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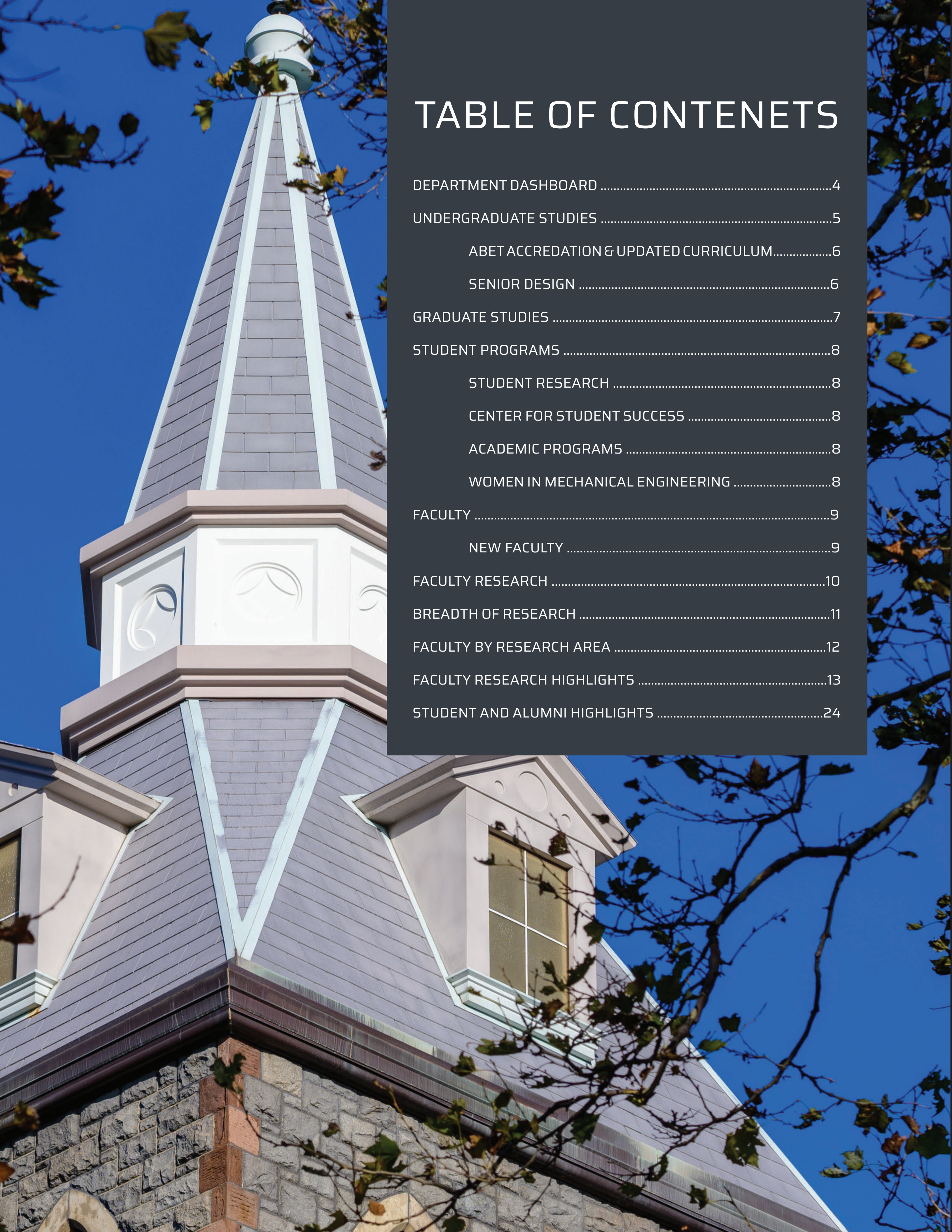
STEVENS
INSTITUTE OF TECHNOLOGY
1870

DEPARTMENT OF
MECHANICAL ENGINEERING

2021-2022
ANNUAL REPORT



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MESSAGE FROM THE CHAIR

IN 1871, STEVENS SELECTED THE FIRST PROFESSOR OF MECHANICAL ENGINEERING TO BE ROBERT THURSTON WHO CREATED THE AMERICAN SOCIETY OF MECHANICAL ENGINEERRS

The past year has been a critical time for the Stevens Institute of Technology Department of Mechanical Engineering as we've defined our strategic initiatives for the next five years. In 2021-2022, the ME Department as part of the strategic planning process plotted its path forward to pursue new heights of success. This process was all-inclusive with input from department members. The results of our strategic planning process serve to guide our collective efforts, channel our energy, and accelerate our desire to achieve excellence in all we do. The 2022-2027 Strategic Plan is available on the Stevens ME Department website for public access.

The ME community is composed of faculty, students, and staff whose tireless pursuit of excellence have made possible the achievements reported here. The accompanying 2021-2022 Annual Report summarizes the current state of the department focusing on the exceptional Department's progress and achievements over the past year.

Over the course of the last year, the ME Department has enjoyed impressive research funding success and increased student enrollment. The department is poised to continue its upward trajectory in the coming years. Buoyed by a collaborative and collegial culture, and the hiring of outstanding new faculty, the ME Department has accelerated its reputation and external standings increasing in rank by 14 places according to the 2022 US News & World Report.

Faculty research efforts are broad, interdisciplinary, and applicable to current challenges. We support impactful research and development with focus in robotics and autonomous systems, micro/nano technology, product design and manufacturing, composite materials, biomechanical engineering, additive manufacturing, wearable rehabilitation devices, hypersonic flows, computational fluid mechanics, and energy and sustainability. This past year, our faculty continued to be recognized by prestigious institutions and societies for their contributions to research, education, and service. This included the NSF CAREER Award, NSF/FSD SIR Grant, NASA Phase I SBIR Grant, ASME Fellow and National Academy of Inventors Fellow among other recognitions. These awards speak to the quality of both our faculty and research.

The global coronavirus pandemic has greatly impacted all members of the Stevens community. During the 2021-2022 school year, the Department of Mechanical Engineering worked to ensure continued growth and opportunities for students. It is wonderful to see students returning to experimental learning and in person classes to get the most out of their educational experiences.

Sincerely,

Souran Manoochehri

Souran Manoochehri
Professor and Department Chair

DEPARTMENT DASHBOARD

37 FULL TIME FACULTY

ME DEPARTMENT CLIMBS **14** PLACES IN NATION, ACCORDING TO LATEST US NEWS & WORLD REPORT

ASSISTANT PROFESSOR ANNIE ZHANG RECEIVES **NSF CAREER** AWARD

$5,189,025 IN FACULTY RESEARCH AWARDS

$3,442,901 IN FACULTY RESEARCH EXPENDITURE

13.6 MILLION IN ACTIVE FACULTY RESEARCH AWARDS

627 UNDERGRADUATE, **217** MASTER AND **70** Ph.D. ENROLLMENTS

159 UNDERGRADUATE DEGREES GRANTED IN 2022

75 GRADUATE DEGREES GRANTED IN 2022

$70,200 AVERAGE STARTING SALARY FOR ME UNDERGRADUATES

100% OF ME UNDERGRADUATES SECURED JOBS OR GRADUATE SCHOOL IN 2022

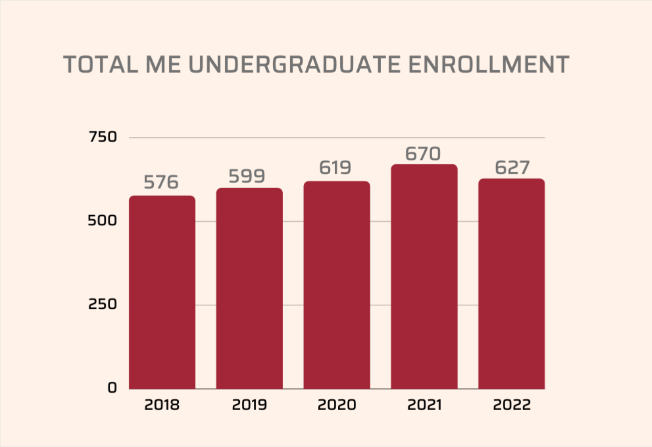
CENTER FOR NEUROMECHANICS: THE FIRST OF ITS KIND IN THE NATION

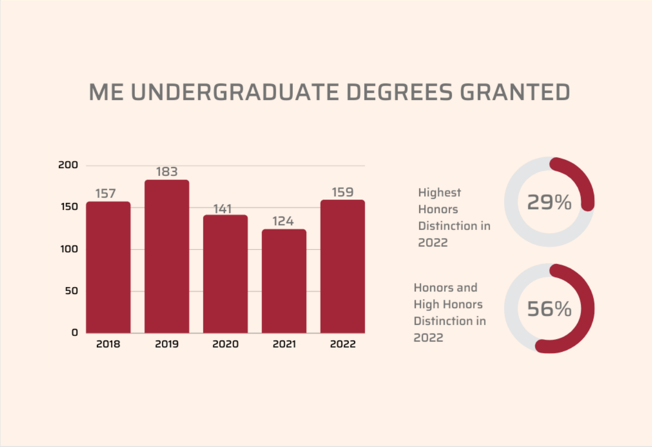
UNDERGRADUATE STUDIES

The Bachelor of Engineering in Mechanical Engineering degree program at Stevens provides a balanced learning experience that combines fundamental principles with hands-on practice. Our rigorous curriculum provides students with a solid knowledge of the fundamental and theoretical principles within traditional and emerging areas in mechanical engineering combined with a strong hands-on experience through laboratories, design projects, and machine shop activities. Hands-on learning is an essential component of the ME undergraduate curriculum which gets ME students well prepared for the real world.

Reflecting on the diversity of subject matter found in the present day practice of mechanical engineering, the Mechanical Engineering program has consistently offered undergraduates a multitude of opportunities for study and research to create the whole engineer.

The 2021-2022 school year had 103 new enrollments for a total of 627 ME undergraduates. The Department of Mechanical Engineering granted 159 undergraduate degrees to the class of 2022 with 46 students graduating with highest honors, 34 with high honors and 55 with honors.

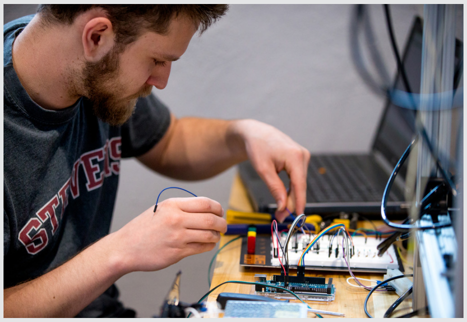




ABET ACCREDITATION AND UPDATED CURRICULUM

A recent highlight of our undergraduate mechanical engineering program is the successful ABET review during spring/summer 2022. The Accreditation Board for Engineering and Technology (ABET) assures that a college or university program meets the quality standards of the profession for which that program prepares graduates. The successful review verifies Stevens' Mechanical Engineering educational experience meets the global standard for technical education and enhances student employment opportunities.

Guided by the recently developed ME 5-year strategic plan, with the aim towards modernization of the ME undergraduate program curriculum while providing more flexibility, faculty review along with student feedback collected over the past few years as part of continuous program assessment, substantial revisions to the program curriculum have been made.



STEVENS INSTITUTE OF TECHNOLOGY WAS FOUNDED IN 1870 OFFERING ONE DEGREE: MECHANICAL ENGINEERING

SENIOR DESIGN

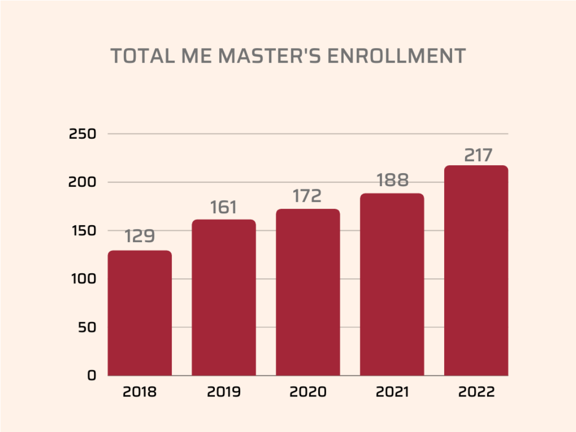
Senior Design is a yearlong capstone course within the Mechanical Engineering curriculum and is an element of distinction within the department. This course is taken during senior year and extends over both semesters. Generally, the senior class is broken into more than thirty multi-disciplinary teams with projects spanning areas such as biomedical, defense, robotics, and energy. Some projects are competition based. Traditionally, the Mechanical Engineering teams have found success at winning the best senior design project as well as the elevator pitch competition at the Stevens Innovation Expo.

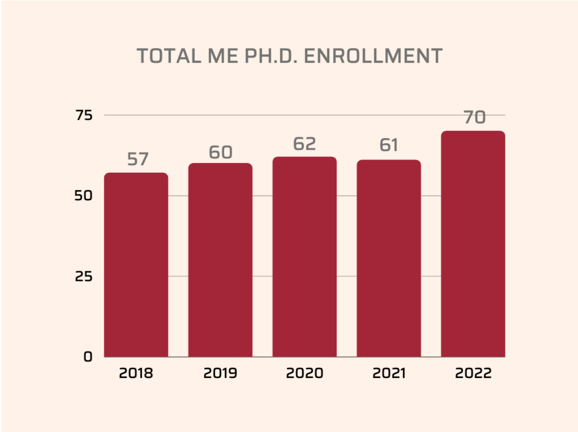
The 2022 Senior Design Award for Mechanical Engineering was given to Firas Asfar, Meghan Haggerty, Art Jani, Matthew Kirby, Maria Manoussakis, and Daniel Tierney for their project the Autonomous Aerial Manipulator 2.0.

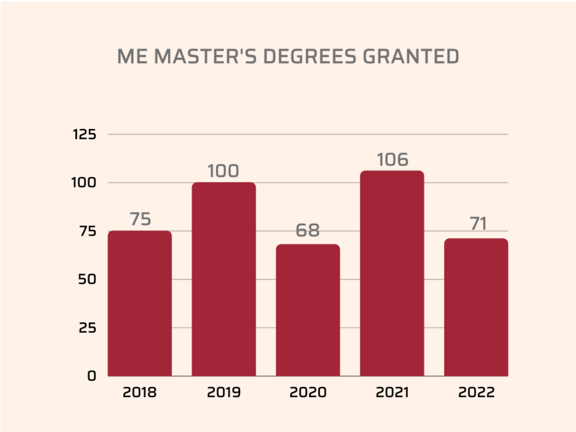
GRADUATE STUDIES

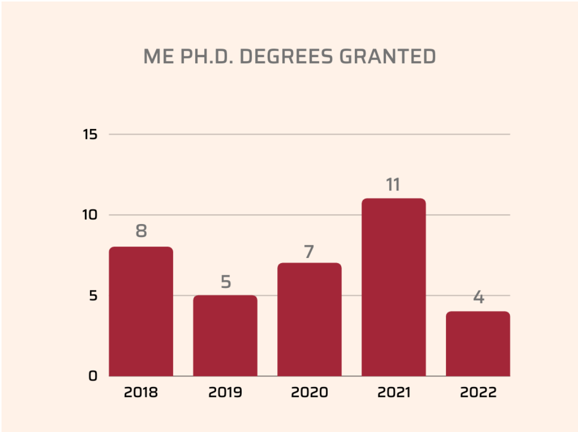
The Department of Mechanical Engineering offers five regular master's degree programs, four joint master's programs, and two special programs. Graduate students can pursue a Master of Engineering in Mechanical Engineering, Pharmaceutical Manufacturing Engineering, or Robotics. Graduate students can also choose to pursue a Ph.D. through the Mechanical Engineering Doctoral Program. The department offers fourteen ME Graduate Certicates for students interested in improving their skills or considering new career paths within the industry. The following outlines the Department's highlights, initiatives, and achievements in graduate studies in 2021-2022. The Department of Mechanical Engineering granted 71 Master's Degrees and 4 Ph.D. degrees for a total of 75 Graduate Degrees in 2022. Master's admission at Stevens reached new heights during 2021-2022.

In the Department of Mechanical Engineering, ME enrollment has been steadily Increasing showing a 66% increase in enrollment over the past 6 years. Ph.D. enrollment has increased 15% in 2021-2022. This marks a record high Ph.D. enrollment for the Department of Mechanical Engineering.









STUDENT PROGRAMS

STUDENT RESEARCH

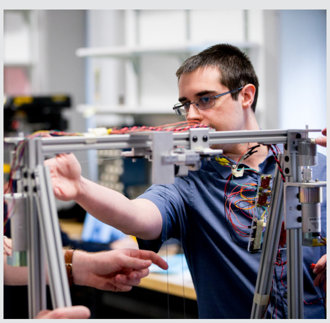
The Department of Mechanical Engineering offers multiple research opportunities for both undergraduate and graduate students. The Department of Mechanical Engineering and the Center for Neuromechanics both offered individual eight- and ten-week summer research programs that provided an invaluable opportunity for undergraduate and masters students to get hands-on experience in mechanical engineering and neuromechanic related research labs.

The 2022 Mechanical Engineering Summer Undergraduate Research Program (SURP) received 72 applications and accepted 25 students. The Center for Neuromechanics offered its first summer program and received 64 applications from multiple departments in the Schaefer School of Engineering and Science. 13 Center for Neuromechanics Fellows were selected and worked in labs across SES that focus on brain health research.

100% OF UNDERGRADUATES SECURED A JOB OR GRADUATE SCHOOL ADMISSION IN 2022

CENTER FOR STUDENT SUCCESS

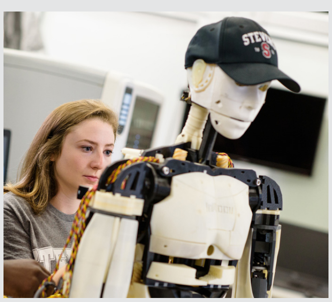
Supporting the overall Stevens strategic goal of excellence, the purpose of Stevens' mechanical engineering student advising is to provide a holistic student resource center committed to promoting the success and encouraging the retention of all students in the mechanical engineering undergraduate program.



ACADEMIC PROGRAMS

The Department of Mechanical Engineering offers 10 academic programs including:

- Bachelor's of Engineering
- 4 Joint Master's Programs
- Master's of Engineering
- Master's of Science
- Master's of Robotics
- Master's of Pharmaceutical Engineering
- Doctorate of Engineering



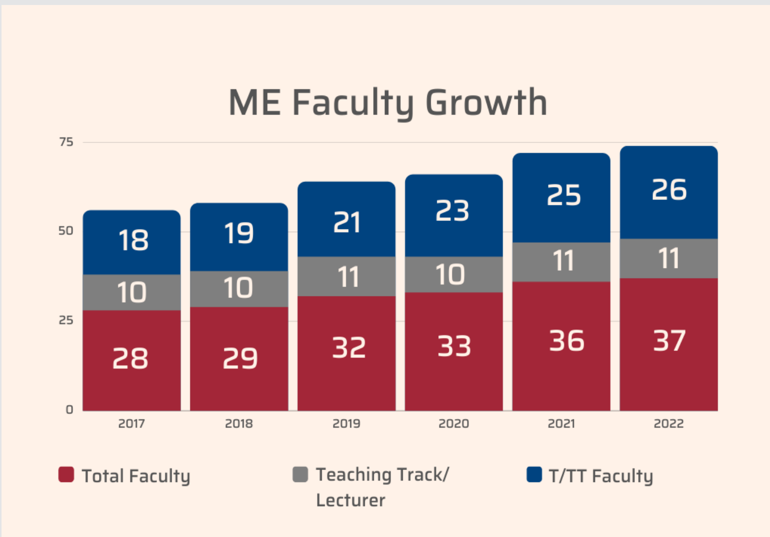
WOMEN IN MECHANICAL ENGINEERING

Professor Maxine Fontaine established the Women in Mechanical Engineering group to provide a community for women students and faculty to meet and connect. The fall 2021 series was graciously hosted by Prof Gizem Acar while Prof Fontaine was on leave. The spring 2022 series included mini-workshops and discussions on various topics including fostering inclusive environments, effective teamwork, staying productive, and managing stress.

FACULTY

The Department's faculty constitutes a body of world-class researchers and educators who practice diverse activities across the engineering spectrum. Dedicated to supporting hands-on learning and research, the faculty provides each student with invaluable experiential knowledge and a myriad of opportunities and resources to further their educational and professional goals. The department's eorts have been globally recognized for world-class faculty, leading-edge research facilities, and a premier location proximate to New York City. The faculty pride themselves on their student-centric approach to guide students toward being leaders of tomorrow.

The total number of Mechanical Engineering Faculty has increased by 28% over the past ve years. The department is composed of 37 current faculty members, 26 are Tenure or Tenure Track (T/TT), and 11 are Teaching Track.



THE TOTAL NUMBER OF ME FACULTY HAS INCREASED 28% IN THE PAST 5 YEARS

NEW FACULTY

Zahra Pournorouz

Assistant Professor

Ph.D.: The University of Texas at Arlington

Specialization: Thermophysical Properties of Synthetic Oil Nanofluids

Chaitanya Krishna Vallabh

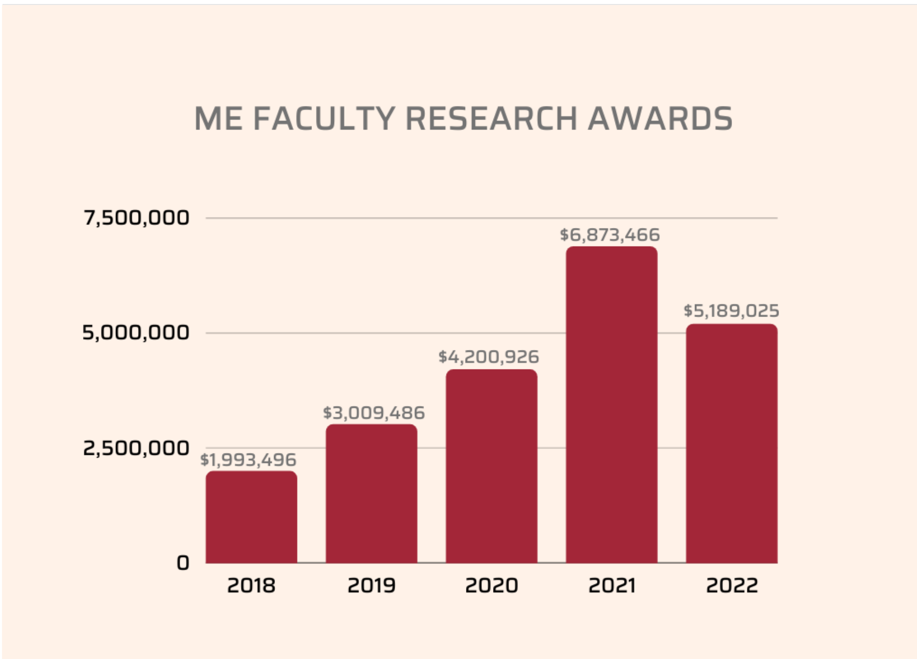
Lecturer

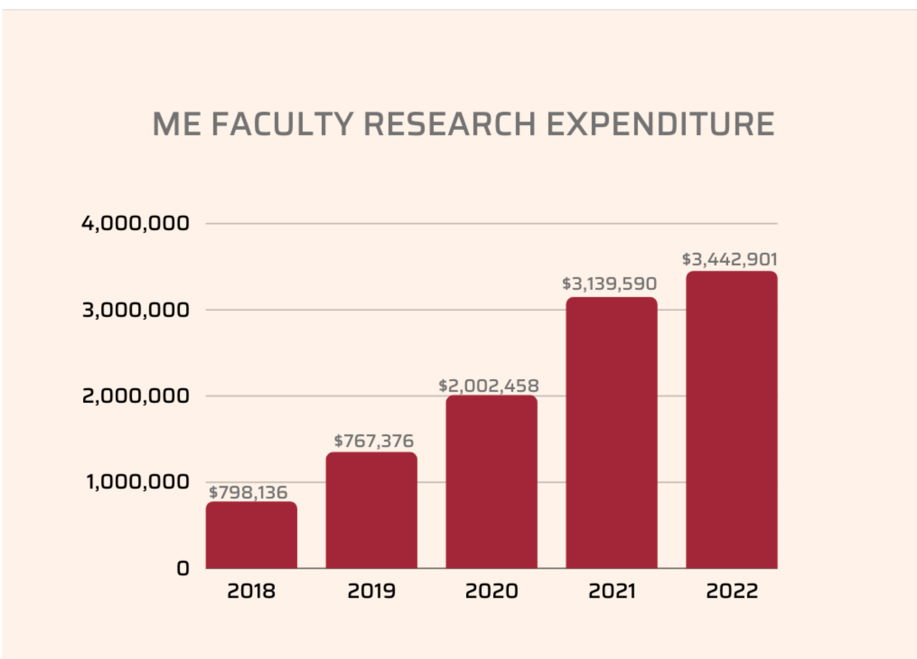
Ph.D.: Clarkson University

Specialization: Dynamics and Vibrations

FACULTY RESEARCH

The Department of Mechanical Engineering is committed to the pursuit of transformative, multidisciplinary research. Our renowned and dedicated faculty members create a deeply collaborative research environment to study problems ranging from hypersonic reacting ow to mobile robotics navigation to soft matter biomechanics to new design and fabrication of 2D materials. ME research has thrived as measured by signicant increases in awards and expenditures recently. The fundng in the department comes from diverse external sources in government and industry with the active awards close to $21 million as of 2022.





BREADTH OF RESEARCH

During this reporting year, the number of multi-PI grants has grown resulting in signicant funding and research laboratory expansions. The funding has helped to create new research initiatives and increased scholarly outputs. It is very important to recognize the diversity in active awards. The total awards granted in 2021-2022 is just over $13.5 million. This research growth has been supported with prestigious external recognitions resulting in seven NSF CAREERs, three ONR YIP, and one AFOSR YIP awards given to our ME faculty despite our small department size.

BREADTH OF RESEARCH

SPONSOR	AMOUNT	PERCENT
Consolidated Edison, Inc.	$ 250,000.00	1.83%
Guide Consortium	$ 100,000.00	0.73%
Muscular Dystrophy Association	$ 199,999.99	1.46%
Nanohmics, Inc.	$ 47,835.00	0.35%
National Aeronautics and Space Administration	$ 513,681.00	3.76%
National Institutes of Health	$ 424,050.00	3.10%
National Science Foundation	$ 5,520,594.00	40.41%
SEO YEONG Co., Ltd.	$ 81,862.00	0.60%
US Department of Agriculture	$ 375,000.00	2.74%
US Department of Defense	$6,148,768.14	45.01%
Army (ACC) - Combat Capabilities Development Command (CCDC)	$ 1,455,336.40	10.65%
Army Medical Research Acquisition Activity	$ 1,497,728.00	10.96%
Office of Naval Research	$ 2,299,594.42	16.83%
Office of the Deputy Assistant Secretary of Defense for Systems Engineering	$ 896,109.32	6.56%
TOTAL	**$13,661,790.13**	

FACULTY BY RESEARCH AREA

The Department of Mechanical Engineering is committed to the pursuit of transformative, multidsciplinary research. Our renowned and dedicated faculty members create a deeply collaborative research enviornment to study problmes ranging from hypersonic reacting flow to mobile robotics navigation to soft matter biomechanics to new design and fabrication of 2D materials.

ROBOTICS AND AUTONOMOUS SYSTEMS

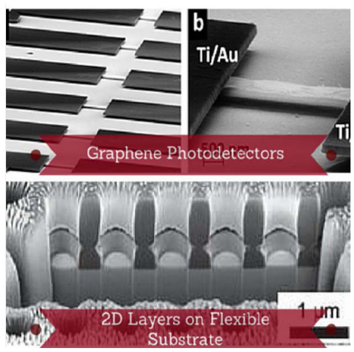
- Brendan Englot
- Kishore Pochiraju
- Hamid Jafarnejad Sani
- Long Wang
- Damiano Zanotto

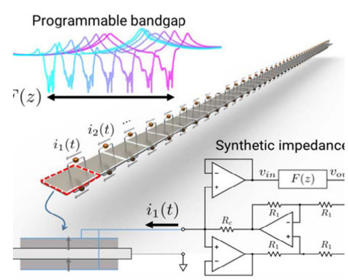
MICRO/NANO TECHNOLOGY

- Chang-Hwan Choi
- Frank Fisher
- Shima Hajimirza
- Yong Shi
- Eui-Hyeok Yang
- Fan Yang
- Annie Zhang

ENERGY, SUSTAINABILITY AND VIBRATIONS

- Gizem Acar
- Chang-Hwan Choi
- Hamid Hadim
- Nicholaus Parziale
- Chirstophe Pierre
- Jason Rabinovitch
- Christopher Sugino





BIOMECHANICS AND HUMAN HEALTH

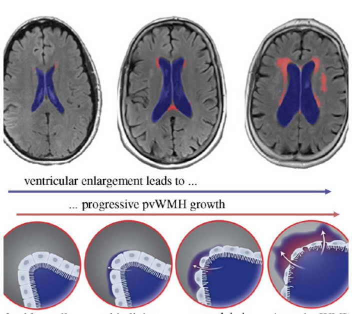
- Robert Chang
- Long Wang
- Johannes Weickenmeier
- Damiano Zanotto

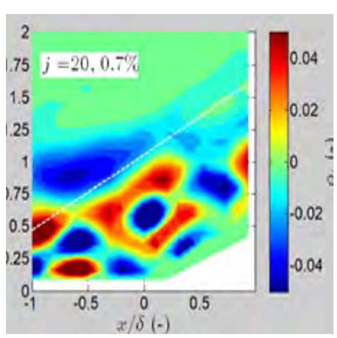
THERMAL-FLUIDS ENGINEERING

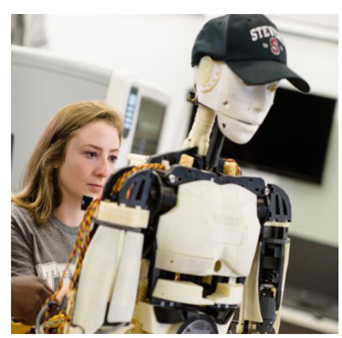
- Hamid Hadim
- Shima Hajimirza
- Nicholaus Parziale
- Jason Rabinovitch
- Fan Yang

DESIGN AND MANUFACTURING

- Robert Chang
- Chang-Hwan Choi
- Sven Esche
- Souran Manoochehri
- Kishore Pochiraju







FACULTY RESEARCH HIGHLIGHTS

INVESTIGATION OF THERMAL TRANSPORT IN MOIRÉ PATTERN STRUCTURED MATERIALS TO PUSH THE EXTREMES OF THERMAL MODULATION

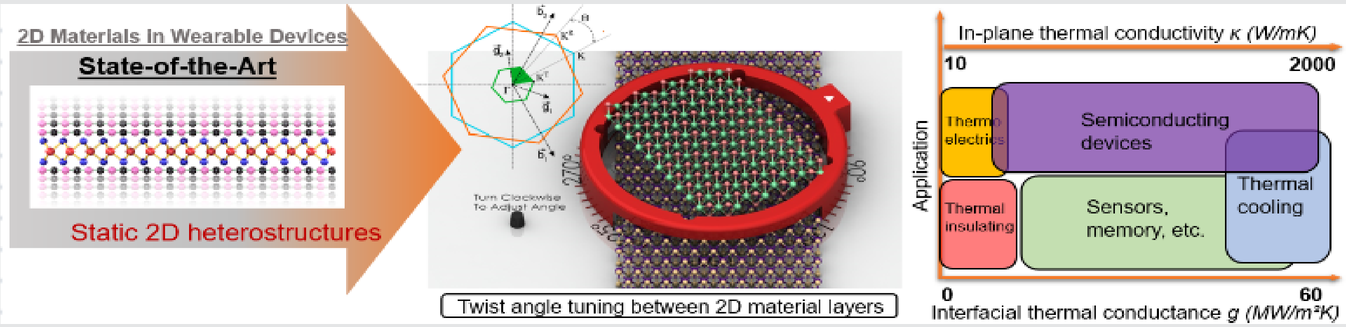
Professor Annie Xian Zhang investigates how "twisting" two sheets of graphene can alter the thermal transport properties of two-dimensional (2D) materials and push the limits of thermal modulation.

That "twisting" relies on Moiré patterns—a geometrical design that shows up when superimposing one periodic hexagonal pattern on top of another and twist the top layer to offset it. The relative angle of that twist changes the pattern, and when the two sheets are actually atom-thick 2D materials such as graphene, the twist angle influences the physical properties of the 2D materials due to the change of the interlayer lattice interactions.

Prof. Zhang's group uses a Raman Spectroscopy System to help determine the thickness of 2D graphene flakes and to characterize the thermal transport properties of 2D materials and their Moiré patterns. A robotic arm will be used to precisely and continuously rotate one layer of graphene on top of another. To investigate how the properties of the 2D material change at a continuously changed twist angle, Prof. Zhang works on using a small robotic arm to precisely rotate one layer of graphene on top of another to create a spectrum of Moiré patterns with different thermal properties.

The knowledge learned will potentially push the thermal modulation limits in skin-like wearable devices made of atomically thin 2D materials and enable modern devices from beyond-Si electronics and sensors to superconducting thermal switches.

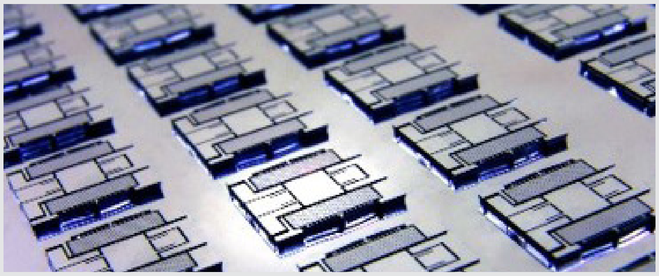
This project will tightly integrate research, education, and outreach. Prof. Zhang will work with a broad range of students, from K-12 to graduate students, with students with developmental delays and those underrepresented in STEM. This project will generate extraordinary materials and inspire students through educational activities.

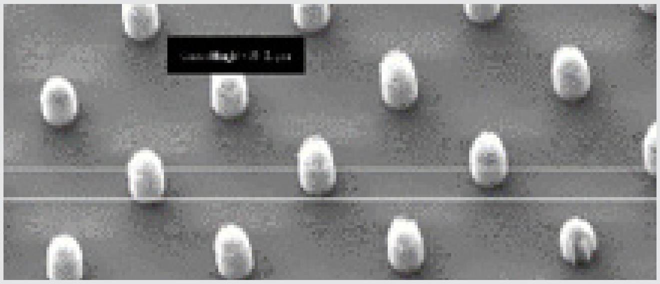


Current state-of-the art research in 2D heterostructures' thermal properties in which the structure is static (left), current proposal to tune twist angle between layers (middle) and its various engineering applications (right).

2D MATERIALS FOR SPINTRONICS AND QUANTUM SENSING

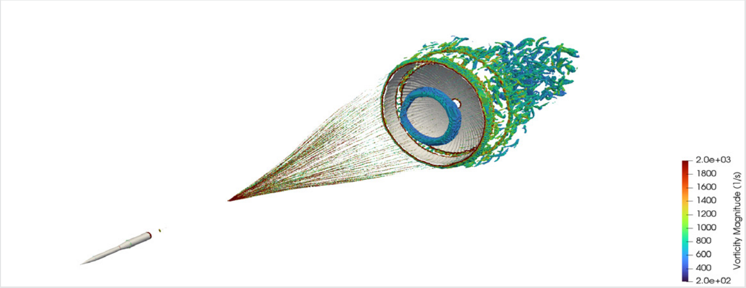
Professor EH Yang and his research group leads 2D materials research toward spintronics and quantum sensing. The research explores the synthesis, doping, and magnetism of two-dimensional (2D) transition metal dichalcogenides (TMDs) as well as their applications in spintronics and quantum sensing. 2D atomic crystals exhibiting magnetic properties provide an ideal platform for exploring new physical phenomena in the 2D limit. These 2D magnets are critical for our ongoing projects, including studying quantum effects in graphene interferometers, electron transport through magnetic tunnel junctions for 2D magnetic random-access memories, and spin-based photovoltaics and thermoelectrics, which can replace charge-based electronics and sensors with spin- and charge-based devices. These explorations on spintronics and quantum sensing in 2D limits represent a substantial shift in the ability to control and investigate micro-, nano- and subatomic phases for future electronics, sensing, healthcare and energy applications.



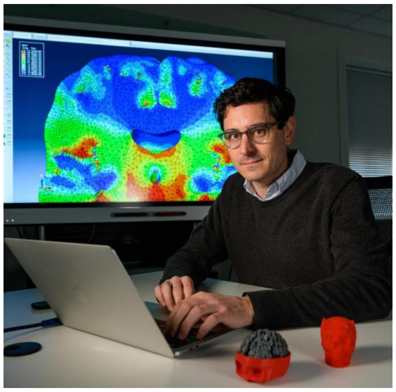


SPACE EXPLORATION

Professor Jason Rabinovitch's research primarily focuses on space exploration and fluid mechanics. In the past year, the group has continued his research investigating computational modeling of permeable textiles for Mars supersonic parachutes. The group now has several projects working on modeling shock/droplet interactions for advanced ehicle design, analyzing images taken of the surface of Mercury by the Messenger mission to identify potential safe landing sites for future Mercury missions, and modeling how the plume observed at the south pole of Enceladus (a moon of Saturn) erupts and investigating plume-surface interactions during the MSL and M2020 spacecraft landings on the surface of Mars. In May, the NASA Phase I SBIR proposal "Reconfigurable Plenoptic Objective for Snapshot Multimodal Flow Diagnostics" was selected for funding with Dr. Liska from Nanohmics as the PI, Prof. Rabinovitch is the academic PI, and Prof. Parziale, also in the ME department, is the academic Co-I. FInally, the group published numerous peer-reviewed publications this year and Prof. Rabinovitch gave a keynote lecture at the 32nd Interation Symposium on Rarefield Gas Dynamics (RGD32) in Seoul, South Korea over the summer.

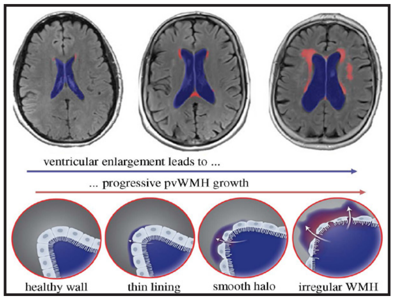


SIMULATING THE EFFECT OF AGIGNG ON THE BRAIN



Professor Johannes Weickenmeier and his research group have been developing computational multiphysics models to simulate the effect of aging on the brain. In recent work, they discovered that the mechanical loading of one of the brain's important functional barriers between fluid compartments and brain tissue undergoes significant stretching and gradually breaks down.

As a result, the barrier's ability to maintain a controlled exchange of fluid, proteins, nutrients, and waste products deteriorates and causes local inflammation. Over time, this process leads to progressive cognitive decline due to degenerating neurons. This work was selected for an Editor's Choice Award from the Engineering with Computers journal. As a next step, the Weickenmeier Lab is collaborating with clinicians at NYU to explore potential biomarkers to detect at-risk patients as early as possible.



ATTACK RESILIENT VISION GUIDED UNMANNED AERIAL VEHICLES

Professor Hamid Jafarnejad Sani and his research group at the Safe Autonomous Systems Lab perform cutting-edge research in the area of controls and robotics, cyber-physical security, and machine learning. Jafarnejad Sani and his research group aim to address resilient and secure control and monitoring of intelligent autonomous systems in uncertain and adversarial environments, conducting experiments using aerial drone platforms to validate their theoretical solutions. Autonomous systems such as unmanned aerial vehicles (UAVs), medical and industrial robots, and self-driving cars operate under uncertainties due to dynamic environments, human-robot interaction, system failures, and malicious cyber-attacks. Jafarnejad Sani's research aims to study and address such challenges by integrating the tools from robust and adaptive control with machine learning and cyber-physical security methods.

In 2022, Jafarnejad Sani's lab received $309,811 in funding from the National Science Foundation for the project "Collaborative Research: Towards Attack-Resilient Vision-Guided Unmanned Aerial Vehicles: An Observability Analysis Approach." Over the last year, the research results from the SAS Lab have been accepted for presentation at the 2021 IEEE Conference on Decision and Control in Austin, TX, the 2022 International Conference on Unmanned Aircraft Systems in Croatia, and the 2023 AIAA Guidance, Navigation, and Control Conference at SciTech Forum in National Harbor, MD. In addition, the group's paper received the best student presentation award at the 2022 STRATUS Conference in Syracuse, New York.

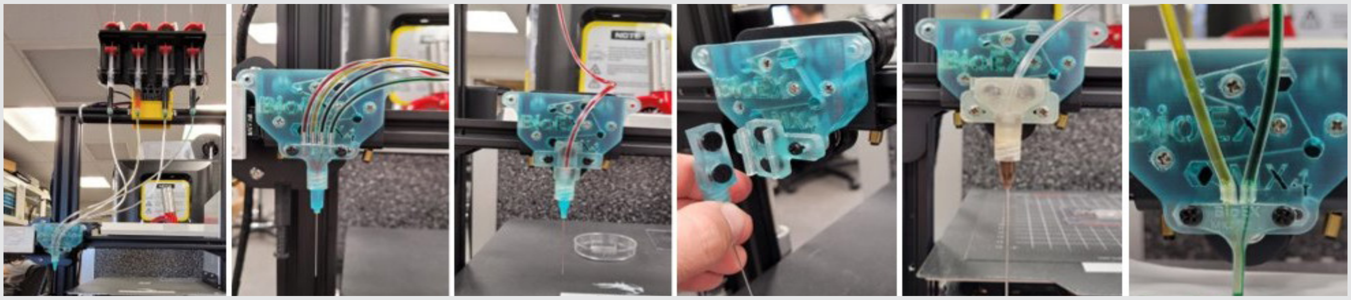
WANT TO 3D PRINT A FUNCTIONAL ORGAN? START BY THINKING SMALL.

Tissue and organ transplantation offer a crucial lifeline for the replacement and repair of diseased or damaged tissues and organs. The promise of 3D bioprinting presents is one possible solution to address the need for functional tissue replacements, but has been fraught with barri-ers, limiting the type of organs that can be printed.

Researchers at Stevens Institute of Technology are now pushing through these barriers by training their focus on innovating new additive manufacturing process capabilities to reproduce any tissue type. The work, led by Professor Robert Chang, could open up pathways for on-demand 3D printing with patient-specific geome-tries and material composition at scale, even in situ or direct printing on an open wound bed.

Advances in biomaterials in tandem with additive manufacturing science and engineering have yielded numerous technologies to create biomimetic analogs of the native extracellular matrix that structurally support all tissues. In order to reproduce tissue properties, the printed analogs must be endowed with appropriate microscale structural features.

Prof. Chang and his research team hope to change that by fasttracking a new 3D printing process that uses microfluidics — the precise manipulation of viscous biopolymer materials through tiny channels — to operate at a far smaller scale than previously attainable. Besides operating on a smaller scale, microfluidics also enables multiple bio-inks, each containing different cells and tissue precursors, to be used interchangeably within a single printed structure, in much the same way that a conventional printer combines colored inks into a single vivid image. That's important because while researchers have already created simple organs such as bladders by encouraging the tissue to grow on 3D-printed scaffolding, more complex multiscale and multicellular solid organs such as livers and kidneys require diverse cell types to be precisely combined.



ROBOTIC HANDS TECHNOLOGY FOR REMOTE FACTORY WORKPLACE

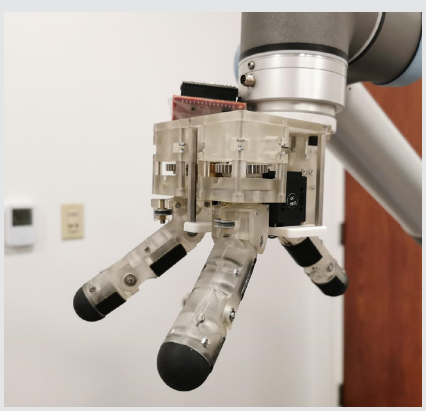
Because manual manufacturing jobs are so technology and location specific, the average person cannot simply network into operating an industrial drill press or screwdriver from their living room couch. Or can they? Professor Long Wang and his research team in the Advanced Manipulators Lab were awarded an NSF grant to extend the capabilities of the Industrial workforce.

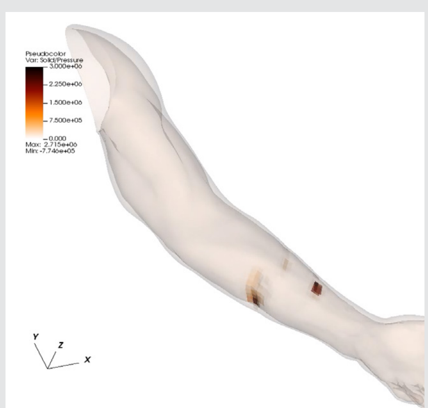
Thier project, “Tool-Grasping Compliance and Stability of Underactuated Hands in Model Mediated Telemanipulation,” will leverage AI to develop a complete, cost- effective solution for operating remotely controlled robotics hands with high levels of control, dexterity, and situational awareness to perform complex manual manufacturing tasks.

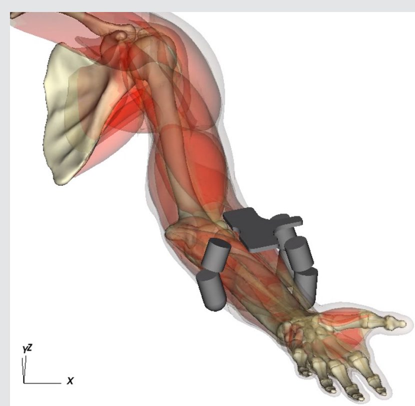
In addition to designing robotic hands that move, grasp and manipulate discrete tools with high force and motion control, stability, and dexterity, Wang will develop a model to train the robot to assist its remote operator with tasks and situations that humans tend to navigate by instinct. The model will also be trained using pre-existing data of the chosen task in context to mitigate communication latency delays that may occur between robot and controller. By attending to such details, Wang hopes to make it possible for human controllers offsite to react and respond to the factory environment as quickly and efficiently as if they were present onsite.

Although inspired by pandemic shutdowns of automobile assembly plants in particular, such technology would open possibilities to any industry that requires the presence and insight of human crews performing manipulation tasks in hazardous conditions, including environmental waste cleanup, space exploration and search and rescue efforts during natural disasters. The project holds the potential to reduce productivity loss and service interruptions that can result in long-term individual and global economic ramifications.

By combining AI-enhanced robotic technology with situational awareness intelligence, haptic feedback and model mediation, Wang aims to make it possible through his telemanipulation framework to devel-op a realistic system of robotic proxies that will allow manufacturing industry workers to be able to perform their jobs remotely just as easily as their office worker colleagues.







USING ARTIFICAL INTELLIGENCE TO PREDICT RADIATION

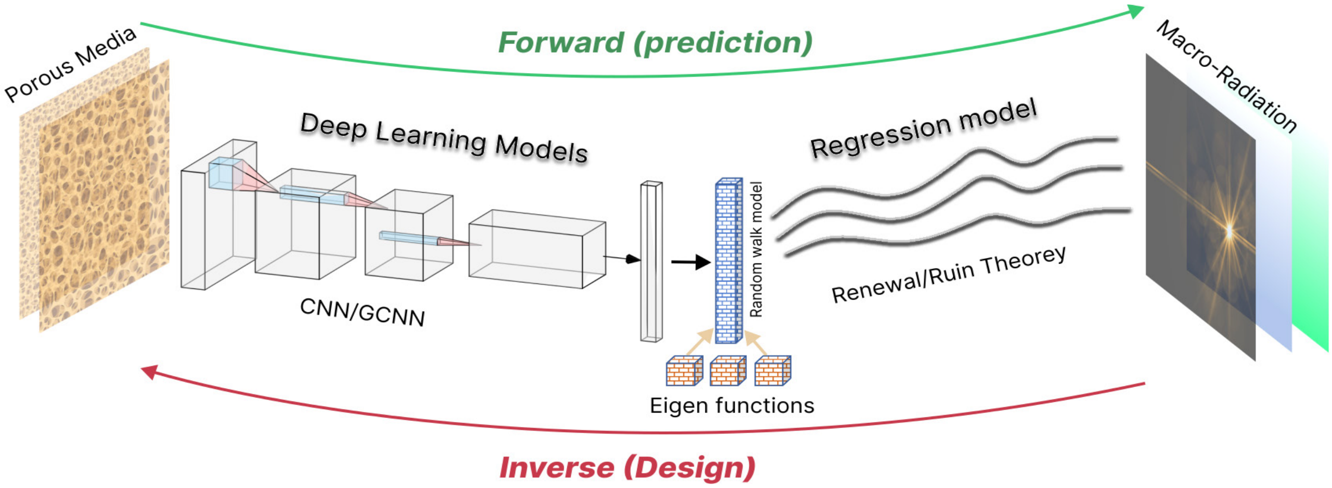
Professor Shima Hajimirza has received National Science Foundation (NSF) award for developing Artificial Intelligence models to predict radiation in very complex multiscale systems.

Conventional solutions for radiation modeling are very time consuming or even infeasible for the simulation of real-world scale configurations. Prof. Hajimirza uses machine learning techniques to learn the output of these lengthy calculations for small scale images of packed beds, and then generalize to larger scale configurations.

Using a combination of ML techniques such as artificial and convolutional neural networks, as well as domain-specific feature engineering, Hajimirza's team has demon strated that the proposed AI tools can improve estimation speeds by multiple orders of magnitude and deliver solutions that are reliable and scalable.

At present most of the developed tools are based on direct supervised learning. The researchers at Energy, Control and Optimization (ECO) Lab, where Prof. Hajimirza is a director, are investigating unsupervised training of deep learning, using techniques similar to Monte Carlo tree search in modern reinforcement learning. They are also combining deep learning modeling with modern statistical techniques such as renewal/risk theory to enhance generality and accuracy of the machine learning estimations.

This research can potentially impact many applications including nuclear reactors, selective laser sintering technology, solar absorbers, solar thermochemical reactors, biological tissues, thermal barriers for jet engines and space vehicles. This research concept can be generalized to predict the end-state of many probabilistic distributed systems representable by image-like or graph structures. The mature version of this technology can be used for the prediction of events in a far broader context such as wildland fire-spread modeling, cancer evolution and more.



INTELLIGENT AND AUTONOMOUS MOBILE ROBOTS ON LAND AND SEA

Professor Brendan Englot and his students in the Robust Field Autonomy Lab develop autonomous navigation solutions for mobile robots tasked with operating in complex environments. Their research encompasses two classes of platforms, lidar-equipped unmanned ground vehicles (UGVs) and sonar-equipped underwater robots.

Their recent work with UGVs has focused on several topics motivated by real-world applications, including: (1) the autonomous inspection of electric distribution substations using a custom built mobile manipulation platform, in which a compact UGV carries a six-degree-of-freedom manipulator arm to collect diagnostic measurements from breaker panels (sponsored by Con Edison), (2) multi-robot localization and navigation in GPS-denied environments, including data-ecient methodologies for UGVs to exchange lidar observations, and learning-enabled methodologies for robots to make intelligent navigation decisions under uncertainty (sponsored by the U.S. Army), and (3) applying the cutting-edge techniques of distributional reinforcement learning to autonomous vehicle routing problems, permitting UGVs to make intelligent decisions to manage risk and uncertainty on the road (sponsored by the Oce of Naval Research).

The lab's recent work with underwater robots is also motivated by strategic priorities of the federal government in this problem space, and currently addresses topics which include: (1) distributed multi-robot localization, navigation, and communication that is compatible with the severe bandwidth limitations of acoustic modems, which are essential for underwater wireless communication at long distances (supported by the Oce of Naval Research), and (2) developing a novel resident autonomous system that is capable of inspecting, cleaning and maintaining an oshore sh farm (supported by the National Institute of Food and Agriculture).

The lab's research on both topics has motivated the development of a highly customized underwater robot platform, based on a product called the BlueROV, that is equipped with high performance acoustic and inertial navigation sensors, and a stereo pair of multi-beam wide aperture imaging sonars. The fusion of these sensors permits Prof. Englot's BlueROV to perform high-resolution underwater 3D mapping to support its autonomous navigation.

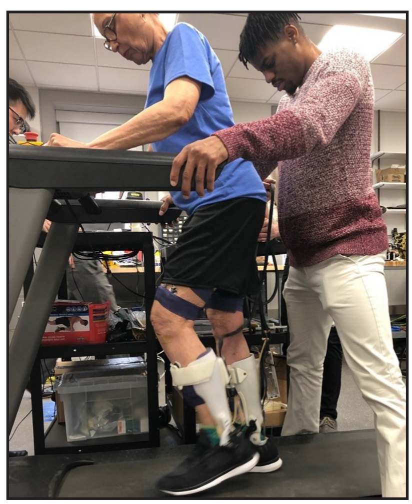
WEARABLE ROBOTICS FOR PHYSICAL REHABILITATION

The Wearable Robotic Systems Lab, led by Professor Damiano Zanotto, aims at establishing new wearable technologies for physical rehabilitation and human motion analysis and monitoring in natural conditions. In the area of wearable robotics, the team has been developing learning-based controllers for robot assisted gait training, which continuously shape an exoskeleton's control policy based on models of the wearer's motor adaptation learned online.

This research, which has been supported by NSF and DoD and involves personnel from Stevens and Kessler Institute for Rehabilitation, ultimately will pave the way for more intuitive and personalized pHRI strategies for powered orthoses and exoskeletons to promote therapeutic outcomes in brain-injured populations, by encouraging an individual's active participation in exercise therapy.

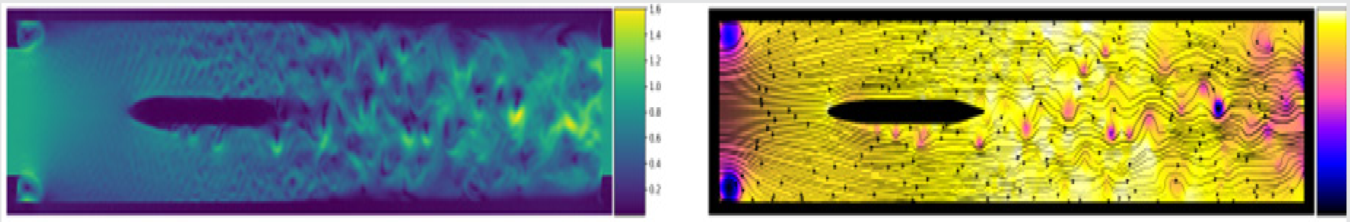
In the area of wearable sensing technologies, Zanotto's team has developed new machine learning inference models that can substantially improve validity and reliability of wearable sensing devices for gait analysis, without the need for subject-specific labelled data.

The goal of this research, which has been supported by grants from NSF and the Muscular Dystrophy Association, is to enable accurate gait monitoring in real-life environments over extended time periods, to detect subtle but clinically meaningful changes in the wearer's motor outputs that may unveil an underlying condition or reflect a patient's responsiveness to treatments. In collaboration with clinical researchers at Columbia University, Stanford Medicine, and Harvard Medical School, the team has been validating this technology on individuals with muscular dystrophies, older adults with gait/balance disorders, and children with a neurodevelopmental disorder.

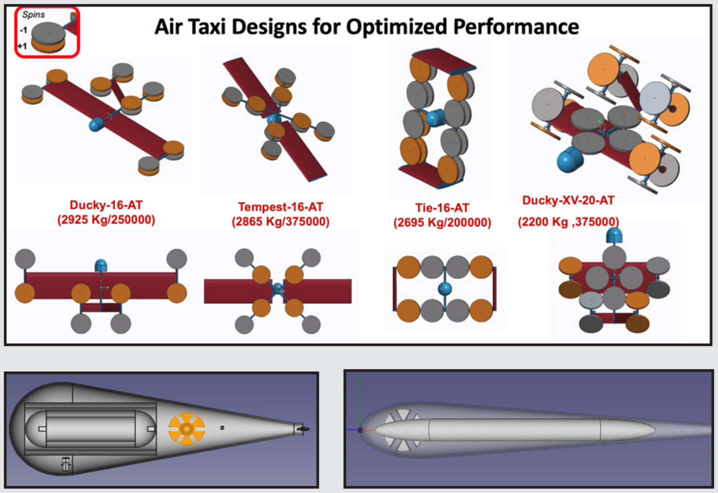


USING ARTIFICAL INTELLIGENCE IN DESIGN AND MANUFACTURING

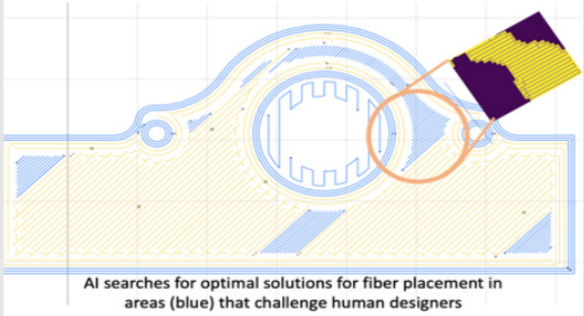
Can AI help us design and manufacture economical, high-performance aerospace and underwater systems that support environmentally friendly circularity? Professor Kishore Pochiraju's research group uses AI/ML techniques with high-resolution computational modeling to architect and optimize the next generation of aerospace, underwater, and bio-mechanical systems. Their research group's innovative methods and tools disrupt traditional designer-in-the-loop system development pipelines. Design of large-scale or complex systems is a multi-domain and high-dimensional problem that requires intensive involvement of a human expert in the loop. This research leads to AI/ML algorithms assisting the human designer in finding novel designs among millions of options in three specific ways. The AI learns domain-specific knowledge with low data through physics-informed neural networks, identifies networks of coupled but low-dimensional optimization problems that can be solved, and reduces computational time and effort through multi-fidelity surrogates. Prof. Pochiraju group's research extends to digital and physical domains and composes an integrated cyber-physical system. Their research is funded through grants from DARPA, Industry, and the US Department of Defense.



AI as a Surrogate: Flow fields around a UUV simulated by a Physics Informed Neural Network (PINN) at a fraction of the computational time of Computational Fluid Dynamics (CFD) simulations. The PINN was trained to predict drag coefficients for any arbitrary shape. Unlike other methods, geometry changes do not require PINN retraining.



AI for System Composition: The AI-Mediated Design process generated the architectures of a multi-rotor air taxi and a long-distance Unmanned Underwater vehicle. The AI-generated novel asymmetric spins for the propeller stacks. AI/ML techniques assigned the propeller spin directions for maximum efficiency. The solutions were counterintuitive to a human designer.

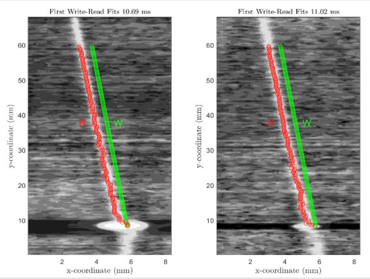


Generative AI helps continuous carbon fiber layout in 3D printing complex objects. AI/ML assists human designers by finding optimal solutions in challenging areas.

HYPERSONIC PROJECTILES

Professor Nicholaus Parziale and his research group study the interests in the thermal/fluid area with applications in defense and energy/sustainability. In his recent project Prof. Parziale suspended liquid drops in the flight path of hypersonic projectiles fired at the Naval Surface Warfare Center's (NSWC) high-speed railgun facility. Drops of diameter 1-3 mm were suspended in place using acoustic levitators and backlit with a pulsed laser synchronized to a high-speed Kirana camera. The interaction of the drops with the incoming projectile and its shockwave was imaged at 2-4 million frames per second (FPS). Front-lit imaging at a slower speed was conducted using a Phantom TMX 7510 camera at 300,000 FPS. The gun's ownflash was the light source for front-lit images.

The drops were observed to flatten, deform into a teardrop shape, and develop their own shock structures which interacted with the shock in front of the projectile. Upon colliding with the projectile, liquid jetting orthogonal to the direction of projectile motion was observed. Smaller drops were seen to translate away from the projectile as a result of high-speed post-shock airflow. The size of droplet flow features and the velocity of liquid jetting was quantified and compared to previously documented phenomena in literature. Tagging velocimetry is demonstrated in the Stevens Shock Tunnel to obtain velocity profiles in high-speed flows over a hollow-cylinder-flare test article. Acetone was used as the tagged tracer in shock-tunnel-generated high-speed air flow excited by the fourth harmonic of the burst-mode Nd:Yag laser (266~nm) at 50~kHz. Freestream velocity is recorded and matches predicted values with good agreement. Additionally, turbulent boundary layer velocity profiles are reported.



ENGINEERING EDUCATION AND OUTREACH PROGRAMS

Professor Maxine Fontaine is an active member of the American Society for Engineering Education (ASEE). Prof. Fontaine's current research interests include spatial visualization skills and adaptive expertise in engineering education. Prof. Fontaine served as the Chair-Elect of the Middle Atlantic Section of ASEE. She also serves as the ASEE campus representative for Stevens.

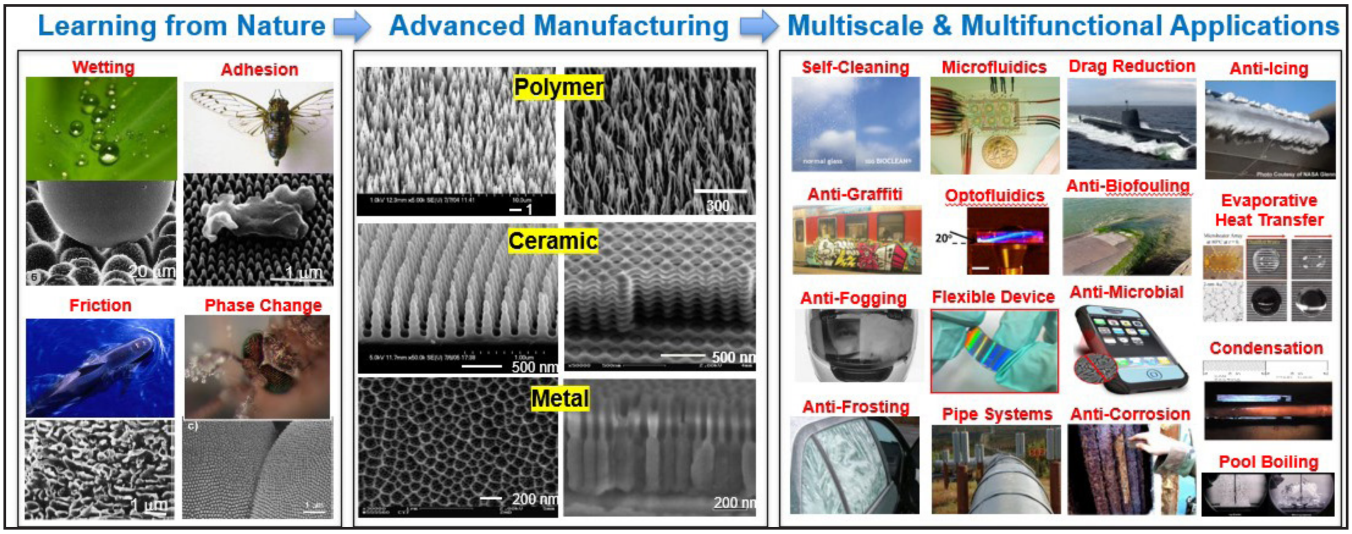
As part of her work as the representative for Stevens, she coordinates multiple outreach events. In February 2022, Prof. Fontaine returned to Brensinger Elementary for the annual "Introduce a Girl to Engineering" event, along with Prof. Shima Hajimirza and several Stevens women engineering students. There were over 200 girls from 5th to 7th grades who participated in the event, which is a part of a nationwide campaign to encourage more girls to pursue STEM fields. The group of Stevens women and faculty spoke about all the ways that engineers contribute to solving world problems, about their own individual engineering journeys, and about the large gender gap in the engineering workforce. By seeing and hearing directly from women in engineering, the hope is that more young girls will see a career in STEM as a desirable and attainable option.

NANOMANUFACTURING TECHNOLOGIES AND SYSTEMS

Professor Chang-Hwan Choi's research perspectives have focused on the fundamental understanding of interfacial phenomena and the development of scalable nanomanufacturing techniques that can allow the scientific studies of nanomechanics and the broad applications of nanostructures, ultimately targeted for the engineering of multifunctional/adaptable surfaces, devices, and systems for multiscale civil/military/energy/bio applications. As scientific quests and engineering applications reach down to a nanometer scale, there is a strong need to fabricate three-dimensional (3D) nanostructures with precise controllability of their pattern, size, and shape over relatively large area of various types of substrate materials at low cost at high rate.

One of Choi's research achievements is in the innovation of nanomanufacturing systems and technologies, especially for large-area 3D nanopatterning and nanostructure fabrication. Inspired by nature, where plants, insects, and marine animals use 3D micro/nano-textured surfaces with tailored surface wettability and mechanical pliability in their components (e.g., leaves, wings, eyes, legs, and skins) for multipurpose, such as self-cleaning, low-friction, anti-fouling, anti-icing, and anti-reflection, with great energy efficiency.

Another significant scientific contribution Choi has made is in surface/interfacial science and phenomena such as wetting, friction, adhesion, and energy transfer. In particular, enabled by the large-area 3D nanopatterning systems and techniques developed by Choi's group, new fundamental understanding of novel interfacial phenomena at the nanoscale, which were unexplored previously due to the lack of experimental precision, has been established, including superhydrophobicity, contact angle hysteresis, tunable wettability of polymers, hydrodynamic slip and friction, phase-chase heat transfer processes such as evaporation, condensation, boiling, and icing, corrosion, and microbiological cell adhesions.

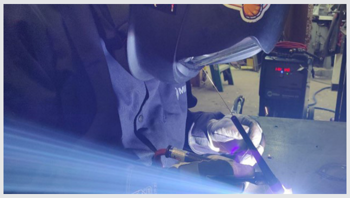


STUDENT & ALUMNI HIGHLIGHTS

Zhuo Chen, recent Stevens Electrical Engineering Ph.D. graduate and Qingya Zhao, current Mechanical Engineering Ph.D. student participated in the Frank Fernandez Automation Summer Term Fellowship for Robotics Research. The two candidates used a mobile robot equipped with an RGB-D sensor that helped guide more than 30 senior citizens in walking exercises.

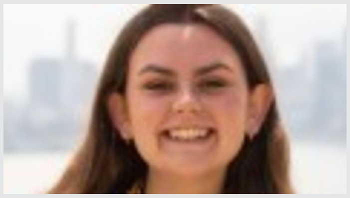
The Stevens SAE Baja team represents the university in international design competitions each year. The team is comprised of freshmans to juniors of various majors. The team is guided by ME Professor Elsyaed Aziz and Director of the MakerCenter Paul J. McClelland. This past year the interdisciplinary team of undergraduate students competed in SAE Baja Rochester and will be competing in Oregon in the coming year.

Mohammad Bahrami, ME Ph.D. Cadidate received best student presentation award at the 2022 STRATUS Confrence in Syracuse NY in May.



Alexandra Canciani, Kayleigh Bowler, and Jett Langhorn were ranked top three research projects at the SURP Conference.

Serena Platt received the Student Research Award from the Center for Neuromechanics at the Stevens BRAIN Confrence.

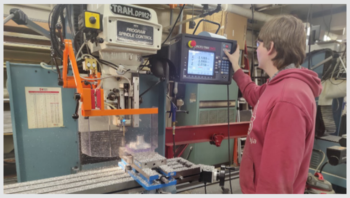


Emily Rose Kovelesky ('22 BEME) is a Stevens young alumna with a degree in Mechanical Engineering. During her five years at Stevens in the cooperative education program, Emily strove to create inclusive and welcoming spaces on campus through her work with the Lore-El Center for Women's Leadership and in her roles as the President of the Society of Women Engineers and Senior Week Committee Chair. She currently is working as a Dynamics Engineer at Collins Aerospace in Rockford, Illinois. She is excited to continue her passion of cultivating an enriching college experience for students and to be a part of planning Stevens' bright future as a member of the Board of Trustees.

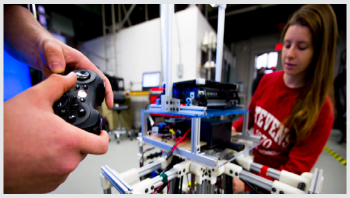
Emil Pitz, ME Ph.D. Candidate received the Stevesn Provost Doctoral Fellowship and Excellence Doctoral Fellowship. His dissertation is titled "Machine Learning for Quantification of Uncertainity in Structural performance.

The Musichanicals (lead by Teaching Associate Professor Mishah U. Salman) performed at the Stevens Entertainment Committee's 2022 Winter Wonderland Concert and also provided live entertainment at the 2022 Department of Mechanical Engineering Faculty & Staff Holiday Dinner. A blend of traditional and original holiday themed songs were performed to the delight of all audiences. The 2022 Musichanicals include Murray Elinson, Marcel Grygo, Mishah U. Salman, Kristina Sunada, and Joseph Tsui.

Kai Cao, recent ME Ph.D. receipeint received the James H. Potter Award and published in the journal "Additive Manufacturing, Advanced Materials Technology, Materials and Design.

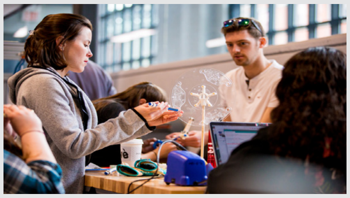


Elham Easy, ME Ph.D. Candidate, was selected to be the session chair of "Applications of Micro and Nano Systems In Medicine and Biology" at the 2022 ASME, IMECE International Conference.



Youmna Mahmound received the Albert and Mildred Buzzelli M.E. Doctoral Studies Award for 2022-2023 academic year.

Soleil Santana has been continuing her research on image processing for plume surface interactions for the Mars 2020 mission which successfully landed on Mars in February 2021. In particular, she focuses on determining the altitude at which the thrusters from Mars 2020 spacecraft started to kick up dust on the surface of Mars during descent. Soleil was selected to be a member of the AIAA Diversity Scholars Program in the spring of 2022, and was able to attend the AIAA Aviation Conference in Chicago in June 2022!



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