, balancing of machinery, friction and wear, vibration and noise control in machines, manipulators and robots, computer-aided design. Prerequisites: MA 227, ME 358

ME 483 Control Systems

Analysis and synthesis of feedback control systems to achieve specified stability and performance criteria, stability via rootlocus techniques, Nyquist's criterion, Bode and Nichol's plots, effect of various control laws and pole-zero compensation on performance, applications to servomechanisms, hydraulic and pneumatic control systems, analysis of nonlinear systems. Prerequisites: MA 227, ME 225

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ME 491 Manufacturing Processes and Systems

Analysis of both bulk-forming (forging, extrusion, rolling, etc.) and sheet-forming processes, metal cutting, and other related manufacturing processes; physics and stochastic nature of manufacturing processes and their effects on quality, rate, cost and flexibility; role of computer-aided manufacturing in manufacturing system automation; methodologies used to plan and control a manufacturing system, forecasting, production scheduling, facility layout, inventory control, and project planning. Prerequisites: ME 345, ME 361

ME 501 **Basic Engineering Mechanics**

This course is intended to provide an introduction to engineering mechanics. Topics include Static and Dynamics, Strength of Materials, and Systems Modeling. The course will emphasize basic relationships in these areas necessary to the understanding of design and manufacturing principles as covered in ME 503.

ME 502 Introduction to Engineering Analysis

Basic concepts and introduction to engineering analysis techniques in mechanical and manufacturing engineering. Topics include: applications of ordinary and partial differential equations, linear algebra and numerical analysis to mechanical and manufacturing engineering system. Prerequisites: ME 501

ME 503 Principles of Mechanical Engineering

This course is intended to provide non-mechanical engineering students with an understanding of the principles of mechanical design. It is given from the viewpoint that design is the central activity of the engineering profession, and it is more concerned with the introduction of mechanical engineering principles pertinent to design of products. This course presents design as an interdisciplinary activity that draws on such diverse subjects as materials selection, modeling and analysis, and manufacturing processes.

ME 504 Interior Ballistics and Design for Projection

The ballistic regimes, simple piezo ballistics, Corner's analysis, Frankle-Baer simulation, interior ballistics interactive simulation, comparison of models, projectile design practice, cannon design practice, exterior intermediate ballistic regimes, flight trajectories, terminal ballistics, numerical simulation of impact and fragmentation. (At Dover, NJ)

ME 505 Theory and Performance of Propellants and Explosives I (3 - 3 - 0)

A treatment of the physical and chemical theoretical principles which govern the characteristics and performance of propellants and explosives; theories to explain stability, sensitivity, combustion, detonation, initiation, power, shaped charge effect, and flash and smoke formations; thermochemical and thermodynamic calculations to enable performance to be predicted; kinetics of reaction of important systems; modern research instrumentation; test procedures; methods of evaluating propellants and explosives.

ME 506 Theory of Performance of Propellants and Explosives II (3 - 3 - 0)

A treatment of the physical and chemical theoretical principles which govern the characteristics and performance of propellants and explosives; theories to explain stability, sensitivity, combustion, detonation, initiation, power, shaped charge effect, and flash and smoke formations; thermochemical and thermodynamic calculations to enable performance to be predicted; kinetics of reaction of important systems; modern research instrumentation; test procedures; methods of evaluating propellants and explosives.

ME 507 Exterior Ballistics

Basic principles of exterior ballistics are introduced. Flight terminology, vacuum trajectories and flat fire point mass trajectories are discussed. Siacci Method, Coriolis Effect, yaw or repose, wind effects, 6-DOF trajectories and modified point mass trajectories are covered. (At Dover, NJ)

ME 508 **Terminal Ballistics**

Simplified equations for determination of flight stability and roll resonance are developed. Terminal ballistics are described and nomenclature introduced. Shock and stress wave effects in material are discussed. Penetration and perforation of solids and the governing equations are described. Penetration of armor by shaped charged jets are discussed. Term project focuses on investigation of terminal ballistic effects tailored to a specific job application. Prerequisites: ME 507

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ME 509 Special Topics in Mechanical Engineering

Courses on special topics of current interest in Mechanical Engineering, including but not limited to, the following: Nuclear Power Engineering and Computer-Aided Building Energy Analysis.

ME 510 Power Plant Engineering

Analysis of thermodynamics, hydraulic, environmental, and economic considerations that affect the design and performance of modern power plants; overview of power generation system and its components, including boilers, turbines, circulating water systems, and condensate-feedwater systems; fuels and combustion; auxiliary pumping and cleanup systems; gas turbine and combined cycles; and introduction to nuclear power plants and alternate energy systems based on geothermal, solar, wind, and ocean energy.

ME 511 Wind Energy-Theory & Application

This course provides the fundamentals of the conversion of wind energy to electricity and describes the effective use of wind energy for a variety of applications. It spans a wide range of fields, from meteorology through mechanical, electrical, structural engineering and aerodynamics, to economics and environmental concerns. Topics include wind energy principles, wind site assessment, wind turbine components, wind power generation machinery, economics of wind energy, environmental concerns and the future of wind power. These topics are covered in sufficient detail for everyones understanding without requiring prior background in all these disciplines. Using the knowledge gained from the course, the students are expected to complete a class project designing a small scale wind energy.

ME 513 Introduction to Nuclear Engineering

A development of the background necessary for nuclear engineering, beginning with a review of atomic physics and including radioactivity, nuclear reactions, neutron physics and elementary reactor theory, reactor dynamics and control, reactor types.

ME 514 Sustainable Energy

This course assesses the current and potential future energy systems, covers resources, extraction, conversion, and end-use, and emphasizes meeting regional and global energy needs in the 21st century in a sustainable manner. Topics relevant to renewable and conventional energy technologies will be presented including fossil fuels, combustion, environmental effects, carbon sequestration, nuclear power, wind power, solar energy, hydrogen and fuel cells. Key attributes will be described within a framework that aids in evaluation and analysis of energy technology systems in the context of political, social, economic, and environmental goals. Cross-listed with: E 580 Prerequisites: Graduate status, undergraduate engineering thermodynamics, undergraduate physics sequence, undergraduate general chemistry. Undergraduate students (e.g., those in the Green Engineering minor) and students not majoring in engineering should request special permission from the instructor.

ME 515 Automotive Engineering

Analysis of the automotive vehicle as an entire integrated system under highway and off-road conditions. Significant subject areas include power-train design, control and stability; suspension design, tire-road interface, soil-vehicle interface, four-wheeled, tracked and unconventional vehicles; emphasis is on design theory.

ME 516 Nuclear Reactor Safety and Waste Disposal

This course covers fundamental principles related to nuclear power reactor reliability, safety and waste disposal. Topics include radiation and radiological concepts and measurement, the fuel cycle and waste classification, State and Federal regulations and regulatory agencies, radiochemistry and the environmental fate of radionuclides, uranium-related wastes, low-level waste characteristics and management, high-level wastes characteristics and management, private fuel storage, waste package stability, risk assessment, geologic repositories, theory of retrievability in waste management, deep-well injection, transporting radioactive wastes, decontamination and decommission, transmutation, an international perspective on radioactive waste management, the Global Nuclear Energy Partnership, and the latest from the Blue Ribbon Commission.

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ME 517 Nuclear Power Plant Design & Operation

This course covers design methodologies for major systems and components in a nuclear power plant and discusses how the integrated nuclear plant works and the challenges an operator faces. The course provides a study of the interrelationship and propagation of effects that systems and design changes have on one another, especially in relation to nuclear power plant operations and safety. Emphasis is placed on how operations of and faults in systems and components can influence reactivity and core behavior. The students will examine a typical nuclear power plant and those components and systems of the nuclear plant system that have the potential for affecting core power and whose failure could be an initiating event for a plant transient. One main outcome is the ability to predict behavior under complex interactions among systems and to predict transient behavior of the integrated nuclear plant considering factors that are important for safe and efficient operation of the plant including reactivity management and control, coolant inventory control and core heat removal. A replica simulator (PCTRAN) is used as an effective way for students to understand accident control, emergency operating procedures and plant control. The course includes case studies and design projects.

ME 518 Solar Energy: Theory & Application

This course is an in depth treatment of the principles and practice associated with using solar radiation as an alternate energy source. It examines the science of solar radiation, technologies for its capture and the design principles that are used to apply solar energy in building design. Cross-listed with: MT 518

ME 519 Solar Energy: System Designs

This course provides an in-depth treatment of how to transfer the latest solar thermal technology available to real world applications. It takes the student through the various phases of development of a solar space heating and photovoltaic integrated building; review occupant's requirements, site analysis, design concept, solar system design, cost estimates, building design, performance predictions and construction. The emphasis of the class is on solar system design methods, economic optimization of solar systems and installation. Cross-listed with: MT 528

ME 520 Analysis and Design of Composites

Composite material characterization; composite mechanics of plates, panels, beams, columns, and rods integrated with design procedures; analysis and design of composite structures, joining methods and procedures, introduction to manufacturing processes of filament winding, braiding, injection, compression and resin transfer molding, machining and drilling, and industrial applications. Cross-listed with: MT 520

ME 521 Nondestructive Evaluation

This course will introduce principles and applications of Nondestructive Evaluation (NDE) techniques which are important in design, manufacturing, and maintenance. Most commonly used methods such as ultrasonics, magnetics, radiography, penetrants, and eddy currents will be discussed. Physical concepts behind each of these methods as well as practical examples of their applications will be emphasized. Cross-listed with: CE 530

ME 522 Mechatronics

This course introduces principles of mechatronics to integrate mechanical, electronic/electrical, and control/computer/ software components for motion control systems. Electromechanical components and integration concepts include: machine construction and control concepts, control modes (open/closed loop, servo, and process control) and motion profiles, motion drivers and actuators (AC drives, motors, gearing, servo and stepper motors), PLC control and programming (ladder and Boolean and combinatorial logic interfaces), microprocessor/computer based (logic, operating systems, SCADA, and HMI), field devices, signal conditioning, and communication (I/O hardware and management, vision systems, protocols, and programming languages), and introduction to system integration.Course includes hands-on lab work, small design projects, case studies, and industry guest lectures.

ME 525 Biomechanics

This course introduces the fundamental principles of mechanics applied to the study of biological systems and relates the design of implants and prosthetics to the biomechanics of the musculoskeletal system. Specific types of tissue covered include bone, ligament, skeletal and cardiac muscle, and articular cartilage. An introduction to the basic concepts of continuum mechanics is provided, including finite-deformation kinematics, stress, constitutive equations, and the governing conservation laws of mass, momentum, and energy applied to deformable continua. Rigid-body kinematics is introduced in the context of applications in biomechanics.

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ME 526 Biofluid Mechanics

This entry-level graduate course provides an introduction to biofluid mechanics with an emphasis on macrocirculation, microcirculation, and other flows in the human body. The fundamental principles of fluid mechanics are reviewed and related to various human biological systems, including the cardiovascular, pulmonary, lymphatic, ocular, synovial and renal systems. Prerequisites: Undergraduate level fluid mechanics, heat transfer, thermodynamics and solid mechanics; Introductory level physical course recommended.

ME 527 Mechanics of Human Movement

This course introduces the basic anatomy of skeletal muscles, tendons, ligaments and joints (including shoulder, hip, knee, foot and ankle). Mechanical principles are applied to the analysis of human movement in daily living, work settings, sports and exercise. Quantitative video analysis techniques are introduced and applied to selected movement analysis projects. Prerequisites: ME 225, ME 361

ME 528 Physiological Systems (for Engineers)

A study of the physiological functions of major organ systems (Neural, Blood, Muscle, Heart, Vascular System Renal, Respiratory and Lymphatics) and how they interact to maintain homeostasis from a systems engineering point of view. Functional anatomy and physiology will be covered as well as quantitative methods for the analysis of organ function and their interactions. An analysis of changes in the major physiological variables with exercise will be used as an example of the integration of the major organs to compensate for stress. Cross-listed with: BME 503 Prerequisites: CH 381 or BIO 381

ME 529 Modern and Advanced Combustion Engines

The internal combustion engine examined in terms of the four fundamental disciplines that determine its characteristics: 1) fluid mechanics; 2) chemistry of combustion and of exhaust emission; 3) first and second laws of thermodynamics, and 4) mechanics of reciprocating and rotary motion; high output Otto and Diesel engines for terrestrial, maritime and aerospace environments; normal and abnormal combustion; stratified charge and advanced low emission engines; hybrid and multifuel engines; Sterling and other space engines; free-piston and rotary-piston concepts and configurations.

ME 530 Introduction to Pharmaceutical Manufacturing

Pharmaceutical manufacturing is vital to the success of the technical operations of a pharmaceutical company. This course is approached from the need to balance company economic considerations with the regulatory compliance requirements of safety, effectiveness, identity, strength, quality, and purity of the products manufactured for distribution and sale by the company. Overview of chemical and biotech process technology and equipment, dosage forms and finishing systems, facility engineering, health, safety and environment concepts, and regulatory issues. Cross-listed with: PME 530, MGT 683

ME 531 Process Safety Management

This course reviews the 12 elements of the Process Safety Management (PSM) model created by the Center for Chemical Process Safety of the American Institute of Chemical Engineers. PSM systems were developed as an expectation/demand of the public, customers, in-plant personnel, stockholders and regulatory agencies because reliance on chemical process technologies were not enough to control, reduce and prevent hazardous materials incidents. PSM systems are comprehensive sets of policies, procedures and practices designed to ensure that barriers to major incidents are in place, in use and effective. The objectives of this course are to: define PSM and why it is important, describe each of the 12 elements and their applicability, identify process safety responsibilities, give real examples and practical applications to help better understand each element, share experiences and lessons learned of all participants, and assess the quality and identify enhancements to student's site PSM program.

ME 532 Air Pollution Principles and Control (3

An introduction to the principles and control of air pollution, including: types and measurement of air pollution; air pollution chemistry; atmospheric dispersion modeling; compressible fluid flow; particle dynamics; ventilation systems; inertial devices; electrostatic precipitators; scrubbers; filters; absorption and adsorption; combustion; condensation. Cross-listed with: EN 506

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ME 535 Good Manufacturing Practice in Pharmaceutical Facilities Design (3 - 3 - 0)

Current Good Manufacturing Practice compliance issues in design of pharmaceutical and biopharmaceutical facilities. Issues related to process flow, material flow, and people flow, and A&E mechanical, industrial, HVAC, automation, electrical, and computer. Bio-safety levels. Developing effective written procedures, so that proper documentation can be provided, and then documenting through validation that processes with a high degree of assurance do what they are intended to do. Levels I, II, and III policies. Clinical phases I, II, III and their effect on plant design. Defending products against contamination. Building quality into products. Cross-listed with: PME 535 Prerequisites: ME 535

Sustainable Design and Operation for FDA Regulated Facilities ME 537 (3 - 3 - 0)

Course addresses the sustainable operation and design of facilities and sites subject to regulatory requirements of US federal agencies such as FDA, NIH, OSHA, EPA, DOE and/or applicable international regulators. Course presents timely issues, challenges and potential benefits of implementing sustainable means and methods to meet new Green Codes and Design Standards that are either in draft review or final version for the regulated facility, whether in planning, design, construction or operation phase. Regulated buildings typically have their own unique requirements in their operation, which require special knowledge to comply and or mitigate safety and regulatory issues, while minimizing impact of rising energy costs to manufacturers, saving scarce resources, and protecting the environment. Furthermore, course introduces the students to resources, survey information of latest sustainable/Green thinking in Green Chemistry, Sustainability and Energy Efficient Design and Products to reduce waste, energy consumption, eliminate unnecessary or optimize manufacturing steps, cut operating costs and be environmentally sensitive. Cross-listed with: PME 537

ME 539 Manufacturing of Biopharmaceutical Products

This course provides a broad overview of topics related to the design and operations of modern biopharmaceutical facilities. It covers process, utilities, and facility design issues, and encompasses all major manufacturing areas, such as fermentation, harvest, primary and final purification, media and buffer preparation, equipment cleaning and sterilization, and critical process utilities. Unit operations include cell culture, centrifugation, conventional and tangential flow filtration, chromatography, solution preparation, and bulk filling. Application of current Good Manufacturing Practices and Bioprocessing Equipment Standards (BPE-2002) will be discussed. Cross-listed with: PME 539, CHE 539

ME 540 Validation in Pharmaceutical Manufacturing

Validation of a pharmaceutical manufacturing process is an essential requirement with respect to compliance with Good Manufacturing Practices (GMP). Course covers: validation concepts for process, equipment, facility, cleaning, sterilization, filtration, analytical methods and computer systems; validation Master Plans, IQ, OQ, and PPQ protocols; and validation for medical devices. Cross-listed with: PME 540, CHE 540 Prerequisites: PME 530 or CHE 530 or ME 530

ME 541 Validation of Computerized Systems

Computers and computerized systems are ubiquitous in pharmaceutical manufacturing. Validation of these systems is essential to assure public safety and compliance with appropriate regulatory issues regarding validation: GMP, GCP, 21CFR Part 11, etc. This course covers validation concepts for various classes of computerized systems and applications used in the pharmaceutical industry; importance of requirements engineering in validation; test protocols and design; organizational maturity considerations. Cross-listed with: PME 541 Prerequisites: ME 540

ME 543 Air-Conditioning

Analysis of refrigeration cycles, properties of refrigerants and coolants; psychrometry; factors affecting human comfort; environmental control requirements in industrial processes; estimation of infiltration and ventilation, heat transmission coefficients, insulation; heating and cooling load on buildings; numerical methods for building energy analysis; selection of air distribution systems, ducting and fans; selection of water and steam distribution systems, piping and pumps.

ME 545 Introduction to Aerospace Engineering

This course lays the foundations in aerospace engineering. Topics include the history of aviation, basic aerodynamics, airfoils, wings and other aerodynamic shapes, aircraft performance, stability and control, aircraft structures (structural analysis and materials), propulsion, flight test, rockets, space flight, and orbits. Prerequisites: ME 342

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ME 546 Introduction to Turbomachinery

Aerodynamic and thermodynamic fundamentals applicable to turbomachinery; design configurations and types of turbomachinery; turbine, compressor and ancillary equipment kinematics, thermodynamics and performance; selection and operational problems of turbomachinery.

ME 547 Validation for Medical Device Manufacturers

This course presents validation for medical device manufacturers in terms of its objectives, strategies, planning, protocols, and documentation. Validation requirements include producing, collecting, analyzing, and managing data and documentation in support of medical device product design and product performance claims. These, as well as manufacturing processes and test methods, are presented within the context of current Quality System Regulations (QSR) as well as Risk Analysis. Qualification is addressed for equipment and operational systems, software and automated systems, and facilities for manufacturing medical devices. Validation in all life cycle phases is presented, both prior to commercial production and during the operating life of the plant, process, and product. Case studies are included as specific examples. Through this course, students will understand how to implement validation studies for medical device manufacturers and to evaluate existing studies. Cross-listed with: PME 547 Prerequisites: ME 580 or ME 660

ME 551 Microprocessor Applications in Mechanical Engineering

Introduction to basic concepts and current state-of-the-art hardware; architecture and elementary programming; instruction sets; fundamental software concepts; interfacing microprocessors to external devices; microprocessors in control systems; hands-on laboratory applications of microprocessors in mechanical engineering systems.

ME 554 Introduction to Computer-Aided Design

An introduction to using a computer system to aid in engineering design, fundamental components of hardware and software; databases and database management, numerical control and computer-aided manufacturing. Integration of manufacturing system from conceptual design through quality control to final shipping is discussed. Applications include solids modeling, CAD drawing and solution using finite element method.

ME 555 Lean Six Sigma

Course explores the current application of Lean Six Sigma in Manufacturing. Topics covered include: Lean Six Sigma Concepts and Techniques, Project and Team Dynamics, Tools of Lean Six Sigma and their Application, and Designing Manufacturing Processes for Lean Six Sigma. Emphasis is on DMAIC, including Define, Measure, Analyze, Improve, and Control methodology, with the students' skill set developed through case studies and project work on actual manufacturing processes using statistical software (Minitab). At the conclusion of this course, students will understand the concepts and principles of Lean Six Sigma, be competent with Minitab software and be able to apply these techniques to manufacturing processes. Cross-listed with: PME 555

ME 560 Total Quality Control

This course provides project managers with the framework, tools and approaches to meet the quality requirements of their projects and their customers, ensuring project success. Cross-listed with: MGT 617

ME 564 Principles of Optimum Design and Manufacture

Application of mathematical optimization techniques, including linear and nonlinear methods, to design and manufacture of devices and systems of interest to mechanical engineers; optimization techniques include: constrained and unconstrained optimization in several variables, problems for structured multi-stage decision, and linear programming; formulation of design and manufacturing problems using computer- based methods; optimum design of parts and assemblies to minimize the cost of manufacture.

ME 565 Introduction to Additive Manufacturing

This course introduces the students to the rapidly growing field of additive manufacturing (more commonly known as 3D printing). The course takes the students through the entire additive manufacturing process, including CAD modeling and tolerancing for additive manufacturing, 3D scanning and file processing, part orientation and layout, model slicing, support and tool path generation, machine and material selection, print optimization as well as an overview of the basic economics of additive manufacturing. The students will get hands-on exposure to many of the technical aspects and applications of additive manufacturing through several projects. The course will also allow students to gain practical experience in machine operation and maintenance tasks such as machine setup and post-processing operations. Prerequisites: E 120 and ME 322

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ME 566 Design for Manufacturability

This course is involved in the design and development of parts and assemblies for manufacturability and functionality; characteristics and capabilities of significant manufacturing processes; principles of design for manufacturability; product planning; conceptual design; embodiment design; dimensional tolerances; optimum design of products to minimize cost of manufacture; materials specifications for ease of manufacturability and good functional results; design for ease of assembly; integrated product development; concurrent engineering practice.

ME 573 Introduction to Microelectromechanical Systems (3 - 3 - 0)

Introduction to microsystem design, modeling and fabrication. Course topics include material properties of Microelectromechanical systems (MEMS), microfabrication technologies, structural behavior, sensing and actuation principles and methods. Emphasis on microsystems design, modeling and simulation including lumped element modeling and finite element analysis. The emerging nano-materials, processes and devices will also be discussed. Student teams design microsystems (sensors, actuators and sensing/control systems) of a variety of types, (optical MEMS, bioMEMS, inertial sensors, etc.) to meet a set of performance specifications using a realistic microfabrication process. Prerequisites: ME 345, ME 361, MT 596

ME 580 Medical Device Design and Technology

Early history of medical devices and procedures. Minimally invasive and open procedures, techniques and devices, including mechanical and electrosurgical devices. Manufacturing methods for catheters, balloons, plastic and metal components. Design of metal device components including material selection and strength and deformation adequacy using material properties and classical mechanics. Selection of insulation materials for and testing of electrosurgical devices. Selection of medical plastics and design elements. Balloon and catheter burst strength. The Poiseuille flow equation and its use for fluid flow through catheters and vessels. Rapid prototyping techniques, advantages and limitations. Understanding of biocompatibility testing and accelerated age testing using the Arrhenius equation. Device sterilization methods and testing. Developing a project plan from brainstorming to product release for a new device. Cross-listed with: PME 580

ME 581 Introduction to Bio Micro Electro Mechanical Systems (BioMEMS) (3 - 3 - 0)

Bringing together the creative talents of electrical, mechanical, optical and chemical engineers, materials specialists, clinicallaboratory scientists, and physicians, the science of biomedical microelectromechanical systems (Bio MEMS) promises to deliver sensitive, selective, fast, low cost, less invasive, and more robust methods for diagnostics, individualized treatment, and novel drug delivery. The goals of this course are to introduce microfabrication, microfluidics, sensors, actuators, drug delivery systems, micro total analysis systems and lab-on-a-chip devices, detection and measurement systems. The main focus is on the fundamental challenges and limitations involved in designing and demonstrating BioMEMS devices.

ME 584 Vibration and Acoustics in Product Design (3 - 3 - 0)

This course offers concurrent design as they apply to quiet product design; vibration and acoustic characteristics in design or products and systems; source-path-receiver model for vibration and acoustics; vibration of single and two degrees of freedom models; features of continuous systems, design for low vibration and vibration control; acoustic plane and spherical waves; acoustical source models; acoustic performance descriptions; design of quiet products and systems; application of computational methods; case studies.

ME 585 Good Manufacturing Practice in Medical Device Facility Design (3 - 3 - 0)

Focus of the course is compliance requirements necessary for Good Manufacturing Practices and Quality Management System. Background includes familiarization of the different categories of medical devices and their manufacturing special requirements. Manufacturing facility requirements are then presented, noting major differences between the various classes of medical devices and also within the classes (e.g. sterility requirements or cleanliness). Included are special requirements for combination products. Regulatory requirements are reviewed. The core of this course is the good engineering practices of facility design. This includes conceptual design, basic engineering, scale up (from lab to manufacturing), procurement, construction, key technologies such as HVAC and utilities requirements, and commissioning, qualification, and validation. Calibration, re-qualification, and maintenance are covered for optimal operational efficiency. Case studies of various manufacturing facilities will be presented. Cross-listed with: PME 585 Prerequisites: ME 580 or ME 660

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ME 587 Human Factors Engineering

This course is a graduate-level introduction to Human Factors Engineering, the discipline that examines the interactions between humans and other elements of a system. The course will present theory, principles, data and methods to design for humans ranging from infants to the aged with special attention to their biological and physical needs. Achieving optimal person- environment interaction requires knowledge about the broad range of human functional capacity, including - but not limited to - anthropometry, biomechanics, sensory processes and others. The course involves a project that applies the obtained knowledge to real world problems with innovative product designs.

ME 590 Environmental Law for Practicing Engineers

Review of laws regarding air, water and noise pollution. Role of engineering representing a company or public before government agencies. Permit system, implementation plans, and other legal sanction. Site studies and environmental impact statements.

ME 594 Computer Methods in Mechanical Engineering

Problems in mechanical engineering illustrating the application of computer methods to solve roots of algebraic and transcendental equations, system of algebraic equations, curve fitting, numerical integration and differentiation, ordinary and partial differential equations.

ME 595 Heat Exchanger Design

Basic principles of heat exchanger design; types of heat exchangers, heat exchanger effectiveness; uncertainty analysis of design and operating parameters; fouling factors; heat transfer augmentation in heat exchangers, two-phase flow, boiling and condensation in heat exchangers, second law of thermodynamics for optimization of heat exchanger design; tube vibrations; codes and standards; individually supervised heat exchanger design project.

ME 596 (3 - 3 - 0)Thermal Analysis and Design in Electronic Packaging

Introduction to electronic packaging, thermal characteristics and operating environment of electronic components, reliability; fundamental concepts and basic modes of heat transfer; contact and interface thermal resistance; convective cooling of components and systems, modeling of chips, packages, and printed circuit boards; finned array and heat sink analysis; cold plate and heat exchanger design and analysis; computer-aided design; heat pipes; liquid and immersion cooling.

ME 597 Integrated Design and Packaging of Electronic Systems

This is a multi-disciplinary course in the analysis and design of electronic systems. Topics include: introduction to conduction, convection and radiation heat transfer as applied to electronic systems; design of heat sinks for small to large frames; structural analysis including shock and vibration modeling; introduction to electromagnetic shielding; integrated product design for manufacturing, reliability and quality control.

ME 598 Introduction to Robotics

Elements of a robotic/flexible automation system; overview of applications; manipulator anatomy; drive systems; end effectors; sensors; computer control: functions, levels of intelligence, motion control, programming and interfacing to sensors and actuators; applications: identification, hardware selection, work cell design, economics, case studies; design of parts and assemblies; advanced topics.

ME 601 Engineering Thermodynamics

Fundamental laws of the thermodynamics of mechanical, thermal and chemical equilibrium systems; thermodynamic properties of materials including multiphase, multicomponent systems with gaseous chemical reactions; analysis of thermodynamic systems (open and closed) based primarily on the first and second laws.

ME 604 Advanced Heat Transfer

Fundamental modes of heat transfer; conduction, thermal resistance, extended surface with variable cross-section area, application of analytical, numerical and analog methods to the steady and unsteady state; convection, fluid flow and elementary boundary layer theory, dimensional analysis, forced convection for internal and external flows, natural convection, laminar and turbulent flow correlation formulas, condensation and boiling; radiation, physical foundations, radiative properties of surfaces, enclosure radiation, view factors, electrical analogy, gas radiation.

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Conduction Heat Transfer ME 605

Lumped, integral and differential formulation of general laws, statement of particular laws, initial and boundary conditions; steady one-dimensional conduction, principles of superposition; extended surfaces, power series solutions and Bessel functions, approximate solutions; steady two- and three-dimensional conduction, unsteady problems, separation of variables and orthogonal functions; steady periodic problems and complex temperature; finite difference formulation and numerical solutions; introduction to finite element formulation of conduction problems.

ME 607 Radiation Heat Transfer

An introduction to the theoretical and empirical foundation of thermoradiation; Plank's Law and Wien's Law; Stefan-Boltzmann law; radiative properties of surfaces; conductors and dielectrics; energy balances on radiating surfaces; radiative properties of gases; energy transitions of molecules; interactions between molecules and radiation; band absorption; equation of radiative transfer in an absorbing, emitting and scattering medium; radiation in a gas filled enclosure; radiation combined with conduction and convection.

Convective Heat Transfer ME 609

Place of convective heat transfer among engineering sciences, concepts related to thermodynamics, mechanics and deformable moving media. General principles: conservation of mass, balance of linear momentum, conservation of total energy, increase of entropy; formulation of parallel flows, buoyancy driven flows, thermal boundary layers, fully developed heat transfer in pipes and channels, heat transfer correlations for turbulent flows.

ME 610 Advanced Topics in Mechanical Engineering

Courses on advanced topics of current interest in Mechanical Engineering, including but not limited to any of the following: steam turbines, random vibrations, stability of nonlinear mechanical systems, stress waves in solids, lubrication theory, radiative heat transfer, mechanism design, buckling of metal structures.

ME 611 **Engineering Acoustics**

Fundamentals of wave motion, acoustical plane waves, spherical waves, transmission of sound through media, radiation of sound, acoustical source mechanisms, absorption of sound, principles of underwater acoustics, ultrasonics.

ME 612 Selected Topics in Air Pollution Technology

This course will concentrate on a group of current topics in air pollution technology. For example: public health aspects of air pollution, incineration, fugitive emissions, modeling and prediction of near-field dispersion, air quality measurement, aerosols, odor control, current industrial applications and practice. The course will extend coverage of air pollution topics into additional areas not covered in conventional courses and provide flexibility for new, timely subjects.

ME 614 Nuclear Reactor Theory & Design

This course covers the basic elements of nuclear reactor theory for reactor core design and operation. Emphasis is placed on thermal and hydraulic analyses of power reactors, neutronics, fuel cycles, economics, nuclear analysis, control and safety. Complete reactor systems are analyzed. Standard reactor design codes are utilized.

ME 615 Thermal Systems Design

Introduction to fluid mechanics and heat transfer; design of piping systems; selection of pumps; analysis and design of heat exchangers; modeling and simulation of thermal systems; system optimization and design; case studies.

ME 616 Thermal-Hydraulics Design of Nuclear Power Reactors

This course covers the application of fundamental thermal and hydraulic principles and their application to nuclear power reactor design and analysis. It assumes that the student has a basic knowledge of fundamental principles in fluid mechanics, thermodynamics and heat transfer. Topics include: principal characteristics of nuclear power reactors; thermal design principles and application; transport equations for single-phase and two-phase flow; thermodynamics of nuclear power plant systems (steady and unsteady flow); thermal analysis of fuel elements; single-phase and two-phase flow and heat transfer; pool and flow boiling; single heated channel steady-state analysis. Major industry software including PCTRAN and TRNSYS are utilized in case studies and design projects.

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ME 617 Flame Structure and Combustion Processes

The structures of flames in a variety of practical combustion devices (e.g., coal and oil burners, reciprocating engines, etc.) are described theoretically and compared to experimental results. Based on this understanding, the basic "tradeoff" between efficiency and pollutant emissions is established.

ME 621 Introduction to Modern Control Engineering

Introduction to state space concepts; state space description of physical systems such as electrical, mechanical, electromechanical, thermal, hydraulic, pneumatic, aerospace, etc. systems. Eigenvalues, eigenvectors and other topics in linear algebra, modal decomposition and other coordination transformations. Relationship between classical transfer function methods and modern state methods. Analysis of linear continuous and discrete time linear systems, solution by state transition matrix, control ability, observability and stability properties; synthesis of linear feedback control systems via pole assignment and stabilizability and performance index minimization. Brief introduction to optimal control, estimation and identification.

ME 622 Optimal Control and Estimation of Dynamical Systems

Introduction to vector stochastic processes; response of linear differential systems to white noise, state estimation of linear stochastic systems by Kalman Filtering, combined optimal control and estimation of continuous time Linear Quadratic Gaussian (LQG) regulators; optimization techniques for dynamic systems using nonlinear programming methods and variational calculus; optimal control of linear and nonlinear systems by Pontryagin's maximum principle and Hamilton-Jacobi-Bellman theory of dynamic programming; computational methods in optimal control and estimation; applications to aerospace, mechanical electrical and other physical systems. Prerequisites: ME 621

ME 623 Design of Control Systems

This course focuses on the application of advanced process control techniques in pharmaceutical and petrochemical industries. Among the topics considered are bioreactor and polymerization reactor modeling, biosensors, state and parameter estimation techniques, optimization of reactor productivity for batch, fed-batch and continuous operations, and expert systems approaches to monitoring and control. An overview of a complete automation project of a pharmaceutical plant, from design to start-up, will be discussed, including process control issues and coordination of interdisciplinary requirements and regulations. Guest speakers from local industry will present current technological trends. A background in differential equations, biochemical engineering and basic process control is required. Cross-listed with: CHE 661

ME 624 Intelligent Mechatronic Systems

This course spans the background, fundamental principles and elements of hardware/software required for design and prototyping intelligent mechatronic systems and fundamentals for developing knowledge-bases, tools and methods that contribute to the intelligent response of system to expected and unexpected stimuli. The course introduces hardware and software development system architectures, interfacing to the analog world with sensors, response synthesis and actuation. Model-based, learning-based and knowledge-based algorithms that enable intelligent response synthesis by the system will be studied. Prerequisite: ME522 Mechatronics I (Preferred but not Required). Prerequisites: ME 522

ME 625 Gas Turbines

Gas turbine cycles, theoretical and practical; cycles with intercooling, recuperation and reheat; the closed cycle turbine; cycles on the H-S charts; heat exchangers; intercoolers; compressor and turbine types; turbine cooling; aircraft gas turbines; turboprops and turbojets; afterburners and wet compression for jets; industrial gas turbines; nuclear fuel applications; regulation of gas turbines.

ME 627 Turbomachines

Fundamental theory of turbomachines for incompressible fluids; Euler theorem; velocity diagrams; hydraulic turbines and pumps; aerodynamic theory of turbomachines; two-dimensional and three-dimensional flow of compressible fluids; boundary layer considerations in turbomachines, loading limits and design corrections; free vortex, solid rotation, and other types of radical equilibrium; axial, radial and mixed flow machines; transonic and supersonic compressors; similarity laws; characteristic curves; off design conditions and regulation.

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ME 628 Manufacturing and Packaging of Pharmaceutical Oral Solid Dosage Products (3-3-0)

The course covers oral solid dosage (OSD) manufacturing and packaging in the pharmaceutical industry. Production unit operations include blending, granulation, size reduction, drying, compressing, and coating for tablets, as well as capsule filling. Packaging aspects reviewed include requirements for primary and secondary containers and labeling, package testing. The course emphasizes design, scale-up, trouble-shooting, validation, and operation of typical OSD manufacturing and packaging facilities, including equipment, material flow, utilities, and quality assurance. Topics related to cGMP, process validation, manufacturing and packaging documentation, QA and QC in OSD manufacturing will be presented. The term project required for this course involves conceptual design of a contract manufacturing and packaging facility for OSD products, including equipment selection, development of the process flow diagrams, room layouts and other design elements, as well as preparation of Standard Operating Procedures for various unit operations. Cross-listed with: PME 628 Prerequisites: PME 530, CHE 530

ME 631 Mechanical Vibrations I

Vibration of linear system with one degree of freedom; multidegree of freedom systems; vibration control; Lagrange's equation; theory of small vibrations; matrix methods; normal coordinates; approximate methods of Holzer and Rayleigh-Stodola.

ME 632 Mechanical Vibrations II

Vibration of continuous systems; theory and application using finite element method; nonlinear systems; transient response, shock and impact phenomena; random vibrations.

ME 635 Modeling and Simulation

This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement and use computers to solve complex systems/products analysis problems. The key emphasis is on problem formulation, model building, data analysis, solution techniques and evaluation of alternative designs/processes in complex systems/products. Overview of modeling techniques and methods used in decision analysis, including multiattribute utility models, decision trees and optimization methods are discussed. Cross-listed with: IPD 611

ME 636 Project Management of Complex Systems

This project-based course exposes students to tools and methodologies useful for forming and managing an effective engineering design team in a business environment. Topis covered will include: personality profiles for creating teams with balanced diversity; computational tools for project coordination and management; real-time electronic documentation as a critical design process variable; and methods for refining project requirements to ensure that the team addresses the right problem with the right solution. Cross-listed with: IPD 612

ME 639 Modeling and Simulation of Pharmaceutical Manufacturing Systems (3 - 3 - 0)

This course will introduce students to the modeling and simulation applications in the pharmaceutical manufacturing. Learn the basics of discreet event simulation and use commercially available software to develop models of various manufacturing and service systems. Approaches to the development of conceptual and computer models, data collection and analysis, model verification and validation, simulation output analysis are discussed. Learn how to model chemical, biochemical and separation processes in pharmaceutical manufacturing using process simulation software. Develop material balances, stream reports, operations and equipment Gantt charts, conduct process debottlenecking and cost analysis. Cross-listed with: PME 639, CHE 639

ME 641 Engineering Analysis I

Introduction to the application of engineering analysis techniques and mathematical principles of mechanical engineering. In addition to analytical and computational techniques, case studies and project-based examples will be given.

ME 642 Engineering Analysis II

Topics included are applications of complex variables, linear algebra, ordinary and partial differential equations, numerical analysis and other mathematical methods applied to mechanical engineering.

ME 644 Computer-Integrated Design and Manufacturing

Fundamentals of Computer-Integrated Design and Manufacturing addresses design and manufacturing as a global closedloop system comprising four major functions: marketing, part design, process specifications and production. The emphasis of this course is on the computer integration of the islands of automation created by isolated computerized systems within these major functions in an enterprise.

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Introduction to the design and control of production systems using mathematical, computational and other modern techniques. Topics that will be investigated include forecasting, inventory systems, aggregate production planning, material requirements planning, project planning, job sequencing, operations scheduling and reliability, in addition to capacity, flexibility and economic analysis of flexible manufacturing systems.

ME 648 Mechanics of Continuous Media

A basically physical approach to the study of continuum Prerequisites: ME 658

Design of Production Systems

ME 649 Design of Water, Steam, & CIP Utility Systems for Pharmaceutical Manufacturing (3 - 3 - 0)

Water and steam systems: water used as excipient, cleaning agent or product dilutent, and water quality selection criteria; generation, storage, and distribution systems; bio-burden control; USP PWS (purified water systems) and USP WFI (water for injection) systems; engineering considerations, including specification, design, installation, validation, operation, testing, and maintenance; common unit operations, including deionization, reverse osmosis, distillation, ultrafiltration, and ozonation systems; process considerations, including pretreatment, storage and distribution, materials of construction, microbial control pyrogen control, and system maintenance; FDA requirements; clean-in-place systems; and steam generation and distribution systems. Cross-listed with: PME 649 Prerequisites: PME 530, CHE 530

ME 651 Analytic Dynamics

ME 645

Fundamentals of Newtonian mechanics; principle of virtual work; d'Alembert's Principle; Hamilton's Principle; Lagrange's equations; Hamilton's equations; motion relative to moving reference frames; rigid-body dynamics; Hamilton-Jacobi equation; applications.

ME 652 Advanced Additive Manufacturing

This advanced graduate-level course introduces the students to the latest developments in and novel applications of additive manufacturing (AM), a new manufacturing method that adds material layer-by-layer to produce objects. In addition to various advanced AM techniques, the course also discusses the implications of AM on current design practice, products and users. Through several projects, the students gain a deep understanding of advanced AM technologies and related applications.

ME 653 Design for Additive Manufactoring

In this graduate course, the students will develop a rich knowledge and deep understanding of design for additive manufacturing concepts and techniques, along with methods for analyzing and optimizing product designs according to additive manufacturing guidelines. This course is structured around the study of the pertinent technical literature, carrying out design assignments, utilizing software tools and completing a comprehensive term project.

ME 654 Advanced Robotics

Robot path control, dynamics of robot systems, mechanical drive systems; microcomputers, computational architectures, digital control of manipulators; sensors, force and compliance control, vision systems, tactile sensing, range finding and navigation; intelligence and task planning. Prerequisites: ME 598

ME 657 Advanced Mechanics of Materials

This course introduces mechanical behaviors, properties and modeling approaches for engineering materials including metals, ceramics, polymers, active materials and micro-/nano-scale materials such as thin films, nanowires and nanotubes. It emphasizes the fundamentals of mechanical behaviors including elasticity, plasticity, fatigue, fracture and creep, constitutive relations and modeling tools as well as the special properties of various materials related to their composition and microstructures. It provide a systematical view of engineering materials for product design and manufacturing or material selection for an engineering system at both macro and micro/nano scales.

ME 658 Advanced Mechanics of Solids

Torsion, bending and shear of beams with solid or thin-walled sections; curved beams; shrink fits, pressure vessels, spinning discs; experimental techniques, strain rosettes; buckling of bars, beams, rings, boiler tubes; thermal stress problems; introduction to theory of elasticity.

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ME 659 Advanced Structural Design

This course deals with methodologies for designing modern structures and other performance-driven products. The course entails aspects of computer-aided engineering (CAE), integration of CAE and design, methodologies for failure and stability analysis, designing with anisotropic materials such as composites, modeling process-material-performance relationships and the use of such models in design, multidisciplinary design optimization and integrated product design automation. Prerequisites: ME 663, ME 641, ME 658, ME 661

ME 660 Medical Devices Manufacturing

Technical tools and knowledge required to operate and manage in medical devices manufacturing environment. Current requirements in medical devices regulations, quality systems, and design elements related to manufacturing steps to assure patients health and safety. Requirements concerning selection and supply of raw materials and components for manufacturing; design and qualification of facilities, equipment, and process systems; testing, controls and inspection for compliance. Combination products, validation, external contractors, and case studies. Focus on understanding the principles and methods required in a medical devices manufacturing environment in compliance with GMP regulations. Cross-listed with: PME 660 Prerequisites: ME 530, and ME 535

ME 661 Advanced Stress Analysis

Stress analysis of axisymmetric bodies; beams on elastic foundations; introduction to plate theory and fracture mechanics; plasticity; creep and fatigue of engineering materials. Prerequisites: ME 663, ME 641, ME 658

ME 663 **Finite-Element Methods**

Development of the fundamental equations of finite-element theory, using the matrix displacement approach. Detailed case studies of one-dimensional (truss and beam), two-dimensional (plane stress/strain and axisymmetric solid), k and plate-bending elements are explained. Applications include interactive model building and solutions. Prerequisites: ME 641, ME 658

ME 664 Special Topics in Applied Finite-Element Methods

This course covers the development and application of finite-element theory to (1) fluid structure interaction, (2) large deformations of incompressible material, (3) electromechanical coupling problems, and (4) nonlinear heat transfer with phase change. Prerequisites: ME 663

ME 665 Advanced Product Development

This course addresses methodologies and tools to define product development phases and also provides experience working in teams to design high-quality competitive products. Primary goals are to improve ability to reason about design, material and process alternatives and apply modeling techniques appropriate for different development phases, as well as development of competitive product design and plans for its manufacture along with facilities layout simulation, testing and service. Topics covered are: user requirements gathering, quality function deployment (QFD), design for assembly, design for materials and manufacturing processes, optimizing the design for cost and producibility, manufacturing process specifications and planning, process control and optimization, SPC and six sigma process, tolerance analysis, flexible manufacturing, product testing and rapid prototyping.

Engineering Fracture Mechanics ME 668

Fracture energy, linear elastic fracture mechanics, stress intensity factor, crack opening displacement (COD), fracture mechanics in design, elastic plastic fracture mechanics, numerical methods in fracture mechanics, introduction to fatigue, fatigue crack initiation, fatigue crack propagation.

ME 669 Theory of Plasticity

Fundamentals of elasticity and plasticity, yield criteria, plastic stress-strain relations, theories of work hardening. Extremum principles. Application to problems of bending, torsion, plane stress and plane strain. Slip line and limit analysis. Prerequisites: ME 658

ME 673 Aeroelasticity

Review of two-dimensional thin airfoil theory, thin air foils in unsteady motion, transient harmonic time dependence; fundamentals of vibration of continuous and lumped systems; aeroelastic vibrations, single degree of freedom flutter, stall flutter, coupled bending-torsion flutter; multiple degrees of freedom, cascades, turbomachines.

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ME 680 Fundamentals of Micro/Nano Fluidics

As an introduction to micro/nano fluidics, course topics include basic fluid mechanical theories, experimental techniques, fabrication techniques and applications of micro/nano fluidics. The theory part will cover continuum fluid mechanics at micro/ nano scales, molecular approaches, capillary effects, electrokinetic flows, acoustofluidics and optofluidics. The experimental part will cover micro/nano rheology and particle image velocimetry. The fabrication part will cover materials and machining techniques for micro/nano fluidic devices. The application part will cover micro/nano fluidic devices for flow control, life sciences and chemistry. As a term project, individual students are required to perform a case study for their own selected topic in micro/nano fluidics, to conduct a literature survey/summary and to propose/analyze their own new design idea of a micro/nano fluidic devices by utilizing the knowledge obtained throughout the course. Cross-listed with: NANO 680

ME 681 Applications of Advanced Micro/Nano Materials, Structures and Devices (3 - 3 - 0)

The goals of this course are to go beyond the introduction stage in Micro-Electro-Mechanical Systems (MEMS) and Nano-Electro-Mechanical Systems (NEMS) to provide students with a strong background in the design and characterization of micro- and nano-scale sensors and actuators with a broad range of applications in VNT-based sensors, actuators and devices, biomedical systems, micro- and nanoscale manipulation, adaptive optics, and microfluidics. The main focus is on the fundamental challenges and limitations involved in designing and demonstrating micro and nano devices and systems. Prerequisites: ME 573, ME 581 or equivalents

ME 682 Advanced Nanofabrication for Nanoelectronics

This course will address the basic concepts of nanoelectronics, including fundamental principles, novel electronic materials, novel fabrication techniques and devices. In particular, it will focus on novel nanofabrication techniques including nanolithography, growth and assembly processes, and characterization techniques to validate its fabrication process related to the area of Nanoelectronics. It will also address the technical issues to develop nano-scale elements/devices including single electron devices, carbon nanotubes as interconnects or transistors, nanowires, graphene materials and devices, spintronic applications and eventually complex organic molecules as memory and logic units. Prerequisites: ME 573

ME 684 **Multiphase Flows**

Fundamental principles of two-phase gas-liquid flow and associated heat transfer as applied to power, chemical, petrochemical, and process industries; topics include: flow patterns, homogeneous and separated flow models, two-phase pressure drops, drift-flux model, critical flow, flooding, nucleation theory, pool and flow boiling, critical heat flux, post-critical heat flux, heat transfer, condensation, and thermal-hydraulic instabilities. Prerequisites: ME 674, ME 601

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ME 674 Fluid Dynamics

Stress in a continuum; kinematics of fluid motion; rate of strain and vorticity; relation between stress and rate of strain; the Navier-Stokes equations; inviscid flow; stream function, velocity potential and circulation; Kelvin and Helmholtz theorems; two-dimensional incompressible flows; the Kuta-Joukowski theorem; introduction to compressible flows, boundary layers and drag-on bodies. Prerequisites: ME 641

ME 675 Computational Fluid Dynamics and Heat Transfer

Computational techniques for solving problems in fluid flow and heat transfer; review of governing equations for fluid flow, special topics in numerical analysis, algorithms for incompressible flow, treatment of complicated geometrical constraints. Prerequisites: ME 594, ME 674

ME 678 Viscous and Turbulent Flows (3 - 3 - 0)

Fundamental equations of viscous flow; solutions of the Newtonian viscous flow equations; laminar boundary layers; stability of laminar flows; fluid turbulence and approximate solutions.

ME 679 Mechanics of Compressible Fluids

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ME 690 Cell Mechanics

This course is designed to introduce the students to the theoretical and experimental approaches to understanding the architecture and mechanics of cellular biology. Emphasis is placed on the mechanical analysis of cytoskeletal filaments, membranes and adhesions as well as the various instrumentation tools used for in vitro characterization of these cell components and phenomena. Also explored are the various models used to describe cell mechanics and the role of converting a mechanical perturbation into a biological cell response, i.e. mechanotransduction in normal physiology. Knowledge of basic cell biology is not assumed and will be systematically reviewed.

ME 691 Additive Manufacturing for Biological Systems

Computer-Aided Tissue Engineering is designed for engineering students interested in acquiring the knowledge and skills necessary to implement enabling computer-aided tools for medical implant design, manufacturing and tissue engineering applications. The students will be introduced to topics on how engineering and biology intersect in biomedical implant design and manufacturing. The 3D modeling, image-based reconstruction and analysis exercises will prepare the student with hands-on sessions on state-of-the-art software and hardware technologies used by leading medical device companies and by the tissue engineering research community. No knowledge in biology is required for this course.

ME 700 Seminar in Mechanical Engineering (0 - 1 - 0)

Presentations and discussions by advanced graduate students on selected topics.

ME 701 ME Co-Op Education Project (0 - 0 - 0)

This course is for ME graduate students who are on Co-Op assignment.

ME 702 Curriculum Practical Training

International graduate students may arrange an internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course provided that the course constitutes and integral part of their educational program. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/her activities during that semester, even if the activity remains ongoing. This is a one-credit course that may be repeated up to a total of three credits.

ME 799 Practicum for Graduate Students (1 - 0 - 0)

Special problem intended for students pursuing Curricular Practical Training.

ME 800 Special Problems in Mechanical Engineering (ME)

3 credits for the degree of Master of Engineering (Mechanical).

ME 801 Special Problems in Mechanical Engineering (PhD)

3 credits for the degree of Doctor of Philosophy.

ME 802 Special Problems in Mechanical Engineering (Deg ME)

3 credits for the degree of Mechanical Engineer.

ME 810 Special Topics in Mechanical Engineering

A participating seminar on topics of current interest and importance in Mechanical Engineering.

ME 900 Thesis in Mechanical Engineering

For the degree of Master of Engineering (Mechanical). Hours and credits to be arranged.

ME 950 Mechanical Engineering Design Project

Design project for the degree of Mechanical Engineer. 12 credits with advisor approval.

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ME 960 Research in Mechanical Engineering

Original work, which may serve as the basis for the dissertation, required for the degree of Doctor of Philosophy. Hours and credits to be arranged.

Integrated Product Development

IPD 601 Integrated Product Development I

The first IPD course addresses methodologies and tools to define product development phases and also provides experience working in teams to design high-quality competitive products. Primary goals are to improve ability to reason about design, material, and process alternatives and apply modeling techniques appropriate for different development phases. Topics covered are: user requirements gathering, quality function deployment (QFD), design for assembly, design for materials and manufacturing processes, and optimizing the design for cost and producibility.

IPD 602 Integrated Product Development II

This course builds on the product definition and development processes. It focuses on the implementation of competitive product design and plans for its manufacture along with facilities layout simulation, testing, and service. Project deliverables are comprehensive product, process and testing specifications. Topics include: manufacturing process specifications and planning, process control and optimization, SPC and six sigma process, tolerance analysis, flexible manufacturing, product testing, and rapid prototyping. Prerequisites: IPD 601

IPD 611 Modeling and Simulation

This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement and use computers to solve complex systems/products analysis problems. The key emphasis is on problem formulation, model building, data analysis, solution techniques and evaluation of alternative designs/processes in complex systems/products. Overview of modeling techniques and methods used in decision analysis, including multi-attribute utility models, decision trees, and optimization methods are discussed. Cross-listed with: ME 635

IPD 612 Project Management and Organizational Design

This project-based course exposes students to tools and methodologies useful for forming and managing an effective engineering design team in a business environment. Topics covered will include: personality profiles for creating teams with balanced diversity; computational tools for project coordination and management; real time electronic documentation as a critical design process variable; and methods for refining project requirements to ensure that the team addresses the right problem with the right solution. Cross-listed with: ME 636

IPD 810Special Topics in Integrated Product Development(3 - 3 - 0)

A participating seminar on topics of current interest and importance in Integrated Product Development.

Product Architecture and Engineering

PAE 610	The Creative Form and the Digital Environment	(3-3-0)
Introduction to the digital environme	ne study of expressive form with integrated functional application. The study of nt;	the Creative Form in the

PAE 620	The Creative Form and the Production Environment	(3-3-0)
Introduction to t	the study of expressive form with integrated production methodologies:	

PAE 630 Introduction to Interactive Digital Media (3 - 3 - 0)

Introduction to the study of expressive form with integrated production methodologies:

PAE 640 Performative Environments (3 - 3 - 0)

Recently there has been a shift in the way we are able to gather and disseminate information about the real world - mostly due to a vast reduction in the expense of computer systems, interconnectivity of devices, and simplified programming interfaces. The focus of this class will be to leverage these technologies to allow us a better understanding of the spaces we inhabit. This course will cover the basics of electronic systems, communication typologies between different systems, sensor types and implementation (light, temperature, energy measurement, occupancy, etc.), data storage – leverage cloud computing, and data visualization of acquired data. Prerequisites: PAE 630

PAE 800 Product-Architecture and Engineering Design Project

Issues of context, methodology, program and fabrication are explored for their possible interrelated meanings and influences on the making of expressive form. This design studio, which is required for the Masters degree, is offered by individual instructors to students who have successfully completed the core curriculum.

PAE 900 Thesis in Product-Architecture and Engineering

Under the supervision of a faculty advisor, students are responsible for the preparation and completion of an independent thesis project. Hours and credits to be arranged.

Pharmaceutical

PME 530 Introduction to Pharmaceutical Manufacturing

Pharmaceutical manufacturing is vital to the success of the technical operations of a pharmaceutical company. This course is approached from the need to balance company economic considerations with the regulatory compliance requirements of safety, effectiveness, identity, strength, quality, and purity of the products manufactured for distribution and sale by the company. Overview of chemical and biotech process technology and equipment; dosage forms and finishing systems; facility engineering; health, safety, and environment concepts; and regulatory issues. Cross-listed with: ME 530, MGT 683

PME 531 Process Safety Management

This course reviews the 12 elements of the Process Safety Management (PSM) model created by the Center for Chemical Process Safety of the American Institute of Chemical Engineers. PSM systems were developed as an expectation/demand of the public, customers, in-plant personnel, stockholders, and regulatory agencies because reliance on chemical process technologies were not enough to control, reduce, and prevent hazardous materials incidents. PSM systems are comprehensive sets of policies, procedures, and practices designed to ensure that barriers to major incidents are in place, in use, and effective. The objectives of this course are to: define PSM and why it is important, describe each of the 12 elements and their applicability, identify process safety responsibilities, give real examples and practical applications to help better understand each element, share experiences and lessons learned of all participants, and assess the quality and identify enhancements to a student's site PSM program. Cross-listed with: CHE 531

PME 535 Good Manufacturing Practice in Pharmaceutical Facilities Design (3 - 3 - 0)

Current Good Manufacturing Practice compliance issues in design of pharmaceutical and biopharmaceutical facilities; issues related to process flow, material flow and people flow, and A&E mechanical, industrial, HVAC, automation, electrical, and computer; bio-safety levels; developing effective written procedures so that proper documentation can be provided, and then documenting through validation that processes with a high degree of assurance do what they are intended to do; levels I, II, and III policies; clinical phases I, II, and III, and their effect on plant design; defending products against contamination; and building quality into products. Cross-listed with: ME 535

PME 537 Sustainable Design and Operation for FDA Regulated Facilities (3 - 3 - 0)

Course addresses the sustainable operation and design of facilities and sites subject to regulatory requirements of US federal agencies such as FDA, NIH, OSHA, EPA, DOE and/or applicable international regulators. Course presents timely issues, challenges and potential benefits of implementing sustainable means and methods to meet new Green Codes and Design Standards that are either in draft review or final version for the regulated facility, whether in planning, design, construction or operation phase. Regulated buildings typically have their own unique requirements in their operation, which require special knowledge to comply and or mitigate safety and regulatory issues, while minimizing impact of rising energy costs to manufacturers, saving scarce resources, and protecting the environment. Furthermore, course introduces the students to resources, survey information of latest sustainable/Green thinking in Green Chemistry, Sustainability and Energy Efficient Design and Products to reduce waste, energy consumption, eliminate unnecessary or optimize manufacturing steps, cut operating costs and be environmentally sensitive. Cross-listed with: ME 537 Prerequisites: PME 535

(3 - 3 - 0)

(3 - 3 - 0)

(1 to 6 - -)

PME 538 Chemical Technology Processes in API Manufacturing

Bulk active pharmaceutical ingredient manufacturing and unit operations; process scale-up; transport processes, including mass, heat, and momentum transfer; process synthesis, analysis, and design; traditional separation processes, including distillation, evaporation, extraction, crystallization, and absorption; new separation processes, including pressure swing adsorption, molecular sieves, ion exchange, reverse osmosis, microfiltration, nanofiltration, ultrafiltration, diafiltration, gas permeation, pervaporation, supercritical fluid extraction, and high performance liquid chromatography (HPLC); and batch and continuous reactors for homogeneous, heterogeneous, catalytic, and non-catalytic reactions. Prerequisites: PME 530, CHE 530, ME 530

PME 539 Manufacturing of Biopharmaceutical Products (3 - 3 - 0)This course provides a broad overview of topics related to the design and operations of modern biopharmaceutical facilities. It covers process, utilities, and facility design issues, and encompasses all major manufacturing areas, such as fermentation, harvest, primary and final purification, media and buffer preparation, equipment cleaning and sterilization, and critical process utilities. Unit operations include cell culture, centrifugation, conventional and tangential flow filtration, chromatography, solution preparation, and bulk filling. Application of current Good Manufacturing Practices and Bioprocessing Equipment

Standards (BPE-2002) will be discussed. Cross-listed with: CHE 539, ME 539 PME 540 Validation in Pharmaceutical Manufacturing

Validation of a pharmaceutical manufacturing process is an essential requirement with respect to compliance with Good Manufacturing Practices (GMP). Course covers: validation concepts for process, equipment, facility, cleaning, sterilization, filtration, analytical methods and computer systems; validation Master Plans, IQ, OQ, and PPQ protocols; and validation for medical devices. Cross-listed with: ME 540, CHE 540 Prerequisites: PME 530 or CHE 530 or ME 530

PME 541 Validation of Computerized Systems

Computers and computerized systems are ubiquitous in pharmaceutical manufacturing. Validation of these systems is essential to assure public safety and compliance with appropriate regulatory issues regarding validation: GMP, GCP, 21CFR Part 11, etc. This course covers validation concepts for various classes of computerized systems and applications used in the pharmaceutical industry; importance of requirements engineering in validation; test protocols and design; organizational maturity considerations. Cross-listed with: ME 541 Prerequisites: PME 540

PME 542 Global Regulation and Compliance in the Pharmaceutical Industry (3 - 3 - 0)

This course explores the economic theory of regulation in general, and the US and international regulatory environments that govern the pharmaceutical and biotechnology industries with particular focus on the US Food and Drug Administration. the European Agency for the Evaluation of Medical Products and the Japanese Ministry of Health, Labor and Welfare. The essential components of Good Laboratory Practices, Good Clinical Practices, and Good Manufacturing Practices regulations will be covered. Students will develop an understanding of the formulation and execution of regulatory strategy and key ethical issues in medical research and production. Where appropriate, case studies will be used to illustrate the challenges and issues associated with compliance as well as the consequences of noncompliance. Ethical issues and the potential consequences of ethical lapses will also be explored. Current events will be used to illustrate key ethical principles and serve as a basis for discussion.

PME 547 Validation for Medical Device Manufacturers

This course presents validation for medical device manufacturers in terms of its objectives, strategies, planning, protocols, and documentation. Validation requirements include producing, collecting, analyzing, and managing data and documentation in support of medical device product design and product performance claims. These, as well as manufacturing processes and test methods, are presented within the context of current Quality System Regulations (QSR) as well as Risk Analysis. Qualification is addressed for equipment and operational systems, software and automated systems, and facilities for manufacturing medical devices. Validation in all life cycle phases is presented, both prior to commercial production and during the operating life of the plant, process, and product. Case studies are included as specific examples. Through this course, students will understand how to implement validation studies for medical device manufacturers and to evaluate existing studies. Cross-listed with: ME 547 Prerequisites: PME 580 or PME 660

(3 - 3 - 0)

(3 - 3 - 0)

(3 - 3 - 0)

PME 551Process Analytical Technology (PAT) in Pharmaceutical Operations(3 - 3 - 0)

This course provides an overview of PAT applications in pharmaceutical operations. At the conclusion of the course, students will understand the PAT life cycle, be able to identify PAT applications likely to yield positive benefit, understand issues of organizing and managing a PAT project and integrating the principles of Quality by Design into the effort (i.e. design control, facility and equipment control, production and process control, and material control). Students will also understand the principles of integrating PAT application projects with the six-sigma approach to process improvement: Define, Measure, Analyze, Improve and Control (DMAIC). Topics covered include: PAT applications, risk analysis/risk management, project management issues (integrating PAT into process and product development, technology transfer to manufacturing, change management, etc.), and the PAT system project life cycle. Examples of PAT impact on workflow, productivity, process variability and product quality will be discussed. Prerequisites: PME 530

PME 555 Lean Six Sigma

Course explores the current application of Lean Six Sigma in Manufacturing. Topics covered include: Lean Six Sigma Concepts and Techniques, Project and Team Dynamics, Tools of Lean Six Sigma and their Application, and Designing Manufacturing Processes for Lean Six Sigma. Emphasis is on DMAIC, including Define, Measure, Analyze, Improve, and Control methodology, with the students' skill set developed through case studies and project work on actual manufacturing processes using statistical software (Minitab). At the conclusion of this course, students will understand the concepts and principles of Lean Six Sigma, be competent with Minitab software and be able to apply these techniques to manufacturing processes. Cross-listed with: ME 555

PME 560 Quality in Pharmaceutical Manufacturing

This course provides a detailed exploration of quality programs with specific application to the particular requirements of the pharmaceutical industry. Students will develop an understanding of the quality philosophy which drives the industry from discovery through manufacturing, and of the systems and tools that are employed to implement and maintain a sustainable and successful quality system. Application of quality strategies in research and development, commercial production, computer systems, post-marketing, and other areas will be included. Where appropriate, case studies will be used to illustrate the challenges and issues associated with quality system deployment.

PME 570 Biopharmaceuticals - Product Development and Upstream Production Systems (3 - 3 - 0)

Course covers the following topics: Structure and physical, chemical and biological attributes of biologics. Product stability, pharmacokinetics, delivery. Critical quality attributes of Pioneer Drugs and Biogenerics. Fundamentals of nucleic acid and protein structure and function. Genetic engineering tools. Modern production vectors and hosts. Cell line and media selection and optimization. Cell-bank characterization and stability. Upstream processes. Culture, fermentation and scale-up. Critical upstream process parameters, regulatory controls and validation. Rapid vaccine manufacturing and monoclonal antibody case studies. Prerequisites: Students must have taken at least one course in organic chemistry and one course in biochemistry, molecular biology, or genetics, or equivalent background as determined by instructor. Cross-listed with: CH 570

PME 580 Medical Device Design and Technology

(3-3-0)

Early history of medical devices and procedures. Minimally invasive and open procedures, techniques and devices, including mechanical and electrosurgical devices. Manufacturing methods for catheters, balloons, plastic and metal components. Design of metal device components including material selection and strength and deformation adequacy using material properties and classical mechanics. Selection of insulation materials for and testing of electrosurgical devices. Selection of medical plastics and design elements. Balloon and catheter burst strength. The Poiseuille flow equation and its use for fluid flow through catheters and vessels. Rapid prototyping techniques, advantages and limitations. Understanding of biocompatibility testing and accelerated age testing using the Arrhenius equation. Device sterilization methods and testing. Developing a project plan from brainstorming to product release for a new device. Cross-listed with: ME 580

(3-3-0)

PME 585 (3 - 3 - 0)Good Manufacturing Practice in Medical Device Facility Design

Focus of the course is compliance requirements necessary for Good Manufacturing Practices and Quality Management System. Background includes familiarization of the different categories of medical devices and their manufacturing special requirements. Manufacturing facility requirements are then presented, noting major differences between the various classes of medical devices and also within the classes (e.g. sterility requirements or cleanliness). Included are special requirements for combination products. Regulatory requirements are reviewed. The core of this course is the good engineering practices of facility design. This includes conceptual design, basic engineering, scale up (from lab to manufacturing), procurement, construction, key technologies such as HVAC and utilities requirements, and commissioning, qualification, and validation. Calibration, re-qualification, and maintenance are covered for optimal operational efficiency. Case studies of various manufacturing facilities will be presented. Cross-listed with: ME 585 Prerequisites: PME 580 or PME 660

PME 590 Risk-Based Compliance in the Pharmaceutical Industry (3 - 3 - 0)

Course presents Quality Risk Management, including Risk-Based Compliance for Cross Contamination, Occupational Safety, and Environmental Protection. Addresses the issues of occupational exposure to high hazard pharmaceutical compounds, and product-to-product cross contamination in multipurpose facilities. Explores issues that a pharmaceutical professional needs to understand regarding projects that put the workforce or product at risk and, in the case of product exposure, impact product quality and regulatory scrutiny. Included are emission sources and essentials, routes of exposure, toxicology, safety and regulatory limits of exposure, exposure control for facilities and processes, quantitative risk assessment, and mitigation techniques. Cross-listed with: EN 590

PME 600 Engineering Economics and Cost Analysis (3 - 3 - 0)

This course presents advanced techniques and analysis designed to permit managers to estimate and use cost information in decision making. Topics include: historical overview of the management accounting process, statistical cost estimation, cost allocation, and uses of cost information in evaluating decisions about pricing, quality, manufacturing processes (e.g., JIT, CIM), investments in new technologies, investment centers, the selection process for capital investments, both tangible and intangible, and how this process is structured and constrained by the time value of money, the source of funds, market demand, and competitive position. Cross-listed with: EM 600

PME 602 Statistical Methods in Pharmaceutical Manufactoring (3 - 3 - 0)

This course is focused on the application of statistics and statistical reasoning in pharmaceutical manufacturing, particularly in production, guality assurance, guality control, validation and analytical laboratories. Basic statistical definitions and concepts are described. Students will learn various measures of central tendency and spread of data, how to present data graphically and be introduced to the probability distributions most commonly encountered in pharmaceutical manufacturing. Approaches to choosing samples for analysis, statistical inference, sample size and power will be discussed. The course also covers regression and correlation, analysis of variance, gage repeatability and reproducibility, statistical process control, process capability analysis and design of experiments as applied to pharmaceutical manufacturing. Students will learn to apply statistical software to analyze common problems that arise in pharmaceutical manufacturing operations, including evaluation of dosage form weight and content uniformity, potency, dissolution, bio-equivalency and other product quality attributes.

PME 609 Introduction to Project Management

This course deals with the problems of managing a project, which is defined as a temporary organization of human and nonhuman resources, within a permanent organization, for the purpose of achieving a specific objective; both operational and conceptual issues will be considered. Operational issues include definition, planning, implementation, control and evaluation of the project. Conceptual issues include project management vs. hierarchical management, matrix organization, project authority, motivation and morale. Cases will be used to illustrate problems in project management and how to resolve them. Cross-listed with: MGT 609

PME 621 Pharmaceutical Mixing

Fundamentals of mixing relevant to pharmaceutical engineering, flow patterns, dead zones, components of mixers, importance of baffling, determination of flow, power, and shear rates, effect of rheology, "shaken, not stirred", why viscosity affects more than just Reynolds numbers, continuous processing, heat transfer, suspending solids that sink or float, wetting out solids, concepts of crystallization, catalysis, mass transfer, liquid-liquid dispersions, emulsions, and separations, fermenters, hydrogenators, other gas-liquid applications, pit-falls of scale-up, why scale-down is the better way to design, process intensification and solids-solids mixing. Cross-listed with: CHE 621

(3 - 3 - 0)

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SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

PME 626 Manufacturing of Biopharmaceutical Products

This course is focused on topics related to the technology, design and operations of modern biopharmaceutical facilities. It covers process, utilities and facility design issues and encompasses all major manufacturing areas, such as fermentation, harvest, primary and final purification, media and buffer preparation, equipment cleaning and sterilization, critical process utilities, unit operations including cell culture, centrifugation, conventional and tangential flow filtration, chromatography, solution preparation, and bulk filling. The application of current Good Manufacturing Practices and Bioprocessing Equipment Standards will be discussed. Prerequisites: PME 530 or ME 530 or CHE 530

PME 628 Manufacturing and Packaging of Pharmaceutical Oral Solid Dosage Products (3 - 3 - 0)

The course covers oral solid dosage (OSD) manufacturing and packaging in the pharmaceutical industry. Production unit operations include blending, granulation, size reduction, drying, compressing, and coating for tablets, as well as capsule filling. Packaging aspects reviewed include requirements for primary and secondary containers and labeling, package testing. The course emphasizes design, scale-up, trouble-shooting, validation, and operation of typical OSD manufacturing and packaging facilities, including equipment, material flow, utilities, and quality assurance. Topics related to cGMP, process validation, manufacturing and packaging documentation, QA and QC in OSD manufacturing will be presented. The term project required for this course involves conceptual design of a contract manufacturing and packaging facility for OSD products, including equipment selection, development of the process flow diagrams, room layouts and other design elements, as well as preparation of Standard Operating Procedures for various unit operations. Cross-listed with: ME 628 Prerequisites: PME 530, ME 530, CHE 530

PME 629 Manufactoring of Sterile Pharmaceuticals

This course is focused on the special characteristics and types of sterile dosage forms and the technologies for their manufacturing. Topics such as environmental and contamination controls, facility design, water and air quality, personnel and other requirements for sterile manufacturing are covered. Sterilization methods for the equipment, components, intermediate and finished products are reviewed. Terminal sterilization and aseptic processing technologies including blowfill-seal and barrier isolation systems are discussed. The course also includes topics such as Good Manufacturing Practices (GMP) regulations and guidance on aseptic manufacturing, quality assurance and control, stability, storage and distribution applicable to sterile dosage forms manufacturing. Prerequisites: CHE 530 or ME 530 or PME 530

PME 638 Chemical Technology Processes in API Manufacturing

Bulk active pharmaceutical ingredient manufacturing and unit operations. Process scale-up. Transport processes, including mass, heat, and momentum transfer. Process synthesis, analysis, and design. Traditional separation processes, including distillation, evaporation, extraction, crystallization, and absorption. New separation processes, including pressure swing adsorption, molecular sieves, ion exchange, reverse osmosis, microfiltration, nanofiltration, ultrafiltration, diafiltration, gas permeation, pervaporation, supercritical fluid extraction, and high performance liquid chromatography (HPLC). Batch and continuous reactors for homogeneous, heterogeneous, catalytic, and non-catalytic reactions.

PME 639 Modeling and Simulation of Pharmaceutical Manufacturing Systems (3-3-0)

This course will introduce students to modeling and simulation applications in pharmaceutical manufacturing. The fundamentals of discrete event simulation and the use of commercially available software to develop models of various manufacturing and service systems will be introduced. Approaches to the development of conceptual and computer models, data collection and analysis, model verification and validation, and simulation output analysis will be discussed. The modeling of chemical, biochemical and separation processes in pharmaceutical manufacturing using process simulation software will be presented. Material balances, stream reports, operations and equipment Gantt charts will be developed and process debottlenecking and cost analysis will be conducted. Cross-listed with: CHE 630, ME 639, CHE 639

PME 640 Contemporary Concepts in Pharmaceutical Validation

Current and evolving validation concepts and standards in pharmaceutical manufacturing, including FDAs GMPs for 21st Century, Risk Assessments (Risk-MaPP, ICH Q7a-Q10, FMEA) and statistics in validation, Commissioning and Qualification (ISPE and ASTM), Computer Systems Validation, Cleaning Validation, Spreadsheet Validation, Lean Manufacturing and Six Sigma, PAT initiative, Equipment Qualification vs. CSV (GAMP and AAPS guidelines). Preparation of draft validation documentation, including master plans, protocols, test procedures and reports. Focus is on concepts and principles required to implement these new qualification and validation approaches in a pharmaceutical manufacturing environment in compliance with FDA and international regulations. Needs knowledge of basic statistics concepts. Prerequisites: PME 530, PME 540

(3 - 3 - 0)

(3 - 3 - 0)

(3 - 3 - 0)

PME 643 Design and Management of Aseptic Pharmaceutical Manufacturing Processes (3 - 3 - 0)

This course presents a systematic methodology for the project management of aseptic pharmaceutical manufacturing processes. This includes the associated equipment and the integration of the preliminary design, detailed design, construction, and validation phases of a project to minimize the challenges, and cost and schedule overruns typically associated with implementing these complex processes. The content includes selection of the project team, defining the process requirements the equipment is required to meet, preparation of the equipment user requirements specifications, preparation of the equipment layout, preparation of the equipment, and installation of the equipment and site acceptance testing. Also addressed will be selection of and dealing with equipment vendors, planning for validation success, and regulatory acceptance.An aseptic manufacturing process case study is used as a basis for the lecture series. The process will be followed from the preparation of the raw data used to determine the process requirements through to final installation and acceptance of the aseptic processing equipment on site. Prerequisites: PME 530, PME 609

PME 646 Biopharmaceuticals Facilities Design

(3-3-0)

(3 - 3 - 0)

Proven techniques and creative tools presented for design, development, and delivery of biopharmaceutical manufacturing facilities. Includes skills and knowledge in bioprocessing requirements, equipment and facility requirements, project management as well as regulatory guidelines and "big-picture" drug development. Also corporate capital management processes to functionally meet corporate requirements from pre-clinical to commercial scale of operations, qualifications to pass regulatory inspections, achieving faster "time-to-market," but not breaking the corporate treasury bank. Course also explores trends in new equipment technology such as disposables or single-use product, new design concepts in aseptic manufacturing, barrier and isolation technologies, new FDA thinking in risk-based compliance approach, process analytical technology, capital project planning and management. Cross-listed with: CHE 646 Prerequisites: PME 530, PME 539, PME 609

PME 649 Design of Water, Steam and CIP Utility Systems for Pharma Manufacturing (3 - 3 - 0) Water & steam systems: (water used as excipient, cleaning agent, or product diluent) water quality selection criteria; generation, storage, and distribution systems; bio-burden control; USP PWS (purified water systems) and USP WFI (water for injection) systems; engineering considerations, including specification, design, installation, validation, operation, testing, and maintenance; common unit operations, including deionization, reverse osmosis, distillation, ultrafiltration, and ozonation systems; process considerations, including pretreatment, storage and distribution, materials of construction, microbial control, pyrogen control, and system maintenance; FDA requirements; clean-in-place systems; and steam generation and distribution systems. Cross-listed with: ME 649

PME 653 Design of PAT Systems for Pharmaceutical Manufacturing (3 - 3 - 0)

The objective of this course is to provide the student with the engineering tools and knowledge required to design and deploy Process Analytical Technology (PAT) solutions in pharmaceutical drug substance and drug product manufacturing. This course provides in-depth coverage of current PAT technologies. At the conclusion of this course, students will understand the engineering theory, principles, and mathematics required to design and deploy these technologies in a pharmaceutical manufacturing environment in compliance with FDA and international regulations. Cross-listed with: CHE 653

PME 660 Medical Devices Manufacturing

Technical tools and knowledge required to operate and manage in medical devices manufacturing environment. Current requirements in medical devices regulations, quality systems, and design elements related to manufacturing steps to assure patients health and safety. Requirements concerning selection and supply of raw materials and components for manufacturing; design and qualification of facilities, equipment, and process systems; testing, controls and inspection for compliance. Combination products, validation, external contractors, and case studies. Focus on understanding the principles and methods required in a medical devices manufacturing environment in compliance with GMP regulations. Cross-listed with: ME 660 Prerequisites: PME 530, and PME 535

PME 701PME Co-Op Education Project(0 - 0 - 0)

This course is for PME graduate students who are on Co-Op assignment.

PME 800 Specical Problems in Pharmaceutical Manufacturing and Engineering

A participating seminar on topics of current interest and importance in Pharmaceutical Manufacturing Practices

PME 810 Special Topics in Pharmaceutical Manufacturing Practices

A participating seminar on topics of current interest and importance in Pharmaceutical Manufacturing Practices

PME 900 Thesis in Pharmaceuticals Manufacturing and Engineering

Under the supervision of a faculty advisor, students are responsible for the preparation and completion of an independent thesis project. Hours and credits to be arranged.

Department of Physics & Engineering Physics

FACULTY

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Wei Li, M.S., Ph.D. Research Associate Professor

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Bernard Rosen, Ph.D. Professor Emeritus

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UNDERGRADUATE PROGRAMS

The laws of physics govern the universe from the formation of stars and galaxies, to the processes in the Earth's atmosphere that determine our climate, to the elementary particles and their interactions that hold together atomic nuclei. Physics also drives many rapidly-advancing technologies, such as information technology, telecommunication, nanoelectronics, and medical technology, including MRI imaging and laser surgery.

The physics program at Stevens combines classroom instruction with hands-on research experience in one of several stateof-the-art research laboratories (Photonics Science and Technology, Optical Communication and Nanodevices, Quantum Electron Science and Technology, NanoPhotonics, Light and Life, or Ultrafast Spectroscopy and Communication). Perhaps the most differentiating feature of the Stevens physics curriculum is SKIL (Science Knowledge Integration Ladder), a sixsemester sequence of project-centered courses. This course sequence lets students work on projects that foster independent learning, innovative problem solving, collaboration and team work, and knowledge integration under the guidance of a faculty advisor. The SKIL sequence starts in the sophomore year with projects that integrate basic scientific knowledge and simple concepts. In the junior and senior years, the projects become more challenging and the level of independence increases.

Bachelor of Science in Physics

Our B.S. degree in Physics is accredited by the Middle States Accreditation Board. Our graduates have a wide range of career opportunities beyond the pursuit of a traditional graduate degree in physics, including employment in a variety of other industries, such as telecommunications, optics, finance, medical technology, or defense. Those who choose to further their physics education are accepted into graduate programs at some of the best schools.

Qualified students may participate in faculty-supervised projects.

Possible technical electives during the later semesters to ensure a complete undergraduate curriculum:

- ▶ PEP 501 Fundamentals of Atomic Physics (3-0-3)
- ▶ PEP 503 Introduction to Solid State Physics (3-0-3)
- ▶ PEP 506 Modern Astrophysics and Cosmology (3-0-3)
- ▶ PEP 507 Introduction to Microelectronics and Photonics (3-0-3)
- ▶ PEP 509 Intermediate Waves and Optics (3-0-3)
- ▶ PEP 510 Modern Optics Lab (0-3-3)
- ▶ PEP 520 Computational Physics (3-0-3)
- ▶ PEP 555 Statistical Physics and Kinetic Theory (3-0-3)
- ▶ PEP 552 Theory of Relativity (3-0-3)
- ▶ PEP 556 Introduction to Quantum Control (3-0-3)

Other physics courses, needed in order to complete a concentration, may be substituted with the consent of your advisor.

Physics Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit	
CH 115	General Chemistry I	3	0	6	3	
CH 117	General Chemistry Laboratory I	0	3	1	1	
CS 105	Introduction to Scientific Computing ¹	2	2	6	3	
MA 121	Differential Calculus	4	0	8	2	
MA 122	Integral Calculus	4	0	8	2	
PEP 111	Mechanics	3	0	6	3	
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3	
	Total	19	5	41	17	

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
BIO 281 Or PEP 151	Biology and Biotechnology Or Introduction to Astronomy	3	0	6	3
MA 123	Series, Vectors, Functions, and Surfaces	4	0	8	2
MA 124	Calculus of Two Variables	4	0	8	2
PEP 112	Electricity and Magnetism	3	0	6	3
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	20	3	41	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
MA 221	Differential Equations	4	0	8	4
PEP 209	Modern Optics	3	0	6	3
PEP 221	Physics Lab I for Scientists	0	3	1	1
PEP 297	SKIL I	1	3	4	2
E 245	Circuits and Systems ²	2	3	7	3
PE 200	Physical Education I	0	2	0	0
	Total	13	11	32	16

Term IV						
Course #	Course Name		Lecture	Lab	Study	Credit
	Humanities ⁴	:	3	0	6	3
MA 227	Multivariable Calculus		3	0	6	3
PEP 222	Physics Lab II for Scientists		0	3	1	1
PEP 242	Modern Physics	:	3	0	6	3
PEP 298	SKIL II		1	3	4	2
PEP 330	Intro to Thermal & Statistical Physics		3	0	0	3
MA 222	Probability and Statistics		3	0	6	3
	Total		16	6	29	18

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
PEP 527	Math Methods for Science and Engineering I	3	0	6	3
PEP 538	Introduction to Mechanics ²	3	0	0	3
PEP 397	SKIL III	1	6	0	3
G.E.	General Elective ⁵	3	0	6	3
	Total	13	6	18	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
PEP 542	Electromagnetism	3	0	6	3
PEP 398	SKIL IV	1	6	5	3
G.E.	General Elective ⁵	3	0	6	3
BT 243	Macroeconomics	3	0	6	3
Or	Or				
BT 244	Microeconomics				
	Total	13	6	29	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
PEP 553	Quantum Mechanics and Engineering Applications	3	0	6	3
PEP 497	SKIL V ³	1	6	5	3
G.E.	General Elective ⁵	3	0	6	3
T.E.	Technical Elective ²	3	0	3	3
	Total	13	6	26	15

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ⁴	3	0	6	3
T.E.	Technical Elective ²	3	0	6	3
PEP 498	SKIL VI ³	1	6	5	3
T.E.	Technical Elective ²	3	0	3	3
T.E.	Technical Elective ²	3	0	6	3
	Total	13	6	26	15

Term VIII

(1) Or CS 115, Intro. to Computer Science.

(2) Technical Electives

(3) SKIL V and SKIL VI can be a year-long Senior Project resulting in a final report or a thesis.

(4) Humanities electives can be found on pages 556-557.

(5) General Elective: chosen by the student- can be used towards a minor or option- can be applied to research or approved international studies

Bachelor of Science in Engineering Physics (EP)

The Department of Physics and Engineering Physics also offers an undergraduate Engineering Physics (EP) Program, which leads to a B.S. degree in Engineering Physics in three concentrations (see below). The program aims to attract students who are intrigued by the possibility of combining a mastery of basic physics concepts with exposure to state-of-the-art engineering technology in selected high-tech areas. The EP Program is a special program that was developed jointly by the Department of Physics and Engineering Physics and the School of Engineering and Science. Students in the EP Program follow a special core curriculum that provides the basic concepts of engineering together with a basic understanding of physical phenomena at a microscopic level and lets them explore the relation of the physics concepts to practical problems of engineering in one of three high-tech areas of concentration: Applied Optics, Microelectronics and Photonics, or Atmospheric and Environmental Science. These concentrations represent high-tech areas of significant current local and global technological and economic interest. The PEP department has both research strengths and educational expertise in these areas where there is significant growth potential. For all concentrations, required and/or elective courses offered by other departments (EE, EN, and MT) can be used to complement departmental course offerings, which provide the students in the program with the necessary diversity, breadth, and depth of educational offerings and research opportunities. The following curriculum shows the common two years and then the final two years separately for each concentration.

Engineering Physics (EP) Curriculum

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Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
PEP 111	Mechanics		0	6	3
E 115	Introduction to Programming	1	2	3	2
E 120	Engineering Graphics	0	2	1	1
E 121	Engineering Design I	0	3	2	2
MA 121	Differential Calculus	4	0	8	2
MA 122	Integral Calculus	4	0	8	2
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	18	10	41	19

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CH 116	General Chemistry II	3	0	6	3
CH 118	General Chemistry Laboratory II	0	3	1	1
PEP 112	Electricity and Magnetism	3	0	6	3
MA 123	Series, Vectors, Functions, and Surfaces	4	0	8	2
MA 124	Calculus of Two Variables	4	0	8	2
E 122	Engineering Design II	0	3	3	2
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
	Total	17	6	38	16

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
MA 221	Differential Equations	4	0	8	4
E 245	Circuits and Systems	2	3	7	3
PEP 221	Physics Lab I for Scientists	0	3	1	1
PEP 209	Modern Optics	3	0	6	3
PEP 297	SKIL I	1	3	4	2
	Total	13	9	32	16

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
MA 227	Multivariable Calculus	3	0	6	3
PEP 222	Physics Lab II for Scientists	0	3	1	1
PEP 242	Modern Physics	3	0	6	3
PEP 298	SKIL II	1	3	4	2
PEP 330	Intro to Thermal & Statistical Physics	3	0	0	3
	Total	13	6	23	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
PEP 527	Math Methods for Science and Engineering I	3	0	6	3
PEP 538	Introduction to Mechanics	3	0	0	3
PEP 397	SKIL III	1	6	0	3
E 243	Probability and Statistics for Engineers	3	0	6	3
T.E.	Technical Elective ¹	3	0	3	3
	Total	16	6	21	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 542	Electromagnetism	3	0	6	3
PEP 509	Intermediate Waves and Optics	3	0	6	3
PEP 398	SKIL IV	1	6	5	3
	Humanities	3	0	6	3
BT 243	Macroeconomics	3	0	3	3
Or	Or				
BT 244	Microeconomics				
	Total	13	6	26	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
PEP 553	Quantum Mechanics and Engineering Applications	3	0	6	3
PEP 510	Modern Optics Lab	3	0	0	3
PEP 577	Laser Theory and Design	3	0	0	3
PEP 497	SKIL V	1	6	5	3
	Total	13	6	17	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
PEP 554	Quantum Mechanics II ²	3	0	6	3
TE	Technical Elective ³	3	0	0	3
PEP 498	SKIL VI	1	6	5	3
G.E.	General Elective	3	0	6	3
	Total	13	6	23	15

Possible Technical Electives (TE): PEP 515, PEP 516, PEP 528, PEP 570, PEP 679, PEP 680, and EE 626 (with instructor's consent)
 Possible CTE/TEs: PEP 515, PEP 516, PEP 528, PEP 540, PEP 570, PEP 679, PEP 680, and EE 626 (with consent of the instructor)
 Can be replaced by PEP 678 with the consent of the instructor.

Microelectronics and Photonics Curriculum

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 507	Introduction to Microelectronics and Photonics	3	0	0	3
PEP 527	Math Methods for Science and Engineering I	3	0	0	3
PEP 538	Introduction to Mechanics	3	0	0	3
PEP 397	SKIL III	1	6	0	3
E 243	Probability and Statistics for Engineers	3	0	6	3
	Humanities	3	0	6	3
	Total	16	6	12	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 542	Electromagnetism	3	0	6	3
PEP 596	Micro-Fabrication Techniques	3	0	6	3
PEP 398	SKIL IV	1	6	5	3
BT 243	Macroeconomics	3	0	3	3
Or	Or				
BT 244	Microeconomics				
	Humanities	3	0	6	3
	Total	13	6	26	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
PEP 553	Quantum Mechanics and Engineering Applications	3	0	6	3
PEP 515	Photonics I	3	0	0	3
PEP 561	Solid State Electronics for Engineering I	3	0	0	3
PEP 497	SKIL V	1	6	5	3
	Total	13	6	17	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
PEP 516	Photonics II ¹	3	0	0	3
PEP 562	Solid State Electronics for Engineering II ¹	3	0	6	3
PEP 498	SKIL VI	1	6	5	3
G.E.	General Elective	3	0	6	3
	Total	13	6	23	15

(1) or CTE Technical Electives. Possible C.T.E./T.E.s: PEP 503, PEP 595, PEP 628, and PEP 678 (with consent of the instructor)

Atmospheric and Environmental Science Curriculum

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	C.T.E/T.E. ¹	3	0	3	3
PEP 538	Introduction to Mechanics	3	0	0	3
PEP 397	SKIL III	1	6	0	3
	Humanities	3	0	6	3
PEP 527	Math Methods for Science and Engineering I	3	0	0	3
E 243	Probability and Statistics for Engineers	3	0	6	3
	Total	16	6	15	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
PEP 542	Electromagnetism	3	0	6	3
EN 550	Environmental Chemistry of Atmospheric Processes	3	0	0	3
PEP 398	SKIL IV	1	6	5	3
	Humanities	3	0	6	3
BT 243	Macroeconomics	3	0	6	3
Or	Or				
BT 244	Microeconomics				
	Total	13	6	23	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
PEP 553	Quantum Mechanics and Engineering Applications	3	0	6	3
PEP 575	Fundamentals of Atmospheric Radiation and Climate	3	0	0	3
	C.T.E/T.E. ¹	3	0	3	3
PEP 497	SKIL V	1	6	5	3
	Total	13	6	20	15

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
T.E.	Technical Elective ¹	3	0	6	3
EN 506	Air Pollution Principles and Control	3	0	6	3
PEP 498	SKIL VI	1	6	5	3
G.E.	General Elective	3	0	6	3
	Total	13	6	29	15

Term VIII

(1) Possible C.T.E./T.E.s: PEP 509, PEP 510, PEP 520, PEP 554, EN 505, EN 541, EN 545 and EN 570

Minors

A minor represents a coherent program of study in a discipline other than the student's major degree program. Successful completion of a minor program is recognized on the transcript and with a Minor Certificate at graduation. Recognition is thus provided for a significant educational experience in another discipline.

General requirements for minor programs in engineering or science:

- Entry to a minor program requires a minimum cumulative GPA of 2.5.
- A student wishing to pursue a minor program must complete a Minor Program Study Plan signed by a Minor Advisor from the relevant discipline. Each minor requires a separate study plan and a student can earn no more than two minors in engineering and science.
- The minor program must be in a discipline other than that of a student's major program of study. As such, minors are distinguished from options within the major discipline or concentrations within the chosen major program.
- The minor program will consist of a coherent sequence of at least six courses. A minimum of two courses (minimum six credits) must be in addition to those courses required to complete a student's major degree program (which includes general education courses).
- In order for a course to count towards a minor, a grade of C or above must be achieved. At the discretion of the Minor Advisor, transfer credits may be applied to a minor, but these must constitute fewer than half of those applied to the minor program.
- ► To receive the minor at graduation, the student must complete a Minor Candidacy Form signed by the Minor Advisor after all minor requirements are fulfilled.

Physics

Required courses for a Minor in Physics:

- ▶ PEP 242 Modern Physics Or PEP 201 Physics III for Engineers
- ▶ PEP 538 Introduction to Mechanics
- ▶ PEP 542 Electromagnetism
- ▶ PEP 553 Introduction to Quantum Mechanics

Plus any two of the following courses:

- ▶ PEP 209 Modern Optics
- ▶ PEP 330 Introduction to Thermal and Statistical Physics
- ▶ PEP 332 Mathematical Methods for Physics
- ▶ PEP 336 Introduction to Astrophysics and Cosmology
- ▶ PEP 501 Fundamentals of Atomic Physics
- ▶ PEP 503 Introduction to Solid State Physics
- ▶ PEP 509 Intermediate Waves and Optics
- ▶ PEP 510 Modern Optics Lab
- ▶ PEP 520 Computational Physics
- ▶ PEP 527 Mathematical Methods of Science and Engineering I
- ▶ PEP 552 Theory of Relativity
- ▶ PEP 554 Quantum Mechanics
- ▶ PEP 555 Statistical Physics and Kinetic Theory

The following are prerequisites needed to undertake the minor program:

- ▶ PEP 111 Mechanics
- ▶ PEP 112 Electricity and Magnetism

Astronomy

Required courses for a Minor in Astronomy:

- ▶ PEP 151 Introduction to Astronomy
- ▶ PEP 336 Introduction to Astrophysics and Cosmology
- Plus four of the following courses:
- ▶ PEP 209 Modern Optics
- ▶ PEP 351 Introduction to Planetary Science
- ▶ PEP 337 Observational Astrophysics
- ▶ PEP 506 Modern Astrophysics and Cosmology
- ▶ PEP 552 Theory of Relativity

The following are prerequisites needed to undertake the minor program:

- ▶ PEP 111 Mechanics
- ▶ PEP 112 Electricity and Magnetism

Photonics

Required courses for a Minor in Photonics:

- ▶ PEP 209 Modern Optics
- ▶ PEP 509 Intermediate Waves and Optics
- ▶ PEP 510 Modern Optics Lab
- ▶ PEP 542 Electromagnetism

Plus two of the following courses:

- ▶ PEP 515 Photonics I
- ▶ PEP 516 Photonics II
- ▶ PEP 570 Guided Wave Optics
- ▶ PEP 577 Laser Theory and Design
- ▶ PEP 578 Laser Applications and Advanced Optics
- ▶ PEP 507 Introduction to Microelectronics and Photonics

The following are prerequisites needed to undertake the minor program:

- MA 221 Differential Equations
- ▶ PEP 112 Electricity and Magnetism

Interdisciplinary Program in Computational Science

For students interested in interdisciplinary science and engineering, Stevens offers an undergraduate computational science program. Computational science is a new field in which techniques from mathematics and computer science are used to solve scientific and engineering problems. See the description of the Program in Computational Science in the Interdisciplinary Programs section.

GRADUATE PROGRAMS

The graduate program in physics is designed for the student who desires to master fundamental concepts and techniques, who is interested in studying applications in various areas of technology and science, and who wishes to keep abreast of the latest experimental and theoretical innovations in these areas. We offer a varied curriculum consisting of either highly specialized courses or broad training in diverse areas.

When you seek an advanced degree, you can gain both breadth and specialization. The required degree courses provide broad skills in basic physics; the elective choices give highly specialized training in a variety of different areas. The Department of Physics and Engineering Physics is large enough to offer rich and varied programs in pure and applied physics, yet it is small enough to sustain the sense of a coherent community in search of knowledge.

Admissions Requirements

- For all graduate programs in physics a B.S. degree is required, which includes the following course work: calculusbased three- or four-semester introductory physics sequence in thermodynamics, electricity and magnetism, mechanics, quantum mechanics, and mathematical methods.
- Ph. D, applicants lacking the above courses are required to take the indicated courses for no graduate credit.

Master of Science - Physics

The Master of Science degree prepares you optimally for further continuation to a Ph.D. program in physics. It is awarded after completion of 30 credits of graduate coursework which include the following required courses:

- ▶ PEP 642 Mechanics
- ▶ PEP 643/644 Electricity and Magnetism I and II
- PEP 554 Quantum Mechanics I
- ▶ PEP 528 Mathematical Methods of Science and Engineering II
- ▶ PEP 555 Statistical Physics and Kinetic Theory
- ▶ PEP 510 Modern Optics Lab (or another lab equivalent)
- One 600-level advanced quantum mechanics course

and two additional elective courses, chosen in consultation with an academic advisor. These courses may be used to conduct research to graduate with an MS Thesis (PEP 900.) Courses with material already covered in undergraduate preparation must be replaced in consultation with an academic advisor.

Master of Engineering - Engineering Physics

The Master of Engineering - Engineering Physics degree program has three options. Students enrolled in a particular option develop a course of study in conjunction with their academic advisor. In contrast to the Master of Science in Physics, the Master of Engineering option is intended to provide the student with deeper insight into the specific area of their choice. Students wanting to continue their education towards a doctoral degree will be optimally prepared for interdisciplinary physics research yet may have to take several additional courses to fulfill the requirements for a Ph.D. in Physics.

The Engineering option in Applied Optics seeks to extend and broaden training in areas pertinent to the field of optics and optical engineering. A bachelor's degree in either science or engineering from an accredited institution is required.

Core Courses in Engineering Physics (Applied Optics)

- ▶ PEP 509 Intermediate Waves and Optics
- ▶ PEP 510 Modern Optics Lab
- PEP 515-516 Photonics I-II
- ▶ PEP 527 Mathematical Methods of Science and Engineering I
- ▶ PEP 542 Electromagnetism
- ▶ PEP 553 Introduction to Quantum Mechanics
- PEP 554 Quantum Mechanics I
- ▶ PEP 577 Laser Theory and Design
- ▶ PEP 578 Laser Applications and Advanced Optics or PEP 678 Physics of Optical Communications Systems

The Engineering Physics option in Solid State Physics seeks to extend and broaden training in those areas pertinent to the field of solid state device engineering. A bachelor's degree in either science or engineering from an accredited institution is required.

Core Courses in Engineering Physics (Solid State Physics)

- ▶ EE 619 Solid State Devices
- ▶ PEP 503 Introduction to Solid State Physics
- ▶ PEP 510 Modern Optics Lab
- ▶ PEP 527 Mathematical Methods of Science and Engineering I
- ▶ PEP 538 Introduction to Mechanics
- ▶ PEP 542 Electromagnetism
- ▶ PEP 553 Intro. to Quantum Mechanics
- PEP 554 Quantum Mechanics I
- ▶ PEP 555 Statistical Physics and Kinetic Theory
- ▶ PEP 680 Quantum Optics

Courses with material already covered in undergraduate preparation must be replaced in consultation with an academic advisor.

Master of Engineering Physics- Concentration Nanotechnology

The Engineering Physics option in Nanotechnology seeks to extend and broaden training in a largely interdisciplinary learning environment with a focus on fundamentals and applications of Nanotechnology. A bachelor degree in either science or engineering from an accredited institution is required. The M.E. degree in nanotechnology will be awarded after completion of 30 credits of graduate coursework with the following requirements:

Core courses required:

- ▶ PEP 538 Introduction to Mechanics
- ▶ PEP 542 Electromagnetism
- ▶ NANO/PEP 553 Introduction to Quantum Mechanics or NANO/PEP 554 Quantum Mechanics I*
- ▶ NANO/PEP 503 Introduction to Solid State Physics
- ▶ NANO/PEP 555 Statistical Physics and Kinetic Theory
- ▶ NANO 600 Nanoscale science and technology
- NANO 525/625 Techniques of surface and nanostructure characterization
- ▶ Regular attendance of the seminar series in the Nanotechnology Curriculum (NANO 700).

In addition to the core courses, the student has to complete three additional courses out of the PEP or NANO program (elective courses) selected in consultation with the adviser. As an option, candidates may choose to execute a Master thesis in the realm of nanotechnology in consultation with an academic advisor for up to six credits to be counted towards the degree in replacement of elected courses.

* Students with a background in Quantum Mechanics should take directly PEP/NAN0554 after consultation with the adviser.

The Physics and Engineering Physics program offers, jointly with Electrical and Computer Engineering (ECE) and Materials Engineering, a unique interdisciplinary concentration in Microelectronics and Photonics Science and Technology. Intended to meet the needs of students and of industry in the areas of design, fabrication, integration, and applications of microelectronic and photonic devices for communications and information systems, the program covers fundamentals, as well as state-of-the-art industrial practices. Designed for maximum flexibility, the program accommodates the background and interests of students with either a master's degree or graduate certificate.

Interdisciplinary Concentration Microelectronics and Photonics Science and Technology

 PEP 507 Introduction to Microelectronics and Photonics* plus three additional courses from The Applied Optics on Solid State Concentration.

Six electives are required from the courses offered below by Materials Engineering, Physics and Engineering Physics, and Electrical Engineering. Three of these courses must be from Physics and Engineering Physics and at least one must be from each of the other two departments. Ten courses are required for the degree.

*Cross-listed as EE 507 and MT 507

Required Concentration Electives

- ▶ PEP 503 Introduction to Solid State Physics
- ▶ PEP 515 Photonics I
- ▶ PEP 516 Photonics II
- ▶ PEP 561 Solid State Electronics for Engineering I
- MT 562 Solid State Electronics for Engineering II
- MT 595 Reliability and Failure of Solid State Devices
- MT 596 Micro-Fabrication Techniques
- ▶ EE 585 Physical Design of Wireless Systems
- ▶ EE 626 Optical Communication Systems
- CPE 690 Introduction to VLSI Design

Doctoral Program - Physics

Doctoral students conduct exciting and cutting-edge research with faculty who are leaders in the field. Ph.D. students must pass a qualifying examination, which consists of two oral examinations. The first oral examination tests mastery of a set of core physics topics (based on core courses PEP 538, 542, 553, 555) while the second oral examination tests the student's ability to discuss physics problems and current research topics with an examining committee of three faculty members. Candidates have two opportunities to pass each examination. The first attempt must be made within the first two years of study at Stevens. Upon successful completion of both examinations, the student becomes a qualified Ph.D. candidate.

Within six weeks after passing the qualification examination a Ph.D. advisory committee shall be formed for each Ph.D. student, consisting of a major advisor on the physics department faculty, an additional physics department faculty member, and a third Stevens faculty member from any department other than Physics. Additional committee members from Stevens or elsewhere may also be included.

Ph.D. candidates are required to have competency in using computer-based methods of calculation and analysis. Students lacking this competency are encouraged to take PEP 520 Computational Physics, or equivalent.

In addition to the core courses required in the 30-credit Master of Science in physics degree (PEP 642, PEP 643, PEP 644, PEP 554, PEP 528, PEP 555, and PEP 510 and one 600-level advanced quantum mechanics course), completion of the following coursework will be required for the Ph. D.

- ▶ PEP 667 Statistical Mechanics
- One 600-level quantum mechanics application course
- Two 700-level courses chosen in consultation with an academic advisor
- ▶ Three Ph.D. signature credits (can be in one or multiple approved courses)

The student will carry out an original research program under the supervision of the major advisor and advisory committee. The results of the research will be presented in a written dissertation. Upon approval of the advisory committee, the written dissertation will be defended by the student in an oral defense. A minimum of 84 credits beyond the baccalaureate degree is required for the Ph.D. degree. Required coursework represents at least 18 credits. At least 12 of the remaining 66 credits must be for the Ph.D. research (PEP 960).

Applications are welcome from students who have already earned a master's degree elsewhere. Applicants with the equivalent of the Stevens Master of Science in physics degree are eligible to take the qualifying exam immediately and become candidates without additional course requirements. Nevertheless, they have to fulfill all described requirements including doctoral coursework, research, any core courses of the Stevens Master of Science in physics which they have not taken in the course of their previous Masters degree, and a total of 54 credits beyond the master's degree.

Applicants with a non-physics master's degree may be required to complete sufficient coursework to meet the requirements for a physics degree in addition to the remaining doctoral requirements outlined above. The details of the makeup work are determined by the department's Graduate Academic Standards and Curriculum committee.

Doctoral Program - Interdisciplinary

In addition to the Ph.D. program in Physics the Department of Physics and Engineering Physics offers an interdisciplinary Ph.D. program in cooperation with other departments in Stevens Institute of Technology. This program aims to address the increasingly cross-cutting nature of doctoral research. The interdisciplinary Ph.D. program aims to take advantage of the complementary educational offerings and research opportunities in multiple areas. Any student who wishes to enter an interdisciplinary program needs to obtain the consent of the participating departments and the subsequent approval of the Dean of Graduate Studies. The student will follow a study plan designed by his/her faculty advisor. In particular, the student must declare which department will be the home department (i.e. the department where the majority of courses is being taken), and arrange for written consent of advisors in both departments involved.

The student will be granted official candidacy in the program upon successful completion of a qualifying exam that will be administered according to the applicable guidelines of the Office of Graduate Studies. For all interdisciplinary programs involving the physics department as either home or secondary department the student is required to pass the first part of the regular Ph.D. qualifying exam of the Physics Department (general physics, based on core courses PEP 538, 542, 553, 555) as well as the corresponding qualifying exam of the other participating department.

All policies of the Office of Graduate Studies that govern the credit and thesis requirements apply to students enrolled in this interdisciplinary program. Identical to the Physics Ph.D. program the interdisciplinary Ph.D. program requires 84 credits. For student with the Physics Department as the home department the following additional guidelines apply:

- A master's degree comparable to the Stevens' Master of Engineering Physics will be recognized and be accounted for with up to 30 credits, whereby the following courses (or equivalent) must be part of the Masters PEP 542, PEP 554.
- ▶ Required core courses of an interdisciplinary Ph.D. if PEP is the home department:
- ▶ PEP 538 Introduction to Mechanics
- NANO / PEP 555 Statistical Physics and Kinetic Theory
- ▶ PEP 643 Electricity and Magnetism I
- ▶ PEP 644 Electricity and Magnetism II
- And Two 600-level courses (in the PEP or secondary department)
- One 700-level course (in the PEP or secondary department)

These requirements allow a student to obtain an Interdisciplinary Ph.D. degree with a designated concentration in nanotechnology and the PEP Department as home department following the requirement of the Nanotechnology Graduate Program (NGP). To qualify for the nanotechnology concentration, the student has to satisfy all the above requirements for an interdisciplinary PhD and must additionally complete the NGP common core courses (NANO 600 and NANO525/625), a minimum of five elective NANO courses, as well as regularly attend the seminar series in the Nanotechnology Curriculum (NANO 700). Note that the requirement for five elective NANO courses are allowed to overlap with the requirements for an interdisciplinary PhD involving the PEP department, in particular, courses NANO/PEP553, NANO/PEP554, NANO/PEP555 are cross-listed with the NPG program. In addition, a Ph.D. candidate must successfully execute a doctoral dissertation in the realm of nanotechnology. Interested students should follow the normal graduate application procedures through the Dean of Graduate Studies.

Graduate Certificate Programs

The Department of Physics and Engineering Physics offers five Graduate Certificate programs to students meeting the regular admission requirements for the master's program. Each Graduate Certificate program is self-contained and highly focused, carrying 12 graduate credits. All of the courses may be used toward the master's degree, as well as for the certificate.

Applied Optics

- ▶ PEP 577 Laser Theory and Design
- ▶ PEP 578 Laser Applications and Advanced Optics or PEP 678 Physics of Optical Communications Systems
- > and two out of the following four courses:
- ▶ PEP 515-516 Photonics I, II
- ▶ PEP 570 Guided-Wave Optics
- ▶ PEP 679 Fourier Optics

Atmospheric and Environmental Science and Engineering (Interdisciplinary with Civil, Ocean, and Environmental Engineering)

- ▶ PEP 575 Fundamentals of Atmospheric Radiation and Climate
- CE 591 Dynamic Meteorology
- ME 532/EN 506 Air Pollution Principles and Control
- ▶ EN 550 Environmental Chemistry of Atmospheric Processes

This graduate certificate program is offered as a campus-based program, as well as a web-based distance learning program.

Microdevices and Microsystems

- ▶ EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- ▶ EE/MT/PEP 595 Reliability and Failure of Solid State Devices
- ▶ EE/MT/PEP 596 Micro-Fabrication Techniques
- ▶ EE/MT/PEP 685 Physical Design of Wireless Systems

Microelectronics

- EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- EE/MT/PEP 561 Solid State Electronics I
- ▶ EE/MT/PEP 562 Solid State Electronics II
- CPE/MT/PEP 690 Introduction to VLSI Design

Photonics

- EE/MT/PEP 507 Introduction to Microelectronics and Photonics
- EE/MT/PEP 515 Photonics I
- EE/MT/PEP 516 Photonics II
- ▶ EE/MT/PEP 626 Optical Communication Systems

EE course descriptions can be found in the Electrical and Computer Engineering section of the catalog.

COURSE OFFERINGS

Physics and Engineering Physics

PEP 111 **Mechanics**

Vectors, kinetics, Newton's laws, dynamics or particles, work and energy, friction, conserverative forces, linear momentum, center-of-mass and relative motion, collisions, angular momentum, static equilibrium, rigid body rotation, Newton's law of gravity, simple harmonic motion, wave motion and sound. Prerequisites: Corequisites: MA 115

PFP 112 **Electricity and Magnetism**

Coulomb's law, concepts of electric field and potential, Gauss' law, capacitance, current and resistance, DC and R-C transient circuits, magnetic fields, Ampere's law, Faraday's law of induction, inductance, A/C circuits, electromagnetic oscillations, Maxwell's equations and electromagnetic waves. Prerequisites: MA 115 or PEP 111, MA 122

PEP 123 Physics for Business & Technology I

This is the first course of a two-course algebra-based introductory physics sequence for students outside of the engineering or science curriculum. This course covers the basic principles and applications of classical mechanics as well as simple thermodynamics. Recitations include a laboratory component.

PEP 124 Physics for Business & Technology II

This is the second course of a two course algebra-based introductory physics sequence for students outside of the engineering or science curriculum. This course covers the basic principles and applications of electricity and magnetism, oscillations and waves, and optics. Recitations include a laboratory component. Prerequisites: PEP 123

PEP 151 Introduction to Astronomy

The course is designed to fulfill a science requirement credit for the general student population. The main objective of the course is to present a coherent introduction to the methods of study and physical properties of astronomical objects. Throughout the course complex objects will be reduced to their essential fetures that explain the observed phenomena. Current and historic observations will be used as the moivation. Data analysis assignments will be given from real observational data (listed as 'Lab' in the syllabus). A set of semester-long group projects in astro-photography will give students a hands-on expereince in imaging astronomical phenomena using everyday digital cameras(listed as'Project' in the syllabus). The course will include an evening demonstration on campus and a visit to the planetarium. In terms of general education, astronomy will be used as a vehicle to introduce the essentials of model-building, justified simplifications, physical reasoning and selfcorrecting nature of scientific method.

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SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

PEP 181 Honors Mechanics

Newtonian mechanics. The course, however, begins with an exploration of high energy particle physics, using the relatistically correct conservation laws as the fundamental organizing principle. Bubble chamber "photograph" of high energy collisions and decays are analyzed. Standard topics in particle dynamics, rotational dynamics of extended bodies, work-energy theorem, angular momentum conservation as well as other less traditional topics such as relativistic coordinate transformation, centerof-mass reference frames, and harmonic oscillatory motion will be explored in depth.

PEP 182 Honors Electricity and Magnetism

Introduction in classical electricity and magnetism, this course emphasizes the interdependence of electromagnetic phenomena. It begins with Maxwell's equations in integral form, and dissects each equation carefully, showing how it is used as well as the experimental evidence for its derivation. Topics such as electrostatic and magnetostatic fields, capacitors, inductors, electromagnetic radiation, waveguide propagation, microwave cavities, dielectrics, and magnetic materials are explored using Maxwell's equations. The transformations of the fields to equivalent inertial reference frames using some ideas from Special Relativity is also explored. The concept of symmetry and its' applications will be studied in depth. Prerequisites: PEP 111

PFP 187 Seminar in Physical Science I

Selected topics in modern physics and applications. By invitation only. Prerequisites: Corequisites: MA 115, PEP 111

PEP 201 Physics III for Engineers

Simple harmonic motion, oscillations and waves; wave-particle dualism; the Schrödinger equation and its interpretation; wave functions; the Heisenberg uncertainty principle; quantum mechanical tunneling and application; quantum mechanics of a particle in a "box," the hydrogen atom; electronic spin; properties of many electron atoms; atomic spectra; principles of lasers and applications; electrons in solids; conductors and semi-conductors; the n-p junction and the transistor; properties of atomic nuclei; radioactivity; fusion and fission. Prerequisites: MA 116, PEP 112 or MA 124

PEP 209 Modern Optics

Concepts of geometrical optics for reflecting and refracting surfaces, thin and thick lens formulations, optical instruments in modern practice, interference, polarization and diffraction effects, resolving power of lenses and instruments, X-ray diffraction, introduction to lasers and coherent optics, principles of holography, concepts of optical fibers, optical signal processing. Prerequisites: PEP 112

PEP 211 Physics Lab for Engineers

An introduction to experimental physics. Students learn to use a variety of techniques and instrumentation, including computer controlled experimentation and analysis, error analysis and statistical treatment of data. Experiments include basic physical and electrical measurements, mechanical, acoustical, and electromagnetic oscillation and waves, and basic quantum physics phenomena.

PEP 221 Physics Lab I for Scientists

An introduction to experimental measurements and data analysis. Students will learn how to use a variety of measurement techniques, including computer-interfaced experimentation, virtual instrumentation, and computational analysis and presentation. First semester experiments include basic mechanical and electrical measurements, motion and friction, RC circuits, the physical pendulum, and electric field mapping. Second semester experiments include the second order electrical system, geometrical and physical optics and traveling and standing waves. Prerequisites: PEP 111 Corequisites: PEP 112

PEP 222 Physics Lab II for Scientists

An introduction to experimental measurements and data analysis. Students will learn how to use a variety of measurement techniques, including computer-interfaced experimentation, virtual instrumentation, and computational analysis and presentation. First semester experiments include basic mechanical and electrical measurements, motion and friction, RC circuits, the physical pendulum, and electric field mapping. Second semester experiments include the second order electrical system, geometrical and physical optics and traveling and standing waves. Prerequisites: PEP 221

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PEP 242 Modern Physics

Simple harmonic motion, oscillations and pendulums; Fourier analysis; wave properties; wave-particle dualism; the Schrödinger equation and its interpretation; wave functions; the Heisenberg uncertainty principle; quantum mechanical tunneling and application; quantum mechanics of a particle in a "box," the hydrogen atom; electronic spin; properties of many electron atoms; atomic spectra; principles of lasers and applications; electrons in solids; conductors and semiconductors; the n-p junction and the transistor; properties of atomic nuclei; radioactivity; fusion and fission. Prerequisites: PEP 112, and MA 221

PEP 297 SKIL I

SKIL (Science Knowledge Integration Ladder) is a six-semester sequence of project-centered courses. This course introduces students to the concept of working on projects that foster independent learning, innovative problem solving, collaboration and teamwork, and knowledge of integration under the guidance of a faculty advisor. SKIL I familiarizes the student with the ideas and realization of project-based learning using simple concepts and basic scientific knowledge. Specific emphasis is put on the development of "Guesstimates" skills, application and recognition of scaling laws as well as fundamental measurement techniques. Prerequisites: PEP 112

PFP 298 SKIL II

Continuation and extension of SKIL I to complex projects. Prerequisites: PEP 297

PEP 330 Intro to Thermal & Statistical Physics

An introduction to statistical mechanics including classical thermodynamics and their statistical foundation. Essential concepts in both classical and quantum statistical mechanics are developed along with their relations to thermodynamics. Topics covered include: laws of thermodynamics, entropy, thermal processes including Carnot engine and refrigerators, basic concepts of probability theory, statistical description of systems of particles, microscopic description of macroscopic quantities such as temperature and entropy, ideal and real gases, Maxwell-Boltzmann distribution, kinetics of classical gases, Bose-Einstein and Fermi-Dirac distributions, blackbody radiation, thermal properties of solids, and phase transitions. Prerequisites: PEP 112, MA124 Corequisites: PEP242 or PEP201

PEP 331 Electromagnetism

Electrostatics; Coulomb-Gauss Law; Poisson-Laplace equations; boundary value problems; image techniques, dielectric media; magnetostatics; multipole expansion, electromagnetic energy, electromagnetic induction, Maxwell's equations, electromagnetic waves, waves in bounded regions, wave equations and retarded solutions, simple dipole antenna radiation theory, transformation law of electromagnetic fields.

PEP 332 Mathematical Methods for Physics

This course is designed to build upon the core mathematics sequence in engineering and thus enable the student to fully utilize quantitative mathematical analysis in the junior and enior level courses in engineering physics. Topics covered will include complex numbers and functions, linear algebra, advanced vector analysis, Fourier series and integrals, special functions for mathematical physics, orthogonal functions solutions to differential equations and elements of tensor analysis. Review of previously covered material will be integrated with topics of greater depth as appropriate. Applications to problems in engineering physics will be stressed throughout. Prerequisites: MA 227

PEP 334 Introduction to Nuclear Physics and Nuclear Reactors (3 - 3 - 0)

Historical introduction; radioactivity; laws of statistics of radioactive decay; alpha decay; square well model; gamma decay; beta decay; beta energy spectrum; neutrinos; nuclear reactions; relativistic treatment; semi-empirical mass formula; nuclear models; uranium and the transuranic elements; fission; nuclear reactors.

PEP 336 Introduction to Astrophysics and Cosmology

Theories of the universe, general relativity, big bang cosmology and the inflationary universe; elementary particle theory and nucleosynthesis in the early universe. Observational cosmology; galaxy formation and galactic structure; stellar evolution and formation of the elements. White dwarfs, neutron stars and black holes; planetary systems and the existence of life in the universe. Prerequisites: PEP 111

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PEP 337 **Observational Astrophysics**

This course focuses on the detection principles and technology of modern telescopes and observatories. Data analysis and instrumentation projects are an essential component of the course. Topics covered include: propagation of astrophysical information via photons and particles, the Earth's atmosphere, spacecraft design and launch, telescope optics, interferometry techniques, and a systematic survey of detection techniques from radio to gamma-ray telescopes and astro-particle instruments. Prerequisites: PEP 112, and PEP 151 Corequisites: PEP 336

PEP 345 Modeling and Simulation

Development of deterministic and non-deterministic models for physical systems, engineering applications, simulation tools for deterministic and non-deterministic systems, case studies and projects.

PEP 351 Introduction to Planetary Science

This course introduces basic concepts of planetary science through the development of simple physical models. The first part of the course studies the planetary formation and related problems - evolution of the planet-satellite systems, orbital stability and impact events. The second part studies planets as equilibrium sytems - topics include planetary atmospheres, climate cycles, seismic activity, and magnetism. The course concludes with the topics of current interest such as global warming, extra-solar planets, and planetary habitability. Prerequisites: MA 124, and PEP 111

PEP 368 Transport: Theory and Simulation

Numerical solution of ordinary differential equations describing oscillation and/or decay. Formulation of diffusion and heat conduction equations (conservation laws, continuity equation, laws of Fick and Fourier). Numerical solution of heat equation by explicit method. Theory of simulation of sound waves.

PEP 397 SKIL III

Continuation and extension of SKIL II to more complex projects. Projects may include research participation in well defined research projects. Prerequisites: PEP 298

PEP 398 SKIL IV

Continuation and extension of SKIL III to more complex projects. Projects may include research participation in well defined research projects. Prerequisites: PEP 397, PEP 509

PEP 443 Modern Physics Laboratory I

You may participate in ongoing faculty research activities or select from a variety of experiments illustrating the phenomena of modern physics, such as the Rydberg constant and Balmer series, the Zeeman effect, charge of the electron, the Hall effect, absorption of photons by matter, statistics of counting processes, x-ray diffraction, nuclear magnetic resonance, the Langmuir probe, Rutherford scattering, and blackbody radiation. Prerequisite: PEP 201 or PEP 242. Prerequisites: MA 222, PEP 201 or PEP 242

PFP 444 Modern Physics Laboratory II

You may participate in ongoing faculty research activities or select from a variety of experiments illustrating the phenomena of modern physics, such as the Rydberg constant and Balmer series, the Zeeman effect, charge of the electron, the Hall effect, absorption of photons by matter, statistics of counting processes, x-ray diffraction, nuclear magnetic resonance, the Langmuir probe, Rutherford scattering, and blackbody radiation. Prerequisites: PEP 443

PEP 497 SKIL V

Continuation of SKIL IV. SKIL V and SKIL VI can be combined into a yearlong senior design project or a research project leading to a thesis. Prerequisites: PEP 398

PEP 498 SKIL VI

Continuation of SKIL V. SKIL V and SKIL VI can be combined into a yearlong senior design project or a research project leading to a thesis. Prerequisites: PEP 497

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PEP 500 Physics Review

"A review course in the fundamentals of physics, especially in mechanics and electromagnetism; dynamics of a particle; systems of particles and their conservation laws; motion of a rigid body; electrostatics, magnetic fields, and currents; and electromagnetic induction. Prerequisites: introductory mechanics and electromagnetism courses which employ calculus and vector analysis. Typical text: Halliday, Resnick, and Walker, Fundamentals of Physics. No credit for Physics or Engineering Physics majors."

PEP 501 Fundamentals of Atomic Physics

The course will cover the most common atomic and nuclear effects, yet covers it in direct relation to a sophisticated quantum mechanical treatment. It thereby connects the theoretical models with the experimental results, showcasing agreement as well as disagreement to outline the validity range of each model. Topics covered include Brownian motion; charge and mass of electrons and ions; Zeeman effect; photoelectric effect; emission, absorption, reflection, refraction, diffraction, absorption, and scattering of X-rays; Compton effect; diffraction of electrons; uncertainty principle; electron optics; atomic spectra and electron distribution; radioactivity; disintegration of nuclei; nuclear processes; nuclear energy; and fission.

PEP 503 Introduction to Solid State Physics

Description of simple physical models which account for electrical conductivity and thermal properties of solids. Basic crystal lattice structures, X-ray diffraction and dispersion curves for phonons and electrons in reciprocal space. Energy bands, Fermi surfaces, metals, insulators, semiconductors, superconductivity and ferromagnetism. Fall semester. Cross-listed with: EE 503, MT 503, NANO 503 Prerequisites: PEP 242, PEP 542

PEP 506 Introduction to Astrophysics and Cosmology (3 - 3 - 0)

Theories of the universe, general relativity, Big Bang cosmology, and the inflationary universe; and elementary particle theory and nucleosynthesis in the early universe. Observational cosmology; galaxy formation and galactic structure; and stellar evolution and formation of the elements. White dwarfs, neutron stars and black holes, planetary systems, and the existence of life in the universe. Prerequisites: MA 221, PEP 242

PEP 507 Introduction to Microelectronics and Photonics (3 - 3 - 0)

An overview of Microelectronics and Photonics Science and Technology. It provides the student who wishes to specialize in the application, physics or fabrication with the necessary knowledge of how the different aspects are interrelated. It is taught in three modules: design and applications, taught by EE faculty; operation of electronic and photonic devices, taught by Physics faculty; fabrication and reliability, taught by the Materials faculty. Cross-listed with: EE 507, MT 507

PEP 509 Intermediate Waves and Optics

The general study of field phenomena; scalar and vector fields and waves; dispersion phase and group velocity; interference, diffraction and polarization; coherence and correlation; geometric and physical optics. Typical text: Hecht and Zajac, Optics. Spring semester. Cross-listed with: EE 509 Prerequisites: PEP 542

PEP 510 Modern Optics Lab

The course is designed to familiarize students with a range of optical instruments and their applications. Included will be the measurement of aberrations in optical systems, thin-film properties, Fourier transform imaging systems, nonlinear optics, and laser beam dynamics. Prerequisites: PEP 209 or PEP 509 or EE 509

PEP 512 Introduction to Nuclear Physics and Nuclear Reactors

Historical introduction; radioactivity; laws of statistics of radioactive decay; alpha decay; square well model; gamma decay; beta decay; beta energy spectrum; neutrinos; nuclear reactions; relativistic treatment; semiempirical mass formula; nuclear models; uranium and the transuranic elements; fission; and nuclear reactors.

PEP 515 Photonics I

This course will cover topics encompassing the fundamental subject matter for the design of optical systems. Topics will include optical system analysis, optical instrument analysis, applications of thin-film coatings and opto-mechanical system design in the first term. The second term will cover the subjects of photometry and radiometry, spectrographic and spectrophotometric systems, infrared radiation measurement and instrumentation, lasers in optical systems and photon-electron conversion. Typical texts: Military Handbook 141 (U.S. Govt. Printing Office); S.P.I.E Reprint Series (Selected Issues); W.J. Smith, Modern Optical Engineering . Cross-listed with: EE 515, MT 515 Prerequisites: PEP 209 or PEP 509 or EE 509

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PEP 516 Photonics II

This course will cover topics encompassing the fundamental subject matter for the design of optical systems. Topics will include optical system analysis, optical instrument analysis, applications of thin-film coatings and opto-mechanical system design in the first term. The second term will cover the subjects of photometry and radiometry, spectrographic and spectrophotometric systems, infrared radiation measurement and instrumentation, lasers in optical systems and photon-electron conversion. Typical texts: Military Handbook 141 (U.S. Govt. Printing Office); S.P.I.E Reprint Series (Selected Issues); W.J. Smith, Modern Optical Engineering . Cross-listed with: EE 516, MT 516 Prerequisites: PEP 209 or PEP 509 or EE 509

PEP 520 **Computational Physics**

Numerical techniques. Numerical methods for integrating Newton's laws, the diffusion equation, Poisson's equation, and the wave equation are discussed. Topics also covered: discrete Fourier transform, stability theory, curve fitting, the diagonalization of matrices, and Monte Carlo methods.

PEP 524 Introduction to Surface Science (3 - 3 - 0)

A phenomenological and theoretical introduction to the field of surface science, including experimental techniques and engineering applications. Topics will include: thermodynamics and structure of surfaces, surface diffusion, electronic properties and space-charge effects, physisorption, and chemisorption.

PEP 525 Techniques of Surface and Nanostructure Characterization (3 - 3 - 0)

Lectures, demonstrations and laboratory experiments, selected from among the following topics, depending on student interest: vacuum technology; thin-film preparation; scanning electron microscopy; infrared spectroscopy, ellipsometry: electron spectroscopies-Auger, photoelectron, LEED; ion spectroscopies SIMS, IBS, field emission; surface properties-area, roughness, and surface tension. Alternate years. Cross-listed with: MT 525, NANO 525, CH 525

PEP 527 Mathematical Methods of Science and Engineering I (3 - 3 - 0)

Fourier series, Bessel functions, and Legendre polynomials as involved in the solution of vibrating systems; tensors and vectors in the theory of elasticity; applications of vector analysis to electrodynamics; vector operations in curvilinear coordinates; numerical methods of interpolation and of integration of functions and differential equations. Prerequisites: MA 227

PEP 528 Mathematical Methods of Science and Engineering II

Vector and Tensor Fields: transformation properties, algebraic and differential operators and identities, geometric interpretation of tensors, integral theorems. Dirac delta-function and Green's function technique for solving linear inhomogeneous equations. N-dimensional complex space: rotations, unitary and hermitian operators, matrix-dyadic-Dirac notation, similarity transformations and diagonalization, Schmidt orthogonalization. Introduction to functions of a complex variable: analyticity, Cauchy's theorem, Taylor and Laurent expansions, analytic continuation, multiple-valued functions, residue theorem, contour integration, asymptotics. As techniques are developed, they are applied to examples in mechanics, electromagnetism and/ or transport theory. Prerequisites: PEP 527

PEP 538 Introduction to Mechanics

Particle motion in one dimension. Simple harmonic oscillators. Motion in two and three dimensions, kinematics, work and energy, conservative forces, central forces, and scattering. Systems of particles, linear and angular momentum theorems, collisions, linear spring systems, and normal modes. Lagrange's equations and applications to simple systems. Introduction to moment of inertia tensor and to Hamilton's equations. Prerequisites: MA 221

PEP 540 **Physical Electronics**

Charged particle motions in electric and magnetic fields; electron and ion optics; charged particle velocity and mass spectrometry; electron and ion beam confinement; thermionic emission; the Pierce gun; field emission; secondary emission; photoelectric effect; sputtering; surface ionization; volume ionization; and Townsend discharge.

PEP 541 Physics of Gas Discharges

Charged particle motion in electric and magnetic fields; electron and ion emission; ion-surface interaction; electrical breakdown in gases; dark discharges and DC glow discharges; confined discharge; AC, RF, and microwave discharges; arc discharges, sparks, and corona discharges; non-thermal gas discharges at atmospheric pressure; and discharge and lowtemperature plasma generation. Typical texts: J.R. Roth, Industrial Plasma Engineering: Principles, Vol. 1, and Y.P. Raizer, Gas Discharge Physics. Cross-listed with: EE 541

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PEP 554 Quantum Mechanics I

(3 - 3 - 0)Basic concepts of quantum mechanics, states, operators; time development of Schrödinger and Heisenberg pictures; representation theory; symmetries; perturbation theory; systems of identical particles, L-S and j-j coupling; fine and hyperfine structure; scattering theory; molecular structure. Cross-listed with: NANO 554 Prerequisites: PEP 538, PEP 553

PEP 553 Quantum Mechanics and Engineering Applications This course is meant to serve as an introduction to formal quantum mechanics as well as to apply the basic formalism to

Data; Melissinos, Experiments in Modern Physics. Prerequisites: PEP 242 or PEP 201

Prerequisites: MA 221

PEP 551

Fluid Mechanics

An experimental presentation of the evidence for atomic and nuclear theories; typical experiments are: excitation potentials; electronic charge; specific charge of the electron; the Balmer series; Zeeman splitting; spectroscopic isotope shifts; the photovoltaic effect; the Hall effect; gamma ray spectrometry; beta ray spectrometry; neutron activation of nuclides; statistics of counting processes; optical and X-ray diffraction; the Langmuir probe; and nuclear magnetic resonance. Fall semester, repeated second semester. By arrangement. Laboratory fee \$5. Typical texts: Young, Statistical Treatment of Experimental

PEP 552

motion of singularities; and cosmology.

Theory of Relativity (3 - 3 - 0)Geometrical foundations of space-time theories, geometrical objects, affine geometry, and metric geometry; structure of space-time theories, symmetry, and conservation laws; Newtonian mechanics; special relativity; foundations of general relativity, Mach's principle, principle of equivalence, principle of general covariance, and Einstein's equations; solution of Einstein's equations; experimental tests of general relativity; conservation laws in general relativity, gravitational radiation, and

Advanced Physics Laboratory I

sources; electron sources; and ion beam handling.

PEP 542

PEP 550

PEP 201

confinement fusion; and laser fusion. Fall semester. Prerequisites: PEP 542 PEP 545 Plasma Processing (3 - 3 - 0)

glow discharges; magnetron discharges. Plasma-surface interaction; sputter deposition of thin films; reactive ion etching, ion milling, and texturing; electron beam-assisted chemical vapor deposition; and ion implantation. Sputtering systems; ion

Description of principle flow phenomena: pipe and channel flows, laminar flow, transition, and turbulence; flow past an object-boundary layer, wake, separation, vortices, and drag; convection in horizontal layers-conduction, convection, and transition from periodic to chaotic behavior. Equations of motion; dynamical scaling; simple viscous flows; inviscid flow; boundary layers, drag, and lift; thermal flows; flow in rotating fluids; hydro-dynamic stability; and transitions to turbulence.

Electrostatics; Coulomb-Gauss law; Poisson-Laplace equations; boundary value problems; image techniques; dielectric media; magnetostatics; multipole expansion; electromagnetic energy; electromagnetic induction; Maxwell's equations; electromagnetic waves, radiation, waves in bounded regions, wave equations and retarded solutions; simple dipole antenna radiation theory; transformation law of electromagnetic fields. Spring semester. Typical text: Reitz, Milford and Christy, Foundation of Electromagnetic Theory. Cross-listed with: EE 542 Prerequisites: MA 221

Plasmas in nature and application of plasma physics; single particle motion; plasma fluid theory; waves in plasmas; diffusion and resistivity; equilibrium and stability; nonlinear effects and thermonuclear reactions; the Lawson condition; magnetic

Electromagnetism

PEP 544 Introduction to Plasma Physics and Controlled Fusion

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Basic plasma physics; some atomic processes; and plasma diagnostics. Plasma production; DC glow discharges and RF

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several generic and important applications. Cross-listed with: NANO 553, PEP 557 Prerequisites: MA 221, PEP 242 or

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Statistical Physics and Kinetic Theory

Kinetic theory: ideal gases, distribution functions, Maxwell-Boltzmann distribution, Boltzmann equation, H-theorem and entropy, and simple transport theory. Thermodynamics: review of first and second laws, thermodynamic potentials, Legendre transformation, and phase transitions. Elementary statistical mechanics: introduction to microcanonical, canonical, and grand canonical distributions, partition functions, simple applications, including ideal Maxwell-Boltzmann, Einstein-Bose, and Fermi-Dirac gases, paramagnetic systems, and blackbody radiation. Cross-listed with: NANO 555 Prerequisites: MA 221, PEP 242

PEP 556 Introduction to Quantum Control

PEP 555

Interference phenomena in electromagnetism and quantum mechanics; interaction of light and matter, principles of coherent control; adaptive and optimal algorithms; Rabi flopping in two-level systems; control of three-level systems including STRIRAP and electromagnetically induced transparency; tools for quantum control; various current and proposed applications. Prerequisites: PEP 553

PEP 557 Quantum Information and Quantum Computation (3 - 3 - 0)

The course will focus on fundamentals of quantum computation. The topics to be covered include: quantum foundation, quantum channel, quantum qubits, noise and decoherence, master equation and Kraus operations, quantum entanglement, quantum circuits, universal quantum gates, quantum algorithms, quantum error correction codes. The course will not only cover the theoretical aspects of quantum computing and quantum information but also cover physical realizations of quantum computers in various physical contexts including quantum optical systems, solid state qubits etc. Cross-listed with: PEP 553

PEP 561 Solid State Electronics for Engineering I

This course introduces fundamentals of semiconductors and basic building blocks of semiconductor devices that are necessary for understanding semiconductor device operations. It is for first-year graduate students and upper-class undergraduate students in electrical engineering, applied physics, engineering physics, optical engineering and materials engineering, who have no previous exposure to solid state physics and semiconductor devices. Topics covered will include description of crystal structures and bonding; introduction to statistical description of electron gas; free-electron theory of metals; motion of electrons in periodic lattice-energy bands; Fermi levels; semiconductors and insulators; electrons and holes in semiconductors; impurity effects; generation and recombination; mobility and other electrical properties of semiconductors; thermal and optical properties; p-n junctions; metal-semiconductor contacts. Cross-listed with: EE 561, MT 561

PEP 562 Solid State Electronics for Engineering II

This course introduces operating principles and develops models of modern semiconductor devices that are useful in the analysis and design of integrated circuits. Topics covered include: charge carrier transport in semiconductors; diffusion and drift, injection, and lifetime of carriers; p-n junction devices; bipolar junction transistors; metal-oxide-semiconductor field effect transistors; metal-semiconductor field effect transistors and high electron mobility transistors, microwave devices; light emitting diodes, semiconductor lasers, and photodetectors; and integrated devices. Cross-listed with: MT 562, EE 562

PEP 570 Guided-Wave Optics

Review of electromagnetic theory; derivation of Fresnels' equations; guided-wave propagation by metallic and dielectric waveguides, including step-index optical fibers and graded-index fibers; optical transmission systems; and nonlinear effects in optical fibers, solitons, and fiber-optic gyroscope.

PEP 575 Fundamentals of Atmospheric Radiation and Climate

This course treats scattering, absorption and emission of electromagnetic radiation in planetary media. The radiative transfer equation is derived, approximate solutions are found. Important heuristic models (Lorentz atom, two-level atom, vibrating rotator) as well as fundamental concepts are discussed including reflectance, absorptance, emittance, radiative warming/ cooling rates, actinic radiation, photolysis and biological dose rates. A unified treatment of radiative transfer within the atmosphere and ocean is provided, and extensive use of two-stream and approximate methods is emphasized. Applications to the climate problem focus on the role of greenhouse gases, aerosols and clouds in explaining the temperature structure of the atmosphere and the equilibrium temperature of the earth. The course is suitable for beginning graduate and upper-level undergraduate students. Prerequisites: MA 221, PEP 242

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PEP 577 Laser Theory and Design

An introductory course to the theory of lasers; treatment of spontaneous and stimulated emission, atomic rate equations, laser oscillation conditions, power output and optimum output coupling; CW and pulsed operation, Q switching, mode selection, and frequency stabilization; excitation of lasers, inversion mechanisms, and typical efficiencies; detailed examination of principal types of lasers, gaseous, solid state, and liquid; chemical lasers, dye lasers, Raman lasers, high power lasers, TEA lasers, gas dynamic lasers. Design considerations for GaAIAs, argon ion, helium neon, carbon dioxide, neodymium YAG and pulsed ruby lasers.

PEP 578 Laser Applications and Advanced Optics

This course covers provides a survey of advanced areas of optics including integrated optics, fiber optics, propagation of light through birefringent crystals, liquid crystals, acousto-optics, electro-optics, nonlinear optics, and ultrafast optics. Particular emphasis is placed on nonlinear optics and wave mixing including harmonic generation, parametric devices, four wave mixing and phase conjugate mirrors, self-phase modulation, solitons, and phase matching.

PEP 579 Nonlinear Optics

This course is dedicated to give students a working knowledge of the fundamental concepts and modern applications of nonlinear optics in optical communications, lasers, optical metrology, and quantum computing. Through this course, students will gain in-depth understanding and master mathematical tools for modeling nonlinear optical susceptibilities, wave propagation and coupling in nonlinear media, harmonic, sum, and difference frequency generation, parametric amplification and oscillation, phase-conjugation via four-wave mixing, self-phase modulation, and solitons. Prerequisites: PEP 542, PEP 553

PEP 580 **Electronic Materials and Devices**

Electronic, magnetic, optical, and thermal properties of materials, the description of these properties based on solid state physics. Description and principles of operation of devices. Cross-listed with: MT 570

PEP 585 Physical Design of Wireless Systems

Physical design of wireless communication systems, emphasizing present and next-generation architectures; impact of non-linear components on performance; noise sources and effects; interference; optimization of receiver and transmitter architectures; individual components(LNAs, power amplifiers, m ixers, fi Iters, VCOs, phase-locked loops, frequency synthesizers, etc.); digital signal processing for adaptable architectures; analog-digital converters; new component technologies (SiGe, MEMS, etc.); specifications of component performance; reconfigurability and the role of digital signal processing in future generation architectures; direct conversion; RF packaging; and minimization of power dissipation in receivers. Cross-listed with: EE 585, MT 585

PFP 595 Reliability and Failure of Solid State Devices (3 - 3 - 0)

Treatment of the electrical, chemical, environmental, and mechanical driving forces that compromise the integrity and lead to the failure of devices. Both chip and packaging level failures will be modeled and quantified statistically. On the packaging level, thermal stresses, solder creep, fatigue and fracture, contact relaxation, corrosion and environmental degradation will be treated. Cross-listed with: MT 595, EE 595 Prerequisites: PEP 507, EE 507 MT 507

PEP 596 **Micro-Fabrication Techniques**

Discussions of aspects of the technology of processing procedures involved in the fabrication of microelectronic devices and microelectromechanical systems (MEMS). Topics with respect to IC fabrication include crystal growth, epitaxy, silicon oxide growth, impurity doping, ion implantation, photo and electron beam lithography, etching, sputtering, thin film metallization, passivation and packaging. Students will also learn that MEMS are sensors and actuators that are designed using different areas of engineering disciplines and they are constructed using a microlithographically-based manufacturing process in conjunction with both semiconductor and micromachining microfabrication technologies. Cross-listed with: MT 596, EE 596, NANO 596 Prerequisites: PEP 507, PEP 501, MT 501, EE 507

Please see the Addendum pages 2-7 for additional Physics courses.



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SCHOOL OF SYSTEMS AND ENTERPRISES (SSE)

The mission of SSE is to provide interdisciplinary and trans-disciplinary education and research rooted in systems thinking. We focus on applying a "systems approach" to better understand the nature of problems and opportunities, and to conceive novel concepts and solutions that achieve breakthrough results across a wide range of domains, including defense, homeland security, cybersecurity, intelligence, nuclear weapons, communications, space, infrastructure, finance, and business solutions. While maintaining an emphasis on technical systems, we pay particular attention to the interplay between these systems and the human enterprises that design and develop them, operate and use them, and sustain and maintain them.

FACULTY

Kathryn Abel, Ph.D. Industry Associate Professor; Undergraduate Engineering Management Program Lead

Mark Ardis, Ph.D. Distinguished Service Professor

James Armstrong Industry Professor

Anthony Barrese, Ph.D. Industry Professor & Associate Dean

Mark Blackburn, Ph.D. Research Associate Professor

Nicholas Bowen, Ph.D. Industry Professor

Dragos Bozdog, Ph.D. Teaching Associate Professor, Financial Engineering Division, and Deputy Director of The Hanlon Financial Systems Lab

John Casti, Ph.D. Senior Research Fellow

Rupak Chatterjee, Ph.D. Research Associate Professor, Financial Engineering Deputy Director

Robbie Cohen, Ph.D. Teaching Professor

Zhenyu Cui, Ph.D. Assistant Professor

Wilson Felder, Ph.D. Visiting Distinguished Service Professor Ionut Florescu, Ph.D. Research Associate Professor, FSL Director

Stacey Gelman Industry Professor & Software Engineering Program Lead

Ralph Giffin Vice Provost, Strategic Initiatives

Paul Grogan, Ph.D. Assistant Professor

Yeganeh M. Hayeri, Ph.D. Assistant Professor

Babak Heydari, Ph.D. Assistant Professor

Steven Hoffenson, Ph.D. Assistant Professor

Eirik Hole Professor of Design

Luca Landoli, Ph.D. Visiting Scholar

Roger Jones, Ph.D. Research Fellow

Jonathan Kaufman, Ph.D. Industry Associate Professor

Khaldoun Khashanah, Ph.D. Professor. Financial Engineering Division Director

Linda Laird Industry Professor

Peter Lin, Ph.D. Industry Associate Professor

Carlo Lipizzi, Ph.D. Industry Assistant Professor, Graduate Engineering Management Program Lead

Thomas Lonon, Ph.D. Teaching Assistant Professor

Mo Mansouri, Ph.D. Research Associate Professor and Director, Program Lead for Systems Engineering and Socio-technical Systems

Somayeh Moazeni, Ph.D. Assistant Professor

Roshanak Nilchiani, Ph.D. Associate Professor

Michael Pennock, Ph.D. Assistant Professor

Michael Pennotti, Ph.D. Industry Professor

Arthur Pyster, Ph.D. Research Professor; Chief Operating Officer of the Systems Engineering Research Center (SERC)

Jose Ramirez-Marquez, Ph.D. Professor and Director of the Enterprise Science and Engineering Division

Bill Robinson Industry Professor

William Rouse, Ph.D. Alexander Crombie Humphreys Professor and Director, CCSE

James Rowland Instructor Nicoleta Serban, Ph.D. Research Fellow

Earl Sprague Lecturer

Richard Turner, Ph.D. Research Professor

Dinesh Verma, Ph.D. Dean and Professor, School of Systems and Enterprises, and Executive Director, Systems Engineering Research Center (SERC)

Gregg Vesonder, Ph.D. Industry Professor and Director, Research, Systems and Software Division

Jon Wade, Ph.D. Research Professor, Chief Technology Officer of the Systems Engineering Research Center (SERC); Division Director, Systems and Software Division (A)

Alex Washburn Industry Professor

Steve Yang, Ph.D. Assistant Professor

Ye Yang, Ph.D. Associate Professor

Zhongyuan Yu, Ph.D. Research Assistant Professor

Teresa Zigh, Ph.D. Industry Associate Professor

Rajarathnam Chandramouli, Ph.D. Joint SSE and SES Chaired Professor

Alan Blumberg, Ph.D. Joint SSE and SES Chaired Professor

Undergraduate Programs

ENGINEERING MANAGEMENT

Stevens has a 140-year history of leading innovation in engineering, science and technology. One of the first universities in the world to offer an engineering management program, today, Stevens continues to advance the discipline of Engineering Management for the 21st century.

The Stevens Engineering Management program prepares students to become decision makers that are able to engineer solutions for complex management problems. Upon graduation, students are able to assume professional positions of increasing responsibility across a broad range of industries, such as: healthcare, technology, business, finance, manufacturing, and information systems.

Bachelor of Engineering in Engineering Management

Engineering Management (EM) is a rapidly expanding field that integrates engineering, technology, management, systems, and business. High-technology companies in the telecommunications, financial services, manufacturing, pharmaceutical, consulting, information technology and other industries utilize the concepts and tools of EM such as project management, quality management, engineering economics, modeling and simulation, systems engineering and integration, and statistical tools. These technology-based companies recruit EM graduates for their expertise in these tools and techniques and to fill a critical need of integrating engineering and business operations.

The EM program combines a strong engineering core with training in accounting, cost analysis, managerial economics, quality management, project management, production and technology management, systems engineering, and engineering design. The course selection offered by this major exemplifies the Stevens interdisciplinary approach to developing strong problem-solving skills. The program prepares students for careers that involve the complex interplay of technology, people, economics, information, and organizations. The program also provides the skills and knowledge needed to enable students to work effectively at the interface between engineering and management and to assume professional positions of increasing responsibility in management or as key systems integrators. Concentrations are available in two areas:

- Systems Engineering
- Financial Engineering

Bachelor of Engineering in Engineering Management Mission & Objectives

The mission of the Bachelor of Engineering in Engineering Management (BEEM) Program is to provide an education based on a strong engineering core, complemented by studies in business, technology, systems, and management, to prepare the graduate to work at the interface between technology/engineering and management, and to be able to assume positions of increasing technical and managerial responsibility. The objectives of the EM program can be summarized as follows:

- EM graduates define, design, develop and assess solutions, as well as manage resources and processes to address complex multidisciplinary problems through their strong broad-based foundation and engineering management education and knowledge of modern technological tools.
- EM graduates effectively lead and work on multidisciplinary project teams and are able to communicate and solve real world problems using knowledge and tools gained from their engineering management education.
- ▶ EM graduates continue sustained intellectual growth in the corporate or academic world.

• EM graduates successfully adapt to diverse technological and societal conditions to bring innovative, flexible and ethical solutions to their work.

Minor in Engineering Management

- EM 275 : Project Management
- EM 224 : Informatics and Software Development
- EM 301 : Accounting & Business Analysis
- EM 360 : Operations Management and Process Engineering

EM Minors take the following courses as part of the Engineering Curriculum:

Required Engineering Core

- ▶ E 355 : Engineering Economics
- ▶ E 243 : Probability and Statistics for Engineers
- ▶ TG 403/404 : Senior Innovation

Required Humanities Core

- ▶ BT 243 : Macroeconomics
- ▶ BT 244 : Microeconomics

An EM minor requires a two-course overload.

Minor in Systems Engineering

The Systems Engineering Minor is open to engineering students enrolled in an engineering major. (Non-engineering majors are not eligible for the SE Minor.)

Entry to the minor is by application only. Students who wish to apply must do so in writing and must possess a cumulative GPA of at least 3.3 at the time of application and have had at least one coop assignment or one relevant summer internship approved by the SE Minor advisor. The minor requires six courses, two of which must be in addition to those required to complete a student's major degree program (i.e. the minor requires a two course overload.) Required courses for the minor are as follows:

- EM 275 Program Management
- ▶ EM 385 Innovative System Design
- ▶ EM 357 Elements of Operations Research
- ▶ EM 585 Introduction to System Architecture and Design
- ▶ HPL 455 Ethical Issues in Science and Technology (which may be taken as a humanities elective)
- One approved course from the major department as specified below.

Students in the Systems Engineering Minor are also required to complete an interdisciplinary Senior Design Project, with their Minor Advisor serving as a co-advisor for the project.

Approved Courses from the Major Department for the SE Minor

These courses may also satisfy requirements within the major department. Some may have prerequisites, which must be taken within the requirements for the major or as additional overload and do not satisfy any SE Minor requirements.

Electrical Engineering

- ▶ EE 441 Introduction to Wireless Systems, or
- ▶ EE 478 Control Systems

Computer Engineering

▶ CPE 441 Introduction to Wireless Systems

Mechanical Engineering

- ▶ ME 421 Energy Conversion Systems, or
- ▶ ME 483 Control Systems

Environmental Engineering

► EN 377 Environmental Systems

Biomedical Engineering

▶ BME 504 Medical Instrumentation and Imaging

Chemical Engineering

▶ CHE 462 Chemical Process Control

Civil Engineering

▶ CE 410 Transportation Engineering Design

Naval Engineering

• OE 524 Introduction to Ship Design and Ship Building

Engineering Management Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experiences I	1	0	0	1
E 120	Engineering Graphics	0	2	1	1
E 121	Engineering Design I	0	3	2	2
E 115	Introduction to Programming	1	2	3	2
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
	Total	12	10	27	17

Term II					
Course #	Course Name	Lecture	Lab	Study	Credit
S.E.	Science Elective I ³	3	0	6	3
PEP 111	Mechanics	3	0	6	3
E 122	Engineering Design II	0	3	3	2
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
MGT 103	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 231	Engineering Design III	0	3	2	2
E 245	Circuits and Systems	2	3	7	3
HUM	Humanities	3	0	6	3
	Total	16	6	37	19

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
MA 227	Multivariable Calculus	3	0	6	3
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics	3	0	6	3
S.E.	Science Elective II ³	3	0	6	3
EM 275	Project Management	3	0	6	3
EM 224	Informatics and Software Development	3	0	0	3
	Total	17	3	31	18

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CE 342	Fluid Mechanics	3	3	6	4
E 321	Engineering Design V	0	3	2	2
E 344	Materials Processing	3	0	6	3
EM 301	Accounting & Business Analysis	3	3	4	4
EM 360	Operations Management and Process Engineering	3	0	3	3
EM 365	Statistics for Engineering Managers	3	2	4	4
	Total	15	11	25	20

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Course #	Course Name	Lecture	Lab	Study	Credit
E 355	Engineering Economics ¹	3	3	6	4
EM 322	Engineering Design VI	1	2	0	2
EM 345	Modeling and Simulation	3	0	3	3
EM 385	Innovative System Design	3	0	3	3
G.E.	General Elective ⁴	3	0	6	3
EM 357	Elements Of Operations Research	3	0	3	3
	Total	16	5	21	18

Term VII

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
G.E.	General Elective ⁴	3	0	6	3
T.G. 403	Senior Innovation I	2	0	4	2
EM 423	Engineering Design VII	0	8	3	3
T.E.	Concentration Elective	3	0	6	3
BT 244	Microeconomics ²	3	0	6	3
EM 489	Data-Mining and Risk Assessment	3	0	0	3
	Total	14	8	25	17

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
EM 450	Logistics and Supply Chain Management	3	0	6	3
G.E.	General Elective ⁴	3	0	6	3
EM 424	Engineering Design VIII	0	8	3	3
HUM	Humanities	3	0	6	3
BT 243	Macroeconomics ²	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
	Total	13	8	29	16

(1) E 355 is a core course for all engineers that is taught by SSE faculty

(2) Students can take BT 243 and 244 in any semester; these courses are part of the humanities requirements.

(3) Science Electives: See pages 78-80 for details.

(4) General Electives: chosen by the student- can be used towards a minor or option- can be applied to research or approved international studies

Engineering Management

Any two out of the following:

- ▶ BIO 281 Biology
- CH 116 Chemistry II
- ▶ PEP 201 Physics III for Engineers with lab
- NANO 200 Intro to Nanotechnology
- ▶ EN250 Quantitative Biology or PEP 151 Introduction to Astronomy, as long as one lab is included in the 2 courses

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Software Engineering

Bachelor of Engineering in Software Engineering

Software Engineering is the discipline dedicated to the engineering principles and techniques required for the sound construction of the computer systems of today and tomorrow. As businesses and institutions integrate new technologies to compete in the global environment they require individuals who are cognizant of the latest techniques in computational intelligence and are armed with the skills required to construct new dynamically interacting components.

Software engineers are trained in all aspects of software creation- from specification through analysis and design, to testing, maintenance and evaluation of the product. They are equipped with advanced knowledge in software architecture, project management, technical planning, risk management and software assurance – areas that are essential in implementing and overseeing software-intensive projects of high technical complexity.

Bachelor of Engineering in Software Engineering Mission and Objectives

The mission of the Bachelor of Engineering in Software Engineering (BESWE) Program is to provide an education based on a strong engineering core, complemented by a strong thread of systems thinking and critical thinking. Students will have an opportunity to explore a domain of interest where they may apply their software engineering skills. Graduates from this program will be able to:

- Design and develop software components for complex systems.
- Communicate with engineers of all disciplines in the languages and methods of those engineers.
- Understand the overall systems context for their projects and apply systems thinking in designing solutions that integrate components of different types, such as hardware, software, and people.

Software Engineering Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CH 115	General Chemistry I	3	0	6	3
CH 117	General Chemistry Laboratory I	0	3	1	1
E 101	Engineering Experience I	1	0	0	1
E 120	Engineering Graphics	0	2	1	1
E 121	Engineering Design I	0	3	2	2
E 115	Introduction to Programming	1	2	3	2
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4
MA 122	Integral Calculus	4	0	8	2
	Total	12	10	27	17

Term II					
Course #	Course Name	Lecture	Lab	Study	Credit
S.E.	Science Elective I ²	3	0	6	3
PEP 111	Mechanics	3	0	6	3
E 122	Engineering Design II	0	3	3	2
CAL 105 Or CAL 103	CAL Colloquium: Knowledge, Nature, Culture Or Writing And Communications Colloquium	3	0	6	3
MA 123; MA 124	Series, Vectors, Functions, and Surfaces; Calculus of Two Variables	4	0	8	4
	Introduction to Entrepreneurial Thinking	1	2	0	2
	Total	14	5	29	17

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
PEP 112	Electricity and Magnetism	3	0	6	3
E 126	Mechanics of Solids	4	0	8	4
E 231	Engineering Design III	0	3	2	2
E 245	Circuits and Systems	2	3	7	3
HUM	Humanities ²	3	0	6	3
	Total	16	6	37	19

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
E 232	Engineering Design IV	2	3	7	3
E 234	Thermodynamics ⁵	3	0	6	3
S.E.	Science Elective II ²	3	0	6	3
MA 134	Discrete Math	3	0	6	3
SSW215	Individual Software Engineering ⁵	3	0	6	3
HUM	Humanities ¹	3	0	6	3
	Total	17	3	37	18

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
CE 342	Transport/Fluid Dynamics ⁵	3	3	6	4
E 321	Engineering Design V	0	3	2	2
E 344	Materials Processing	3	0	6	3
E 243	Probability & Statistics	3	0	6	3
SSW 315	Object Based Software Development ⁵	3	0	6	3
HUM	Humanities ¹	3	0	6	3
	Total	15	6	32	18

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Course #	Course Name	Lecture	Lab	Study	Credit
E 355	Engineering Economics ¹	3	3	6	4
SSW 345	Model-Based Software Engineering ⁵	3	0	6	3
SW 322	Software Design Evolution ⁵	3	0	6	3
SSW 564	Software Requirements Engineering ⁵	3	0	6	3
G.E.	General Elective ³	3	0	6	3
D.E.	Domain Elective ³	3	0	6	3
	Total	18	3	36	19

Term VII

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
G.E.	General Elective ³	3	0	6	3
SSW 555	Agile Methods for Software Development ⁵	3	0	6	3
SSW 533	Software Estimation and Metrics ⁵	3	0	6	3
D.E.	Domain Elective ⁴	3	0	6	3
SSW 423	Engineering Design VII ⁵	0	8	6	3
TG 403	Senior Innovation I	2	0	4	2
	Total	15	8	34	17

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
SSW 567	Software Testing and Quality Assurance ⁵	3	0	6	3
SYS 481	Systems Engineering Architecture ⁵	3	0	6	3
G.E.	General Elective ³	3	0	6	3
SSW 424	Engineering Design VIII ⁵	0	8	3	3
HUM	Humanities ¹	3	0	6	3
TG 404	Senior Innovation II	1	0	2	1
	Total	13	8	29	16

(1) Humanities Requirement: see pages 556-557 for details.

(2) Science Elective: see pages 78-80 for details.

(3) General Elective: Chosen by student; Can be used towards a minor or option; Can be applied to research or approved international studies.

(4) Domain Elective: Chosen by student; Can be used towards a minor or option.

(5) Core Option - Specific course determined by engineering program.

Software Engineering

Any two of the following:

- ▶ BIO 281 Biology
- ▶ CH 116 Chemistry II
- ▶ PEP 201 Physics III for Engineers with lab
- NANO 200 Intro to Nanotechnology
- ▶ EN250 Quantitative Biology or PEP 151 Introduction to Astronomy, as long as one lab is included in the 2 courses

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Graduate Programs

Today's engineered systems are more complex than their predecessors, not only in the sophistication of elements from which they are constructed, but in the number and nature of the interconnections between those elements. System failures today, whether an automobile malfunction on a busy highway or the loss of a spacecraft on a distant planet, are much more likely to result from an unanticipated interaction between elements than from the failure of a single part.

Enterprises represent a special case of systems, one with enormous economic importance. While not traditionally considered within the same domain as technical systems, enterprises are increasingly viewed as representatives of a broader class of human designed systems, of which technical systems are only one example.

Stevens created the School of Systems and Enterprises (SSE) with the mission to provide interdisciplinary and trans-disciplinary education and research rooted in systems thinking. We focus on applying a "systems approach" to better understand the nature of problems and opportunities, and to conceive novel concepts and solutions that achieve breakthrough results.

The following graduate programs are offered by SSE.

Master of Science

Financial Analytics

Financial Analytics focuses on advanced development in fundamental data processing, machine learning, statistical modeling and optimization. The target of a student in this program is on broader financial services and the financial technology industry. Program graduates are expected to be able to handle complex financial data, build advanced analytical models, deliver effective visualization product, and utilize cloud-based data-driven analytics technology.

Taught by renowned faculty who are practitioners and researchers, the master's degree consists of 11 courses (33 credits): 9 required core courses and 2 electives.

Required Core Courses

- ▶ FE 530: Introduction to Financial Engineering
 - Or FE 535: Introduction to Financial Risk Management
- ▶ FE 582: Foundations of Data Science with
 - FE 513: Practical Aspects of Database Design (lab)
- ▶ FE 541: Applied Statistics with Application in Finance
- ▶ FE 550: Data Visualization Application
 - Or EM 622: Data Analysis & Visualization for Decision-Making
- ▶ FE 542: Time Series with Applications to Finance
 - Or MA 641: Time Series Analysis I
- ▶ FE 590: Introduction to Knowledge Engineering
 - Or MIS 637: Knowledge Discovery in Databases I
 - Or BIA 656: Statistical Learning & Analytics
 - Or CS 513/SOC 550: Knowledge Discovery and Data Mining

- ▶ FE 595: Financial Systems Technology
 - Or CS 549: Distributed Systems and Cloud Computing
- ▶ FE 630: Portfolio Theory and Applications
 - Or FE 646: Optimization Models and Methods in Finance
 - Or MA 629: Convex Analysis and Optimization
- ▶ FE 800: Special Projects in Financial Engineering

Elective Courses

Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the two electives; or choose the electives from our course catalog. All elective courses must be approved by an advisor. A list of available graduate certificates is included in this catalog and on the School of Systems and Enterprises website.

Financial Engineering

The vast complexity of financial markets compels industry to look for experts who not only understand how they work, but also possess the mathematical knowledge to uncover their patterns and the computer skills to exploit them. To achieve success, banking and securities industries must come to grips with securities valuation, risk management, portfolio structuring, and regulation-knowledge embracing applied mathematics, computational techniques, statistical analysis, and economic theory. The goal of the degree is to produce graduate who can make pricing, hedging, trading, and portfolio-management decisions in the financial services enterprise. With sharply honed practical skills complimented by strong technical elements, graduates are in demand in the industries-investment banking, risk management, securities trading and portfolio management. Students wishing to enroll in any of the FE programs must have an undergraduate degree in an engineering or science discipline and strong quantitative background.

This master's degree is also available in the 4+1 program; please see further information in the Undergraduate Programs section.

The master's degree requires 10 courses (30 credits): six core required courses and four elective courses.

Required Core Courses

- ▶ FE 610: Stochastic Calculus for Financial Engineers
- ▶ FE 620: Pricing and Hedging
- ▶ FE 621: Computational Methods in Finance
- ▶ FE 630: Portfolio Theory and Applications
- ▶ FE 680: Advanced Derivatives
- ▶ FE 800: Special Problems in Financial Engineering (3 credits)
 - Or FE 900: Thesis in Financial Engineering (6 credits)

Elective Courses

Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the four electives; or choose the electives from our course catalog. All elective courses must be approved by an advisor. A list of available graduate certificates is included in this catalog and on the School of Systems and Enterprises website.

Software Engineering

The Software Engineering master's program combines a deep core in software engineering principles and practices with application to a series of increasingly complex systems challenges drawn from the real world. Our students are trained in all aspects of software creation- from specification through analysis and design, to testing, maintenance and evaluation of the product. They are equipped with advanced knowledge in software architecture, project management, technical planning, risk management and software assurance – areas that are essential in implementing and overseeing software-intensive projects of high technical complexity.

This master's degree is also available in the 4+1 program; please see further information in the Undergraduate Programs section.

The master's degree requires 10 courses (30 credits): eight core required courses and two elective courses.

Required Core Courses

- SSW 540: Fundamentals of Software Engineering
- SSW 555: Agile Methods for Software Development Method
- SSW 564: Software Requirements Analysis and Engineering
- SSW 565: Software Architecture and Component-Based Design
- SSW 567: Software Testing, Quality Assurance and Maintenance
- SSW 533: Cost Estimation and Measurement
- SSW 690: Software Engineering Studio (Phase 1)
- SSW 695: Software Engineering Studio (Capstone Phase 2)

Elective Courses

Electives must be approved by advisor and can be chosen from software engineering, engineering management or computer science. Students with extensive experience in software engineering may be able to substitute additional elective courses for some required courses, with the approval of their graduate studies advisor. Most students in the master's program come with a solid foundation in software programming and discrete mathematics, but students may also use their electives to take ramp courses in these areas.

Sociotechnical Systems

Sociotechnical Systems are complex large-scale technology-intensive systems with a large number of stakeholders, where technological complexity and social complexity need to be tackled in an integrated fashion. Examples include the internet (and its problems of security, privacy, and design), urban, regional and global transportation systems, regional and national power grids, telecommunication networks, the global financial system, environmental systems, national healthcare systems, cities and other large-scale projects with significant societal impact.

The program provides an interdisciplinary blend of courses in systems engineering, financial engineering and enterprise science and consists of 10 courses (30 credits): six required core courses and four electives.

Required Core Courses

- ▶ ES 621: Fundamentals of Enterprise Systems
- ▶ ES 660: Multi-Agent Socio-Technical Systems
- SYS 655: Robust Engineering Design
- SYS 681: Dynamic Modeling of Systems and Enterprises

- ES 684: Systems Thinking
- ▶ ES 630: Modeling and Visualization of Complex Systems and Enterprises
 - Or EM 622: Data Visualization for Decision-Making

Elective Courses

Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the four electives; or choose the electives from our course catalog. All elective courses must be approved by an advisor. A list of available graduate certificates is included in this catalog and on the School of Systems and Enterprises website.

Master of Engineering

Engineering Management

Many engineers find themselves at a decision point about five years after graduation, when they must choose either to continue with their technical specialty or to enter the ranks of technical management. Those who choose the latter often find themselves inadequately prepared for their new responsibilities, having little experience or training in management, accounting, business strategy, team development and other vital management skills. Engineering Management fills these gaps in engineering and science education with studies in business, management and systems engineering by affording the traditional engineer with formal education in the human, financial, and management skills necessary to develop high quality, cost efficient, technically complex systems and products.

This master's degree is also available in the 4+1 program; please see further information in the Undergraduate Programs section.

The master's degree requires 10 courses (30 credits): six core required courses and four elective courses.

Required Core Courses

- ▶ EM 600: Engineering Economics
- ▶ EM 605: Elements of Operations Research
- ▶ EM 612: Project Management of Complex Systems
 - Or EM 680: Designing and Managing the Development Enterprise
- ▶ EM 624: Informatics for Engineering Management
- SYS 660: Decision and Risk Analysis
- SYS 611: Modeling and Simulation
 - Or SYS 681: Dynamic Modeling of Systems and Enterprise

Elective Courses

Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the four electives; or choose the electives from our course catalog. All elective courses must be approved by an advisor. A list of available graduate certificates is included in this catalog and on the School of Systems and Enterprises website.

Systems Analytics

Data-driven insights and analytics are facilitating and optimizing intelligent decision-making across industries today. Intended to meet the need for professionals who can harness complex data and convert it into meaningful information, the master's in systems analytics at the School of Systems and Enterprises is providing students with expertise in visualizing, manipulating and extracting important concepts from systems data, and complementing it with traditional systems decision-making. The

master's degree equips students with state-of-the art data visualization and knowledge extraction techniques for the purpose of analyzing trends, assessing risk, discovering patterns, and building decision models that can better develop, maintain and improve complex engineering systems and enterprises.

This master's degree consists of 11 courses (30 credits): seven required core courses (2 of which total 3 credits) and four electives as described below.

Required Core Courses

- EM 622: Data Analysis and Visualization Techniques for Decision making
 - Or ES 630: Modeling and Visualization of Complex Systems and Enterprises
- SYS 660: Decision and Risk Analysis
- ▶ SYS 670: Forecasting and Demand Modeling Systems
- ES 660: Multi-Agent Socio-Technical Systems
- SYS 611: Modeling and Simulation
 - Or SYS681: Dynamic Modeling of Systems and Enterprises
- ▶ FE 582: Foundations of Financial Data Science (2 credits)
- ▶ FE 513: Practical Aspects of Database Design Lab (1 credit)

Elective Courses

Students are encouraged to take and integrated four-course sequence leading to a graduate certificate for the four electives, or choose the electives from the course catalog. All elective courses must be approved by an advisor. A list of available graduate certificates is included in this catalog and on the School of Systems and Enterprises website.

Space Systems Engineering

The Master of Engineering in Space Systems Engineering at Stevens, delivered by the primary authors in the field of space systems today, provides experienced professionals with the edge needed to excel in this increasingly complex and competitive industry. Stevens is a recognized provider of space systems engineering education to NASA employees and space industry professionals worldwide, taught in partnership with Teaching Science and Technology, Inc. (TSTI). The degree allows professionals working in government and industry to combine a robust technical education in space systems design and development, as well as key space system engineering processes and tools, with a holistic understanding of systems engineering principles.

The program consists of 10 courses (30 credits): six required core courses and four electives as described below.

Required Core Courses

- SYS 625: Fundamentals of Systems Engineering
- SYS 650: System Architecture and Design
- > SYS 632: Designing Space Missions and Systems Or SYS 635: Human Spaceflight
- SYS 633: Mission and Systems Design Verification and Validation
 - Or SYS 605: Systems Integration
- ▶ EM 612: Project Management of Complex Systems
- SYS 800: Master's Project

Electives

Students must choose a total of four courses from the two concentrations listed below:

Space Concentration Electives

- ▶ SYS 632: Designing Space Missions and Systems
- SYS 635: Human Spaceflight
- ▶ SYS 636: Space Launch and Transportation Systems
- ▶ SYS 637: Cost-Effective Space Mission Operations
- SYS 638: Crew Exploration and Vehicle Design Exercise

Systems Concentration Electives

- SYS 611: Modeling and Simulation
- SYS 645: Design for System Reliability, Maintainability and Supportability
- > SYS 660: Decision and Risk Analysis
- SYS 635: Human Spaceflight

Systems Engineering

The SSE Systems Engineering graduate program offers a multidisciplinary approach to engineering education by providing a blend of engineering, systems, and management subjects. Our graduates manage engineering and technology, are able to address systems integration, life cycle issues, and systems thinking at the system and enterprise levels, in a market where globalization, technology, quality, complexity, and productivity are the key business drivers.

This master's degree is also available in the 4+1 program; please see further information in the Undergraduate Programs section.

The program consists of 10 courses (30 credits): five required core courses and five electives. Additionally, at least 3 credits and up to 6 credits, must be applied towards a thesis or a project (as SYS 800 or SYS 900).

Required Core Courses

- SYS 625: Fundamentals of Systems Engineering
- SYS 650: System Architecture and Design
- ▶ SYS 605: Systems Integration
- ▶ EM 612: Project Management of Complex Systems

Elective Courses

Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the four electives; or choose the electives from our course catalog. A fifth elective course must be a quantitative course, including but not limited to: SYS 116, SYS 645, or SYS 660. All elective courses must be approved by an advisor. A list of available graduate certificates is included in this catalog and on the School of Systems and Enterprises website.

Master of Philosophy

The Master of Philosophy (M.Phil.) is a postgraduate research degree. It is offered to enrolled Ph.D. students who achieve a record of distinction during the pre-dissertation phase. Because the Master of Philosophy is not designed as a terminal degree, its requirements are integrated with the requirements for the Doctor of Philosophy degree: potential candidates for the Master of Philosophy degree must be qualified to pursue the doctorate and have been advised to apply for admission to a doctoral program.

This degree requires a minimum of two years of advanced study beyond the master's degree. Placed between the Master's degree and the Doctor of Philosophy, the Master of Philosophy marks a student's successful completion of all requirements for the doctorate, except the final phase of research and the dissertation. The degree is intended to provide recognition that a prospective doctoral candidate has successfully and expeditiously completed a major phase of graduate study and has achieved a comprehensive mastery of the general field of concentration.

DOCTORAL PROGRAMS

The programs leading to the Doctor of Philosophy (Ph.D.) degree are designed to develop the student's ability to perform research or high-level design in Systems Engineering, Financial Engineering, Engineering Management and/or Enterprise Systems. Admission to the doctoral program is made through the school's Committee on Doctoral Admissions (CDA) and is based on a review of the candidate's scholastic record, professional accomplishments and the fit between his/her research objectives and those of the available SSE faculty. All admitted students must have the potential to advance the state of the art in their field of research.

For domestic students, admission to the doctoral programs in SSE requires that the candidate has graduated from an ABET accredited undergraduate program, preferably in engineering or science. A master's degree is usually required before a student is admitted to the doctoral program. A student's master's level academic performance and/or career must reflect his/ her ability to pursue advanced studies and perform independent research. Typically a GPA of 3.5 or better at master's level and 3.0 or better at the undergraduate level is required for admission to the doctoral program. International students must also demonstrate proficiency in the English language prior to admission by scoring at least 550 (210 for computer-based) on the TOEFL examination.

All doctoral applicants are required to submit Graduate Record Exam (GRE) results. Applicants may submit GMAT scores in lieu of GREs for the Doctorate in Engineering Management and Financial Engineering.

In addition, each applicant must submit a current resume or curriculum vitae, three recommendations, evidence of written work and a statement of purpose. The Statement of Purpose should be limited to three pages and describe the applicant's academic interests, proposed course work, research interests and rationale, general career objectives and desired full/ part-time student status. Applicants are strongly encouraged to review the available doctoral advisors on the SSE website http://www.stevens.edu/school-systems-enterprises/faculty and identify those who they believe are most closely aligned with their desired areas of research in their Statement of Purpose. The Statement of Purpose not only represents the student's interests, motivations and goals, but also is a reflection of his/her ability to communicate effectively and reflects the maturity of his/her research aspirations. Each applicant must submit an example of his/her written technical work. This work should be written solely by the applicant; published work, if available, is most desirable. All applications for part-time studies must include a letter of commitment from the applicant's employer.

Application Deadlines

- Fall applications: March 15th
 - If seeking financial support: February 1st
- Spring applications: October 15th
 - Applicants seeking financial support are encouraged to apply as early as possible

Coursework & Requirements

The following is a summary of coursework and the requirements for a doctoral degree in the School of Systems and Enterprises.

Course & Research Work

54 credits of graduate work in an approved program of study beyond the bachelor's degree consisting of:

- A maximum of 30 credit hours obtained in a master's program
- A minimum of 15 credits of additional graduate course work
- A minimum of 15 credit hours of dissertation work
- Completion of SSE core course requirements
- Completion of Stevens Doctoral Signature Course

Examinations

- Written and Oral Qualifying Examination due by the end of the 4th semester
- Dissertation Proposal Defense (also called Preliminary Examination)
- Dissertation Defense (also called Final Examination)

Dissertation

The dissertation is the capstone of the doctoral program and should result in research that advances the state of the art in the chosen field. Dissertations may be written in a traditional format or composed of a portfolio where the main body of the dissertation integrates a set of refereed journals and peer reviewed conference papers, which are included as appendices for the details. Regardless of the format, the results of the research must be deemed publishable in major scholarly journals. The following are the guidelines for publication prior to dissertation defense, but should be considered the norm:

- One (1) accepted peer reviewed journal article
- One (1) submitted peer reviewed journal article
- Two (2) presented refereed conference papers

The intent of this requirement is the belief that peer reviewed research produces a superior dissertation, providing a broad review of quality and dissemination of the results to a wider community. (See <u>http://library.stevens.edu/submit</u> for specific formatting and submission information.)

All research that involves human subjects requires Institutional Review Board (IRB) approval.

Core Course Requirements

To ensure that every student has the skills to be successful in his/her chosen field, ensure consistency in skill set standards and provide a common experience between students, there are a number of core courses requirements.

Core courses required for all SSE doctorate degrees:*

- > Systems Thinking ES684 *Not required for Ph.D. Financial Engineering
- ▶ Research Methods SYS710

Area Specific

Selection of one (1) course from each of the following two areas (other courses may be accepted based on the approval of the advisor and the Associate Dean of Research):

Quantitative Methods

- EM605 Elements of Operations Research
- ▶ FE610 Stochastic Calculus for Financial Engineers
- ▶ FE621 Computational Methods in Finance
- SYS611 Modeling and Simulation
- SYS645 Design for Reliability, Maintainability, and Supportability
- SYS660 Decision and Risk Analysis
- SYS670 Forecasting and Demand Modeling Systems
- SYS681 Dynamic Modeling of Systems and Enterprise

Economics, Financial Systems & Policy

- EM600 Engineering Economics and Cost Analysis
- ▶ FE620 Pricing and Hedging
- ▶ FE630 Portfolio Theory and Applications
- ▶ FE635 Financial Enterprise Risk Engineering
- ▶ FE655 Systemic Risk and Financial Regulation
- ▶ FE680 Advanced Derivatives

Domain Specific - Selection of three (3) courses from degree domain

Domain Non-Specific - Selection of one (1) course from any domain

Note that each doctoral program might have additional core course requirements. Students should contact their advisor to ensure that they have complied with their specific program requirements. In general, these are courses that are required for the master's degree in the area. It is recommended that the core course requirements are completed before the student enrolls in any elective courses.

Graduate Certificates

Certificates are offered on-campus, online and at sponsor locations. They can be completed as an individual credential or incorporated into a related master's degree for those meeting the program admission requirements. Certificates are four courses (12 credits) unless otherwise noted.

Acquisition and Management of Trusted Software Systems

This graduate certificate covers those topics and skills needed by managers to successfully deploy trustworthy systems. It prepares graduates to identify and prevent security vulnerabilities in modern software systems. The required courses are:

- SES 602 Secure Systems Foundations
- SSW 533 Software Estimation and Measurement
- SSW 564 Software Requirements Analysis and Engineering
- SSW 687 Acquisition and Management of Large Software Systems

Advanced Systems Architecture

This graduate certificate provides systems engineers and architects with a cross discipline approach to creating solutions based on the broad and complete view of systems and enterprises. The required courses are:

- SYS 625 Fundamentals of Systems Engineering
- SYS 650 System Architecture and Design
- ▶ SYS 750 Advanced System and Software Architecture Modeling and Assessment
- ▶ ES 679 Architecting the Extended Enterprise

Algorithmic Trading Strategies

Recent years have seen unprecedented change in financial systems technology. Algorithmic trading has become a dominant component of trade volumes on exchanges. The implementation of software and automatic decision support systems in dynamic markets has become part of the skills needed to succeed in the domain of algorithmic finance. This four-course certificate is designed to provide financial engineers with the necessary understanding of architecting and implementing a financial trading systems. The required courses are:

- ▶ FE 545 Design, Patterns and Derivatives Pricing
- ▶ FE 570 Market Microstructure and Trading Strategies
- ▶ FE 620 Pricing and Hedging
- ▶ FE 670 Algorithmic Trading Strategies

Data Exploration and Visualization for Risk and Decision Making

This graduate certificate will improve students' career toolkit to include decision making by visualizing, manipulating and extracting important concepts from data. The emphasis of this certificate is for the student to be able to understand the latest techniques in data visualization and knowledge extraction, and to leverage such understanding with the latest techniques for decision-making and risk analysis.

The required courses are:

- EM 622 Data Analysis and Visualization Techniques for Decision making
- ▶ EM 623 Data Science and Knowledge Discovery in Engineering Management
- ▶ EM 624 Informatics for EM
- SYS 660 Decision and Risk Analysis

Dependable Systems

The set of courses in this certificate gives a strong foundation and concentration in the design and engineering of dependable, software-intensive systems. Dependability of a computer system is defined as the "[..] the trustworthiness of a computing system which allows reliance to be justifiably placed on the service it delivers." This graduate certificate provides a credential of a student's mastery of the engineering of system dependability through the advanced study of software reliability, safety, resilience and security.

The required courses are:

- SSW 540 Fundamentals of Quantitative Software Engineering
- SSW 565 Software Architecture and Component-Based Design
- SSW 689 Engineering of Trusted Software Systems
- CS 573 Fundamentals of Cybersecurity or SES 602 Secure Systems Foundations

Development of Trusted Software Systems

This graduate certificate provides the knowledge and skills needed by experienced software engineers to develop trustworthy systems. It prepares graduates to develop software systems that function correctly and are free of security vulnerabilities.

The required courses are:

- SSW 556 Software Development for Trusted Systems
- SSW 689 Engineering of Trusted Software Systems
- SES 602 Secure Systems Foundations
- SES 603 Secure Systems Laboratory

Engineering Management

Engineering Management (EM) is a rapidly expanding field that combines engineering, technology, management, systems and business. High-technology companies in the telecommunications, financial services, manufacturing, pharmaceutical, consulting, information technology and other industries utilize EM concepts and tools such as project management, quality management, engineering economics, modeling and simulation, systems engineering and integration, and statistical tools. Given that most students will spend most of their professional careers in a management or supervisory capacity, this certificate provides many of the skills necessary to be successful in the 21st century global economy.

The required courses are:

- ▶ EM 600 Engineering Economics and Cost Analysis
- ▶ EM 605 Elements of Operations Research
- ▶ EM 612 Project Management of Complex Systems
- EM 680 Designing and Managing the Development Enterprise

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Enterprise Architecture and Governance

The graduate certificate in enterprise architecture and governance adapts and applies traditional systems engineering approaches and systems thinking techniques to a broader class of human-centric systems that we refer to as an enterprise, of which a technical system is only one part.

The required courses are:

- ▶ ES 621 Introduction to Enterprise Systems
- ▶ ES 677 Enterprise Governance
- MIS 712 Enterprise Architecture
- ES 684 Systems Thinking

Financial Computing - 15 credits

The Financial Computing certificate will enable students to operate effectively in the complex financial computing environment. Students will develop expertise in implementation of financial computing models, knowledge of financial databases, financial engineering software and specialized programming languages. The hands-on skills combined with a real-life financial computing project will enable them to compete in the financial industry.

The required courses are:

- ▶ FE 505 Technical Writing in Finance 1 credit
- ▶ FE 522 C++ Programming in Finance 3 credits
- ▶ FE 511 Introduction to Bloomberg and Thomson Reuters 1 credit
- ▶ FE 621 Computational Methods Finance 3 credits
- ▶ FE 699 Project in Financial Computing 2 credits

Choose one elective between:

- ▶ FE 543 Introduction to Stochastic Calculus for Finance 3 credits
- ▶ FE 610 Stochastic Calculus for Finance 3 credits

Choose two electives between:

- ▶ FE 513 Practical Aspects of Database Design 1 credit
- ▶ FE 514 VBA in Finance 1 credit
- ▶ FE 515 Introduction to R 1 credit
- ▶ FE 516 MATLAB for Finance 1 credit
- ▶ FE 517 SAS for Finance 1 credit
- ▶ FE 518 Mathematica for Finance 1 credit
- ▶ FE 519 Advanced Bloomberg 1 credit
- ▶ FE 520 Introduction to Python in Financial Applications 1 credit
- ▶ FE 521 Web Design 1 credit
- ▶ FE 529 GPU Computing 1 credit

Financial Engineering

The components of financial problem solving are embedded in the methods of applied mathematics, computational techniques, statistical analysis and economic theory. In a financial engineering program, those components are directed towards solving problems in securities valuation, risk management, portfolio structuring and regulatory concerns with emphasis on tools and training in stochastic modeling, optimization and simulation techniques.

The required courses are:

- ▶ FE 610 Stochastic Calculus for Financial Engineers
- ▶ FE 620 Pricing and Hedging
- ▶ FE 621 Computational Methods in Finance
- ▶ FE 630 Portfolio Theory and Applications

Financial Risk Engineering

The recent turbulence in the financial system heightened the need for a much stronger understanding of the financial system, its environment and the risk measures applied in the industry to quantify risk it in its multiple hierarchies. This certificate enables the graduate to fill this need and play an important role in balancing the interests of shareholders with the appropriate levels of risk taken by the managers and decision makers.

The required courses are:

- ▶ FE 535 Introduction to Risk Management
- ▶ FE 610 Stochastic Calculus for Financial Engineers
- ▶ FE 635 Financial Enterprise Risk Engineering
- ▶ FE 655 Systemic Risk and Financial Regulation

Financial Services Analytics - 5 course, 15 credits

Financial services analytics (FSA) is the science and technology of creating data-driven insights and analytics decisionmaking for the financial services industry. These insights increase the effectiveness of business operations, enhance customer relationships, improve product offerings, and improve risk analysis and risk management. This certificate will prepare students with an array of statistical learning methods and database skills in order to create end-to-end business decision making data analytic tools from an enterprise level systems approach.

The required courses are:

- ▶ FE 582 Foundations of Financial Data Science 2 credits
- ▶ FE 513 Practical Aspects of Database Design (lab) 1 credit
- ▶ FE 590 Introduction to Knowledge Engineering 3 credits
- ▶ FE 595 Financial Systems Technology (Analytical Financial Systems Design) 3 credits
- ▶ FE 550 Data Visualization Applications 3 credits
- ▶ FE 800 Special Projects in Financial Engineering 3 credits

Financial Software Engineering

This graduate certificate is aimed at intra-system super structural software applications (ISSS). Retail software platforms, web trading desks, pricing software tools for new instruments including derivatives products and stochastic portfolio simulators, and cutting edge information and knowledge discovery tools in a firm are all examples of software engineering or ISSS in financial institutions. This certificate explores these applications and how they work within a financial institutions overall enterprise system.

The required courses are:

- SSW 540 Fundamentals of Software Engineering
- SSW 565 Software Architecture and Component-based Design
- ▶ FE 610 Stochastic Calculus for Financial Engineers
- ▶ FE 620 Pricing and Hedging

Financial Statistics

In our data driven world the capability of analyzing and drawing meaningful conclusions from said data is paramount. This statement is valid to all areas of science and engineering, particularly to finance. The certificate as designed will allow a student to have all the necessary tools to be able to analyze data in a scientific and fundamentally correct way.

The required courses are:

- ▶ FE 541 Applied Statistics with Applications in Finance
- ▶ FE 542 Time Series and Applications to Finance
- ▶ FE 590 Introduction to Knowledge Engineering
- ▶ FE 610 Stochastic Calculus for Financial Engineering

Infrastructure Management

The certificate in infrastructure management integrates crucial activities spanning the entire life cycle of infrastructure systems. These four courses provide the backbone for approaching infrastructure systems from a top-level management and decision-making perspective. This certificate is relevant for professionals who wish to complement existing knowledge, skills and experience in one of the infrastructure areas that constitute the focus of the program.

The required courses are:

- ES 690 Introduction to Infrastructure Systems
- ▶ ES 691 Advanced Topics in Infrastructure Systems
- SYS 681 Dynamic Modeling of Systems and Enterprises
- ▶ EM 612 Project Management of Complex Systems
 - Or MGT 612 Human Side of Project Leadership

Integrated Ship Systems Engineering

This certificate provides professionals in government and industry with robust technical education in ship design and development, key ship systems engineering processes and tools, and a holistic understanding of systems engineering principles.

The required courses are:

- ▶ SYS 625 Fundamentals of Systems Engineering
- SYS 650 Systems Architecture and Design
- OE 661 Principles of Naval Ship Systems
- ▶ OE 660 Naval Ship Acquisition Process
- ▶ OE 524 Introduction to Ship Design and Ship Building

Logistics and Supply Chain Analysis

The logistics and supply chain analysis certificate focuses on the theory and practice of designing and analyzing supply chains. It will provide quantitative tools to identify key drivers of supply chain performance such as inventory, transportation, information and facilities from a holistic perspective. This graduate certificate program has a "how-to" orientation and the understanding gained in the courses can be immediately applied to the solution of on-the-job problems.

The required courses are:

- SYS 640 System Supportability and Logistics
- ▶ EM 665 Integrated Supply Chain Management
- SYS 670 Forecasting and Demand Modeling Systems
- ▶ EM 605 Elements of Operations Research
 - Or SYS 611 Simulation and Modeling

Sociotechnical Systems

This certificate prepares students to understand and develop solutions for problems involving systems and enterprises that are socio-technical in nature, i.e. including the human element in understanding the qualitative and quantitative process of evolving the enterprise/system.

The required courses are:

- ▶ ES 621 Fundamentals of Enterprise Systems
- ▶ ES 677 Governing Development
- ▶ ES 660 Multi-Agent Socio-technical Systems
- ES 684 Systems Thinking

Software Acquisition and Integration

The courses in this certificate provide students with the skills and knowledge needed to participate in and lead complex software-enabled system development and acquisition programs.

The required courses are:

- SSW 540 Fundamentals of Quantitative Software Engineering
- SSW 564 Software Requirements Analysis and Engineering
- SSW 687 Acquisition and Management of Large Software Systems
- SYS 605 Systems Integration

Software Design and Development

This graduate program certifies that the student has a sound mastery of software development methods, processes and techniques. Students who complete the program should be well positioned to take technical leadership positions in software design and development.

The required courses are:

- SSW 555 Agile Methods for Software Development
- SSW 565 Software Architecture and Component-Based Design
- CS 574 Object-oriented Design and Analysis
- CS 546 Web Programming
 - Or CS 548 Engineering of Enterprise Software Systems

Software Engineering

Creating successful systems is more than just writing software. This introductory certificate gives you a strong foundation in the fundamentals of software engineering - the engineering that is required to create software systems that work.

The required courses are:

- SSW 540 Fundamentals of Quantitative Software Engineering
- SSW 533 Software Estimation and Measurement

Choose two additional Software Engineering courses (SSW Prefix) or two from:

- CS501 Introduction to Java Programming
- CS546 Web Programming
- ▶ EM 612 Project Management of Complex Systems

Software Engineering in Finance

Clearing systems, payment systems and settlement systems are all examples of inter-system infrastructural software (ISIS). For example the Clearing House Interbank Payments System (CHIPS) is a patented algorithm for payment netting whose participants must have an account with the New York Federal Reserve Bank. The FedWire, SWIFT and SunGard are at the core of ISIS where the "Buy" side of the market meets the "Sell" side of the market through intermediaries and Banks with clearinghouses and custodians. The graduate certificate in software engineering in finance explores this class of problems dealing with inter-financial systems information flows.

The required courses are:

- SSW 540 Fundamentals of Software Engineering
- SSW565 Software Architecture and Component-based Design
- ▶ FE 595 Financial Systems Technology
- MGT 623 Financial Management
 - Or MGT 638 Corporate Finance

Software Program Management

This graduate certificate provides a credential of a student's mastery of the program and project management skill set applicable to the engineering, development and integration of software systems. These software engineering management practices and skills are widely applied within the software development communities responsible for large software systems.

The required courses are:

- SSW 540 Fundamentals of Quantitative Software Engineering
- SSW 533 Software Estimation and Measurement
- ▶ EM 612/MGT 609 Project Management for Complex Systems
- SSW 687 Acquisition and Management for Large Software Systems

Software Systems Architecture

Software systems architecture is one of the most important activities in any system development project. Systems succeed or fail because of their architecture. This graduate certificate is an intensive, in-depth study of the best practices of software systems architecture and design.

The required courses are:

- SSW 540 Fundamentals of Software Engineering
- SYS 650 System Architecture and Design
- SSW 565 Software Architecture and Component-Based Design
- SYS 750 Advanced System & Software Architecture

Space Systems Engineering

The certificate integrates crucial activities spanning the entire life cycle. Information and capabilities are learned by participants in hands-on space system and mission design assignments focusing on: operations, concept development, space system architecture, verification and validation, as well as key system engineering processes and tools. These four courses provide the backbone for the development of space systems engineers. This certificate is relevant for professionals who wish to complement their existing knowledge and skills base to include state of the art spacecraft and mission analysis design combined with a holistic systems engineering and architecture perspective.

The required courses are:

- SYS 625 Fundamentals of Systems Engineering
- SYS 650 System Architecture and Design

- ▶ SYS 632 Designing Space Missions and Systems
 - Or SYS 635 Human Spaceflight
- SYS 633 Mission and Systems Design Verification and Validation
 - Or SYS 605 Systems Integration

Systems-Centric Software Engineering

The courses in the certificate address software engineering in a way that integrates critical aspects of systems engineering and incorporates best practices to make those systems trustworthy. Modern society depends on large-scale software-intensive systems of astonishing complexity. For almost all interesting systems, the majority of the value is delivered through software and the majority of the engineering challenges are addressed through software. Because the consequences of failure in such systems are so high, it is vital that the software be assured or trustworthy; i.e., it has the characteristics that users depend on, including correctness, security, safety, and availability.

The required courses are:

- SSW 540 Fundamentals of Software Engineering
- ▶ SYS 625 Fundamentals of Systems Engineering
- ▶ EM 612 Project Management of Complex Systems
- SSW 565 Software Architecture and Component-Based Design

Systems and Supportability Engineering

This four-course cluster presents innovative methods and practices to integrate system reliability, maintainability, and supportability considerations into the systems engineering process. On the other hand, methods to optimize necessary logistics resources and processes are critical and are also studied in this sequence of courses. Current business trends are discussed and assessed.

The required courses are:

- ▶ SYS 625 Fundamentals of Systems Engineering
- SYS 640 System Supportability and Logistic
- > SYS 645 Design for System Reliability, Maintainability, and Supportability
- SYS 650 System Architecture and Design

Systems Engineering and Architecting

The topics covered and material presented in this certificate provides an interdisciplinary approach based on an "entire view" of missions and operational environments, and combines the capabilities of platforms, systems, operators and support to fashion solutions that meet customer needs.

The required courses are:

- SYS 625 Fundamentals of Systems Engineering
- SYS 650 System Architecture and Design
- ▶ EM 612 Project Management of Complex Systems
- SYS 605 Systems Integration

Systems Engineering of Embedded/Cyber-Physical Systems

The Systems Engineering of Embedded/Cyber-Physical Systems (CPS) four-course certificate program has been designed to provide engineers with systems engineering skills such that they can be effective in small, agile teams in the development of such systems. This certificate will provide students with a solid foundation in the fundamentals and practical use of tools for the conception, design, implementation and sustainment of embedded and CPS from a systems perspective using an integrated, intensive team-based project experience throughout the life cycle. The skills obtained will be applicable to the systems engineering of systems in other domains, but are focused on systems with the attributes of embedded and cyber-physical systems.

The required courses are:

- SYS 671 Conception of Cyber-Physical Systems
- SYS 672 Design of Cyber-Physical Systems
- ▶ SYS 673 Implementation of Cyber-Physical Systems
- ▶ SYS 674 Sustainment of Cyber-Physical Systems

Systems Engineering Management

This certificate is designed for program managers, project managers and lead systems engineers involved with conceiving, defining, architecting, integrating and testing complex and multi-functional systems. Students are introduced to the concept of the "extended" enterprise and the delivery of a value chain solution. Additionally, the human, financial, organizational and systems integration skills necessary to make project teams more productive are addressed in this graduate certificate offering.

The required courses are:

- ▶ EM 612 Project Management of Complex Systems
- ▶ SYS 625 Fundamentals of Systems Engineering
- SYS 660 Decision and Risk Analysis
- EM 680 Designing and Managing the Development Enterprise

Systems Lens for Technical Leaders (Special programs only)

Systems Security and Information Assurance (Special programs only)

Systems Security Engineering

This certificate integrates crucial topics spanning the lifecycle of secure systems. Participants are provided hands-on assignments focusing on: technology governance, security requirements, secure system architecture, security system engineering and information assurance.

The required courses are:

- SES 602 Secure Systems Foundations
- ▶ SES 622 Fundamentals of Systems Engineering Security
- SES 623 Systems Security Architecture and Design
- SYS 660 Decision and Risk Analysis

Urban Resilience

Dedicated to the proposition that coastal cities can increase their resilience to extreme weather while simultaneously improving their quality of life, this four-course certificate program will teach students and professionals of diverse backgrounds the necessary data-driven and science-based tools to make resilience in their communities a reality.

The required courses are:

- ES 520 The Nature of Urban Design
- ▶ OE 511 Urban Oceanography
- ▶ ES 630 Modeling and Visualization of Complex Systems and Enterprises
- ▶ EM 622 Data Analysis and Visualization Techniques for Decision-Making

SET Graduate Certificates

SET Graduate Certificates are offered as part of a special program provided to a specific Government sponsor and are not offered outside of that program. There are currently four SET Certificates, as follows:

- Modeling and Simulation
- Software Engineering Fundamentals
- Systems Engineering Foundation
- Systems Security

4+1 Program with Drew University

Stevens Institute of Technology (Stevens) and Drew University (Drew) have established a 4+1 and a 4+1.5 Bachelor of Arts / Master of Science partnership. Drew University currently offers students a B.A. in computer science, a minor in computer science and multiple liberal arts degrees. Based on the student's course of study and their academic performance, they will pursue different paths as they work towards a Software Engineering M.S. degree at Stevens. Students with a major or minor in computer science will take two master level software engineering courses at Drew enabling them to complete their Masters, potentially in one academic year at Stevens with the successful completion of 8 courses. Students without a computer science major or minor from Drew will complete their Masters at Stevens with 10 Stevens' courses, which they are expected to complete successfully in a year and half.

The purpose of these programs is to provide qualified students at Drew University with a seamless pathway into the Master of Science in Software Engineering at Stevens Institute of Technology. The details of these programs are explained in more detail below.

4+1 Program

The Drew University / Stevens Institute of Technology 4+1 B.A./M.S. in Software Engineering program allows qualified computer science majors or minors to complete the Bachelor of Arts degree at Drew and the Master of Science degree at Stevens in five years instead of the five and one half years that it would normally require.

Students are eligible to apply to the Drew/Stevens program coordinator for provisional acceptance once they have completed 48 credits towards Drew graduation. The requirements for provisional acceptance are a GPA of at least 3.0 overall and in their computer science courses, recommendation of the Drew/Stevens program coordinator, and no academic integrity violations.

CSCI 540 and 600 successfully completed at Drew with a grade of 3.3 or above will be transferred to Stevens and applied to the M.S. in Software Engineering as the equivalent of SSW 540 and 690. Taking these two courses at Drew reduces the number of credits needed for the M.S. degree, thus allowing the M.S. in Software Engineering to be completed in one

calendar year. Drew students admitted to Stevens through this program will complete an additional eight graduate-level courses at Stevens Institute of Technology. N.B., the two graduate-level courses completed at Drew must be above and beyond the 128-credit requirement for the Drew Bachelor of Arts degree.

4+1.5 Program

The Drew University/Stevens Institute of Technology 4+1.5 Bachelor of Arts/Master of Science in Software Engineering program allows Drew students without a major or minor in Computer Science the ability to complete the Drew B.A. and the Stevens M.S. in Software Engineering in five and one half years. Upon completing the Drew degree, students will enroll at Stevens to complete the graduate degree. Meeting the entry requirements for the program will guarantee admission to Stevens.

International Programs

Programs with Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)

ITESM - Campus Guadalajara - is a research-intensive university with the mission to form persons with integrity, ethical standards and a humanistic outlook, who are internationally competitive in their professional fields; at the same time, they will be good citizens committed to the economic, political, social and cultural development of their community and to the sustainable use of natural resources.

Stevens and ITESM, in recognition of the value of international cooperation and student mobility, and as a supplement to any exchange agreement, have agreed to conjointly offer encompassing Dual Degree Programs involving:

Master of Engineering in Systems Engineering (MSE) at SIT and Master in Science in Quality Systems and Productivity (MCP) at ITESM.

Candidates take the following four Stevens Institute of Technology Systems engineering courses:

- SYS 625 Fundamentals of Systems Engineering
- SYS 605 Systems Integration
- SYS 650 System Architecture and Design
- ▶ EM 612 Project Management of Complex Systems

And two additional courses from either:

- SYS 645 Design for Reliability, Maintainability & Supportability
- ▶ EM 680 Designing and Managing the Development System
- SYS 640 System Supportability and Logistics

ITESM Masters in Quality Systems and Productivity candidates take the following courses:

- ▶ GI 5000 Research and Innovation Methods
- ▶ GI 4000 Leadership for Business Innovation (1.5)

And four out of the five following courses:

- ▶ IN 4019 Quality Management and Competitiveness
- MA 4009 Statistical Methods
- IN 4016 Optimization Methods for Decision Making
- ▶ IN 4017 Production Engineering
- IN 4018 Supply Chain Management

- ▶ GI 5007 Thesis Project 1*
- GI 5008 Thesis Project 2*
- *Students develop a Thesis/Project under guidance of ITESM-SIT Faculty

Master of Science in Financial Engineering (MFE) at SIT and Master in Finance (MAF) at ITESM, Master in International Business (MIB) at ITESM or Master in Business Administration (MBA) at ITESM

Candidates take the following Stevens Institute of Technology financial engineering courses:

- ▶ FE 610 Stochastic Calculus for Financial Engineers
 - Or FE 543 Introduction to Stochastic Calculus for Finance
- ▶ FE 620 Pricing and Hedging
- ▶ FE 621 Computational Methods in Finance

And three out of the following electives:

- ▶ FE 630 Portfolio Theory and Applications
- ▶ FE 680 Advance Derivatives
- ▶ FE 635 Financial Enterprise Risk Engineering
- ▶ FE 655 Systemic Risk and Financial Regulation

ITESM Masters in International Business candidates take the following international business courses:

- ▶ GA 4044 Introduction to Economics
- GA 4075 Managerial Accounting
- ▶ GA 4076 Financial Accounting
- ▶ GA 4081 Fundamentals of Finance
- ▶ GA 4043 Interpersonal Skills for International Management
- ► GA 4048 Consulting Project I
- ▶ GA 4053 Leadership for Sustainable Development
- ▶ GA 4083 Introduction to Latin American Management
- ▶ GA 4084 Quantitative Methods
- ► GA 4040 Marketing
- GA 4045 NAFTA Business Environment
- ► GA 4042 Elective I
- GA 4047 Elective II

ITESM Master in Finance candidates take the following courses:

One course of the following ITESM courses:

- AD 4003 Business Policy, Ethics & Corporate Social Responsibility
- ▶ DS 4002 Leadership for Sustainable Development

And seven of the following ITESM courses:

- ▶ FZ 5004 Finance Project
- ▶ S 4009 Financial Econometrics
- ▶ FZ 4005 Financial Economics
- ▶ FZ 4006 Introduction to Corporate Finance
- FZ 4008 Investments
- ▶ FZ 5000 International Financial Management
- FZ 4007 Advanced Corporate Finance
- ▶ FZ 5003 Capstone Seminar in Finance

ITESM Masters in Business Administration candidates take the following courses:

One course of the following ITESM courses:

- AD 4003 Business Policy, Ethics & Corporate Social Responsibility
- DS 4002 Leadership for Sustainable Development

And seven of the following ITESM courses:

- ▶ EC 4005 Managerial Economics
- CD 4000 Operations Management
- MT 4001 Marketing Management
- ▶ RH 4000 Leadership and Organizational Behavior
- ▶ AD 4004 Competitive Strategy and Business Design
- ▶ AD 4005 Entrepreneurship and Intrapreneurship
- AD 5000 Negotiations and Decisions in Multicultural Environments
- AD 5001 Seminar in Transnational Management and Corporate Strategy

Master of Engineering in Engineering Management (MEM) and Master in International Business (MIB) at ITESM or Master in Business Administration (MBA) at ITESM

Candidates take the following Stevens Institute of Technology courses:

- ▶ EM 600 Engineering Economics & Cost Analysis
- SYS 611 Modeling and Simulation
 - Or SYS 681 Dynamic Modeling of Systems and Enterprises
- ▶ EM 680 Designing and Managing the Development System
 - Or EM 612 Project Management of Complex Systems
- ▶ EM 624 Informatics for Engineering Management
- SYS 660 Decision and Risk Analysis
- ▶ EM 632 Data Science and Knowledge Discovery in Engineering Management

ITESM Masters in International Business candidates take the following International Business courses:

- ▶ GA 4044 Introduction to Economics
- ► GA 4075 Managerial Accounting
- ▶ GA 4076 Financial Accounting
- ▶ GA 4081 Fundamentals of Finance
- ▶ GA 4043 Interpersonal Skills for International Management
- GA 4048 Consulting Project I
- ▶ GA 4053 Leadership for Sustainable Development
- ▶ GA 4083 Introduction to Latin American Management
- ► GA 4084 Quantitative Methods
- GA 4040 Marketing
- GA 4045 NAFTA Business Environment
- ► GA 4042 Elective I
- ► GA 4047 Elective II

ITESM Masters in Business Administration candidates take the following courses:

One course of the following ITESM courses:

- AD 4003 Business Policy, Ethics & Corporate Social Responsibility
- DS 4002 Leadership for Sustainable Development

And seven of the following ITESM courses:

- ▶ EC 4005 Managerial Economics
- CD 4000 Operations Management
- MT 4001 Marketing Management
- RH 4000 Leadership and Organizational Behavior
- AD 4004 Competitive Strategy and Business Design
- AD 4005 Entrepreneurship and Intrapreneurship
- AD 5000 Negotiations and Decisions in Multicultural Environments
- AD 5001 Seminar in Transnational Management and Corporate Strategy

Applicants should apply to their perspective host university. Cohorts are accepted for both the fall and spring terms.

Program with Nanyang Technological University (NTU)

The SSE in partnership with the School of Mechanical and Aerospace Engineering, Nanyang Technological University (NTU), Singapore, offers a dual degree program leading to Master of Engineering in Systems Engineering (through Stevens) and a Master of Science in Systems and Project Management (through NTU). The program mission is to prepare graduates in the twin competencies of systems engineering and project management, both sharing a common complex systems thinking and perspective. This dual degree program aims to broaden the participants' educational experience and prepare them for a successful career in leadership positions in delivering systems-based products, services and solutions to the industries,

businesses and government especially with countries in or have interest in developing businesses in Southeast Asia, India, and China.

The program is designed to be a resident program with students spending a minimum of one semester at the non-host university. To meet the degree requirements, candidates must earn 30 course credits by taking five courses from Stevens and four courses from NTU, plus an independent study project. Students should take the following courses from the SSE:

- SYS 625: Fundamentals of Systems Engineering
- SYS 650: System Architecture and Design
- SYS 605: Systems Integration
- ▶ EM 612: Project Management of Complex Systems
- SYS 660 : Decision and Risk Analysis
 - Or EM 680: Designing and Managing the Development Enterprise

While studying at NTU, candidates must select four of the following System and Project Management (SPM) courses:

- SPM 21/M6141 Quality Engineering
- SPM 22/M6205 Systems Simulation & Modeling
- SPM 23/M6601 Human Factors Engineering
- SPM 25/M6925 Enterprise IT/IS Project Management
- SPM 26/L6103 Supply Chain: Strategy and Design
- SPM 29/M6929 Management of Complex Engineering Projects
- SPM 30/M6426 Management of Technology and Innovation
- SPM 31/M6930 Project Estimation and Cost Management

All students in the program are required to take M6588 Independent Study from NTU producing a three credit hour capstone project. Note that students wishing to pursue a graduate certificate in Systems Engineering Management through Stevens are required to take EM 680 and SPM22.

Applicants should apply to their perspective host university. Cohorts are accepted for both the fall and spring terms.

Program with National University of Malaysia (UKM)

SSE, in partnership with the National University of Malaysia (UKM), offers a dual degree program leading to Master of Engineering (ME) in Systems Engineering or Engineering Management from Stevens and a Master of Science (MSc) in Industrial and Technology Management from UKM. For candidates to gain this dual master's degree they must fulfill a minimum of 33 credits by:

- 1. Completing 3 core courses at UKM and 2 technical elective, and
- 2. Completing 4 core courses in Systems Engineering at SIT and 1 technical elective, and
- 3. Completing 1 project-based UKM independent study.

Applicants should apply to their perspective host university.

Program with University College of South East Norway (UCSEN) (formerly Buskerud)

The SSE in partnership with the University College of South East Norway (UCSEN) in Kongsberg, Norway, offers a dual degree program leading to Master of Engineering in Systems Engineering from Stevens and a Master Degree in Systems Engineering from UCSEN. The dual degree program aims to broaden the participants' educational experience and prepare them for a successful career in leadership positions delivering systems-based products, services and solutions to industries, businesses and government, especially with countries in or who have interest in developing businesses in Scandinavia and Northern Europe. Students should apply to their perspective host universities. The program is designed to be a resident program with students spending a minimum of one semester at the non-host university. To meet the degree requirements, candidates must earn 30 course credits by taking five courses from Stevens and four courses plus a Master Project from UCSEN.

COURSE OFFERINGS

Engineering Management

EM 224 Informatics and Software Development

This course deals with the challenges associated with the variety and volume of information encountered in today's workplace, and working with others in a software development environment. Students will analyze and work with both structured and semi-structured data, using the python programming language. Students will learn about the types of software development environments they are likely to encounter in their careers. The capstone of the course is a small-group project that analyzes real-world data to answer a business or research question. Prerequisites: Corequisites: EM 275

FM 275 **Project Management**

This course presents the tools and techniques for project definition, work breakdown, estimating, resource planning, critical path development, scheduling, project monitoring and control and scope management. Students will use project management software to accomplish these tasks. In addition, the student will become familiar with the responsibilities, skills and effective leadership styles of a good project manager. The role organization design plays in project management will also be addressed.

EM 301 Accounting & Business Analysis

This course introduces students to the fundamental concepts of financial and managerial accounting, with an emphasis on actions managers can take to more effectively address the goals of the firm. Key topics covered include the preparation and analysis of financial statements, particularly creating cash flow statements needed for engineering economic analysis; consideration of variable costs, fixed costs, cost of goods sold, operating costs, product costs, period costs; job costing and process costing; application of accounting information for decision-making; marketing decisions, production decisions; capital budgeting: depreciation, taxation; budgeting process, master budgets, flexible budgets, analysis of budget variances; asset valuation, and inventory costing. The laboratory portion of the course provides the student opportunity to use the personal computer for solving problems related to the major topics of the course, such as spreadsheet analysis, and in addition covers managerial topics, including sessions focused on group dynamics and teamwork, research using the Internet and business ethics

EM 322 Engineering Design VI

This course is an integral part of the Engineering Management program - it provides students with experience and tools for new product/process development. Students will participate in a semester long class project meant to provide the students with insights that will serve to improve their senior project experience. Participation will be in small groups, and will complement EM385. Students will explore the detail design through validation in the systems engineering lifecycle. Tools that have been introduced in earlier engineering management courses may be brought together as part of this pre senior design experience. Students will be required to maintain an engineering notebook throughout the course. Prerequisites: E 321 Corequisites: EM 345, EM 385

EM 345 Modeling and Simulation

This course covers contemporary decision support models of forecasting, optimization and simulation for management. Students will learn how to identify the problem situation, choose the appropriate methods, collect the data and find the solution. The course also covers handling the information and generating alternative decisions based upon operations

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research optimization, statistical simulation, and systems dynamic forecasting. Computer simulations will be performed on PCs using user-friendly graphical interface with multimedia report generation for visualization and animation. Students will also be trained in management simulations for group decision support. Prerequisites: EM 365

EM 357 Elements of Operations Research

Application of forecasting and optimization models to typical engineering management situations and problems. Topics include: optimization theory and its special topics (linear programming, transportation models, and assignment models), dynamic programming, forecasting models, decision trees, game theory, and queuing theory. Applications to resource allocation, scheduling and routing, location of facilities, and waiting lines will be covered. Prerequisites: EM 365

EM 360 Operations Management and Process Engineering

The aim of the course is to provide an introduction to major business process problems, issues with a focus on process solutions that confront managers in highly competitive manufacturing and service environments. The course provides students with conceptual frameworks and qualitative/quantitative tools to deal with these issues. The course also explores the interconnections between business strategy and business processes. A rigorous introduction is provided for people aspiring to a career in designing and managing business processes, or for people aspiring to enter the management consulting world.

EM 364 Statistics For Engineers Laboratory

This one credit course is the lab component of EM 365. The lab provides an integrated experience with statistics and probability on real and manipulated data sets using flipped classroom and project based learning environments. Those students who have taken E 243 at Stevens, or have other credit for statistics, are still required to take this one credit EM Statistics lab. Prerequisites: Corequisites: EM 365

EM 365 Statistics for Engineering Managers

Provides a working knowledge of basic statistics as it is most often applied in engineering. Topics include: fundamentals of probability theory, review of distributions of special interest in statistics, analysis and enumeration of data, linear regression and correlation, statistical design of engineering experiments, completely randomized design, randomized block design, factorial experiments, engineering applications and use of the computer as a tool for statistical analysis.

EM 385 Innovative System Design

This project-based course addresses the fundamentals of systems engineering. Principles and concepts of systems engineering within a life-cycle perspective are presented through case studies and applied throughout the course to a student-selected team project. The initial focus is on the understanding of business drivers for systems engineering and the generation of innovative ideas. Students then engage in analysis, synthesis, and evaluation activities as they progress through the conceptual and preliminary design phases. Emphasis is placed on tools and methodologies for system evaluation during all phases of the design process with the goal of enhancing the effectiveness and efficiency of deployed systems as well as reducing operational and support costs. Prerequisites: Corequisites: EM 365

EM 423 Engineering Design VII

This year long two-course sequence involves the students in a small-team Engineering Management project. The problem for the project is taken from industry, business, government or a not-for-profit organization. Each student team works with a client and is expected to collect data, analyze it and develop a design by the end of the first semester. In the second semester the design solution of the problem is completed and a written report is submitted for binding. During the year, oral and written progress reports are presented to peers and clients. The total project involves the application of the subject areas covered in the EM 385 Engineering Management Laboratory course, as well as skills learned in the other technical and non-technical courses of the Engineering Management curriculum. Prerequisites: EM 275, and EM 301, and EM 322, and EM 345, and EM 385

EM 424 Engineering Design VIII

This year long two-course sequence involves the students in a small-team Engineering Management project. The problem for the project is taken from industry, business, government or a not-for-profit organization. Each student team works with a client and is expected to collect data, analyze it and develop a design by the end of the first semester. In the second semester the design solution of the problem is completed and a written report is submitted for binding. During the year, oral and written progress reports are presented to peers and clients. The total project involves the application of the subject areas covered in the EM 385 Engineering Management Laboratory course, as well as skills learned in the other technical and non-technical courses of the Engineering Management curriculum. Prerequisites: EM 385

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EM 450 Logistics and Supply Chain Management

This course will provide an introduction to supply chains, logistics & supply chain management. Topics covered include supply chain performance and metrics related to facilities, inventory, transportation, sourcing, pricing and information. Design of distribution networks, forecasting, and planning of demand & supply would be covered. Contemporary topics like e-business, IT and global supply chains would also be covered. Prerequisites: EM 357 or BT 223

EM 451 Analysis of Networks & Strategies

This course is designed to help with understanding the complexity, structure and dynamics of a highly connected world. It takes an interdisciplinary look at economics, sociology, information science and applied mathematics to discuss some of the fundamental features of networks and their behavior. The course is designed to equip students with a modeling lens to analyze, quantify and reason about structures, dynamics and evolution of complex networks. Key topics that are covered in the course are mathematical description of complex networks, fundamental measures of network structure, diffusion and cascading, voting and economic and market implications. The course will also have a particular emphasis on game theory as the method to model resource allocation in networks in the presence of autonomous agents. Prerequisites: EM 365

EM 489 Data-Mining and Risk Assessment

This course will use tools and techniques which have proven to be of value in recognizing patterns, making predictions, and evaluation risk from both large data sets (using data-mining techniques), and small data sets (using networks constructed from problem definition and discovery). Both approaches are critical to today's engineers and managers, because they span a range of possible data availability and reliability. Using these tools and techniques, the student will survey applications, and have hands-on experimenttaion with both data mining and network construction, using real-world examples and situations. Prerequisites: EM 224, and EM 365

EM 498 Research in Engineering Management I

Individual investigation of a substantive character undertaken at an undergraduate level under the guidance of a member of the departmental faculty. A written report is required. Hours to be arranged with the faculty advisor. Prior approval required. This course can be used as a general elective. EM 498 and EM 499 cannot be taken simultaneously.

EM 499 Research In Engineering Management II

Individual investigation of a substantive character undertaken at an undergraduate level under the guidance of a member of the departmental faculty. A written report is required. Hours to be arranged with the faculty advisor. Prior approval required. This course can be used as a general elective. EM 498 and EM 499 cannot be taken simultaneously.

Introduction to Systems Architecture and Design EM 585

EM 585 builds on EM 385 and gives the student a practical introduction to Systems Architecture and Design. Lectures will introduce the students to the motivation for System Architecture and Design, the different views on a System Architecture, as well as theory and best practices on behavioral definition, logical and physical partitioning, and interface definitions. Key aspects of system verification and validation will also be discussed. Tutorials will give the students practical experience using SySML and a commercial modeling tool to model system architectures. The students will apply the principles on a team project, designing and building a robot. Pre-requisite EM 385 or instructor approval. Prerequisites: EM 385

EM 600 Engineering Economics and Cost Analysis

This course presents advanced techniques and analysis designed to permit managers to estimate and use cost information in decision making. Topics include: historical overview of the management accounting process, statistical cost estimation, cost allocation, and uses of cost information in evaluating decisions about pricing, quality, manufacturing processes (e.g., JIT, CIM), investments in new technologies, investment centers, the selection process for capital investments, both tangible and intangible, and how this process is structured and constrained by the time value of money, the source of funds, market demand, and competitive position. Cross-listed with: PME 600, MGT 618

Elements of Operations Research EM 605

This course brings a strong modeling orientation to bear on the process of obtaining and utilizing resources to produce and deliver useful goods and services so as to meet the goals of the organization. Decision-oriented models such as linear programming, inventory control, and forecasting are discussed and then implemented utilizing spreadsheets and other commercial software. A review of the fundamentals of statistical analysis oriented toward business problems will also be conducted.

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EM 612 Project Management of Complex Systems

This project-based course exposes students to tools and methodologies useful for forming and managing an effective engineering design team in a bussiness environment. Topics covered will include: personality profiles for creating teams with balanced diversity; computational tools for project coordination and management; real time electronic documentation as a critical design process variable; and methods for refining project requirements to ensure that the team addresses the right problem with the right solution.

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This course provides a hands-on introduction to the modern techniques for visualizing data and leverages such techniques with the corresponding problem solving skills necessary to complement data visualization into specific strategic decision making. The student will first learn to use the latest off the shelf software for data visualization. In specific the student will learn the following languages: R, D3, Google refine and Spot fire.

EM 623 Data Science and Knowledge Discovery

This course provides an hands-on introduction to the major techniques and solutions to discover knowledge in data and text. Traditional data mining along with text mining and network analysis will be presented and will be used by the students via open source software, addressing information mining needs on both structured and unstructured data.

EM 624 Informatics for Engineering Management

This course enables the Engineering Management student to acquire the knowledge and skills he/she will need to handle the variety and volume of information encountered in today's workplace. The course uses Python, which is rapidly becoming the language of choice for information handling and data analysis. Students will work with both structured and semi-structured data.

EM 630 Introduction to Complexity and Dynamic Systems

This course will introduce and explore complexity and chaos, and investigate a broad range of examples from both natural (biological) and man-made systems. Complex systems, distinct from, but related to, complicated systems, display a range of behaviors. One of the most distinguishing of these behaviors is emergence - behavior that is not predictable from knowledge of specific, individual agent capabilities. In addition, systems are said to be complex when emergent behavior is not resulting from a central control, when they display chaotic characteristics, and when the systems have more frequent occurrences of rare events, especially when initial conditions vary. This course will study and model complex and adaptive (as well as nonadaptive) systems, and will present and discuss the characteristics of complex and chaotic systems. Prerequisites: E 243, and MA 221

Quality and Process Management EM 650

Principles and techniques of total quality management (TQM) with emphasis on their application to technical organizations. Topics include management philosophy, concepts and critique of quality "Gurus"; TQM modeling and strategy; TQM tools and techniques; Dept. of Defense 5000.51-G TQM guides; review and critique of the Deming and Baldrige Awards; concurrent engineering; quality function, deployment and design for cost. Students will form teams to analyze a case study involving TQM concepts and techniques (Formerly EM750).

EM 665 Integrated Supply Chain Management

This course illustrates the theory and practice of designing and analyzing supply chains. It provides tool sets to identify key drivers of supply chain performance such as inventory, transportation, information and facilities. Recognizing the interactions between the supply and demand components, the course provides a methodology for implementing integrated supply chains, enabling a framework to leverage these dynamics for effective product/process design and enterprise operations.

EM 680 Designing and Managing the Development Enterprise

This course addresses the design of the peopled-system that is responsible for designing and testing a product or operational system. There are three keys to designing the development system that are emphasized as part of this course: the fact that the design process should be a discovery process, the critical feedback and control activities that must be implemented for cost-discovery process, the critical feedback and control activities that must be implemented for cost-effective success, and the design of risk management(with an emphasis on adaptive testing) activities. This course will focus on the functional processes that must be performed by the development system, but will also address physical resources(people and software) and associated organizational structures.

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EM 690 Selected topics fr	Selected Topics in Engineering Management om various areas within Engineering Management.	(3-3-0)
one-on-one cours	Special Problems in Engineering Management (ME) the degree of Master of Engineering (Engineering Management). This course is typic se between a faculty member and a student. A student may take up to two special p program. A department technical report is required as the final product for this course.	roblems course in a
EM 801Special Problems in Engineering Management (PhD)(3)Three credit for the degree of Doctor of Philosophy. This course is typically conducted as a one-on-one investigation of a topic of particular interest between a faculty member and a student and is often used to explore topical areas that can serve as a dissertation. A student may take up to two special problems course in a Ph.D. degree program. A department technical report is required as the final product for this course.		
	Special Topics in Engineering Management om various areas within Engineering Management. This course is typically taught to me ne form of a visiting professor's course. Prerequisite: consent of instructor.	(3) ore than one student
EM 900 For the degree of credit to be arran	Thesis in Engineering Management (ME) Master of Engineering (Engineering Management). A minimum of six credit hours is ged.	(1 to 6) required. Hours and
-	Research in Engineering Management (PhD) ich may serve as the basis for the dissertation, required for the degree of Doctor of Phi 1960 research is required for the Ph.D. degree. Hours and credits to be arranged.	() Iosophy. A minimum

Socio-technical Systems

ES 522 Parametric Modeling in the Urban Environment

Parametric modeling links mathematical modeling with spatial modeling. The course provides a practical introduction to the concepts and application of parametric modeling, using examples from the built environment to apply those techniques at a number of scales ranging from a city-scale urban grid to the individual building elements within it. The course will be structured around the practical, hands-on application of the techniques addressed, using Grasshopper 3d as the primary parametric programming platform. The history, theory, and broader applications of computational parametric modeling and design will be periodically addressed where needed and more in-depth reading swill be provided as supplementary texts. Cross-listed with: CE 522

ES 621 Fundamentals of Enterprise Systems (3 - 3 - 0)

Traditional systems engineering techniques must be adapted to understand a broader class of human designed systems that we refer to as an enterprise, of which a technical system is only one part. Students will learn how describe the value of systems engineering on complex projects, provide a (common) global view of the system and enterprise, elicit and write good requirements, and understand how to develop robust and efficient architectures. Students should complete this class with "next steps" knowledge of tools, templates, capability patterns, and community. Case studies and examples are used throughout to give students an appreciation of how systems engineering tools, techniques, and thinking can be applied to the real world enterprises that we encounter daily.

ES 640 Community and Resilience

Cities, even large global mega-cities, can best be understood as a collection of communities in neighborhoods, all served by common urban infrastructures. To many citizens, those infrastructures were invisible until they failed in times of crisis. Their lack of resilience brought home the point that community needs drive the functional requirements for buildings and infrastructure. Delivered as a combination of lectures and seminars, we can begin to address questions such as "How do we measure functionality at the many scales that affect community?" and "How are their benefits and costs delivered to each significantly different community within the city?" Finally, "How do we measure the resilience we seek to achieve at a community level?"

ES 677 Governing Development

For a variety of business reasons, today's business and government organizations are demonstrating a heightened interest in governance. Development programs and organizations have unique governance concerns due to inherent uncertainty of development efforts. Moving beyond platitudes, this course introduces modern concepts of organizational governance and their application to organizations that develop systems and products. Course topics include the business climate forcing an emphasis on governance; a general governance framework, including definitions of governance elements; governance as a process; governance solutions for the development teams; development governance styles; and advanced topics.

ES 678 Engineering of Agile Systems and Enterprises

Real-time responsiveness characterizes systems at the forefront of competition, enterprise, strategy, warfare, governance, innovation, engineering, development, information, integration, and virtually anything designed today for purpose. This course covers fundamental objectives, performance metrics, analysis frameworks, and design principles for engineering agile and resilient systems. Real examples are analyzed in case studies for their change proficiency and response ability. Response capability frameworks are applied in analysis and requirements development. Architecture and design principles which enable resilient and innovative response are illuminated and then applied in synthesis exercises. Hands-on, minds-on exercises prepare and guide the participant in applying the knowledge. Systems for case study and focus can run the range from products and processes to governance and infrastructure to enterprises and systems-of-systems.

ES 679 Architecting the Extended Enterprise

This course presents a systems architecting process to achieve enterprise integration both within and between corporate boundaries. The process leverages systems thinking - the antithesis of scientific reductionism, which fails to appreciate the interrelationships between components that make-up a system. Systems thinking has proven to be successful in the delivery of integrated technology products, and is now being applied to understanding the structure and dynamics of organizations for which communications and co-stuff in general is a key to business success; in other words inter-relationships are prime in managing an enterprise. The systems approach further emphasizes emergence, wider systems and the environment. These concepts are crucial to architecting an enterprise in consideration of issues of decentralization, alliance advantage, and market phenomena. Prerequisites: SDOE 675

ES 683 Design of Agile Systems and Enterprises

The frontier of systems engineering today seeks new levels of system capability and behavior, and expects to find that benefit in higher forms of systems that elude traditional control and creation concepts. Common themes converge here in a study of agility across a seemingly wide variety of interesting system types, characterized principally by aspects of self-organization and systems of systems. Esthetic quality in systems and enterprises makes the difference between enforced compliance and embraced experience; and determines the positive or negative vectors of self-organization and emergence. This module explores the value and nature of esthetic design quality, principles and architectures for harnessing self organized systems of systems, agility as risk management and reality confrontation, and similar issues at the edge of agile system and enterprise knowledge. (Formerly SYS790) Prerequisites: ES 678

ES 684 Systems Thinking

It takes something special for the term system to have such ubiquity. The downside is that it is overused, improperly so, detracting from its power. This class builds upon a solid conceptual foundation to ensure that the system/enterprise is properly defined, conceived, and realized. Uniquely, the class shows how it is possible to use systems in order to think more deeply and to act more decisively. This approach is made possible by emphasizing the simultaneity of perspectives, the role of paradox, and the centrality of soft issues in resolving complexity. The SystemitooITM is used to structure and conduct analysis of decisions. This class is aimed at policy and decision-makers at all levels in an organization. Prerequisites: SYS 625

FS 690 Introduction to Infrastructure Systems

Selected topics from various areas within Enterprise Systems. This course is typically taught to more than one student and often takes the form of a visiting professors course.

ES 691 Advanced Topics in Infrastructure Systems

Building on the topics presented in ES 690, this course introduces advanced topics in infrastructure systems, focusing on tools and methodologies crucial to infrastructure systems analysis and planning. Topics discussed include CLIOS analysis and dynamic modeling of infrastructure systems, fundamentals of network analysis, decision analysis for infrastructure systems, and infrastructure resiliency. Prerequisites: ES 690

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ES 800 Special Problems in Enterprise Systems (ME)

Three credits for the degree of Master of Science (Enterprise Systems). This course is typically conducted as a one-on-one course between a faculty member and a student. A student may take up to two special problems courses in a master's degree program. A department technical report is required as the final product for this course.

ES 801 Special Problmes in Enterprise Systems (PhD)

Three credits for the degree of Doctor of Philosophy. This course is typically conducted as a one-on-one one investigation of a topic of particular interest between a faculty member and a student and is often used to explore topical areas that can serve as a dissertation. A student may take up to two special problems courses in a Ph.D. degree program. A department technical report is required as the final product for this course.

ES 810 Selected Topics in Enterprise Systems (3 - 3 - 0)

Selected topics from various areas within Enterprise Systems. This course is typically taught to more than one student and often takes the form of a visiting professor's course.

ES 900 Thesis in Enterprise Systems

For the degree of Master of Science (Engineering Systems). A minimum of six credit hours is required for the thesis. Hours and credits to be arranged.

ES 960 Research in Enterprise Systems

Original work, which may serve as the basis for the dissertation, required for the degree of Doctor of Philosophy. A minimum of 30 hours of ES 960 research is required for the Ph.D. degree. Hours and credits to be arranged.

Financial Engineering

FE 505 Financial Lab: Technical Writing in Finance

This course teaches financial engineers how to write well-constructed, persuasive technical papers, and how to make oral presentations more effectively. It uses practical examples, in-class assignments, and homework exercises. This course reduces the anxiety that is frequently associated with technical writing and speaking. It emphasizes the collaborative aspects of the technical writing and revision process. It teaches the use of the LaTeX typesetting system for preparing technical manuscripts and presentations. In addition, the course teaches students how to present their work to both technical and not-technical audiences by creating cogent, striking, and well-designed figures and presentation slides.

FE 511 Introduction to Bloomberg and Thomson Reuters

This course is designed to teach students the nature and availability of the financial data available at Stevens. The focus of the course will be on equity, futures, FX, options, swaps, CDS's, interest rate swaps etc. They will learn to how use a Bloomberg terminal. As part of the course the students will be certified in the 4 areas that Bloomberg offers certification. We will cover the Thomson–Reuters Tick history data and basics of using this data. The course also introduces basics of applied statistics. Bloomberg terminal access will be required for any student taking the course on the web.

FE 512 Database Engineering

The course provides an introduction to SQL databases and NoSQL databases as available to the Hanlon Financial Systems Lab. At the end of the course the students will be familiar with all the lab resources as well as a working knowledge on how to use them. The students will receive hands on instructions about setting up and working with databases. Most of the software will be introduced using case studies or demonstrations, followed by a lecture of related fundamental knowledge. The course covers SQL (MySQL, WinSQL, PosgreSQL), NoSQL (IBM DB2, OneTick) and database managers Aqua. The course will cover accessing databases using API, SQLConnect and Access methods for DB2.

FE 513 Financial Lab: Practical Aspects of Database Design

The course provides a practical introduction to SQL databases and Hadoop cluster systems as available in the Hanlon Financial Systems Lab. Students will receive hands on instruction about setting up and working with databases. Most of the software will be introduced using case studies or demonstrations, followed by a lecture of related fundamental knowledge. The course covers SQL, NoSQL, and database management systems. The course will cover accessing databases using API.

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FE 514 Financial lab: VBA in Finance

This course is an introduction to programming with VBA - the Visual Basic for Applications language. In particular, we will be using VBA within MS Excel, and time permitting, MS Access as well. Excel is used everywhere in finance, and VBA allows practitioners to go beyond standard spreadsheet calculation and modeling. Programming with VBA (and using macros) enhances the versatility and power of Excel. The goal of this course is to teach our students Excel usage at a high level using VBA, for front office applications in financial institutions. Financial and mathematical applications will be presented and studied throughout the course.

FE 515 Introduction to R

In this course the students will learn the basics of the open source programming language R. The language will be introduced using financial data and applications. Basic statistical knowledge is required to complete the course. The course is designed so that upon completion the students will be able to use R for assignments and research using data particularly in finance.

FE 516 MATLAB for Finance

In this course the students will learn the basics of Matlab programming using financial data and applications. The language will be introduced using financial data and applications. This short course is intended for students with little or no experience with the software covering Matlab's basic operations and features. In addition, the course works through several simple applications, to give the students the necessary knowledge on developing their own projects. Topics covered include iteration, functions, arrays, and Matlab graphics. Assignments are designed to build an appreciation for randomness, simulation, and the role of approximation.

FE 517 SAS for Finance

In this course the students will learn the basics of SAS programming using financial data and applications. The course provides an introduction to programming, graphics, and data analysis using SAS Software. The course concentrates on fundamental components of SAS Software: data processing, managing SAS libraries, graphical and statistical procedures, creating, formatting and exporting reports. In addition, several advanced topics will be introduced: SAS SQL procedures and SAS Macro Language. The supporting applications illustrate financial data analysis with special emphasis on large data sets.

FE 518 Mathematica for Finance

The course provides an introduction to programming, graphics, and financial data analysis using Mathematica. Students will learn programming in Mathematica Software, starting with elementary but quickly moving to advanced programming. They will learn it as an integrated quantitative methodology for analysis of markets, and optimal trading in stocks and options. The course is based on "hands-on" projects dealing with contemporary topics in financial mathematics and it complements theoretical courses of finance.

(1 - 0 - 1)FE 520 Introduction to Python for Financial Applications

This course is a primer on Python (language syntax, data structures, basic data processing, Python functions, modules and classes). The remainder of the course covers open source Python tools relevant to solving financial programming problems. The lecture, supporting examples, and practical applications are intertwined. The content will be delivered in a fully equipped financial computing laboratory where the students are immersed in case studies of real life applications. There will be reading assignments of the corresponding chapters in the textbook and additional materials will be provided.

FE 521 Web Design

This course is designed to teach students how to configure and code using PHP Hypertext Processor. Students will also learn how to create dynamically generated web pages using PHP and how to connect to databases.

FE 522 C++ Programming in Finance

This course is a hands on C++ introduction for Financial applications. The course will teach the basics of C++ and will teach the student how to program for finance. Very little time will be spent on the philosophy and much more time on the actual programming. QT and Visual Studio will be used as IDE's throughout the course. The course will be designed as a prerequisite for other advanced courses at Stevens.

FE 529 GPU Computing in Finance

In this course the students will learn the basics of CUDA programming using financial data and applications. They will learn how to use C++, Matlab and R to access the GPU in their computer and to use the Stevens GPU cluster. The course is designed for Nvidia CUDA but the basics are easily transferable to Open CL.

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FE 530 Introduction to Financial Engineering

This course introduces a range of topics that the current scope of financial engineering encompasses. Topics include basic terminology and definitions, markets, instruments, positions, conventions, cash flow engineering, simple derivatives, mechanics of options, derivatives engineering, arbitrage-free theorem, efficient market hypothesis, introductory pricing tools, and volatility engineering.

FE 535 Introduction to Financial Risk Management

This course deals with risk management concepts in financial systems. Topics include identifying sources of risk in financial systems, classification of events, probability of undesirable events, risk and uncertainty, risk in games and gambling, risk and insurance, hedging and the use of derivatives, the use of Bayesian analysis to process incomplete information, portfolio beta and diversification, active management of risk/return profile of financial enterprises, propagation of risk, and risk metrics.

Probability theory for FE FE 540

Topics include discrete and continuous distributions, multivariate probability, transformations, pattern appearance, moment generating functions, Laws of large numbers, Markov chains and diffusion processes, prices in markets as random variables and processes, filtrations and information. Applications target financial engineering examples.

FE 541 Applied Statistics with Applications in Finance

The course prepares students to employ essential ideas and reasoning of applied statistics. Topics include data analysis, data production, maximum likelihood, method of moments, Bayesian estimators, hypothesis testing, tests of population, multivariate analysis, categorical data analysis, multiple regression, analysis of variance, nonlinear regression, risk measures, bootstrap methods and permutation tests. The course is designed to familiarize students with statistical software needed for analysis of the data. Financial applications are emphasized but the course serves areas of science and engineering where statistical concepts are needed. This course is a graduate course and is covering topics for a deeper understanding than undergraduate courses such as MA331 and BT221. Furthermore, the course will cover fundamental statistical topics which are the basis of any advanced course applying statistical notions such as MGT718, BT652 as well as courses on machine learning, knowledge discovery, big data, time series, etc.

FE 542 Time Series with Applications to Finance

In this course the students will learn how to estimate financial data model and predict using time series models. The course will cover linear time series (ARIMA) models, conditional heteroskedastic models (ARCH type models), non-linear models (TAR, STAR, MSA), non-parametric models (kernel regression, local regression, neural networks), non-parametric methods of evaluating fit such as bootstrap, parametric bootstrap and cross-validation. The course will also introduce multivariate time series models such as VAR. Prerequisites: FE 541 or MA 331 or MA 541 or MA 612

FF 543 Introduction to Stochastic Calculus for Finance

This course introduces the stochastic calculus to students of finance and financial engineering. The course deals with Markov chains, Poisson processes, random walks, Brownian motion, asset prices as processes, limits of stochastic sequences, Ito sums and integral, fundamental models in modern finance, price dynamics and elementary examples of stochastic differential equations.

FE 545 Design, Patterns and Derivatives Pricing

This course covers the design and implementation of financial models using object oriented programming. It discusses advanced applications on quantitative finance with special emphasis on derivatives pricing.

FE 550 Data Visualization Applications

Effective visualization of complex data allows for useful insights, more effective communication, and making decisions. This course investigates methods for visualizing financial datasets from a variety of perspectives in order to best identify the right tool for a given task. Students will use a number of tools to refine their data and create visualizations, including: R and associated visualization libraries, Ruby on Rails visualization tools, ManyEyes, HTML5 & CSS 3, D3.js and related javascript libraries, Google Chart Tools, Google Refine, and image-editing programs. Prerequisites: FE 540

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FE 555 2D Data Visualization Programming for Financial Applications

Building effective and efficient tools for next generation integration of data analysis into strategic decision-making requires knowledge of existing software packages as well as the ability to build or extend software when needed. This course will address strategies for representing complex data through coverage of responsive web technologies, programming methods, libraries, and current techniques for transforming local and distributed data sets into meaningful visualizations using data acquisition and machine learning techniques. Prerequisites: FE 540

FE 570 Market Microstructure and Trading Strategies

The course offers an overview of modern financial markets for various securities: equities, FX, and fixed income, different types of traders, orders, and market structures, market microstructure models used for describing price formation in dealer markets (inventory models and information-based models), models of the limit-order markets, optimal order execution: optimal order slicing, and maker-versus-taker strategies. The course introduces several typical trading strategies by introducing technical analysis, including trend, momentum, and oscillator-based strategies, arbitrage trading strategies, including pair trading, implementation and methods of strategies back-testing.

FE 571 Quantitative Hedge Fund Strategies

Hedge funds are among the most influential participants in the financial markets with unique features. They are subject to less regulation and their strategies vary significantly from one another. Examples of common strategies include discretionary investing, quantitative equity investing, global macro, managed futures and exploitation of arbitrage opportunities. This course provides an overview of the hedge fund industry by going into the mechanics of the industry and then follows with detailed descriptions of the different strategies employed. Furthermore, it provides the economic intuition behind each of these strategies as well as the implementation along with practical considerations. It also discusses various examples of how financial engineering toolsets can be utilized to enhance hedge fund performance. In addition, this course emphasizes on the practical techniques of building a quantitative trading system using R programming language. Topics such as the lifecycle of developing a sound trading strategy and strategy validation in the form of back-testing are introduced. Prerequisites: FE 570

FE 575 Introduction to Econophysics

The course will apply certain concepts from statistical physics to the description of real-life financial time series. It will introduce the notion of Random Walk from the physicist stand-point and propose various statistical tests as comparisons of real-life financial time series properties with those of a Random Walk. The course will introduce statistical description of financial data with emphasis on long-memory correlation functions. The course will introduce Levy stochastic processes and their analytical properties and use them to parameterize the real-life financial time series probability density functions. Through homework's and final project, the course will stress phenomenological hands-on work with financial data. The course will culminate with the final project in which students will learn to extract the learned price anomalies through development of basic trading strategies. The dangers of over fitting of financial data will be studied through walk-forward outof-sample trading simulations, which will teach student to become more prudent practical quantitative analysis.

FE 580 Securitization of Financial Assests

This course provides a theoretical and practical analysis of the asset-backed security market. Topics include: Duration And Convexity of Bond Yields, Price Dynamics of Mortgages and Cash Flows, Default Risk, Interest Rate Volatility, Interest Rate Risk Management of Mortgage-Backed Securitization, Securitization, Corporate Debt and The Securitization Markets, Asset-Backed Commercial Paper, Collateralized Loan Obligations, Structuring Synthetic Collateralized Loan Obligations, Securitization of Revolving Credit, Financial Derivatives and Their Use as Hedging Tools. Half of the course is in the Hanlon Financial Systems Lab, where theoretical models are illustrated with real scenarios.

FE 582 Foundations of Financial Data Science

This course will provide an overview of issues and trends in data quality, data storage, data scrubbing, data flows, and data encryption. Topics will include data abstractions and integration, enterprise level data issues, data management issues with collection, warehousing, preprocessing and querying. Furthermore, the Hadoop based programming framework for big data issues will be introduced along with any governance and policy issues. Prerequisites: Corequisites: FE 513

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FE 590 Introduction to Knowledge Engineering

Introduction to information theory: the thermodynamic approach of Shannon and Brillouin. Data conditioning, model dissection, extrapolation, and other issues in building industrial strength data-driven models. Pattern recognition-based modeling and data mining: theory and algorithmic structure of clustering, classification, feature extraction, Radial Basis Functions, and other data mining techniques. Non-linear data-driven model building through pattern identification and knowledge extraction. Adaptive learning systems and genetic algorithms. Case studies emphasizing financial applications: handling financial, economic, market, and demographic data; and time series analysis and leading indicator identification.

FE 595 Financial Systems Technology

This course deals with financial technology underlying activities of markets, institutions and participants. The overriding purpose is to develop end-to-end business decision making data analytics tools along with enterprise level systems thinking. Statistical learning algorithms will be connected to financial objects identification and authentication along with the appropriate databases to create enterprise level financial services analytics systems.

FE 610 Stochastic Calculus for Financial Engineers

This course provides the mathematical foundation for understanding modern financial theory. It includes topics such as basic probability, random variables, discrete continous distributions, random processes, Brownian motion, and an introduction to Ito's calculus. Applications to financial instruments are discussed throughout the course.

FE 620 Pricing and Hedging

This course deals with basic financial derivatives theory, arbitrage, hedging, and risk. The theory discusses Ito's lemma, the diffusion equation and parabolic partial differential equations, and the Black-Scholes model and formulae. The course includes applications of asset price random walks, the log-normal distribution, and estimating volatility from historic data. Numerical techniques, such as finite difference and binomial methods, are used to value options for practical examples. Financial information and software packages available on the Internet are used for modeling and analysis. Prerequisites: Corequisites: FE 610

FE 621 Computational Methods in Finance

This course provides computational tools used in industry by the modern financial analyst. The current financial models and algorithms are further studied and numerically analyzed using regression and time series analysis, decision methods, and simulation techniques. The results are applied to forecasting involving asset pricing, hedging, portfolio and risk assessment, some portfolio and risk management models, investment strategies, and other relevant financial problems. Emphasis will be placed on using modern software.

FE 625 Emerging Markets: Risks and Models (3 - 3 - 0)

This course covers the basics of Emerging Markets instruments, models, risks, hedging and trading practices. Emerging Markets have seen a dramatic increase in volume, especially since the latest crisis in the developed markets. Geographically the course will be focused on the 4 BRIC countries (Brazil, Russia, India and China) and Mexico. The student should develop a deep understanding of the main differences between Developed Markets and Emerging Markets risk and trading. Many of the unique attributes and models in Emerging Markets have now been adopted by Developed Markets since the 2008 crisis, given students an edge in understanding the latest trends in the markets. Main topics to be covered include: funding in EM; XC basis markets; OIS and local collateralization; Credit Valuation Adjustment (CVA); Extinguishable XC swaps; Inflation indexes and inflation currencies; Capital Constraints, Convertibility and Transferability.

FE 630 Portfolio Theory and Applications

This course introduces the modern portfolio theory and optimal portfolio selection using optimization techniques such as linear programming. Topics include contingent investment decisions, deferral options, combination options and mergers and acquisitions. The course introduces various concepts of financial risk measures. Prerequisites: FE 620, FE 621

FE 635 Financial Enterprise Risk Engineering

This course deals with risk assessment and engineering in financial systems. It covers credit risk, market risk, operational risk, liquidity risk, and model risk. Topics include classical measures of risk such as VaR, methods for monitoring volatilities and correlations, copulas, credit derivatives, the calculation of economic capital, and risk-adjusted return on capital (RAROC). The nature of bank regulation and the Basel II capital requirements for banks are examined. Case studies illustrate risk engineering successes and failures in financial enterprises. Prerequisites: FE 535

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This course deals with aspects of systemic risk in financial systems. It covers a review of classical risk measures and introduces non-classical risk measures such as Extreme Value Theory. It also covers the study of financial systems as a system of complex adaptive systems, agent-based modeling, history and analysis of bubble formations as a systemic risk, the role of rating agencies, the financial systems ecosystem, risk and regulatory environment, risk and the sociopolitical environment. It also studies international financial inter-system risk propagation and containment and its impact on international financial systems, the International Monetary Fund assessments and the effect of extreme risk on poverty, international instability and globalization.

FE 670 Algorithmic Trading Strategies

Systemic Risk and Financial Regulation

FE 655

This course investigates statistical methods implemented in multiple quantitative trading strategies with emphasis on automated trading and based on combined technical-analytic and fundamental indicators to enhance the trade-decision making mechanism. Topics explore high-frequency finance, markets and data, time series, microscopic operators, and micro-patterns. Methodologies include, but not limited to, Bayesian classifiers, weak classifiers, boosting and general metaalgorithmic emerging methods of machine learning applied to trading strategies. Back-testing and assessment of model risk are explored. Prerequisites: FE 545

FE 680 Advanced Derivatives

This course deals with fixed-income securities and interest-rate sensitive instruments. Topics include term structure of interest rates, treasury securities, strips, swaps, swaptions, one-factor, two-factor interest rate models, Heath-Jarrow-Merton (HJM) models and credit derivatives: credit default swaps (CDS), collateralized debt obligations (CDOs), and Mortgagebacked securities (MGS).

FE 699 Project in Financial Engineering

A student is given a particular problem in financial engineering to be completed in one semester. The nature of the problem may be computational or theoretical depending on the student's track. It is encouraged that the problems be related and, in some instances, posed by the financial engineering industry.

FE 700 Master's Thesis in Financial Engineering

This is the thesis option equivalent to one elective and FE 699. The thesis option requires the approval of the advisor and is recommended only for full-time students. The student will produce a Master's thesis in financial engineering.

FE 710 Applied Stochastic Differential Equations

Topics include Ito calculus review, linear stochastic differential equations (SDE's), examples of solvable SDE's, weak and strong solutions, existence and uniqueness of strong solutions, Ito-Taylor expansions, SDE for Markov processes with jumps, Levy processes, forward and backward equtions and the Feynman-Kac representation formula, and introduction to stochastic control. Applications are mostly from fianncial engineering but applications in areas such as population dynamics, energy, climatology and seismology may also be presented. Prerequisites: FE 610, MA 611, MA 623

FE 720 The Volatility Surface: Risk and Models

In this course students will understand the implied volatility, and the empirical static and dynamic behavior of the volatility surface formed using option prices for all strikes and expirations. The students will also examine the volatility risk, stochastic volatility and local volatility models, numerical methods for volatility surface calibration, Monte Carlo simulation of stochastic volatility models, and pricing options through fast Fourier transform. Topics include: the Black-Scholes implied volatility, empirical statics and dynamics of the volatility surface, volatility risk premium, stochastic volatility models (Heston, Hull-White, Stein-Stein, SABR, Bates, Scott, etc), Dupire's local volatility model, Heston-Nandi GARCH model, arbitrage-free properties of the volatility surface, volatility surface parametrization and calibration, simulation of the Heston model, stochastic volatility model with jumps, option pricing based on fast Fourier transforms, and volatility derivatives (Variance swap, CBOE VIX futures and options, etc). Other advanced current research topics will be introduced as well. The students are required to have a solid working knowledge of stochastic calculus, and FE610 is a pre-requisite for this course. The course uses statistical softwares such as Matlab or R throughout. A companion one credit of a relevant lab course is recommended if this knowledge is not acquired before. Prerequisites: FE 610

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FE 900 Master's Thesis in Financial Engineering

For the degree of Master of Science (Financial Engineering). A minimum of six credit hours is required for the thesis. Hours and credits to be arranged.

Systems Design and Operational Effectiveness

SDOE 681 Dynamic Modeling of Systems and Enterprises

The course introduces students to system dynamics models of business policy analysis and forecasting of associated management problems of complex systems and enterprise. The course covers advanced techniques of policy and strategy development applications: system thinking and modeling dynamics of growth and stability, including interaction of human factors with the technology. The tools of increasing power and complexity are offered for student's business and management applications: causal feedback diagrams, technology process graphs, information processing flowcharts, decision scenarios. Students will get hands-on training in systems modeling by STELLA and AnyLogic software languages and perform their own case studies of real system of technology and/or business development. Prerequisite: Course in statistics.

Systems Engineering Security

SES 543 Fundamentals of IS Audit and Controls

Information systems contain a variety of risks and organizations establish control mechanisms to mitigate the risks. This course focuses on how information systems controls can be designed, monitored, and tested. Control standards will be examined as well as industry-specific regulations that require information systems auditing. Students will learn how their organizations measure, mitigate, and monitor risks related to the information systems they rely on.

SES 544 Information Systems Audit and Control Practices (3 - 3 - 0)

The management of risks in information systems (IS) requires robust Enterprise Risk Management programs and practices to protect critical business processes and ensure continuous operation and service delivery. This course focuses on how information systems managers establish comprehensive IS controls architectures that manage enterprise risks in systems development, acquisition, service management, resiliency, information asset protection, regulatory compliance, and technical architecture. Enterprise audit and control programs will be analyzed. Students will learn how the management of their organizations manage the risks in their business information systems. Prerequisites: SES 543

SES 546 Information Security Management

This course focuses on the analysis and management of information security architectures. Information security architectures consist of organizational, process, and technology (e.g., data, applications, network, systems) domains. The integration and effective management of such architectures is essential to effectively responding to technical risk dynamics. The course will focus on evaluating the architectural domains and their integration. The course will rely on management research on information security, risk, IT strategic planning, and distributed computing. The student will learn the relationships between business requirements, technical requirements and technical risk, and make appropriate choices for risk mitigation. The course will provide insights on the continuous management of the information security function in organizations.

Three credits for the degree of Master of Science (Financial Engineering). This course is typically conducted as a one-on-one course between a faculty member and a student. A student may take up to two special problems courses in a master's degree program. A department technical report is required as the final product for this course. Prerequisite: consent of instructor.

FE 810 Selected Topics in Financial Engineering

Selected topics from various areas within Financial Engineering. This course is typically taught to more than one student and often takes the form of a visiting professor's course. Prerequisite: consent of instructor.

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SES 548 **Risk Analysis and Economics of Security**

This course provides a working knowledge of risk analysis and management for enterprise security. The emphasis is on modeling, analysis and economic evaluation of technology risks. The students learn about business continuity and disaster recovery planning, security risks, tangible and intangible consequences of security failures, risk mitigation options and economic trade offs. The first part of the course covers the basics of risk identification, assessment, control and mitigation using a system framework. The second part covers application of decision theory and engineering economics to security options based on models that consider risk profile and uncertainty in enterprise security problems. The learning is reinforced through case reviews and team projects.

SES 602 Secure Systems Foundations

SES 602 encompasses all aspects of systemic security issues. Systemic security components include infrastructure as well as information attributes, disruption profiles, identity management, security information management, and recovery alternatives. The course also addresses human and workforce components of security such as governance processes, technology management, and enterprise systems operations. SES 602 provides a solid background in systemic methods, tools, and procedures for value preservation in an environment of changing threats. It covers all concepts important in evaluating enterprise security design alternatives.

SES 603 Secure Systems Laboratory

SES 603 extends the Secure Systems Foundations course, SES 602 by providing a hands-on environment to explore the concepts learned in SES 602. It includes exposure the methods, processes and tools that are commonly used to implement security features as well as those used by attackers to breach system security. Students will be divided into teams which alternately assume role and responsibilities of enterprise management, enterprise administration, enterprise operations, and enterprise adversary. Challenging lab scenarios will provide students with experience in executing the responsibilities associated with each role. Prerequisites: SES 602

(3 - 3 - 0)**SES 622** Fundamentals of Security Systems Engineering

Presents principles and processes for designing secure systems, including how to approach stakeholder needs analysis, to distinguish between needs and solutions, and to translate security requirements into design specifications. Students will learn how the fundamental organization of a system contributes to or detracts from the engineer's ability to provide secure design, and to recognize how security-related components compose a system of interest within any system. The course will provide an understanding of the difference between functional and nonfunctional requirements for security features as well as an understanding of how security requirements may be derived from unintended inputs and undesired outputs. Crosslisted with: SES 623 Prerequisites: SES 602, SES 603

SES 623 Systems Security Architecture and Design

This course enhances the systems security knowledge base introduced in SES 622 with project experience in security design and architecture. It covers systems security considerations in functional analysis, decomposition, and requirements processes, and teaches practical heuristics for developing secure architectures. It demonstrates how to incorporate threat and vulnerability analysis into the architecture and design process. The students execute multiple phases of a project wherein a system security strategy is proposed, designed, architected, and supplemented with operational guidelines. Prerequisites: SES 622

Software Engineering

SSW 215 Individual Software Engineering

In this course students learn to practice a disciplined engineering process for developing software. Individual skills and practices, such as effort estimation and unit testing, are mastered so that students can become successful members of software engineering teams. Best practices in software engineering are followed, including the use of simple design patterns with well-known properties. Students work in small teams to construct a simple web service using the industry standard Ruby programming language, Rails framework and MySQL database technology. Prerequisites: E 115

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SSW 533 Cost Estimation and Metrics

The course deals with the management of software projects using objective metrics that help developers and managers to understand the scope of the work to be accomplished, the risks that will occur, the tasks to be performed, the resources and effort to be expended, and the schedule to be observed. It provides the student with a thorough introduction to facility with, and understanding of such industry-standard software sizing metrics as Function, Feature, and Object Points and their relationship to the lines-of-code metric. It provides the student with a thorough introduction to and understanding of such industry-standard software estimation tools such as COCOMO II used in cost estimation. Cross-listed with: CS 533

SSW 540 Fundamentals of Software Engineering

This course introduces the subject of software engineering, also known as software development process or software development best practice from a quantitative, i.e., analytic- and metrics-based point of view. Topics include introductions to: software life-cycle process models from the heaviest weight, used on very large projects, to the lightest weight, e.g., extreme programming; industry-standard software engineering tools; teamwork; project planning and management; object-oriented analysis and design. The course is case history and project oriented.

SSW 541 Fundamentals of Software Engineering for Non-software Engineers (3 - 3 - 0)

This course teaches the fundamentals of software and software engineering for those who need to understand how software systems are developed, but are not expected to have direct responsibility for software development themselves.

SSW 555 Agile Methods for Software Development

In software problem areas that require exploratory development efforts, those with complex requirements and high levels of change, agile software development practices are highly effective when deployed in a collaborative, people-centered organizational culture. This course examines agile methods, including Extreme Programming (XP), Scrum, Lean, Crystal, Dynamic Systems Development Method and Feature-Driven Development to understand how rapid realization of software occurs most effectively. The ability of agile development teams to rapidly develop high quality, customer-valued software is examined and contrasted with teams following more traditional methodologies that emphasize planning and documentation. Students will learn agile development principles and techniques covering the entire software development process from problem conception through development, testing and deployment, and will be able to effectively participate in and manage agile software developments as a result of their successfully completing this course. Case studies and software development projects are used throughout. Cross-listed with: CS 555

SSW 556 Software Development for Trusted Systems (3 - 3 - 0)

Software systems need to be free from security vulnerabilities, such as buffer overflow and stack smashing. Unfortunately, avoiding these weaknesses when programming in popular languages like C and C++ requires special discipline and attention to details not often stressed in introductory courses. This course teaches students to recognize security weaknesses and other vulnerabilities in existing software and to use techniques that avoid those vulnerabilities when developing new software. They practice using secure coding standards and disciplined development methods on industrial case studies and a course project. Prerequisite: Programming experience in C or C++, or permission of the instructor.

SSW 564 Software Requirements Analysis and Engineering

Requirements Acquisition is one of the least understood and hardest phases in the development of software products, especially because requirements are often unclear in the minds of many or most stakeholders. This course deals with the identification of stakeholders, the elicitation and verification of requirements from them, and translation into detailed requirements for a new or to-be-extended software product. It deals further with the analysis and modeling of requirements, the first steps in the direction of software design. The quality assurance aspects of the software requirements phase of the software development process is studied. Also an introduction to several formal methods for requirements specification is presented. Prerequisites: CS 551, SSW 540

SSW 565 Software Architecture and Component-Based Design (3 - 0 - 0)

This course introduces students to the software design process and it's models; representations of design/architecture; software architectures and design plans; design methods; design state assessment; design quality assurance; and design verification.

SSW 567 Software Testing, Quality Assurance, and Maintenance

This course introduces students to systematic testing of software systems, software verification, symbolic execution, software debugging, quality assurance, measurement and prediction of software reliability, project management, software maintenance, software reuse and reverse engineering.

SSW 687 Engineering of Large Software Systems

Students will learn how to deal with issues impacting industrial software developments. A broad range of topics will be covered, emphasizing large project issues. Large software projects are those employing 50 or more software developers for three years or more. Throughout the course, emphasis will be placed on quantitative evaluation of alternatives. Specific examples and case histories from real projects in the telephone industry are provided. Students will learn how to create architectures for large systems based on the '4+1' model; how to use modern software connector technology; module decomposition; scaling of agile methods to large projects, the use of work flows to drive software process and database designs, test plans, and implementation; and configuration control and software manufacturing. The special issues of database conversion data consistency, database maintenance, and performance tuning will be addressed for large data bases. The physical environment of the computer systems, including multisite deployment, software releases, and special management report generation, are examined. Prerequisites: SSW 540

SSW 689 Engineering of Trusted Software Systems

Trusted systems are dependable, safe, and secure. None of this happens by accident – it all must be engineered in. The course goes beyond the traditional software engineering, quality and development courses to focus on the theory and practical techniques required to create trusted systems. The course covers software reliability engineering, software security engineering, control systems concepts, hazard analysis and management, trusted architecture patterns, and software fault and failure tolerance and management. Specific techniques such as analysis of attack patterns, degraded operation, simplex architectures and rejuvenations, are studied in depth to understand their usefulness and contribution to an overall trusted system solution. Case studies (e.g. Mars Rover) and team projects (e.g. analyzing and reengineering a system to be trustworthy) are used throughout. Prerequisites: SSW 533

SSW 810 Selected Topics in Systems Centric Software Engineering (3 - 3 - 0)

Selected topics from various areas within Software Engineering. This course is typically taught to more than one student and often takes the form of a visiting professor's course. Prerequisite: consent of instructor. Prerequisites: Consent of instructor

Systems Engineering

SYS 501 Probability and Statistics for Systems Engineering

This course is designed for students with a background in engineering, technology, or science that have not taken a class in statistics or need a refresher class. In this class we will apply probability and statistics throughout a system's life cycle. Topics include the roles of probability and statistics in Systems Engineering, the nature of uncertainty, axioms and properties of probability models and statistics, hypothesis testing, design of experiments, basic performance requirements, quality assurance specification, functional decomposition, technical performance measurements, statistical verification, and simulation.

SYS 581 Introduction to Systems Engineering

The growing complexity of today's engineered systems presents daunting challenges to those who are charged with creating, operating, enhancing and sustaining them throughout their lifecycles. While the components of these systems require no less design effort than in the past, attention to the components is not sufficient to ensure overall system success. This course focuses on the interactions between the elements of a complex system, the context within which they are designed and operate, and the relationships between the technical systems and the organizations that design them and the enterprises that they serve. Students develop the understanding of techniques and processes that can help them ensure that their individual contributions are not only excellent in themselves, but that they become part of a cohesive, successful whole. This course may not be applied toward a Master's of Engineering in Systems Engineering or Engineering Management.

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Design of Experiments and Optimization

This course is an application oriented with theoretical arguments approached from an intuitive level rather than from a rigorous mathematical approach. This course teaches the student how statistical analyses are performed while assuring the student an understanding of the basic mathematical concepts. The course will focus on "real world" uses of statistical analysis and reliability theory. The student will use the software to solve problems. Included in this course will demonstrate Markov modeling techniques. This course is a perquisite to the System Reliability and Life Cycle Analysis course.

SYS 605 Systems Integration

SYS 595

This course will explore and discuss issues related to the integration and testing of complex systems. First and foremost, students will be exposed to issues relating to the formulation of system operational assessment and concept. Subsequently, functional modeling and analysis methods will be used to represent the system functionality and capability, leading to the packaging of these functions and capabilities into high-level system architecture. Specific focus will be given to issues of interface management and testability. The course will also address the related management issues pertaining to integrated product teams, vendors and suppliers, and subcontractors. In addition, selected articles will be researched to demonstrate the techniques explored in class.

SYS 611 Simulation and Modeling

This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement, and use computers to solve complex systems/products analysis problems. The key emphasis is on problem formulation, model building, data analysis, solution techniques, and evaluation of alternative designs/ processes in complex systems/products. Overview of modeling techniques and methods used in decision analysis, including Monte Carlo and discrete event simulation is presented.

SYS 625 Fundamentals of Systems Engineering

This course discusses fundamentals of systems engineering. Initial focus is on need identification and problems definition. Thereafter, synthesis, analysis, and evaluation activities during conceptual and preliminary system design phases are discussed and articulated through examples and case studies. Emphasis is placed on enhancing the effectiveness and efficiency of deployed systems while concurrently reducing their operation and support costs. Accordingly, course participants are introduced to methods that influence system design and architecture from a long-term operation and support perspective.

SYS 630 DAU Level I Certification Examinationion

This will test the knowledge of students who have achieved the equivalent of Level I certification through the Defense Acquisition University or who have completed selected industry training programs. Typically students take 80 hours training for this certification level equivalent. Upon successful completion (graded pass/fail), students will be awarded 3 credits toward a Master of Engineering in Systems Engineering.

SYS 631 Level II Certification Examination

This will test the knowledge of students who have achieved the equivalent of Level II certification through the Defense Acquisition University or who have completed selected industry training programs. Typically students take more than 160 hours training for this certification level equivalent. Upon successful completion (graded pass/fail), students will be awarded between 3 and 6 credits toward a Master of Engineering in Systems Engineering.

SYS 632Designing Space Missions and Systems (Module version is SDOE 632)(3 - 0 - 0)

This course examines the real-world application of the entire space systems engineering discipline. Taking a processoriented approach, the course starts with basic mission objectives and examines the principles and practical methods for mission design and operations in depth. Interactive discussions focus on initial requirements definition, operations concept development, architecture tradeoffs, payload design, bus sizing, subsystem definition, system manufacturing, verification and operations. This is a hands-on course with a focus on robotic missions for science, military and commercial applications.

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SYS 635 Human Spaceflight

This course provides the conceptual framework for developing space missions of human spacecraft starting from a blank sheet of paper. It describes and teaches the human space mission design and analysis process. The entire course is process oriented to equip each participant with practical tools to complete a conceptual design and analyze the impacts of evolving requirements. At the end of this course you will be better able to tie mission elements together and perform tradeoffs between system design and mission operations that must occur, during the early stages of planning, in order to deliver cost-effective results. Cross-listed with: SDOE 635

SYS 636 Space Launch and Transportation Systems

This course provides an integrated view of space launch and transportation systems (SLaTS) design and operations. It analyzes customer needs, objectives and requirements, through launch and transportation system design, development, test and manufacturing to creating operations concepts and infrastructure capabilities. Lifecycle cost and the business case will be assessed. The thrust of this course is to identify technical risk and mitigate it in the most cost-effective manner, while maintaining the technical integrity of the vehicle(s) and infrastructure. In the course you will take a fresh look at space launch and transportation systems by emphasizing a process-oriented approach for creating cost-effective concepts to meet customer needs and objectives. This process describes how to translate SLaTS objectives, requirements, and constraints into viable and cost-effective operations concepts. Vehicle design presentations show practical, detailed approaches and tools to analyze and design manned and unmanned, reusable and expendable vehicles for both launch and interplanetary systems, including architecture and configuration, payloads, and vehicle subsystems. Course presentations on launch operations describe the functions to be performed, define and evaluate the key issues, help you develop an appropriate operations concept, and assess the complexity and cost of operations. Special emphasis is placed on describing the interrelationships and tradeoffs between system design and launch operations that must occur during the early stages of planning in order to deliver effective systems.

SYS 637 **Cost-Effective Space Mission Operations**

This course examines the real-world space mission operations. Taking a process-oriented approach, the course provides an in-depth view of the entirety of space mission operations, including the concept of operations and all functions that are performed in support of a space mission. Interactive discussions focus on initial requirements definition, operations concept development, functional allocation among spacecraft, payload, ground system and operators. A detailed model is provided that allows the user to estimate operations complexity and then prepare an estimate of the number of operators required and overall cost. This is a hands-on course with a focus on space missions for science, military and commercial applications.

SYS 638 Crew Exploration Vehicle Design

This unique course gives participants a hands-on opportunity to apply key principles of space systems engineering. Participants are given a set of customer expectations in the form of broad mission objectives for a crew exploration vehicle with the task of applying systems engineering process to define top-level system requirements and design key elements of the system. The end result will be a system design review during which students present and defend their design decisions. Prerequisites: SYS 635, SDOE 635, SYS 632, SDOE 632

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This unique course gives students a hands-on opportunity to apply key principles of space systems engineering. In part 1 of the course, students are given a set of customer expectations in the form of broad mission objectives. Using state-ofthe-industry mission design and analysis tools (provided), the task is to apply systems engineering process to define toplevel system requirements and design key elements of the system. The end result will be a system design review during which students present and defend their design decisions. In part 2 of the course, students experience system realization processes first-hand by integrating, verifying, validating and delivering the shoe box-sized EyasSAT educational satellite. Lecture is combined with hands-on experience. From the part-level to the system level, students will implement a rigorous assembly, integration, verification and validation plan on real hardware and software applying "test like you fly, fly like you

SYS 633 Mission and System Design Verification and Validation

SCHOOL OF SYSTEMS AND ENTERPRISES

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SYS 640 System Supportability and Logistics

The supportability of a system can be defined as the ability of the system to be supported in a cost effective and timely manner, with a minimum of logistics support resources. The required resources might include test and support equipment, trained maintenance personnel, spare and repair parts, technical documentation and special facilities. For large complex systems, supportability considerations may be significant and often have a major impact upon life-cycle cost. It is therefore particularly important that these considerations be included early during the system design trade studies and design decision-making.

SYS 645 Design for System Reliability, Maintainability, and Supportability (3 - 0 - 0)

This course provides the participant with the tools and techniques that can be used early in the design phase to effectively influence a design from the perspective of system reliability, maintainability, and supportability. Students will be introduced to various requirements definition and analysis tools and techniques to include quality function deployment, input-output matrices, and parameter taxonomies. An overview of the system functional analysis and system architecture development heuristics will be provided.

SYS 650 System Architecture and Design

This course discusses the fundamentals of system architecting and the architecting process, along with practical heuristics. Furthermore, the course has a strong "how-to" orientation, and numerous case studies are used to convey and discuss good architectural concepts as well as lessons learned. Adaptation of the architectural process to ensure effective application of COTS will also be discussed. In this regard, the course participants will be introduced to an architectural assessment and evaluation model. Linkages between early architectural decisions, driven by customer requirements and concept of operations, and the system operational and support costs are highlighted. Prerequisites: SYS 625

SYS 655 **Robust Engineering Design**

This course is designed to enable engineers, scientists, and analysts from all disciplines to recognize potential benefits resulting from the application of robust engineering design methods within a systems engineering context. By focusing on links between sub-system requirements and hardware/software product development, robust engineering design methods can be used to improve product quality and systems architecting. Topics such as Design and Development Process and Methodology, Need Analysis and Requirements Definition, Quality Engineering, Taguchi Methods, Design of Experiments, Introduction to Response Surface Methods, and Statistical Analysis of Data will be presented.

SYS 660 Decision and Risk Analysis

This course is a study of analytic techniques for rational decision-making that addresses uncertainty, conflicting objectives, and risk attitudes. This course covers modeling uncertainty; rational decision-making principles; representing decision problems with value trees, decision trees and influence diagrams; solving value hierarchies; defining and calculating the value of information; incorporating risk attitudes into the analysis; and conducting sensitivity analyses.

SYS 667 Complex System Technologies and Application Domains

This course serves as an overview of phenomenology and technologies associated with the development, design, construction, and life cycle management of network centric systems and systems of systems. The goal of this class is to provide the early career engineers and scientists who have been educated in a traditional academic disciplines, visibility into the interdisciplinary methods, processes, terminology, and tools needed to integrate these technologies into an operationally and cost effective adaptive network centric systems of systems.

Forecasting and Demand Modeling Systems SYS 670

This course covers the theory and application of modeling aggregate demand, fragmented demand and consumer behavior using statistical methods for analysis and forecasting for facilities, services and products. It also aims to provide students with both the conceptual basis and tools necessary to conduct market segmentation studies, defining and identifying criteria for effective segmentation, along with techniques for simultaneous profiling of segments and models for dynamic segmentation. All of this provides a window on the external environment, thereby contributing input and context to product, process and systems design decisions and their ongoing management.

SYS 671 Conception of CPS: Deciding What to Build and Why

The first course focuses on the conceptual design portion of the lifecycle of Cyber-Physical systems. Critical elements include the ideas of systems and design thinking, and elegant design. An Ideation process, as pioneered by the likes of IDEA and other prominent design firms is used to spark the creative process. The opportunity is conceived and defined using Kano Maps, marketing segmentation and conjoint analysis techniques. A QFD process is used to collect, organize and analyze customer needs, and transform these into product specifications. Concepts are generated, selected and tested. Finally, these concepts are specified using concept of operation, conceptual design and using case scenarios and technical requires. A workshop on Model-Based Systems Engineering (MBSE), particularly, SysML is used as a means for specification and also to provide a foundation for future modeling work. Lectures are interspersed with individual and group project based activities. the students go through a design review process in preparation for their final report.

SYS 672Desing of CPS: Ensuring Systems Work and Are Robust(3 - 3 - 0)

Ensuring systems work and are robust educates students on the transition from cyber-physical system concept and preliminary requirements to detailed architecture and design based on prioritized, allocated and traceable architecturally significant requirements. Students will create models of system structure and activities, make appropriate technology selections, and perform analyses for reliability, performance, safety and security. Trade space analyses will be performed.

SYS 673Implementation of CPS: Bringing Solutions to Life(3 - 3 - 0)

This third course focuses on the continuous implementation, integration, testing, analysis, and verification and validation of cyber systems (CPS). This course builds on Course 2 using a metaphor where the students plan on a successful product launch, using our project to work through continuous integration and test and ultimately bringing a robust solution to life in the form of a working CPS system. We intersperse lectures with individual and group project based activities to ensure that the developed system is functional and robust. We discuss and use the most effective techniques for fault and failure tolerance, analysis, and testing method and principles. We plan to capitalize on simulation and physical systems resources for continuous and automated testing and discuss the balance of testing versus analysis. The students will continuously collect evidence of quality, performance measures and traceability information.

SYS 674 Sustainment of CPS: Managing Evolution

This course focuses on managing the evolution of a cyber-physical system after its initial release to the market until its retirement. The course approaches this topic on three levels. The foundation is to put in place policies, processes and infrastructure to support, maintain and respond to quality issues for released instances of the system. The second level is to drive the evolution of the system's capabilities and characteristics based on evolving needs and enabling technologies. The third level is to proactively "disrupt" the market by reframing the opportunity and reinventing they system based on internal innovation, or responding to external disruptions in the marketplace or the technology space. Prerequisites: SYS 671, and SYS 672, and SYS 673

SYS 675 Dynamic Pricing Systems

Dynamic pricing is defined as the buying and selling of goods and services in free markets where the prices fluctuate in response to supply and demand and changing. This course illustrates the difference between static and dynamic pricing, and covers various dynamic pricing models and methodologies for successful pricing. This course also illustrates the fact that effective pricing optimization is based on modeling of demand and elasticity of demand at a very granular level. It will explore various dynamic pricing models and explore and identify factors relevant in choosing dynamic pricing models that best support the operational effectiveness, external environment and business strategy of a particular firm.

SYS 681 Dynamic Modeling of Systems and Enterprise

The course introduces students to fundamentals of system dynamics modeling of complex systems and enterprises. System Dynamics is a modeling approach that has been developed at MIT in the 1960s. System dynamics is used for variety of applications ranging from supply chain management, decision analysis, innovation diffusion and management and other management as well as engineering applications of complex systems. This course we will cover the basic fundamentals of systems dynamics and enable students to learn and build system dynamic models including causal links and loop diagrams, stock and flows with application to modeling contagion in systems, innovation diffusion, delays in complex systems and many more examples and applications.

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SYS 703 Curricular Practical Training

International graduate students may arrange an educationally relevant internship or paying position off campus and receive Curricular Practical Training (CPT) credit via this course. Students must maintain their full time status while receiving CPT. Prior approval of the program director is required for enrollment. To justify enrollment, the student must have a concrete commitment from a specific employer for a specific project, and must provide to the program director for his/her approval a description of the program director with sufficient advance notice so that the program director has time to review the materials and determine if the project is appropriate. The project must be educationally relevant; i.e., it must help the student develop skills consistent with the goals of the educational program. During the semester, the student must submit written progress reports. At the end of the semester, the student must submit for grading a written report that describes his/her activities during that semester, even if the activity remains ongoing. The student must also present his/her activities in an accompanying oral presentation that is also graded. This is a one-credit course that may be repeated up to a total of three credits.

SYS 710 Research Methodologies

Research philosophy, ethics, and methodology will be discussed. Each student will, under the guidance of the instructor, formulate a problem, search the literature, and develop a research design. In addition, the student will examine and criticize research reports with specialemphasis on the statement of the problem, the sampling and measuring techniques that are used, and theanalyses and interpretation of the data. Emphasis is on applying research methodology to real-world organizational problems.

SYS 725 Advances in System of Systems Engineering

The discipline of Systems Engineering (SE) provides us with necessary engineering and management guidance to successfully design and develop a system rather than focus on its separate individual components. However, due to the rapidly increasing complexity of today's dynamic environment, we are faced with the need to engineer multiple integrated complex systems. In response to this emerging paradigm shift, a new discipline of System of Systems Engineering (SoSE) has evolved. This course serves as an overview of the advances in SoSE and provides the students the capability to apply this knowledge in the synthesis, analysis, and evaluation of activities during the lifecycle of a System of Systems (SoS) through case study analysis. Prerequisites: SYS 625

SYS 744Advanced Data Analysis for Data Mining and Knowledge Discovery(3 - 0 - 0)

This data driven course focuses on the subjects of both traditional and modern data analysis and mining techniques. The course emphasizes the analysis of business and engineering data using a combination of theoretical techniques and commercially available software to solve problems. Topics such as data analysis and presentation, linear and nonlinear regression, analysis of variance, factor analysis, cluster analysis, neural networks, and classification trees will be presented. The course will make extensive use of the Splus software packages. However, students will be encouraged to use a wide variety of industry standard data analysis and mining tools including SPSS, SAS, MATLAB, and BrainMaker.

SYS 750Advanced System and Software Architecture Modeling and Assessment(3 - 3 - 0)

This course presents the fundamentals of complex systems architecting using the Object Modeling Group's (OMG) SysML. It addresses the differences between functional decomposition and object oriented decomposition while architecting complex systems. Emphasis is placed on modeling mission objectives to the definition of the system level architecture. Topics include identification of system level architecture alternatives and considerations, including definition of objectives for physical (hardware) and logical (software) structure, information and system assurance, behavior, cost, performance and human integration based on the system concept at every level of system decomposition. System of System (SoS) architecture is examined, addressing composition of multiple systems and engineering new, emergent behavior in the SoS. Examples used will come from a variety of operational environments (e.g. communications systems, space systems, weapon systems, etc) Special consideration is given to the importance of effective construction and transitioning of the SysML models to software engineering for software intensive systems projects. Prerequisites: SYS 625, and SYS 650

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SYS 760 Advanced Decision and Risk Analysis

This course is the advanced study of analytic techniques for rational decision making that addresses uncertainty, conflicting objectives, and risk attitudes. This course covers advanced techniques for modeling uncertainty; values and risk preference. The advanced techniques for modeling uncertainty include Bayesian networks and the various approaches for both representing joint probability distributions and computing posterior distributions given new evidence. The techniques for modeling preferences address various degrees of preferential dependence among objectives. Finally, the risk preference techniques address non-exponential risk preference and the associated computation of value of information. These techniques are valuable as part of the risk management process, conduct of systems engineering trade-offs, and managing systems engineering projects Prerequisites: SYS 660

SYS 800Special Problems in Systems Engineering (ME)(3 - -)

Three credits for the degree of Master of Engineering (Systems Engineering). This course is typically conducted as a one-onone course between a faculty member and a student. A student may take up to two special problems courses in a master's degree program. A department technical report is required as the final product for this course.

SYS 801 Special Problems in Systems Engineering (PhD)

Three credits for the degree of Doctor of Philosophy. This course is typically conducted as a one-on-one one investigation of a topic of particular interest between a faculty member and a student and is often used to explore topical areas that can serve as a dissertation. A student may take up to two special problems courses in a Ph.D. degree program. A department technical report is required as the final product for this course. Students enrolled in the SDOE program should enroll in course number SDOE 801.

SYS 810Selected Topics in Systems Engineering(3 - 3 - 0)

Selected topics from various areas within Systems Engineering. This course is typically taught to more than one student and often takes the form of a visiting professor's course. Prerequisite: consent of instructor. Prerequisites: Consent of instructor

SYS 900 Thesis in Systems Engineering (ME)

A minimum of six credit hours is required for the thesis. Hours and credits to be arranged. Students enrolled in the SDOE program should enroll in course number SDOE 900.

SYS 960 Research in System Engineering (PhD)

Original work, which may serve as the basis for the dissertation, required for the degree of Doctor of Philosophy. A minimum of 30 hours of SYS 960 research is required for the Ph.D. degree. Students enrolled in the SDOE program should enroll in course number SDOE 960. Hours and credits to be arranged.

Engineering Management

TG 401 Entrepreneurship and Business for Engineers and Scientists (3 - 3 - 0)

Aspects of entrepreneurship and business most relevant for technical people and the practice of Technogenesis. Investigates business-related considerations in successfully commercializing new technology. Exposes technologists to five critical aspects of creating a successful new venture and/or a successful product or service business within a existing enterprise : (1) market and customer analysis, (2) beating the competition, (3) planning and managing for profitability, (4) high-tech marketing and sales, and (5) business partnerships and acquisitions. Students should take this course if they: (1) desire to maximize their effectiveness as technologists by understanding the business and customer considerations that impact the work of technologist, (2) intend to lead or participate in a technology based new venture/start-up, or (3) contemplate an eventual transition from a technical to a business management career. It is intended for either advanced undergraduate (junior or senior) or graduate students in engineering or science curricula.

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TG 403 Senior Innovation I

This course supports the senior design students in varying engineering disciplines to develop business ideas for their projects and to successfully convey their ideas to potential investors and other stakeholders. It is a practical course where students will develop the basic documentation and skills necessary to understand, manage, communicate and present their project from a business perspective. Early on the emphasis will be on the management of the project and the revision of the design based on prospective users/stakeholers feedback. Students will be asked to identify and assess the business potential of the technology/ technical solution/system that the students are developing in their senior design. Students will learn how to assess this potential among several, non-technical dimensions, inlcuding the identification and analysis of the target market, the assessment of the competition, and the economic feasibility and financial prospects of a new venture created around the product or technology that is being developed in the senior design. To culminate their understanding of the challenges of startup processes, the students will develop overview Executive Summaries and be able to describe their project from a business perspective, not just the technical perspective, as well as, present a project/elevator pitch and compete at the Pitch Competition.

TG 404 Senior Innovation II

This course supports the senior design students in varying engineering disciplines to develop business ideas for their projects and to successfully convey their ideas to potential investors and other stakeholders. It is a practical course where students will develop the basic documentation and skills necessary to understand, manage, communicate and present their project from a business perspective. Early on the emphasis will be on the management of the project and the revision of the design based on prospective users/stakeholers feedback. Students will be asked to identify and assess the business potential of the technology/technical solution/system that the students are developing in their senior design. Students will learn how to assess this potential among several, non-technical dimensions, inlcuding the identification and analysis of the target market, the assessment of the competition, and the economic feasibility and financial prospects of a new venture created around the product or technology that is being developed in the senior design. To culminate their understanding of the challenges of startup processes, the students will develop overview Executive Summaries and be able to describe their project from a business perspective, not just the technical perspective, as well as, present a project/elevator pitch and compete at the Pitch Competition. Prerequisites: TG 403

TG 421Entrepreneurial Analysis of Engineering Design(3 - 3 - 0)

This course provides students with tools needed to commercialize their senior design technology. Topics include engineering economic analysis and issues of marketing, venture capital, intellectual property and project management. These topics are from the view of an entrepreneur who is creating knowledge that can be licensed and/or used in a start-up business. These topics are critical elements in implementing Technogenesis. Cross-listed with: E 421 Prerequisites: E 321, E 355 Corequisites: E 423, E 424

TG 501Entrepreneurship and Business for Engineers and Scientists(3 - 3 - 0)

Aspects of entrepreneurship and business most relevant for technical people and the practice of Technogenesis. Investigates business-related considerations in successfully commercializing new technology. Exposes technologists to five critical aspects of creating a successful new venture and/or a successful product or service business within an existing enterprise: (1) market and customer analysis, (2) beating the competition, (3) planning and managing for profitability, (4) high-tech marketing and sales, and (5) business partnerships and acquisitions. Students should take this course if they: (1) desire to maximize their effectiveness as technologists by understanding the business and customer considerations that impact the work of technologists, (2) intend to lead or participate in a technology-based new venture/start-up, or (3) contemplate an eventual transition from a technical to a business management career. It is intended for either advanced undergraduate (junior or senior) or graduate students in engineering or science curricula.

TG 810 Special Topics in Technogenesis

A participating seminar on topics of current interest and importance in Technogenesis.

SCHOOL OF BUSINESS

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SCHOOL OF BUSINESS

FACULTY

Richard Anderson, Ph.D. Affiliate Assistant Professor

Zvi Aronson, Ph.D. Affiliate Associate Professor

Christopher Asakiewicz, Ph.D. Industry Associate Professor & Director Business Intelligence & Analytics Program

Suman Banerjee, Ph.D. Associate Professor

David Belanger, Ph.D. Senior Research Fellow

Tal Ben-Zvi, Ph.D. Associate Professor

Stefano Bonini, Ph.D. Assistant Professor

George Calhoun, Ph.D. Distinguished Service Professor

Yan Chen, Ph.D. Assistant Professor

Ricardo Collado, Ph.D. Assistant Professor

German Creamer, CFA, Ph.D. Associate Professor

Mahmoud Daneshmand, Ph.D. Industry Professor

Peter Dominick, Ph.D. Industry Associate Professor

Edward Friedman, Ph.D. Emeritus Professor

Lawrence Gastwirt, Ph.D. Director Hamed Ghoddusi, Ph.D. Assistant Professor

Trish Gorman, Ph.D. Director, Stevens Alliance for Innovation & Leadership

Eleni Gousgounis, Ph.D. Assistant Professor

William Guth, Ph.D. Scholar in Residence

Elaine Henry, Ph.D. Associate Professor

Patricia Holahan, Ph.D. Associate Professor

Nan Hu, Ph.D. Associate Professor

Jonathan Kaufman, Ph.D. Affiliate Associate Professor of Quantitative Finance & Financial Engineering

C. Timothy Koeller, Ph.D. Professor

Peter Koen, Ph.D. Associate Professor

Theodoros Lappas, Ph.D. Assistant Professor

Thomas Lechler, Ph.D. Associate Professor; Director of PhD Program

Chihoon Lee, Ph.D. Associate Professor

Aron Lindberg, Ph.D. Assistant Professor

Fang-Chun Liu, Ph.D. Assistant Professor

SCHOOL OF BUSINESS

Donald Lombardi, Ph.D. Industry Associate Professor

Gary Lynn, Ph.D. Associate Professor

Adriana Madzharov, Ph.D. Assistant Professor

Feng Mai, Ph.D. Assistant Professor

Alan Maltz, Ph.D. Executive-in-Residence

Murad Mithani, Ph.D. Assistant Professor

Joseph Morabito, Ph.D. Associate Graduate Professor

Ann Murphy, Ph.D. Associate Dean for the Undergraduate Enterprise; Associate Professor

Jeffrey Nickerson, Ph.D. Professor and Director of the Center for Decision Technologies

Michael Parfett, Ph.D. Distinguished Industry Professor

Gregory Prastacos, Ph.D. Dean, School of Business; Professor Richard Reilly, Ph.D. Emeritus Professor

Panagiotis Repoussis, Ph.D. Visiting Assistant Professor

Paul Rohmeyer, Ph.D. Industry Associate Professor

Brian Rothschild, M.B.A. Director of Graduate Management Programs

Kevin Ryan, Ph.D. Affiliate Associate Professor

Joelle Saad-Lessler, Ph.D. Associate Industry Professor

Gaurav Sabnis, Ph.D. Assistant Professor

Edward Stohr, Ph.D. Professor

Vartuhi Tonoyan, Ph.D. Assistant Professor

Alkiviadis Vazacopoulos, Ph.D. Associate Industry Professor

Ying Wu, Ph.D. Assistant Professor

Michael zur Muehlen, Ph.D. Associate Dean for the Graduate Enterprise; Associate Professor

Undergraduate Programs

BACHELOR OF SCIENCE IN BUSINESS

A business degree from the School of Business is one of the most challenging, yet rewarding experiences, you'll ever have. Choose from majors that emphasize advancing technologies and cutting-edge research with world class professors. Get realworld experience through corporate partnerships and prepare for exceptional career placement. Enjoy the benefits of our unique location, just minutes away from the world's Business Capital. You'll find many opportunities in just one place - the School of Business.

Business Majors:

- Business & Technology
- ▶ Economics
- ▶ Finance
- Information Systems
- Management
- Marketing

Major in Business & Technology

This major requires four courses in a Business concentration and four courses in Technology concentration (for a total of 8 courses for the major).

Technology Concentration

Choose coursework from approved list available at the Student Support Center in Babbio 303. If all 4 courses are taken in the same technology area, then this constitutes a "concentration". Otherwise, they are electives.

Business Concentration

Students choose coursework from one of the six business concentrations:

Marketing Concentration (students select 4 courses from the following)

- BT 214 Market Analytics and Research
- BT 403 Marketing Strategy in a Digital World
- BT 435 Social Media and Network Analysis
- BT 445 Virtual and Physical Consumer Behavior
- ▶ BT 465 Integrated Marketing Communications
- BT 466 Data Analytics

Finance Concentration (students select 4 courses from the following)

- BT 325 Financial Statement Analysis or FIN510 Financial Statement Analysis
- ▶ BT 425 Portfolio Management
- ▶ BT 426 Equity Valuation
- ▶ QF 430 Introduction to Derivatives
- BT 440 Money, Banking and Financial Institutions
- ▶ BT 442 Fixed Income
- BT 454 International Economics and Finance

International Business Concentration (students select 4 courses from the following)

- > 3-4 courses taken while studying abroad, with approval from Associate Dean
- ▶ Up to 1 international Business course taken at Stevens Institute

Information Systems Concentration (students select 4 courses from the following)

- Whichever of the 3 courses (BT416 Business Process Management, BT421 Systems Analysis & Design or MIS460 IT Strategy) that the student didn't take as part of their required coursework
- BT 310 Programming for Mobile Applications
- BT 333 Database Management
- ▶ BT 353 Project Management
- BT 422 Decision Making
- BT 435 Social Media and Network Analysis or IS Seminar (TBD)
- BT 466 Data Analytics

Management Concentration (select 4 courses from the following)

- ▶ BT 353 Project Management
- BT 422 Decision Making
- BT 447 Creativity and Innovation
- +1 "Management Elective" from approved list.

Economics Concentration (select 4 courses from the following)

- ▶ BT 343 Intermediate Macroeconomics
- ▶ BT 344 Intermediate Microeconomics
- ▶ QF 200 Financial Econometrics
- BT 440 Money, Banking and Financial Institutions
- ▶ BT 454 International Economics and Finance

Business & Technology Curriculum

Term I

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Course #	Course Name	Lecture	Lab	Study	Credit
MA 117	Calculus for Business and Liberal Arts	3	1	8	4
PEP 123	Physics for Business & Technology I	2	2	4	3
BT 244	Microeconomics	3	0	6	3
MIS 201	Fundamentals of Information Systems	2	2	8	4
PE 200	Physical Education I	0	2	0	0
CAL 103 Or CAL 105	Writing And Communications Colloquium Or CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
	Total	13	7	32	17

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 105	CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
Or	Or				
CAL 103	Writing And Communications Colloquium				
BT 100	Principles of Management	3	0	6	3
MA 119	Multivariable Calculus & Finite Mathematics	3	0	6	4
PEP 124	Physics for Business & Technology II	3	0	6	3
Or	Or				
CH 115	General Chemistry I				
Or	Or				
BIO 281	Biology and Biotechnology				
CS 105	Introduction to Scientific Computing	2	2	6	3
Or	Or				
CS 115	Introduction to Computer Science				
PE 200	Physical Education II	0	2	0	0
	Total	14	4	30	16

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
BT 221	Statistics	3	0	6	3
BT 223	Applied Models and Simulation	3	0	6	3
BT 200	Financial Accounting	3	0	6	3
	Humanities	3	0	6	3
PE 200	Physical Education III	0	2	0	0
	IS requirement	3	0	6	3
BT 290	Business Career Seminar	0	1	1	1
	Total	15	3	31	16

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Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
BT 321	Corporate Finance	3	0	6	3
BT 243	Macroeconomics	3	0	6	3
	Humanities	3	0	6	3
BT 215	Managerial Accounting	3	0	6	3
	IS Requirement	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	2	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Technology Concentration	3	0	6	3
	Technology Concentration	3	0	6	3
	Business Concentration	3	0	6	3
BT 350	Marketing	3	0	6	3
BT 360	International Business	3	0	6	3
	General Elective	3	0	6	3
	Total	18	0	36	18

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Technology Concentration	3	0	6	3
BT 372	Entrepreneurship	3	0	6	3
	Business Concentration	3	0	6	3
	General Elective	3	0	6	3
BT 301	Strategy	3	0	6	3
	Total	15	0	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Business Concentration	3	0	6	3
BT 411	Senior Design I	0	2	4	2
BT 401	Capital Structure & Strategy Audit	3	0	6	3
BT 330	Social Psychology and Organizational Behavior	3	0	6	3
EM 450	Logistics and Supply Chain Management	3	0	6	3
	Total	12	2	28	14

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Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Business Concentration	3	0	6	3
BT 412	Senior Design II	0	6	6	3
BT 413	Business Law	3	0	6	3
	General Elective	3	0	6	3
	Technology Concentration	3	0	6	3
	Total	15	6	30	15

Major in Economics (all six courses are required)

- ▶ BT 343 Intermediate Macroeconomics Theory
- ▶ BT 344 Intermediate Microeconomics Theory
- ▶ QF 200 Financial Econometrics
- BT 440 Money, Banking and Financial Institutions
- ▶ BT 454 International Finance and Economics
- Economics Elective

Major in Finance (all eight courses are required)

- BT 425 Portfolio Management
- ▶ BT 426 Equity Valuation
- BT 440 Money, Banking and Financial Institutions
- ▶ BT 325 Financial Statement Analysis or FIN 510 Financial Statement Analysis
- ▶ QF 103 Basic Financial Tools
- ▶ QF 430 Intro to Derivatives
- ▶ BT 442 Fixed Income Analysis
- Finance elective

Major in Information Systems (all six courses are required)

- ▶ BT 435 Social Media and Network Analysis
- CS 115 Intro to Computer Science
- ▶ BT 310 Programming for Mobile Applications
- ▶ BT 333 Database Management
- ▶ BT 422 Decision Making
- BT 466- Data Analytics

Major in Management (all six courses are required - students choose electives from a list of pre-approved courses)

- BT 353 Project Management
- BT 422 Decision Making
- BT 447 Creativity and Innovation
- Management Elective
- Management Elective
- Management Elective

Major in Marketing (all six courses are required)

- BT 214 Marketing Analytics & Research
- BT 465 Integrated Marketing Communications
- BT 403 Marketing Strategy in a Digital World
- BT 445 Virtual and Physical Consumer Behavior
- ▶ BT 435 Social Media and Network Analysis
- BT 466 Data Analytics

Business Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit	
CAL 103	Writing And Communications Colloquium	3	0	6	3	
Or	Or					
CAL 105	CAL Colloquium: Knowledge, Nature, Culture					
MA 117	Calculus for Business and Liberal Arts	3	1	8	4	
PEP 123	Physics for Business & Technology I	2	2	6	3	
BT 244	Microeconomics	3	0	6	3	
MIS 201	Fundamentals of Information Systems	2	2	8	4	
PE 200	Physical Education I	0	2	0	0	
	Total	13	7	34	17	

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 105	CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
Or	Or				
CAL 103	Writing And Communications Colloquium				
MA 119	Multivariable Calculus & Finite Mathematics	3	0	6	3
PEP 124	Physics for Business & Technology II	3	0	6	3
Or	Or				
CH 115	General Chemistry I				
Or	Or				
BIO 281	Biology and Biotechnology				

CS 105	Introduction to Scientific Computing	2	2	6	3
Or	Or				
CS 115	Introduction to Computer Science				
BT 100	Principles of Management	3	0	6	3
PE 200	Physical Education II	0	2	0	0
	Total	14	4	30	16

Term III

Course #	Course Name	Lecture	Lab	Study	Credit	
BT 221	Statistics	3	0	6	3	
BT 223	Applied Models and Simulation	3	0	6	3	
	Humanities	3	0	6	3	
BT 200	Financial Accounting	3	0	6	3	
	IS Requirement	3	0	6	3	
BT 290	Business Career Seminar	0	1	1	1	
PE 200	Physical Education III	0	2	0	0	
	Total	15	3	31	16	

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
BT 243	Macroeconomics	3	0	6	3
BT 215	Managerial Accounting	3	0	6	3
	IS Requirement	3	0	6	3
BT321	Corporate Finance	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
	Total	15	2	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Business Major	3	0	6	3
BT 360	International Business	3	0	6	3
	Business Major	3	0	6	3
	Technology Elective	3	0	6	3
BT 350	Marketing	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Business Major	3	0	6	3
	Business Major	3	0	6	3
BT 372	Entrepreneurship	3	0	6	3
BT301	Strategy	3	0	6	3
	General Elective	3	0	6	3
	Total	15	0	30	15

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Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Business Major	3	0	6	3
BT 330	Social Psychology and Organizational Behavior	3	0	6	3
EM 450	Logistics and Supply Chain Management	3	0	6	3
BT 411	Senior Design I	0	2	4	3
BT 401	Capital Structure & Strategy Audit	3	0	6	3
	Total	12	2	28	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Business Major	3	0	6	3
	Technology Elective	3	0	6	3
BT 413	Business Law,	3	0	3	3
BT 412	Senior Design II	0	6	6	3
	Free Elective	3	0	6	3
	Total	12	6	27	15

Bachelor of Science in Quantitative Finance

The Stevens QF program has been designed to provide students with a thorough and rigorous foundation in this multidisciplinary field. Students will be selected for strong quantitative aptitude, high motivation and work ethic, and a strong interest in the field of business and finance.

Over the course of eight semester terms, plus an optional intensive summer session in our study abroad module (typically in the summer after Sophomore year), through approximately 140 credit-hours of course work, students may choose to follow one out of four main "threads" in the QF curriculum.

<u>Quantitative Methods</u>: this thread draws on the curriculum of Stevens' Mathematics department and includes a minimum of one year of calculus, and one year of probability and statistics. Electives in this thread extend to more advanced calculus (multivariable, stochastic) and other quantitative techniques used in advanced financial applications.

Required Coursework:

- MA 232 Linear Algebra
- MA 331 Intermediate Statistics
- MA 450 Optimization Models in Finance
- FE 530 Probability

<u>Computer Science</u>: this thread draws on the curriculum offered by the Stevens Computer Science department (in the School of Science and Engineering). It begins at the introductory level, and includes seven core courses, building to a reasonable proficiency in C++, basic financial modeling tools and techniques, and an intermediate level of proficiency in web- based programming; beyond the required core. There are elective courses in fields such as data mining, machine learning and computerized trading platform architectures for students interested in developing advanced computer science capabilities.

Required Coursework:

- CS 442 Databases
- CS 559 Machine Learning

- ▶ QF XXX Web Technologies for Finance (under development)
- ▶ QF XXX Data Visualization for Finance (under development)

<u>Finance & Economics</u>: (including Financial Engineering): this thread draws on both the Business & Technology Program (Steven's successful undergraduate business degree) and the graduate program in Financial Engineering (in the School of Systems & Enterprises). It encompasses the standard business and finance foundation disciplines such as accounting, economics, corporate and international finance and capital markets - as well as QF - specific topics such as financial engineering, risk management, and market regulation & securities law. Electives drawn principally from the Financial Engineering department cover advanced topics such as derivatives pricing, hedging strategies, fixed income securities and computational finance.

Required Coursework:

- BT 426 Equity Valuation
- BT 440 Money, Banking and Financial Institutions
- BT 442 Fixed Income
- ▶ BT 454 International Finance and Economics

Quantitative Finance Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit	
CS 105	Introduction to Scientific Computing	2	2	6	3	
BT 221	Statistics	3	0	6	3	
QF 101	Introduction to Quantitative Finance I	3	0	6	3	
MA 121; MA 122	Differential Calculus; Integral Calculus	4	0	8	4	
PE 200	Physical Education I	0	2	0	0	
CAL 103 Or CAL 105	Writing And Communications Colloquium Or	3	0	6	3	
QF 103	CAL Colloquium: Knowledge, Nature, Culture Introduction to Financial Tools and Technology	0	1	0	1	
	Total	15	5	32	17	

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 105	CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
Or	Or				
CAL 103	Writing And Communications Colloquium				
CS 115	Introduction to Computer Science	3	2	8	4
BT 200	Financial Accounting	3	0	6	3
QF 102	Introduction to Quantitative Finance II	3	0	6	3
MA 123;	Series, Vectors, Functions, and Surfaces;	4	0	8	4
MA 124	Calculus of Two Variables				
QF 104	Data Management in R	0	1	0	1
PE 200	Physical Education II	0	2	0	0
	Total	17	5	32	18

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
MA 221	Differential Equations	4	0	8	4
BT 244	Microeconomics	3	0	6	3
BT 321	Corporate Finance	3	0	6	3
QF 200	Financial Econometrics	3	0	3	3
PE 200	Physical Education III	0	2	0	0
CS 135	Discrete Math	3	2	8	4
	Total	16	4	31	17

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
MA 230	Multivariable Calculus and Optimization	3	0	6	3
QF 430	Introduction to Derivatives	3	0	6	3
QF 202	Introduction to Financial Time Series	3	0	6	3
	Science Elective	3	0	6	3
PE 200	Physical Education IV	0	2	0	0
CS 284	Data Structure	4	0	8	4
	Total	16	4	32	16

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
FE 543	Introduction to Stochastic Calculus for Finance	3	0	6	3
QF 301	Advanced Time Series Analytics and Machine Learning	3	0	6	3
CS 385	Algorithms	4	0	8	4
	QF Concentration	3	0	6	3
FIN510	Financial Statement Analysis	3	0	6	3
FE 535	Introduction to Financial Risk Management	3	0	6	3
	Total	19	0	38	19

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
HPL456	Business Ethics	3	0	6	3
QF465	C++ for Finance	3	0	6	3
QF 302	Financial Market Microstructure and Trading	3	0	6	3
	QF Concentration	3	0	6	3
	QF Elective	3	0	6	3
	Total	15	0	30	15

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Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities	3	0	6	3
	QF Elective	3	0	6	3
	QF Concentration	3	0	6	3
	General Elective	3	0	6	3
QF 401	Senior Design Research Projects in Quantitative Finance I	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
QF 402	Senior Design Research Projects in Quantitative Finance II	3	0	6	3
	Humanities	3	0	6	3
	QF Elective	3	0	6	3
	General Elective	3	0	6	3
	QF Concentration	3	0	6	3
	Total	15	0	30	15

(1) E 115 and CS 105 are NOT substitutable; The sequence of CS 181-182 is equivalent to CS 115-284-385

Business Minors

Marketing Minor

- ▶ BT 100 Principles of Management (no prerequisite)
- ▶ BT 214 Marketing Analytics & Research (BT 350 prerequisite)
- BT 350 Marketing (no prerequisite)
- ▶ BT 403 Marketing Strategy in a Digital World (BT350 prerequisite)
- BT 435 Social Media and Network Analysis (BT350 prerequisite)
- ▶ BT 465 Integrated Marketing Communications (BT350 prerequisite)

Finance Minor

- BT 200 Financial Accounting (no prerequisite)
- ▶ BT 321 Corporate Finance (BT 200 prerequisite)
- BT 425 Portfolio Management (BT 321 prerequisite)
- BT 426 Equity Valuation (BT 321 prerequisite)
- ▶ QF 430 Introduction to Derivatives (BT 321 prerequisite)
- BT 440 Money, Banking and Financial Institutions (BT 321 prerequisite)

International Business Minor

- BT 100 Principles of Management (no prerequisite)
- ▶ BT 360 International Business

Plus 4 courses in international business, international economics or cross-cultural studies while studying abroad. These courses require approval from an Associate Dean of the School of Business Undergraduate Studies.

Entrepreneurship Minor

Entrepreneurship Minor for Business students

- ▶ BT 244 Microeconomics
- ▶ BT 372 Entrepreneurship
- BT 419 Entrepreneurial Practicum
- ▶ E 355 Engineering Economy or E 356 Engineering Economy; or BT 200 Financial Accounting
- BT 447 Creativity and Innovation
- MGT 472 Assessment and Financing of Technical Business Opportunities

Entrepreneurship Minor for non-Business students

- ▶ BT 244 Microeconomics
- BT 372 Entrepreneurship
- BT 419 Entrepreneurial Practicum
- ▶ E 355 Engineering Economy or E 356 Engineering Economy; or BT 200 Financial Accounting
- MGT 472 Assessment and Financing of Technical Business Opportunities
- MGT103 Introduction to Entrepreneurship

Information Systems Minor

Requirements for a minor in Information Systems (not available to majors in Computer Science, Computer Engineering, Cybersecurity, Information Systems, and Service-Oriented Computing):

- BT 333 Database Management
- ▶ BT 416 Business Process Management
- ▶ BT 421 Systems Analysis and Design
- CS 115 Introduction to Computer Science or CS 105 Introduction to Programming
- MIS 201 Fundamentals of Information Systems with Excel Lab
- MGT 460 IT Strategy

Quantitative Finance Minor

- ▶ QF 101 Introduction to Quantitative Finance I (no prerequisite)
- ▶ QF 102 Introduction to Quantitative Finance II (no prerequisite but preferred to take QF 101 and QF102 in sequence)
- BT 200 Financial Accounting (no prerequisite)
- ▶ BT 321 Corporate Finance (BT 200 prerequisite)
- ▶ QF430 Introduction to Derivatives (BT 321 prerequisite)
- ▶ FE 535 Introduction to Financial Risk Management

Plus one of the following:

- ▶ QF 200 Financial Econometrics (QF101/QF102 and Statistics course prerequisites)
- ▶ QF 202 Financial Time Series (QF101/QF102 and Statistics course prerequisites)
- ▶ FE 530 Introduction to Financial Engineering (QF101/QF102 and Statistics course prerequisites)

Economics Minor

Economics minor for BSB non-Economic major Students:

Required:

- BT 215 (or equivalent, e.g., EM 301) Managerial Accounting
- ▶ BT 321 Corporate Finance
- BT 243 Macroeconomics
- ▶ BT 244 Microeconomics

Plus one course from among the following:

- ▶ HHS 123 European Society and Cultural History to 1500
- ▶ HHS 124 History of European Society and Culture Since 1500
- ▶ HHS 125 U.S. History to 1865
- HHS 126 U.S. History Since 1865
- HSS 127 Introduction to Political Science I: National Government

Electives: Two courses from among the following:

- HSS 360 Public Policy Analysis
- HHS 371 US Presidency and the Legislative Process
- HSS 379 International Politics
- ▶ HSS 377 Sociology of Globalization
- HHS 479 Studies in the History of Technology
- HHS 414 Industrial America
- HHS 312 Technology and Society in America
- HHS 465 Engineering in History
- HHS 367 Twentieth Century History
- ▶ HPL 480 Environmental Policy
- HST 360 Research & Innovation Policy
- BT 440 Money, Banking and Financial Institutions
- BT 454 International Economics and Finance
- ▶ BT 442 Fixed Income

Economics Minor for Quantitative Finance Students:

Required:

- BT 200 Financial Accounting
- ▶ BT 321 Corporate Finance
- BT 243 Macroeconomics
- BT 244 Microeconomics

Plus one course from among the following:

- HHS 123 European Society and Cultural History to 1500
- ▶ HHS 124 History of European Society and Culture Since 1500
- HHS 125 U.S. History to 1865
- HHS 126 U.S. History Since 1865
- HSS 127 Intro. to Political Science I: National Government

Electives: Two courses from among the following:

- HSS 360 Public Policy Analysis
- HHS 371 US Presidency and the Legislative Process
- HSS 379 International Politics
- HSS 377 Sociology of Globalization
- HHS 479 Studies in the History of Technology
- HHS 414 Industrial America
- HHS 312 Technology and Society in America
- ▶ HHS 465 Engineering in History
- HHS 367 Twentieth Century History
- HPL 480 Environmental Policy
- HST 360 Research & Innovation Policy
- BT 440 Money, Banking and Financial Institutions
- BT 454 International Economics and Finance
- ▶ BT 442 Fixed Income Analysis

Economics Minor for Engineering/Science/ Arts & Letter Students:

Required:

- E 355 Engineering Economy (E 356 for science, arts & letters majors)
- ▶ BT 243 Macroeconomics
- ▶ BT 244 Microeconomics

Plus one course from among the following:

- ▶ HHS 123 European Society and Cultural History to 1500
- ▶ HHS 124 History of European Society and Culture Since 1500
- HHS 125 U.S. History to 1865
- HHS 126 U.S. History Since 1865
- HSS 127 Intro. to Political Science I: National Government

Electives: Three courses from among the following:

- HSS 360 Public Policy Analysis
- HHS 371 US Presidency and the Legislative Process
- HSS 379 International Politics
- HSS 377 Sociology of Globalization
- HHS 479 Studies in the History of Technology
- HHS 414 Industrial America
- HHS 312 Technology and Society in America
- HHS 465 Engineering in History
- HHS 367 Twentieth Century History
- HPL 480 Environmental Policy
- HST 360 Research & Innovation Policy
- BT 440 Money, Banking and Financial Institutions
- BT 454 International Economics & Finance and/or
- BT 442 Fixed Income Analysis

Graduation Requirements

Physical Education Requirements

- All undergraduate students must complete a minimum of four semesters of Physical Education (P.E.). A large number of activities are offered in lifetime, team and wellness areas.
- All P.E. courses must be completed by the end of the sixth semester. Students can enroll in more than the minimum required P.E. for graduation and are encouraged to do so.
- Participation in varsity sports can be used to satisfy up to three semesters of the P.E. requirement.

Humanities Requirement

All undergraduate students are required to fulfill certain Humanities requirements in order to graduate. Please see pages 556-557 for a breakdown of specific requirements by program.

Graduate Programs

Business success in the 21st century is increasingly dependent on the strategic development and use of technology. This is a complex challenge as the solution to many business problems relies on the convergence of a number of technologies and their proper alignment with customer requirements and business strategy.

Our educational programs are directed at:

- ▶ Technology professionals wishing to acquire business knowledge and management skills
- Business professionals wishing to learn about technology and how technology must be managed to achieve business objectives.

The School of Business offers the following master's degree programs:

- Master of Science in Business Intelligence and Analytics (BI&A)
- Master of Science in Information Systems (MSIS)
- Master of Science in Management (MSM)
- Master of Science in Finance (MFIN)
- Master of Science in Enterprise Project Management (MS-EPM)
- Master of Science in Network & Communication Management & Services (NCMS)
- Master of Business Administration (MBA)
- Master of Science in Technology Management (MSTM)
- Executive MBA (EMBA)
- Ph.D. in Business Administration

This catalog describes each of these degree programs in detail.

Educational Approach

The Business School's graduate programs are designed to maximize the management potential of each student. Students can choose concentrations within each degree program or electives that enable students to complement their degree by specializing in a number of areas ranging from soft skills development to technical specialties outside the domain of the concentration. Students may also choose electives from other schools at Stevens.

The School of Business faculty members are leaders in research and education in the business and technical disciplines that are relevant to decision making, innovation and action in an increasingly global, technology-driven world. Our educational programs provide students with knowledge that is both rigorous and relevant. Of equal importance, our programs emphasize the holistic development of each individual student through the development of life-long skills and abilities such as oral and written communication, team participation and leadership, decision making and ethical reasoning.

Ethics and Communications Education

Ethics Workshop: The ethics requirement is incorporated into the course work for the following required courses *MGT 609 Project Management Fundamentals, BIA 650 Process Analytics and Optimization (for BI&A students), MGT 635 Managerial Judgment & Decision Making (for MBA students) and MGT 798 Integration & Application of Technology Management (for MSTM and EMBA students).* Students are automatically enrolled in *MGT 899 - Ethics Workshop* at no cost. This workshop carries zero credit and will not appear on the student's official transcript. Completion of all exercises and the survey associated with the Ethics Workshop is sufficient to satisfy the ethics requirement.

Communication Skills: Written and oral communications training and assessment are conducted in conjunction with the following required courses: *MGT 609 Project Management Fundamentals, BIA 650 Process Analytics and Optimization (for BI&A students), MGT 630 Global Business & Markets (Oral Communications) and MGT 635 Managerial Judgment & Decision Making (Written Communications) (for MBA students.)*

Students in these courses are automatically enrolled in *MGT 898: Writing Support and Assessment Program.* This online workshop carries zero credit and will not appear on the student's official transcript. *Students in the MSTM and EMBA program take EMT 758 Oral & Written Communications, in lieu of MGT 898 for zero credit.* Students who do not pass the written assessment will be required to take *MGT 897: Online Writing Tutorial* for no cost for zero credit.

English Requirements for International Students

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test. TOEFL and IELTS score requirements are identical to the ELC requirements listed on pages 43-44 of the catalog.

MASTER OF SCIENCE IN BUSINESS INTELLIGENCE AND ANALYTICS (BI&A)

The MS in Business Intelligence and Analytics (BI&A) is designed for full-time and part-time students who have undergraduate degrees in science, mathematics, computer science or engineering. The program produces analytical thinkers who can pursue careers as data scientists in a variety of industries. The BI&A program includes courses in databases, data warehousing, data mining, social networking and risk modeling. The program is both theoretical and applied in that each course combines relevant theories and techniques with a number of examples and student exercises that illustrate industry applications of data analytics. A capstone course provides opportunity for students to apply the concepts, principles, and methods they have learned to real problems in an application domain of their choice.

The BI&A program prepares students for careers as business analysts and data scientists in multiple industries such as finance, manufacturing, retail and media and communications.

Degree Requirements: The MS in Business Intelligence and Analytics consists of 12 courses (36 credits). A minimum GPA of 3.0 is required to graduate.

Admission Requirements: The BI&A program is designed for students with a strong technical background in mathematics, economics, engineering, or computer science. Admissions decisions are made on a rolling basis. Students can apply at any time during the year.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

International students must also submit a GMAT/GRE score.

Prerequisites: 4-year undergraduate degree; calculus (1 year); at least one course in programming or programming experience and one course covering basic probability, hypothesis testing and estimation.

Structure of the BI&A Program

The 12 required courses for the BI&A program encompass six subject areas that conceptually comprise the field of BI&A. The program culminates in a "practicum" course that applies the concepts and techniques learned in prior courses to realworld problems. Oral and written communications skills, analytical thinking and ethical reasoning are emphasized throughout the curriculum.

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Organizational Context

FIN 615 Financial Decision Making

Data Management

- MIS 630 Strategic Data Management
- MIS 636 Data Warehousing & Business Intelligence

Optimization and Risk Analysis

- ▶ BIA 650 Process Analytics and Optimization
- BIA 670 Risk Management: Methods and Applications

Statistics

- ▶ BIA 652 Multivariate Data Analytics
- ▶ BIA 654 Experimental Design

Data Mining and Machine Learning

- MIS 637 Knowledge Discovery in Databases
- ▶ BIA 656 Statistical Learning & Analytics *

Social Network Analytics

- ▶ BIA 658 Social Network Analytics (cross-listed with MIS 669)
- ▶ BIA 660 Web Analytics*

Management Applications

- ▶ BIA 672 Customer Analytics*
- ▶ BIA 674 Supply Chain Analytics*

Practicum

- BIA 686 Applied Analytics in a World of Big Data
- * Choose two out of these four courses with permission of an advisor.

Electives

Many electives are available for qualified students who waive one of more of the required courses (e.g., FIN 615). For example:

Computer Science

- CS 506 Introduction to IT Security
- CS 538 Visual Analytics
- ▶ CS 559 Machine Learning
- CS 578 Privacy in a Networked World
- CS 581 Online Social Networks
- CS 586 Machine Learning for Gaming
- SOC 653 Introduction to Text Mining and Statistical Natural Language Processing

Financial Engineering

- ▶ FE 511 Intro to Bloomberg & Thomson Reuters (1 credit)
- ▶ FE 515 Introduction to R (1 credit)
- ▶ FE 520 Intro to Python for Financial Applications (1 credit)
- ▶ FE 635 Financial Enterprise Risk Engineering
- ▶ FE 670 Algorithmic Trading Strategies

Information Systems

- MIS 661 Marketing Online
- MIS 710 Process Innovation and Management
- MIS 730 Integrating IT Architecture

International students may also elect to take a Curricular Practical Training (CPT) course (BIA 702) which involves an educationally relevant, practical assignment aimed at augmenting the academic content of the student's program. Students engage in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. The CPT is intended to provide students with practical experience that complements their academic knowledge through active learning under real-world conditions.

MASTER OF SCIENCE IN INFORMATION SYSTEMS (MSIS)

Rapid advancements in technology, dynamic markets, and the changing global business environment have led to intense global competition in which shorter product life cycles and efficient and effective computing services are a competitive necessity. Information systems professionals are required to identify innovative opportunities for leveraging IT for competitive advantage. Close alignment of IT and business is essential. Organizations need IT professionals who are effective at working closely with their business partners, and business people need to better understand how to work closely with their IT partners.

This program is designed for information systems professionals seeking to advance their careers in the IT sector of the business, or as IT experts in other areas of business. It is also suitable for business professionals looking for ways to leverage their IT resources. In addition to strong practical, real-world IT and management skills, graduates of the program leave with improved communication, interpersonal, and team skills.

The MSIS program prepares students for careers such as: Business Analyst, Internal IT Consultant, IT Manager, Management Consultant, Data Analyst, Knowledge Manager, Social Media Expert and Technology Specialist.

In addition to off-campus (corporate-sponsored) programs, the MSIS program is offered on campus on weekdays and Saturdays and via Stevens WebCampus platform. Courses are offered year-round, in fall, spring and summer semesters.

Degree Requirements: The MS in Information Systems consists of 12 courses (36 credits). A minimum GPA of 3.0 is required to graduate.

Admission Requirements: The Master of Science in Information Systems program is designed for working professionals with at least two years of work experience. Applicants who do not meet this work experience requirement, but have outstanding academic records, may be considered for admission. Admission to the program requires a bachelor's degree with at least a "B" average. Applications should include two letters of recommendation.

Meeting minimum admissions standards does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications necessary to be considered for admission.

Admissions decisions are made on a rolling basis. Students can apply at any time during the year.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

International students must also submit a GMAT/GRE score.

Structure of the MSIS Program

The MS in Information Systems program has 3 components:

- 1. Common Business Core (3 courses)
- 2. Degree Requirement (6 courses)
- 3. Concentrations (3 courses)

MSIS Common Business Core

- MGT 609 Project Management Fundamentals
- FIN 615 Financial Decision Making
- MGT 689 Organizational Behavior and Design

MSIS Degree Requirements

- MIS 620 Analysis and Development of Information Systems
- MIS 630 Database Systems and Decision Support
- MIS 699 Managing Emerging Information Technologies
- MIS 710 Process Innovation and Management
- MIS 730 Integrating IS Technologies
- MIS 760 Strategic Issues in Information Management

MSIS Concentrations

The final 3 courses are free electives that can be chosen with the help of the faculty advisor, or a specific combination of courses selected from one of four designated concentrations in the MSIS program.

MSIS students can choose from four specific 3-course concentrations:

- Business Intelligence & Analytics
- Business Process Management & Service Innovation
- Social Media
- Project Management

The courses comprising each of these MSIS concentrations are listed below.

Business Intelligence and Analytics

IT is emerging from an era in which the emphasis was on producing information to one in which competitive advantage can only be obtained by sophisticated analysis of large volumes of information. There is a strong demand on Wall Street and in all areas of business for graduates with the analytic skills provided by this concentration.

- MIS 635 Designing the Knowledge Organization
- MIS 636 Data Warehousing and Business Intelligence
- MIS 637 Knowledge Discovery in Databases

With approval of their advisor students can substitute BIA courses and select FE courses in the Business Intelligence and Analytics concentration.

Business Process Management & Service Innovation

Organizations need effective and efficient processes to execute their strategies and successfully compete in a rapidly changing world of global competition. Business School faculty members are leaders in research and education on business process management (BPM) with a particular emphasis on relationship of processes to organizational strategy and structure and supply chain management. There is strong demand in all areas of business for graduates who can analyze, design and implement effective business processes.

- MIS 690 Supply Chain Management and Strategy
- MIS 712 BPM and Workflow Implementation
- MIS 714 Service Innovation

With approval of their advisor students can choose BIA 650 Process Optimization and Analytics and/or BIA 674 Supply Chain Analytics as electives in the Business Process Management & Service Innovation concentration.

Social Media

Social media are fundamentally transforming every aspect of our political, social and business lives. Consumers now connect to each other and to businesses through large-scale dynamic networks based on non-traditional Internet and mobile media. Companies must analyze the huge amount of data that is generated minute-by minute by social media to understand and influence their customers, and to predict and take advantage of important trends. Social network analysis is an exciting new field with strong demand for the kinds of skills that are developed in this concentration.

- MIS 661 Marketing On-line
- MIS 668 Social Network Analytics
- ▶ BIA 660 Web Analytics

Project Management

This concentration deals with project and program management concepts with an emphasis on managing technology-centric projects in private and public enterprises.

- MGT 610 Strategic Perspectives in Project Management
- MGT 611 Project Analytics
- MGT 612 Leading People & Projects

Free Electives (no concentration option)

MSIS students may elect to take three courses that fit their interests rather than a specific concentration in the MSIS program. Courses may be chosen from within the School of Business or from other Schools at Stevens.

International students may also elect to take a Curricular Practical Training (CPT) course (MIS702) which involves an educationally relevant, practical assignment aimed at augmenting the academic content of the student's program. Students engage in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. The CPT is intended to provide students with practical experience that complements their academic knowledge through active learning under real-world conditions.

The courses that are available in each of these areas are described later in a separate section of the catalog.

MASTER OF SCIENCE IN MANAGEMENT (MSM)

The Master of Science in Management (MSM) program is a generalist graduate business program designed specifically for individuals with non-business academic backgrounds/degrees. Students do not need any professional work experience to be admitted to this 30-credit program. Grounded in the fields of management, economics, applied psychology, and quantitative methods, the unique 10-course curriculum encompasses the primary business disciplines to help you round out your undergraduate training and experience. Students will learn how economics, technology, social science and quantitative methods can be used to solve today's complex and managerial challenges.

In today's competitive global workplace, having the right technical skills is extremely important, but it is often not enough. Businesses need people who can enter the workplace with the ability to transform technical expertise into business solutions. Through the MSM coursework and other learning experiences, students are guided in developing a core set of critical thinking, collaboration, communication and innovation skills that are keys to success at the intersection business and technology. The MSM courses help students master business fundamentals and enrich their capacity to communicate effectively across business and technical domains.

Stevens is renowned for excellence in project management, leadership and innovation management. Not only are these skills important to technical professionals, they also impart a competitive edge regardless of previous field of study or current type of work. Our faculty includes thought leaders who are experienced professionals, many of whom were managers at Fortune 500 organizations. Be a part of a major technical university that on the one hand has a rich tradition of excellence in applied science and engineering, and on the other is also home to original thought leaders in management science.

The MS in Management program is offered on campus on weekdays and via the WebCampus platform. Courses are offered year-round, in fall, spring and summer semesters. Corporate sponsored programs are also offered at company sites.

Degree Requirements: The MS in Management degree comprises 10 courses (30 credits). A minimum GPA of 3.0 is required to graduate.

Admission Requirements: The Master of Science in Management program is designed for students having less than two years work experience. Admission to the program requires a bachelor's degree with at least a "B" average, and two letters of recommendation. Meeting minimum admissions standards does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications necessary to be considered for admission.

Students can apply at any time during the year. Admissions decisions are made on a rolling basis.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

International students must also submit a GMAT/GRE score.

Structure of the MSM Program

The MSM program comprises eight business core courses and two electives:

Business Core

- MGT 609 Project Management Fundamentals
- FIN 615 Financial Decision Making
- MGT 606 Economics for Managers
- MGT 641 Marketing Management
- MGT 657 Operations Management
- MGT 671 Technology and Innovation Management
- MGT 689 Organizational Behavior and Design
- MGT 699 Strategic Management

Electives

Students choose two additional electives from an array of courses. Courses may be chosen from within the School of Business or from other Schools at Stevens.

Students may also elect to take a Curricular Practical Training (CPT) course (MGT 702) which involves an educationally relevant, practical assignment aimed at augmenting the academic content of the student's program. Students engage in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. The CPT is intended to provide students with practical experience that complements their academic knowledge through active learning under real-world conditions.

MASTER OF SCIENCE IN FINANCE (MFIN)

The Master of Science in Finance (MFin) is a 36-credit degree program that addresses the needs of students looking to advance their management careers in the financial sector. It consists of core courses covering fundamental topics in finance and economics, the management of financial technologies, and allows students to specialize in topics such as regulatory and market environments, the management of risks, or financial project management.

The Finance curriculum is structured in such a way as to provide students with a rigorous education that will familiarize them with the terminology, methods and application areas of economics, finance and financial technology, while providing an understanding of the financing needs of companies and the market mechanisms available to meet these needs. Graduates will be able to apply financial technologies for analysis, forecasting and management; assess the financial health of an organization; develop comprehensive plans that address financial management needs of an organization; and lead business and technology teams.

Graduates of the Master of Finance program will:

- be familiar with terminology, methods, and application areas of economics, finance, and financial technology
- understand the financing needs of organizations and the market mechanisms available to meet these needs
- be able to apply common financial technologies for analysis, forecasting, and management of financial enterprises
- be able to assess the financial health of an organization
- be able to develop a comprehensive plans that address the financial management needs of an organization
- lead combined business and technology teams in the delivery of change projects

Degree Requirements: The MS in Finance degree comprises 12 courses (36 credits). A minimum GPA of 3.0 is required to graduate.

Admission Requirements: The Master of Science in Finance is designed for working professionals who want to advance their management careers in the financial sector. Applicants should have a minimum of two years of work experience.

Applicants who do not meet the work experience requirement, but have outstanding academic records, may be considered for admission. Admission to the program requires a bachelor's degree with at least a "B" average, and two letters of recommendation. Meeting minimum admissions standards does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications necessary to be considered for admission.

Meeting minimum admissions standards does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications necessary to be considered for admission.

Admissions decisions are made on a rolling basis. Students can apply at any time during the year.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

International students must also submit a GMAT/GRE score.

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Structure of the MS in Finance Program

Pre-requisites

Students should have taken undergraduate courses in Accounting, Finance, and Statistics, or demonstrable work experience in these areas. Students that lack background in either of these areas will take FIN 623 (for financial management), FIN 600 (for accounting) and/or MGT 620 (for statistics) during a pre-requisite semester.

Curriculum

Economics Core

- ▶ MGT 606 Economics for Managers
- ▶ FIN 620 Financial Econometrics
- ▶ MGT 700 Econometrics

Finance Core

- FIN 629 Banking & Credit
- FIN 627 Investment Management
- ▶ FIN 638 Corporate Finance
- FIN 510 Financial Statement Analysis

Financial Technology Core

- ▶ FE 511 Introduction to Bloomberg & Thomson Reuters
- ▶ FE 515 Introduction to R
- ▶ FE 514 Introduction to SAS

Electives: Choose 4 courses from finance or related areas

Financial Management

- MGT 607 Managerial Economics
- MGT 609 Project Management Fundamentals
- ▶ MGT 611 Project Analytics
- ▶ FIN 530 Investment Banking
- ▶ FIN 545 Risk Management for Financial Cybersecurity
- ▶ FIN 626 Private Equity and Venture Capital
- FIN 628 Derivatives

Business Intelligence & Analytics

- MIS 636 Data Warehousing and Business Intelligence
- BIA 652 Multivariate Data Analysis I
- ▶ BIA 656 Statistical Learning and Analytics
- ▶ BIA 670 Risk Management Methods and Applications
- ▶ BIA 672 Customer Analytics

Financial Engineering

- ▶ FE 535 Introduction to Financial Risk Management
- ▶ FE 655 Systemic Risk and Financial Regulation

Operations

- MIS 710 Process Innovation and Management
- MIS 712 Advanced Business Process Management
- MIS 714 Service Innovation

MASTER OF SCIENCE IN ENTERPRISE PROJECT MANAGEMENT (MS-EPM)

The Master of Science in Enterprise Project Management (MS-EPM) is a 36-credit degree program that blends courses in strategic perspectives, project planning, project portfolio management, and cross-project leadership for an applied curriculum that teaches you to manage and serve as a leader at an enterprise level.

This curriculum encompasses a strategic approach to project management that goes beyond the traditional tools, tactics, and PMI Certification preparation taught in most PM programs. The Stevens EPM program prepares students to:

- Lead transformational, large-scale projects and project teams across units, enterprises and multiple organizations;
- Gain insight and skills pertaining to leadership, cultural and behavioral project environment
- Lead change and span boundaries across complex enterprise systems
- Bridge cultural and organizational gaps

The program offers a unique blend of small class sizes, intense collaboration, and global professional networking opportunities. Graduates will leave Stevens with better communications, interpersonal and team skills enabling them to plan, implement and manage complex enterprise level projects.

Degree Requirements: The MS in Enterprise Management degree comprises 12 courses (36 credits). A minimum GPA of 3.0 is required to graduate.

Admission Requirements: The Master of Science in Enterprise Project Management is designed for working professionals who want to excel in managing enterprise-level projects, programs, portfolios, and project management offices. Applicants should have a minimum of one-year work experience.

Applicants who do not meet the work experience requirement, but have outstanding academic records, may be considered for admission. Admission to the program requires a bachelor's degree with at least a "B" average, and two letters of recommendation. Meeting minimum admissions standards does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications necessary to be considered for admission.

Students can apply at any time during the year. Admissions decisions are made on a rolling basis.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

International students must also submit a GMAT/GRE score.

Curriculum of the MS-EPM Program

The Master of Science in Enterprise Project Management (MS-EPM), a 36-credit degree program (12 courses) that encompasses courses in strategic perspectives, project planning, project portfolio management and cross-project leadership for an applied curriculum that teaches you to manage and serve as a leader.

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Degree Requirements

- ▶ FIN 615 Financial Decision Making
- MGT 689 Organizational Behavior and Design
- MGT 609 Project Management Fundamentals
- MGT 612 Leading People and Projects
- MGT 611 Project Analytics
- MGT 641 Marketing Management
- MGT 613 Project Portfolio Management and the Project Management Office
- MGT 610 Strategic Perspectives in Project Management
- MGT 619 Leading across Projects and Programs
- MGT 614 Advanced Project Management
- MIS 710 Process Innovation
- MGT 699 Strategic Management

MASTER OF SCIENCE IN NETWORKS & COMMUNICATION MANAGEMENT & SERVICES (MS-NCMS)

The Networks & Communication Management & Services graduate program is an interdisciplinary program between the School of Business and the Electrical and Computer Engineering Department of the School of Engineering and Science. The School of Business administers the program. This program is STEM (Science, Technology, Engineering and Mathematics)-designated by the Department of Homeland Security. A CoOP is an available option for students seeking work experience.

The Networks & Communication Management & Services curriculum addresses the demanding requirements of the global communications industry, businesses, and government for technical expertise combined with business skills. The program provides students with advanced technical knowledge of applied communications integrated with business management.

This program prepares students to plan, implement and manage leading edge communications capabilities. The goal of this student is to become a technical business and management professional responsible for planning communications products and services; for leading the resources required to implement the plan, including people, product, networks, and systems, and for the decisions and budgeting for development, acquisition, installation, and maintenance of products and services. Each sector of industry (government, regulatory, service providers, financial, equipment vendor, consultant, and R&D) will have corresponding profiles of professionals who need such technical expertise and management skills. This degree program builds an advanced foundation for more specialized study while enabling professionals from all industry sectors to understand and interact with customers and communications professionals who make the decisions on how businesses will exploit communications capabilities for.

Specialized courses are available in the areas of management of wireless networks, broadband communications, communications security, and project management.

In addition to off-campus (corporate-sponsored) programs, Networks & Communication Management & Services is offered on campus on weekdays and via the WebCampus platform. Courses are offered year-round, in fall, spring and summer semesters.

Degree Requirements: The MS in Networks & Communication Management & Services degree comprises 12 courses (36 credits). A minimum GPA of 3.0 is required to graduate.

Admission Requirements: Admission to the Master of Networks & Communication Management & Services program requires a bachelor's degree with at least a B average, including a semester of calculus. For students who lack this prerequisite, Stevens offers a non-credit calculus course for telecommunications management (e.g., TM 500).

Admissions decisions are made on a rolling basis. Students can apply at any time during the year.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

International students must also submit a GMAT/GRE score.

Prerequisites may include a semester of microeconomics (TM 500 or equivalent)

Structure of the Telecom Program

The MS in Telecommunications Management program has 3 components:

- 1. Common Business Core (3 courses)
- 2. Degree Requirements (6 courses)
- 3. Concentrations (3 courses)

Common Business Core

- MGT 609 Introduction to Project Management
- ▶ FIN 615 Financial Decision Making
- MGT 689 Organizational Behavior and Design

Telecom Degree Requirements

- ▶ TM 601 Principles of Applied Telecommunications Technologies
- TM 605 Probability and Stochastic Processes
- ▶ TM 610 Business Information Networks
- ▶ TM 612 Regulation & Policy in the Telecommunications Industry
- ▶ TM 615 Wireless Communications & Mobile Computing
- ▶ TM 630 Broadband Networking: Services & Technology

Telecom Concentrations

The final 3 courses are selected from one of two specific concentrations within the MS Networks & Communication Management & Services program, or from within a general concentration category designed to accommodate a broad choice of electives.

The MS Telecom Management program offers two concentrations.

- Management of Broadband and Converged Networks
- Management of Wireless Networks

The courses required to complete each of these concentrations are listed below.

Management of Broadband and Converged Networks

Students selecting this major will be eligible for a Graduate Certificate in the Management of Broadband Communications and Converged Networks.

- TM 617 Next Generation Wireless Networks
- TM 631 Broadband Service Management
- TM 632 Communications Industry Strategy & Structure

Management of Wireless Networks Concentration

Students selecting this major will be eligible for a Graduate Certificate in the Management of Wireless Networks.

- TM 616 Global Wireless Industry
- TM 617 Next Generation Wireless Networks
- ▶ TM 618 Performance of Emerging Wireless Networks

Or

▶ TM/EE 584 Wireless Systems Security

Elective Options

Students may also choose broad range of electives to meet a student's specific growth objective in other domains intended to broaden his/her perspective while complementing the MS Networks & Communication Management & Services degree. This option requires approval of a faculty advisor.

Courses may be chosen from within the School of Business or from other schools at Stevens.

Students may also elect to take a Curricular Practical Training (CPT) course (TM 702) which involves an educationally relevant, practical assignment aimed at augmenting the academic content of the student's program. Students engage in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. The CPT is intended to provide students with practical experience that complements their academic knowledge through active learning under real-world conditions.

The courses that are available in each of these areas are described later in a separate section of the catalog.

MASTER OF BUSINESS ADMINISTRATION (MBA)

To stand out in today's business world, you need three essential competencies. First, you need to be proficient in the basic business disciplines, such as finance, accounting, and marketing. Second, you must possess the key skills that enable you to collaborate and lead, communicate, be creative and think strategically. Third, with technology being essential to running nearly every facet of business, you need to understand how to nurture and leverage technology for business success.

The Stevens MBA is uniquely designed to equip you with these three essential elements. It will position you to operate effectively at the intersection of business and technology, which is where 21st century businesses need you to be. Our curriculum is designed to help you master a core set of skills which we refer to as the four Cs - Critical Thinking, Collaboration, Communication and Creativity - that are keys to your success in fast-paced technology driven environments. It will provide you with the knowledge, skills and leadership capability that will enable you to deliver value to your company and enhance your career.

You will learn from faculty members who remain connected with high-tech organizations around the globe and engage in cutting edge research in such areas as entrepreneurship, innovation and project management. You will draw upon Stevens' rich heritage in the management sciences, and its 140+ years as an applied technological university, which puts technology at the core of your learning experience.

There are two MBA program options - the Flex MBA for full-time and part-time students having a minimum of two years work experience, and the Experienced Professional MBA that is a weekend, cohort-based program that is offered on the Stevens campus on alternate Saturdays. Applicants to the EMBA must have 5+ years of work experience.

The following sections pertain to the FLEX MBA program. The Experience Professional MBA program is discussed later in the catalog.

Incorporating a technology-centric approach with skills development that encompasses the four Cs, the Flex MBA program is designed to help students succeed in today's fast-paced technology-driven environment. Graduates from the program will be able to apply their skills to contribute to excellence at the intersection of business and technology, and lead their organizations in an increasingly complex and competitive world.

The Flex MBA program is offered on campus on weekdays and via WebCampus. It can also be delivered off-campus in corporate-sponsored programs,

Degree Requirements: The Flex MBA degree comprises 16 courses (48 credits). A minimum GPA of 3.0 is required to graduate. Students with a master's degree from the Business School may be able to apply courses from their MS towards their MBA degree. Depending on concentration chosen, as few as eight additional courses may be required for the MBA degree.

Admission Requirements: Applicants to the Flex MBA program are required to have completed a four-year bachelor's degree and have at least two years of work experience. All applicants must submit transcripts showing academic achievement in prior studies (bachelor's degree with at least a "B" average), two letters of recommendation, and a resume. All applicants (domestic and international) to the MBA program must submit a GMAT score (or GRE score if taken previously). Note: The GMAT requirement is waived for domestic candidates possessing an MS degree and 5 years of work experience. Meeting minimum admissions standards does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications necessary to be considered for admission.

Admission decisions are made on a rolling basis. Students can apply at any time during the year.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

Structure of the Flex MBA Program

The Flex MBA is a 48-credit degree program that comprises 16 courses. The program also offers the option for students to pursue a dual MS-MBA degree.

The Flex MBA program has four components:

- 1. Business Core Foundation (8 courses)
- 2. Breadth (3 courses)
- 3. Capstone (1 course)
- 4. Concentrations (4 courses)

Business Core

- ▶ FIN 600 Financial and Managerial Accounting
- MGT 606 Economics for Managers
- MGT 612 Leading People & Projects
- MGT 620 Statistical Models*
- FIN 623 Financial Management
- MGT 630 Global Business & Markets*
- MGT 641 Marketing Management

- MGT 657 Operations & Supply Chain Management
- MGT 699 Strategic Management
- * Select one (Note: MGT 620 is a required course for students taking a concentration in Business Intelligence & Analytics, Finance, Marketing and Project Management)

Breadth

- MGT 635 Managerial Judgment & Decision Making
- MGT 663 Discovering & Exploiting Entrepreneurial Opportunities
- MGT 671 Technology & Innovation Management

Capstone

- MGT 798 Integration & Application of Technology Management**
- ▶ MGT 810 Field Consulting Project (full-time student option)**
- ** Select one (Note: The Field Consulting Project is subject to availability and is open to full-time students only)

MBA Concentrations

The Flex MBA program offers six concentrations:

- Business Intelligence & Analytics
- ▶ Finance
- Information Systems
- Innovation & Entrepreneurship
- Marketing
- Project Management

The courses comprising each concentration are listed below.

Business Intelligence & Analytics

Organizations today are generating and storing massive amounts of data about their customers, their suppliers, and even their own employees, with the attendant challenge of analyzing these massive datasets to gain key insights to make informed decisions that enhance business value. And with more and more organizations embracing the 'big data' revolution, there is huge demand for business professionals and managers with strong analytical skills and ability to turn the numbers and stats into practical, actionable business insight. This concentration will provide you with the analytical skills needed to work in this high-demand field, enabling you to pursue careers in data-rich business environments.

- BIA 672 Marketing Analytics
- BIA 674 Supply Chain Analytics
- ▶ BIA 658 Social Network Analytics
- BIA 670 Risk Management: Methods & Applications
- MIS 636 Data Warehousing & Business Intelligence

Choose 4 out of the 5 courses.

Finance

This concentration provides the basic theory and practice of corporate financial management and examines the structure of financial markets and major financial instruments. Topics include: discounting, net present value, risk, the capital asset pricing model, diversification, the term structure of interest rates, financial markets, the efficient markets hypothesis, technical and fundamental analysis, options pricing, derivatives and portfolio management. Finance students find positions in management consulting, banking and corporate finance departments. Our close proximity to Wall St. makes this major a natural choice for many students.

- ▶ FIN 638 Corporate Finance
- FIN 626 Venture Capital
- FIN 627 Investment Management
- ▶ FIN 628 Derivatives

Information Systems

The Information Systems concentration balances general management courses with courses that are specifically designed to provide depth in information technology and management. This is an ideal education for people wishing to advance to the highest ranks within a corporate IT department. Alternatively, this mix of skills is suitable for students wishing to be business leaders in functional departments such as marketing, finance and operations.

- MIS 620 Analysis and Development of Information Systems
- MIS 630 Database Systems and Decision Support
- MIS 710 Process Innovation and Management
- MIS 730 Integrating IS Technologies

Innovation & Entrepreneurship

This concentration provides students with the knowledge and skills needed to assess technology-driven market opportunities and to start entrepreneurial ventures. In addition to joining or starting entrepreneurial ventures, students in this concentration can find employment opportunities in consulting and high-growth companies in a broad range of industries.

- MGT 672 Venture Capital
- MGT 672 Realizing Value from Intellectual Property
- MGT 673 Global Innovation Management
- MGT 696 Human-Centered Design Thinking

Marketing

Advances in technology are dramatically changing the way in which products and services are marketed. This major gives you an understanding of those changes and what is driving them, and provides you with the skills and technological savvy to pursue a successful marketing career.

- MGT 648 Consumer and Business Behavior
- MIS 661 Marketing On-line
- BIA 672 Marketing Analytics
- MGT 646 Marketing Strategy

Project Management

Excellence in project execution is the hallmark of successful companies. This major teaches new concepts in strategic project management and leadership that were developed by the School of Business faculty and have achieved international acclaim. Students in the MBA in TM with a PM major take a number of project management courses in addition to the core business courses.

- MGT 609 Project Management Fundamentals
- MGT 610 Strategic Perspectives on Project Management
- MGT 611 Project Analytics
- MGT 619 Leading Across Projects

MASTER OF SCIENCE-MASTER OF BUSINESS ADMINISTRATION

The MS-MBA is a coordinated dual degree program enabling students who graduate with a Business School MS to apply relevant courses from their MS to their MBA degree. In most cases, the MBA degree can be obtained with 24-36 credits (8-12 courses) of additional course work depending on the chosen MBA concentration. MS graduates must submit an application for admission to the MBA program.

The combination of courses comprising the MS and MBA degrees provides in-depth preparation for graduates wishing to assume either general management or technology-related managerial positions. The program is designed to allow students to specialize in areas that are relevant to their careers.

MASTER OF SCIENCE IN TECHNOLOGY MANAGEMENT (MSTM)

The Master of Science in Technology Management (MSTM) is a part-time program specifically designed for experienced professionals wishing to move to a broader role in technology and business management. The MSTM program focuses on the effective management and use of technology in technology-intensive businesses. It integrates business and technology topics aimed at educating students to manage technology creatively in order to enhance business competitiveness in a global business environment. Students learn general business skills, such as accounting, finance and marketing, along with emphasis on development of technology management skills encompassing technology strategy, emerging technology and corporate entrepreneurship to assure alignment of technology strategy with business strategy.

The MSTM program consists of twelve courses that are completed in six trimesters. The courses are supplemented with workshops and practicums utilizing business simulation tools that reinforce classroom concepts, while providing students with experience running a high-tech company. The Global Business and Markets course also encompasses an international study tour where students travel abroad to countries such as China where they participate in company visits and lectures, as well as some cultural and sightseeing activities, in order to gain first-hand experience and understanding of the unique business culture and context of that country.

Courses are scheduled on alternating Saturdays on the Stevens campus from 8:30 a.m. to 5:15 p.m. In the final semester, the capstone course requires 5 consecutive Saturday sessions on the Stevens campus. Students complete their MSTM degree in 21 months.

Degree Requirements: The MS in Technology Management consists of 10 courses (30 credits). A minimum GPA of 3.0 is required to graduate.

Admission requirements: Admission to the MSTM program requires that applicants have:

- A bachelor's degree in a relevant technical discipline.*
- ▶ 5 + years of relevant full-time work experience managerial experience is preferred but is not required for admission to the program.
 - * Consideration will be given to prospective students with non-technical undergraduate degrees provided they have appropriate technology-based work experience.

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Meeting minimum admission requirements does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications to be considered for admission. Consideration will be given to prospective students with non-technical undergraduate degrees provided they have appropriate technology-based work experience.

Note: The GMAT is not required for admission to the MSTM program.

Structure of the MSTM Program

- ▶ EMT 740 Technology Leadership Development
- ▶ EMT 606 Economics
- EMT 642 Marketing Strategy
- ▶ EMT 624 Financial and Managerial Accounting
- EMT 623 Financial Management
- EMT 677 Managing Emerging Technology
- ▶ EMT 696 Design Thinking
- ▶ EMT 715 Strategic Business Management
- ▶ EMT 752 Corporate Entrepreneurship
- EMT 657 Operations Management

EXECUTIVE MBA (EMBA)

The EMBA program is designed for experienced professionals wishing to expand their business and technology management skills beyond the boundaries provided by the MSTM program. Applicants should have a bachelor's degree in a technical discipline, and have at least five years work experience in a technology-related field. All applicants must submit transcripts showing academic achievement in prior studies, two letters of recommendation from their companies, a letter stating their career objectives, and resume.

Degree Requirements: The Experienced Professional MBA program consists of 16 courses (48 credits). A minimum GPA of 3.0 is required to graduate.

Admission requirements: Admission to the EMBA program requires that applicants have:

- A bachelor's degree in a relevant technical discipline.*
- ▶ 5 + years of relevant full-time work experience managerial experience is preferred but is not required for admission to the program.
 - * Consideration will be given to prospective students with non-technical undergraduate degrees provided they have appropriate technology-based work experience.

Meeting minimum admission requirements does not guarantee admission; minimum requirements serve as a guide to the minimum expected qualifications to be considered for admission. Consideration will be given to prospective students with non-technical undergraduate degrees provided they have appropriate technology-based work experience. The EMBA program encompasses the MSTM curriculum, but includes additional courses that further enhance skills in business management. Students who wish to obtain their E MBA degree through this program take all of the courses in the MSTM curriculum, and then proceed to a 6-course extension program leading to the EMBA degree. The additional courses comprise:

- ▶ EMT 635 Managerial Judgment & Decision Making
- EMT 678 Big Data Seminar

- EMT 695 Leading Creative Collaboration
- ▶ EMT 638 Corporate Finance
- EMT 630 Global Business and Markets includes International Trip
- EMT 798 Integration and Application of Technology Management

Master of Philosophy

The Master of Philosophy (M.Phil.) is a postgraduate research degree. It is offered to enrolled Ph.D. students who achieve a record of distinction during the pre-dissertation phase. Because the Master of Philosophy is not designed as a terminal degree, its requirements are integrated with the requirements for the Doctor of Philosophy degree: potential candidates for the Master of Philosophy degree must be qualified to pursue the doctorate and have been advised to apply for admission to a doctoral program.

This degree requires a minimum of two years of advanced study beyond the baccalaureate degree. Placed between the Master's degree and the Doctor of Philosophy, the Master of Philosophy marks a student's successful completion of all requirements for the doctorate, except the final phase of research and the dissertation. The degree is intended to provide recognition that a prospective doctoral candidate has successfully and expeditiously completed a major phase of graduate study and has achieved a comprehensive mastery of the general field of concentration.

PH.D. IN BUSINESS ADMINISTRATION

The School of Business Ph.D. in Business Administration program defines itself at the intersection of three research domains: Information Systems & Analytics, Entrepreneurship & Innovation Management and Finance. These three research domains are strongly represented by the faculty of the Business School and provide different perspectives on business administration.

The design of the Ph.D. program is based on the assumption that novel research ideas often occur at the intersection of different knowledge domains. The unique combination of these three research domains and their integrated discussion will lead to creative and innovative research questions within and across these domains. The combination will also encourage the development of the interdisciplinary skill sets necessary to conduct innovative research. The majority of Ph.D. programs focus on theory and analytical skills. The integration of three research domains complements this fundamental skill set with the skills necessary for creating and applying this knowledge. Our students are challenged to create new technologies for analyzing relevant research questions related to important problems we face today.

Students of the program will chose one of the three research domains as their research focus and they can study aspects of the other two domains as part of the program. Because of the specific integration of the knowledge domains the program offers a truly interdisciplinary experience. This is achieved by a common set of required courses and by the selection of individual courses.

Degree Requirements: The Ph.D. program in Business Administration consists of a minimum of 36 credits of coursework and a maximum of 18 research credits.

Admission Requirements: The Ph.D. program is designed for the exceptional student possessing a strong quantitative background and a degree in management or related topics. Students who are interested in joining the program must fulfill the following requirements:

- Students must have earned a 4-year undergraduate degree from an accredited college or university.
- > Students must have earned a master's degree in Business, Finance, MIS or related field.
- Students must have attained a basic knowledge of statistics comparable to MGT620 Statistical Models.
- Students must have completed undergraduate course work in mathematics including the equivalent of two semesters of calculus and one semester of linear algebra, or they must acquire this background before entering the program.

International students for whom English is a second language must demonstrate English language proficiency by submitting the results of a TOEFL or an IELTS test.

All students are required to submit GMAT or GRE test scores not older than 3 years.

Admissions decisions are made beginning in February for the following fall semester. Students are encouraged to apply at any time during the year but it is preferred that complete applications are submitted by January 31.

Depending on the student's background, several non-credit business, information technology and finance foundation courses may also be required.

Structure of the Ph.D. Program

Course work (36 credits). All courses are worth 3 credits unless otherwise specified.

- ▶ Five common core courses addressing research methods, economic theory and research design.
- Two domain specific courses addressing fundamental research questions.
- ▶ Four elective courses that could involve independent study as well as master's and doctoral courses.
- ▶ Signature doctoral course PRV 961 required for all doctoral students at Stevens.
- Special Method Workshops (SEM, Conjoint Measurement etc.)
- MGT 960 Dissertation/ Research (18 credits)

A preliminary examination is usually taken after the second semester of fulltime study. A qualifying examination is usually taken after finishing the 4th semester of full-time study.

A proposal for the student's PhD dissertation is usually defended at the end of the third year of full-time study.

The final PhD dissertation is usually defended at the end of the fourth year of full-time study.

Program Learning Objectives

The program's learning objectives are to prepare students to pursue an academic or industry research career.

The program's required common courses will provide students with the foundations needed to conduct independent research.

The domain specific courses will introduce students to the foundations of the three research domains and equip them with the knowledge required to conduct research within a domain.

These courses develop skills in understanding and analyzing as well as in creating and applying.

- Understanding and analyzing skills are addressed by discussing the theoretical foundations of the domains and fundamental methods.
- Creating and applying skills are developed by theory building and developing tools to analyze specific social and economic phenomena.

Graduate Certificate Programs

The School of Business offers the following programs leading to a graduate certificate of Special Study. Students are required to meet regular admission requirements for the master's program and complete the courses listed below. Each graduate certificate program is self-contained and highly focused, carrying 12 graduate credits. All of the graduate certificate courses may also be applied toward the master's degree.

Industry-Oriented Certificates

Healthcare Management (4 courses, 12 credits)

- MGT 616 Healthcare Leadership and Management
- MGT 609 Project Management Fundamentals
- MGT 612 Leading People and Projects

One elective chosen from the following:

- MGT 614 Advanced Project Management
- MIS 689 IT Management for the Healthcare Professional.
- MGT 689 Organizational Behavior & Design

Discipline-Based Certificates

Business Intelligence and Analytics (4 courses, 12 credits)

All graduate certificate students will normally take:

- MIS 636 Data Warehousing & Business Intelligence*
- ▶ MIS 637 Knowledge Discovery in Databases*

Practitioners will normally take 2 of the following 3 courses:

- ▶ BIA 652 Multivariate Data Analytics*
- ▶ BIA 658 Social Network Analytics*
- ▶ BIA 672 Marketing Analysis
- BIA 674 Supply Chain Analysis

People intending to go on to the BI&A MS Degree will normally take 2 of the following 3 courses:

- ▶ BIA 652 Multivariate Data Analytics
- ▶ BIA 656 Statistical Learning and Analytics
- ▶ BIA 660 Web Analytics
 - * These four graduate certificate courses are available online.

Marketing Analytics

- ▶ BIA 672 Marketing Analytics*
- Choose 3 out of the following courses:
- ▶ BIA 652 Multivariate Data Analytics
- ▶ BIA 658 Social Network Analytics (X-List with MIS669)
- ▶ BIA 660 Web Analytics
- MIS 637 Knowledge Discovery in Databases
 - * Required for a Graduate Certificate in Marketing Analytics

Supply Chain Analytics

- ▶ BIA 672 Supply Chain Analytics*
- Choose 3 out of the following courses:
- ▶ BIA 650 Process Analytics and Optimization
- MGT 657 Operations Management
- ▶ BIA 658 Social Network Analytics
- MIS 637 Knowledge Discovery in Databases
 - * Required for a Graduate Certificate in Supply Chain Analytics

Business Process Management & Service Innovation (4 courses, 12 credits)

Choose four of the following courses:

- MIS 690 Supply Chain Management and Strategy
- MIS 710 Process Innovation & Management
- MIS 712 BPM and Workflow Implementation
- MIS 690 Supply Chain Management and Strategy
- MIS 714 Service Innovation
- ▶ BIA 650 Process Optimization & Analytics
- ▶ BIA 657 Supply Chain Analytics

Information Management (4 courses, 12 credits)

- MIS 620 Analysis and Development of Information Systems
- MIS 630 Data and Knowledge Management
- MIS 699 Managing Emerging Information Technologies
- MIS 760 Information Technology Strategy

General Management (4 courses, 12 credits)

- FIN 615 Financial Decision Making
- MGT 641 Marketing Management
- MGT 689 Organization Theory and Behavior
- MGT 699 Strategic Management

Project Management (4 courses, 12 credits)

- MGT 609 Introduction to Project Management
- MGT 610 Strategic Perspectives on Project Management
- MGT 611 Project Analytics
- MGT 612 Leading People and Projects

Technology Management (4 courses, 12 credits)

- FIN 615 Financial Decision Making
- MGT 641 Marketing Management
- MGT 671 Technology & Innovation Management
- MGT 699 Strategic Management

Telecommunications Management (4 courses, 12 credits)

- ▶ TM 601 Principles of Applied Telecommunications Technology
- TM 605 Probability and Stochastic Processes
- ▶ TM 610 Business Information Networks
- ▶ TM 612 Regulation and Policy in the Telecommunications Industry

COURSE OFFERINGS

Business and Technology

BT 100 Principles of Management

This course designed to provide a foundation of knowledge on the subject of management, while moving you closer to being an effective manager yourself. We discuss the functions, tasks, and responsibilities of managers in modern organizations. And we will focus on how managers engage their resources to achieve their goals. As this in an introductory course, we will survey a broad range of topics relevant to management scholars and managers.

BT 181 Seminar in Business

This course will broadly address the issue of how management decisions are made in a corporate business environment. The focus will be on understanding the tools, people and processes that are used in large public companies to make major decisions. We will explore this in the context of the major decisions made by senior management, as opposed to day-to-day decision-making. As a survey course we will only highlight the theory and detailed mechanics of complex decision-making. Our focus will be to discuss the issues faced by executives in solving complex problems that require their attention and review the methods used by business executives to handle uncertainty, mitigate risk and create outcomes that address the needs of the business. Throughout the course we will examine the decision-making process from the perspective of different departments; marketing, sales, corporate planning, production, financing, etc.While many of the planning, financial and analytical tools are common, their application within different departments can and will vary. The course will consist of two components: 1. Lectures and reading on decision-making tools, methods and procedures. 2. Business case discussion on the application of decision-making tools to timely issues faced by leading corporations.

BT 200 Financial Accounting

This course deals with the methods and principles of financial accounting. It is concerned with the measurement of the results of business activities and with the preparation and use of financial reports such as the balance sheet and income statement. Topics include: the accounting cycle, principles of accrual accounting, the measurement and reporting of detailed balance sheet items and the analysis of financial reports. Ethical issues in accounting will be addressed.

BT 214 Marketing Analytics and Research

This course exposes students to the entire marketing research process, from the problem formulation stage(at the very beginning) to the research findings report(at the very end). This objective is achieved in two ways: in the classroom, where the approach is one of discussion, lecture, and in-class exercises; and in the real world, where students are required to work closely with an actual business client on a marketing research project concerning an actual product or service.(The instructor assists the students in securing a business client.) During the course, the topics covered include: the marketing research process and problem formulation , research design, primary data collection, data collection forms, attitude measurement, sampling procedures, sample size, collecting the data, data analysis interpretation of results, and the final research report. The course builds heavily on the statistical foundation laid down during the prerequisite BT221 Statistics. A statistical package (SPSS) will be used during the analysis stage of the research process. Prerequisites: BT 221, BT 350

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This course covers contemporary decision support models of forecasting, optimization and simulation for business activity. Students learn how to identify the problem situation, choose the appropriate methods, collect the data and find the solution. Handling the information and generating of alternative decisions based on operations research optimization, statistical simulation and system dynamic forecasting. Computer simulations will be performed on PCs equipped by user-friendly graphical interface with multimedia reports generation for visualization and animation. Students will also be trained in business game simulations for group decision support.

BT 243 Macroeconomics

The forces which govern the overall performance of the national economy are covered. Areas discussed include the essence of the economic problem, supply and demand analysis, national income theory, the monetary system, alternative approaches to economic policy, current macroeconomic problems, and international economics.

BT 244 **Microeconomics**

The focus of this course is on the behavior of and interactions between individual participants in the economic system. In addition to providing a theoretical basis for the analysis of these economic questions, the course also develops applications of these theories to a number of current problems. Topics include: the nature of economic decisions, the theory of market processes, models of imperfect competition, public policy towards competition, the allocation of factors of production, discrimination, poverty and earnings, and energy.

BT 290 **Business Career Semimar**

This seminar is a one-credit, pass-fail course designed to provide sophomore students in their fall semester with tools, resources and support to start their job search and manage their careers. Each week, students will learn about a different aspect of strategic career planning and get practice applying lessons learned to their own future careers. Students will also get some exposure to the underlying theory of strategic career planning - e.g., motivational, network, and job satisfaction theories - as well as to major research findings.

BT 301 Strategy

Students learn how to set preliminary goals, objectives, and strategies. They begin to develop the specific aspects of their business plan, including an actual sales/revenue plan. Topics covered also include preparing an research and development plan and the use of historical information to prepare sales, revenues, and marketing expense estimates. Students work independently and in class, individually and in teams.

BT 321 Corporate Finance

This course will focus on the appropriate capital structure for a corporation. Topics covered include financial statement analysis, time value of money, valuation of financial instruments, risk and reward, capital structures, the capital asset pricing model and cash management. Prerequisites: BT 200

BT 325 **Financial Statement Analysis**

This course will review how firms communicate through financial statements. It discusses how accounting regulations and managerial discretion influence financial statements. The course will cover how to use financial statement analysis as an integral part of the strategic analysis of firms. The course will focus on how to interpret financial statements, analyze cash flows and make judgments about earnings quality. Prerequisites: BT 200, BT 321

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This course focuses on the managerial uses of accounting Prerequisites: BT 200

BT 221 Statistics

This course provides students with an understanding of the use of statistical methods as applied to business problems, in general, and to marketing research applications in particular. Topics include: descriptive statistics; probability theory, discrete and continuous probability distributions; sampling theory and sampling distributions; interval estimation; hypothesis testing; statistical inference about means, proportions, and variances; tests of goodness-of-fit and independence; analysis of variance and experimental design; simple and multiple regression; correlation analysis. This course has been developed with particular attention to the specific statistical foundation required by students enrolling in BT214 Marketing Research the next term. A statistical package (SPSS) will be used throughout the term.

BT 223 Applied Models and Simulation

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BT 330 Social Psychology and Organizational Behavior

Using an applied and experiential format, this course exposes students to theory, methods and research in organizational behavior and social psychology. Topics relating to individual differences and group dynamics in organizational settings are stressed. Learning occurs through discussion, group activities, and the completion of assessment instruments. Emphasis is on helping students understand and improve their skills in key areas, including decision-making, leadership, negotiation, and conflict resolution.

BT 333 Database Management

The course addresses the application of relational databases to solve business problems. It focuses on relational database model, multi-table query languages, file and index organization and integrity. Advanced topics include calculations in creating professional and useful reports, pivot tables and charts for data mining, database maintenance and the customization of a database with programming languages. Upon completion of this course students will be able to design, implement and maintain a relational database. Prerequisites: MIS 201 or BT 121

BT 350 Marketing

The purpose of this course is to provide the conceptual frameworks and decision tools required for the success in both technology-based and non-technology-based markets: the student learns to define and select specific customer segments; to monitor the business environment for both opportunities and threats, with particular attention to the ever changing technological and global context; and to develop marketing strategies for serving each targeted customer segment profitably. Although this course introduces the student to the basic theory and analytical methods characterizing modern marketing practice, there is an emphasis on both the marketing of technology products/services as well as the impact of technology on the general practice of marketing. Students are required to present both detailed marketing plans and several rigorous case analyses.

BT 353 Project Management

This course will describe the problems of managing a project within a permanent organization for the purpose of achieving a specific objective. It will broadly cover the operational and conceptual issues faced by modern project managers. At the end of this course, students should be able to develop, execute, and control a basic project plan capable of supporting business objectives linked to measures of success for a single project.

BT 360 International Business

The International Business course focuses on the impact of variation in the economic, political, legal, social, and cultural contexts of nations on the competitive business strategies of local and multinational firms.

BT 372 Entrepreneurship

Students are confronted with the challenges, problems and issues faced by inventors who seek to transform their inventions into economic viable innovations. This integrative course develops the fundamental business skills necessary to identify, evaluate, develop and exploit business opportunities.

BT 401 Capital Structure & Strategy Audit

Students learn how to use their business plan, deal with problems encountered, update, and get funding. They are exposed to the issues of law, ethics, and negotiation as applied to business implementation. Students are required to make their first full-plan presentation to peers and faculty. Topics include type of capital and alternative sources, venture capital, and building the organizational infrastructure for plan support. Prerequisites: BT301

BT 403 Marketing Strategy in a Digital World

Marketing Strategy in a Digital World is a course designed to give Marketing students an intensive and application-oriented look at how marketing strategy works in the real world. The emphasis of the case is going to be on cases, analysis, real life examples, and presentations. Prerequisites: BT 350

BT 411 Senior Design I

BT411 is divided into two segments. The first segment involves working in teams on a pre-defined problem; working through one full cycle of Lean Business Processes. For the second segment, armed with this stem-to-stern experience, students then plan and focus on work for a client's business. Teams form into project teams, propose a project for approval, submit a project plan, work though several cycles of each stage of Lean Business development, to test, refine, and build a sustainable program to help your client's business.

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BT 412 Senior Design II

BT 412 is the second of a two-semester sequence. In this course students focus on refining their business models and consulting plans, especially by clarifying their diagnoses and hypotheses, systematically testing assumptions, prototyping and testing solutions, and working to execute their recommendations. Teams will present their final 'product' (business model & prototype, consulting analysis & solution) to their client and to the School of Business community. Prerequisites: BT 411

BT 413 **Business Law**

The course introduces students to the fundamental concepts and legal principles that they can expect to encounter in various roles as managers/professionals in public and private companies, consultants and/or entrepreneurs, together with the ethical criteria, moral values and social norms in the environments they will face. The course will cover the American judicial system, international law in a global economy, ethics and business decision making, and different forms of business structure, contracts, business torts, products liability, insurance, employment law, criminal law and the recent Dodd-Frank Wall Street Reform & Consumer Protection Act.

BT 416 **Business Process Management**

The course addresses the methods and techniques required to analyze, design, implement, automate, and evaluate business processes. Structured along the phases of the Business Process Management (BPM) life cycle, students learn to analyze organizational performance from a process perspective, redesign processes using value-focused techniques, design workflows and implement them in BPM systems, simulate new process designs, and create process analytics applications using dashboards. The course leads students from process discovery through conceptual and technical process design through the implementation and management of workflows to the structure of process-aware information systems. Upon completion of this course students will be able to assess the efficiency and effectiveness of an organization from a process perspective, conduct process improvement projects, and determine the role of technology in supporting corporate processes. Prerequisites: MIS 201

BT 419 Entrepreneurship Practicum

This capstone course within the Entrepreneurship minor is designed to develop the content and presentation of the technical and business elements of students' entrepreneurial business plans. Starting with the technical aspects of the design project, students are led through the components of a complete business plan, with instruction and practice in the writing and presentation of the plan. As a capstone exercise, students complete the course by presenting their business plans in an 'Elevator Pitch' event at which venture capitalists and other investors rate the quality of student presentations and entrepreneurial business ideas. Prerequisites: BT 372 or MGT 472

BT 421 Systems Analysis and Design

This course focuses on the analysis and development of systems to meet the increasing need for information within organizations. It presents and analyzes various topics such as systems development life cycle, analysis and design techniques, information systems planning and project identification and selection, requirements collection and structuring, process modeling, data modeling, design of interface and data management, system implementation and operation, system maintenance, and change management implications of systems.

BT 422 **Decision Making**

The objective is to acquaint you with the research and principles of judgment and decision making. Most of the material covered is about understanding and improving the judgment and decision making processes of managers and other professionals. Understanding decision making involves examining how decision makers think about difficult problems and characterizing the limitations of human decision making ability. By understanding how decisions are made, we can provide guidelines and techniques for overcoming limitations and improving the quality of decision making. This includes understanding statistically-based decision making, the psychological aspects of decision making and rational approaches to decision making. The course's goal is to provide insights and tools that will enable you to support and improve your own decision making, to understand the decision making of others, and to enhance the decision quality of team and groups that you lead.

BT 425 Portfolio Management

An introduction to the investment management process emphasizing measuring and managing investment risk and return. Topics will include investment objectives and constraints, modern portfolio theory, CAPM, efficient markets, stock and bond valuation models, performance evaluation, futures and options. Cross-listed with: BT321

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Recently, the advent of electronically mediated social networks has transformed the way we interact in government,

BT 435

educational, and business institutions. A set of social network analysis methods, with roots in sociology, graph theory, and computer science, can help us make sense of this complicated phenomenon. This course will provide a basic understanding of electronically mediated social networks in the context of the management discipline of marketing. In order to provide this understanding, we will survey ideas that have surfaced in, management, psychology, computer science, and sociology. By the end of the course, students will be capable of understanding electronically mediated social networks: the way they form, the way they grow, and the way they are applied in business. Students will be capable of analyzing existing networks, and will also be able to build new networks. That is, there will be labs in which tools and techniques for both understanding and designing electronically mediated social networks will be explained and used. Students will also be asked to actively participate in creating a part of an electronically mediated social network: working in teams, they will attempt to create ideas or applications that will go viral: they will attempt to create an information cascade. Prerequisites: BT350

BT 440 Money, Banking and Financial Institutions

Social Media and Network Analysis

This course explores the economics of banking and financial markets. Topics to be discussed include: an overview of finanical markets and institutions, the theory of interest rates, rational expectations theory, the Efficient Market Hypothesis, the roles, functions, and structures of financial institutions, the U.S. banking industry, and central banking and the conduct of monetary policy. Prerequisites: BT 321

BT 442 **Fixed Income Analysis**

The aim of this course is to provide you with an introduction to the valuation of fixed income securities and the management of fixed income investment portfolios. We will start with the basics of bond pricing - the relationship between the price of a bond, measures of return on the bond and measures of risk. Next, we will discuss the credit rick assessment and bond issuance process from a market practitioner perspective. The tools for the valuation of bonds, fixed income derivatives and credit derivatives will be the focus of the third segment of the course. Prerequisites: BT 321, BT 440

BT 445 Virtual and Physical Consumer Behavior

Marketing begins and ends with the consumer. The purpose of this course is to introduce students to the study of consumer behavior. This is an interdisciplinary course that integrates perspectives from marketing, psychology, sociology, anthropology, and economics in order to examine the elements of the consumer decision-making process and to enable formulation of marketing strategies. Students will take the perspective of a marketing manager who needs knowledge of consumer behavior in order to develop, evaluate and implement effective marketing strategies. The course integrates lectures, case analysis, and discussions to focus on the implications of social science concepts for marketing strategy. Prerequisites: BT350

BT 450 **Global Management Seminar**

This seminar will examine the processes of globalization for multi-national companies and why they seek markets in other countries. US and foreign countries cultural, labor and management issues will be compared. How management practices transfer across cultures will also be examined. Includes visits to overseas companies as part of a field study experience.

BT 454 International Economics and Finance

"This course applies principles of economics and finance to the international setting. The first half of the course deals with microeconomic and macroeconomic issues of international trade and covers such issues as (i) why countries trade, (ii) the theory and practice of trade policy including multilateral trade liberalization within the WTO and regional economic integration. (iii) exchange rates. The second half of the course teaches students how to be effective global financial managers. To achieve this goal, the course focuses on important topics that include the fundamentals of the macroeconomic environment of international financial management, the financial environment in which the multinational firm and its managers must function, and foreign exchange management and financial management in a multinational firm." Prerequisites: BT 243 or BT 244, and BT 321

BT 426 **Equity Valuation**

This is an advanced course that is designed to provide you with a comprehensive perspective of how financial theory is applied to valuation problems. The tools and techniques that will form the foundation of the course can be applied to a broad range of valuation topics that extend beyond securities (or public equities) and will encompass pricing for: private enterprise valuation and term sheets; intellectual property rights and patents; marketing and distribution agreements; commercial real estate leases; licensing agreements; options and insurance contracts. The course will center on intrinsic enterprise or project evaluation and will build upon the concepts introduced in the basic Corporate Finance course. Cross-listed with: BT321

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BT 465 Integrated Marketing Communications

This course will give students an insightful overview of the practice and power of public relations, and its role in the marketing mix. No longer an industry relegated to sending out press releases as a means to communicate, this course will help students understand the power of communication across all genres, and appreciate the role of communication/reputation management in all aspects of business. From corporate earnings announcements to employee relations and philanthropic endeavors, this course will relay the basic elements for this effective tool. This course, taught by a practicing professional, will give an overview of outside PR counsel; internal PR departments; and how to manage the specialty function.

BT 499 Independent Study

Independent study allows the student to participate in research, explore a topic not covered by existing courses, or continue to study in greater depth a topic introduced by a course. Independent study courses must be conducted under the guidance of a full time faculty member, whose approval is required prior to enrollment. The student and faculty member must agree on the scope and details of participation in advance. Independent Study courses carry one to three credits.

BT343 Intermediate Macroeconomic Theory

This is an intermediate macroeconomics course designed with the goal of providing a deeper understanding of current events, macroeconomic theory and economic policy. The course will cover long-run economic performance and its determinants, as well as short-run dynamics and economic fluctuations. This distinction should allow students to comprehend the implications of public policies that have a persistent impact on the economy, such as those that address growth, structural unemployment, inflation and government debt, from the monetary and fiscal policies that have a more immediate effect on economic outcomes. The role of central banks, governments, financial institutions, and globalization will also be addressed. Throughout the course, examples of the real world will be considered and the final part of the course will address recent issues in the macroeconomic debate. Prerequisites: BT243

BT344 Intermediate Microeconomic Theory

This is a course in intermediate microeconomics designed with the goal of providing students with a deeper understanding of economic analysis. It broadly involves the study of consumer and firm behavior starting from the standard perfect competiton paradigm and introducing models of imperfect competition. Throughout the course, formal models will be motivated and discussed. The theory will be accompanied by the study of real world applications, as well as considering economic policies targeted at specific industries or sectors. Prerequisites: BT244

BT447 Creativity and Innovation

This course is about creativity and innovation, which are now the main sources of competitive advantage in many industires. Many firms now rely on products developed within the prior three to five years for a large portion of their revenues and profits. In this course, we will explore such key topics as the industry dynamics of technological innovation, the formulation of technological innovation strategy, and the implementation of technological innovation strategy. We will strive to go beyond simply learning concepts, although understanding major concepts is of critical improtance to hte management of technology and innovation. Throughout the course, key conceptual frameworks will be linked to applications in a variety of organizational inad industrial settings.

Business Intelligence and Analytics

BIA 650 Optimization and Process Analytics

This course covers basic concepts in optimization and heuristic search with an emphasis on process improvement and optimization. This course emphasizes the application of mathematical optimization models over the underlying mathematics of their algorithms. While the skills developed in this course can be applied to a very broad range of business problems, the practice examples and student exercises will focus on the following areas: healthcare, logistics and supply chain optimization, capital budgeting, asset management, portfolio analysis. Most of the student exercises will involve the use of Microsoft Excel's "Solver" add-on package for mathematical optimization.

BIA 652 Multivariate Data Analysis I

This course introduces basic methods underlying multivariate analysis through computer applications using R, which is used by many data scientists and is an attractive environment for learning multivariate analysis. Students will master multivariate analysis techniques, including principal components analysis, factor analysis, structural equation modeling, multidimensional scaling, correspondence analysis, cluster analysis, multivariate analysis of variance, discriminant function analysis, logistic

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regression, as well as other methods used for dimension reduction, pattern recognition, classification, and forecasting. Students will build expertise in applying these techniques to real data through class exercises and a project, and learn how to visualize data and present results. This proficiency will enable students to become sophisticated data analysts, and to help make more informed design, marketing, and business decisions. Prerequisite is MGT 620 or equivalent; basic knowledge of descriptive and inferential statistics is expected.

BIA 654 Experimental Design II

This course introduces basic methods underlying multivariate analysis through computer applications using R, which is used by many data scientists and is an attractive environment for learning multivariate analysis. Students will master multivariate analysis techniques, including principal components analysis, factor analysis, structural equation modeling, multidimensional scaling, correspondence analysis, cluster analysis, multivariate analysis of variance, discriminant function analysis, logistic regression, as well as other methods used for dimension reduction, pattern recognition, classification, and forecasting. Students will build expertise in applying these techniques to real data through class exercises and a project, and learn how to visualize data and present results. This proficiency will enable students to become sophisticated data analysts, and to help make more informed design, marketing, and business decisions. Prerequisite is MGT 620 or equivalent; basic knowledge of descriptive and inferential statistics is expected.

BIA 656 Statistical Learning & Analytics

The significant amount of corporate information available requires a systematic and analytical approach to select the most important information and anticipate major events. Statistical learning algorithms facilitate this process understanding, modeling and forecasting the behavior of major corporate variables. This course introduces time series and statistical and graphical models used for inference and prediction. The emphasis of the course is in the learning capability of the algorithms and their application to finance, direct marketing, operations, and biomedicine. Students should have a basic knowledge of probability theory, and linear algebra.

BIA 658 Social Network Analysis

This course introduces concepts and theories of social networks as well as techniques to conduct marketing research from a network perspective. Network concepts covered include graph-theoretic fundamentals, centrality, cohesion, affiliations, equivalence, and roles. Network theories covered include embeddedness, social capital, homophily, and models of network growth. Design issues will also be covered, including data sampling and hypothesis testing. Another focus of this course is on marketing applications of social network analysis, in particular the use of knowledge about network properties and behavior, such as hubs and paths, the robustness of the network, and information cascades, to better broadcast products and search targets. Application areas include customer profiling, community detection, targeting, sentiment analysis, and development of recommendation systems. Prerequisites are BIA 652, BIA 654, MIS 637, and BIA 656. Knowledge and skills learned in these required courses (e.g., R, python, machine learning) are applied to social network analysis.

BIA 660 Web Analytics

In this course, students will learn through hands-on experience how to extract data from the web and analyze web-scale data using distributed computing. Students will learn different analysis methods that are widely used across the range of internet companies, from start-ups to online giants like Amazon or Google. At the end of the course, students will apply these methods to answer real scientific question or to create a useful web application. Prerequisites: BIA 652, MIS 637, BIA 656

BIA 670 Risk Management Methods and Applications

Theoretical and practical aspects of risk assessment and management will be covered. Major topics include: Importance of innovation and technological changes in current competitive environment, risk and uncertainty, decision trees, binomial methods and derivation of Black-Scholes option pricing formula, extension of option methodology to non-financial (real) options, VAR (value at risk), a framework of risk assessment, and several real-world case studies. The course is designed for all students in the School of Technology Management. Prerequisites: TM 605 or CS 505, TM 500

BIA 672 Marketing Analytics

In this course, students will learn about marketing analytics techniques such as segmentation, positioning, and forecasting, which form the cornerstone of marketing strategy in the industry. Students will work on cases and data from real companies, analyze the data, and learn to present their conclusions and make strategic recommendations. Prerequisites: BIA 656

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BIA 674 Supply Chain Analytics

Supply chain analytics is one of the fastest growing business intelligence application areas. Important element in Supply Chain Management is to have timely access to trends and metrics across key performance indicators, while recent advances in information and communication technologies have contributed to the rapid increase of data-driven decision making. The topics covered will be divided into strategic and supply chain design and operations, including -among others- supplier analytics, capacity planning, demand-supply matching, sales and operations planning, location analysis and network management, inventory management and sourcing. The primary goal of the course is to familiarize the students with tactical and strategic issues surrounding the design and operation of supply chains, to develop supply chain analytical skills for solving real life problems, and to teach students a wide range of methods and tools -in the areas of predictive, descriptive and prescriptive analytics- to efficiently manage demand and supply networks.

BIA 676 Data Streams Analytics: Internet of Things

In recent years, the progress in sensor technologies, RFID (Radio Frequency Identification) tags, smart phones and other smart devices has made it possible to measure, record, and report large streams of transactional data in real time. Such data sets, which continuously and rapidly grow over time, are referred to as Big Data Streams. Analysis of streaming data poses a number of unique challenges which are not easily solved through direct applications of well-known data mining methods and algorithms developed for traditional static data. This course will serve as a first course on the emerging field of "Data Streams Analytics". It will provide an introduction to IoT, sensors & devices, the architecture and environment in which these devices generate data streams, the data quality & data cleaning, data acquisition, and emerging methodologies and algorithms for knowledge discovery from data streams. Topics include: synopsis & sampling techniques, sliding windows, computing the entropy in streams, data streams correlations, change detection, outliers & anomaly detection.

BIA 678 Big Data Seminar

The field of Big Data is emerging as one of the transformative business processes of recent times. It utilizes classic techniques from business intelligence & analysis (BI&A), along with a new tools and processes to deal with the volume, velocity, and variety associate with big data. As they enter the workforce, a significant percentage of BIA students will be directly involved with big data as technologists, managers, or users. This course will build on their understanding of the basic concepts of BI&A to provide them with the background to succeed in the evolving data-centric world, not only from the point of view of the technologies required, but also in terms of management, governance, and organization.

BIA 680 Applied Analytics/Life Sciences

The capstone course brings together the key elements of the business intelligence and analytics curriculum. Students have an opportunity to apply the concepts, principles, and methods they have learned to real problems in an application domain associated with their area of interest. At the end of the course, students present their projects in a poster session for review by industry practitioners in pharmaceutical and life sciences.

BIA 686 Applied Analytics in a World of Big Data

Business intelligence and analytics is key to enabling successful competition in today's world of "big data". This course focuses on helping students to not only understand how best to leverage business intelligence and analytics to become more effective decision makers, making smarter decisions and generating better results for their organizations. Students have an opportunity to apply the concepts, principles, and methods associated with four areas of analytics (text, descriptive, predictive, and prescriptive) to real problems in an application domain associated with their area of interest.

BIA 702 Curricular Practical Training

This course involves an educationally relevant, practical assignment that augments the academic content of the student's program. Students engage in a project in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports and at the end of the semester, a detailed written report that describes his/her activities and knowledge gained during that semester. This is a one-credit course that may be repeated up to a total of three credits.

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SCHOOL OF BUSINESS

Finance

FIN 510 **Financial Statement Analysis**

This course deals with (1) interpretation of financial statements, (2) evaluation of the alignment between business strategies and financial performance, (3) identification of potential business risks, and (4) comparison of performance of different companies. The course introduces business analysis and valuation techniques and utilizes real world data to help students comprehend financial statement analysis tools. Topics covers financial statement information, tools of financial statement analysis, and forecasting and valuation techniqes. Prerequisites: MGT 600

FIN 620 **Financial Econometrics**

This course introduces the main concepts of data analysis and econometrics applied to financial problems. The course explores data analysis techniques; time series models; multivariate, factor and Bayesian models applied to high frequency trading, volatility forecast, risk management, portfolio optimization, and asset pricing. Students will work with historical databases, conduct their own analysis, and test trading and/or investment strategies based on the techniques reviewed during the class. Prerequisites: BIA 652 or MGT 700

FIN 702 Curricular Practical Training

This course involves an educationally relevant, practical assignment that augments the academic content of the student's program. Students engage in a project in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports and at the end of the semester, a detailed written report that describes his/her activities and knowledge gained during that semester. This is a one-credit course that may be repeated up to a total of three credits. With approval of the Program Director and faculty supervisor, students may also take this course for up to three credits in one semester.

FIN 800	Special Problems in Finance (MS)	(1 to 6)
With permission of the instructor. Limit of six credits for the degree of Master of Science.		
FIN 801 With permission (Special Problems in Finance (PHD) of the instructor. Limit of six credits for the degree of Doctor of Philosophy.	(1 to 6)
FIN 810	Special Topics in Finance	(3)

A participating seminar on topics of current interest and importance in Management of Finance.

FIN 900 Thesis in Finance (MS) (1 to 12 - -)

For the degree of Master of Science. Hours and credits to be arranged.

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This course concentrates on IT trends and issues in the financial services industry. Due to the diversity of this industry (banking, brokerage, and insurance), along with the assortment of customer characteristics (i.e. retail vs. institutional), we will modularize the lectures by industry and customer partitions. This segregation will provide for a better understanding of this ever-changing industry. Upon successful completion of this course, students will have a solid understanding of the industry, market dynamics, and how their roles in technology have an immense impact in the industry. This course will cover the structure and functioning of financial services, from the perspective of banking, insurance, capital markets, and brokerage. Topics include industry consolidation and globalization, investment banking, fixed-income markets, the equity markets, the regulatory environment, and financial analysis approaches. Trends in IT and its effect on each of these areas will be discussed.

FIN 683 Financial Services Industry Back Office

This course is designed to provide the student with an in-depth understanding of the back-office trade process and the role of information technology (IT) in this process, with the goal of helping the student to be an effective provider of information system development and operations in this arena. The various phases of the trade process will be described, including key regulatory requirements. The current contributions of IT to the process will be reviewed, including straight-through processing, T+1 and foreign exchange trades. Topics include the structure and vocabulary of a trade and trade processing, the street-side view of a process flow, global processing, regulatory and compliance, back-office best practices, improving efficiencies and real-time processing.

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FIN 684 Financial Services Industry Marketing and Sales

This course concentrates on effective selling and marketing IT strategies in the financial services industry. Due to the diversity of this industry (banking, brokerage, and insurance), along with the multiplicity of customer characteristic (retail vs. institutional), we will modularize the lectures by industry and customer partitions. This segregation will provide for a better understanding of this ever-changing industry. Upon successful completion of this program, students will identify client constituent's product needs and the ability for financial services companies to deliver this product (service) in a timely, cost-effective fashion. Corporate branding and marketing strategies will be reviewed and challenged by the student. Topics include the "sell-side", the "buy-side", the selling distribution process, e-business selling strategies, marketing strategies and corporate bonding, the role of data warehousing and sales data mining, and partnership with the client.

Information Systems

MIS 201 Fundamentals of Information Systems

This course provides an introduction to systems and development concepts, information technology and application software. It explains how information is used in organizations and the effects IT has on the organization's structure, processes, employees, customers, and suppliers. In addition, the course describes how IT enables improvement in quality, timeliness, and competitive advantage. Structure and functions of computers and telecommunications systems are also examined.

MIS 410 Designing Information Systems

This course covers information systems design and implementation. Students will demonstrate their mastery of the design process acquired in earlier courses by engaging in the physical design and implementation process for an information system of a limited scope.

MIS 430 Integrating Information Systems

This course focuses on the relationships and the interdependencies among networks, hardware, data, and applications. The students will learn how to design in the large, make appropriate choices about architecture in relationship to overall organization goals, understand the different mechanisms for coordination available, and create a process for establishing and maintaining an ongoing enterprise architecture.

MIS 440 Information Networks

This course provides an in-depth knowledge of data communications and networking requirements including networking and telecommunications technologies, hardware, and software. Emphasis is upon the analysis and design of networking applications in organizations. Management of telecommunications networks, cost-benefit analysis, and evaluation of connectivity options are covered. Students learn to evaluate, select, and implement different communication options within an organization.

MIS 460 IT Strategy: Strategic Issues in IT Management

This course introduces students to the use of computerized information systems to satisfy strategic business needs. It outlines the concepts of information systems for competitive advantage, data as a resource and IS and IT planning and implementation. It concentrates on developing the students' competency in current/emerging issues in creating and coordinating the key activities necessary to manage the day-to-day IT functions of a company.

MIS 620 Analysis and Development of Information Systems

This course presents and analyzes various approaches to information analysis and development of organizational information systems within a system development life-cycle (SDLC), e.g. the waterfall, concentric, and prototyping approaches. Topics include strategic planning for SDLC, front-end and back-end phases of SDLC, project management, CASE methodologies, and balancing user, organizational, and technical considerations.

MIS 630 Data and Knowledge Management

This course deals with strategic uses of data, data structures, file organizations and hardware as determinants of planning for and implementing a enterprise-wide data management scheme. Major course topics include data as valuable enterprise resource, inherent characteristics of data, modeling the data requirements of an enterprise, data repositories and system development life cycles.

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MIS 635 Designing the Knowledge Organization

This course will focus on the design and management of the knowledging organization organizations that generate and apply knowledge. A central theme of this course is the design of knowledge work. We concentrate on both micro- and macro-design and their interrelationships: individual, team, task, process, and organization levels. This courses comprises what is generally termed knowledge management and by extension the learning organization.

MIS 636 Data Warehousing and Business Intelligence

This course focuses on the design and management of data warehouse (DW) and business intelligence (BI) systems. The course is organized around the following general themes: Knowledge Discovery in Databases, Planning and Business Requirements, Architecture, Data Design, Implementation, Business Intelligence, Deployment, Maintenance and Growth, and Emerging Issues. Practical examples and case studies are presented throughout the course.

MIS 637 Knowledge Discovery in Databases 1

This course will focus on Data Mining & Knowledge Discovery Algorithms and their applications in solving real world business and operation problems. We concentrate on demonstrating how discovering the hidden knowledge in corporate databases will help managers to make near-real time intelligent business and operation decisions. The course will begin with an introduction to Data Mining and Knowledge Discovery in Databases. Methodological and practical aspects of knowledge discovery algorithms including: Data Preprocessing, k-Nearest Neighborhood algorithm, Machine Learning and Decision Trees, Artificial Neural Networks, Clustering, and Algorithm Evaluation Techniques will be covered. Practical examples and case studies will be present throughout the course.

MIS 638 Knowledge Discovery in Databases II

This course will focus on Data Mining & Knowledge Discovery Methods and Models. We concentrate on both methods and applications. The course will begin with a n introduction to probability, statistics, and sampling techniques. Methodological and practical aspects of knowledge discovery tools and techniques including: Principle Components, Linear Regression, Logistic Regression, Naive Bayes Estimations and Bayesian Networks will be covered. Practical examples and case studies will be present throughout the course.

MIS 661 Marketing Online

This course provides a basic understanding of social network theories and the way they are applied in online marketing. Students will develop this understanding from three aspects: (1) social network theories and marketing theories, (2) the techniques and best practices of online marketing, and (3) social network analysis. The specific topics include the representation of networks and basic concepts of network theories, such as strength of weak ties, centrality, clustering coefficient, small world network. These topics also include online marketing techniques: such as email marketing, search engine optimization, social media marketing, etc. Also students will be expected to conduct quantitative analysis of marketing data, such as MDS, cluster analysis and opinion mining.

Analyzing and Leveraging Social Media Websites (3 - 3 - 0)MIS 669

The growing use of websites, such as Facebook and Twitter, allows everyone to generate and share content. These social media tools have become integral to our everyday lives. Students will learn various techniques for analyzing user behavior in social media websites by applying prominent theories that influence human behavior in these environments. They will examine these websites and evaluate their positive and negative impacts on society. The skills and knowledge that students acquire in this course will allow them to make recommendations for leveraging websites and other products/services that involve social media technologies. Cross-listed with: TM 669

MIS 685 The Healthcare Value Chain

This course has been designed to provide foundational knowledge about the healthcare industry for information technology (IT) professionals working in (or aspiring to work in) the healthcare industry. After an introduction to the U.S. healthcare system from a stakeholder perspective, students learn about the information and communication needs of key interdependent stakeholders: healthcare providers (hospitals, physicians), suppliers of surgical and non-surgical equipment and drugs, thirdparty insurers and payers (including government), and the healthcare consumer (patients). The course materials include readings by current thought leaders, in-depth case studies, background summaries prepared by the instructor, and public Web-based resources. Students gain up-to-date knowledge about current healthcare IT solutions used by key players in the healthcare valuechain, and also learn about resources for understanding future IT-related trends in this fast-changing industry. This course is also a pre-requisite for three MIS courses that focus on specific types of HIT applications and the process changes and healthcare data needed to support them: MIS 686, MIS 687, and MIS 688

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IT Management for the Healthcare Professional

This course has been designed to provide the healthcare professional (physicians, nurses, allied health, and other healthcare professionals) with a foundation in information management. The adoption of clinical systems (electronic medical records, computerized physician ordering, e-prescribing) by healthcare providers, and the growth of evidence-based decision support systems within healthcare providers, suppliers, insurers, and payers in the healthcare value chain, is expected to significantly increase. For the effective utilization of these investments, healthcare professionals who have a mastery of IT management fundamentals are needed to participate in the design, development, and support of all of these types of IT investments. Students will gain an up-to-date knowledge about managing healthcare IT (HIT), and also become familiar with resources for keeping up-to-date with IT terminology and trends in this fast-changing industry.

MIS 690 Supply Chain Management and Strategy

MIS 689

This course serves as the foundation course for studying strategic supply chain management within the Howe School. The course explores the major elements of the supply chain, and exposes students to leading edge thinking on supply chain strategy as well as practical tools and methods for its implementation. Topics covered include: Supply Chain Management Principles and the Customer; Supply Chain Networks and Organizations; Product Lifecycle Implications to Supply Chains; Forecasting and Inventory Management; Supply Chain Processes; Supply Chain Information Systems; Supply Chain Performance and Metrics; Lean Supply Chains; Risk Management; and Legal and Ethical Issues.

MIS 691 Procurement and Supplier Management

The Procurement and Supplier Management course explores the strategic issues in procurement and supply management, including the purchasing process, procurement cycle, purchasing research, relationships with suppliers, negotiation, commodity planning, as well as price and value analysis. The course covers the organizational, strategic, and operational aspects of procurement and supply management, along with an integrated view of how product/service supply networks are being designed and deployed to meet the needs of a highly differentiated customer base.

MIS 692 Distribution and Logistics Management

The Distribution and Logistics Management course explores the strategic issues in order, transportation, and distribution management, including the provisioning of finished goods and services to meet planned or actual demand. The course covers in-depth Distribution and Logistics Principles; Customer Fulfillment; Product Lifecycle Management; Distribution and Logistics Processes; Information Systems; Future Trends; as well as, Regulatory and Import/Export Issues.

MIS 699 Managing Emerging Information Technology

IT organizations must be able to leverage new technologies. This course focuses on how organizations can effectively and efficiently assess trends and emerging technologies in data and knowledge management, information networks, and analyzing and developing application systems. Students will learn how to help their organizations define, select, and adopt new information technologies.

MIS 710 Process Innovation and Management

This course focuses on the role of Information Technology (IT) in reengineering and enhancing key business processes. The implications for organizational structures and processes, as the result of increased opportunities to deploy information and streamline business systems, are covered. Cross-listed with: NIS 630

MIS 712 Advanced Business Process Management

The course addresses the techniques and concepts required to map, implement, automate, and evaluate business processes. Focusing on the technical and implementation aspects of Business Process Management, the course leads students from technical process design through the implementation and management of workflows to the structure of process-aware information systems. It discusses the distinction between business processes and business rules and outlines how they can be supported by technology. It details the technical structure of process-aware applications and provides an overview of technology standards that affect BPM systems. Modules on the run-time monitoring of processes and post-execution evaluation techniques complete this course. Prerequisites: MIS 501, MIS 620 Corequisites: MIS 710

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MIS 714 Service Innovation

This course leads students through the identification, analysis, definition, and deployment of service opportunities within public and private organizations. Each of these phases is analyzed in detail to encompass the principal activities, methods, tools and techniques applied in the respective phase. Students will learn how to identify appropriate supporting techniques and information technologies for the different phases of the service life cycle, assess the role of technology, and gauge the organizational impact of service-focused operations. The objective of the course is to enable students to identify, implement and evaluate innovative service offerings in their organization.

MIS 722 Research Seminar: Business Process Management & Innovation (3 - 0 - 0)

The course introduces PhD students to research areas surrounding the design, implementation, and improvement of organizational processes. The process-oriented analysis of organizations serves as a focal point for the integration of business requirements (in form of business processes) with technology capabilities (in form of process support systems). Research topics within the area of process innovation range from organization theory and workplace design to control theory and the formal representation of processes. Students will discuss seminal research papers in the individual course modules and develop a research paper of their own on a topic related to process innovation. Prerequisites: MIS 710 or permission of the instructor

MIS 730 Integrating Information System Technologies

This course focuses on the issues surrounding the design of an overall Information Technology architecture. The traditional approach in organizations is to segment the problem into four areas - network, hardware, data, and applications. Instead, this course concentrates on the interdependencies among these architectures. In addition, this course will utilize management research on organizational integration and coordination. The student will learn how to design in the large, make appropriate choices about architecture in relationship to overall organization goals, understand the different mechanisms for coordination available, and create a process for establishing and maintaining an ongoing enterprise architecture. Cross-listed with: NIS 633 Prerequisites: MIS 620, MIS 630 MIS 640

MIS 735 Managing IT Service Processes

MIS 735 entails the examination of architecture and process considerations for maximizing the quality and integrity of IT services and software, including measurements, compliance testing, and audits. The course maps to the Service Strategy and Service Design domains of ITIL. Prerequisites: MIS 501

MIS 760 Information Technology Strategy

The objective of this course is to address the important question, "How does one improve the alignment of business and Information Technology strategies?" The course is designed for advanced graduate students. It provides the student with the most current approaches to deriving business and Information Technology strategies, while ensuring harmony among the organizations. Topics include business strategy, business infrastructure, IT strategy, strategic alignment, methods/metrics for building strategies, and achieving alignment. Cross-listed with: NIS 632 Prerequisites: MIS 750

MIS 800 Special Problems in MIS (MS)

With permission of the instructor. Limit of six credits for the degree of Master of Science. Cross-listed with: MGT 800

MIS 810 Special Topics in Management of Information Systems

A participating seminar on topics of current interest and importance in Management of Information Systems.

MIS 900 Thesis in MIS (MS)

For the degree of Master of Science. Six to 12 credits with departmental approval.

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Management

FIN 600 Financial and Managerial Accounting

This course will develop accounting analysis useful for managerial decision-making purposes. Topics will include an introduction to elements of financial accounting, cost-profit-volume analysis, manufacturing costs and elements of cost accounting, special decision analysis, budgeting, variances, and controllability and responsibility accounting.

FIN 615 Financial Decision Making

Corporate financial management requires the ability to understand the past performance of the firm in accounting terms; while also being able to project the future economic consequences of the firm in financial terms. This course provides the requisite survey of accounting and finance methods and principles to allow technical executives to make effective decisions that maximize shareholder value.

principles of valuation and risk. Specific applications include the valuation of debt and equity securities as well as capital budgeting analysis, financial manager's functions, liquidity vs. profitability, financial planning, capital budgeting, management of long term funds, money and capital markets, debt and equity, management of assets, cash and accounts receivable,

inventory and fixed assets. Additional topics include derivative markets. Prerequisites: MGT 600 or MGT 615

FIN 623 **Financial Management**

Capital Markets FIN 625

This course is designed to familiarize the student with the current workings of the capital markets. This course describes fundamental analytical techniques and state-of-the-art financial instruments. It begins with the time value of money and progresses to bond mathematics, portfolio management, and derivatives. The role of information technology is emphasized in both the development and delivery of financial instruments. Students will learn to structure IT applications to meet the needs of a trader or broker. Topics include the time value of money, bond math, the yield curve, analytical tools, trading and investment strategies, money market instruments and repurchase agreements, corporate bonds, macroeconomic dynamics, derivatives, securitization, equities, and the role of IT in capital markets Prerequisites: MGT 600

FIN 626 Venture Capital

This course addresses the fundamentals of venture capital, which includes the venture capital industry, the structure of venture capital firms and venture capital investments. It addresses in some detail the relationship between venture risk and return, the cost of venture capital and the valuation of high growth companies. The course covers a variety of valuation methods as well as analysis of company capital structure or "cap tables".

FIN 627 **Investment Management**

This course takes a practical approach to managing investments. It covers a wide variety of investment vehicles ranging from pure equity and debt offerings to complex derivatives and options. Various investment strategies are presented which are focused on the different fundamental approaches and tactics used by leading investors to achieve their financial goals. The course also focuses on investment styles, including momentum, growth, income, distressed, asset allocation, and vulture investing, to name just a few. Students participate in real time simulation experiences to create viable portfolios of stocks, bonds and other investments; while tracking their performance against the overall market and the class on a weekly basis throughout the course. Prerequisites: MGT 623

FIN 628 Derivatives

This course covers the fundamentals of financial derivatives, including the basic properties and the pricing of futures, options and swaps. It also explores trading and hedging strategies involving financial derivatives. Special topics, such as exotic options and credit derivatives, are explored. The course provides the foundation of financial derivatives and lays the ground for a rigorous risk management course and other advanced quantitative courses, such as stochastic finance.

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MGT 197 **Online Writing Tutorial**

Students who do not pass the written assessment in MGT198 will be required to take MGT197: Online Writing Tutorial for no cost and zero credit. Completion of all the online quizzes in the tutorial is sufficient to obtain a passing grade.

MGT 198 Writing Assessment

Written and oral communications training and assessment are conduction in conjunction with a required course in the BS in Business program. Students in this course are automatically enrolled in MGT198: Writing and Assessment Program. This online workshop carries zero credits and will not appear on the student's official transcript.

MGT 199 Ethics Quiz

The ethics requirement is incorporated into the course work for a required course in the BS in Business program. Students are automatically enrolled into MGT199 - Ethics Workshop at no cost. This workshop carries zero credit and will not appear on the student's official transcript. Completion of all exercises and the survey associated with the Ethics Workshop is sufficient to satisfy the ethics requirement.

MGT 401 **MIS/DBMS/Networks**

This sequence develops the use of industry-standard personal productivity packages to develop reports and information in support of the key decision-making responsibilities of management. Advanced uses of the spreadsheet are developed, including the creation of aneffective business system using the spreadsheet's macro language. More complicated problems are approached using an industry-standard database management system. A course segment presents the integrated systems approach, including the use of local area networks (such as the campus-wide network) to solve complex business problems.

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FIN 629 Banking & Credit

This is an intermediate/advanced level course that addresses money flows and the cost of credit for major money market institutions, including banks, bank holding companies and the "shadow banking" system. It entails a broad survey of the structure and financial condition of the banking industry. The course provides a theoretical and practical understanding of why these markets exist, who the key players are; how the markets work, the rules governing their operation and how they are evolving. We will spend considerable time in discussing regulation of the financial markets and financial services industry.

FIN 638 Corporate Finance

"This course serves as a second semester sequence in corporate finance. Students enrolling should have a mastery of the topics of covered in Managerial Finance I (EMT 623), including time value of money, capital budgeting, risk adjusted hurdle rates, managerial accounting, and ratio analysis. Among the topics covered in EMT 723 are: leverage on the balance sheet and weighted average cost of capital; bankruptcy, turnarounds, and recapitalizations; international currency hedging; stock options; private equity valuation; mergers and acquisitions; and the issuance of public and private securities." Cross-listed with: EMT 638 Prerequisites: BT 221, MGT 600, and MGT 623

Management

MGT 103 Introduction to Entrepreneurial Thinking

The overall objective of this course is to create an entrepreneurial mindset in freshman undergraduate students and to provide them enough basic material in a highly interactive format so they have enough basic material to become an entrepreneur. The course will create passion and excitement for becoming an entrepreneur. This will be done through inspiring seminars from local entrepreneurs. Live interactive video lectures from world recognized entrepreneurs will also be included. Enough basic material in the areas of teaming and leadership, strategy and management, market and market research, finance, production, oral presentations and funding so that the students understand what entrepreneurship is all about. The course will be taught in a highly interactive format. Only one formal lecture - the first introductory - is part of the course. The remaining formal material is taught using carefully choreographed and integrated self-teaching modules. In-class time is focused on active discussions, team activities and running a computer simulation which emulates a start-up company.

MGT 111 Social Psychology and Organizational Behaviour

Using an applied and experiential format, this course exposes students to theory, methods and research in organizational behavior and social psychology. Topics relating to individual differences and group dynamics in organizational settings are stressed. Learning occurs through discussion, group activities, and the completion of assessment instruments. Emphasis is on helping students understand and improve their skills in key areas, including decision-making, leadership, negotiation, and conflict resolution.

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MGT 609 **Project Management Fundamentals**

This course deals with the basic problems of managing a project, defined as a temporary organization built for the purpose of achieving a specific objective. Both operational and conceptual issues will be considered. Operational issues include definition, planning, implementation, control, and evaluation of the project. Conceptual issues include project management vs. hierarchical management, matrix organization, project authority, motivation, and morale. Cases will be used to illustrate problems in project management and how to resolve them. Cross-listed with: PME 609

MGT 610 Strategic Perspectives on Project Management

This course provides a theoretical perspective on project management for a better understanding of project implementation in modern organizations. The course is based on the premise that success in project leadership depends on a proper managerial style and attitude, and not on specific tools for planning and controlling. The course focuses on developing the manager's conceptual thinking and on building "the project manager's mind." The course helps managers see the entire project landscape and the long-term issues that are critical to project success. It will also address the organizational aspects of initiating and running the program. Prerequisites: MGT 609

MGT 414 Entrepreneurship Practicum

This capstone course within the Entrepreneurship minor is designed to develop the content and presentation of the technical and business elements of students entrepreneurial business plans. Starting with the technical aspects of the design project, students are led through the components of a complete business plan, with instruction and practice in the writing and presentation of the plan. As a capstone exercise, students complete the course by presenting their business plans in an Elevator Pitch event at which venture capitalists and other investors rate the quality of student presentations and entrepreneurial business ideas.

MGT 458 Principles of Management

Managerial decision-making and its impact on society are the central theme; emphasis is on the selection and implementation of corporate goals, measures of corporate performance and concepts of industrial regulations.

MGT 472 Assessment and Financing of Technical Business Opportunities

You will be a member of a small learning group in which the dynamics of human behavior are learned through supervised experience. As the group develops, the basic principles of group interaction become apparent to you, as do your own contributions, emotions and motivations. With faculty guidance, and at the group's own initiative, group dynamics and interpersonal interaction on many levels are investigated.

MGT 546 Marketing Strategy

Every firm needs to devise and execute marketing strategies for their offerings to translate into customer value and profits based on an understanding of the consumer and the marketplace. This course is designed to give students an intensive and application-oriented look at how marketing strategy works in the real world. It will include examples and exercises of the role quantitative analysis plays in marketing strategy decisions. The emphasis of this course will be on cases, analysis, real life examples, and presentations.

MGT 548 Consumer Behavior

Marketing begins and ends with the consumer. The purpose of this course is to introduce students to the study of consumer behavior. This is an interdisciplinary course that integrates perspectives from marketing, psychology, sociology, anthropology, and economics in order to examine the elements of the consumer decision-making process and to enable formulation of marketing strategies. Students will take the perspective of a marketing manager who needs knowledge of consumer behavior in order to develop, evaluate and implement effective marketing strategies. The course integrates lectures, case analysis, and discussions to focus on the implications of social science concepts for marketing strategy.

MGT 606 Economics for Managers

This course introduces managers to the essence of business economics - the theories, concepts and ideas that form the economist's tool kit encompassing both the microeconomic and macroeconomic environments. Microeconomic topics include demand and supply, elasticity, consumer choice, production, cost, profit maximization, market structure, and game theory while the Macroeconomic topics will be GDP, inflation, unemployment, aggregate demand, aggregate supply, fiscal and monetary policies. In addition the basic concepts in international trade and finance will be discussed.

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MGT 611 **Project Analytics**

Formalized procedures, tools, and techniques used in conceptual and detailed planning of the project. Development of work breakdown structure as the foundation for project cost and project duration. Application of project data in monitoring the project progress and in formulating remedial actions in response to unexpected occurrences. Prerequisites: MGT 609

MGT 612 Leading People and Projects

Project success depends, largely, on the human side. Success in motivating project workers, organizing and leading project teams, communication and sharing information, and conflict resolution, are just a few areas that are critical for project success. However, being primarily technical people, many project managers tend to neglect these "soft" issues, assuming they are less important or that they should be addressed by direct functional managers. The purpose of this course is to increase awareness of project managers to the critical issues of managing people and to present some of the theories and practices of leading project workers and teams.

MGT 613 Program Office and Portfolio Management (3 - 0 - 0)

A comprehensive, all-inclusive description of the Project Management Office (PMO), highlighting features most appropriate and relevantto specific project situations. Motivations for adopting a PMO, such as project performance, project manager competency or the organizational desire to excel. Short-term and long-term functions are identified and discussed. Project evaluation models and PMO implementation guidelines are presented and discussed in detail. Prerequisites: MGT 614 Corequisites: MGT 611

MGT 614 Advanced Project Management

This course deals with advanced problems in project management that were not addressed in previous courses. It also expands on several previously mentioned topics. The course addresses the critical points in project management for the experienced project manager and looks at projects in their broad sense, as seen by top management and from an organizational global perspective. Prerequisites: MGT 609 Corequisites: MGT 610

MGT 616 Healthcare Leadership and Management

This course provides an overview of critical leadership and management applications and strategies unique to the healthcare industry, such as customer/patient analysis, criterion-based performance evaluation and TimeLine mapping. Current field dynamics of healthcare organizations are explored and instruction in essential management accountabilities directly relevant to the industry is presented comprehensively in both theory and practical application.

MGT 617 Project Quality Management

This course provides project managers with the framework, tools and approaches to meet the quality requirements of their projects and their customers, ensuring project success. Cross-listed with: ME 560

MGT 619 Leading Across Projects

This course focuses on key leadership skills for addressing the complex challenges posed by program management, highlymatrixed environments and cross-national collaborations It's purpose is enhance individuals' abilities to develop others, strategically integrate efforts across groups, and drive change. The concepts presented are theory and research driven so that participants can deepen their conceptual understanding. At the same time, the course calls upon learners to address real-life challenges they face as program and or director level leaders. Each session presents effective techniques and uses experiential exercises or assignments to provide plenty of practice. The course also requires participants to further transfer learning to their workplaces through focused development planning and coaching support. Prerequisites: MGT 609, and MGT 612

MGT 620 Statistical Models

The major portion of the course covers an introduction to the probabilistic and statistical concepts and models used in dayto-day business decision-making. Topics include data analysis, correlational techniques, regression, statistical inference, and forecasting.

MGT 630 Global Business and Markets

There will be a review of probability and statistics as needed and then moves on to regression with a single regressor, multiple regression, the basics of functional form analysis, and the evaluation of regression studies. There will be a focus on using econometrics software in estimating econometrics models learned during the semester and interpreting the results. Crosslisted with: EMT 630 Prerequisites: MGT 699

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MGT 635 Managerial Judgment and Decision-Making

Executives make decisions every day in the face of uncertainty. The objective of this course is to help students understand how decisions are made, why they are often less than optimal, and how decision-making can be improved. This course will contrast how managers do make decisions with how they should make decisions, by thinking about how "rational" decision makers should act, by conducting in-class exercises and examining empirical evidence of how individuals do act (often erroneously) in managerial situations. The course will include statistical tools for decision-making, as well as treatment of the psychological factors involved in making decisions. Cross-listed with: EMT 635

MGT 641 Marketing Management

The study of marketing principles from the conceptual, analytical, and managerial points of view. Topics include: strategic planning, market segmentation, product life-cycle, new product development, advertising and selling, pricing, distribution, governmental, and other environmental influences as these factors relate to markets and the business structure.

MGT 650 International Business Management

This course provides students with an exposure to management in the international economic environment; global industries and regional markets, multinational corporations and international economic organizations. Casestudies, business games and presentations illustrate different strategies of firms considering the competitive environment, the national culture, legislation and taxation policy of local governments, and the organizational structure of the firm.

MGT 657 **Operations Management**

Covers the general area of management of operations, both manufacturing and non-manufacturing. The focus of the course is on productivity and total quality management. Topics include quality control and quality management, systems of inventory control, work and materials scheduling, and process management.

MGT 663 Discovering and Exploiting Entrepreneurial Opportunities (3 - 3 - 0)

In this course, students will evaluate and create their own prospective business strategies. They will develop an understanding of entrepreneurship and innovation in starting and growing a business venture. Students will be given an opportunity to actually start their own business or create a business in their company by learning how to take advantage of the new order of business opportunities of the information age. This course's main objective is to show students how to identify these opportunities, be able to formulate and evaluate both qualitatively and quantitatively whether the opportunity is worth pursuing, and, of course, how it may be pursued. Actual case studies and experiences will be intertwined with the course content. Cross-listed with: MIS 663

MGT 664 **Business Law**

The course introduces students to the fundamental concepts and legal principles that they can expect to encounter in various roles as managers/professionals in public and private companies, consultants and/or entrepreneurs, together with the ethical criteria, moral values and social norms in the environments they will face. The course will cover the American judicial system, international law in a global economy, ethics and business decision making, and different forms of business structure, contracts, business torts, products liability, insurance, employment law, criminal law and the recent Dodd-Frank Wall Street Reform & Consumer Protection Act. Cross-listed with: EMT 664

MGT 671 Technology and Innovation Management

This course introduces the student to topics in the management of technology and examines the critical role of technology as a strategic resource to enable management to achieve organizational objectives. Topics include entrepreneurship, developing and managing new ventures, managing innovation, the technology life-cycle and technology forecasting, management of research and development (R&D) personnel and projects, evaluation of R&D projects, and integrating technology strategy with the organization's overall business strategy. Prerequisites: MGT 699

MGT 672 Realizing Value from Intellectual Property

This course examines the valuation, patenting, and licensing of early-stage technology as a means to exploit innovation. By understanding technology to be a negotiable asset for the firm, we take a fundamentally different approach than venture capital models, which focus on the enterprise, rather than the commercialization of technology itself. Accordingly, we study the economics and theory of intellectual property; valuation of intangible assets; IP agreements and protection regimes; negotiations and trading techniques; and licensing and litigation strategies. Prerequisites: MGT 671

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MGT 673 **Global Innovation Mangement**

This course is focused on the globalization paradigm and its effects on the management of innovation. It is an interdisciplinary course, which analyzes the different managerial areas of strategy, organization, technology, and market as integrated with the innovation process in a global context. The underlying theories and models are explored to understand how the innovation process is affected by local, national, and global influences; what cultural and organizational drivers are at work; and how to manage commercialization of new products on a life-cycle basis, in a diverse and ever-changing global market. Case studies will be used to support the theoretical constructs and reinforce learning. Prerequisites: MGT 671

MGT 675 New Product and Service Innovation

This course provides students with the most current theories of innovation when organizations create new tangible products and intangible services. From team and organizational processes, to the evolving portfolio, the innovating enterprise competes on the basis of change. By building upon material covered in Technology Innovation Management (MGT 671), this course will deepen students' knowledge of the innovation process in the enterprise and will pay special attention to service industries. The course will be taught with lectures and real-world cases. Upon completion, students will have enhanced their knowledge of the innovative enterprise and increased their practical skills for careers in technology management. Prerequisites: MGT 671

MGT 677 **Emerging Technologies**

This course discusses emerging technologies, how they evolve, how to identify them, and the effect of international, political, social, economic, and cultural factors on them. Topics covered in the course include accuracy of past technology forecasts, how to improve them, international perspectives on emerging technologies, future customer trends, and forecasting methodologies such as monitoring, expert opinion, trend analysis, and scenario construction. Emerging technologies will be examined through student company examples, invited speakers, and videos. Cross-listed with: EMT 677

MGT 681 Pharmaceutical Industry New Drug Development

This course provides an overview of the drug and biologics development process from discovery through regulatory approval. Special attention is given to the roles, functions, and importance of the various disciplines involved in the R&D process, their interactions with each other, and the strategic management of these functions. Attention will also be given to key technologies used throughout the R&D process. The economics of pharmaceutical R&D, as well as trends in licensing, outsourcing, and partnerships will be covered. The student will gain an understanding of R&D strategy and the relationship between R&D and sales, marketing, and manufacturing.

MGT 682 Pharmaceutical Industry Marketing and Sales (3 - 3 - 0)

This course addresses the business issues, management activities and technologies pertaining to the management of the modern pharmaceutical supply chain. This includes all components of the drug development life cycle starting from the sourcing of materials needed to support pharmaceutical R&D, and ending with the distribution of drugs to retail pharmacies and physicians. The course focuses on the organizational, management and information technology issues and considerations related to the logistics-related activities of the pharmaceutical industry which are comprised of sales, marketing and supply chain management related functions.

MGT 686 Pharmaceutical Industry Trends and Issues

The course will provide an overall look at IT in the pharmaceutical industry, its structure, and trends and issues which have driven it, are affecting it now, and are likely to change it in the future. This course will focus on the business forces shaping the pharmaceutical industry. In addition, this course will use management research on the integration of IT with the business. The student will learn how to evaluate important business trends and how IT can be used to support business success. Topics include a pharmaceutical industry overview, regulatory compliance, new drug development, manufacturing and logistics, product marketing, the role of IT in the pharmaceutical industry, company strategies, e-pharma, and 21st century pharmaceutical-market future trends. Cross-listed with: MIS 671

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MGT 700

An introduction to the science of designing statistical models of economic processes. Students will be required to build and estimate a number of models during the term. Topics include: regression theory, statistical difficulties in regression analysis, advanced topics in single-equation regression, models of qualitative choice (such as, probit, logit), and simultaneous equation estimation. Prerequisites: MGT 503

MGT 701	MGT Co-Op Education Project	(0-0-0)

This course is for MGT graduate students who are on Co-Op assignment.

MGT 687 Pharmaceutical Industry Supply Chain

This course focuses on the issues surrounding supply chain design, planning, and execution for the pharmaceutical and biotech industries from drug discovery to delivery. This course will use research on information systems, optimization, e-business, and decision-support technologies and lessons learned from their effective use in global supply chain management for manufacturing and distribution in the process industries. Students will learn how to evaluate global supply chain issues from the perspectives of various stakeholders in relationship to overall organization and societal goals. They will further understand the different mechanisms for collaboration and create a process for establishing and maintaining an effective global SCM solution architecture. Topics include good manufacturing practice and regulations, advanced planning and scheduling, global competition, mergers and acquisitions, innovation, new tools and partnerships, effective global supply chain management, and qualifying for a global supply chain manager position. Cross-listed with: MIS 673

MGT 689 Organizational Behavior and Design

This course exposes students to the macro and micro aspects of organizational behavior and theory that are essential to technology management. The macro aspects will focus on structural contingency theory as an approach to effective organizational design. The micro aspects will focus on leadership, teams, and individual behavior (e.g., motivation, job attitudes). Specific issues and problems which are covered include: the relationship of the organization with the external environment, the influence of the organization's strategies, culture, size, and production technology on the organization's design, and strategies for managing organizational processes such as teams, conflict, power/politics and organizational change. Current topics, that are key to technology management (e.g., virtual teams), will be stressed.

MGT 695 Leading Creative Collaboration

Innovative organizations are led by people who relentlessly nurture creative collaborations. These leaders stimulate imagination, teach others how to turn imagination into creativity, and build group structures and processes to enable people to turn creative ideas into innovations that drive business results. This course builds individual awareness of creativity and collaboration skills while increasing the student's capacity for both. It teaches the science behind techniques, tools, interpersonal skills, leadership skills, organizational strategies, and environmental designs that increase group effectiveness. The overall goal is to strengthen the student's ability to lead others to address meaningful problems and possibilities wherever they may be found. Cross-listed with: EMT 695

MGT 696 Human-Centered Design Thinking

This course deals with the theory and methods associated with design thinking, a problem-solving protocol that spurs innovation and solves complex problems. Design thinking involves a unique form of inquiry which goes well beyond product and service design. Students will develop an appreciation for design and develop skills for studying design systems. These concepts and methods have wide applicability as they can be used to design organizations of people, information structures, compensation systems as well as the entire consumer experience. Applying these approaches can often create entirely new systems that are more useful and usable. The logic of this approach can sometimes solve "wicked problems" which have

MGT 699 Strategic Management

Econometrics

An interdisciplinary course which examines the elements of, and the framework for, developing and implementing organizational strategy and policy in competitive environments. The course analyzes management problems both from a technical-economic perspective and from a behavioral perspective. Topics treated include: assessment of organizational strengths and weaknesses, threats, and opportunities; sources of competitive advantage; organizational structure and strategic planning; and leadership, organizational development, and total quality management. The case method of instruction is used extensively in this course. Prerequisites: MGT 600

defied previous solutions. Cross-listed with: EMT 696

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MGT 702 **Curricular Practical Training**

This course involves an educationally relevant, practical assignment that augments the academic content of the student's program. Students engage in a project in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports and at the end of the semester, a detailed written report that describes his/her activities and knowledge gained during that semester. This is a one-credit course that may be repeated up to a total of three credits. With approval of the Program Director and faculty supervisor, students may also take this course for three credits in one semester.

PhD Seminar in Entrepreneurship Theory MGT 711

This course is a Ph.D. seminar course in entrepreneurship. Research on the performance of entrepreneurial new ventures will be analyzed from a theoretical perspective. Relevant studies will be drawn from the economics, management science, and strategic management literatures dealing with entrepreneurship. Emphasis will be placed on the strategic management and competitive environments of new ventures in their early development stages, and topics will be discussed in relation to theoretical concepts in technology and innovation management.

MGT 718 Multivariate Analysis

Experimental design, statistical estimation, and hypothesis testing from multivariate distributions. Topics covered will include regression models, multivariate analysis of variance, canonical correlations, classification procedures, and factor analysis. Computer applications of these techniques will be examined. Cross-listed with: SYS 718

MGT 719 **Research Methods**

Research philosophy, ethics, and methodology will be discussed. Each student will, under the guidance of the instructor, formulate a problem, search the literature, and develop a research design. In addition, the student will examine and criticize research reports with special emphasis on the statement of the problem, the sampling and measuring techniques that are used, and the analyses and interpretation of the data. Emphasis is on applying research methodology to real-world organizational problems.

MGT 721 **Qualitative Research Methods**

This course is designed to develop the doctoral student's knowledge about a range of qualitative research approaches currently used to conduct management research. Methodological readings authored by social scientists and management researchers on ontological and epistemological assumptions underlying positivist, interpretive, and critical approaches will be examined. Empirical research published in leading journals using case study, action research, ethnography, grounded theory, and other methods will be assessed based on established criteria with the goal of preparing students to conduct and evaluate qualitative research. Students will acquire skills in qualitative research design, data generation, and data analysis techniques through readings, written critiques, and seminar discussions, as well as participation in a qualitative research study. Prerequisites: MGT 719

MGT 730 Design and Analysis of Experiments

This course starts with the design and analysis of one factor analysis of variance. Methods of testing specific questions using planned comparisons are stressed. Models with two or more factors are considered with detailed instruction on the analysis of interactions. Repeated-measures designs are also covered, as well as designs with random and fixed factors. Prerequisites: MGT 620

MGT 734 **Design Science Research Seminar**

In this graduate Ph.D. seminar, we will actively explore design science. We will read the existing literature and write our own papers. As part of this, we will run simulations and design new mechanisms and interfaces. The end result of the course will be the production of models: simulations that represent social and technical phenomena - and a paper, authored individually or jointly, suitable for publication.

MGT 735 Economic Foundations of Management Research (3 - 3 - 0)

This course focuses on developing theoretical knowledge and understanding of economic concepts related to decisionmaking, consumer behavior, and competitive strategy. It introduces the methods and techniques for analyzing economic activities. It aims to improve the understanding of managerial decision-making processes by presenting analytic tools by examining the principal theories of decision-making and strategic behavior.

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Theory in Management Research

This course introduces students to the relevant management and organizational theories used in management research, including their origins, substance and significance to the effective conduct of research. In addition, students are expected to develop the capacity to identify and apply theories to the study of specific management phenomena.

MGT 769 Colloquia Series Research Seminar

MGT 753

This course is designed to provide doctoral students with an in-depth knowledge about the research process in technology management and related disciplines. The course content includes assigned readings about conducting academic research in general, as well as assigned readings related to public Howe School research colloquium presentations by different guest speakers during the course of the semester. Students will prepare for the presentation by reading the assigned papers and writing up a set of questions to be posed during the discussion with the presenter, which will take place after the presentation. Each semester there will be six or seven guest speakers who will formally present their research during the first hour of the seminar. After the talk, guest speakers will discuss issues related to conducting research with doctoral students. In the weeks without guest speakers, students discuss assigned readings related to conducting academic research with other class members.

MGT 786 Social Network Analysis Research Seminar

This course addresses concepts and theories of social networks and social network analysis. Core concepts include representations and models of networks, basic descriptive statistics at the individual and network level, and standard models of network formation. The course also covers more advanced topics in network theory, including community detection, processes over networks such as contagion and influence, and models of dynamic networks.

MGT 787 Statistical Learning and Analytics Research Seminar (3 - 3 - 0)

The significant amount of corporate information available requires a systematic and analytical approach to select the most important information and anticipate major events. Statistical learning algorithms facilitate this process understanding, modeling and forecasting the behavior of major corporate variables.

MGT 798 Integration and Application of Technology Management (3 - 3 - 0)

This is the capstone course for the program. It is designed to integrate the knowledge developed in the other courses via a business simulation in which teams of students compete in running their companies in a complex simulated environment. The course includes lectures and workshops that demonstrate theory and techniques of cross-functional decision making in the management of technology. Individuals and teams will be observed and assessment feedback will be given. Cross-listed with: EMT 798 Prerequisites: MGT 600, and MGT 623, and MGT 641, and MGT 657, and MGT 699

Special Problems in Management (MS) **MGT 800** (1 to 6 - -)

With permission of the instructor. Limit of six credits for the degree of Master of Science. Cross-listed with: MIS 800

MGT 801 Special Problems in Mangement (PhD)

With permission of the instructor. Limit of six credits for the degree of Doctor of Philosophy.

MGT 802 Project Management Examination

This will test the project management knowledge of students who have completed approved training programs in project management. Upon successful completion, (graded pass/fail) students will be awarded 12 credits toward the Master of Science in management with a Project Management concentration. The credits cannot be used toward the Project Management Graduate Certificate of Special Study and are not transferable to other institutions.

MGT 803 Project Management Examination

This will test the project management knowledge of students from AT&T, Lucent Technologies and Verizon who have completed company-sponsored project management courses. Upon successful completion, (graded pass/fail) students will be awarded three credits towards a Master of Science degree. The examination is normally given twice each year.

MGT 810 Special Topics in Management

A participating seminar on topics of current interest and importance in Management.

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MGT 898 Written Communications

Written and oral communications training and assessment are conducted in this online workshop which carries zero credit and will not appear on the student's official transcript. All full-time graduate students are required to take MGT898. To this end, students in certain required graduate courses are automatically enrolled in MGT 898. Students who do not pass the written assessment will be required to take MGT 897: Online Writing Tutorial.

MGT 899 Ethics Quiz

All graduate students in the School of Business must participate in an online ethics workshop in order to graduate. The ethics requirement is part of the course work for MGT 609 - Introduction to Project Management. Students who are enrolled in MGT 609 are automatically enrolled in MGT 899 - Ethics Workshop at no cost. This workshop carries zero credit and will not appear on the student's official transcript. Completion of all exercises associated with the Ethics Workshop is sufficient to satisfy the ethics requirement. This course is required for all students who enrolled in the fall semester 2010 or later.

MGT 900 Thesis in Management (MS)

For the degree of Master of Science. Hours and credits to be arranged.

MGT 960 Research in Management (PhD)

Original research leading to a doctoral dissertation. Hours and credits to be arranged.

MIS 702 Curricular Practical Training

This course involves an educationally relevant, practical assignment that augments the academic content of the student's program. Students engage in a project in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports and at the end of the semester, a detailed written report that describes his/her activities and knowledge gained during that semester. This is a one-credit course that may be repeated up to a total of three credits. With approval of the Program Director and faculty supervisor, students may also take this course for three credits in one semester.

TM 702 Curricular Practical Training

This course involves an educationally relevant, practical assignment that augments the academic content of the student's program. Students engage in a project in a company project related to the focus of their academic program. The project is conducted under the supervision of a faculty advisor and an industry mentor. During the semester, the student must submit written progress reports and at the end of the semester, a detailed written report that describes his/her activities and knowledge gained during that semester. This is a one-credit course that may be repeated up to a total of three credits. With approval of the Program Director and faculty supervisor, students may also take this course for three credits in one semester.

Quantitative Finance

QF 101 Quantitative Finance

This is the 1st Spine Course in the Quantitative Finance program. The course objective is to introduce students to the basics of business, finance, and the capital markets as a foundation for subsequent Spine Courses. There is no pre-requisite, and no prior knowledge of business or finance topics is assumed.

QF 102 Basic Financial Tools

This is the 2nd Spine Course in the Quantitative Finance program. The course objective is to familiarize students with the methods of creating and managing investment portfolios. This involves understanding basic concepts of portfolio construction, integrating investment decisions across multiple positions and asset categories. A Secondary objective is to expand the student's familiarity with the sources and formats of the standard financial reports prepared by public companies in the United States, and to allow students to gain experience in accessing and using publicly available financial information. In addition, students will continue to gain experience with the use of real-time market information on traded securities and the application of simple valuation metrics. Third, students will examine the more prominent types of business models in the financial industry, including commercial banks, investment banks, asset managers and other financial service companies. Prerequisites: QF 101

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QF 103 Introduction to Financial Tools and Technology

The course will introduce students to the Bloomberg terminal, from technical analysis to fundamental analysis. Students will also learn how to retrieve historical data from Bloomberg and analyze that data in the SAS statistical program. The course arms the students with skill-sets typically learned on the job.

QF 104 Data Management in R

Objective of this course is to provide students with formal training on various advanced skills in R, students will be pre-loaded with these skills prior to entering the workplace. After taking this course, students will be able to understand 1) advanced R, 2) how to read/write financial data to/from SQL and noSQL databases, 3) basic regression techniques, and 4) how to construct and run off-the-shelf machine learning algorithms. This lab session will employ a lecture followed by in-class exercises based on material from the lecture. There will be between 5 exercises to be completed outside of the lab session; these assignments will be related to what material is taught in the main lecture.

QF 197 Online Writing Tutorial

Students who do not pass the written assessment in QF198 will be required to take QF197: Online Writing Tutorial for no cost and zero credit. Completion of all the online quizzes in the tutorial is sufficient to obtain a passing grade.

QF 198 Writing Assessment

Written and oral communications training and assessment are conduction in conjunction with a required course in the BS in Business program. Students in this course are automatically enrolled in QF198: Writing and Assessment Program. This online workshop carries zero credits and will not appear on the student's official transcript.

QF 199 Ethics Quiz

The ethics requirement is incorporated into the course work for a required course in the BS in Business program. Students are automatically enrolled into QF199 - Ethics Workshop at no cost. This workshop carries zero credit and will not appear on the student's official transcript. Completion of all exercises and the survey associated with the Ethics Workshop is sufficient to satisfy the ethics requirement.

QF 200 **Financial Ecomometrics**

Econometrics, literally "economic measurement," is a branch of economics that attempts to quantify theoretical relationships. This course will have both a theoretical and applied econometrics components. There will be a focus on using econometrics software in estimating econometrics models learned during the semester and interpreting the results. There will be a review of probability and statistics as needed and then moves on to regression with a single regressor, multiple regression, the basics of functional form analysis, and the evaluation of regression studies. There will be a focus on using econometrics software in estimating econometrics models learned during the semester and interpreting the results. Prerequisites: BT 221 or MA 222

QF 202 **Financial Time Series**

Students will study the application of quantitative methods to the field of finance, including investment theory and risk management. Among topics covered will be regression analysis, building asset/business cash flow models of a business, sensitivity analysis, value at risk (VAR) models, probability transition matrices and stochastic difference equations (SDE's). Prerequisites: QF 201 or QF 200

QF 301 Advanced Time Series Analytics and Maching Learning

This course will cover the main topics of the analysis of time series to evaluate risk and return of the main products of capital markets (equity, fixed income, and derivatives). Students will work with historical databases, conduct their own analysis, and test trading strategies based on the techniques reviewed during the class. Prerequisites: QF 202, BT 221, and MA 331 or **MGT 620**

QF 302 Financial Market Microstructure and Trading

This course will offer students an understanding of the main micro-structural features of financial markets, and the opportunity to test and practice different trading strategies. The course concentrates on the operations of exchanges, trading systems and broker/dealer intermediaries. Students will have a high level view of the trading decision process, market structure design, and market structure regulation. The course is based on computer simulations that recreate a trading environment and the typical challenges faced by professional traders.

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QF 427 Investment Practicum I

The Stevens Investment Practicum is a student managed investment fund (SMIF) staffed by enrolled students and advised by faculty/staff advisory committee. The Practicum is intended to be an Advanced course for Stevens/ Howe QF and BT and possibly other students considering the pursuit of an investment management career. Prerequisites: BT 321 Corequisites: BT 426

QF 428 Investment Practicum II

The Stevens Investment Practicum is a student managed investment fund (SMIF) staffed by enrolled students and advised by faculty/staff advisory committee. The Practicum is intended to be an Advanced course for Stevens/ Howe QF and BT and possibly other students considering the pursuit of an investment management career. Prerequisites: BT 321, and QF 427

QF 430 Introduction to Derivatives

This is a course on the fundamentals of financial derivatives, covering the basic properties and the pricing fundamentals of futures, options and swaps. It also explores trading and hedging strategies involving financial derivatives. Finally, time permitting special topics such as exotic options and credit derivatives are explored. The course provides the foundation of financial derivatives and lays the ground for a rigorous risk management course and other advanced quantitative courses, such as stochastic finance. It also provides students with some of the knowledge required for the CME competition and the CFA examination. Prerequisites: BT 425

QF 465 C++ for Fiance

C++ is the main program used in the financial industry because of its efficiency and object oriented structure that facilitates the development of specialized financial libraries. The course will extend the students' knowledge base, learned in QF365, and move them further into C++ object oriented programming through the use of design patterns and expose them how to price out derivative instruments learned throughout the quantitative finance curriculum. Prerequisites: QF365 or CS385

Telecommunications Management

TM 500 Calculus for Telecommunications Managers

The goal of this course is to provide students with the background in calculus necessary for the telecommunications curriculum. Topics covered include review of algebra, coordinates in the plane and functions, differentiation, series, geometric series and exponential series, elements of counting, illustrations of the material on discrete distributions, z-transform, integration of simple functions, integrals over the entire line and basic probability densities. The eleven topics listed can be expanded or contracted depending on how students react to the material. E.g. the topic of functions of two variables can be changed by emphasizing discrete functions and their relationship to joint distributions. Some topics (e.g. coordinates in the plane and functions) may require two sessions. However, it is planned to cover the entire material in 13 sessions.

TM 550 Introduction to Telecommunications Concepts

This course sets the foundation for courses that are to follow, covering concepts and major technologies of the telecommunications industry. Telecommunications regulations, end-to-end service, and historical events are stressed. This course is open to Telecommunications majors only and is intended for students with a minimal telecommunications background.

TM 584 Wireless Systems Security

Wireless systems and their unique vulnerabilities to attack; system security issues in the context of wireless systems, including satellite, terrestrial microwave, military tactical communications, public safety, cellular, and wireless LAN networks; security topics: confidentiality/privacy, integrity, availability, and control of fraudulent usage of networks. Issues addressed include jamming, interception, and means to avoid them. Case studies and student projects are an important component of the course. Cross-listed with: NIS 584, EE 584

TM 586Wireless Networking: Architecture, Protocols and Standards(3 - 0 - 0)

This course addresses the fundamentals of wireless networking, including architectures, protocols, and standards. It describes concepts, technology, and applications of wireless networking as used in current and next-generation wireless networks. It explains the engineering aspects of network functions and designs. Issues such as mobility management, wireless enterprise networks, GSM, network signaling, WAP, mobile IP, and 3G systems are covered. Cross-listed with: EE 586, NIS 586

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propagation factors and selected cellular design approaches is presented. Wireless data are introduced by examining cellular digital packet data. Selected goals and challenges of the field of mobile computing are examined, along with the resulting

on global companies are also studied.

TM 612

TM 615

TM 616 The Global Wireless Industry

network architectures and applications. Prerequisites: TM 601, TM 610

This course is focused on the global wireless industry and mobile wireless systems. The course will analyze the various complexities facing management when deploying or operating a wireless mobility system. The four main areas of the management of mobile wireless systems that will be covered in the course are the global wireless mobility market, regulatory requirements, management challenges, and decision methods. The course will utilize a combination of traditional instructorled material in addition to homework assignments that will be geared toward reinforcing the lecture material. A team-based class project will also be assigned. Specific topics covered include the global wireless industry (service providers, handset and infrastructure vendors, and standards and trade organizations), international regulation, wireless operators' organization and metrics, and the initial planning, deployment decisions, forecasting, and budget considerations in wireless system deployment.

performance, and analysis studies for Ethernet and token ring as primary technologies; internetworking; metropolitan area networks (MAN) including FDDI and DQDB; and wide area networking (WAN) technologies including frame relay and asynchronous transfer mode (ATM). Prerequisites: TM 601 (3 - 0 - 0)TM 611 **Emerging Telecommunication Technologies** This course covers a wide range of emerging state-of-the-art transmission and switching technologies, evolving communication protocols, and their applications. This course is a super-loaded look at the key technologies that are about to enter the

mainstream. The course studies technologies that impact both the service provider industry, as well as the corporate enterprise IT environment. Topics included in this course are: VoIP protocols (H.323, SIP, SGCP, MGCP, IPDC, etc.) and soft

Historical perspective of telecommunications as a regulated industry; effects of regulation on industry growth in pre- and postdivestiture environments; special case of divestiture of AT&T; government regulatory agencies and processes; management issues related to business between regulated and non-regulated corporations; and tariff structures, rules, and rate-making in the regulated environment. Issues of privatization and deregulation in international telecommunications and their effects

This course provides a broad overview of the important field of wireless and personal communications. Topics to be examined include the mobile wireless standards of AMPS, North American TDMA (IS-138), GSM, and CDMA (IS-95). Security and privacy, network management, and interworking in wireless systems (IS-41) will also be examined. An overview of RF

and performance analyses for distributed networks; network topologies; local area networks (LAN) functional characteristics,

TM 610 **Business Information Networks** Concentrated study of data and computer communications, information network architectures, and standards. Topics include: IP networking, information characteristics and requirements for voice, video, image, and data; protocol definitions

Poisson processes, birth-death processes, and Markov processes. Cross-listed with: NIS 505

LANs (IEEE 802.11a/b/g, 802.15, 802.16, etc.); management and performance modeling tools.

Wireless Communications and Mobile Computing

Regulation and Policy in the Telecommunication Industry

and competitive environment. The main issues of telecommunications systems and network transmission, signaling, and switching are covered. Attention is given to the following topics: analog and digital communications, telephony, data communications, signal types, modulation, multiplexing,; network design concepts, and relevant standards. These topics are presented with attention to the functional interrelationship of the various sectors of the industry, business, and government regulatory bodies, all of which are affected by this technology. TM 605 Probability for Telecommunications Managers (3 - 0 - 0)

This course provides a background in probability and stochastic processes necessary for the analysis of telecommunications systems. Topics include: axioms of probability, combinatorial methods, discrete and continuous random variables, expectation,

This course covers required technical concepts of applied telecommunications and an overview of the industry as a regulated

TM 601 Principles of Applied Telecommunications Technology

SCHOOL OF BUSINESS

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switches; Multiprotocol Label Switching (MPLS) and their applications such as VPN and Traffic Engineering; Wavelength Division Multiplexing (WDM) and optical switching; Gigabit/10 Gigabit Ethernet and Storage Area Networks (SAN); Wireless

(3 - 0 - 0)

SCHOOL OF BUSINESS

TM 617 Next Generation Wireless Systems

This course provides a broad perspective on the services, applications, requirements, architecture, standards, and impact of emerging wireless networks. The new wireless services and applications, which are driving the development and deployment of new wireless networks, are defined and differentiated. The tradeoffs between customer requirements and network performance are analyzed. The fundamentals of next generation network interfaces and resource management and the impact of multiple international standards are explored. The architecture and operational scenarios of the two major third generation standards (UMTS and cdma2000) are examined and differentiated. UMTS and cdma2000 are compared from multiple perspectives, including network evolution, services and applications, global markets, and financial perspectives. Specific topics examined include services, applications, and QoS in next generation wireless networks along with the architecture and operational scenarios of global standards (UMTS and cdma2000) in next generation wireless networks. Prerequisites: TM 615

TM 618 Wireless Network Performance Management

This course develops a fundamental understanding of the performance, management, and life-cycle analysis of emerging mobile wireless networks. The major components of a mobile wireless network, the Radio Access Network (RAN), and the core Back-Bone Network (BBN), are described in terms of their major functional elements. The impact of these functional elements upon the ability of the system to achieve established performance metrics is examined. This course will also examine the trade-offs in system performance and management that each of the elements has on system complexity, planning, and ability to meet the required performance objectives. Life-cycle analysis and, in particular, the migration of mobile wireless systems to third generation networks is discussed with emphasis on the impact of migration on system architecture and cost. The topics of system performance, management, and life-cycle analysis are crucial to wireless managers and professionals in the planning and migration of mobile wireless networks. The course includes a team project where the students will apply the knowledge covered by the course to a practical case study. Prerequisites: TM 605, TM 615 TM 610

TM 619 E-Commerce Technologies

The course provides an understanding of electronic commerce and related architectures, protocols and technologies. The course introduces the E-commerce concept, objectives, and market drivers, and identifies its requirements, underpinning techniques, and technologies. These include Internet techniques like tunneling and Telnet and WWW techniques like Forms, and Common Gateway Interface (CGI). Other related topics such as multimedia, intelligent agents and their applications in E-commerce, the client/server model, and Commitment, Concurrency and Recovery (CCR) are also presented. Network, service, and application management, which are important aspects of E-commerce, are discussed. Quality of Service (QoS) management, Service Level Agreement (SLA) management, Application Programming Interface (APIs), and the role of Application Service Providers (ASPs) are discussed. There will be strong emphasis on the important topic of securitymanagement. Topics here include security concepts and technologies, types of security attacks, encryption techniques, public key systems, Data Encryption Standard (DES), and authentication techniques. Virtual Private Networks (VPNs), secure tunneling techniques, firewalls, Intranets, extranets, and VPN management are covered. The policy and regulatory issues in E-commerce are discussed. Finally, various E-commerce applications in the areas of finance, securities, trading, auctions, and travel are described. The course includes some E-commerce case studies and demonstrations. Cross-listed with: CPE 619, NIS 619, CS 619 Prerequisites: CPE 678, MGT 776, CS 666, TM 610

TM 621 Telecommunications Signaling and Switching

This course covers the technologies of switching systems for circuit, packet, and broadband-switched networks. The focus of this courses switching systems instead of transmission systems. Topics include: telephony switching, switching fabric architectures and analysis of their complexity, optical and photonic switching, Asynchronous Transfer Mode (ATM) forbroadband networks. The various layers of ATM are investigated with switching fabric and architecture alternatives. Included in this course is the study of high-speed packet networks based on Label Switching (MPLS) and their applications (e.g., VPN, Traffic Engineering). Other related topics include IP telephony and its standards such as H.323, SIP, SGCP. This course also covers circuit-switched network signaling used in user-to-network and network-to-network call control. Major topics include Common Channel Signaling System (CCS7), Signaling Transfer Point (STP), ISDN User Part (ISUP), Transaction Capabilities Part (TCAP), and routing techniques. The course will cover Inter-working of SS7 and IP Session Initiated Protocol (SIP), H.323 signaling protocol series. Included in the course are discussions on existing products in the industry such as Lucent Technologies' 5ESS, Ericsson's AXE10, Juniper's M160, Tellium's Aurora System. Prerequisites: TM 601, TM 605, TM 610

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SCHOOL OF BUSINESS

TM 624 Network Management

This course presents technical management issues of network control and operations. This subject is approached with and introduction of organization issues and requirements for network systems groups within corporations, and then principally concentrates on the current technical issues of network management standards such as SNMP and SNMPv2. The course requires the students to engage in the detailed study of the evolving standards of Management Information Bases (MIB) in the industry and the messaging protocols required to implement Network Management Systems (NMS). Semester projects include the group development of computer based simulated network management systems to apply the knowledge gained in the course and detailed competitive analysis of current systems implemented in industry. Topics include network management concepts; administrative and operational management; performance management; fault management; configuration management; security management and accounting management; Remote Network Management (RMON). Cross-listed with: MIS 640 Prerequisites: TM 601, TM 605, TM 610

TM 630 Broadband Networking Services and Technology

This course provides a broad and comprehensive study of the technologies enabling broadband services and networking. High-speed network access technologies, core-network architectures, and the broadband service environment are the focus of this course. The broadband access technologies of Digital Subscriber Line (DSL), cable modem service, optical fiber-based access, and the high-speed wireless technologies of WiFi and WiMAX are examined and differentiated. The core-network technologies of DWDM, MetroEthernet, MPLS, RSVP, as well as the services-converging IP Multimedia Sub-system (IMS) are discussed and studied as enabling technologies for broadband services. An overview is provided of key broadband services: VoIP, IPTV, streaming video and Video on Demand. Security standards and regulatory issues are addressed. The course concludes with a discussion of the opportunities and threats posed to service providers and the communications industry by the emerging disruptive technologies of broadband networking. Prerequisites: TM 601, TM 610

TM 631 Broadband Service Management

Broadband Service Management is a comprehensive course for those interested in deploying and operating broadband networks from a technical and managerial aspect. A broadband network's success is based on its ability to deliver a desired service with a specific service requirement referred to as a Service Level Agreement (SLA). The Service Level Management whether it is with an operator, infrastructure vendor, Third Party Vendor (3PV) or customer all have specific Key Performance Indicators (KPI) associated with them. The ability to define, identify, and manage those Key Performance Indicators associated with a broadband network Service Level Agreement requires a thorough understanding of the entire broadband ecosystem. Prerequisites: TM 630

TM 669 (3 - 3 - 0)Analyzing and Leveraging Social Media Websites

The growing use of websites, such as Facebook and Twitter, allows everyone to generate and share content. These social media tools have become integral to our everyday lives. Students will learn various techniques for analyzing user behavior in social media websites by applying prominent theories that influence human behavior in these environments. They will examine these websites and evaluate their positive and negative impacts on society. The skills and knowledge that students acquire in this course will allow them to make recommendations for leveraging websites and other products/services that involve social media technologies. Cross-listed with: MIS 669

Decision Analysis for Corporate Network Systems TM 670

This course surveys sector implementation of corporate telecommunication networks and the business issues involved in their selection. Issues of equipment acquisition, financing, and accounting will be studied in depth. Additionally, the equipment/system selection process will use the techniques of probabilistic outcomes, simulation, sensitivity analysis, and multi-attribute analysis to better define the risks and opportunities of these investments. Also studied are telecommunications systems' effects on the balance sheet of the corporation as financial assets or liabilities: strategic assets, active revenueproducing tools, or passive service provision in the corporation's realization of a business plan. Prerequisites: TM 601, TM 610 MGT 600 MGT 618

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This course introduc	ces managers to the essence of business economics - the theories, concepts an
the economist's tool	kit encompassing both the microeconomic and macroeconomic environments. Mic
include demand and	supply, elasticity, consumer choice, production, cost, profit maximization, market s
theory while the Mac	croeconomic topics will be GDP, inflation, unemployment, aggregate demand, aggr
and monetary policie	s. In addition the basic concepts in international trade and finance will be discussed
EMT 623 F	inancial Management
This course covers t	ne fundamental principles of finance. The primary concepts covered include the tir
principles of valuation	n and risk. Specific applications include the valuation of debt and equity securitie
budgeting analysis, fi	nancial manager's functions, liquidity vs. profitability, financial planning, capital budg
of long torm funds	money and capital markets, debt and equity, management of assets, cash and ad

An investigation of a current research topic under the direction of a faculty member. A written report is required which should have the substance of a publishable article. Special Problems in Telecommunications Management (PhD) With permission of the instructor. Limit of six credits for the degree of Doctor of Philosophy.

Special Problems in Telecommunications Management (MS)

E-business Security and Information Assurance

Selected Topics in Telecommunications Management

TM Co-Op Education Project

This course is for TM graduate students who are on Co-Op assignment.

TM 810 (3--) Special Topics in Telecommunications Management A participating seminar on topics of current interest and importance in Telecommunications Management.

A participating seminar on topics of current interest and importance in the field of applied telecommunications technology

Information assurance and security are recognized as very important issues in electronic business transactions and financial systems, from the managers, users, and providers viewpoints. This course addresses the security of e-business and cyber environments from an end-to-end perspective, including data center security and access security. Topics include: application, server, and database security, virtual local area networks (VLANs), secureaccess techniques, and secure electronic payment systems like SET (Secure Electronic Transaction). The course also reviews financial Electronic Data Interchange (EDI) and smart card security in banking applications. The course includes a project and some lab experiments related to SSL, SET,

(1 to 12 - -) TM 900 Thesis in Telecommunications Management (MS) For the degree of Master of Science. Hours and credits to be arranged.

Master of Technology for Experienced Professionals

FMT 606 Economics for Managers

TM 694

TM 701

TM 765

TM 800

TM 801

and networking.

EDI, server and application security.

Т and ideas that form licroeconomic topics tl ir structure, and game t gregate supply, fiscal ed. а

E

ime value of money, Т es as well as capital h geting, management accounts receivable, inventory and fixed assets. Additional topics include derivative markets.

EMT 624 Financial Analysis for Technical Organizations

This course presents concepts regarding the collection, processing, and reporting of financial information in a technologybased business. Managerial accounting and cost accounting, and their uses and limitations will be discussed. Use of financial statements, budgets, and cost estimates in management decision-making will be emphasized. The impact of the risk and uncertainty associated with financial decisions will be illustrated via case studies.

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EMT 630 Global Business and Markets

This is a comprehensive course in global business and markets providing a broad, multidisciplinary understanding of global business. The theoretical context for engaging in international trade is established, with attention to the current economic and political environment. Then the business level rationale and techniques for initiating trade, as well as the functional area decisions that must be made, are discussed. Topics include: cultural differences; international trade; regional economic integration; international monetary system; entry strategies; strategic alliances; exporting and importing; global production and logistics; global marketing. Cross-listed with: MGT 630

EMT 635 Managerial Judgment and Decision-Making

Executives make decisions every day in the face of uncertainty. The objective of this course is to help students understand how decisions are made, why they are often less than optimal, and how decision-making can be improved. This course will contrast how managers do make decisions with how they should make decisions, by thinking about how "rational" decision makers should act, by conducting in-class exercises and examining empirical evidence of how individuals do act (often erroneously) in managerial situations. The course will include statistical tools for decision-making, as well as treatment of the psychological factors involved in making decisions. Cross-listed with: MGT 635

EMT 638 **Corporate Finance**

This course serves as a second semester sequence in corporate finance. Students enrolling should have a mastery of the topics of covered in Managerial Finance I (EMT 623), including time value of money, capital budgeting, risk adjusted hurdle rates, managerial accounting, and ratio analysis. Among the topics covered in EMT 638 are: leverage on the balance sheet and weighted average cost of capital; bankruptcy, turnarounds, and recapitalizations; international currency hedging; stock options; private equity valuation; mergers and acquisitions; and the issuance of public and private securities. Cross-listed with: MGT 638 Prerequisites: EMT 623

EMT 642 Marketing Strategy

This course focuses on the methodology involved in developing and writing an effective marketing plan. It covers how to obtain the information that is needed and how to write a rigorous marketing plan for a product or service. The course details the steps needed to perform a market opportunity analysis (MOA) and explores how to develop market-based strategies and tactics to capitalize on the identified opportunities.

EMT 675 New Product and Service Innovation

This course provides students with the most current theories and tools to function effectively in the corporate environment when there is constant change. By building upon material covered in Technology Innovation Management (MGT 671), this course will deepen students' knowledge of the innovation process in the enterprise and will pay special attention to service industries. The course will be taught with lectures and real world cases. Upon completion, students will have enhanced their knowledge of the innovative enterprise and increased their practical skills for careers in technology management. Prerequisites: MGT 671

EMT 677 **Emerging Technologies**

This course discusses emerging technologies, how they evolve, how to identify them, and the effect of international, political, social, economic, and cultural factors on them. Topics covered in the course include accuracy of past technology forecasts, how to improve them, international perspective on emerging technologies, future customer trends, and forecasting methodologies such as monitoring, expert opinion, trend analysis, and scenario construction. Emerging technologies will be examined through student company examples, invited speakers, and videos. Cross-listed with: MGT 677

EMT 695 Leading Creative Collaboration

Innovative organizations are led by people who relentlessly nurture creative collaborations. These leaders stimulate imagination, teach others how to turn imagination into creativity, and build group structures and processes to enable people to turn creative ideas into innovations that drive business results. This course builds individual awareness of creativity and collaboration skills while increasing the student's capacity for both. It teaches the science behind techniques, tools, interpersonal skills, leadership skills, organizational strategies, and environmental designs that increase group effectiveness. The overall goal is to strengthen the student's ability to lead others to address meaningful problems and possibilities wherever they may be found. Cross-listed with: MGT 695

SCHOOL OF BUSINESS

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EMT 696 Human-Centered Design Thinking

This course deals with the theory and methods associated with design thinking, a problem-solving protocol that spurs innovation and solves complex problems. Design thinking involves a unique form of inquiry which goes well beyond product and service design. Students will develop an appreciation for design and develop skills for studying design systems. These concepts and methods have wide applicability as they can be used to design organizations of people, information structures, compensation systems as well as the entire consumer experience. Applying these approaches can often create entirely new systems that are more useful and usable. The logic of this approach can sometimes solve "wicked problems" which have defied previous solutions. Cross-listed with: MGT 696

EMT 714 Technology Strategy

This course discusses the technology strategy process and develops skills, methodologies, and critical thinking in order to achieve technological competitive advantage. Subjects covered include technology life-cycles, type and characteristics of RD&E project portfolio selection, and an overview of successful development strategies. Case studies will be used to build competence and confidence in the concepts.

EMT 715 Strategic Business Management

This course focuses on the major elements of the strategic management model, including mission, external and global environment, company profile, strategic analysis and choice, long- and short-term objectives; action plans/tactics, policies, restructuring, reengineering, strategic control, and continuous process improvement (CPI). Student teams analyze and formulate strategies for companies they select.

Team Leadership Development in Technical Organizations (3 - 3 - 0)EMT 740

This course focuses on understanding the interplay of group, inter-group, and organizational factors on the performance of multifunctional teams in technology-based organizations. The course integrates theory and research on multifunctional teams with the skills necessary for effectively managing them. Topics covered include managing decision-making and conflict in multifunctional teams, managing the team's boundary and inter-group relations, organizational designs that support working cross-functionally, and measuring and rewarding team performance. Cases are used to illustrate the problems of working cross-functionally. Individuals are given feedback on their team management skills.

EMT 751 Project Management and Leadership

This course provides a theoretical and practical perspective on modern project management and leadership in technologybased organizations and forms the conceptual basis to develop "a project leader mindset." The course will focus on strategic project success, as well as project cultures, project organization, and project processes as they are employed in different project types and for different levels of project uncertainty, complexity, and pace. The leadership part of the course is based on the premise that people are the real engine behind project results, and they must be led and motivated in a very unique way. Different leadership styles will be discussed, together with motivation and career issues, in different project and organizational settings.

EMT 752 Corporate Entrepreneuring

This course focuses on corporate venturing and entrepreneurship. Business and financial issues associated with starting and buying an entrepreneurial, high-technology business are addressed. Subjects covered include a discussion of previous corporate ventures, critical success factors, and an international perspective on corporate venturing. Lessons learned from new technology start-ups will be discussed, along with an evaluation of the decision processes used by venture capitalists. The final project is the development of a venture plan for the student's company. Over half of the business plans receive funding. Startup funding on previous projects has ranged from \$50,000 to \$1,000,000,000.

EMT 758 Practicum - Oral & Written Communication Competency (3 - 3 - 0)

In this workshop/lab, students will learn several skills to help them present and write more effectively. Specific topics include components of effective writing, ten steps for effective presentations, using advanced computer technologies in oral presentations, and portraying the correct image. Students will be graded on several team and individual oral presentations and written reports throughout the program to demonstrate their competency in both oral and written communications. Each student will have an oral/written report card. Cross-listed with: MIS 758

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SCHOOL OF BUSINESS

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SCHOOL OF BUSINESS

EMT 798Integration and Application of Technology Management(3 - 3 - 0)

This is the capstone course for the program. It is designed to integrate the knowledge developed in the other courses via a business simulation in which teams of students compete in running their companies in a complex simulated environment. The course includes lectures and workshops that demonstrate theory and techniques of cross-functional decision-making in the management of technology. Individuals and teams will be observed and assessment feedback will be given. (5.0 credits) Cross-listed with: MGT 798

EMT 800	Special Problem: EMTM	(3-3-0)
One to six credits	. Limit of 6 credits for the degree of Master of Technology Management (EMTM).	

EMT 810	Special Topics in Management of Technology	(3-3-0)

A participating seminar on topics of current interest and importance in Management of Technology.

COLLEGE OF ARTS AND LETTERS

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COLLEGE OF ARTS AND LETTERS

The College of Arts & Letters (CAL) offers a broad education in the liberal arts for every Stevens student. It provides a wide range of introductory and advanced courses in classical disciplines, such as Literature, History, Philosophy, the Social Sciences, Visual Arts, and Music, as well as in interdisciplinary fields such as Science, Technology, and Society and Science Communication. As befits the history and mission of Stevens, the College of Arts & Letters seeks to encounter the traditional humanities, social sciences, and fine arts with questions emerging from science and technology. Interdisciplinary work both across the programs at CAL and other programs at Stevens lets faculty and students realize the potential of traditional and innovative disciplines. Study of the liberal and fine arts is aimed at the development of an open and inquiring mind, and prepares the Stevens student to confront the world both in a critical way and with empathy and imagination in respect to human concerns. Such preparation requires cultural and historical literacy, a knowledge and appreciation of the rich intellectual, social and artistic heritage of humanity, and a thoughtful examination of its ethical and aesthetic values. A liberal education of this nature also demands the ability to reason clearly and analytically, and to write and communicate effectively. For this reason, programs at CAL also emphasize the practical exercise and development of writing and communication skills.

The Freshman Experience

The College of Arts and Letters administers the Freshman Experience program for all incoming freshmen and transfer students. The Freshman Experience includes two courses for domestic students and three courses for international students.

Incoming domestic freshmen and transfer students take CAL 103 - Writing and Communications Colloquium and CAL 105 - CAL Colloquium: Knowledge, Nature, Culture, during their first two terms. Students begin with one of these classes and take the other in the following semester.

Incoming international undergraduate students will take CAL 101 – English Skills during their first semester, with CAL 103 and CAL 105 being taken during their second and third semesters. If an incoming international undergraduate student is able to demonstrate mastery of the English language via the language diagnostic that is administered on the first day of classes, they will be able to skip CAL 101, beginning immediately in CAL 103.

While Advanced Placement (AP) credit cannot be applied to CAL 103 or CAL 105, transfer credit may be accepted for similar courses taken at another university, if equivalence can be established. CAL 101 is a three-credit course that can be used to fulfill free elective credits (but not CAL/Humanities credits).

Writing and Communications

The Writing & Communications Center (WCC), in the College of Arts and Letters, empowers students by helping them develop the written and oral communication skills essential to their success in academic coursework and beyond Stevens. The goal of the WCC is to help students become autonomous and capable writers in their own right.

FACULTY

Carlos Alomar Distinguished Artist in Residence, Music & Technology

Andrew Brick, B.A. Industry Associate Professor, Music & Techology Director, Program in Music and Technology

Diana Bush, Ph.D. Teaching Assistant Professor Seth Cluett, Ph.D. Assistant Professor, Music & Technology

Lindsey Cormack, Ph.D. Assistant Professor, Social Sciences/Political Science

Garry Dobbins, Ph.D. Teaching Associate Professor, Philosophy

COLLEGE OF ARTS AND LETTERS

Aysegul Durakoglu, Ph.D. Teaching Associate Professor, Music & Technology

Karina Everett, Ph.D. Teaching Assistant Professor

David Farber, Ph.D. Distinguished Career Professor of Science and Technology Studies

Michael Geselowitz, Ph.D. Industry Associate Professor, History

Richard (Ricky) Graham, Ph.D. Assistant Professor, Music & Technology

Robin Hammerman, Ph.D. Teaching Assistant Professor

Robert Harari, M.S. Industry Associate Professor, Music & Technology

Mary Ann Hellrigel, Ph.D. Industry Associate Professor, History

John Horgan, Ph.D. Director, Center for Science Writings

Kristyn Karl, Ph.D. Assistant Professor, Social Sciences/Political Science

Susan Levin, Ph.D. Professor, Literature

Ashley Lytle, Ph.D. Assistant Professor, Social Sciences/Psychology

Theresa MacPhail, Ph.D. Assistant Professor, Science and Technology Studies

Alexander Magoun, Ph.D. Industry Associate Professor, History

Christopher Manzione, M.F.A. Assistant Professor, Visual Arts and Technology

Jennifer McBryan, Ph.D. Teaching Assistant Professor

Billy Middleton, M.A. Teaching Assistant Professor, Director of Assessment Gregory Morgan, Ph.D. Associate Professor, Philosophy

Joyce Mullan, Ph.D. Teaching Assistant Professor, Pre-Law Advisor

Nicholas O'Brien, M.F.A. Assistant Professor, Visual Arts & Technology

Benjamin Ogden, Ph.D. Teaching Assistant Professor

Anthony Pennino, Ph.D. Assistant Professor, Literature

Andrew Rubenfeld, Ph.D. Teaching Professor, Literature

Deborah Sinnreich-Levi, Ph.D. Associate Professor, Literature

Michael Steinmann, M.D. Professor, Philosophy Director, Program in Humanities and Social Sciences

Lindsey Swindall, Ph.D. Teaching Assistant Professor

Yu Tao, Ph.D. Assistant Professor, Social Sciences/ Sociology

Kelland Thomas, D.M.A. Dean, College of Arts & Letters Professor, Music & Technology

Jeff Thompson, M.F.A. Assistant Professor, Director, Visual Arts and Technology

John Vardalas, Ph.D. Industry Associate Professor, History

Lee Vinsel, Ph.D. Assistant Professor, Science and Technology Studies Director, Program in Science and Technology Studies

Jason Vredenburg Teaching Assistant Professor

Alex Wellerstein, Ph.D. Assistant Professor, Science and Technology Studies

Mary Robin Whitney, Ph.D. Teaching Assistant Professor

Undergraduate Programs

B.A. AND B.S. DEGREE PROGRAM

The College of Arts and Letters at Stevens offers distinctive B.A. and B.S. degree programs in a variety of humanistic and arts disciplines. Successful completion of a degree requires a secondary concentration in another discipline including but not limited to engineering, management, physics, chemistry, computer science, or another humanistic discipline. This breadth of experience provides students with an opportunity to achieve significant competence in a scientific, technological, or professional field, and prepares them for a variety of careers. Moreover, the comprehensive and rigorous curricula of CAL provide the foundations and expertise necessary for graduate level work in the chosen field of study, or for professional programs in law, medicine, or management.

Students can earn a degree by majoring in one of the following fields of study:

Bachelor of Arts degrees:

- History
- ▶ Literature
- Philosophy
- Social Sciences
- Science Communication
- Visual Arts and Technology
- Music and Technology

Bachelor of Science degree:

Science, Technology, and Society

Alternatively, an individualized inter-disciplinary B.A. program may be chosen upon approval of the CAL Curriculum Committee.

In the first two years, CAL majors study a number of core classes, starting with the two-course sequence of the Freshman Experience which offers a broad introduction to the humanistic disciplines studied at the College of Arts and Letters (CAL 105), as well as an introduction to academic writing (CAL 103).

Majors in the humanities, social sciences, and STS take a sequence of four classes which cover the traditional humanistic disciplines as they pertain to problems and topics in science and technology, the "common core." The common core for the first two years consists of the following classes:

- 1. History of Science and Technology (HHS 130)
- 2. Introduction to Science and Technology Studies (HST 120)
- 3. Images of Science in Literature (HLI 220)
- 4. Science and Metaphysics (HPL 112)

Students then take 10 additional classes in their major discipline. The number of classes on the 100/200-level can vary according to the discipline (see distribution requirements). In addition, students have to take two upper-division classes in another humanities discipline outside of their major field.

During their second term, the two areas of concentration have to be identified. The major concentration must be in one of the humanistic fields. For a secondary concentration students may also build on the basic courses in computing, mathematics,

and science, and draw on the resources and courses available in other departments at Stevens. Secondary concentration programs are available in all the disciplines of the Institute. Alternatively, students may complete a minor in a second field within CAL. Although a limited number of electives are designated for the second concentration, the open electives can be used if greater depth is desired in the field.

In addition, students are required to take a class in Writing and Research Methods. The class should be taken in the first semester of the junior year. It provides the necessary preparation for serious academic work in the last two years, as well as for the senior thesis which is required as a culmination of the major concentration. Students can take CAL 301, Seminar in Writing and Research Methods, or, alternatively, a research methods class in their disciplines, such as HHS 301, Introduction to Historical Methods. Other discipline-specific classes may be available as well. Students also can take any other upper-division class in their major discipline and use it to fulfill special requirements in research and research writing. The advisor has discretion on which course may be used as a research methods class. A class taken as research methods class must be identified separately on the study plan and may not be declared after the fact. In addition to regular classes, research method classes can be taken either as a class by application or as tutorial.

In addition, students have to take the following classes:

- CAL 498, Thesis Research (first semester of senior year),
- CAL 499, Senior Thesis (second semester of senior year, 4 credits)

Both classes require formal registration. Midterm and final grades will be given. Students must pass CAL 498 in order to register for CAL 499. If CAL 498 has to be retaken, the completion of the thesis will be postponed for one semester. The sequence of classes is necessary to insure adequate preparation for thesis writing. All graduating CAL majors participate in CAL Senior Design Day and the Stevens Innovation Exhibition (posters or other forms of display).

Overview of required classes for single B.A. or B.S. degree in the humanities, social sciences, and STS:

- CAL 103 and CAL 105
- ▶ 4 classes in the common core (HHS 130, HST 120, HLI 220, HPL 112)
- ▶ 10 classes in the major discipline (at least one on the 100/200 level)
- ▶ 2 additional upper-division humanities classes outside of the discipline
- CAL 301 or Writing and Research Methods class
- CAL 498 and CAL 499

Students pursue their CAL degrees while also enrolled in courses in computing, mathematics, and the sciences. CAL major students have specific requirements with respect to classes in mathematics, science, and computing. Four mandatory classes have to be distributed in the following way:

- Mathematics, two classes.
- Science, one class.
- Computer Science, one class.

In addition, major students take one Environmental Studies Course and one Global Studies Course. These classes can be chosen from all areas taught at Stevens, including not only the humanities but also engineering, science, technology management, etc. The choice of classes has to be approved by the advisor. If no course is available, students can replace this requirement with a free elective.

For the Bachelor of Science degree in Science, Technology, and Society additional requirements apply pertaining to classes in mathematics and science. Besides the four classes mentioned above (mathematics, science, computer science), two

additional classes from the fields of mathematics, science, computer science or engineering have to be taken, for a total of at least 18 credits. The choice of classes also has to be approved by the advisor.

Students in Music & Technology and Visual Arts & Technology take different core classes, both with respect to the humanities and the core classes in their discipline. For the most current information, see the website of the respective programs at the site of the College of Arts & Letters.

Instead of CAL 301, 498, and 499, students in Visual Arts & Technology take:

- HAR 301: Professional Practices
- HAR 498: Capstone I
- HAR 499: Capstone II

There are various distribution requirements for the different major classes besides the common core, depending on the discipline. They are as follows (note that classes from the common core are not listed again below):

- History. Required: one year of a freshman/sophomore history sequence: History of European Society and Culture I & II (HHS 123, 124), United States History until 1865 (HHS 125) and United States History since 1865 (HHS 126); and electives from among the history concentration (American, European, History of Science, and World), selected in consultation with the faculty advisor. Students also have to take the Introduction to Historical Methods (HHS 301).
- Literature. Required: one year of the freshman/sophomore literature sequence: Western Literature: Classical Literature (HLI 113), Western Literature: Middle Ages to the Present (HLI 114); one class on a major person; one class in American literature; one class in classical-medieval or Renaissance-modern literature; one class in 19th or 20th century literature; one class in non-Western literature. Remaining courses are selected in consultation with your advisor.
- Philosophy. Required: Theories of Human Nature (HPL 111); Ethics (HPL 339), Social and Political Philosophy (HPL 340), or Aesthetics (HPL 348); Philosophy of Science (HPL 368) or Logic (HPL 442); Theories of Knowledge and Reality (HPL 347), Philosophy of Language (HPL 443), or Philosophy of Mind (HPL 444).
- Social Sciences. Social Sciences major students choose a concentration in Political Science, Sociology, or Psychology. At least five classes should be taken in the chosen concentration. Remaining courses are selected in consultation with the advisor. At least two of the introductory classes have to be taken: Political Science I: National Government (HSS 127), Introduction to Sociology (HSS 141), Fundamentals of Psychology (HSS 175).
- Science, Technology, and Society. Required: Introduction to Science and Technology Studies (HST 120), Research and Innovation Policy (HST 360). Remaining courses are selected in consultation with the advisor.
- Science Communication. Required: Introduction to Science Communication (HST 160), Seminar in Science Writing (HST 401). Remaining courses are selected in consultation with the advisor.
- Visual Arts & Technology See web page for details.
- Music & Technology See web page for details.

Minors

Students can obtain a minor at the College of Arts and Letters. They must submit a study plan to their CAL advisor or another faculty member at CAL. Those completing the minor receive a certificate upon graduation. Students have to achieve a C or better in each course of the minor.

CAL minors may be earned in the following disciplines:

- History
- Literature
- Philosophy
- Social Sciences
- Science, Technology, and Society
- Science Communication
- Visual Arts & Technology
- Music & Technology
- Theater and Technology
- Film Studies
- Gender and Culture Studies
- Pre-law and Public Policy
- Turkish and Middle Eastern Studies

The minor requires a total of 9 humanities courses including the Freshman Experience (CAL 103 and CAL 105). Beyond these courses, a minimum of six courses in the minor discipline has to be taken. Depending on the discipline and with the approval of the advisor, these can be

- ▶ one 100/200-level course and five upper-division (300/400-level) courses Or
- ▶ two 100/200-level courses and four upper-division (300/400-level) courses.

For minors in History, Literature, and Philosophy, students must take one upper-division course in a CAL discipline outside the minor field. In the Social Sciences, at least two concentrations must be covered. For a minor in the humanities and social sciences, all courses must qualify for humanities credit. For specific requirements in Science and Technology Studies, Visual Arts, and Music, refer to the respective website or the advisors.

History Curriculum

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Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
HHS 130	History of Science & Technology	3	0	6	3
HST 120	Introduction to Science & Technology Studies	3	0	6	3
CS 105	Introduction to Scientific Computing	2	2	6	3
Or	Or				
CS 115	Introduction to Computer Science				
	Major Specific Course ¹	3	0	6	3
	Total	14	2	30	15

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Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
HLI 220	Images of Science in Literature	3	0	6	3
HPL 112	Science and Metaphysics	3	0	6	3
	Mathematics ²	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Total	15	0	30	15

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Environmental/Global Studies ⁴ or Elective	3	0	6	3
	Mathematics ²	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Total	15	0	30	15

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Science ⁵	3	0	6	3
	Environmental/Global Studies ⁴ or Elective	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Seminar in Writing and Research Methods	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit	
	Major Specific Course ¹	3	0	6	3	
	Secondary Concentration ³	3	0	6	3	
CAL 498	Thesis preparation	3	0	6	3	
	Elective ⁶	3	0	6	3	
	Elective ⁶	3	0	6	3	
	Total	15	0	30	15	

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Secondary Concentration ³	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
CAL 499	Senior Thesis	4	0	8	4
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	16	0	32	16

(1) Major Specific Course: To be determined with your faculty advisor.

(2) Math requirement: See list. Other courses are to be determined with your faculty advisor.

(3) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.

(4) Environmental /Global Studies must be approved by your faculty advisor.

(5) Science requirement: See list. Other courses are to be determined with your faculty advisor.

(6) General Elective: Chosen by the student. Can be used towards a minor or option. Can be applied to research or approved international studies

(7) CAL upper level non-major course: A class in a humanities discipline that is not part of the student's primary or, if applicable, secondary major.

Philosophy Curriculum

Term I

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Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
HHS 130	History of Science & Technology	3	0	6	3
HST 120	Introduction to Science & Technology Studies	3	0	6	3
CS 105	Introduction to Scientific Computing	2	2	6	3
Or	Or				
CS 115	Introduction to Computer Science	3	0	6	3
	Major Specific Course	3	0	6	3
	Total	14	2	30	15

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
HLI 220	Images of Science in Literature	3	0	6	3
HPL 112	Science and Metaphysics	3	0	6	3
	Mathematics ²				
	Major Specific Course ¹	3	0	6	3
	Total				

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Environmental Studies or Elective ⁴	3	0	6	3
	Mathematics ²				
	Secondary Concentration ³	3	0	6	3
	Total				

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Science ⁵				
	Global Studies or Elective ⁴	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total				

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Seminar in Writing and Research Methods	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
CAL 498	Thesis Preparation	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Secondary Concentration ³	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
CAL 499	Senior Thesis	4	0	8	4
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	16	0	32	16

(1) Major Specific Course: To be determined with your faculty advisor.

- (2) Math requirement: See list. Other courses are to be determined with your faculty advisor.
- (3) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.
- (4) Environmental /Global Studies must be approved by your faculty advisor.
- (5) Science requirement: See list. Other courses are to be determined with your faculty advisor.
- (6) General Elective: Chosen by the student. Can be used towards a minor or option. Can be applied to research or approved international studies
- (7) CAL upper level non-major course: A class in a humanities discipline that is not part of the student's primary or, if applicable, secondary major.

Social Sciences Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 105	CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
HHS 130	History of Science & Technology	3	0	6	3
HST 120	Introduction to Science & Technology Studies	3	0	6	3
CS 105	Introduction to Scientific Computing	2	2	6	3
Or	Or				
CS 115	Introduction to Computer Science				
	Major Specific Course ¹	3	0	6	3
	Total	14	2	30	15

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
HLI 220	Images of Science in Literature	3	0	6	3
HPL 112	Science and Metaphysics ⁴	3	0	6	3
	Mathematics ²				
	Major Specific Course ¹	3	0	6	3
	Total				

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Environmental Studies or Elective ⁴	3	0	6	3
	Mathematics ²				
	Secondary Concentration ³	3	0	6	3
	Total				

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Science ⁵	3	0	6	3
	Global Studies or Elective ⁴	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Seminar in Writing and Research Methods	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ²	3	0	6	3
CAL 498	Thesis Preparation	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Secondary Concentration ²	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
CAL 499	Senior Thesis	4	0	8	4
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	16	0	32	16

(1) Major Specific Course: To be determined with your faculty advisor.

- (2) Math requirement: See list. Other courses are to be determined with your faculty advisor.
- (3) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.
- (4) Environmental /Global Studies must be approved by your faculty advisor.
- (5) Science requirement: See list. Other courses are to be determined with your faculty advisor.
- (6) General Elective: Chosen by the student. Can be used towards a minor or option. Can be applied to research or approved international studies
- (7) CAL upper level non-major course: A class in a humanities discipline that is not part of the student's primary or, if applicable, secondary major.

Literature Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 105	CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
HHS 130	History of Science & Technology	3	0	6	3
HST 120	Introduction to Science & Technology Studies	3	0	6	3
CS 105	Introduction to Scientific Computing	2	0	6	3
Or	Or				
CS 115	Introduction to Computer Science				
	Major Specific Course ¹	3	0	6	3
	Total	14	0	30	15

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
HLI 220	Images of Science in Literature	3	0	6	3
HPL 112	Science and Metaphysics ⁴	3	0	6	3
	Mathematics ²	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Total	15	0	30	15

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Environmental/Global Studies or Elective ⁴	3	0	6	3
	Mathematics ²	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Total	15	0	30	15

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Science ⁵	3	0	6	3
	Environmental/Global Studies or Elective ⁴	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Seminar in Writing and Research Methods	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
CAL 498	Thesis Preparation	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Secondary Concentration ³	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
CAL 499	Senior Thesis	4	0	8	4
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	16	0	32	16

(1) Major Specific Course: To be determined with your faculty advisor.

(2) Math requirement: See list. Other courses are to be determined with your faculty advisor.

- (3) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.
- (4) Environmental /Global Studies must be approved by your faculty advisor.

(5) Science requirement: See list. Other courses are to be determined with your faculty advisor.

(6) General Elective: Chosen by the student. Can be used towards a minor or option.Can be applied to research or approved international studies

(7) CAL upper level non-major course: A class in a humanities discipline that is not part of the student's primary or, if applicable, secondary major.

Music and Technology Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing And Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
CS 105	Introduction to Scientific Computing	2	2	4	3
Or	Or				
CS 115	Introduction to Computer Science				
HMU 201	Music Theory I	3	0	6	3
HMU 220	Piano Class I	3	0	6	3
HMU 205	Introduction to Digital Media	3	0	6	3
HMU 496	Music Performance: Private Lessons	0	0	6	.5
	Total	14	2	34	15.5

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing And Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
	100 Level Humanities ¹	3	0	6	3
HMU 202	Music Theory II	3	0	6	3
HMU 221	Piano Class II	3	0	6	3
HMU 205	Introductions to Digital Media	3	1	6	3
HMU 496	Music Performance: Private Lessons ²	0	0	0	.5
	Total	15	1	30	15.5

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	100 Level Humanities	3	0	6	3
	Math Course ³	3	0	6	3
PE 200	Physical Education I	0	0	0	0
HMU 101	Music History I	3	0	6	3
HMU 303	Music Theory III	3	0	6	3
HMU 397	Orchestration I	3	0	6	3
HMU 231	Sound Recording I	3	4	6	3
HMU 496	Music Performance: Private Lessons ²	0	0	0	.5
	Total	18	4	36	18.5

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Humanities ¹	3	0	6	3
	Math	3	0	6	3
PE 200	Physical Education II	0	0	0	0
HMU 102	Music History II	3	0	6	3
HMU 304	Music Theory IV	3	0	6	3
HMU 232	Sound Recording II	2	2	4	3
HMU 496	Music Performance: Private Lessons ²	0	0	0	.5
HMU 497	Music Performance: Recital/Ensemble ²	0	0	0	.5
	Total	14	2	28	16

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Science Course ⁴	3	0	6	3
PE 200	Physical Education III	0	0	0	0
HMU 333	Sound Recording III	2	2	4	3
HMU 498	Ensemble	0	0	0	1
HMU 310	Music Composition	3	0	6	3
	2nd Concentration ⁵	3	0	6	3
	Humanities 300/400 level ¹	3	0	6	3
	Total	14	2	28	16

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 301	Seminar in Writing and Research Methods	3	0	6	3
	Science Course ⁴	3	0	6	3
PE 200	Physical Education IV	0	0	0	0
HMU 498	Ensemble	0	0	0	1
HMU 334	Sound Recording IV	2	2	4	3
	2nd concentration ⁵	3	0	6	3
	2nd concentration ⁵	3	0	6	3
	2nd concentration ⁵	3	0	6	3
	Total	17	2	34	19

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 498	Thesis Preparation	3	0	6	3
HMU 407	Sound Design	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 499	Senior Thesis	4	0	8	4
HMU 405	Electronic Music	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	16	0	32	16

(1) Humanities Requirement: CAL 103, CAL105 and 6 additional Humanities of which one must be a 300/400 upper level course. Muisc Courses that satisfy Humanities Requirements include: HMU 101, HMU102, HMU350

2) Students may adopt the following Ensemble/Recital requirement in place of their respective catalog Ensemble/Recital requirements by having a variance signed by the division director or Dean -2 Semesters HMU 498 DOTA Ensemble (Only HMU498 DOTA Ensemble will qualify for the HMU498 requirement.) -1 Semester of HMU 497 Recital

3) Math courses: See list. Other courses are to be determined with your faculty advisor.

4) Science courses: See list. Other courses are to be determined with your faculty advisor.

5) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.

6) General Elective: Chosen by the student. Can be used towards a minor or option. Can be applied to research or approved international studies

Science Communication

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 105	CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
HHS 130	History of Science & Technology	3	0	6	3
HST 112	Science and Metaphysics	3	0	6	3
CS 105	Introduction to Scientific Computing	2	2	4	3
Or	Or				
CS 115	Introduction to Computer Science				
HST 160	Introduction to Science Communication	3	0	6	3
	Total	14	2	28	15

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
HLI 220	Images of Science in Literature	3	0	6	3
HPL 120	Introduction to Science & Technology Studies	3	0	6	3
	Mathematics ²	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Total	15		30	15

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Environmental Studies or Elective ⁴	3	0	6	3
	Mathematics ²	3	0	6	3
	Secondary Concentration ²	3	0	6	3
	Total	15	0	30	15

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Science ⁵	3	0	6	3
	Global Studies or Elective ⁴	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Secondary concentration ³	3	0	6	3
	Seminar in Writing and Research Methods	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	General Elective ⁷	3	0	6	3
	General Elective ⁷	3	0	6	3
	Total	15	0	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
CAL 498	Thesis Preparation	3	0	6	3
	General Elective ⁷	3	0	6	3
	General Elective ⁷	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Secondary Concentration ³	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
CAL 499	Senior Thesis	4	0	8	4
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	16	0	32	16

(1) Major Specific Course: To be determined with your faculty advisor.

(2) Math requirement: See list. Other courses are to be determined with your faculty advisor.

(3) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.

(4) Environmental /Global Studies must be approved by your faculty advisor.

(5) Science requirement: See list. Other courses are to be determined with your faculty advisor.

(6) General Elective: Chosen by the student. Can be used towards a minor or option. Can be applied to research or approved international studies

(7) CAL upper level non-major course: A class in a humanities discipline that is not part of the student's primary or, if applicable, secondary major.

Science, Technology, and Society

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 105	CAL Colloquium: Knowledge, Nature, Culture	3	0	6	3
HHS 130	History of Science & Technology	3	0	6	3
HST 120	Introduction to Science & Technology Studies	3	0	6	3
CS 105	Introduction to Scientific Computing	3	0	6	3
Or	Or				
CS 115	Introduction to Computer Science				
	Major Specific Course ¹	3	0	6	3
	Total	15	0	30	15

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
HLI 220	Images of Science in Literature	3	0	6	3
HPL 112	Science and Metaphysics	3	0	6	3
	Mathematics ²	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Total	15	0	30	15

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Term III

Course #	Course Name	Le	ecture	Lab	Study	Credit
	Major Specific Course ¹	3		0	6	3
	Major Specific Course ¹	3		0	6	3
	Environmental Studies or Elective ⁴	3		0	6	3
	Mathematics ²	3		0	6	3
	Secondary Concentration ³	3		0	6	3
	Total	15	5	0	30	15

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Science ⁵	3	0	6	3
	Global Studies or Elective ⁴	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Major Specific Course ¹	3	0	6	3
	Secondary concentration ³	3	0	6	3
	Seminar in Writing and Research Methods	3	0	6	3
	Science ⁵	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Science ⁵	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
	Major Specific Course ¹	3	0	6	3
	Secondary Concentration ³	3	0	6	3
CAL 498	Thesis Preparation	3	0	6	3
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
	Secondary Concentration ³	3	0	6	3
	CAL upper level non-major course ⁷	3	0	6	3
CAL 499	Senior Thesis	4	0	8	4
	General Elective ⁶	3	0	6	3
	General Elective ⁶	3	0	6	3
	Total	16	0	32	16

(1) Major Specific Course: To be determined with your faculty advisor.

(2) Math requirement: See list. Other courses are to be determined with your faculty advisor.

(3) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.

(4) Environmental /Global Studies must be approved by your faculty advisor.

(5) Science requirement: See list. Other courses are to be determined with your faculty advisor.

(6) General Elective: Chosen by the student. Can be used towards a minor or option.Can be applied to research or approved international studies.

(7) CAL upper level non-major course: A class in a humanities discipline that is not part of the student's primary or, if applicable, secondary major.

Visual Arts and Technology Curriculum

Term I

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communications Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
HAR 110	Foundation 2D: Color & Composition	3	0	6	3
HAR 112	Drawing I	3	0	6	3
HAR 181	History of Art: Prehistory to Modern	3	0	6	3
	Math, CS, or Science ²	3	0	6	3
	Total	15	0	30	15

Term II

Course #	Course Name	Lecture	Lab	Study	Credit
CAL 103	Writing & Communication Colloquium	3	0	6	3
Or	Or				
CAL 105	CAL Colloquium: Knowledge, Nature, Culture				
HAR 111	Foundation 3D: Form & Space	3	0	6	3
HAR 113	Drawing II	3	0	6	3
HAR 114	Introduction to Photography	3	0	6	3
	Math, CS, or Science ²	3	0	6	3
	Total	15	0	30	15

Term III

Course #	Course Name	Lecture	Lab	Study	Credit
HAR 220	Video I	3	0	6	3
HAR 241	Design I	3	0	6	3
HAR 230	Animation I	3	0	6	3
	CAL core requirement ⁴	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Total	15	0	30	15

Term IV

Course #	Course Name	Lecture	Lab	Study	Credit
HAR 280	Modern Art History & Theory	3	0	6	3
HAR 240	Web Design I	3	0	6	3
	General elective ⁵	3	0	6	3
	CAL core requirement ⁴	3	0	6	3
	Math, CS, or Science ²	3	0	6	3
	Total	15	0	30	15

Term V

Course #	Course Name	Lecture	Lab	Study	Credit
HAR 250	Data Visualization I	3	0	6	3
	General Elective ⁵	3	0	6	3
	General Elective ⁵	3	0	6	3
	General Elective ⁵	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Total	15	0	30	15

Term VI

Course #	Course Name	Lecture	Lab	Study	Credit	
	300-level major concentration ¹	3	0	6	3	
HAR 301	Professional Practices	3	0	6	3	
	CAL core requirement ⁴	3	0	6	3	
	Math, CS, or Science ²	3	0	6	3	
	Secondary Concentration ³	3	0	6	3	
	Total	15	0	30	15	

Term VII

Course #	Course Name	Lecture	Lab	Study	Credit
HAR 498	Capstone I	3	0	6	3
	General Elective ⁵	3	0	6	3
	General Elective ⁵	3	0	6	3
	CAL core requirement ⁴	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Total	15	0	30	15

Term VIII

Course #	Course Name	Lecture	Lab	Study	Credit
HAR 499	Capstone II	4	0	8	4
	400-level major concentration ¹	3	0	6	3
	General Elective ⁵	3	0	6	3
	General Elective ⁵	3	0	6	3
	Secondary Concentration ³	3	0	6	3
	Total	16	0	30	16

(1) HAR course only.

(2) Math, Science or Computer Science: To be determined with your faculty advisor.

- (3) Secondary Concentration: The concentration can be chosen from all disciplines offered at Stevens Institute of Technology upon consultation with the advisor.
- (4) CAL Core Requirement: See program website details.
- (5) General Elective: Chosen by the student. Can be used towards a minor or option. Can be applied to research or approved international studies.

Math and Science Requirements for CAL Students

The following courses fulfill the science requirements for CAL students:

- ▶ PEP 151 Introduction to Astronomy
- ▶ PEP 123 Physics I for Business & Technology
- ▶ PEP 124 Physics II for Business & Technology
- ▶ BIO 281 Biology & Biotechnology
- ▶ EN 250 Quantitative Biology
- NANO 200 Intro to Nanotechnology
- ▶ CH 115 Chemistry I
- CH 116 Chemistry II
- ▶ PEP 111 Mechanics
- ▶ PEP 112 Electricity & Magnetism

The following courses fulfill the math requirements for CAL students:

- MA 117 Calculus for Business & Liberal Arts
- MA 119 Multivariable Calculus & Finite Math for Business & Liberal Arts
- MA 121/122 Differential/Integral Calculus
- MA 123/124 Series, Vectors, Functions & Surfaces/ Calculus of two variables

Humanities Requirements

All undergraduate students are required to complete CAL 103, Writing and Communications, and CAL 105, Knowledge, Nature, Culture.

Following the completion of CAL 103 and CAL 105, students must meet the humanities requirements below:

- Engineering students: Four additional humanities classes. At least one must be at the 100 or 200 level, at least one must be at the 300 or 400 level, and courses must cover at least two different disciplines within CAL.
- Science and Math students: Six additional humanities classes. At least one must be at the 100 or 200 level, at least one must be at the 300 or 400 level, and courses must cover at least two different disciplines within CAL.
- Computer Science, Cybersecurity, and Information Systems (for 2011 & 2012 incoming classes) students: Six additional humanities classes. At least one must be at the 100 or 200 level, at least one must be at the 300 or 400 level, and courses must cover at least two different disciplines within CAL. One of the six additional classes must be either HSS 371 or HPL 455.
- Cybersecurity (for 2014 incoming class and LATER):Four additional humanities classes. At least one must be at the 100 or 200 level, at least one must be at the 300 or 400 level, and courses must cover at least two different disciplines within CAL. One of the four additional classes must be either HSS 371 or HPL 455.
- Business & Technology (Marketing, Finance, Economics, & Information Systems) and Quantitative Finance students: Two additional humanities classes. One must be at the 100 or 200 level, one must be at the 300 or 400 level, and courses must cover at least two different disciplines within CAL.

No advance placement or transfer credit will be given for CAL 103 or CAL 105.

International students will be placed in CAL 101 during their first semester. After successful completion of CAL 101, international students must take CAL 103, followed by CAL 105. A diagnostic will be administered during the first week of CAL 101 and students who surpass the requirements of the diagnostic may transfer to CAL 103. CAL 101 may be used to satisfy a general or free elective requirement.

BT 243, Macroeconomics, and BT 244, Microeconomics, may be counted as upper-level humanities courses, provided they are not required courses in the student's major.

The only art and music classes that fulfill humanities requirements are:

Music

- HMU 101 Music History I
- HMU 102 Music History II
- HMU 192 Music Appreciation I
- HMU 193 Music Appreciation II
- HMU 195 History of Electronic and Experimental Music
- HMU 350 Music of the Eastern Mediterranean

Other classes in the history of music can qualify, but are very rarely taught. Music Theory currently does not qualify for Humanities credit.

Visual Arts

- ▶ HAR 181 History of Technology in the Arts
- HAR 180 History of Art: Prehistory to the Modern Era
- ▶ HAR 280 Modern Art History and Theory

- ▶ HAR 281 History of Photography
- HAR 282 History of Middle Eastern Art
- HAR 380 Contemporary Art
- HAR 381 Media Theory
- ▶ HAR 495 Special Topics

Other classes in the history of art, for example classes with an HAR 495 prefix (in Fall 14: History of Design), can qualify, but are very rarely taught.

Students may complete 6 semesters of HMU 490, Music Performance: Concert Band Or 6 semesters of HMU 491, Music Performance: Jazz Ensemble Or HMU 492 Music Appreciation: Stevens Choir as a general elective.

COURSE OFFERINGS

General Humanities

CAL 101	English Skills	(3-6-0)
Open to Internation	onal Students Only. Cannot be used for Humanities Credit.	

CAL 103 Writing And Communications Colloquium

This course empowers students with the written and oral communications skills essential for both university-level academic discourse as well as success outside Stevens in the professional world. Tailored to the Stevens student, styles of writing and communications include technical writing, business proposals and reports, scientific reports, expository writing, promotional documents and advertising, PowerPoint presentations, and team presentations. The course covers the strategies for formulating effective arguments and conveying them to a wider audience. Special attention is given to the skills necessary for professional document structure, successful presentation techniques and grammatical/style considerations.

CAL Colloquium: Knowledge, Nature, Culture CAL 105

This course introduces students to all the humanistic disciplines offered by the College of Arts and Letters: history, literature, philosophy, the social sciences, art, and music. By studying seminal works and engaging in discussions and debates regarding the themes and ideas presented in them, students learn how to examine evidence in formulating ideas, how to subject opinions, both their own, as well those of others, to rational evaluation, and in the end, how to appreciate and respect a wide diversity of opinions and points of view.

CAL 108	Studies in History & Social Science II	(3-3-0)

Topics include significant issues in history and political science.

CAL 301 Seminar in Writing and Research Methods

A working seminar in which students will become acquainted with the various research methods and resources in the Humanities disciplines, and with the modes of presentation characteristic of each discipline. Special attention will be paid to clarity of expression and logical structure of essays and research papers.

CAL 401 Seminar in Science Writing

This course provides a critical examination of topics addressed in events sponsored by the Center for Science Writings, during which prominent science writers delve into a variety of aspects of science and technology-and their impact on societyfrom both a historical and contemporary point of view. In addition to regular weekly class meetings, students have the unique opportunity to meet CSW speakers to discuss their work.

CAL 495 Independent Study I

Independent study allows the student to participate in research, explore a topic not covered by existing courses, or continue to study in greater depth a topic introduced by a course. Independent study courses must be conducted under the guidance of a full time faculty member, whose approval is required prior to enrollment. The student and faculty member must agree on the scope and details of participation in advance. Independent Study courses carry one to three credits.

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CAL 496 Independent Study II

Independent study allows the student to participate in research, explore a topic not covered by existing courses, or continue to study in greater depth a topic introduced by a course. Independent study courses must be conducted under the guidance of a full time faculty member, whose approval is required prior to enrollment. The student and faculty member must agree on the scope and details of participation in advance. Independent Study courses carry one to three credits.

CAL 498 Thesis Preparation

The student will complete a major research thesis in the area of concentration under the guidance of a faculty advisor. Open to Bachelor of Arts students only.

CAL 499 Senior Thesis

An individual program of study arranged between student and instructor. A tutorial plan must be prepared (and presented to the Tutorial Committee of the Department of the Humanities) outlining the program and indicating the nature and scope of the project (generally a written paper). Upon completion of the program, the student will receive a grade and credit for a humanities elective.

HUM 500 Foundations of Business and Professional Communications (3 - 0 - 0)

The course covers topics that include brainstorming, organizing, writing and revision of technical documents, as well as preparation of verbal presentations with visual aids. In this overview class, students will be exposed to these skills, and have time to generate their own documents and presentations for feedback, but Hum 500 is primarily designed to give the students a foundation so that they may continue on with other, more specialized, classes in this field. Students in need of ESL/ESD attention will receive it. The course may be offered as a week-long intensive class designed to get students familiar with the basic concepts and tools they will need to master in order to pursue the Certificate Program in Professional Communications or other Stevens graduate degrees or programs.

HUM 501 Foundations of Technical Communication

This course introduces professional communications: How should professionals construct technical documents for the business or scientific/technical community? What are the techniques writers need for specialized, clear writing? Topics include: genres of technical writing; successful writing strategies; design principles; format; and contents. Students will practice the techniques presented through weekly writing assignments.

HUM 502 **Professional Presentations**

This course will present a range of professional presentation techniques: oral, web-based, and audio-visual. Students' existing skills will be sharpened and enhanced with knowledge of current best professional practices. Weekly assignments will guarantee that students will master new techniques.

HUM 503 Advanced Documentation Techniques

This course sharpens students' ability to deliver written descriptions, explanations, and instructions to a diverse audience who may not share the writers' technical expertise. Students will create overviews and abstracts; lay out guidelines for readers; craft orderly instructions and explanations; insert necessary illustrations that enhance the documentation; build links to the next set of instructions; summarize effectively; and format for maximum comprehension.

HUM 504 Foundations of Business Plan Writing

This course introduces the foundations of writing a business plan. Topics include: what investors and lenders are looking for; the key elements of a business plan; and special considerations when writing a business plan for an international endeavor or web-based or web-supplemented businesses. Students will demonstrate their knowledge of the material presented through weekly writing assignments.

HUM 530 Writing for Engineers

This course is an introduction to writing for engineers. As technical writers, engineers may often feel that their task is merely to "inform," but as has been dramatically illustrated over the last few years, "informing" can be vital to successful system deployment and operation. Lives are often affected by not only the accuracy of an engineer's calculations, but by a clear and understandable presentation of conclusions and recommendations. The ability to write clearly and effectively is essential to an engineer.

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HUM 535 Writing for International Marketing

This course introduces the issues related to writing for international markets. What factors make writing for an international market different from writing for a domestic market? Topics covered include: the influence on writing of the key elements that make each nation different; the behavior of foreign consumers; translation issues; and considerations when writing presentations, instructional texts, business plans, and Web content for international audiences.

HUM 540 Foundations in Financial Writing

This course is concerned with the communication of financial information in writing: How should financial professionals construct documents? What are the writing techniques needed to make the numbers tell their own story? Topics include genres of financial writing; successful writing strategies; organizing information; and using tables and charts.

HUM 545 Writing for Health Care Professionals

This course introduces essential concepts for writing in pharmaceutical houses, medical advertising agencies, and other medical settings. Topics covered include basic medical terminology, appropriate AMA style and form and format in the use of professional research, preparation of meeting and conference materials for professionals in the field, and working with physicians.

HUM 550 Writing for the Web

This course dispels the myths about writing for the Web and provides students with the skills to move successfully from print to web. The dynamic medium of the Internet not only demands concise, clear, well-organized copy, but an ability to operate in a non-linear world. This course will enable students to: reinforce good technical writing practices; incorporate usability issues when designing information for the Web; think in non-linear ways; recognize the different functions of web copy and how to write for each (educational, promotional, information-seeking); and understand the different delivery methods and how they influence the layout of the information and audio-visual choices.

HUM 555 Writing for Project Management

This course introduces the writing tasks that are critical to project management as it is used across a wide variety of industries. Topics covered include: the language of work breakdown structures; addressing project requirements; the semantics of risk analysis; assessing scope; and designing and building a project plan. Students will review online project management tools. Students will apply the techniques of writing for project management by creating a project plan to manage some aspect of an academic or extra-curricular activity.

HUM 560 Writing for and About the Science Community

This course introduces the interpretation and analysis of complex scientific information and the translation of difficult scientific concepts into lively and readable prose. Topics include: effective interview techniques; information-gathering skills; news and feature article structure; editing; and writing for the general public, scientists, and industry. Students will practice these skills through in-class and take-home writing assignments. Writing assignments will progress from short, weekly articles to longer pieces. By the end of the semester, each student will write a feature article.

HUM 565 Publicity Writing: Techniques of Packaging Information

This course introduces the technical aspects of publicity writing. Topics include: writing a press bio; writing a topic summary; the art of the press release; the basics of the op-ed; and organizing the short informational feature. The course will include "how-to" discussions regarding inquiries from the press and the public, and ways to negotiate direct contacts with both. Guest speakers from the press/marketing field will make occasional presentations during the length of the course.

HUM 570 Proposal Writing

This course helps students developing a case for support for a nonprofit organization, making long-range programmatic and financial plans, researching potential funders, and preparing proposal materials. Students will learn how to find funding sources and will make regular presentations on their research and writing samples. The class will compile a comprehensive set of funding resources, as well as sample grants and planning documents. Guest speakers will share professional insights and experiences.

COLLEGE OF ARTS AND LETTERS

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History		
HHS 119 This course survey	The Ancient World ys world history of the ancient era.	(3-3-0)
HHS 120 This course exami	Origins of Western Culture nes the foundations of Western Culture.	(3-3-0)
	European Society and Cultural History to 1500 HS 124, 223, 224 investigate the social, economic, intellectual, political and cultural trends of the present in lectures and discussion.	(3-3-0) s in Europe from
HHS 124 A continuation of	History of European Society and Culture Since 1500 HHS 123. Prerequisites: HHS 123	(3-3-0)
	United States History to 1865 IHS 126 examine the main trends in the socioeconomic, political, and diplomatic history of hary period to the present.	(3-3-0) of the U.S. from
HHS 126 A continuation of	United States History Since 1865 HS 125. Group B, 100-level course. Prerequisites: HS 125	(3-3-0)
ideas, the scientif	Topics in the History of Science and Technology etion to the humanistic study of science and technology. Discussion will cover the natu ic method, and scientific change; the structure of scientific communities, relations betwee he place of science in society.	
Babylonian science	History of Science and Technology of science and technology. Principal topics include science and technology in prehistor and culture, Greek science, Medieval technology and science, the Scientific Revolution cal science, Darwin, and the Darwinian Revolution.	
the course follows	Survey of the Islamic World les a survey of the origin and development of the modern Islamic World. Beginning in sixth- the theological and political development of the Muslim community. It explores the reason had and the reasons for its spread throughout the Middle East, North Africa, and Southern e world.	ons for the great
HHS 301	Introduction to Historical Methods	(3-3-0)

This is an intensive writing and research seminar designed to introduce students to the world of historical research and the historian's craft. History majors are required to take this course during the spring semester of their junior year.

HHS 309 Newton and the Scientific Revolution

An analysis of the intellectual and methodological transformations of sixteenth and seventeenth century science and the development of the modern world view. This course focuses on the major scientific figures of the age (Galileo, Descartes, Newton) with particular attention to the study of original texts. The social and institutional transformations of science in this period are also considered.

HHS 310 Social History of Science

This course analyzes science as a social entity. The connections between science and society are studied in the first instance through a historical survey of the externals of science: the non-cognitive social, institutional, and professional dimensions of the scientific enterprise. On a case-study basis, the course proceeds to investigate more theoretical problems concerning relations between scientific knowledge and social structure, particularly as interpreted in the Strong Program of the Sociology of Knowledge. Students complete individual projects arising out of themes developed in class.

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An examination of the historical process whereby the scientific enterprise became a central concern of the state in modern industrial societies.

HHS 312 Technology and Society in America

This course surveys the origins and significance of technological developments in American history from the first settlements to the present. It emphasizes the social, cultural, political, and economic significance of technology in American history.

HHS 313 Science, Faith, and the American Imagination

Science and Society in the 20th Century

This course examines instances in American history in which "scientific" conclusions were widely perceived to be authoritative and true but were later shown to be fraudulent or false. The course examines effects that conclusions of this sort had not only on the culture at large but particularly on creative writers whose work in turn evokes tension between personal insight and faith in empirically derived "truth."

HHS 319 The Roman Republic

HHS 311

A study of early Roman civilization from the founding of the city of Rome in 753 B.C. to the collapse of the Republic under Julius Caesar. Readings in ancient sources and modern texts.

HHS 322 American Cultural History

"America Cultural History" provides an introduction to ways of analyzing conflicts between dominant and minority groups in American life.

HHS 323 Women and Gender in American History

This course focuses on the history of the United States from the perspective of women's experiences and the role gender plays in shaping and defining American history from the colonial era to the present. It examines women's social, political, and economic lives; their roles in society, their familial roles, their struggle to achieve civil rights; changes in their legal status; and the rise of feminism.

HHS 325 African-American Studies

An exploration of the African-American experience in the United States from the time of the Atlantic Slave Trade to the present. Topics include social and political dynamics shaping African-American history with particular attention focused on Reconstruction, the Great Migration, and the Civil Rights Movement. Numerous African-American leaders and their concepts for an African-American identity are also emphasized, including the W. E. B. Du Bois and Booker T. Washington debates, as well as speeches from Malcolm X and Martin Luther King, Jr.

HHS 338 The Russian Revolution and the Soviet Regime

The course begins with the contradictions inherent in semi-feudal Russia during the age of imperialism which culminated in the collapse of the Tsarist autocracy during World War I. There is a close analysis of the revolutionary year 1917 to determine the reasons for the failure of the liberal Kerensky regime on the one hand, and the rise of the Soviets and Bolsheviks on the other. Marxist-Leninist ideology is studied and compared to economic, social, and political programs during the revolution and during its consolidation in the period of the civil war and in the Stalinist era. The course also covers more recent Russian history.

HHS 340 History of the Middle East to 1800

This course is a general survey of the Middle East beginning in pre-Islamic Arabia in the year 600 and ending with the Napoleonic invasion of Egypt in 1798. The course examines the early formation of the Muslim community and follows its growth under the Umayyid and Abbasid empires. It also explores the influence of the Persians and the Turks in the region, examining the Ottoman and Safavid empires, the Mongol invasion, and ultimately the influence of Western European powers leading to Napoleon's conquest of Egypt in 1798.

HHS 341 History of the Middle East Since 1800

This course is a survey of the development of the modern Middle East from the Napoleonic invasion of Egypt in 1798 to the present. The course examines the early efforts for political reform and the beginnings of nationalism with particular emphasis on the period following World War I and the development of modern Middle Eastern nation states.

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COLLEGE OF ARTS AND LETTERS

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Science and Technology in Islamic History

This course is an introductory survey of an important aspect of Islamic civilization, the scientific and technological achievements of early Islam. The passion for knowledge led early Muslims to internalize, assimilate and expand the scientific knowledge of older civilizations, including those of Greece, India, China and the Byzantium. This course explores their accomplishments in cosmology, mathematics, astrology, geography, medicine, natural sciences, alchemy, optics, engineering and architecture. It also explores the ways in which Muslim scientific achievements influenced the advance of science in the Western world from the Crusaders and the Renaissance to the modern era. The contributions of early Muslims to the advance of Western civilization in general and sciences and arts in particular are not necessarily well integrated phenomena into the Western historiography. This course attempts to fill this gap.

HHS 355 U.S. Foreign Relations

HHS 345

Selected topics in American diplomatic history are studied, including nationalism, imperialism, economic diplomacy, missionary diplomacy, isolationism, world war, cold war, and detente. Readings include diplomatic correspondence, documents, interpretive articles, and monographs.

A study of Ancient Athens in the High Classical period, from the Persian wars to the end of the fifth century BC. Topics will include the rise of democracy under Pericles, as well as achievements in art and architecture, philosophy, and drama.

HHS 356 The Golden Age of Athens

HHS 357 Latin American History

A survey of the history of the different Latin-American nations from pre-colonial times to the present.

HHS 361 Scientific Revolution: Galileo

An analysis of the intellectual and methodological transformations of sixteenth and seventeenth century science and the development of the modern world view. This course focuses on the major scientific figures of the age (Galileo, Descartes, Newton) with particular attention to the study of original texts. The social and institutional transformations of science in this period are also considered.

HHS 363 Darwin and the Darwinian Revolution

An examination of the life and work of Charles Darwin. Surveys the background to Darwin's theory of evolution, the process of its discovery, and its presentation in The Origin of Species (1859). Other topics include the social and political dimensions to Darwinism and contemporary controversies surrounding evolutionary theory.

History of Modern Germany HHS 365

German history from its origins, but concentrating on the period from 1870 to the present. German industrialization, the dominant role of Prussia in unification, World War I, the Weimar and Nazi periods, World War II and the post-war era, including current developments, will be covered.

HHS 367 **Twentieth-Century History**

A survey of 20th century Middle Eastern history and politics. This course will explore the issues of nationalism, secularism and social transformations set within the predominantly Islamic Middle East. The different paths adopted by Turkey, Iran and Egypt will be among the major topics to be explored.

Studies in the Scientific Revolution HHS 369

An analysis of the intellectual and methodological transformations of sixteenth- and seventeenth-century science and the development of the modern world view. This course focuses on the major scientific figures of the age (Galileo, Descartes, Newton), with particular attention to the study of original texts. The social and institutional transformations of science in this period are also considered.

HHS 370 US Constitutional Law I: Early Foundations and Federalism (3 - 3 - 0)

An historical and theorectical analysis of the Constitutional Convention, the US Constitution, its foundations, conceptual and idealistic basis for the national government. The decision-making and policymaking roles of the US Supreme Court through case law is closely examined as it relates to governmental powers and federalism.

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HHS 371 Modern US Presidency and the Legislative Process

An exploration of the modern American political experience from the turn of the twentieth century to the present. This course examines the historical significance of the American policymaking process. Discussions center on presidential administrations, Congress and political parties addressing domestic agendas and policies. Highlighted eras promoting government activism include Progressivism, New Dealism, Great Society measures and recent political proposals.

HHS 373 US Constitutional Law II: Civil Liberties and Civil Rights

An historical and political analysis of the US Constitution as it relates to civil liberties and civil rights. The decision-making and policymaking roles of the US Supreme Court through case law in these areas are closely examined.

HHS 374 Psychohistory

An interdisciplinary inquiry into individual and group motivations underlying socially significant historical experiences. Selected issues include personality formation through the ages (Martin Luther and Andrew Jackson), individual and collective consciousness (Anne Hutchinson and the Salem witchcraft hysteria), and psychobiographies of Woodrow Wilson, Adolf Hitler, and others.

HHS 378 Modern European History (3 - 3 - 0)

Selected contemporary persepctives on European history since the French Revolution up to the creation of the European Union.

HHS 384 The United States and the Rise of the Modern Middle East

This course concerns social, economic, political, and cultural impressions of the Middle East reported by American writers, diplomats, and missionaries during the nineteenth century. American interest in Middle Eastern arts, particularly architecture and furniture design, are also explored.

HHS 386 Ancient Civilizations: The Roman Empire

Analyses of the foundation, expansion, and decline of the Roman Empire with an evaluation of its place in history.

HHS 390 History of Money, Credit, and Banking

This course explores the history of mediums of exchange and the consequent development of credit and credit exchange mechanisms from earliest times until the present. In particular, this course examines the relationship of money and credit to the technological environment and how evolving technologies, ranging from metallurgy to electronics, have created and shaped historical eras. Periods covered include pre-feudal, feudal, early capitalist, and modern times.

HHS 391 Metropolitan Developmental Studies

An historical analysis of post World War II suburban-urban growth policies. Examines the successes and failures of developmental proposals, especially social and environmental implications of Federal Housing Administrative incentives: de-facto segregation, commercial-residential sprawl; Smart Growth; New Urbanism and other high density concepts. Urban redevelopment policies, include brownfield, waterfront sites and the public provision of cultural and tourism infrastructure; incentives to promote gentrification; historic preservation; mixed income/community feasibility; and economic development policies, such as business improvement, tax abatements, enterprise zones and transit villages.

HHS 397 Historical Materialism

An analysis of history taking material factors into account. Course probes this theme from the point of view of historical change over time, case studies of material factors shaping history, and historiographically, that is, how the historical and theoretical literature has treated the exigencies of the material world and parameters governing human interaction with the material world.

HHS 414 Industrial America

In the late nineteenth and early twentieth centuries the United States was fundamentally transformed. This course examines the nation's genesis as an industrial and economic power and society's adaptation to the industrial age. It also considers the impact of industrialism on such historical problems as technological change, economic development, race and gender relations, political participation, reform movements, urbanization, immigration, imperialism, and globalization.

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HHS 415 Religion in America

"Religion in America" maps various routes pursued by religious groups in the United States--a culture in which there has been no "established" religion and in which symbiotic relations between the secular world and religious practices/beliefs continually evolve. The course will look principally at religion as a business, religion as a force in politics, and religion in conflict with science and technology.

HHS 420 Modern East Asian Studies

This course explores the modern economic and political development of China, Korea, and Japan from the late nineteenth century to the present and responses to Western imperialism. The rise of Chinese and Korean communism and Japanese fascism during the twentieth century are especially emphasized. There is also a close examination and comparison of development in additional Asian countries such as the Philippines and Vietnam.

HHS 429 The Scientist, the Engineer, and the Computer

To confront the student with social, political, legal, and ethical issues that professional scientists and engineers are being forced to reexamine in the light of the computer revolution. The course reviews traditional principles while challenging the student to recognize that technological innovation often drives social change and, specifically, that innovations as sweeping as the rapid and continuing changes in computer technology sometimes lead scientists and engineers into completely uncharted territory.

HHS 430 History of Modern Turkey

A study of the emergence and development of the Turkish Republic. The course examines the Republic's origins in the Ottoman Empire and traces its development from the period after the First World War to the present.

HHS 431 20th Century Arab Nationalism

A survey of the development of Arab Nationalist movements in the Middle East beginning in the period following WWI and the collapse of the Ottoman Empire, and tracing the different approaches to nationalism adopted in response to late Colonial forces and the emerging state of Israel.

HHS 432 History of Nationalism in the Middle East

A comparative review of the differing histories and alternative approaches to nationalism in the three major Middle Eastern States.

HHS 433 History of Central Asia

A survey of the History of Central Asia from the period of Persian domination through the Mongol period, the development of the Khanates leading to the Russian conquest, and finally to today's reemergence of autonomous states.

HHS 434 History of the Ottoman Empire

An examination of the economic, social and political transformations that created one of Europe's most powerful empires from 1299 until 1918. The course follows the growth and later dismemberment of the Empire, with special focus on the continuities found in the region today.

HHS 451 From Ape to Adam: Understanding Human Evolution

A survey of recent developments in evolutionary theory and the prehistory of the genus Homo in its several incarnations – Homo habilis, Homo erectus, and Homo sapiens.

HHS 453 Justice in War

Legal and moral issues associated with just and unjust wars in historical perspective and the issue of war crimes in international, legal, and moral terms.

HHS 460 Technogenesis in American History

Taught through problem-based learning techniques, the course entails intensive readings on American genesis of technologies through mainly biographical accounts ranging from Eli Whitney's rifles with interchangeable parts to Jim Clark's development of Netscape in Silicon Valley, and the contemporary role of universities in generating intellectual property. Such topics as the inventive-entrepreneurial process, patents, and the role of government in sponsoring research and development, and the development of Management of Technology techniques are covered.

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HHS 465From Caves to Cathedrals: Engineering and Technology Until 1500(3 - 3 - 0)

This course is a social and cultural history of engineering prehistoric times through the 14th century CE. It examines the nature and the role of the engineer and engineering in a global context in the pre-modern period. Through a series of case studies involving lecture, reading, discussion, and technical demonstrations, the course will examine the technical, economic, political, ideological, and cultural factors that can influence the contents, direction, location, and rhythm of engineering innovation. Particular attention will be paid to the variety of engineering approaches in the pre-modern world, and to non-western attitudes towards technology. This course complements HHS 466, from "Water, Wind & Steam: Engineering from 1400 – 1700" and "Engineering Empire from 1700 to the Present," but none of these courses is a prerequisite for any of the others.

HHS 466 Water, Wind & Steam: Engineering From 1400-1750 (3 - 3 - 0)

This course is a social and cultural history of engineering in the early modern era, the 15th, 16th, 17th, and early 18th centuries. Through a series of case studies involving lecture, reading, and discussion, the course will examine the technical, economic, political, ideological, and cultural factors that can influence the contents, direction, location, and rhythm of engineering innovation. Particular attention will be paid to the emergence of science-based engineering in early modern Europe, and the conditions that were going to lead to its spread throughout the world during the modern period. This course complements HHS 465, from "Caves to Cathedrals: Engineering Until 1500" and "Engineering Empire from 1700 to the Present," but none of these courses is a prerequisite for any of the others.

HHS 467 Engineering Empire From 1700 to 2000

This course highlights selected engineers in the 18th, 19th, and 20th centuries who both contributed to and were influenced by their country's politics, economy, society, or culture. Through readings, discussions, lectures, and assignments we shall see, in countries from France to the U.S. to China, how engineers helped modern nations shape the world inside and beyond their borders. This course complements HHS 465, from "Caves to Cathedrals: Engineering Until 1500" and "Wind, Water & Steam: Engineering from 1400 – 1750,"but none of these courses is a prerequisite for any of the others.

HHS 468The Electronic Century: Engineering The Last 100 Years(3 - 3 - 0)

This course surveys the history of electronic and computing technologies from the invention of the electron tube in 1904, through the invention of the transistor, to the internet and the smart phone of today. Most of the semester will be devoted to the trajectories of applications of electricity and electronics to three broad areas of American society—communications, electric power and light, and computing; the social, cultural, political, and economic significance of these technological areas in global history; and the interplay between these technologies and others. Historians of technology have written much on these subjects, and their work will form the basis for the readings, discussions, and writing in this course.

HHS 469 History of England: 1066 - Present

The impact of the Norman Conquest on kingship, government, and social structure; the reign of the Tudors on church and state; the Puritan and Lockean revolutions on the development of Parliament and Common Law; the two party system on reform; the industrial revolution on economic power and Empire; and Britain's role in world wars and the twentieth century. Particular attention is paid to the development of individual rights.

HHS 473 Renaissance Studies: Leonardo da Vinci

The life and times of the Renaissance artist-engineer, the institutions and influences which created his imagination, inventiveness, and great works of art. The course also covers what he was not, exploding popular myths about his achievements, and investigates his life on a personal, more human level.

HHS 475 Environmental Sustainability in Historical Perspective

The course examines the genealogy of the construct of "sustainability" and the efforts to address its inherent challenges in a variety of places and times. The course is chronological and thematic, with each unit reflecting the mood of the times regarding the conceptual framework of sustainability and reaction/responses, such as the Romantic response to industrialization in Europe and the rise of the Ecology movement in the United States in the late 1960s. It will also provide students with substantive grounding in historical case studies of environmental issues, and develop intellectual tools for understanding and solving contemporary sustainability challenges globally.

Examination of the history of medical science in the Western World from Greek antiquity to the present.

HHS 479 (3 - 3 - 0)Studies in the History of Technology

This course takes a thematic approach to the history of technology in the modern era. Topics may include the study of invention, innovation, and standardization; industrial research and development; technological systems; transnational exchanges: histories of gender, labor, and race: and the emergence of a global 'Network Society.'

HHS 483 History and Geography

A survey of recent trends in the application of ecological and geographical perspectives in historical studies. Some emphasis on historiography is appropriate for thesis writers.

HHS 495 Seminar in History

Research topics in history and methods of historical scholarship.

History of Medicine

Social Sciences

HHS 476

HSS 121 Introduction to Urban Studies I: Early Cities and Civilizations (3 - 3 - 0)An examination of the origins, nature and progress of urban society. Selected readings focus on recurrent and persistent urban problems: overcrowding, traffic congestion, political corruption, faulty sanitation systems, etc.; a student may also engage in field analysis projects which relate either to home town areas or to the North Jersey region.

HSS 122	Introduction to Urban Studies II: Modern Cities and Local Politics	(3-3-0)
Major emphasis	is on current economic, environmental and social problems.	

HSS 127 Introduction to Political Science I: National Government (3 - 3 - 0)An introduction to the evolution and operation of the U.S. federal government. This course focuses on problems in energy

policy, foreign policy, elections, and civil rights.

Introduction to Political Science II: Judicial Process HSS 128

A survey of the evolution of juries and recent legal and social scientific analysis of jury rules. Case studies are used to explain the scope of issues decided by juries and conceptions of justice used to evaluate their performance.

HSS 141 Introduction to Sociology

The objective of this course is to provide students with a general survey of the field of sociology. This course aims at providing students with a way to think about and understand the social world and one's place in it. Therefore, the lectures, readings and assignments will focus on understanding the basic social processes and how they can be applied to everyday events, both small and large, both personal and political.

HSS 142 Introduction to Sociology II

This course is the second part of Introduction to Sociology. This part can be taken alone or in conjunction with the first part (HSS 141). While the first part emphasizes the relationships between individual lives and larger social forces, this part discusses social issues from a global perspective. After taking this course, students will be able to analyze and evaluate globalization and its consequences as well as the positions of different groups of people in the increasingly global social world.

HSS 175 Fundamentals of Psychology I: Brain, Mind and Behavior (3 - 3 - 0)

This course emphasizes the biological underpinnings of behavior and of mental processes. What do we know? How do we come to know? What do we want? Why do we act the way we do? In this course these fundamental questions of psychology are mainly looked at from a biological perspective that emphasizes the study of the brain and nervous systems. Historical, philosophical, and evolutionary perspectives on mental processes are considered, as well.

HSS 176 Fundamentals of Psychology II: Development, Personality, and Pathology (3 - 3 - 0)

An introduction to issues and theories in Life Span Development, Personality Theory, and psychological disorders. Topics include cognitive and social development, attachment, moral thinking, and psychoanalytical theory. Focus is placed on those seminal theories that have had lasting import for psychology as well as other disciplines. These theories include, but are not

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HSS 321 Modern Urban Culture

This course examines aspects of modern subcultural American life including deviancy and delinquency, crime, drug abuse, and ethnicity.

HSS 322 Cultural Studies

Drawing on theory and practice from such diverse disciplines as history, media studies, literary criticism, psychology, and sociology, Cultural Studies investigates the production, distribution, and consumption of cultural artifacts. Issues concerning race, class, gender, and sexual orientation are explored with attention to the analysis of social phenomenon.

HSS 324 Comparative Ethnic Culture

This course is a survey of various cultural traditions. Typical study units include Afro-American, Asian, Hispanic, and American ethnic cultures in historical perspective.

HSS 325 Identity Politics and Legal Theory

Theories, tactics, goals, and the impact of organized minorities and how they relate and transform American political identity. Groups studied include African Americans, Latinos, Asians, Native Americans, and other politically marginalized minorities. Feminism, queer theory, race conscious theory, and critical race theory are closely examined particularly as they relate to court decisions and legal precedents in case law.

HSS 330 Developmental Psychology

This course presents an overview of the theoretical backgrounds as well as the historical and very current research in the field of life span developmental psychology. Special emphasis will be placed on infancy and childhood, adolescent and young adult development. All aspects of development, i.e. physical, cognitive, emotional and social will be addressed. Ongoing issues such as: critical vs. sensitive periods, brain plasticity and malleability, the nature/nurture controversy will be addressed throughout the semester.

HSS 331 Biological Psychology

Biological Psychology explores the physiological underpinnings of mental processes and behavior by covering the basic anatomy and physiology of the nervous system. The study of topics such as visual perception, language, depression, schizophrenia and their relation to neurological structure and deficit as well as their ultimate relationship to human consciousness will constitute the essential components of the class.

HSS 360 Public Policy Analysis

This course offers perspectives utilized in the analysis and evaluation of public policymaking and policy results. Policy approaches include cost-benefit allocations, budgetary procedures and feasibility impact studies. Normative constraints and political implications of systematic policy analysis are also examined, particularly in relation to public infrastructure projects.

HSS 371 Computers and Society

An introduction to arguments about the relationship between computing and society, the impact of computing activities on social relationships, and the evolution of institutions to regulate computer-mediated activities.

HSS 373 Social Choice Theory

An introduction to the history of and theoretical principles associated with using voting techniques to resolve conflicts. Emphasis is placed on the analysis of operational rules. Student projects constitute a major part of the course.

HSS 375 History of Psychology

An analysis of the historical development of psychology. Issues such as perception, learning, cognition, and memory are explored within the context of various schools of thought.

HSS 376 Theories of Personality

What is theory? What is personality? A review of Freud, Adler, Sullivan, Jung, Rogers, etc., on the nature of personality.

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HSS 377 Sociology of Globalization

This course provides an introduction to the concept of globalization, including its history, foundations, and implications from the end of World War II to the present day. Topics covered include the nature of globalism, economic and social trends, the roles of government in embracing globalization, global inequality, the rise of cities in the global economy, and the sociological implications of globalization. Particular emphasis will be placed on global/local tensions, especially as they relate to the response of local societies to global influences in both developed and developing countries. Students will perform analyses of globalization through discussions of current events relating to global society.

HSS 379 International Politics

An analysis of the contemporary international political framework. The course explores the character of the state system, the nation-state, the role of leadership personality, transnational actors, the balance-of-power, security and economic issues, the nature and limitations of power, the uses of terrorism, and Third World issues.

HSS 380 Energy, Politics and Administration

An introduction to the study of the conflicts associated with energy problems. Topics included are the relationship between federal and state governments and the energy industry, economic models, and comparison of the social consequences of energy production systems.

HSS 401 Seminar in Leadership Studies

This course will study the human phenomenon of leadership, focusing on the two main (and oft-times competing) analyses of leadership: the Humanistic approach and the Behaviorist approach.

HSS 410 Arab Nationalism and the Formation of the Middle East

This course will explore the birth, triumph, and fall of Arab nationalism, focusing not only on intellectual and political leaders of the movement, but also incidents in history which in one way or another shaped political and/or social traits of the movement. The factors that contributed to the development and/or decline of the movement that will be examined are: the rise of colonialism, the dissolution of the Ottoman Empire, World War I and World War II, the Cold War, emergence of the state of Israel, and the recent incidents in the region and the world. The ideological links between Arab nationalism and modern radical movements will also be examined.

HSS 415 Islamic Political Thought

This course surveys the philosophical foundations and developmental stages of Islamic political thought from the Prophet to the modern ages. In the first part of this course, the theories of early 'Muslim' philosophers, i.e. Avicenna, Al-Farabi, Al-Ghazali, Averreos, and Ibn Khaldun, on the state, government, and politics will be examined. The second part will concentrate on pre-modern (Al-Mawardi) and modern Muslim intellectuals who contributed to the genre of Islamic political philosophy, including liberal and radical trends.

HSS 441 Gender and Race in Science and Engineering

This course discusses important issues related to gender and race in science and engineering (S&E). The issues include S&E as professions and social institutions as well as the experiences of women and minorities as S&E students, professionals, and the users of current science and technologies. In addition, this course explores the current social issues and policy concerns regarding gender and race in science and technology.

HSS 454 The Geography of Science

This course applies principles of economics and finance to the international setting. The first half of the course deals with microeconomic and macroeconomic issues of international trade and covers such issues as (i) why countries trade, (ii) the theory and practice of trade policy including multilateral trade liberalization within the WTO and regional economic integration, (iii) exchange rates. The second half of the course teaches students how to be effective global financial managers. To achieve this goal, the course focuses on important topics that include the fundamentals of the macroeconomic environment of international financial management, the financial environment in which the multinational firm and its managers must function, and foreign exchange management and financial management in a multinational firm.

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HSS 458 Sociology of Science and Technology

This course addresses various theories, approaches, and methodologies used in the sociology of scientific knowledge, including the strong programme, relativism, actor-network theory, gendered accounts of science, and laboratory studies. In addition, it discusses the relationships between science, technology, and society, such as how science and technology influence society and how society influences science and technology. Furthermore, the course explores the issues related to science and technology workforces and policies. The issues discussed in the course occur in both the U.S. and other countries, and the readings discussed in the course crosscut sociology and other disciplines. Cross-listed with: CAL 558

HSS 477 Psychology of Religion

A survey of different approaches to the psychological interpretations of religious phenomena such as the image of God, rituals, myths, faith healing, meditation, mysticism, and conversion.

HSS 478 Psychology of Gender

An analysis of gender differences and perceptions in contemporary society.

HSS 479 Sociology of Gender

This course introduces students to the study of gender from a sociological perspective. It focuses on gender as a social construction that occurs during interaction and influences our social relationships as well as personal experiences. We examine how gender and power are interrelated. To address these questions, we will, first of all, investigate theories and studies that explain gender differences from biological and cultural perspectives. then, we will analyze how gender shapes and is shaped by large social institutions such as education, the workplace, the family, politics, and media. In this course, we will also explore the intersections of gender, race, class and sexual orientation. The readings, class discussions, and assignments are designed to help students improve their critical thinking skills, understand the social construction of gender, learn about sociological research, and develop their communication skills.

HSS 480 Introduction to Anthropology

Anthropology, in the broadest sense, is the study of mankind. It is the empirical study of human cultures, societies, and the everyday practices, rituals, representations, beliefs, symbols, relationships, and values involved in navigating in our increasingly interconnected world. This course will introduce students to the concepts, terms, methods, and history of anthropology. Throughout the term, we will focus on how cultures change and shift through time, in relationship to space, and through individual and group action.

HSS 481 Cultural Anthropology

An examination of the varieties of organization of human societies in a comparative ethnographic context.

HSS 488 Science and Human Nature (3 - 3 - 0)

An introduction to recent Darwinian and sociobiological theories of human nature.

HSS 489 Freud and Jung

An in-depth and extensive study and discussion of the theories of Sigmund Freud and Carl Jung. Each theory is examined individually; the nature of the unconscious, dream interpretations, religious symbolism, and the aim of psychotherapy are critically examined. Students read from primary sources including Freud's Interpretation of Dreams, Totem and Taboo, Jung's Man and His Symbols and Modern Man in Search of a Soul, as well as from biographical material, and other secondary sources. Emphasis on points of confluence and of departure between the two. The course is limited to 15 students.

HSS 495 Seminar in Social Science

This course will provide more advanced students with an opportunity to pursue in-depth study of a particular problem and/ or topic within the field of Social Science (Political Science, Psychology, Sociology) that has either not been covered in other courses or has only been superficially "touched upon."

COGN 603 Practicum

A seminar devoted to student projects that integrate knowledge from previous courses and work experience to analyze a problem based on an understanding of the complex role of cognition in modeling processes and producing innovations.

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Language

LFR 101 Beginning French I

An introduction to the fundamentals of the French language; this course is for true beginners. Students will learn basic grammatical structures and develop proficiency in speaking and listening. They will learn to communicate at a novice-high conversational level. Students will also complete the course with the ability to identify unique features of French cultures. The course will be conducted entirely in French.

LFR 102 Beginning French II

Students will expand their knowledge of grammatical structures. They will learn to communicate in the target language both in professional and real-world settings. Using current terminology, students will begin to explore fields such as technology, science, and business. Students will learn to identify major cultural trends in art, music and literature. The course will be conducted almost entirely in French. Prerequisites: LFR 101

I FR 201 Intermediate French

The third course of the four-course series continues the study of the four communicative skills (reading, writing, listening, speaking). Students will enrich their vocabulary and learn more advanced grammar combining past tense forms to tell complex stories, give commands, and express doubt. Students will have more opportunities to use the language for realworld purposes. Students will encounter literature from France and the French-speaking world, and further discover popular culture through communicative multimedia videos, French news websites, and class discussions. The course will be conducted entirely in French. Prerequisites: LFR 102

Literature

HLI 105 Special Topics in Literature (3--)

The subject of this course changes, but recent topics have been an in-depth study of Shakespeare's Hamlet, consideration of three of his comedies, and a study of literary New York.

HLI 113 Western Literature: Classical Literature

Readings in core texts of western literature produced by civilizations of the ancient world.. Representative texts include works by: Homer, Sophocles and Virgil, and readings in the Hebrew and Christian Bibles. Sections of this course may takes up great books of science such as Vitruvius' Ten Books on Architecture read in conjunction with Virgil's Aeneid.

HLI 114 Western Literature: Middle Ages to the Present

Readings in core texts of western literature from medieval times to the present. Representative authors include Chretien, Dante, Racine, Shakespeare, de Lafayette, and Kafka. Instruction in basic elements of rhetoric and composition is also emphasized. Group A, 100-level course.

HLI 115 The English Language: Language of Ideas (3 - 3 - 0)

Examination of the philosophical use of language as it deals with concepts and value judgments.

HII 116 Analysis of Literary Forms (3 - 3 - 0)

Uses of language to convey thought and feeling in a variety of fictional and nonfictional forms.

HLI 117 Colonial and Romantic American Literature (3 - 3 - 0)

A survey of European culture as the foundation of American culture. Course emphasizes literary evelopments and also provides a brief introduction to major developments in western architecture, music, and art.

Realist and Modern American Literature (3 - 3 - 0)HLI 118

A study of American literature with reference to parallel developments in architecture, art, music and film. American literature seen as a response to European culture and to problems unique to life in the New World.

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HLI 201 Introduction to Theater

The theatre's ability to cultivate empathy, to raise questions about societal practices, to explore the human condition, to foster collaboration, and to create community make it a dynamic and unique forum in which to participate as audience or practitioner. This course examines the development of the theatre from its roots in Ancient Greece to the present day. Students will examine that evolution from a number of critical points: theatre's literature, history, technological innovations, and social role. The class will read works of dramatic literature and historical texts. Attendance at NYC theatrical productions and "hands-on" exposure to the process of theatrical creation will complement the course readings. Cross-listed with: HTH 201

HLI 220 Images of Science in Literature

This course introduces students to the discipline of literature by examining literary works of different genres that focus on science and scientific inquiry. Special attention is given to the ways that scientific advances have challenged conventional beliefs about the structure of the world and humanity's place in it. The course will examine how, throughout the centuries, science has been considered as a source for liberation and innovation on the one hand or oppression and even possible transgression on the other. Readings may include works by Aeschylus (Prometheus Bound), Marlowe (Doctor Faustus), Blake, Brecht, Stoppard, Vonnegut, and others.

HLI 221 Introduction to Cinema

This course provides an introduction to the study of film as a separate genre. The course concentrates on formal analysis of the aesthetic, ideological, and technological elements that comprise the multiple languages of cinema. The course introduces the student to various genres of narrative cinema as well as to different categories of cinema such as experimental, documentary, and hybrid forms. Although this course analyzes some work produced in the United States, it also provides the student with an introduction to cinema as an artistic practice that spans the globe, including contemporary as well as historical modes. Cross-listed with: HTH 221

HLI 312 Modern Literature

A survey of Modernism in European Literature. The authors to be considered include Rimbaud, Mallarme, Rilke, and Mann. Developments in architecture, music, and art are provided, as well.

HLI 314 19th Century English Literature: Victorians

A survey of poets and prose writers such as Thomas Carlyle, Alfred Lord Tennyson, Elizabeth Barrett Browning, John Stuart Mill, Charles Dickens, Oscar Wilde, and Christina Rossetti who in the days of Queen Victoria created texts that reflect our own concerns with religion and science, spirituality and materialism, labor and capital, gender and space, Christmas and goblins.

HLI 315 Language, Meaning and Reality

This course is a form of argument about meaning that emphasizes two points: 1) the language we have available determines our idea of reality and 2) semantic structures seem to convey their own independent meanings in spite of what speakers of the language may think they intend.

HLI 316 Science Fiction

A study of the fiction of science and the science of fiction through the reading of authors from Mary Shelley (Frankenstein) to William Gibson (Neuromancer), the viewing of films such as Metropolis and Dune, and the writing of a piece of science fiction.

HII 317 The Creative Act

A study of literary works concerned with sources of creativity. To be considered are texts such as Mann's Death in Venice, Rilke's Sonnets to Orpheus, and Wordsworth's The Prelude.

HLI 318 Caribbean Litr & Culture

Course examines the interrelationship of literary works and the ethnic heritage of their authors and/or the texts themselves.

Ethnicity and Literature HLI 319

Course examines the interrelationship of literary works and the ethnic heritage of their authors and/or the texts themselves.

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HLI 321 Literature, Science and Technology

This course investigates the views man has expressed about the advent impact of technology and science across recorded history. Questions that might be addressed include: What is the relationship between religion and technology? Has man always viewed technological innovations as positive? What relationship is there between man's vision of utopian society and technology? Readings may include, but are not limited to, novels, philosophical treatises, and the literature of various societies.

HLI 330 Classical Mythology

Myths are much more than entertaining stories; they teach much about their cultures. Myths pervade our lives and represent a discrete way of thinking, different from rational logic. In this course, students will see how Western civilization was enriched by Greek and Roman myths. Myths from the ancient Near East also reached the West through the Judeo-Christian tradition. This course provides an introduction to ancient civilizations and their literary, religious, and artistic legacies.

HLI 331 Shakespeare

Selected plays by Shakespeare will be read and analyzed both as literary and performance texts. Students are required to attend a professional production of a Shakespearean play in New York City.

HLI 332 Literary Heritage of Russia

Reading in classical, pre-Soviet literature of Russia, including Gogol, Turgenev, Dostoevsky, Tolstoy and Chekhow.

HLI 334 Chaucer: The Journey and the Dreams

This course includes Geoffrey Chaucer's major works The Canterbury Tales and the dream vision poems. The latter are based on accepted contemporary psychological theory that dreams teach solutions to real life problems. In The Canterbury Tales, pilgrims who meet at a roadside tavern tell each other stories about contemporary morals, love, religion, and war as they journey to Canterbury Cathedral. Students will encounter a range of medieval literary genres (e.g., romance, epic, fabliau, and saint's life) while studying the mores and customs of the fourteenth century. Topics include medieval ideas on fate and religion, marriage, magic, science, and technology.

HLI 335 Shakespeare in the City

During the summer, Shakespeare is presented in parks and parking lots throughout New York City. In this course, we read and discuss plays and then go to see them. We view both traditional and experimental productions. Sometimes we see more than one production of a play, if a number of companies decide to do it.

HLI 336 The Short Story

The study of prose fiction in short story form. Texts consist of representative selections of the short story genre that offer a wide variety of techniques and themes. All students will participate in classroom critical analysis.

HLI 337 History of the English Language

A study of the Indo-European origins and development of English from Old English Anglo-Saxon, to Chaucer's Middle English and the Modern English Period.

HLI 338 Thoreau and Environment

This course examines the beginnings of the environmental movement in America by focusing on the writings of Henry David Thoreau and his contemporaries. Primary readings include works by Meriwether Lewis and William Clark, John James Audubon, James Fenimore Cooper, William Cullen Bryant, Ralph Waldo Emerson, Emily Dickinson, John Muir, Sarah Orne Jewett, and Jack London. Contextual material includes works by Hector St. Jean de Crevecoeur, Thomas Jefferson, William Bartram, Philip Freneau, Louis Agassiz, Susan Fenimore Cooper, George Perkins Marsh, Gifford Pinchot, and Theodore Roosevelt.

HLI 341 19th Century English Literature: Romanticism

Consideration of texts by writers of the romantic movement in England: Blake, Coleridge, William and Dorothy Wordsworth, Percy Bysshe and Mary Shelley, Keats, and Byron.

HLI 342 Modern Drama

A survey of theatrical innovation in modern and contemporary Europe and the United States. Students will analyze dramatic literature and create scenic designs for one or more plays studied in class. Group attendance at a theatrical performance in New York City outside of class time is required.

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HLI 344 **British Fiction**

Readings from the novel's beginnings in England up to contemporary works. Selections include works such as Defoe's Robinson Crusoe, Richardson's Pamela, Austen's Pride and Prejudice, Bronte's Wuthering Heights, Dickens' Hard Times, and Woolf's To the Lighthouse.

HLI 345 A Survey of Dramatic Literature

Readings of plays from the dramatic productions of Aeschylus to modern works of theatre. Students attend professional productions in New York City and often have an opportunity to interact with those involved in bringing them to the stage.

HLI 349 American Poetry to 1900

Readings in authors such as Bradstreet, Bryant, Longfellow, Poe, Whitman, and Dickinson.

HLI 351 Romanticism: Painting, Literature, Music (3 - 3 - 0)

A study of works produced during the British and European romantic movements by. PAINTERS such as David, Turner, Delacroix, Gericault; WRITERS such as Hugo, Goethe, Byron, Sand; COMPOSERS such as Berlioz, Wagner, Chopin. Students attend a professional concert or opera in New York City.

HLI 352 The American Renaissance in Literature

An introduction to works by such writers as Emerson, Thoreau Whitman, Poe, Hawthorne, Melville, and Dickinson. An examination of 19th-century race relations in America from a literary perspective is emphasized.

HLI 354 American Culture

An interpretation of Amercan civilization through its literature and cultural forms. The course involves close reading of a few works of American literature written since World War II.

HLI 357 American Films-American Fiction

An interpretation of American civilization through its literature and cultural forms. The course this semester will involve close reading of a few works by some of the giants of American literature since the Second World War.

HLI 358 American Poetry: 20th Century

A study of works of major American poets of the twentieth century including Pound, Eliot, Williams, Moore, Stevens, Lowell, Ashbery, and Ginsberg.

HLI 362 British Fiction: Twentieth Century (3 - 3 - 0)

Development of British fiction from James Joyce to Doris Lessing.

HLI 363 Modern Irish Literature

This course examines the journey Ireland has taken from British colony to what Fintan O'Toole describes as an island unmoored. Students will explore the complex nature of political, religious, and cultural forces found in the assigned works. Historically, literature is particularly important in the context of Irish nationalism as it served as a means for crafting an identity independent of a British one. Irish authors also contributed greatly to both the Modernist and Post-Modernist movements, and the course will provide a strong foundation in those practices.

HII 370 Introduction to Journalism

An introduction to the basic methods of journalism, including gathering and verifying facts, finding and interviewing sources, and constructing compelling narratives.

Survey of Latin American Literature: Motorcyclists, Writers, and Revolutionaries HLI 380 (3 - 3 - 0)Utilizing Che Guevara's journeys from The Motorcycle Diaries and from later in his life as its spine, this course surveys post-1945 Latin American literature. The emphasis will be placed on works that explore issues of poverty, oppression, and disenfranchisement. The course will further explore specific genres of fiction such as magical realism and examine how they came to evolve in Latin America. The course could include such writers as Gabriel Garcia Marquez, Pablo Neruda, and Guillermo Cabrera Infante.

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HLI 390 Modern Culture: Lit and Film

Modern Culture provides an introduction to modernism in literature and film. Students read and view a range of works that illustrate aesthetic and cultural aspects of modernism, including political, social, and religious matters, and the influence of technology on works by Crane, Leger, Antheil, and others. The course is not intended as a survey of the principal modernist texts and films but rather as an introduction to certain key notions and modes that are characteristic of Modernism from the 1870s to 1948.

HLI 408 **Creative Writing**

Creative Writing is a beginner's workshop in the creation of poetry and fiction. Students examine issues such as narrative structure, stanza forms, free verse, and so on. The course explores distinctions between writing as a craft and writing as a process more closely allied with prophecy and gnosis. The impact of the computer on writing is examined. Students read works on poetics and theories of fiction, in particular mimetic and expressionistic theories developed in the West, and learn to shape their own work accordingly. Brief writing assignments are assigned weekly with a longer writing project developed over the part of the course and due the final day of class.

HLI 409 Rhetoric and Technical Writing

An introduction to classical and modern expository and argumentative writing and speech, as well as an introduction to contemporary technical and science writing.

HLI 410 Wanderers, Warriors, Sinners and Saints: Medieval Literature

This course along with HLI 412, 416 includes a survey of comparative literature of the medieval period, the increasing focus on the individual in society in medieval romance, and the legend of King Arthur. Works and authors studied include: The Quest for the Holy Grail, The Death of King Arthur, Sir Gawain and the Green Knight, The Song of Roland, Bede, Geoffrey of Monmouth, Marie de France, Chrétien de Troyes, Gottfried von Strassburg, Dante, and Boccaccio.

HLI 412 Medieval Romances: Rise of the Individual (3 - 3 - 0)

This course focuses on the developing interest in the individual in society in medieval romance. Works and authors studied include: Sir Gawain and the Green Knight, Chretien de Troyes and Gottfried von Strassburg. The course follows the adventuring knight on his quests.

HII 413 Literature by Women: The Tradition in English (3 - 3 - 0)

A survey of women authors writing in English from the fourteenth century to the present.

HLI 414 Literature and Empire

This course examines the role of empire building and its influence on the novel, prose, and poetry of the late nineteenth century. Readings present an overview of both colonial and post-colonial literature against the historical background. This course also examines relevant films to explore how the twentieth and twenty-first centuries portray imperialism.

HII 415 The Bible as Literature (3 - 0 - 0)

Analysis of selections from the Hebrew and Christian Bibles as literary texts.

HLI 416 The Legend of King Arthur

The course covers a variety of texts beginning with the earliest chronicle reports of a great battle leader — Arthur, king of Britain — and ending with high medieval romances such as The Death of King Arthur. The course explores the birth of the Arthurian legend. Was there ever a historical Arthur? Did he arise to save his people? Will he come again as legend has promised? How has his story developed in literature and popular culture? Delving into the mythic past of Europe, the readings include folk-tales and historical chronicles, and students will immerse themselves in some of earliest sword and sorcery literature, and observe along the way how developing technologies enhanced warrior cultures.

English Literature from Beowulf to the Restoration (1660) (3 - 3 - 0)HLI 417

A study of major works and authors including Beowulf, Chaucer, Spenser, Milton, Shakespeare, Wordsworth and Wolf.

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HLI 418 Literature and Critical Theory

The application of contemporary literary theory derived from Heidegger and modern linguistics to the study of postmodern American literature. Students are introduced to various literary theories developed by Barthes, Kristeva, Lacan, Derrida, and Foucault, and then asked to apply these theories in considerations of works by such postmodern American writers as Pynchon, Bronk, Gass, Spicer, and Ashbery.

HLI 419 Literature of Islam

Examination of a few major twentieth-century Turkish, Persian, and Arabic texts in English translation. Readings would include poetry and fiction by such authors as Ece Ayhan, Orhan Pamuk, Mohsen Makhmalbaf, and Mahmoud Darwish.

HLI 420 America in the Great Depression and the Second World War (3 - 3 - 0)

A survey of American culture 1929-1945. The course will center on the work of a few major writers (Pound, Williams, Stevens, etc.) but will also consider developments in American music, art and movies of the period.

HLI 421 Power and Politics, Kinship and Kings I: Ancient to Renaissance (3 - 3 - 0)

From the ancient times to the present, literature has engaged political issues. This course traces the intrigues of civil and familial power as captured in significant literary works which offer profound statements, creatively wrought, about vital moral, social and political principles concentrating on works up to the Renaissance. Questions such as whether civilizations can expect their leaders to be ethical in addition to powerful or what happens to society when leaders confront evolving social conditions such as wars, civil unrest or new legal systems or what interplay there may be among the leader (often a man), his family, and the led will be examined in a variety of genres, such as tragedy and epic, and can be explored by invoking the moral imagination. By considering these questions through the vehicle of fiction, literature elicits not only the audience or readers' intellect, but their emotions as well - in both cases, by means of reader-response. One pressing question we will tackle is whether fiction that engages issues of power and politics does - or can function to - change the world.

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A survey of English literature from the restoration of the monarchy to the present.

HII 447 Survey of British Literature

A study of major works and authors, including Beowulf, Chaucer, Spenser, Milton, Shakespeare, Wordsworth, and Wolf.

HLI 471 Literature and the Arts

This course offers consideration of literary texts and their relationships to other art forms. Students will study works of literature and attend related cultural events in New York City. A typical semester may include attendance of "Hamlet" at the Metropolitan Opera, "Hard Times" at the Pearl Theater Company,or an exhibit on El Greco, Iconography, and the "Book of John" at the Alexander S. Onassis Public Benefit Foundation.

HLI 474 The Novel in America

A survey of the development of the novel in America from the late eighteenth century to the present. Included are works by authors such as: Nathaniel Hawthorne, Harriet Beecher Stowe, William Faulkner, Henry James, Edith Wharton, and Philip Roth.

HLI 476 Contemporary Culture: Literature and Film, 1950-the present

Contemporary Culture provides an introduction to work in literature and film from 1950 to the present. Students read and view a range of works that illustrate aesthetic and cultural aspects of contemporary literature and film, including political, social, and religious matters, and the influence of technology on works by Ginsberg, Seybald, Godard, and others. The course is not intended as a survey of the principal contemporary texts and films but rather as an introduction to various key notions and modes that are characteristic of our time.

Music & Technology

HMU 101 Music History I

During this course, we will review Western Medieval and Renaissance art music from the 2nd century B.C. to 1600 A.D. from several perspectives: as individual masterworks, as representatives of various composers, as examples of particular styles and forms, as analytic "problems," and as artworks derived from changing social circumstances. We will emphasize the development of skills in talking and writing "about" monophonic, liturgical and polyphonic music. The course will include lectures and class discussions, assigned readings, written assignments, and periodic examinations.

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The student will receive an overview of the styles, learn about the social system of the period which directed the style and will also learn specifics about individual instruments which were used to create the sound.

HMU 102

HMU 120 History of Technology and the Arts

Music History II

The cultural convergence of music, performance, theater, and visual art has variously been termed multimedia, hybrid arts, intermedia, interdisciplinary arts, and transmedia, among others. This course looks at how artistic disciplines inform one another and how parallel developments in technology have played a significant role in the history of the arts and music, from early tribal rituals to our contemporary digital age. Organized as a historical survey of technology and the arts, the course will move beyond the idea of the arts as simple modes of expression to consider how it has been an active site of cultural practice. The course will begin with the concept of "techne," first used in antiquity, as a means of establishing the philosophical basis of creative practice and showing the fundamental unity between art, science and technology. Through weekly lectures, readings, and discussion, we will explore the many ways that science and technology informs and inspires the creative production. By the end of the course students will understand the ways in which diverse modalities of artistic practice function as forms of symbolic communication with aesthetic material, cultural and political dimensions. Cross-listed with: HAR 120

In this course, student will review western Baroque to Classic music from 1600 to 1780, from several perspectives: as individual expressions of various composers, as examples of particular styles and forms, as analytic problems, and as artworks derived from changing social circumstances. This course emphasizes the development of skills in talking and writing about piano, pipe organ, orchestral and early opera music. Some composers include Bach, Vivaldi, Purcell, Pachebel, and Handel. The course will in discussions, assigned readings, oral presentations, and periodic examinations. Goals: To learn by reading notation and listening to samples of the earliest forms of music; To acquire verbal skills which are needed to explain music styles; To learn about the culture of the time which inspired the compositions. Outcomes: This is a continuation in Music History commencing with the earliest forms of the Baroque era from 1600 to the Classic Era near through the 1700's

HMU 192 Music Appreciation I

The development of listening techniques used to aid in the appreciation of classical music; and analysis of representative compositions covering the Baroque, Classical, Romantic and Modern periods.

HMU 193 Music Appreciation II

This is part two of the Music Appreciation sequence. The course aims to guide and strengthen students in developing the skills of active listening in order to increase their enjoyment of ballet music, film music, music theater and opera. To this end, the course strengthens the students' ability to identify and respond to the basic conventions of ballet, film, music theater and opera and the way that the basic musical building blocks - melody, harmony, rhythm, tempo, tone color and form - take creative advantage of these conventions for expressive purposes, including the creation of mood, characterization, narration and storytelling. The course is not intended as a historical survey of the genres of ballet, film music, music theater or opera. Rather, it focuses on important core works from these genres, placed in their historical and stylistic context for purposes of comparison and appreciation. The aim throughout is to focus on works that an interested music lover is liable to hear in the normal course of their musical experience and that form a basis for further in-depth exploration of selected examples of contemporary pop and commercial music in these and related genres, including hip-hop and music video, that will build on the students' pre-existing interest and enthusiasm. Finally, and unique to the Music and Technology program at Stevens, the course draws special attention, wherever appropriate, to important milestones in the development of music technology and their impact on the development of music in the genres of ballet, film music, music theater and opera as well as related contemporary genres. Prerequisites: None. Group A, 100-level course. Prerequisites: HMU 192

HMU 195 History of Electronic and Experimental Music

This course will provide an extensive overview of the development of electronic music, from early experiments and innovations in the late 19th century through to modern-day electronic music. This course will also provide an extensive overview of salient technical and artistic methodologies cultivated throughout the development of electronic music. This course will also explore the correlation between technological change and societal change.

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HMU 200 **Elementary Harmony**

HMU 202 Music Theory II

HMU 201

Music Theory II continues the presentation of the material and procedures of tonal music with the study of harmonic syntax as it pertains to tonal cadences, intermediary harmonies modulation and tonicization in major and minor, and fundamental concepts of diatonic sequences. Students continue their mastery of 4-part writing with Roman numeral and figured bass analysis and undertake writing assignments in second and third species counterpoint in two voices. Aural skills are developed with alto clef "fixed-do" solfege primarily in minor. Prerequisites: HMU 201

This course begins with a review of the rudiments of music (scales, modes, key signatures, time signatures, rhythm, meter, intervals, and basic acoustical principles) and a review of important compositional trends that have affected the course of Western musical history. Students are then introduced to the triad and seventh chords in all inversions. All theoretical study is accompanied by listening, score analysis, and actual writing. All incoming students should already know how to read music (treble and bass clefs). Prerequisites: none. Does not fulfill general humanities requirements; may be taken as a free elective.

With the presumption of no previous formal study, Music Theory I presents the fundamental materials and procedures of tonal music. The students are introduced to elements of music theory, including scales, key signatures, intervals, triads, seventh chords, Roman numeral and figured bass analysis, 4-part writing, and first species counterpoint. Aural skills are

HMU 205 Introduction to Digital Media

Music Theory I

developed with the introduction to "fixed-do" solfege.

This course introduces students to theoretical and practical experiences in interdisciplinary production technologies, with an emphasis on visual and aural design principles. Projects may include creating and editing digital images, music, sound, video, text, and motion graphics. Students will work in teams to create projects. Not for general Humanities credit. Crosslisted with: HAR 205

HMU 210 Introduction to Music Technology

This course involves production tools available in hardware and software utilized to make compositions and sound tracks for an array of visual and live performance environments. The course provides an introduction to these areas, offering background important to other courses in the program that students may take in the future. Topics include the music business, general recording studio protocol, MIDI (Musical Instrument Digital Interface), basic recording techniques with ProTools, techno music production sequencing with Digital Performer, synthesizer history and programming, electronic music and synthestration, interactive applications such as MAX, sound design, digital sampling for visual art support with Mach 5, and sound-effect libraries, music programs for the Web Quicktime, Real Audio, and Windows Media Player applications, mastering with ProTools Plug-Ins, Peak, Roxio Jam and Toast, and MP3 creation and web uploading and distribution with e-commerce.

HMU 211 MIDI and Electronic Music

The Musical Instrument Digital Interface (MIDI) revolutionized the production world of electronic music. This course will explore the fine details of the code, as well as the everyday studio and stage use of the protocol. The student will explore all types of synthesis techniques via keyboards, tone modules, and software plug-ins. There will also be an overview of traditional electronic music from the last century to the present. In the weekly lab, the student will explore the software and hardware interconnection process and create an artistic experiment in electronic music as a final project.

HMU 220 Piano Class I

In order for students to acquire the most basic and fundamental piano techniques, students will undertake rudimentary exercises designed to facilitate the most common fingering techniques and hand positions. Students will be required to demonstrate the ability to play major scales, simple arpeggios, and develop muscle memory for basic intervals. By the end of the semester, students should be able to read 2 part treble and bass compositions.

HMU 221 Piano Class II

Piano II is the second in a series of Piano Instruction for Beginner/Intermediate Music Technology Students and all students interested in learning how to play piano and/or keyboards. This class will focus on the Development of Functional Keyboard skills. Prerequisites: HMU 220

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HMU 224 Piano Class IV

Piano Class 4 is the fourth class in a four semester sequence of group piano classes offered by the Music and Technology Program. The class concentrates on advanced piano skills including the development of a contemporary repertoire, advanced piano technique, advanced concepts in keyboard improvisation, score reading and accompaniment techniques. Prerequisites: HMU 223

HMU 230 Sound and Vision

The primary focus of this course will be the theoretical study of sound and light wave theory as it relates to productions techniques: for audio, the basics of transducer technology and signal flow; for vision, electromagnetic waveforms, theory of optics, and the different applications of capturing visuals through digital means. At the completion of the course, students will be able to understand wave theory, transducer theory, basic acoustic properties of sound and hearing, basic understanding of characteristics of light and color, signal flow and practical applications of the above. Ultimately students will have the theoretical foundations to develop their audio/visual engineering skills as an art form. Not for general Humanities credit. Cross-listed with: HAR 230

Fundamentals of sound recording technology with focus on composer-operated tools to generate the art. Presents an

explored. Students will experience the producing and recording of a multi-track song project at the completion of the course.

HMU 231 Sound Recording I

HMU 232 Sound Recording II

Mixing consoles in project studios will be explored and more advanced techniques in dynamics, equalization, reverberation, and signal processing. Students will meet in small groups for at least four hours a week to execute organized studio "hands on" lab exercises. Students will experience the producing and recording of a more advanced multi-track song project at the completion of the course. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HMU 231

HMU 240 Introduction to Web Media for the Arts

Webtools for the Arts will examine current internet technologies and web portal developments and their application to the Arts. Through the implementation of basic principles of php, MySql, html, Java and other webtools, students will learn to not only incorporate media content representing their particular interest in the arts but also implement authentication and Ecommerce tools, customize, embed and implement external web content, explore creative and alternative blog usages and explore the next generation cloud environment. Not for general Humanities credit. Cross-listed with: HAR 240

HMU 260 Software Instrument Design

This course will provide students with the fundamental understanding of the role and construction of software-based musical instruments. The course will focus on the development of skill-sets in commercial and open-source platforms. Students will also be introduced to low-level coding logic, providing the opportunity to develop and contribute original externals for prominent music production environments.

HMU 303 Music Theory III

Music Theory III continues the presentation of the material and procedures of tonal music with the study of elements of melodic and rhythmic figuration, dissonance and chromaticism, modal mixture, and an advanced examination of applied chords and diatonic modulation. Students undertake writing assignments in 4th and 5th species counterpoint in two voices. Species counterpoint is incorporated into 4 part-writing exercises. Aural skills are developed with and chromatic alterations. Prerequisites: HMU 202

HMU 304 Music Theory IV

Music Theory IV continues the presentation of the material and procedures of tonal music with a continued study of dissonance and chromaticism including 7th, 9th, 11th and 13th chords, Neapolitan II, Augmented Sixth chords, and chromatic voice leading techniques. Students undertake writing assignments in species counterpoint in three voices. Aural skills are developed with more complex "fixed-do" solfege primarily in mixed modes with chromatic alterations. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HMU 303

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understanding of the terms and basic skills needed to make quality recordings of the art on the "ProTools" non-linear based system. Microphone, Monitor, Mixer, Digital Signal Processing "Plug-Ins," Dynamics, and basic studio acoustics will be

HMU 310 Music Composition

Music Composition is a one semester course that presents a detailed analysis of the techniques of music composition. The course will focus on Form and Structure, Stylistic Movements, and Compositional Techniques. Students will be expected to demonstrate their understanding of all concepts presented in class via a series of quizzes and two significant works they will compose during the course of the semester. Music Composition will deepen the students understanding and implementation of the various techniques of musical composition. Since all students will have completed HMU202 (formerly 302), HMU420 will allow for a stronger and more coherent understanding of the implementation of those concepts and will greatly enhance the students understanding of the concepts presented in HMU 303 & 304 & 405. Prerequisites: HMU 202 or HMU 302.

HMU 314 Electroacoustic Composition

This course will explore the historical context, methods and current research trends surrounding the composition of electroacoustic music. Students will record and shape environmental sound recordings using digital audio platforms to explore the soundscape (sonic environment) as compositional form. Through this creative process, students will explore the integration and segregation of both traditional music and environmental sound events into different musical streams based on comparative analyses of their sonic structures. The final course assignment will require students to apply new knowledge and music production skill-sets to produce their own original electroacoustic composition.

HMU 322 Piano Class III

Piano III is the third in a series of Piano Instruction for Beginner/Intermediate Music Technology Students and all students interested in learning how to play piano and/or keyboards. This class will focus on the Development of Functional Keyboard skills. Prerequisites: HMU 221 or permission of the instructor.

HMU 324 Piano Class IV

Piano IV is the fourth in a series of Piano Instruction for Beginner/Intermediate Music Technology Students and all students interested in learning how to play piano and/or keyboards. This class will focus on the Development of Functional Keyboard skills. Prerequisites: HMU 322 or permission of the instructor.

HMU 333 Sound Recording III (formerly 412)

Lecture will be based around advanced implementation of recording techniques and procedures in the professional studio environment. Students will end the semester with; a thorough understanding of large frame in-line audio mixing consoles, additional advanced microphone placement techniques, and understanding of transducer experimentation. Synchronization between analog machines and digital audio workstations and MIDI interfaces will be explored. The student will gain the ability to troubleshoot and avoid externally generated noise in an audio system. Students will experience the entire engineering process that goes into integrating tracks from a live recording session with songs, from running the original recording session to producing the final mix. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HMU 232

HMU 334 Sound Recording IV

As the final semester of Sound Recording Arts, students are expected to fully understand the basic principles of audio engineering and the studio environment as a workplace. This class is designed to specifically address digital audio production. Although many of the topics have been mentioned in previous classes, course work will require in depth analysis of the many elements of this production format. Additionally, we will be studying in depth, advanced audio techniques. Students will be required to bring an audio example every class to be evaluated and attempt to recreate using the studio as lab. By the end of the semester, students will understand advanced principals of digital recording and the practical application thereof. Additionally, students will have in depth experiential knowledge of recording practices and advanced production techniques. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HMU 333

HMU 350 Music of the Eastern Mediterranean

This course is an introductory survey of the music of the Eastern Mediterranean as explored by Traditional and Modern Turkish music. It explores the Balkan, Greek, and Persian influences from earliest times as well as Western composition and idioms. Modern jazz, rock, dance, and video influences will be examined, as well.

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HMU 387 African-American Popular Music

HMU 351

This course traces the development of black popular music from its earliest roots in northwest Africa to the urban centers of the United States.

the environments in which they might create productions. Prerequisites: MA 115 or MA 117, MA 122

sound vibration, transducer theory, room acoustic design and isolation design are discussed and explored. Recording Studio design will be explored and the mysteries of the room "appearance" will be explained. The more informed an individual is about the topic of acoustics; the art of music production becomes more efficiently achieved. The student will complete the course with a thorough understanding of acoustical design techniques. This knowledge will not only prepare the student for professional studio design and construction (music, audio/video for post production), it is also applicable in understanding

HMU 392 Music Appreciation I

Musical Acoustics

The development of listening techniques used to aid in the appreciation of classical music; and analysis of representative compositions covering the Baroque, Classical, Romantic and Modern periods.

HMU 393 Music Appreciation II

A survey and analysis of representative composers through critical listening and analysis of important music literature. Prerequisites: HMU 392

HMU 394 History of Jazz (3 - 3 - 0)

Techniques in how to listen and what to listen for. History of the idiom. Analysis of outstanding performances and styles.

HMU 395 Elementary Harmony

This course begins with a review of the rudiments of music (scales, modes, key signatures, time signatures, rhythm, meter, intervals, and basic acoustical principles) and a review of important compositional trends that have affected the course of Western musical history. Students are then introduced to the triad and seventh chords in all inversions. All theoretical study is accompanied by listening, score analysis, and actual writing. All incoming students should already know how to read music (treble and bass clefs). Prerequisites: none. Does not fulfill general humanities requirements; may be taken as a free elective.

HMU 397 Orchestration I

This course is an exploration of traditional orchestral instruments. The student will learn fine details related to the characteristics of instruments in the orchestral family with classroom examples of masterpieces in the classical repertoire, as well as by experiencing either live demonstrations or sampled demonstrations by the instructor. The student will learn the basics of expanding a piano score to woodwind, brass, and string quartets. Cross-listed with: HMU 398

HMU 398 Orchestration II

This is part two of a two-semester sequence. Whereas Orchestration I explored the mechanical aspects of the orchestra and presented the physical and technical boundaries of each instrument contained therein, Orchestration II explores the aesthetic principals engaged when writing for this most unique subject, and the student will be introduced to the art of conducting. In addition to completing the Adler text, students will spend significant time in the MAC Lab realizing their orchestrations of the standard literature from Mozart to Penderecki. To this extent, we will use the new interactive edition of the classic Principles of Orchestration by one of history's greatest orchestrators, Rimsky Korsakov. Does not fulfill general humanities requirements; may be taken as a free elective. Cross-listed with: HMU 397 Prerequisites: HMU 397

HMU 401 Introduction to Music and Technology

This course involves production tools available in hardware and software utilized to make compositions and sound tracks for an array of visual and live performance environments. The course provides an introduction to these areas, offering background important to other courses in the program that students may take in the future. Topics include the music business, general recording studio protocol, MIDI (Musical Instrument Digital Interface), basic recording techniques with "ProTools," techno music production sequencing with "Digital Performer," synthesizer history and programming, electronic music and "synthestration," interactive applications such as "MAX," sound design, and digital sampling for visual art support with "Mach 5" and sound-effect libraries, music programs for the web: quicktime, real audio and windows media player applications, mastering with ProTools "Plug-Ins," "Peak," "Roxio Jam" and "Toast," plus "MP3" creation and web uploading and distribution with e-commerce.

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(3-3-0) This course deals with the basic principals of physics as it relates to sound. Sound wave transmission, musical instrument

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HMU 402 MIDI and Electronic Music

The Musical Instrument Digital Interface (MIDI) revolutionized the production world of Electronic Music. This course will explore the fine details of the code as well as the everyday studio and stage use of the protocol. The student will explore all types of synthesis techniques via keyboards, tone modules and software plug-ins. There will also be an overview of traditional electronic music from the last century to the present. In the weekly lab, the student will explore the software and hardware interconnection process and create an artistic experiment in electronic music as a final project.

HMU 404 Techno Music Composition

The exciting art of techno music has dynamically transformed over the years, incorporating elements of classical electronic music and cutting-edge high-tech innovations. This course will explore the techniques and enable the student to have a greater understanding of the tools of the trade. Each class will preview examples of the most well known works over the years, and demonstrate the technique, since sounds often recycle years later, i.e., sample loops in current compositions, for example. The students will participate in weekly lab exercises by creating music in the Media Arts Center with state-of-the-art software and will apply advanced music theory skills. The final project shall be a three-song student composition professional "demo." Guest producers will be invited to join us in class. Basic keyboard or iGuitar skills are required. Prerequisites: HMU 401, HMU 395

HMU 405 **Electronic Music**

An introduction and survey of the art of sound synthesis, Electronic Music will focus on synthesizer programming utilizing subtractive synthesis, filter manipulation, voltage control amplifiers and ADSR generators. As well, a historical presentation will expose the student to the evolution of non-acoustic sounds. Weekly labs and assignments will allow the student to implement those synthesis techniques presented in class. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HMU 211, HMU 450

Audio Post Production HMU 406

HMU 406 explores the integration of audio production for such visual mediums as television, film and interactive games. Through an analysis of various commercial visual media The course introduces 1) the techniques and terminology representing the technical parameters common to both audio and visual producers 2) the psychological impact of sound association 3) the implementation of audio tools in the creation of . ADR (automatic dialog replacement), Music Editing, Sound effects and/ or Foley.. 4) An understanding of the commercial marketing impact of sound. Prerequisites: HMU 211, HMU 210, HMU 232

HMU 407 Sound Design

Sound Design calls upon major technical elements from HMU 410-413 from psychoacoustics to sound wave manipulation within the digital to create soundscapes that enhance the art of story telling. The student will learn to create original sound effects, use and manipulate existing sound effect libraries, and identify the audio needs of a visual image. They will use the Digital Audio Workstation (DAW), as instructed in the Sound Recording course series, to integrate audio and visual elements. They will also be able to create a stand-alone soundscape for radio or audio only internet applications. Via lab assignments, students will complete the course with the foundation for an audio portfolio - demo CD. Prerequisites: HMU 232, HMU 231

HMU 410 Sound Recording Technology

Fundamentals of sound recording technology with focus on composer-operated tools to generate the art. Presents an understanding of the terms and basic skills needed to make quality recordings of the art on the "ProTools" non-linear based system. Microphone, Monitor, Mixer, Digital Signal Processing "Plug-Ins," Dynamics, and basic studio acoustics will be explored. Students will experience the producing and recording of a multi-track song project at the completion of the course.

HMU 412 Audio Engineering Science III

Lecture will be based around advanced implementation of recording techniques and procedures in the professional studio environment. Students will end the semester with; a thorough understanding of large frame in-line audio mixing consoles, additional advanced microphone placement techniques and understanding of transducer experimentation. Synchronization between analog machines and digital audio workstations & MIDI interfaces will be explored. The student will gain the ability to troubleshoot and avoid externally generated noise in an audio system. Students will experience the entire engineering process that goes into integrating tracks from a live recording session with songs, from running the original recording session to producing the final mix.

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HMU 413 Sound Recording IV

As the final semester of Sound Recording Arts, students are expected to fully understand the basic principles of audio engineering and the studio environment as a workplace. This class is designed to specifically address digital audio production. Although many of the topics have been mentioned in previous classes, course work will require in depth analysis of the many elements of this production format. Additionally, we will be studying in depth, advanced audio techniques. Students will be required to bring an audio example every class to be evaluated and attempt to recreate using the studio as lab. By the end of the semester, students will understand advanced principals of digital recording and the practical application thereof. Additionally, students will have in depth experiential knowledge of recording practices and advanced production techniques. Does not fulfill general humanities requirements; may be taken as a free elective.

HMU 415 Contemporary Music Theory

Contemporary Music Theory is a one semester presentation of the materials and procedures of music emanating from the evolution of Romanticism through Impressionism and arriving at the dismantling of tonality in the 20th century. In this class, melodic, rhythmic and harmonic analysis will transcend the triadic structures of the common period as presented in Music Theory I-IV. Students will be expected to demonstrate their understanding of all concepts presented in class via a series of quizzes and two significant works they will compose during the course of the semester. Prerequisites: HMU 304

HMU 420 Spatial Music Applications

Spatial Music Applications will explore the intersection between the spatial features of traditional music structures and the environmental soundscape. The course will present a perspective on aesthetics through the creation of original spatial audio works. Students will engage with spatial music applications, composing large-scale sonic works for multi-channel loudspeaker arrays. Students will develop their own spatialization tools in order create dynamic spatial works; interrogating the notion of dynamic spatial gesture as a means to develop compositional narrative and to function as a temporal sonic signature.

HMU 450 Music Business

This course is an overview of the vast music business world and what a real and successful producer must know to compete in today's commercial music environment. Topics include: discovering an act, training, development, music union memberships, performance, music attorney expectations, management contracts, booking agents, promoters, publishing deals, performance rights organizations, production deals, recording studio management, record deals and labels, interactive media and Web promotion, and distribution. Guest speakers may be invited to class and students may visit "indie" and major label headquarters. All students will be encouraged to participate in the student organized Media Label Club

HMU 480 Media Culture and Theory

This course will survey key benchmarks and documents in the history of media technologies while also introducing critical readings of 20th and 21st century media culture, both from the theoretical field of media studies and the creative works of artists, filmmakers, and writers. We will explore how media technologies from print and photography through film, radio, television, video, the Internet, games, and social software have been successively introduced, disseminated, and commodified, and how their mediations have profoundly affected the way we experience and interpret our contemporary society and culture. Students will be required to complete readings every week, to contribute to a class web project including blogs and wiki, and to produce short papers and presentations that respond to and analyze the readings, in-class screenings, and other material we discuss. Prerequisites: none.

HMU 490	Music Performance: Concert Band	(0.5-0-0)
The study and	I performance of popular Concert Band repositories.	
HMU 491 The study and	Music Performance: Jazz Ensemble I performance of modern music.	(0.5-0-1)
HMU 492 The study and	Music Performance: Stevens Choir performance of choral masterworks.	(0.5-0.5-1)
HMU 493	Music Through Multimedia and Technology	(3-3-0)

This lecture course, with interactive studio demonstrations, is an introduction and overview of the world of multimedia. The student explores the basics of audio, graphics, photography, and video production through the use of digital audio, medi and music production, digital graphics, and photography and video software.

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HMU 496 Music Performance: Private Lessons

All Music and Technology majors are required to take four semesters of musical instrument instruction. After choosing an instrument (subject to availability), the student will be assigned an instructor with whom weekly lessons are arranged. Lessons are 1 hour/week with grade evaluations based on a combination of homework and in-class performance. The first two semesters of lessons are taken under HMU 496, while the second two are under HMU 497 and require a recital/ performance.

HMU 497 Music Performance: Recital/Ensemble

The third and fourth semesters of musical instrument instruction are taken under HMU 497 and require all students to perform in a recital setting to be determined in consultation with the instructor. Grade evaluations based on a combination of homework, in-class performance and recital performance.

HMU 498 Ensemble

Upon completion of the Recital requirement (HMU 497), Music and Technology majors must enroll in two additional semesters of Ensemble. They may complete this requirement in one of two ways: 1) By becoming an active member of a Stevens sanctioned (student life) ensemble, or 2) by participating in a private Ensemble (consisting of at least three members, 66% of whom must be Music & Technology students). In both cases, there must be faculty supervision and approval. Prerequisites: HMU 497

HMU 499 Thesis Tutorial

Thesis tutorial.

HMU 510 Audio Programming

This course provides a comprehensive grounding in the design of modules for prominent computer music software environments. Topics include modulation synthesis objects, sample-accurate sequencers, and spectral processing modules, as well as an overview of how these digital audio applications can be applied in musical practice. Prerequisites: HMU 260

HMU 520 Spatial Music Composition

Spatial music intentionally foregrounds spatial location and proximity cues within a musical work. This course explores the spatial features of traditional and electroacoustic music through the development of spatial audio applications and multichannel music compositions. Topics include perspectives on soundscape design, directional hearing, and the role of emerging spatial audio practices in the composition and performance of electroacoustic music. Prerequisites: HMU 314

Philosophy

HPL 111 Philosophy I: Theories of Human Nature

This course is intended as a general introduction to the discipline of philosophy through an examination of various attempts throughout history to answer the very fundamental question, "What does it mean to be human?" Topics discussed include happiness, the soul, virtue, good and evil, and the like. Readings from classical sources include Plato, Aristotle, Augustine, Hume, Mill, Nietzsche, Sartre and others.

HPL 112 Science and Metaphysics

This course provides an examination of philosophical concepts and ideas that address questions regarding the problem of knowledge (epistemology), methods of reasoning and the nature of reality (metaphysics). Special attention will be given to applying these topics to an introduction to the philosophy of natural science. Readings include classical sources such as Plato, Aristotle, Descartes, Hume, Kant, and Hegel, as well as contemporary works.

HPL 339 Ethics

A discussion and critical analysis of leading contemporary ethical theories, including utilitarianism, intuitionism, and virtue theories, among others. In addition, some consideration of criticisms by feminist philosophers of these traditional approaches to ethics will be given.

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HPL 340 Social and Political Philosophy

A study of the relation of the individual to society and the state. Major issues to be examined include the nature of freedom, justice and equality, alienation, and political authority. Also includes an analysis of political models such as liberalism, socialism, conservatism, and anarchism, as well as alternative conceptions of democracy.

HPL 345 Introduction to Minority Group Identity and Legal Theory

Theories, tactics, goals, and impact or organized minorities and how they relate and transform the American political sphere; groups studied include African-Americans, Latinos, Asians, Indians, and other politically marginalized minorities. Court decisions and legal precedents of mentioned groups in case law are closely examined in this course.

HPL 346 Modern Philosophy

The philosophy of Immanuel Kant (1724-1804). Readings from his works on reason, science, and morals.

HPL 347 Theories of Knowledge and Reality

A comprehensive examination of the disciplines of Epistemology and Metaphysic; topics addressed include being and reality, logic and language, the concept of truth, skepticism, causality, and knowledge. Readings are both historical and contemporary in nature.

HPL 348 **Aesthetics**

An exploration of theories of art and of aesthetic experience. Questions addressed include the following: Are judgments of taste objective? What are the roles of form, expression, and representation in the arts? How is art related to society? What is the nature of creativity in art and science? What is the relationship between creativity and madness? Examples are drawn from the various art forms, including painting, literature, music, dance, and film.

HPI 350 Ancient and Medieval Philosophy

A comprehensive study of Ancient and Medieval philosophers beginning with the Greek Pre-Socratics, through Plato and Aristotle, the post-Aristotelian schools of Epicureanism, Stoicism and Skepticism, through Plotinus, Augustine, and major Medieval thinkers such as Anselm, Avicenna, Averroes, and Thomas Aguinas.

HPL 368 Philosophy of Science

A critical analysis of the aims and methods of science, and its principles, practices, and achievements.

HPL 369 Science and Religion

This course investigates the history of the opposition of science and religion, beginning with the emergence of philosophy as an alternative to mythology, through the scholastic dominance of the Aristotelian world-view, to the Scientific Revolution, the emergence and acceptance of evolution, and beyond. Special attention will be given to current attempts at reconciling and/ or harmonizing these traditionally antithetical disciplines.

HPL 370 Philosophy of Technology

An introduction to the theoretical problems involved in the study of technology. Topics include the nature of technology as tool and system, the question of technological determinism, political implications of technology, and the impact on human nature.

HPL 371 Philosophy of Time

Time is one of the fundamental problems in philosophy. It poses specific challenges for any analysis or definition. Many philosophers have even denied the existence of time. Others have pointed at the difference between the linear time of nature and the non-linear time of human experience. The class will discuss classical and modern texts. It will raise questions such as: why is there only one direction of time? Does time have a beginning? Is time travel possible? Is time real or a product of our understanding? Is a timeless existence possible?

HPL 380 **Environmental Ethics**

An examination of basic positions in the field of environmental ethics with emphasis on principles of sustainability, whether there are legal and moral rights for nature, human treatment of animals, and environmental policy and decision-making. Prerequisites: HPL 111, HPL 112

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HPL 440 Citizenship, Nationality and Ethnicity in Contemporary Global Perspective (3 - 3 - 0)

The resurgence of nationalism, ethnicity, and the affirmation of cultural difference in the contemporary world has created problems for older conceptions of citizenship and universal rights. Philosophical arguments underlying alternative conceptions of social, political, and cultural identity and the conflicts that have emerged recently concerning claims to national recognition and cultural group rights. A related theme is the tension between the diversity of cultures on the one hand and increasing global interconnectedness on the other.

HPL 442 Logic

An examination of the methods and techniques of formal logic, including the history of the discipline from Aristotle through Leibniz, Frege, Russell, Quine, and others.

HPL 443 The Philosophy of Language (3 - 3 - 0)

Problems of meaning and reference in Frege, Russell, Wittgenstein, and others.

HPL 444 Philosophy of Mind

A philosophical examination of the mind and mental functioning. Some questions addressed include the following: Can we know what it is like to be a bat? Could it be that everyone (other than oneself) is a robot? What is the relationship between mind and brain? Can computers think? Readings include the work of Nagel, Wittgenstein, and Freud, among others.

HPL 445 The History of Philosophy

A consideration of the historical development of the western philosophical tradition, beginning with the pre-Socratics, up and through contemporary thinkers. The course will examine the recurrence of perennial problems in the history of intellectual thought.

HPL 447 Marx, Nietzsche, Freud: the Modern Individual and Society (3 - 3 - 0)

A study of major thinkers and movements in the nineteenth century including Kant, Hegel, Marx, Kierkegaard, Nietzsche, Mill, James, and Freud. Issues discussed will include the nature of scientific knowledge, political and moral right, and the emergence of psychological theory.

HPL 448 Contemporary Philosophy

Studies of current trends in analytic and Continental philosophy.

HPL 449 Philosophy of Law

What is the basis for the authority of the law? What are the competing theories of crime and punishment? What are the grounds of legal rights and duties? What are the relations among justice, liberty, and equality in the law? We will also consider such current legal issues as the insanity defense, the death penalty, the rights of unborn children, regulation of the internet, and affirmative action.

HPL 450 Global and International Ethics (3 - 3 - 0)

This course will focus on some of the new ethical issues that face social and political actors in the current period of globalization. We will examine the value questions that arise in relations among nation-states in such contexts as human rights, distributive justice, economic development, and the preservation of the environment. Among the topics to be discussed are just war theory and the analysis and response to terrorism; hunger, welfare, and global distributive justice; immigration and refugees; international business ethics; racism and sexism in national and international contexts; and democracy and the Internet. To illuminate these issues, we will consider alternative contemporary perspectives in political philosophy, including liberal, communitarian, and feminist approaches, and will examine their implications for politics in the context of emerging global frameworks. Emphasis will be placed on oral presentations and intensive discussion.

HPL 455 Ethical Issues in Science and Technology

Consideration of such issues as the ethical responsibility of scientists and technologists for the uses of their knowledge, the ethics of scientific research, and truth and fraud in science and engineering. We will study such contemporary moral questions as those concerning the uses and abuses of nuclear energy, environmental pollution and the preservation of natural resources, and the impact of new technologies on the right to privacy.

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HPL 457 **Bioethics**

The course is intended as an introduction to the key issues and methodologies of bioethics. It refers to the central problems in bioethics (autonomy of the patient, organ transplantation, stem cell debate, cloning, etc.), as much as to newer developments, such as genetic enhancement and the commercialization of the body. A main focus is to explore the field of bioethics in an interdisciplinary way and to bring not only ethical, legal, or scientific criteria into play, but also those from an existential, social, or cultural background. A short introduction to the moral theories used in applied ethics is given. The course helps to develop a responsible and sensitive conduct in future studies or occupations.

HPL 458 Computability and Logic

The algorithm: its theory, history, and philosophical significance.

HPL 459 The Philosophy of Social Science

This course examines the conceptual foundations of such disciplines as economics, sociology, anthropology, and political science. Readings include excerpts from Smith, Marx, Weber, Durkheim, and Winch, among others.

HPL 460 Philosophy and Feminism

This course is a general introduction to both the history and present concerns of feminist philosophy. Readings include classic essays of feminist thought by Wollstonecraft, Mill, Engels, and others as well as contemporary writings in philosophy and feminism. This course serves as a foundation for a minor in Gender Studies. No prior courses in philosophy are required.

HPL 461 American Philosophy

An examination of the work of the American Pragmatists. Readings from the works of James, Pierce, Dewey, Rorty, Putnam, and West, among others.

HPI 462 Eastern Philosophy

An introduction to classical philosophical texts from India and East Asia, including texts from the Hindu, Buddhist, Confucian, and Daoist tradition.

HPL 463 Existentialism

This course examines the popular philosophical movement known as "Existentialism." In addition to reading such seminar thinkers as Kierkegaard, Nietzsche, Heidegger, Sartre, and Camus, attention will be given to works outside the rubric of philosophy proper, including literature and cinema.

HPL 464 Philosophy in Film

The primary aim of this course is to introduce students to the medium of film as a possible vehicle for the presentation and examination of key philosophical concepts and ideas such as the nature of reality, time, and the question of the good life. Special consideration will be given to the ways this mode of presentation might differ from more traditional methods such as the philosophical treatise or essay. Throughout this course we will analyze classical as well as more recent films.

HPL 468 Women Philosophers of the Twentieth Century

This course follows the work of the following Edith Stein, Simone Weil, Iris Murdoch, Simone de Beauvoir, Hannah Ardent, and Ayn Rand. These are all seminal thinkers who began their philosophical work in the first half of the twentieth century and went on to influence the course of intellectual thought for a generation to come. And yet, more often than not, these women tend to be omitted from the traditional canon of twentieth-century philosophy. One goal of this course is to consider why that is the case.

HPL 470 War and Human Nature

This course is an examination of theories of and possible solutions to warfare purveyed by prominent thinkers, from Plato and Aristotle up through modern scientists such as Steven Pinker.

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HPL 480 Environmental Policy: Philosophical and Economic Issues

This course introduces students to environmental policy and ethics, with special attention to the importance of economic considerations. Specific issues to be covered may include: the equity-efficiency contrast, different decision-making structures, the role of narratives in policy-making, externalities, public goods, property rights, market-failure, benefit-cost analysis, justice, the choice of categories in quantifying policy problems, the relationship of formal and informal rules, propaganda versus information, and the normative idea of rights. This course is an introduction to the interplay of politics, economics, and ethics as they enter into policy-making in the environmental arena.

HPL 495 Seminar in Philosophy

The Seminar in Philosophy is intended to provide students with an in-depth examination of the work of either one specific philosopher (or pair of philosophers), or a particular work in the history of philosophy that has had a profound impact on the development of intellectual thought. Special attention will be given to how the philosopher or work in question influenced work outside philosophy.

Policy and Innovation

CAL 510 Foundations of Technology and Policy

This course explores perspectives in the policy process for science and technology - agenda setting, problem definition, framing the terms of debate, formulation and analysis of options, implementation and evaluation of policy outcomes with regards to economic, social and ethical dimensions. In addition to lectures on technology policy and ethics, exercises will aim at developing skills to work on the interface between technology and societal/ethical issues. Case studies and group projects that illustrate issues involving multiple stakeholders with different value structures, high levels of uncertainty, multiple levels of complexity and value trade-offs that are characteristic of science and technology policy and ethics problems will be used to illustrate the inherent complexities of the problem landscape.

CAL 529 History of Modern Science and Technology

An in depth survey of the history of science and technology from the Industrial Revolution to the present. Themes include the relationship between science and technology, the emergence of industrial research, the concept of a technological system, the history of innovation policy, and the uneven development of global capitalism. In addition to lectures on the history of science, technology, and industry, class discussions will develop skills in reading and interpreting a variety of primary and secondary sources. Students will learn research skills and gain familiarity with library, archival, and online collections by designing and completing a research project and paper.

CAL 539 Foundations of Ethics

An in-depth study of the most important theories of ethics—virtue ethics; deontological ethics; Utilitarianism—and their 20th and 21st century development. The class covers milestones in the history of ethics, insofar as they still have an impact on current discussions. Virtue ethics is studied in its classical form in Aristotle, which also allows students to address the unresolved problem of the scientific status of ethical theories. The class covers deontological and utilitarian ethics in their canonical form in Kant and Mill. Various methods and approaches that either criticize or transform these ethical theories are discussed in order to explore the theoretical options open to a 21st century ethicist. In addition to the basic moral theories, the class covers some of the necessary elements of human agency, i.e. free will, responsibility, and motivation. Finally, it covers some work in social ethics that has particular relevance for questions of economic justice and injustice.

CAL 541 Sociology of Science and Technology

This course addresses various theories, approaches, and methodologies used in the sociology of scientific knowledge, including the strong programme, relativism, actor-network theory, gendered accounts of science, and laboratory studies. In addition, it discusses the relationships between science, technology, and society, such as how science and technology influence society and how society influences science and technology. Furthermore, the course explores the issues related to science and technology workforces and policies. The issues discussed in the course occur in both the U.S. and other countries, and the readings discussed in the course crosscut sociology and other disciplines.

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CAL 555 Engineering and Computer Ethics

The class examines the central ethical problems that arise in the impact of technology on modern society, such as the responsibility of engineers, the precautionary principle, questions of risk/benefit-calculation, whistle-blowing. Special focus is laid on the assessment of emerging technologies, such as nanotechnology. The class also examines issues concerning the use and the development of computer technology, such as privacy, intellectual property, virtual realities, and artificial intelligence.

CAL 556 Ethics of Business & Technology

This course offers an in-depth introduction to the applied ethics of technology-driven business. Beginning with an overview of the principles of business ethics, including Kantian Business Ethics, Virtue Based Ethics, and Stakeholder theories, we will move on to more specific topics including: the proper goals of business in society, the role of the public good in business, intellectual property, globalization, the ethics of advertising, and the status of the corporation as a moral agent. The course will end with a critical examination of more ethical dilemmas arising from technology-driven business and industry. Particular attention will be given to recent corporate scandals as cases of ethical failure.

CAL 557 Bioethics

The course gives an introduction to the key issues and methodologies of bioethics. It refers to the central problems in bioethics (autonomy of the patient, organ transplantation, stem cell debate, cloning, etc.), as much as to newer developments, such as genetic enhancement and the commercialization of the body. A main focus is to explore the field of bioethics in an interdisciplinary way and to bring not only ethical, legal, or scientific criteria into play, but also those from an existential, social, or cultural background. An introduction to the moral theories used in applied ethics is given. The course helps to develop a responsible and sensitive conduct in future studies or occupations.

CAL 558 Sociology of Science

This course addresses various theories, approaches, and methodologies used in the sociology of scientific knowledge, including the strong programme, relativism, actor-network theory, gendered accounts of science, and laboratory studies. In addition, it discusses the relationships between science, technology, and society, such as how science and technology influence society and how society influences science and technology. Furthermore, the course explores the issues related to science and technology workforces and policies. The issues discussed in the course occur in both the U.S. and other countries, and the readings discussed in the course crosscut sociology and other disciplines. Cross-listed with: HSS 458

CAL 568 Philosophy of Science and Technology

This course provides an in-depth analysis of the area of philosophy that examines the aims, methods, goals, and practices of "science" and the quest for "scientific truth." In addition to the traditional topics of induction and confirmation, falsification, theory-ladeness of observation, demarcation, realism/instrumentalism/relativism debates, and the "science wars" of the late 20th century, special attention is given to current debates regarding the role of cultural, sociological, and psychological factors in scientific work as well as the state of particular scientific fields. Readings include such seminal figures as Hempel, Carnap, Duhem, Goodman, Popper, Kuhn, Lakatos, and Feyerabend, as well as contemporary thinkers like Putnam, McMullin, van Fraassen, and Kitcher.

CAL 580 Environmental Ethics

This course is an in depth overview of various debates in environmental ethics. We will consider the way in which ethical theories inform environmental decision-making in a number of situations including a selection of the following: the conservation of biodiversity, global climate change, human population growth, animal exploitation in agriculture, air and water pollution, and urban solid waste. Questions addressed include the following: Should we be concerned about the impact of human life on the environment? To what extent should sacrifices be made in order to protect the environment? Which ethical frameworks are most effective in resolving disputes? To what extent are solutions based purely on economic concerns inadequate? Special attention will be given to the ways in which traditional ethical theories must be amended in order to address environmental concerns. Prerequisites: CAL 539

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CAL 581 **Environmental Policy**

This course considers issues at the intersection of ecology, economics, public policy, and ethics. Specific issues to be covered may include: the history of environmental policy in the US, the role of Federal agencies in forming environmental policy, how values ought to play a role in environmental science, externalities, public goods, property rights, market-failure, benefit-cost analysis, environmental justice, the policy questions resulting from global climate change, propaganda versus information, and how pollution can infringe on human rights.

CAL 800	Special Problems in CAL: Inquiries of Sociology	(1 to 6)
CAL 900	Thesis in CAL (MA)	(1 to 10)

Professional Communications

COMM 500 Foundations of Business and Professional Communications (3 - 3 - 0)

The course covers topics that include brainstorming, organizing, writing and revision of technical documents, as well as preparation of verbal presentations with visual aids. In this overview class, students will be exposed to these skills, and have time to generate their own documents and presentations for feedback, but COMM 500 is primarily designed to give the students a foundation so that they may continue on with other, more specialized, classes in this field. Students in need of ESL/ESD attention will receive it. The course may be offered as a week-long intensive class designed to get students familiar with the basic concepts and tools they will need to master in order to pursue the Certificate Program in Professional Communications or other Stevens graduate degrees or programs.

COMM 501 Foundations of Technical Communication

This course introduces professional communications: how should professionals construct technical documents for the business or scientific/technical community? What are the techniques writers need for specialized, clear writing? Topics include: genres of technical writing; successful writingstrategies; design principles; format and contents. Students will practice the techniques presented through weekly writing assignments.

COMM 502 **Professional Presentations**

This course will present a range of professional presentation techniques: oral, web-based, audio-visual. Students' existing skills will be sharpened and enhanced with knowledge of current best professional practices. Weekly assignments will guarantee students will master newtechniques.

COMM 503 Advanced Documentation Technique

This course sharpens students' ability to deliver written descriptions, explanations and instructions to a diverse audience who may not share the writer's technical expertise. Students will create overviews and abstracts; lay out guidelines for readers; craft orderly instructions and explanations; insert necessary illustrations that enhance the documentation; build links to the next set of instructions; summarize effectively; and format for maximum comprehension.

COMM 504 Foundations of Business Plan Writing

This course introduces the foundations of writing a business plan. Topics include: what investors and lenders are looking for; the key elements of a business plan; special considerations when writing a business plan for an international endeavor or web-based or web-supplemented businesses. Students will demonstrate their knowledge of the material presented through weekly writing assignments.

COMM 510 Masters Thesis Preparation

This course helps students prepare to write their masters theses. Topics covered include use of databases in research; appropriate organization and development of masters-level research writing; review of technical writing; and general grammar and syntax overview. This course is of special use to speakers of English as a Second Language.

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COMM 530 Writing for Engineers

This course is an introduction to writing for engineers. As technical writers, engineers may often feel their task to be only one of "informing," but as has been dramatically illustrated over the last few years, "informing" can be vital to successful system deployment and operation. Lives are often affected by not only the accuracy of an engineer's calculations, but by a clear and understandable presentation of conclusions and recommendations. The ability to write clearly and effectively is essential to an engineer.

COMM 535 Writing for International Marketing

This course introduces the issues related to writing for international markets. What factors make writing for an international market different from writing for a domestic market? Topics covered include: the influence on writing of the key elements that make each nation different; the behavior of foreign consumers; translation issues; considerations when writing presentations, instructional texts, business plans, and web content for international audiences.

COMM 540 Foundations of Financial Writing

This course is concerned with the communication of financial information in writing: How should financial professionals construct documents? What are the writing techniques needed to make the numbers tell their own story? Topics include genres of financial writing; successful writing strategies; organizing information; using tables and charts.

COMM 545 Writing for Health Care Professionals

This course introduces essential concepts for writing in pharmaceutical houses, medical advertising agencies, and other medical settings. Topics covered include basic medical terminology, appropriate AMA style, and form and format in the use of professional research; preparation of meeting and conference materials for professionals in the field, and working with physicians.

COMM 550 Writing for the Web

This course dispels the myths about writing for the web and provides students with the skills to move successfully from print to web. The dynamic medium of the Internet not only demands concise, clear, well-organized copy, but an ability to operate in a non-linear world. This course will enable students to: reinforce good technical writing practices; incorporate usability issues when designing information for the web; think in non-linear ways; recognize the different functions of web copy and how to write for each (educational, promotional, information-seeking); understand the different delivery methods and how they influence the layout of the information and audio-visual choices.

COMM 555 Writing for Project Management

This course introduces the writing tasks that are critical to project management as it is used across a wide variety of industries. Topics covered include: the language of work breakdown structures; addressing project requirements; the semantics of risk analysis; assessing scope; and designing and building a project plan. Students will review online project management tools. Students will apply the techniques of writing for project management by creating a project plan to manage some aspect of an academic or extra-curricular activity.

COMM 560 Writing For and About the Science Community

This course introduces the interpretation and analysis of complex scientific information – and the translation of difficult scientific concepts into lively and readable prose. Topics include: effective interview techniques; information-gathering skills; news and feature article structure; editing; writing for the general public, scientists and industry. Students will practice these skills through in-class and take-home writing assignments. Writing assignments will progress from short, weekly articles to longer pieces. By the end of the semester, each student will write a feature article.

COMM 565 Publicity Writing: Techniques of Packaging Information

This course introduces the technical aspects of publicity writing. Topics include: writing a press bio; writing a topic summary; the art of the press release; the basics of the op-ed; and organizing the short informational feature. The course will include "how-to" discussions regarding inquiries from the press and the public, and ways to negotiate direct contacts with both. Guest speakers from the press/marketing field will make occasional presentations during the length of the course.

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COMM 570 **Proposal Writing**

This course helps students developing a case for support for a nonprofit organization, making long-range programmatic and financial plans, researching potential funders, and preparing proposal materials. Students will learn how to find funding sources and will make regular presentations on their research and writing samples. The class will compile a comprehensive set of funding resources, as well as sample grants and planning documents. Guest speakers will share professional insights and experiences.

COMM 810 Special Topics in Professional Communications

A participating seminar on topics of current interest and importance in Professional Communications.

Science, Technology & Society

HST 120 Intro to Science & Tech Studies

This course examines the politics and morality of science and technology. It uses an interdisciplinary perspective, known as Science and Technology Studies(STS), that includes anthropology, history, philosophy, and sociology. It begins by exploring the history of the field, which arose from scientists' concerns about nuclear arms, atomic energy, and environmental degradation. It will introduce basic concepts such as social construction and technological determinism. Topics will include social studies of scientific community, the pursuits of objectivity, how politics and values are built into technologies, and perceptions of technological and environmental risk. The course emphasizes conceptual tools that students can apply in their own encounters with technology.

HST 160 Introduction to Science Communication

Students will learn the skills required for researching, analyzing and writing about science-related topics (including medicine, engineering and the environment) in an informed and ethical manner. The course will help prepare students for careers in science journalism and/or science communication for corporate, governmental and nonprofit organizations. The course will also help teach engineering and science majors how to communicate more effectively to peers and the public.

HST 320 Science and the Media

Course Description: This course will examine how the various media shape public perceptions of science, with special attention given to engineering and medicine. Our primary focus will be topics with a social and/or political dimension, including brain science, genetic engineering, psychiatric drugs, artificial intelligence, national security, economics as well as the clash between science and religion. Students will learn how to read influential publications with a critical eye, enabling them to distinguish between bias and hype on the one hand, and fairness and accuracy on the other.

HST 325 **Visualizing Society**

This course examines the creation and reception of visual representations of socially-relevant data. Students analyze existing data visualization methods from the fields of science, health, economics, demography, geography, and science and technology studies. At the same time, students make their own interactive data visualizations for web browsers using data of relevance to social and scientific issues such as crime, medicine, environment, war, and race. While not a course in data visualization, students will be required to do some basic coding, web design, and graphic design in developing their own projects. No prerequisite courses or experience will be required.

HST 330 **Environmental Communication**

Environmental Communication introduces the study and practice of how individuals and institutions craft, distribute, understand, and use messages about the environment and human interactions with it. Topics include the study of important communication principles, the mass media and social media, the planning of effective communication campaigns, close analysis of global climate change and sustainable energy, and communication across different cultures. This course provides students with the tools, techniques, and strategies necessary for persuasive, professional, and scientifically rigorous communication about environmental issues.

HST 340 Global Public Health

This course examines the emergent field of global public health through the disciplinary lenses of science and technology studies. Throughout the course, students examine the global dimensions in current local and national practices of public health and discuss the impact of developments in science and technology on the development of disease surveillance, prevention, and response programs. Students will read and learn to analyze critically a variety of sources, such as academic texts and scientific papers, news media coverage of global health in action, and policy drafts and reports.

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HST 360 Research and Innovation Policy

This course explores key issues in public policies that shape scientific and technological activity. Course themes include: the historical origins of American and international science and technology policy; the complex relationship between science, technology, and democracy; forms of adversarial and promotional regulation; and scientific controversies in the recent past and present. Students will finish the semester with a project in which they apply theoretical insights from science and technology studies to the analysis of complex public policy questions.

HST 366 History of the Automobile 1893-Future

This class explores the history of the automobile in the United States from 1893, when the Duryea Brothers built the first internal combustion engine vehicle in the US, to possible futures, for instance, dominated by self-driving cars. The class examines the many sides of the automobile as a technological system, with topics including production, consumption, labor, energy, government, culture, spatial transformation, the environment, media representations, and human mating habits. The class focuses on the entire system of the automobile—not just the car itself—but also roads, traffic signals, parking lots and meters, gas stations, garages, and many other things and systems surrounding the car.

HST 370 Biology, Eugenics, and Society

This course examines how matters of biological and environmental determinism have been treated by scientists, humanists, activists, and other prominent Americans from the 18th century through the present day. Students will approach this subject through the disciplinary lenses of science and technology studies, and examine sources that illuminate conceptualizations of the nature-nuture distinction in relation to biology, race, class, intelligence, health, and athletic ability from the "Founding Fathers" through the 21st century. Readings can include selections from Thomas Jefferson, Charles Darwin, Francis Galton, Booker T. Washington, the founders of the American eugenics movement, Franz Boas, Margaret Mead, B.F. Skinner, and the authors of "The Bell Curve."

HST 390 Anthropology of Technology

This course will examine different technologies and scientific developments through the lens of cultural anthropology. Each time the course is taught, the focus will be on how technology affects one of the different aspects of American culture, with topics possibly including: love and kinship; sports and games; death and mourning; work, labor, and money; food and fashion; and language and communication. The course will focus on different global and local subcultures within the US, examining how different groups use and integrate the same technologies. Students will become familiar with anthropological concepts and theory. They will be introduced to the ethnographic method and qualitative analysis of social phenomena, collaborating in small groups to produce an ethnographic research project.

HST 401 Seminar in Science Writing

This course provides an in-depth exploration of scientific controversies that raise ethical, philosophical and political questions. Potential issues include physicists' quest for a "theory of everything," conflicts between science and religion, global warming and other environmental concerns, the search for "clean" energy, the nature-nurture debate, the mind-body problem, genetic engineering of humans and research on nuclear arms and other weapons. The core of the course will be public presentations organized by the Stevens Center for Science Writings (see list of events below). Students are required to attend these CSW events; read books and/or articles by the CSW speakers; prepare questions for CSW speakers; write papers on the issues raised by CSW speakers in their writings and lectures; and discuss these issues in class on non-presentation weeks. There are no exams in this course.

HST 415 The Nuclear Era

The course provides an overview of the nuclear era, starting with its beginnings during WWII. It demonstrates how developments in scientific research and technological development drove the creation of an immense military-industrialacademic enterprise. The Cold War precipitated an arms race that led to a new social reality based upon Mutually Assured Destruction. Students will learn how nuclear weapons have shaped international relations in the 21st Century, how non-state entities and the related possibilities of nuclear terrorism have come into prime focus, and how societies have integrated the production of nuclear energy. They also will gain a greater appreciation for the cultural novelties of the nuclear era, as well as for the changing social and political contexts of decision-making. Throughout the whole course, the existential threat of nuclear weapons technologies will be examined and discussed.

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HST 450 The History of Stevens

This class examines the history of the Stevens family, the Stevens Institute of Technology, and the relationship between the family, the school, and the city of Hoboken, New Jersey. Through these topics, the class will approach the broader subjects of cultural history, economic development, the history of science and technology, and American higher education in the 19th, 20th, and 21st centuries. Student projects will draw on archival manuscripts and artifacts in SC Williams Library.

HST 470 War and Science

This course will examine scientific theories of war--including biological, ecological and cultural models--as well as the historical interactions between science and militarism.

HST 495 Health, Policy, and Society

This course covers the social aspects of policy-making with respect to public health. It emphasizes the public health benefits that citizens receive, and how those benefits can be promoted or weakened through active citizen participation in the decision making process. The course also examines how technological innovations can improve medical practice, create better health outcomes, and challenge existing public health policies. Furthermore, it compares the similarities and differences between the American health system and systems in other countries (including Canada and European nations), based on factors such as access, affordability, and overall quality of the public health infrastructure. Course readings and assignments concentrate on the political, economic, and ethical aspects of health care policy, as well as the importance of communication in the policymaking process and the provision of health care.

Visual Arts & Technology

HTH 201 Introduction to Theater

The theatre's ability to cultivate empathy, to raise questions about societal practices, to explore the human condition, to foster collaboration, and to create community make it a dynamic and unique forum in which to participate as audience or practitioner. This course examines the development of the theatre from its roots in Ancient Greece to the present day. Students will examine that evolution from a number of critical points: theatre's literature, history, technological innovations, and social role. The class will read works of dramatic literature and historical texts. Attendance at NYC theatrical productions and "hands-on" exposure to the process of theatrical creation will complement the course readings. Cross-listed with: HLI 201

HTH 202 Introduction to Theater Design

This course introduces students to theatrical design. The course will examine the collaborative nature of theater and the interrelationship between art and technology in the design fields. An emphasis will be placed on the historic contributions of such key theater artists as Richard Wagner, Edward Gordon Craig, and Bertolt Brecht in the area of design and how their influence is still felt today. In the classroom, students will create a design element for the hypothetical production of a play or musical. Studio Course: Not for General Humanities credit. Prerequisites: Corequisites:

Foundation 2D: Color and Composition HAR 110

This course traverses through the elemental study of two-dimensional art and design--structural elements, organizational principles, psychological effects, and communicative functions--focusing on both the technical and the imaginative. Problemsolving studio assignments and critiques combined with visits to museums and galleries enable students to develop criteria for the analysis and evaluation of images created both by themselves and by others.

HAR 111 Foundations of 3D: Form and Space

This studio course explores the concepts of form and space, focusing on hands-on experiences using different types of materials to create three-dimensional sculptural works. Students are encouraged to be experimental with their combination and use of materials. This course will address formal elements of design and construction in relation to contemporary art works through video documentation, slides and books. Readings that accompany class discussions and a visit to Manhattan will be assigned throughout the semester.

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HAR 112 Drawing I

This course will approach the basics of drawing as an integrative tool where ideas and processes are explored and expanded through the drawing medium. Skills will be rendered through observation, manipulation, and coordinating and understanding these practices. Through problem solving within a range of projects, each student will begin to develop a visual language and the drawing skills that can be applied to conceptual, visual, and technical disciplines. Does not fulfill general humanities requirements; may be taken as a free elective.

HAR 113 Drawing II

Students will focus and expand their visual and conceptual knowledge and technical skills by drawing from the nude model, as well as explore new issues, dialogues, and skills surrounding the medium of drawing. The class will include studio course work and independent projects, as well as group field trips to see current drawing exhibitions in New York City. A class presentation of a chosen artist, as well as a supporting written paper, will be required of each student. The final project will be an interdisciplinary independent project designed and created by each student. Does not fulfill general humanities requirements; may be taken as a free elective.

HAR 114 Introduction To Photography

This course provides an introduction to the techniques, processes, history, and language of photography. Students will gain a technical understanding of cameras, production techniques, and post-production/presentation in order to develop their abilities to communicate creatively through studio exercises, discussion, and homework projects.

HAR 120 History of Technology and the Arts

The cultural convergence of music, performance, theater, and visual art has variously been termed multimedia, hybrid arts, intermedia, interdisciplinary arts, and transmedia, among others. This course looks at how artistic disciplines inform one another and how parallel developments in technology have played a significant role in the history of the arts and music, from early tribal rituals to our contemporary digital age. Organized as a historical survey of technology and the arts, the course will move beyond the idea of the arts as simple modes of expression to consider how it has been an active site of cultural practice. The course will begin with the concept of "techne," first used in antiquity, as a means of establishing the philosophical basis of creative practice and showing the fundamental unity between art, science and technology. Through weekly lectures, readings, and discussion, we will explore the many ways that science and technology informs and inspires the creative production. By the end of the course students will understand the ways in which diverse modalities of artistic practice function as forms of symbolic communication with aesthetic material, cultural and political dimensions. Cross-listed with: HMU 120

HAR 180 History of Art: Prehistory to the Modern Era

This course will introduce the formal vocabularies specific to works of art and familiarize the student with the complex interaction between form, meaning, and historical context. Course readings will consist of historical documents, as well as recent critical and historical writing. Western and non-Western objects and architecture dating from pre-history to the mid-nineteenth century will be discussed at length in the classroom and at museums. Group B, 100-level course.

HAR 191 Modern Art History and Theory

This course introduces students to key moments in the history of modern art in the newly industrial societies of America, Europe, and the [former] Soviet Union. Painting, sculpture, and photography from the 1850s to the 1980s will be examined. Focusing on a wide range of methodological questions, this course will also consider the relationship between avant-garde culture and mass culture, the implications of emergent technologies for cultural production, and the development of radical avant-gardism in the context of authoritarian political formations and advancing global capitalism.

HAR 193 Introduction to Art & Technology

This is an orientation to the interdisciplinary field of art and technology. The course explores the territory at the intersection of the technical, scientific, entertainment and fine arts communities. We will cover topics in contemporary media forms, online communities, the history of the art/technology field, as well as provide an overview of software used in the Internet, print, entertainment, design and communications industries. The seminar will encourage critical and analytical thinking through a stimulating range of hands-on and scholarly activities, including seminar lectures, readings, exposure to various kinds of media, discussions, field trips, a series of research papers and presentations, and a final project.

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HAR 205 Introduction to Digital Media

This course introduces students to theoretical and practical experiences in interdisciplinary production technologies, with an emphasis on visual and aural design principles. Projects may include creating and editing digital images, music, sound, video, text, and motion graphics. Students will work in teams to create projects. Not for general Humanities credit. Crosslisted with: HMU 205

HAR 220 Video I

This course will serve as an introduction to video production using current video technologies. Students will learn basic production skills and they will be introduced to the history of experimental film and video. There will also be a discussion of visual structure. In this course students will develop and shoot footage that may be used for Video II.

HAR 230 Sound and Vision

The primary focus of this course will be the theoretical study of sound and light wave theory as it relates to productions techniques: for audio, the basics of transducer technology and signal flow; for vision, electromagnetic waveforms, theory of optics, and the different applications of capturing visuals through digital means. At the completion of the course, students will be able to understand wave theory, transducer theory, basic acoustic properties of sound and hearing, basic understanding of characteristics of light and color, signal flow and practical applications of the above. Ultimately students will have the theoretical foundations to develop their audio/visual engineering skills as an art form. Not for general Humanities credit. Cross-listed with: HMU 230

HAR 240 Introduction to Web Media for the Arts

Webtools for the Arts will examine current internet technologies and web portal developments and their application to the Arts. Through the implementation of basic principles of php, MySql, html, Java and other webtools, students will learn to not only incorporate media content representing their particular interest in the arts but also implement authentication and Ecommerce tools, customize, embed and implement external web content, explore creative and alternative blog usages and explore the next generation cloud environment. Not for general Humanities credit. Cross-listed with: HMU 240

HAR 241 Design I

New digital technologies have had a profound impact on contemporary art making. This course will examine digital imaging concepts, methods, history, and aesthetics. Students will capture, edit, alter, and publish digital images and work on a variety of projects.

HAR 260 Game Design I

An introduction to the mechanics of games as well as a technical introduction to building videogames.

HAR 271 Creative Programming

This interdisciplinary course introduces students to programming languages created for artists and designers for making practical and experimental interactive artworks. Leveraging the power of custom-written software, this project-based class focuses on interactivity through the lens of videogames. Students will design a series of games, as well as learn about artists/ designers using code for creative projects, and the mechanics and history of popular and art games.

HAR 280 Modern Art History and Theory

This course introduces students to key moments in the history of modern art in the newly industrial societies of America. Europe, and the Soviet Union. Painting, culpture, and photography from the 1850s to the 1980s will be examined. Focusing on a wide range of methodological questions, this course will also consider the relationship between avant-garde culture and mass culture, the implications of emergent technologies for cultural production, and the development of radical avantgardism in the context of authoritarian political formations and advancing global capitalism.

HAR 281 History of Photography

This course introduces students to the history of photography from its beginnings in the 1830s to the recent practices of artists working with photographic technologies in the context of postmodernity. The primary task of the course will be to develop visual literacy and familiarity with the complex and contradictory genres and social functions of photographic image production. At the same time, this course will introduce the difficulty of writing the history of photography as a separate discipline that operates both inside and outside histories of modern art.

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HAR 301 Professional Practices

This course covers the essentials of being a professional artist or designer: professional writing, portfolio preparation, finding exhibition and job opportunities, and finances for creatives. By the end of the semester, students will have crafted a portfolio of their work, as well as a professional packet for seeking internships, jobs, and exhibition opportunities. Additionally, the course marks the beginning of the Visual Art & Technology thesis process. Students will conduct research and write an artist statement outlining other artists and creatives whose work is an influence.

HAR 311 Digital Imaging II

This is an intermediate course in digital print media, with an emphasis on how it informs and evolves visual language for artistic expression. Students will consider multiples, sequencing, notation, gesture, and narrative concerns, combining formal elements with experimentation across media; these media may include: printmaking, drawing, painting, photography, and sculpture. Students continue to work with computer software applications as tools to develop a more in-depth knowledge and vocabulary of the technical, theoretic, and aesthetic possibilities inherent in the medium. Classroom lectures and hands-on lab exercises compliment readings and problem-solving projects. One trip to Manhattan and one scheduled Media Industry Forum on campus is required.Prerequisite: HAR 310 or permission of the instructor. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HAR 241

HAR 312 Digital Imaging III

This is an advanced studio art course in digital image-making concepts and techniques, allowing in-depth exploration of extended computer-based photo and compositing projects. Aesthetic issues are balanced with technical issues, and artistic criteria such as composition, lighting, and the creative process are emphasized. The class combines demonstrations/ presentations/tutorials followed by independent hands-on project-based activities applying acquired techniques. There will be opportunity for in-class discussions, critiques and presentations. Students are expected to demonstrate time management skills, work independently and meet deadlines. Prerequisites: HAR 311

HAR 320 Video II

This course will serve as an introduction to video production using current video technologies. Students will learn basic production skills and they will be introduced to the history of experimental film and video. There will also be a discussion of visual structure. In this course students will develop and shoot footage that may be used for Video II. Prerequisites: HAR 220

HAR 330 Animation I

This course introduces students to modeling and simple computer animation using the industry-standard tool, Autodest Maya. It also provides a foundation for further work with 3-D and imaging tools. In addition to technical subjects, students will learn about the history, artistic practice, and developmental trajectory of 3-D graphics. It is recommended (but not required) that the student consider Animation as a two-semester sequence, with the student planning to register for HAR 331 Animation II the second semester. Does not fulfill general humanities requirements; may be taken as a free elective.

HAR 331 Animation II

Building upon the fundamentals of animation and how they can be applied through Autodesk Maya, the focus of this course will be for the students to develop the skills necessary to create a final project that shows the ultimate type of animation character. Students will accomplish this task through observation and practice and are encouraged, in their own creative expression, to explore non-discursive modes of articulation and communication. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HAR 330

HAR 332 Animation III

This rigorous and intensive computer animation course builds upon Animation I & II. The course is designed for the serious 3-D animation student who is expecting to continue working in animation. It continues the approach of increasing skills and artistic practice in all areas of 3-D animation: concept, modeling, animation, and rendering. This is not just a software training course. While understanding advanced software tools will be necessary to attain the objectives of this course, grade evaluation is based on the student's development and successful demonstrations of mastery of timing, visual design, and storytelling abilities. Throughout the class, students will be encouraged to find their own artistic voice. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HAR 331

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HAR 340 Design II

In this course, students will build on their experiences in Design I with a focus for books and other sequential material. Students will learn industry-standard software, mock-up printed prototypes, and understand how to prepare a project for professional printing and binding. Prerequisites: HAR 241

HAR 342 Motion Graphics

This is an introductory studio-based class designed to teach students the methods and applications for creating graphicand text-based animation for digital video, film and the Internet, and introduces students to the aesthetics and creative philosophies in the field. Through lectures, in-class tutorials, readings, discussions, and weekly projects, students learn professional techniques to develop creative projects and practical approaches to visual problem solving. The class covers techniques ranging from simple animations to complex special effects, and students are required to create all resources for animation purposes including digital image and recorded content. Does not fulfill general humanities requirements; may be taken as a free elective. Prerequisites: HAR 240

HAR 360 Game Design II

Building upon game design foundations in the introductory prerequisite, this class delves deeper into designing, building, and critically thinking about games. With a focus on 3D, collaborative design team building, and alternative practices, this class will give students the tools to building unique game experiences. Prerequisites: HAR 260

HAR 372 Technology and the Landscape

This hybrid studio/seminar course examines how technology has shaped our experience of the landscape, from stone tools to the invention of perspective to algorithmic and virtual worlds. Through creative projects, readings, writing, and field visits, students will explore how technology has shaped the landscape, ways of recording it, and our cultural relationship with the natural and built world. Not for humanities credit.

HAR 380 Media Culture and Theory

This course will survey key benchmarks and documents in the history of media technologies, while also introducing critical readings of 20th- and 21st-Century media culture, both from the theoretical field of media studies and the creative works of artists, filmmakers, and writers. We will explore how media technologies from print and photography through film, radio, television, video, the Internet, games, and social software have been successively introduced, disseminated, and commodified, and how their mediations have profoundly affected the way we experience and interpret our contemporary society and culture. Students will be required to complete readings every week, to contribute to a class Web project including blogs and wiki, and to produce short papers and presentations that respond to and analyze the readings, in-class screenings, and other material we discuss.

HAR 385 Contemporary Art

This course is an overview of a broad range of topics about contemporary fine art. We examine theoretical issues, modern and post-modern styles, and the industry and practice of visual art through bi-weekly visits to galleries and museums in Manhattan. Readings, papers, and presentations are required. This course approaches its subject matter from the artists' standpoint and is taught by a professional artist. Prerequisites: HAR 280

HAR 387 American Films

This course examines American fiction films in terms of their historical development through the studio system and in terms of current narrative theory. The course is concerned with ways in which narratives are constructed and ways in which they provide the appearance of "meaning." Particular attention is given to film noir. Various European films that strongly influenced, or parallel, merican works are also examined.

HAR 389 History of Middle Eastern Art

This course is a survey of the myriad art and architectural forms of the Middle East. From earliest origins in Mesopotamia and Egypt, the course examines Byzantine and Sassanid influences on the development of Islamic Art under the Umayyids and Abbassids, as well as the Ottomans and Persians. It follows these influences through the nineteenth and twentieth centuries, examining the current state of art, including film, in the Middle East.

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HAR 420 Video III

Video III is a projects-centered class for advanced students who have already built up technical skill, historical knowledge and formal vocabularies in the video medium through their earlier studies, and are now motivated to produce more intensive video projects of their own design. Video III will build on the skills and concepts introduced in Video I and II, giving students the opportunity to explore the theory, history and practice of video as a time-based art medium in more depth through screenings of artists' work and reading of artists' texts. Video III will also give students the opportunity to develop projects with more formal and technical complexity through technical lectures in special topics in advanced production and postproduction, focused around issues relevant to the interests of students enrolled in the course - for example, surround sound mixing, interactive authoring or multi-channel editing. Prerequisites: HAR 320

HAR 430 Net Art and Design

An introduction to the principles and strategies of net art through readings, encounters with artwork, projects, and practical instruction in graphic, multimedia, and interaction design for the Web. Techniques and design problems will be studied through historical and current examples of networked artistic practices. This is a studio course, focused on creative production and peer critique, which meets for four hours, once a week, and also requires students to put in weekly lab time outside of class to complete their assignments. Students will be expected to produce and present three net art projects over the course of the semester, including one final project that must be launched online. Students are not expected to have previous programming experience but should already be familiar with the digital imaging, audio, and/or video tools necessary to produce media that they wish to include in their projects. While this course will introduce students to some of the technologies used by net artists, it should not be taken as a programming class, and cannot be used as an equivalent to technical courses offered by other departments.

HAR 460 Game Design III

As the highest level course offered in the Game Design concentration for Visual Art and Technology, this course is structured to give advanced students the opportunity to develop from the ground up a complete, well-polished, ready-to-market game. Furthermore, this class will focus on the later stages of development, prototyping, testing, and distribution for students finalizing large-scale or ambitious game projects. Prerequisites: HAR 360

HAR 486 Art and Technology

This course is an overview of a broad range of topics about contemporary fine art combined with complementary hands-on experiences in the creative process. We examine theoretical issues, modern and post-modern styles, and the industry of visual art, as well as make art to further enhance our awareness and understanding of visual imagery. This course approaches its subject matter from the artist¹s standpoint and is taught by a professional artist.

HAR 490 Internship in Art and Technology

An internship is a short-term work experience that emphasizes learning. It is an essential way to try out a career, develop new skills, combine academic theory with "hands-on" experience, and build up a resume. This is an independent and individually-initiated program of work arranged between the student and an institution, organization, or business. Internship requires a plan (prepared with the job supervisor) to be presented to the Internship faculty sponsor, per approval, in the Program in Art & Technology, outlining the scope of work before starting the internship. It is expected that Internship will run approximately 8 to 12 hours per week for 14 weeks (or 112 to 168 hours per academic session) per 3 credits. A scheduled bi-weekly meeting with a group to discuss internships and career interests is expected. The student's internship performance will be evaluated by the following: a) a weekly journal describing the student's involvement in various activities and projects; b) an approximately five-page reflective essay in which the student integrates prior coursework with the internship experience (a theory and practice exercise); c) a basic report indicating the extent to which scope of work was accomplished; d) attendance and participation in group meetings; e) a written evaluation from the student's supervisor; f) a portfolio of work accomplished during the internship, if appropriate. Does not fulfill general humanities requirements; may be taken as a free elective.

Topics in Art & Technology HAR 495

This course has a different topic or theme each semester, and can be taken twice, subject to advisor approval. Visiting artists who have been invited to work at Stevens will design this course, which will be studio-based or in a seminar format. Teaching methods and evaluation will vary with the instructor. Registration by permission of the instructor or ARTC director only. Topics might include: "The Artist's Book," "The Body and New Physicality," "Database Art," "Negotiating the Everyday," "Transmedia."

COLLEGE OF ARTS AND LETTERS

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COLLEGE OF ARTS AND LETTERS

HAR 498 Senior Project and Exhibition

Art & Technology students are required to produce a significant body of work or major project in the last semester of their senior year in which the ideas, methods of investigation, and execution are determined by the student under the guidance and direction of a faculty advisor. HAR 498, in combination with the prerequisite (HUM 499) is the culmination of their undergraduate experience. Students are responsible for finding faculty advisors in their area of choice, which may be one person for both HUM 499 and HAR 498, or two faculty members working together during the yearlong process. During the seventh semester, students work in HUM 499 tutorial to begin their research and create a model for their senior projects. Their final semester at Stevens is spent in production. Plans and a schedule are developed with their advisor(s), and they meet every week or two to discuss and evaluate student progress. Group meetings with other seniors and advisors are encouraged. At the end of the semester, the project and substantial analytical paper situating the project are juried by a committee of three, and the project is publicly exhibited. The paper with accompanying visual documentation of the project is submitted to the library. Prerequisites: HUM 499 Corequisites: HUM 499

HAR 499 Capstone 2

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This course is intended as the capstone experience for Visual Art & Technology students, a focused time to prepare your thesis project and paper. During this semester, we will have a series of group and individual critiques of thesis work in progress, as well as work together to plan, promote, install, and host a reception for the thesis exhibitions, and organize participation in Innovation Expo through posters or other presentations.



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SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

PEP 601 Fundamentals of Data Transmitting

The course is the first part of the graduate certificate program "Wireless Secure Network Design" which includes also three other courses - PEP 602, 603 and 604. Program focuses on heterogeneous wireless systems used by first-responders police, fire fighters, National Guard and other emergency forces - to protect the public during large scale crises, such as natural disasters and acts of terrorism. The program also includes analysis of homeland defense, financial and military operations using secure wireless systems. At the end of the program students will learn how protect existing wireless systems and how design highly secure systems for a future use. The course presents a comprehensive analysis of different parts of the electromagnetic spectrum, transmission and modulation technologies, hardware new artificially engineered materials, and MEMS with accent on security and robustness of communications. Fall Semester

PEP 602 Secure and Robust Communications

The course presents an overview of areas of first responders and military activities and using of different heterogeneous wireless systems during large scale crises, such as natural disasters, acts of terrorism, and also during homeland defense, financial and military operations. The course includes an analysis of different wireless network architectures from security point of view. The course is the second part of the graduate certificate program "Wireless Secure Network Design" which includes also three other courses - PEP 601, 603 and 604. Fall semester.

PEP 603 Physical and Logical Security

The course presents an overview of different methods of authentication and authorization in secure wireless networks. The course focused on different methods of physical data and link protection, probability of detection and interception, anti-jam and covert capabilities, active and passive protection methods and equipment. The course is the third part of the graduate certificate program "Wireless Secure Network Design" which includes also three other courses - PEP 601, 602 and 604. Spring Semester

PEP 604 Secure Telecomm Wireless System Design

The course presents an overview of different methods used in secure heterogeneous wireless systems design. Large scale infrastructure and ad hoc networks test and simulation are one of the major parts of the course. The course also includes practical exercises and lab experiments. The course is the last part of the graduate certificate program "Wireless Secure Network Design" which includes also three other courses - PEP 601, 602 and 603. Students successfully finished all four courses will receive a graduate certificate in wireless secure network design. Spring Semester.

PEP 607 Plasma Physics I

Motion of charged particles in electromagnetic field; Boltzmann equation for plasma; properties of magnetoplasmas; and fundamentals of magnetohydrodynamics. Applications to include: mirror geometry, high frequency confinement, plasma confinement, and heating by means of magnetic fields; motion of plasmas along and across magnetic field lines; magnetohydrodynamic stability theory; plasma oscillations; microinstabilities waves in magnetoplasma; dispersion relations; Fokker-Planck equation for plasmas; plasma conductivity; runaway electrons; relaxation times; radiation phenomena in magnetoplasmas; stability theories; finite Larmor radius stabilization; minimum-B stability; and universal instabilities. Typical text: Schmidt, Physics of High Temperature Plasmas. Fall semester. Prerequisites: PEP 555, PEP 642, PEP 643

PEP 608 Plasma Physics II

Motion of charged particles in electromagnetic field; Boltzmann equation for plasma; properties of magnetoplasmas; and fundamentals of magnetohydrodynamics. Applications to include: mirror geometry, high frequency confinement, plasma confinement, and heating by means of magnetic fields; motion of plasmas along and across magnetic field lines; magnetohydrodynamic stability theory; plasma oscillations; microinstabilities waves in magnetoplasma; dispersion relations; Fokker-Planck equation for plasmas; plasma conductivity; runaway electrons; relaxation times; radiation phenomena in magnetoplasmas; stability theories; finite Larmor radius stabilization; minimum-B stability; and universal instabilities. Typical text: Schmidt, Physics of High Temperature Plasmas. Spring semester. Prerequisites: PEP 607

PEP 610 Advanced Modern Optics Laboratory

A continuation of PEP 510 for those students desiring a more thorough knowledge of optical systems. Included would be the use of an OTDR, ellipsometry, vacuum deposition of thin films, and other instrumentation. Students are encouraged to pursue their individual interests using the available equipment. Spring or fall term by arrangement. Prerequisites: PEP 510

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PEP 619 Solid State Devices

Operating principle, modeling, and fabrication of solid state devices for modern optical and electronic system implementation; recent developments in solid state devices and integrated circuits; devices covered include bipolar and MOS diodes and transistors, MESFET, MOSFET transistors, tunnel, IMPATT and BARITT diodes, transferred electron devices, light emitting diodes, semiconductor injection and quantum-well lasers, PIN, and avalanche photodetectors. Prerequisites: EE 503

PEP 621 Quantum Chemistry

Theorems and postulates of quantum mechanics; operator relationships; solutions of the Schrödinger equation for model systems; variational and perturbation methods; pure spin states; Hartree-Fock self-consistent field theory; and applications to many-electron atoms and molecules. CH 520 is an alternative prerequisite. Prerequisites: PEP 554

PEP 626 Optical Communication Systems

Topics covered include components for and design of optical communication systems; propagation of optical signals in single mode and multimode optical fibers; optical sources and photodetectors; optical modulators and multiplexers; optical communication systems: coherent modulators, optical fiber amplifiers and repeaters, transcontinental and transoceanic optical telecommunication system design; optical fiber local area networks.

PEP 630 Nonlinear Dynamics

Definition of dynamical systems; phase space and equilibrium states and their classification; nonlinear oscillator with and without dissipation; Van der Pol generator; Poincare map; slow and fast motion; forced nonlinear oscillator: linear and nonlinear resonances; forced generators: synchronization; Poincaré indices and bifurcations; solitons; shock waves; weak turbulence; regular patterns in dissipative media; and chaos: fractal dimension, and Lyapunov exponents. Typical textbooks: H.D.I. Abarbanel, M.I. Rabinovich, and M.M. Sushchik, Introduction to Nonlinear Dynamics for Physicists; R.H. Abraham and C.D. Shaw, Dynamics: The Geometry of Behavior. Prerequisites: PEP 528

PEP 642 Mechanics

Lagrangian and Hamiltonian formulations of mechanics, rigid body motion, elasticity, mechanics of continuous media, small vibration theory, special relativity, canonical transformations, and perturbation theory. Typical text: Goldstein, Classical Mechanics. Prerequisites: PEP 538

PEP 643 Electricity and Magnetism I

Electrostatics, boundary value problems, Green's function techniques, methods of image, inversion, and conformal mapping; multipole expansion. Magnetostatics, vector potential. Maxwell's equations and conservation laws. Electromagnetic wave propagation in media. Crystal optics. Fall semester. Typical texts: Jackson, Classical Electrodynamics; Landau and Lifshitz, Electrodynamics in Continuous Media. Prerequisites: PEP 542, PEP 528

PEP 644 Electricity and Magnetism II

Interaction of electromagnetic waves with matter, dispersion, waveguides and resonant cavities, radiating systems, scattering and diffraction, covariant electromagnetic theory, motion of relativistic particles in electromagnetic fields, relativistic radiation theory, radiation damping, and self-fields. Spring semester. Typical texts: Jackson, Classical Electrodynamics and Landau and Lifshitz, The Classical Theory of Fields, Electrodynamics in Continuous Media. Prerequisites: PEP 643

PEP 651 Advanced Physics Lab II

Advanced laboratory work in modern physics arranged to suit your requirement. Fall and spring semesters. Typical text: see PEP551.

PEP 653 Quantum Mechanics II

This course is a continuation of PEP 554. Topics include: principles of quantum dynamics, time-dependent perturbation theory, scattering theory, the density matrix, quantization of the electromagnetic field, interaction of photons with atoms and non-relativistic particles, identical particles, and second quantization for many-body systems. Typical text: Quantum Mechanics by E. Merzbacher. Prerequisites: PEP 542, PEP 554

SCHAEFER SCHOOL OF ENGINEERING AND SCIENCE

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PEP 657 Quantum Field Theory Methods in Statistical and Many-Body Physics (3 - 0 - 3)

Dirac notation; Transformation theory; Second quantization; Particle creation and annihilation operators; Schrodinger, Heisenberg and Interaction Pictures; Linear response; S-matrix; Density matrix; Superoperators and non-Markovian kinetic equations; Schwinger Action Principle and variational calculus; Quantum Hamilton equations; Field equations with particle sources, potential and phonon sources; Retarded Green's functions; Localized state in continuumand chemisorption; Dyson equation; T-matrix; Impurity scattering; Self-consistent Born approximation;Density-of-states;Greens function matching; Ensemble averages and statistical thermodynamics, Bose and Fermi distributions, Bose condensation; Thermodynamic Green's functions; Lehmann spectral representation; periodicity/antipeiodicity in imaginary time and Matsubara Fourier series/frequencies; Anallytic continuation to real time; Multiparticle Green's functions; Linked cluster theorem; Random phase approximation; Perturbation theory for green's functions, self-energy and vertex functions by variational differential formulation; Shielded potential perturbation theory;Imaginary time contour ordering Langreth algebra and the GKB Ansatz. Typical texts: Kadanoff and Baym, Quantum Statistical Mechanics, and Inkson, Many-Body Theory of Solids. Corequisites: PEP 554 Prerequisites: PEP 242

PEP 657 Quantum Statistical Mechanics

The course features the application of modern field theory methods and especially Feynman diagrams to fermion and boson system and critical phenomena. The initial text will be Quantum field theory and statistical physic by Abrikosov, Gorkov and Dzyalizhinski. Also discussed will be an introduction to scaling and the renormalization group (Wilson papers, texts of Pfeuty and Toulose, Ma and Reichl). Other topics will include broken symmetry non-phonon mechanisms in fermion superconductivity, field theory generalizations of the independent particle or Hartree-Fock model for non-homogeneous Fermion systems, Feynman path integrals and Wiener measure in statistical physics, exact properties of the Ising model, Feynman path integrals and Wiener measure in statistical physics, onset of ferromagnetism and spin-fluctuations. Prerequisites: PEP 242

PEP 658 Quantum Statistical Mechanics

The course features the application of modern field theory methods and especially Feynman diagrams to fermion and boson system and critical phenomena. The initial text will be Quantum field theory and statistical physic by Abrikosov, Gorkov and Dzyalizhinski. Also discussed will be an introduction to scaling and the renormalization group (Wilson papers, texts of Pfeuty and Toulose, Ma and Reichl). Other topics will include broken symmetry non-phonon mechanisms in fermion superconductivity, field theory generalizations of the independent particle or Hartree-Fock model for non-homogeneous Fermion systems, Feynman path integrals and Wiener measure in statistical physics, exact properties of the Ising model, Feynman path integrals and Wiener measure in statistical physics, onset of ferromagnetism and spin-fluctuations. Prerequisites: PEP 242

PEP 661 Solid State Physics I

Crystal symmetry. Space-group-theory analysis of normal modes of lattice vibration, phonon dispersion relations, and Raman and infrared activity. Crystal field splitting of ion energy level and transition selection rules. Bloch theorem and calculation of electronic energy bands through tight binding and pseudopotential methods for metals and semiconductors and Fermi surfaces. Transport theory, electrical conduction, thermal properties, cyclotron resonance, de Haas van Alfen, and Hall effects. Dia-, para-, and ferro-magnetism and magnon spinwaves. Fall semester. Typical texts: Callaway, Quantum Theory of Solid State; Ashcroft and Mermin, Solid State Physics; and Kittel, Quantum Theory of Solids. Prerequisites: PEP 544

PEP 662 Solid State Physics II

Crystal symmetry. Space-group-theory analysis of normal modes of lattice vibration, phonon dispersion relations, and Raman and infrared activity. Crystal field splitting of ion energy level and transition selection rules. Bloch theorem and calculation of electronic energy bands through tight binding and pseudopotential methods for metals and semiconductors and Fermi surfaces. Transport theory, electrical conduction, thermal properties, cyclotron resonance, de Haas van Alfen, and Hall effects. Dia-, para-, and ferro-magnetism and magnon spinwaves. Spring semester. Typical texts: Callaway, Quantum Theory of Solid State; Ashcroft and Mermin, Solid State Physics; and Kittel, Quantum Theory of Solids. Prerequisites: PEP 661

PEP 667 Statistical Mechanics

Advanced transport theory, classical statistical mechanics, fluctuation theory, quantum statistical mechanics, ideal Bose and Fermi gases, imperfect gases, phase transitions, superfluids, Ising model critical phenomena, and renormalization group. Typical text: Huang, Statistical Mechanics. Prerequisites: PEP 555

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PEP 678 Physics of Optical Communication Systems

This course explains the physics behind modern optical communication systems at high data rates. The first half of this course covers information theory and light propagation over fiber optic waveguide channels; semiconductor laser sources and detectors; high speed digital optic links; and dense wavelength division multiplexing methods and devices. The second half of this course covers quantum optical information theory; coherent systems and quantum correlations; optical solition-based communication; squeezed light and noise limitations; de-phasing and de-coherence; teleportation and secure communication system protocols; and cryptography and chaotic optics. Prerequisites: PEP 553

PEP 679 Fourier Optics

Abbe diffraction theory of image formation, spatial filtering, coherence lengths, and areas. Holograms; speckle photography; impulse response function; CTF, OTF, and MTF of lens system; and coherent and incoherent optical signal processing. Spring semester. Typical text: Goodman, Introduction to Fourier Optics.

PEP 680 Quantum Optics

This course explores the quantum mechanical aspects of the theory of electromagnetic radiation and its interaction with matter. Topics covered include Einstein's theory of emission and absorption, Planck's law, quantum theory of light-matter interaction, classical fluctuation theory, quantized radiation field, photon quantum statistics, squeezing, and nonlinear interactions. Offered in alternate years. Typical text: Loudon, Quantum Theory of Light. Prerequisites: PEP 509, PEP 542, PEP 554

PEP 685 Physical Design of Wireless Systems

Physical design of wireless communication systems, emphasizing present and next generation architectures. Impact of non-linear components on performance; noise sources and effects; interference; optimization of receiver and transmitter architectures; individual components (LNAs, power amplifiers, mixers, filters, VCOs, phase-locked loops, frequency synthesizers, etc.); digital signal processing for adaptable architectures; analog-digital converters; new component technologies (SiGe, MEMS, etc.); specifications of component performance; reconfigurability and the role of digital signal processing in future generation architectures; direct conversion; RF packaging; minimization of power dissipation in receivers.

PEP 690 Introduction to VLSI Design

Introduction to the principles and design techniques of very large scale integrated circuits (VLSI). Topics include: MOS transistor characteristics, DC analysis, resistance, capacitance models, transient analysis, propagation delay, power dissipation, CMOS logic design, transistor sizing, layout methodologies, clocking schemes, case studies. Students will use VLSI CAD tools for layout, and simulation.

PEP 691 Physics and Applications of Semiconductor Nanostructures (3 - 0 - 3)

This course is intended to introduce the concept of electronic energy band engineering for device applications. Topics to be covered are electronic energy bands, optical properties, electrical transport properties of multiple quantum wells, superlattices, quantum wires, and quantum dots; mesoscopic systems, applications of such structures in various solid state devices, such as high electron mobility, resonant tunneling diodes, and other negative differential conductance devices, double-heterojunction injection lasers, superlattice-based infrared detectors, electron-wave devices (wave guides, couplers, switching devices), and other novel concepts and ideas made possible by nano-fabrication technology. Fall semester. Typical text: M. Jaros, Physics and Applications of Semiconductor Microstructures; G. Bastard, Wave Mechanics Applied to Semiconductor Heterostructures. Prerequisites: PEP 503, PEP 553

PEP 700 Quantum Electron Physics and Technology Seminar

This seminar is focused on nanostructure-scale electron systems that are so small that their dynamic and statistical properties can only be properly described by quantum mechanics. This includes many submicron semiconductor devices based on heterostructures, quantum wells, superlattices, etc., and it interfaces solid state physics with surface physics and optics. Outstanding visiting scientists make presentations, as well as some faculty members and doctoral research students discussing their thesis work and related journal articles. Participation in these seminars is regarded as an important part of the research education of a physicist working in condensed matter physics and/or surface physics and optics.

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PEP 701 Seminar on Current Topics in Physics and Applications

This seminar is focused on current topics in physics and their applications in various areas. The format of the seminar is similar to PEP 700, but the scope of the seminar covers a broader range of topics, including interdisciplinary areas and applications such as low-temperature plasma science and technology, atmospheric and environmental science and technology, and other topics. One credit per semester. PEP 700 and PEP 701 may be taken for up to three credits.

PEP 704 Group Theory for Physics in Solid State and Molecular Physics (3 - 0 - 3)

Group theory for physicists with applications to solid state and molecular physics. Relation between group theory and quantum (or classical) mechanics, between classes and observables, and between representations and states. Point groups: full rotation group, crystallographic point groups, and spin-associated double groups. Crystal field theory with and without spin, selection rules and character tables, and use of product representation. Form of macroscopic crystal tensors molecular vibrational states and spectra. Translational properties of crystals. Energy band structure. Formal classification of space groups with examples. Time reversal and Onsager relations with examples. Lattice vibrations and phonons. Localized valence orbitals in chemistry. Hartree-Fock many-electron wave-functions. Phase transitions. Representative texts: M. Lax Symmetry, Principles in Solid State and Molecular Physics; Heine Group, Theory in Quantum Mechanics. Prerequisites: PEP 554

PEP 722 Molecular Spectroscopy

Theoretical foundations of spectroscopic methods and their application to the study of atomic and molecular structure and properties; theory of absorption and emission of radiation; line spectra of complex atoms; group theory; rotational, vibrational, and electronic spectroscopy of diatomic and polyatomic molecules; infrared, Raman, and uv-vis spectroscopy; laser spectroscopy and applications; photoelectron spectroscopy; and multi-photon processes. Prerequisites: PEP 509, PEP 554

PEP 740 The Physics of Nanostructures

Progress in the technology of nanostructure growth; space and time scales; quantum confined systems; quantum wells, coupled wells, and superlattices; quantum wires and quantum dots; electronic states; magnetic field effects; electron-phonon interaction; and quantum transport in nanostructures: Kubo formalism and Butikker-Landau formalism; spectroscopy of quantum dots; Coulomb blockade, coupled dots, and artificial molecules; weal localization; universal conductance fluctuations; phase-breaking time; theory of open quantum systems: fluctuation-dissipation theorem; and applications to guantum transport in nanostructures. Prerequisites: PEP 554, PEP 661

PEP 750 Quantum Field Theory

This course is open to students who have taken PEP 754 or its equivalent. It concerns itself with modern field theory; such topics as Yang-Mills fields, the renormalization group, and functional integration. It will concern itself with applications to both elementary particles and condensed matter physics; i.e. the theory of critical exponents. Typical text: C. Quigg, Gauge Theories of Strong, Weak, and Electromagnetic Interactions. Prerequisites: PEP 754

PEP 751 **Elementary Particles**

This course is open to students who have taken PEP 754 or its equivalent. It is an introduction to the theory of elementary particles. It stresses symmetries of both the strong and weak interactions. It presents a detailed study of SU(3) and the quark model, as well as the Cabbibo theory of the weak interactions. Typical text: F. Close, An Introduction to Quarks and Partons. Prerequisites: PEP 754

PEP 754 Advanced Quantum Mechanics

This course is an introduction to relativistic quantum mechanics and quantum field theory. Relativistic wave equations, including the Klein-Gordon equation and the Dirac equation. Commutation relation and canonical quantization of free fields. Spin and statistics of Bose and Fermi fields. Interacting quantum fields: interaction representation and S-matrix perturbation theory, Feynman diagrams, and renormalization theory with applications to quantum electrodynamics. Typical texts: Advanced Quantum Mechanics by J. J. Sakurai and Quantum Field Theory by F. Mandl and G. Shaw. Prerequisites: PEP 653

PEP 764 Advanced Quantum Mechanics

Second quantization of Bose and Fermi fields; interaction and Heisenberg pictures; S-matrix theory; quantum electrodynamics; diagrammatic techniques. Fall semester, by request. Typical texts: Mandl, Introduction to Quantum Field Theory; Sakurai, Advanced Quantum Mechanics.

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PEP 777 Methods of Quantum Control

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Since its emergence over 75 years ago, quantum mechanics brings each generation new challenging investigations and discoveries of quantum phenomena. In this course we introduce the results of research on quantum properties of light and matter that afford the possibility of unprecedented control over dynamics of atoms and molecules. The course Methods of Quantum Control is developed for students interested in understanding of the light-matter interactions and learning about advanced methods of control of ultrafast dynamics in atomic and molecular systems using femtosecond laser pulses that allow one to achieve a desired quantum yield. Topics include: Photoexcitation of a molecule with a pulse of light. Photodissociation. Energy-resolved quantities. Weak-field coherent control. Photodissociation from a Superposition State. One- vs. Three-Photon Interference. Pump-dump control, Tannor-Rice scheme. Wave packet motion on a potential energy surface. Pump-dump excitation with many levels. Silberberg's model using the phase step. Applications for selective excitation. Strong-field control. Femtosecond pulses. Time-dependent problems. Two-level systems. Rotating-wave approximation. State-interaction representation. Field-interaction representation. Dressed-state analysis. Rabi Oscillations. Strong-field control by pulse area, pi-pulses. Stimulated Raman Spectroscopy. Maxwell-Bloch equations. Control by femtosecond pulse amplitude modulation. Strong-field control using chirped pulses. Characteristics of chirped laser pulses. Adiabatic dressed states. Adiabatic passage. Dark states, Stimulated Raman adiabatic passage. Non-impulsive Raman scattering. Chirped pulse adiabatic passage control. Optimal Control theory. Adaptive learning technique. Applications: selective excitation of vibrational modes in molecular gas CO2 and liquid methanol. Coherent control in equilibrated condensed phases. Density matrix representation. Liouville von Neumann equations with relaxation terms in the field-interaction representation. Dressed states in the density matrix representation in the presence of dephasing. Prerequisites: PEP 527, PEP 554

PEP 800 Special Topics in Physics (MS) (3 - 0 - 0)

Topics include any one of the following: magnetohydrodynamics, quantum mechanics, general relativity, many-body problem, nuclear physics, quantum field theory, low temperature physics, diffraction theory, and particle physics. Limit of six credits for the master's degree.

PEP 801 One to six credits	Special Topics in Physics (PhD) . Limit of six credits for the degree of Doctor of Philosophy.	(1-0-1)
PEP 810 A participating se	Special Topics in Physics and Engineering Physics eminar on topics of current interest and importance in Physics and Engineering Physics.	(3-0-3)
PEP 900 For the degree of	Thesis in Physics (MS) Master of Science. Five to ten credits with departmental approval.	(0-0-0)
PEP 901 For the degree of	Thesis in Engineering Physics Master of Engineering. Five to ten credits with departmental approval.	(0-0-0)

PEP 960 Research in Physics (PhD)

Original experimental or theoretical research undertaken under the guidance of the faculty of the department which may serve as the basis for the dissertation required for the degree of Doctor of Philosophy. Hours and credits to be arranged. This course is open to students who have passed the doctoral qualifying examination; a student who has already taken the required doctoral courses may register for this in the term in which s/he intends to take the qualifying examination.