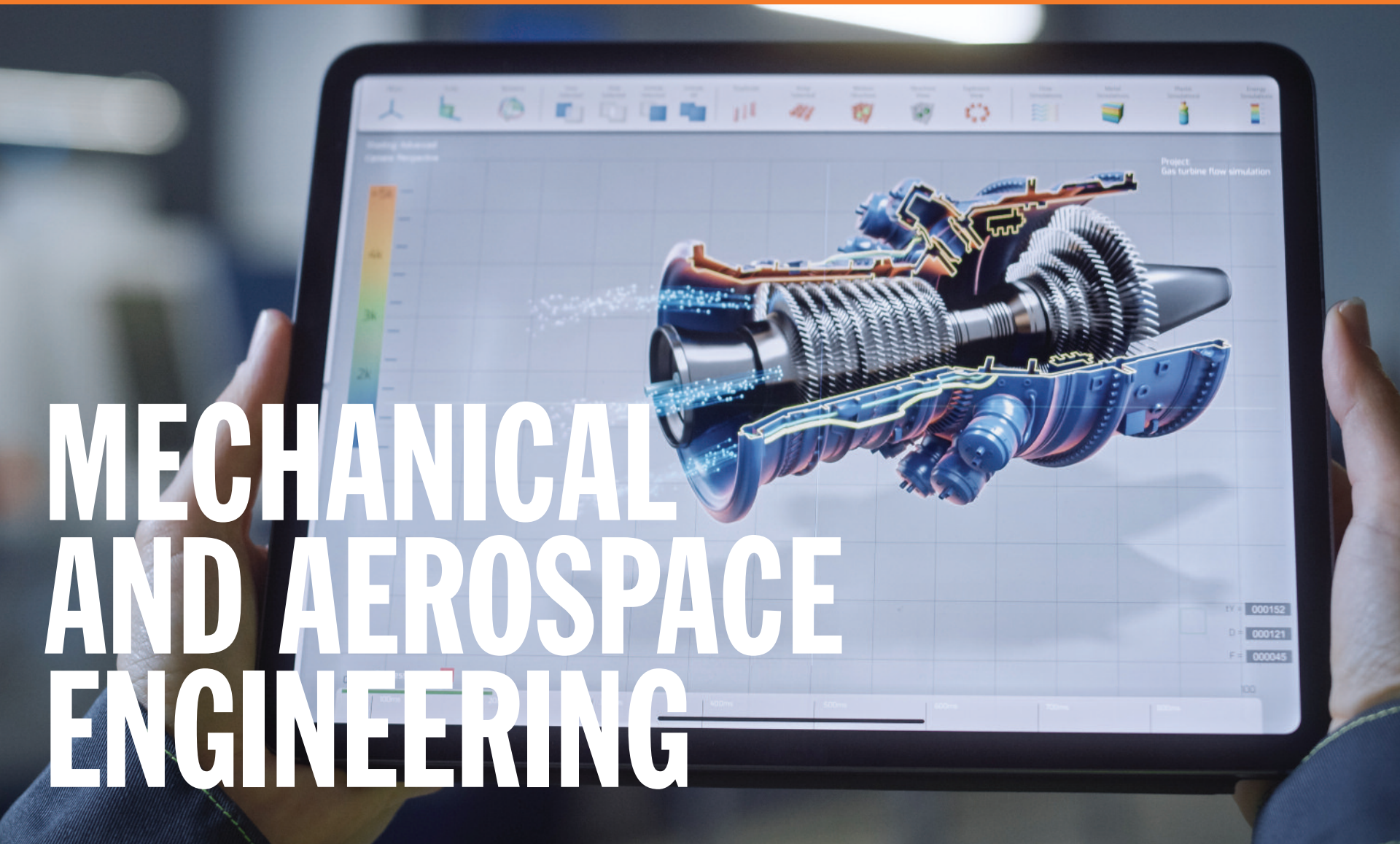
Howard A. Stone, Chair



MECHANICAL AND AEROSPACE ENGINEERING

CONTENTS

MAE BY THE NUMBERS

Distinctive Characteristics of the Department of Mechanical and Aerospace Engineering (MAE):

360 INDIVIDUALS (Includes students, faculty, staff, etc.)

137 Undergraduate Students

1 Lecturer

65 Visiting & Professional Researchers

The department concentrates its research activities in five broadly defined areas with many faculty involved with two or more areas. The five areas are:

- Applied Physics
- Dynamics & Controls
- Fluid Mechanics
- Propulsion & Energy Sciences
- Materials Science

22 Full-time Faculty

116 Graduate Students

16 Administrative & Technical Staff

3 Research Active Emeritus Faculty

About the Department of Mechanical and Aerospace Engineering at Princeton University

Princeton's Department of Mechanical and Aerospace Engineering (MAE) has played a leading role in propulsion, combustion, aerospace dynamics, and fluid dynamics over the past half century, with expansion in recent decades into dynamics and control, applied physics, and materials science.

Our multi-disciplinary focus and attention to both engineering fundamentals and groundbreaking research helps us train graduate and undergraduate students for future leadership in areas of rapidly evolving technologies.

As a result, the people of MAE are providing engineering solutions to address the world's challenges in the areas of food production, biotechnology, energy production, efficiency and management, sustainability, transportation, communication, and health, safety and security.

Together, we take on future challenges, today.

MAE is:

Applied Physics • Dynamics and Controls • Fluid Mechanics • Materials Science
Propulsion & Energy Sciences

Challenges:

Space Exploration • Satellite Technology • Pollution and Alternative Fuels • Energy Usage • Battery Technology • Novel Optical Systems • Propulsion Systems • Mechanics of Fluids and Solids • Stability and Control of Vehicles • Aircraft Performance Instrumentation

Cross-disciplinary Collaboration:

Astronautics • Bio-Inspired Design • Bioengineering • Medical Applications Combustion and Energy Conversion • Computational Engineering • Environmental and Energy Technologies • Laser-Matter Interactions • Security • Vehicle Sciences and Applications

Reigniting the MAE Engine

By Howard A. Stone, MAE Chair and Donald R. Dixon '69 and Elizabeth W. Dixon Professor

The 2021-2022 academic year was a return to some sense of normalcy, one small step at a time. Students were back on campus in the fall, and most activities bore some semblance to Princeton and MAE's pre-pandemic structure. The spring semester was even more normal when the mask mandate was dropped in March. Throughout the year, the Department was even busier than usual as we had more than 20 Master of Engineering students (all former MAE undergraduates).

Many new additions to the faculty brought new intellectual excitement to the research and teaching activities in MAE and SEAS.

Ryne Beeson, an expert in astronautics, joined us in September and promptly began teaching one of the space design courses.

Emily Carter (joint with ACEE) returned to campus in the late fall, further strengthening our material science and computational science efforts. She will also be engaged in building stronger bridges with the Princeton Plasma Physics Laboratory.

Aimy Wissa, an expert in robotics, joined us in January and taught a bio-inspired design course in the spring semester.

Radhika Nagpal, an expert in robotics and computer systems whose position is joint with COS, also joined us in January.

Finally, **Christine Allen-Blanchette**, whose research integrates machine learning with the investigation of physical systems, officially began on the faculty on July 1, 2022. She is jointly appointed with the Center for Statistics and Machine Learning.

In addition, during the academic year we ran a faculty search that proved exciting and successful. **Aditya Sood**, an expert in solid-state material science, accepted our offer and will start in January 2023. **Alison Ferris**, an expert in combustion, will also be joining us, likely in June 2024. Aditya and Alison are both accomplished experimentalists.

It is evident from the above that MAE continues to support key areas of strength while beginning new and timely research directions.

We are thrilled that during the spring semester, **Julia Mikhailova** and **Andrej Kosmrlj** were tenured and promoted to associate professor. **Michael Mueller** and **Marcus Hultmark** advanced to full professor.

The future is bright and we are looking forward to the next steps. I look forward to the hallways of MAE continuing to be busy with activity and creativity. ♦

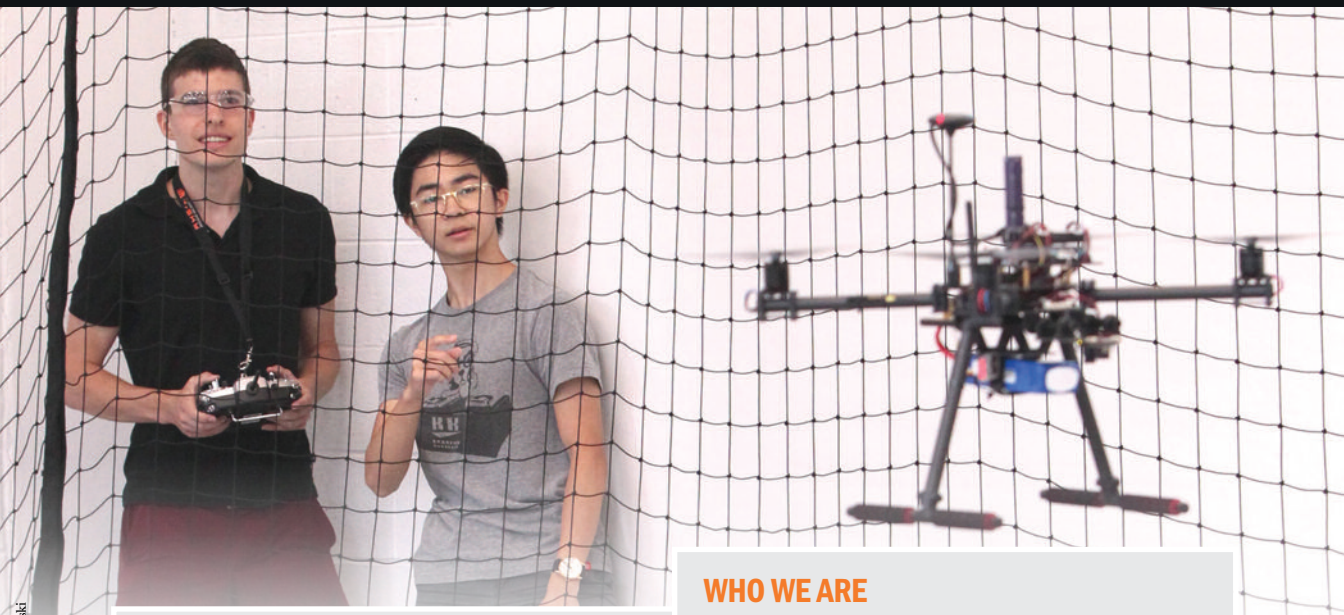


Photo by Frank Wojciechowski

WHAT WE DO

MAE is unique in that it represents disciplines recognized at most universities in two or even three separate departments. We support two of Princeton's five ABET-accredited undergraduate degree programs in SEAS.

Our active, world-leading research programs range from uncovering basic principles to testing innovative theories in and beyond the traditional MAE realm of topics. For example, MAE faculty are active in:

- Robotics and dynamical systems that play a prominent role in leading SEAS into areas now described as cyberphysical systems
- Materials sciences, including problems spanning engineering materials to biomechanics
- Bioengineering
- Propulsion and combustion
- Fluid mechanics, including studies of turbulence, environmental flows, and complex fluids
- Several areas of applied physics, including fundamental studies of laser-material interactions, electric propulsion, fusion energy, and nuclear security

MAE faculty collaborate broadly with colleagues across campus and around the world, working with disciplines that include chemical and biological engineering, civil and environmental engineering, computer science, ecology and evolutionary biology, mathematics, molecular biology, neuroscience, operations research, physics, and public and international affairs. They also maintain a vibrant seminar series and intellectual community, including postdocs, graduate students, undergraduates, and many visiting researchers.

WHO WE ARE

Operating under the auspices of Princeton University's School of Engineering and Applied Science (SEAS), the Department of Mechanical and Aerospace Engineering (MAE) at Princeton University consists of 22 full-time faculty members and one lecturer. The Department has a long history of academic success (currently six regular or emeriti faculty are members of the NAE and/or NAS*) and societal impact.

** Carter, Dryer, Law, Miles, Smits, and Stone.*

> "Many new additions to the faculty brought new intellectual excitement to the research and teaching activities in MAE and SEAS."

YEAR IN REVIEW

Here are some highlights of the many stories about MAE student, faculty, and staff achievements from the past academic year. For more details, please visit https://mae.princeton.edu/about-mae/news.

August 2021

Lidard named to Aviation Week Network's "20 Twenties"

Justin Lidard '25 was picked by *Aviation Week* as one of the top 20 aerospace students from around the world. Known as the "20 Twenties," the award is based on academic performance, broader civic contribution, and the value of the candidates' research or design project.

Mezhericher receives ICTAM 2020+1 Early Career Fellowship

Maksim Mezhericher, research scholar in the MAE Complex Fluids Group, received the fellowship from the U.S. National Committee on Theoretical and Applied Mechanics, operated by the National Academy of Sciences. The award was announced at the virtual 25th International Congress of Theoretical and Applied Mechanics (ICTAM 2020+1).

Ju Awarded the 2021 AIAA Propellants and Combustion Award

Yiguang Ju, Robert Porter Patterson Professor and director of Princeton's Program in Sustainable Energy, was recognized by the American Institute of Aeronautics and Astronautics (AIAA) for his outstanding contributions in studies of near-limit combustion, plasma-assisted combustion, micro combustion, and cool flames. The award was announced at AIAA's Propulsion and Energy Forum and Exposition.

Smits receives 2020 Batchelor Prize in Fluid Mechanics

Alexander Lex Smits received the 2020 Batchelor Prize in Fluid Mechanics, after a one year delay due to Covid-19. He also presented a lecture about his field at the International Congress in Theoretical and Applied Mechanics (ICTAM) Milano 2020+1.

Smits, the Eugene Higgins Professor of Mechanical and Aerospace Engineering, Emeritus, was recognized for "his seminal contributions to our understanding of the structure of wall turbulence at very large Reynolds and Mach numbers, especially through the design of innovative experiments and measurement devices, and also for pioneering work on bio-inspired propulsion and on drag reduction using modified surfaces." He also was lauded for inspiring interest in biomimetic flows, including propulsion, energy harvesting and vortex dynamics, often with the practical objective of improving the efficiency of fluid-based systems.

September 2021

Mueller elected AIAA Associate Fellow

Professor Michael Mueller was inducted into the American Institute of Aeronautics and Astronautics (AIAA) Class of 2022 Associate Fellows in January during the AIAA SciTech Forum.

"This distinguished group of individuals exemplify passion and dedication to advancing the aerospace profession," said AIAA President Basil Hassan. "Each of them was selected because of their significant and lasting contributions to the field. They are truly shaping the future of aerospace."

Photo by David Kelly Crow

September 2021

Eminent researcher and leader Emily Carter returns to Princeton with focus on climate

Emily Carter, former dean of engineering and an eminent researcher in a wide range of science and engineering fields related to sustainability, returned to the Princeton University faculty in December 2021.

She is a Gerhard R. Andlinger '52 Professor in Energy and the Environment and Professor of Mechanical and Aerospace Engineering and the Andlinger Center for Energy and the Environment. She also took on the newly created role of senior strategic advisor for sustainability science at the Princeton Plasma Physics Laboratory (PPPL), a U.S. Department of Energy national laboratory at Princeton.

She was a Princeton faculty member for 15 years and founding director of the Andlinger Center. In 2019, she became executive vice chancellor and provost of the University of California, Los Angeles.

"In the last year, it has become clearer to me than ever that we have a small window of opportunity to make a difference on averting the worst effects of climate change," Carter noted about her decision to focus fully on environmental sustainability through her roles at Princeton. "Climate change has only accelerated. In California, we have witnessed some of the worst wildfires in history. I have been horrified and feel the need to return fulltime to advancing the science, engineering, and policy we need to protect our planet and humanity."

Former MAE undergrads named to national science and technology advisory council

Frances Arnold '79 and John Dabiri '01 were named to the President's Council of Advisors on Science and Technology (PCAST). Arnold is the Linus Pauling Professor of Chemical Engineering, Bioengineering, and Biochemistry at Caltech. She won the Nobel Prize for Chemistry in 2018, the first American woman to do so. Dabiri is the Centennial Professor of Aeronautics and Mechanical Engineering at Caltech and was a MacArthur Foundation "Genius" Fellow.

October 2021

Lacey selected for the DOE Science Graduate Student Research Program

Cristian Lacey was one of 65 graduate students named to the U.S. Department of Energy (DOE) Science Graduate Student Research program, which offers world-class training and access to state-of-the-art facilities and resources at DOE national laboratories. He worked at Sandia National Laboratories in Livermore, Calif., from February to May 2022.

Lacey is a member of Professor Michael Mueller's Computational Turbulent Reacting Flow Laboratory, where his research leverages machine learning to develop new hybrid physics-derived and data-derived turbulent combustion models for Large Eddy Simulation.

November 2021

O'Donnell named a J. Rich Steers awardee

Logan O'Donnell, a Master of Engineering student, was named a J. Rich Steers Awardee by the New York City Post of the American Military Engineers. In addition to his academic career, O'Donnell is also a 2nd lieutenant and platoon leader in the U.S. Army Reserve. The Steers award,

established by a former New York City-based construction and civil engineering company, is given to students whose academic performance shows potential for further engineering study and practice.

Energy storage scholar Hatzell joins Department

Much of what we know about solid state batteries today is based on research by Kelsey Hatzell, who joined Princeton as an assistant professor of mechanical and aerospace engineering and the Andlinger Center for Energy and the Environment in July 2021. She previously led Vanderbilt University's Inks and Interfaces research group, which used synchrotron x-ray tomography to see what happens inside solid state batteries.

November 2021

Leonard uses the tools of nonlinear dynamics to investigate what drives political polarization of U.S. lawmakers

A study led by Naomi Ehrich Leonard, Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering, and Keena Lipsitz, associate professor of political science at Queens College, CUNY, with Princeton doctoral student Anastasia Bizyaeva, created a model which illustrates how conservative swings in public opinion exacerbate polarization among lawmakers.

"By combining our expertise on political processes together with our expertise on feedback and nonlinearity in complex time-varying processes, we were able to make new discoveries about the mechanisms that can explain, and potentially mitigate, political polarization," Leonard said.

The study, published in the December 2021 issue of the *Proceedings of the National Academy of Sciences*, was cited by a *New York Times* opinion article.

Photo by David Kelly Crow


Photo by Frank Wojciechowski

Her Princeton lab is studying how ions and molecules move through interfaces beyond batteries and energy storage systems. Broad impacts may include electrifying industrial processes and developing separation processes for water treatment, desalination, carbon dioxide sequestration, and utilization, and other applications.

Bizyaeva and Lee receive Engineering School Awards for Excellence

Anastasia Bizyaeva and Jinyoung Lee were among the 15 graduate students to receive the School of Engineering and Applied Science Awards for Excellence. The annual recognition honors graduate students who have "excelled in every dimension — classes, research, teaching, and leadership — during their time at Princeton," said Dean Andrea Goldsmith.

Farsoiya wins Gallery of Fluid Motion award

Postdoctoral Research Associate Palas Kumar Farsoiya won the American Physical Society's Division of Fluid Dynamics award for his poster at the 39th Annual Gallery of Fluid Motion. The Gallery of Fluid Motion consists of posters and videos submitted by attendees illustrating the science — and often also the beauty — of fluid motion. Farsoiya's winning poster, entitled "Gas transfer by breaking waves," showed where wind-driven waves cause regions of concentrated air bubbles in the water.

December 2021

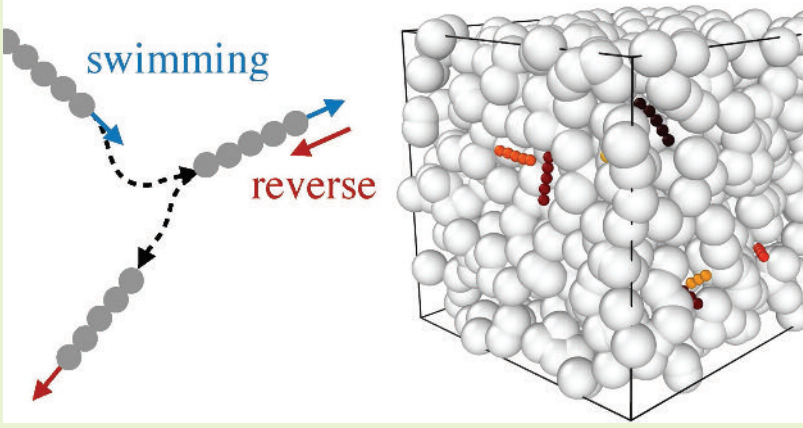
Kurzthaler, Stone, and collaborators find the best way for bacteria to navigate maze-like environments

A new model explains how a hop-and-trap strategy used by bacteria when they move through porous obstacle-laden environments like soil and tissue could be used to develop self-propelled polymers, which may in the future become microrobots capable of navigating tumor tissue to deliver a chemotherapy drug.

"We wanted to understand how the details of this [hop-and-trap] mechanism impact how fast [bacteria] spread and how far they can move within that environment," said Christina Kurzthaler, a postdoctoral research associate who is the first author of the study published in *Nature Communications*.

"It was a puzzle why certain rotation rates of the bacteria led to certain spreading… for about 30 years," noted senior author Howard Stone, the Donald R. Dixon '69 and Elizabeth W. Dixon Professor of mechanical and aerospace engineering. "This use of modeling with modern experiments has shed new light on an old problem and ties it to the geometry of the porous media."

The new model also provides a criterion for developing polymers capable of carrying pharmaceuticals through the body or finding and degrading pollutants in soil.



December 2021

Carter wins 2021 Materials Theory Award from the Material Research Society

Emily Carter, Gerhard R. Andlinger '52 Professor in Energy and the Environment

and Professor of Mechanical and Aerospace Engineering and the Andlinger Center for Energy and the Environment, was honored "for advances in quantum mechanics theory with broad applications to materials and chemical sciences."

In addition to accepting the honor at the virtual 2021 Materials Research Society Fall Meeting, Carter presented her lecture, entitled, "Quantum-Derived Materials Solutions for a Sustainable Future," and served as a panelist with fellow award recipients.


Photo by Sameer Khan

***Forbes* article features Socolow, planetary identity, and Destiny Studies**

The wide-ranging article, called "Unwinding Doomsday's Clock," chronicled work done by Professor Emeritus Robert Socolow and others to help human beings have a wider perspective about their impact on the Earth.

"We don't know that there's life anywhere else, and until such time as we do, we ought to consider ourselves to be something extraordinary in the universe, who are figuring out who we are," said Socolow. "We have been delinquent in not bringing planetary thinking into science education from kindergarten on up."

His work on planetary identity expanded to the new field of Destiny Studies. He described the field's mission in an article for the *Bulletin of the Atomic Scientists*, whose members vote annually on where to set the Doomsday Clock — the metaphorical symbol of how close humans have come to destroying the planet.

"The goal," he wrote, "should be to foster science and technology, to intensify planetary consciousness, to strengthen those international institutions that reinforce the reality that all countries are in one boat, to resist over

December 2021

Nagpal named as one of *Newsweek's* 50 Visionaries and Innovators

Radhika Nagpal, professor of mechanical and aerospace engineering and computer science, was lauded by *Newsweek* for her work creating tiny robots that mimic real-life organisms. She sees the potential for tackling complex jobs like cleaning up chemical spills, building dams, and inspecting bridges, among other tasks that are considered too "dirty, dull or dangerous" for human beings.

Before joining Princeton in 2022, Nagpal led a team at the Wyss Institute for Biologically Inspired Engineering at Harvard, which created a thousand-robot army called "the Kilobots" that are used in research and education around the world In 2021, her lab team built underwater robots, called the BlueSwarm, which act like a school of fish while monitoring damage to coral reefs.


Photo by David Kelly Crow

managing the planet, and to learn to think coherently about future time."

January 2022

Tong named a 2022 Recipient of the Matthew Isakowitz Fellowship

Kevin Tong '22, was one of 30 students from around the country chosen for the highly selective summer internship and executive mentorship program designed to inspire the next generation of commercial spaceflight leaders. Tong, whose undergraduate work focused on designing CubeSats and advancing space infrastructure capabilities, did his internship in the summer of 2022 at Lynk Global, which is developing a satellite-to-mobile-phone network.

February 2022

Grad students Ricks and Zaman win presentation awards at the First Energy and Informatics International Forum

Wilson Ricks and Wahid Zaman received presentation awards at the First Energy and Informatics International Forum. The program is part of the curriculum of the Tokyo Institute of Technology, in which students develop their design thinking ability by synthesizing scholarly knowledge, exploring interdisciplinary research, crossing transdisciplinary lines, and adding to the multi-disciplinary work done at the border between energy and information.

Ricks received the Gold Medal for his presentation on –The Value of In-Reservoir Energy Storage for Flexible Operation of Geothermal Systems." Zaman received a Silver Medal for "Influence of Kinetic Limitations in Stable Cycling of All Solid-state Li-metal Batteries."

Niki Abbasi, above right, receiving her award.

March 2022

Excellence in Teaching Awards go to Arnold, Jenkins, Abbasi, and Cathcart

The 2020-2021 School of Engineering and Applied Science Excellence in Teaching Awards were awarded to Professor Jesse Jenkins for ENE 422 Introduction to the Electricity Sector: Engineering, Economics, and Regulation; Professor Craig Arnold for MAE 324 Structure and Properties of Materials, graduate teaching assistant Niki Abbasi for MAE 222 Mechanics of Fluids, and graduate teaching assistant Charlotte Cathcart for MAE 223 Modern Solid Mechanics.

March 2022

Energy expert tapped to lead national study on sustainable use of carbon

The National Academies of Sciences, Engineering and Medicine appointed Professor Emily Carter, Gerhard R. Andlinger '52 Professor in Energy and the Environment and Professor of Mechanical and Aerospace Engineering and the Andlinger Center for Energy and the Environment, to chair a study on how to turn carbon from a climate-changing pollutant into useful commercial products. The committee is tasked with exploring "regional and national market opportunities as well as infrastructure and research needs" to help the nation stop contributing to the buildup of carbon in the atmosphere. Congress mandated the study in the Energy Act of 2020.

April 2022

Mueller receives Early Career Researcher Award

Michael Mueller, professor of mechanical and aerospace engineering and director of graduate studies, won the annual Hiroshi Tsuji Early Career Researcher Award from the Combustion Institute for significant contributions and research in fundamental or applied combustion or combustion-related fields.

May 2022

Stone elected to the Royal Society

Howard A. Stone, the Donald R. Dixon '69 and Elizabeth W. Dixon Professor in Mechanical and Aerospace Engineering and department chair, was named Foreign

Photo by David Kelly Crow

Member of the Royal Society, the scientific academy of the United Kingdom created in 1660. Its membership has included Newton, Darwin, and Einstein.

Stone is a noted fluid motion researcher. His research group has examined problems of fluid flow and transport phenomena that occur in biofilms, microfluidic devices and technologies, water treatment, and thin-film coatings. During the COVID-19 pandemic, Stone and colleagues studied how a virus could be transmitted by the respiratory jets from asymptomatic individuals during ordinary activities, including speech.

Chase, Roggeveen and Gouveia honored with Graduate School Teaching Award

Graduate students Danielle Chase, James Roggeveen and Bernardo Gouveia received the Graduate School Teaching Award for their contributions to EGR 156 Foundations of Engineering: Multivariable Calculus, which is part of MAE's first-year foundational engineering sequence.

May 2022

Arnold named Princeton's vice dean for innovation

Craig B. Arnold, the Susan Dod Brown Professor of Mechanical and Aerospace Engineering and director of the Princeton Institute of Materials, became Princeton University's vice dean for innovation on July 1, 2022.

Photo by Frank Wojciechowski

"Craig Arnold exemplifies the entrepreneurial spirit of Princeton," said Dean for Research Pablo G. Debenedetti, the Class of 1950 Professor in Engineering and Applied Science and professor of chemical and biological engineering. "Throughout the University, Craig is recognized for his pioneering research, his visionary leadership of the Princeton Institute of Materials, his entrepreneurship, and his outstanding service on behalf of Princeton."

His role within the Office of the Dean for Research includes strengthening the University's capacity to engage with technology investors, industry, entrepreneurs, alumni, and other potential partners. The position leads the Princeton Innovation initiative and oversees the University's efforts to grow Princeton's culture of innovation across disciplines.

Photo by Frank Wojciechowski

May 2022

New course helps students implement visions through virtual reality

Jointly offered by the schools of engineering and architecture, the virtual and augmented reality course introduces students in the humanities, sciences, and engineering to technology that can help them demonstrate their ideas visually.

"The idea is not to focus on programming," said Alexander Glaser, associate professor of mechanical and aerospace engineering and public and international affairs, who used VR in his work researching nuclear energy and arms control. "The idea is to give the students enough skill to implement their vision."

To teach the course, Glaser teamed up with Forrest Meggers, an associate professor of architecture, who used the technology around innovative and sustainable systems for heating and cooling buildings.

Qiao receives Best Student Paper Award at AES Convention

Ph.D. student Yue Qiao, advised by Professor Edgar Choueiri, was awarded the "Best Student Paper Award" at the Audio Engineering Society's 152nd International Convention held in the Netherlands. His paper, co-authored with Choueiri, was entitled, "The performance of a Personal Sound Zone System with Generic and Individualized Binaural Room Transfer Functions."

* * *

For details on these and other stories, please visit https://mae.princeton.edu/about-mae/news.

STUDENT PROFILES

Navreeta Singh:

Embracing Biomechanics, Materials Science, and the Rich Opportunities of Research

DEGREE: BSE 2022 MAJOR: MECHANICAL ENGINEERING

Across her undergraduate academic career, Navreeta Singh has interned at the Air Force Research Laboratory and two other labs, co-authored two papers, and completed a year-long Princeton lab research project that characterizes the properties of microscopic-animal proteins.

"Doing research has been an important part of my undergraduate experience," says Singh, who graduated in 2022 and did her senior project peering through some of the most sophisticated microscopes and imaging tools available at the university. "It's allowed me to start applying what I've been learning in my classes and helped me grow a lot as a scientist and engineer."

Growing up, Singh's interest in engineering evolved from tinkering and constructing things from erector sets and pieces of wood. She built a Rube Goldberg machine and an automatic tuning device for her violin.

At Princeton, she discovered her love of materials science and biomechanics, delving into the depths of the very small to study how individual molecules and atoms behave and interact with one another in a variety of biological and other materials.

Her senior project, as a researcher in Assistant Professor Daniel Cohen's Lab, involved investigating the disordered proteins that enable microscopic animals called tardigrades or "water bears" to withstand extreme drought conditions. The research could improve the ability to store stem cells, embryos, and vaccines without the use of refrigeration.

"Navreeta is a great collaborator in the lab, and her enthusiasm is contagious," Professor Cohen says. "She is a pleasure to work with and to teach."

Tiny mite-sized water bears are related to insects and have eight legs and pudgy bodies. They are found in almost any wet or damp environment — from oceans, lakes, and swamps to the inner reaches of moss and other vegetation. They are widely used in research because of their amazing ability to survive in harsh environments, including acute drought, scorching heat, freezing temperatures, and even outer space.

When its habitat dries out, the tardigrade goes into a "tun state." Its body shuts down into a dehydrated ball, with its metabolism rate declining to near nonexistence. It can remain in this state for years or even decades and revive itself as soon as enough moisture returns.

Singh's project emulates how tardigrade disordered proteins withstand drought by forming a fibrous, hydrogel structure when they're dehydrated. Other experiments include suspending the proteins in the hydrogels along with mammalian cells to see if the gels protect cells under arid conditions.

> **"Navreeta is a great collaborator in the lab, and her enthusiasm is contagious. She is a pleasure to work with and to teach."**
>
> *—Assistant Professor Daniel Cohen*

Photo by Michael Franken

"Biological systems are beautiful and complex, and I enjoy applying principles of physics and mathematics to model and mimic them," Singh says. "I especially enjoy studying and imaging at the microscale, where we can elucidate details that explain large-scale phenomena. But I honestly didn't realize that I could combine physics with biology until I got to college. I hadn't even heard of the field of biomechanics until I came to Princeton."

She then started working in Assistant Professor Andrej Košmrlj's lab as an intern researching epithelial tissue, which lines nearly every part of the body, including the skin, blood vessels, intestines, and other organs. The epithelial cells that make up this tissue serve numerous purposes, including protecting the body against foreign objects and enabling better nutrient absorption.

"We know that the mechanical properties of epithelial tissue are really complex, but we need to quantify them better," Singh says. "We don't understand, for example, how they react under a wide range of shearing frequencies."

Singh used computer simulations called meshing to study the characteristics of epithelial tissue's viscosity and elasticity. Meshing divides an object into thousands or millions of smaller elements to see how atoms, molecules, or cells work in conjunction with one another under a variety of conditions and stresses. The more detailed a mesh is, the more accurate the model will be. Singh combined thousands of cells to closely monitor the mechanical properties that occur as tissues in the body are stressed.

Singh also studied syphilis vaccine development as an intern at the University of Connecticut. Untreated syphilis can cause severe long-term health problems, including damage to the heart, brain, or other organs. It can also be spread from mother to child in the womb, causing birth defects and even death.

Last year, Singh was an Air Armament Scholar at the Air Force Research Laboratory in Florida. She researched molecular dynamic simulations for explosive materials to study how pore shape at the molecular level affects explosion.

"It was a great opportunity. I had the chance to see some of the innovative technologies that the military is funding," Singh says, adding that the experience increased her interest in defense and policy. As a result, she pursued a History and Practice of Diplomacy certificate at Princeton.

"I find that an interdisciplinary approach to academics, whether that's between engineering and biology or technology and foreign policy, opens up a lot of spaces for really interesting work," she adds. ♦

Kevin Tong:

Designing CubeSats and Space Infrastructure

DEGREE: BSE 2022 MAJOR: MECHANICAL AND AEROSPACE ENGINEERING

Imagine leaving the dealership with a new car and a full tank of gas, but never being able to refuel it or perform any major maintenance. That's how Kevin Tong describes today's spacecraft approach.

"There is currently no cost-effective way to apply additional energy in space," explains Tong, who earned a certificate in Robotics and Intelligence Systems in addition to his MAE degree. "We need to find methods of creating more effective infrastructure, such as orbital refueling or recharging and portable maintenance stations."

He adds, "This is important both for space missions and expanding our presence in the solar system and also, for us here on the ground, so we do not waste energy and create more space junk."

Tong, who describes himself as "interested in everything," has expanded his knowledge of how the world works by exploring archeology digs, microfluidics, and satellite design.

Designing space infrastructure involves large models, but his senior thesis project exists on a much smaller scale: 10 cm to be exact. As part of Princeton's NanoSat Laboratory, he is developing a CubeSat nanosatellite with an Earth horizon sensor.

CubeSats are tiny box-like satellites that conduct scientific experiments such as weather tracking, navigational mapping, or even gathering data on endangered species. As part of NASA's CubeSat Launch Initiative, universities like Princeton can send their designs into space for much lower cost than traditional space vehicles. More than 1,500 CubeSats have been launched in the last 20 years.

"This program is a great way to lower costs and give academics and students access to space," he explains. "Instead of costing millions of dollars to design a large satellite, CubeSats can be made for a few thousand."

Tong's current research project is part of a larger effort at the NanoSat Lab to take the cost savings further by building on a shoestring budget with off-the-shelf hobby electronics.

"Kevin's senior thesis project is to design and implement a horizon sensor for tiny satellites like CubeSats that is an order-of-magnitude cheaper and less processor-intensive than the current state of the art," says Michael Galvin, senior technical support in mechanical engineering who serves as Tong's advisor on the project. "Such a sensor would further enable our Princeton CubeSat architecture, which is designed to offer the lowest bar-to-entry possible for hands-on, student-level do-it-yourself CubeSat projects, especially Earth observation missions."

Tong tested the sensor's performance through a stratospheric balloon launch, one of the first high-altitude balloon launches conducted by a Princeton student.

As an intern at The Aerospace Corporation, Tong co-led a concept design team that developed a mission plan to send paired CubeSats around the moon. The goal was to demonstrate CubeSat proximity operations and the feasibility of large-scale spacecraft refueling outside of low Earth orbit.

Tong also won the 2022 Matthew Isakowitz Fellowship, which inspires the next generation of aerospace leaders by connecting them with prestigious mentors and summer

internships in the commercial spaceflight industry. In the summer of 2022, Tong worked at Lynk, a company that is developing a "cell tower in space."

Howard Stone, the Donald R. Dixon '69 and Elizabeth W. Dixon Professor Chair of MAE, says he always learns something new when Tong is around.

"He is a pleasure to work with and impressive to talk to. He has a hardware project related to imaging by satellites, but he is also interested in understanding the problem more quantitatively using mathematical modeling," Professor Stone says.

Before Tong became involved with the NanoSat Laboratory, he conducted research in the Complex Fluids Group with Professor Stone. He investigated the monodispersed stable bubbling regime that is produced in thin fluid films when they interact with small gas jets.

Tong became intrigued by engineering in high school. He was involved in several FIRST Robotics Competitions and enjoyed working with his hands to build the hardware. He also was the one of the first students in the club to incorporate CAD software into the design process.

"The challenge with these competitions is you only have six weeks to build everything. It forces you to think quickly and tackle problems in a short period of time," he says.

A well-rounded education has always been important to Tong. Each semester, he tried to take at least one course in the humanities, studying architecture, archaeology, and music. The summer after his freshman year, Tong spent six weeks at a dig site in Greece as part of the Archeology in the Field program. Using tools from a wheelbarrow to a laser rangefinder, he found shattered pots and buried walls dating as far back as the sixth century BCE.

Outside of the classroom, Tong held a leadership role with the Princeton Racing Electric team. This is an ambitious student-led project to design and race an all-electric, single occupant racecar. Because of the COVID-19 pandemic, the team had to design virtually for almost two years and the final competition was canceled numerous times. Tong drove the vehicle in person for the first time this spring.

Photo by Michael Franken

"Kevin's senior thesis project is to design and implement a horizon sensor for tiny satellites like CubeSats that is an order-of-magnitude cheaper and less processor-intensive than the current state of the art. Such a sensor would further enable our Princeton CubeSat architecture, which is designed to offer the lowest bar-to-entry possible for hands-on, student-level do-it-yourself CubeSat projects, especially Earth observation missions."

—Michael Galvin, senior technical support in mechanical engineering, who serves as Tong's advisor on the project

Tong's next stop is graduate school. In 10 years, he hopes to be working in the space industry, helping make his dreams of orbital infrastructure come true.

"I would like to be in a hands-on type of role," Tong explains. "It is such an exciting time in aerospace, and I am just hoping to be a part of it." ♦

James Roggeveen:

Intrigued by Space — and Surface Phenomena

DEGREE: Ph.D. CANDIDATE (2024) RESEARCH AREA: FLUID MECHANICS

For Princeton Ph.D. candidate James Roggeveen, there was not one path, but many experiences — in geography and academia — that led him to where he is today.

One such experience was attending Cambridge University, where he received his Master of Advanced Study in 2019. Another was a 2016 NASA internship where he "became obsessed with space."

And, perhaps most incongruously, another experience that shaped his path was serving as captain of the MIT Asian Dance Team. "It was a little disparate," he says. "Almost everyone on my floor auditioned. It was a very inclusive dance team. It becomes your social circle."

Roggeveen received his BS in Mechanical Engineering from MIT in 2018. There, he explored the dynamics of fluid films undergoing Faraday instability resting on a still bath.

From there, he was off to Cambridge in the UK. "It was better than anything I could have dreamed of," he says. "I was a little unprepared. Turns out I was very unprepared."

Still, that didn't stop him from receiving a degree with distinction and writing a thesis on gravity currents passing over cavities. Roggeveen admits that the original challenge was that "I was coming from an engineering background and entering a math program."

But the grandeur of the setting was not lost on him. "It's immersed in history. You go into your dining hall and it was built by Henry VIII," he says with a chuckle.

At first, he had no idea that Princeton was his next destination.

"I was pretty sure I wasn't coming here. I was a staunch New Englander," says the Nantucket, Mass., native. "I relied on my friends from undergrad," he says about making his choice. He also discussed theoretical fluid work with his advisor and it turned out Princeton "was, by far, the best fit for me."

His thesis research at Princeton investigates how to explain fluid phenomena. "I use math to explain something observed in nature or take an existing model to use math to explain properties, and how we can expect these systems to behave," says Roggeveen, who received a Sayre Award for Academic Excellence for first year achievements. His second year included a Guggenheim Fellowship for excellence in coursework and research.

He doctoral advisor is Howard Stone, Donald R. Dixon '69 and Elizabeth W. Dixon Professor and Chair of MAE. "James is a pleasure to work with," says Professor Stone. "He is very flexible intellectually and combines keen insights

Photo by Michael Franken

with strong mathematical abilities. He is also a magnificent member of our community."

Growing up, Roggeveen was a three-season sailor in Nantucket. In the sixth grade, he started attending science fairs and found himself gravitating towards experiments that involved fluids. There was not much of a science focus in high school, he says, but he connected with a scientist who advised him. He looked into things like ice freezing and built his own wind tunnel.

He did an internship at NASA's Jet Propulsion Lab in 2016 and connected with the engineers, not the astronauts. Referring to his favorite movie from childhood, *Apollo 13*, he remembers wanting to "be one of the cool guys solving the problems."

"This was the fulfillment of a childhood dream" he recalls. He then spent part of 2017 as a vehicle engineering intern at Elon Musk's Space X, where as a member of the Falcon 9 Vehicle Integration and Test team he worked on development and deployment of manufacturing and process improvements. On his second day he was taken by his boss inside one of the booster's fuel tanks and six weeks later got to see that same booster take off from mission control.

"It was a very cool experience," he says. "I realized I liked more fundamental research versus working in the corporate world."

His desire to work in research was confirmed during a 2018 internship at Samsung Electronics. "This sped up my desire to not be in corporate," he remembers.

At this point, through MIT, he became an instructor in the Global Teaching Labs in South Korea. He designed and taught workshops on robotics and STEM to low-income middle and high school students in Seoul.

> **"James is a pleasure to work with. He is very flexible intellectually and combines keen insights with strong mathematical abilities. He is also a magnificent member of our community."**
>
> *—Howard Stone, Donald R. Dixon '69 and Elizabeth W. Dixon Professor and Chair of MAE*

"I had a blast. I liked learning languages," says Roggeveen, who is proficient in Chinese, Korean and French. "It was tough in some ways. I was forced to use language skills. I had a fear at first of talking to anyone who wasn't my teacher. But you can have a productive communication even if you're not nailing the words."

At Princeton, he continues to pay it forward as a resident graduate student. "We host events for the undergrads," he explains. "We're around if they need advice in life, or just someone to talk to." ♦

Meghan Booker:

Developing Memory Frameworks for Robots

DEGREE: Ph.D. CANDIDATE (2023)
RESEARCH AREA: CONTROL, ROBOTICS AND DYNAMICAL SYSTEMS

How much memory does a robot need to complete a task? Are there fundamental tradeoffs between memory and task performance?

These are the questions Meghan Booker is trying to understand in her research.

For example, robots often use a map to navigate through obstacles to get to a goal, such as a corner of a room. But that solution can be problematic — maps take up a good deal of memory space, contain irrelevant geometric details about the room and obstacles, and are not very useful out in the field where conditions are uncertain.

"The map is not the memory representation the robot really needs to complete this navigation task," explains Booker. "Instead, we can jointly design the control policy and memory representation to follow the wall of the room rather than use the map to navigate through the obstacles. The wall-following policy only uses depth sensor measurements about the wall's location in memory. Additionally, by relying on the map, the robot ends up taking actions using extra information that might not even be relevant to the task at hand, such as colors of the obstacles."

As part of Professor Anirudha Majumdar's Intelligent Robot Motion (IRoM) Lab, Booker is trying to automatically generate the minimal amount of memory a robot needs to complete a given task. She is developing memory frameworks that take up minimal amounts of space, while being task-relevant and computationally efficient.

"There is also a theoretical importance to understanding memory for robot tasks and that can help us design better, more efficient algorithms and robotic systems," she says.

"When we enter the real world with all these uncertainties, it becomes even more important to have a clear-cut theoretical framework to guide our expectations on what capabilities robots need for a specific task. Right now, it is very ad-hoc."

Booker is also investigating memory frameworks that exhibit strong recall so a robot can complete complex, long-term tasks. Important applications for this approach include autonomous cars, which handle an immense amount of data; drones, which are small and have limited space for memory; and in-home assistance robots, which are expected to handle many tasks over a long time period. These insights into memory, she says, also have applications in other fields such as neuroscience.

"Meghan was one of the first students to join my research group when I started as faculty at Princeton. Her work has helped shape and crystallize our group's efforts. She has contributed greatly to the growth of the research group, both in terms of research and other efforts including student recruitment, outreach, and mentoring undergraduate students," says Anirudha Majumdar, assistant professor of MAE.

Booker's interest in engineering began in high school, where she participated in Project Lead the Way courses and developed a passion for problem solving and working as a team to tackle STEM challenges. She was first introduced to robotics during an intensive summer program in artificial intelligence at St. Paul's School in Concord, N.H.

Photo by Michael Franken

"What I enjoy most about robotics is that it has a feedback loop," she explains. "Robotics is a constant cycle of developing your hypothesis, making algorithms to actually run on the robot, and then testing your theory and algorithm on a physical robot in the real world."

Her expertise in electrical engineering parlays well with the control aspects of robotics. As an undergraduate at the Ohio State University (OSU), she majored in electrical engineering and had several internships at Raytheon Company. Her undergraduate thesis investigated the impact of cyber-attacks on unmanned aerial vehicles connected to the cloud. This work led to Booker participating in OSU's Denman Undergraduate Research Forum and receiving First Place Paper at the Institute of Electrical and Electronics Engineers Region 2 Student Activities Conference.

At Princeton, Booker organizes the Robotics Project Group meetings. This engineering collaborative includes researchers from MAE, ECE, COS, and other departments, and they are working on a project to create a team of ground vehicle robots to clean up trash in places like public parks, parking lots after events, or beaches after storms.

As a first-generation college student, Booker is passionate about mentoring undergraduates at Princeton. She serves as a teaching assistant for Introduction to Robotics and Introduction to Engineering Dynamics. In 2021, she won the Crocco Award for Teaching Excellence in MAE.

"I enjoy working with students to help them find the right direction, whether it be solving a challenging problem or finding a career path," Booker says. "I am very grateful for all of the great mentors I had that helped me learn about the opportunities that were out there. Teaching is my way of thanking them and giving back." ♦

"Meghan was one of the first students to join my research group when I started as faculty at Princeton. Her work has helped shape and crystallize our group's efforts. She has contributed greatly to the growth of the research group, both in terms of research and other efforts including student recruitment, outreach, and mentoring undergraduate students."

—Anirudha Majumdar, assistant professor of MAE

FACULTY

Meet the People

The faculty and students of MAE harness their expertise and curiosity to improve how human beings interact with the world through engineering.

Professor
Craig Arnold
Emily Carter
Edgar Choueiri
Mikko Haataja
Marcus Hultmark
Yiguang Ju
Chung (Ed) Law
Naomi Leonard
Michael Littman
Luigi Martinelli
Michael Mueller
Radhika Nagpal
Clarence Rowley
Howard Stone, *Chair*

Associate Professor
Alexander Glaser
Egemen Koleman
Andrej Kosmrlj
Julia Mikhailova
Daniel Nosenchuck

Assistant Professor
Christine Allen-Blanchette
Ryne Beeson
Daniel Cohen
Luc Deike
Kelsey Hatzell
Jesse Jenkins
Ani Majumdar
Aimy Wissa

Lecturer
Lamyaa El-Gabry
Glenn Northey (part-time)

Visiting Research Scholar
Francesco Grasso

Senior Scholar
N. Jeremy Kasdin
Richard Miles
Alexander Smits
SzymonSuckewer

Associated Faculty
Amir Ali Ahmadi, *Operations Research & Financial Engineering*
Elie Bou-Zeid, *Civil & Environmental Engineering*
Nathaniel Fisch, *Astrophysical Sciences*
Bruce Koel, *Chemical & Biological Engineering*
Glaucio Paulino, *Civil & Environmental Engineering*
David Spergel, *Astrophysical Sciences*
Salvatore Torquato, *Chemistry*
Robert Vanderbei, *Operations Research & Financial Engineering*
Claire White, *Civil & Environmental Engineering*

DEPARTMENTAL COMMITTEES
Graduate Committee:
Michael Mueller, *Chair*
Edgar Choueiri
Daniel Cohen
Luc Deike
Ani Majumdar

Director of Graduate Studies:
Michael Mueller

Undergraduate Committee:
Michael Littman, *Chair*
Craig Arnold

Marcus Hultmark
Lamyaa El-Gabry
Yiguang Ju
Andrej Kosmrlj
Luigi Martinelli
Alex Glaser, *Ex-officio*

Seminar Committee:
Marcus Hultmark, *Chair*
Alex Glaser
Emily Carter
Ed Law
Ani Majumdar

Honors and Awards Committee:
C.K. Law, *Chair*
Howard Stone
Naomi Leonard

Search Officer:
Michael Mueller

SEAS EPAC Committee:
Luigi Martinelli

Sustainable Energy Program
Yiguang Ju, *Chair*

Climate & Inclusion Committee:
Michael Mueller, *Co-chair*
Luc Deike, *Co-chair*
Jeff Addo
Ananth Govind Rajan
Qingjun Yang
Anastasia Bizyaeva
Alec Farid
Jiarong Wu
Howard Stone, *Ex-officio*
Jennifer Widdis, *Ex-officio*
Katerina Zara, *Ex-officio*

Teaching Schedule Coordinators:
Michael Littman
Michael Mueller
Theresa Russo, *Ex-officio*
Katerina Zara, *Ex-officio*

First Year Advisers:
Daniel Cohen
Lamyaa El-Gabry
Andrej Kosmrlj
Ani Majumdar
Gigi Martinelli
Daniel Nosenchuck

Class of 2021
Craig Arnold
Luc Deike
Lamyaa El-Gabry
Yiguang Ju
Michael Littman
Gigi Martinelli
Daniel Nosenchuck
Clancy Rowley

Class of 2022
Craig Arnold
Daniel Cohen
Mikko Haataja
Marcus Hultmark
Yiguang Ju
Andrej Kosmrlj
Michael Littman
Ani Majumdar
Luigi Martinelli
Daniel Nosenchuck

Class of 2023
Craig Arnold
Michael Littman
Gigi Martinelli
Daniel Nosenchuck

Department Safety Managers
Jonathan Prevost
Julia Mikhailova

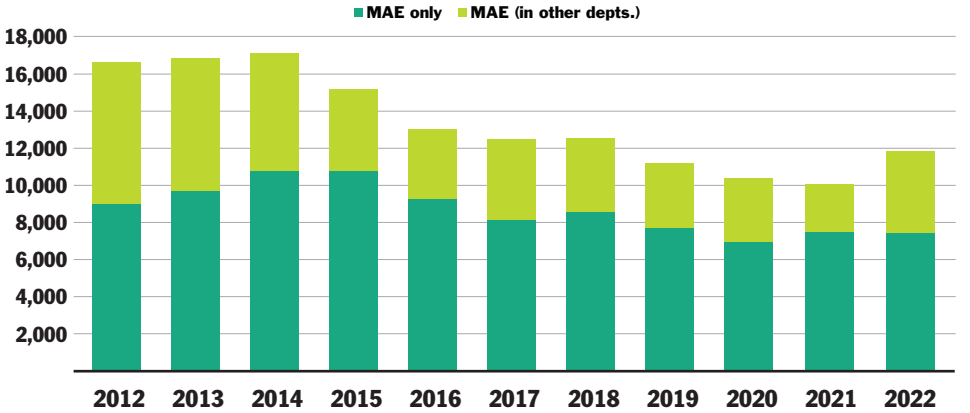
Chemical Hygiene Officer
Michael Littman

SEAS Lab Safety Committee Representatives:
Al Gaillard
Michael Littman
Jonathan Prevost
Michael Vocaturo

Student Organization Representatives:
AIAA: Michael Mueller
ASME: Mikko Haataja
SAE: Yiguang Ju
MRS: Craig Arnold
Tau Beta Pi (SEAS-wide):
Michael Mueller, Howard Stone

Sponsored Research Volume

(in thousands)



FACULTY AWARDS, HONORS AND RECOGNITION

Amir Ali Ahmadi (Associated Faculty, Assistant Professor of Operations Research & Financial Engr.)

- 2021 Plenary Speaker at the triennial SIAM Conference on Optimization
- 2022 Plenary Speaker at the Colombian Conference on Applied and Industrial Mathematics

Craig Arnold (Professor, Vice Dean of Innovation)

- 2021 Dean's commendation for Outstanding Teaching
- 2022 Princeton E-Council Excellence in Teaching Award

Garry Brown (Professor, Emeritus)

- 2020 A.O. (Order of Australia) in the Queen's Birthday Honours' List

Emily Carter (Professor)

- 2021 Materials Theory Award, Materials Research Society
- 2022 Richard S. H. Mah Lecturer, Northwestern University, Department of Chemical and Biological Engineering
- 2022 Harrison Shull Distinguished Lecturer, Indiana University Bloomington, Department of Chemistry

Lamyaa El-Gabry (Lecturer)

- 2022 Selected as Associate Editor of the Journal of Turbomachinery

Luc Deike (Assistant Professor)

- 2021 American Physical Society Division of Fluid Dynamics
- 2021, Milton Van Dyke Award (Gallery of fluid motion).
- 2021 Alfred Rheinstein faculty award from the School of Engineering and Applied Sciences Princeton University.

Yiguang Ju (Professor & Director of the Program in Sustainable Energy)

- 2021 AIAA Propellants & Combustion Award, the American Institute of Aeronautics and Astronautics (AIAA)
- 2022 Distinguished Teacher Award, School of Engineering and Applied Sciences, Princeton University
- 2022 Alfred C. Egerton Gold Medal for distinguished, continuing, and encouraging contributions to the field of combustion,The Combustion Institute

C.K. (Ed) Law (Professor)

- 2022 Lifetime Achievement Award for "Foundational Contributions to Fuel Chemistry, Reacting Flows, and Green Energy,"

Michael Mueller (Associate Professor)

- 2022 Hiroshi Tsuji Early Career Researcher Award, The Combustion Institute
- 2022 Associate Fellow, American Institute of Aeronautics and Astronautics

Radhika Nagpal (Professor)

- 2021 Select as Newsweek's Greatest 50 Disruptors
- 2022 Appointed as the Norman R. Augustine '57 - '59 Professor in Engineering
- 2022 Association of Computing Machinery Fellow

David Spergel (Associated Faculty, Professor of Astrophysical Sciences)

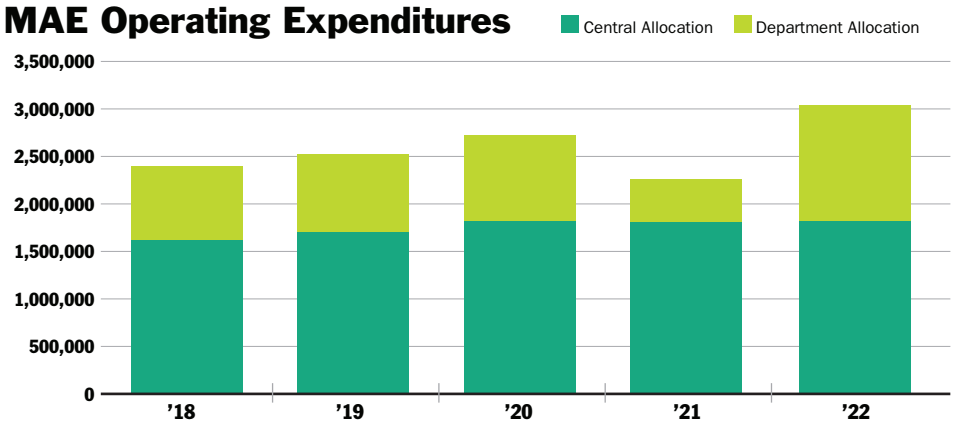
- 2021 Nasa Distinguished Service Award
- 2022 Election to American Philosophical Society

Howard Stone (Professor & Chair)

- 2022 Elected to the American Philosophical Society
- 2022 Elected as Foreign Member of the Royal Society of the United Kingdom

Szymon Suckewer (Professor, Emeritus)

- 2021 Elected to National Academy of Inventors (NAI)



Seminar Series

Beyond the classroom, student learning is enhanced through an expanding program of lectures, seminars, colloquia and conferences brought to the University. Leading scholars from outside the Princeton community give lectures about exciting, leading-edge research in fields related to mechanical and aerospace engineering.

Craig Arnold, MAE, Princeton University, *Ultra High-Speed Variable Focus Optics for Laser-Based Advanced Imaging and Manufacturing*

Elie R. Bou-Zeid, CEE, Princeton University, *Simulations of Flow and Heat Transfer Over Urban Terrain: Thermal Roughness Lengths and City-Scale Secondary Circulations*

Emily A. Carter, MAE, Princeton University, *Quantum Design of Materials for a Sustainable Future*

Edgar Choueiri, MAE, Princeton University, *High-Power Plasma Propulsion for Piloted Missions to the Moon and Mars*

John O. Dabiri, California Institute of Technology, *Baetjer Colloquium—Bioinspired Ocean Exploration*

Emily C. Davidson, CBE, Princeton University, *Hierarchical Control Over Polymer Assembly for Functional, Responsive Polymer Architectures*

Arthur Dogariu, MAE, Princeton University, *Ultrafast Optical Diagnostics for Aerospace Applications*

Amy Gladfelter, University of North Carolina, *Modes of Control of RNA-Protein Condensates*

Robert J. Goldston, Plasma, Princeton University, *New Developments in Fusion Energy*

Yiguang Ju, MAE, Princeton University, *Control of Plasma Chemistry and Dynamics for Low Carbon Energy Conversion*

Ralf I. Kaiser University of Hawaii at Manoa, *A Unified Framework on Molecular Mass Growth Processes to Polycyclic Aromatic Hydrocarbons - From Deep Space to Combustion Systems and Nanomaterials*

Andrej Košmrlj, MAE, Princeton University, *Pattern Formation in Biological Systems via Mechanical Instabilities and Phase Separation*

Julia M. Mikhailova, MAE, Princeton University, *Plasma Optics for Ultrafast High-Field Science*

Michele L. Sarazen, CBE, Princeton University, *Metal-Organic Frameworks (MOFs) As Catalysts and Catalyst Precursors For Small-Molecule Conversions*

Mary Caswell Stoddard, EEB, Princeton University, *Evolution and Engineering in the Avian World*

Corina E. Tarnita, EEB, Princeton University, *Lack of Synchronization: A Key for Collective Systems Robustness?*

Gabriel A. Vecchi, Geoscience, Princeton University, *Understanding Hurricanes: Past, Present and Future*

Gerard Wysocki, ECE, Princeton University, *Mid-IR and THz Chemical Sensing and Hyperspectral Imaging With Semiconductor Frequency Combs*

UNDERGRADUATE

Class of 2022 Senior Projects

Senior Thesis Projects are the culminating experience for the undergraduate mechanical and aerospace engineering programs. They participate, in teams, groups or individually, in a research or engineering project that includes elements of engineering design.

The Class of 2022 completed the following interesting and exciting year-long projects.

Individual Thesis Projects

Hayden Burt, *Subjective Listening Tests for the Evaluation of Generic, Mismatched, and Individualized Personal Sound Zone Filters*

Mathias Cross, *Modelling and Optimization of a Geoexchange Coaxial Bore Heat Exchanger*

Attila Delingat, *Performance Characterization of an Electric Motor for Marine Propulsion*

Margaret Donovan, *Streamlining the Data Management Plan for the Miniaturized Laser Heterodyne Radiometer(mini-LHR)*

Ricky Feig, *Visualizing Changes in Mean Radiant Temperature with the SMART Sensor*

Joseph Feng, *Autonomous robotic inspection of nuclear facilities with minimal memory for maximum security*

Grace Gong, *Launching Ultrathin Foil Floating Capabilities at the Princeton Space Physics Lab*

Tucker Hill, *Development of a Port Fuel Injection System Utilizing 3D Printed Components*

Bennett Holmes, *Gaussian Process Regression for Efficiently Approximating the Flow of the Circular Restricted Three-Body Problem*

Sydney Hsu, *Development of an Origami Deployable CubeSat Aeroshell*

Patrick Huang, *Optimization of Electric Vehicle Lithium-ion Battery Design Parameters for Stationary Storage Applications in the Electricity Grid*

Jackson Hunter, *Using Tendon-Based Control to Create a Hand and Forearm Prostheses Prototype*

Matthew Kellenberger, *Optimizing the Cooling System of an Electric Powered Speedboat*

Shay McBride, *Solid State Batteries in Industry with a Focus on eVTOL: an overview and a calculator*

Tavaris Noel, *The Design and Development of a Remote Controlled Skateboard*

Lucy Norton, *Vision-Based Control and Navigation of an Autonomous Underwater Vehicle in Crowded Environments*

An-Ya Olson, *On the Design of Efficient Global Search Algorithms for Spacecraft Trajectory Optimization Problems*

Annie Price, *Planar Laser Induced Fluorescence Measurements of CH2O in Ozone Assisted Cool Flames*

Lily Rezai, *Design and Development of a Compliant End Effector for a Pressure-Sensing Robotic Gripper*

Harry Shapiro: *Carbon-Adjusted Dispatch Optimization for Princeton's Campus Energy Plants*

Nathaniel Shields, *A Noninvasive Peripheral Neural Interface*

Miles Simpkins, *The Design and Manufacturing of a Composite UAV Airframe for Dynamic Soaring*

Navreeta Singh: *Exploring Engineered Desiccation Tolerance in Mammalian Cells*

Delan Stallworth, *The Future of Engineering Production: Electric Power and Additive Manufacturing*

Kevin Tong, *Survey, Design, and High-Altitude Testing of Novel CubeSat Earth Horizon Sensors*

Thomas Van Liere, *Design and Optimization of a Rear Wing for a Formula Hybrid Racecar*

Ned Williamson, *Characterization of 5.1kWh Lithium-Iron-Phosphate Electric Vehicle Battery Pack for High Performance Marine-Specific Loads and Applications*

Sarah Witzman, *Design of Robotic Mechanism for Rhythm Bots Art Installation*

Alfred Yoon, *Scalability of Graphene Carbon-Fiber Aerogel for Desalination*

Team or Group Projects

Ritvik Agnihotri and Nathan Yates, *Optimization of Drivetrain and Propellor Design for a Gas-to-electric Motor Conversion in Marine Application*

Jose Ambrocio Ayala Garcia and Sophie Chen, *Robotic Cutting of Biomembranes for Cartilage Replacement Surgery*

Yulissa Cantero, Leonardo Espinoza Zuniga, Izabella Moran and Mench Julia Santelices, *Martian Moon Investigation and Developmental Acquisition of Samples (MIDAS)*

Josh Coleman, Dayan Mitchell and Logan O'Donnell, *Low-Cost Jet Engine Design as a Basis for Stand-Alone Power Generation*

Nancy Diallo and Niklas Wegmann, *An Investigation into Effective Design Parameters for the Experimental Analysis of an Air-Breathing MPD Thruster in Very Low Earth Orbits*

Seth Freeman and Polina Zhilkina, *Ocean wave energy capture through ferrofluid sloshing*

Pranav Iyer and Ainil Norazman, *Automated Defect Detection: An End-to-End Pipeline from Data to Deployment*

Bethwel Kiplimo and Kenalpha Kipyegon, *The Air we Breathe: Design and Analysis of a Wireless, Integrated CO2Sensor For Air Quality Monitoring*

Thomas McBride and Yousuf Tariq-Shuaib, *Development of a Non-Assisted Rotating Detonation Engine*

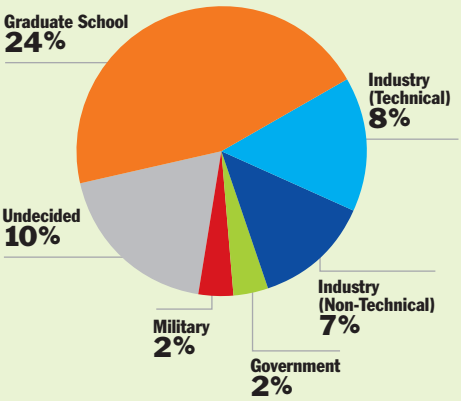
Senior Independent Work (One Semester Projects)

Justice Chukwuma, *Optimized Wheel Design for Traction and Travel over Noise*

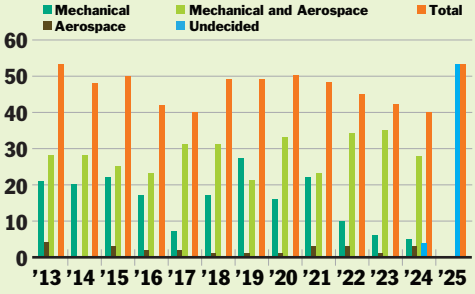
Lauren Howard, *Static Balancing of a 2Degree-of-Freedom Serial Manipulator with Torsional Wrapping Cams*

Jack Monaco, *Project Bird Brain: Development of an Avionics Package for a Robotic Ornithopter*

Post-Graduate Plans for Graduating Seniors



Actual Enrollment by Concentration by Class Year



MAE supports the education of 160 undergraduate students from the U.S. and around the world, preparing them for a career or further study. In addition to getting exposure to vast learning resources through our faculty and research staff, students also have the chance to apply their discipline to their own projects and/or collaborate with MAE classmates and students in other disciplines.

GRADUATE

Graduate Programs

The majority of outstanding technical problems in today's science and engineering fields require a multi-disciplinary research approach at the intersection of engineering, physics, chemistry, biological science, and applied mathematics. Our graduate students, who can earn a Ph.D. or MSE, stand at the center of these challenges. Through their research and study, they contribute new knowledge in mechanical and aerospace engineering to answer the challenges to important societal, scientific, and industrial problems.

2021-22 Graduate Students

Claudia Brunner
Advisor: Marcus Hultmark
Thesis: Unsteady aerodynamics with applications for wind turbines
Position: Postdoctoral Researcher, Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Welsey Chang
Advisor: Daniel Steingart
Thesis: Characterizing Chemo-Mechanical Behavior of Lithium Metal Batteries
Position: Postdoctoral Fellow, Columbia University, Department of Chemical Engineering

Timothy Chen
Advisor: Yiguang Ju and Egemen Kolemen
Thesis: In situ time-resolved laser diagnostics for plasma methane reforming
Position: Postdoctoral Appointee, Sandia National Laboratories, Albuquerque, New Mexico

Matthew Heinrich
Advisor: Daniel Cohen and Andrej Kosmrlj
Thesis: Macroscopic Tissue Growth, Expansion, and Collision: Biophysical Insights Toward Tissue Sheet Engineering Strategies
Position: Scientist, Process Development, Moderna Therapeutics, Norwood Massachusetts

Kelly Huang
Advisor: Marcus Hultmark
Thesis: Experimental Methods for Understanding Turbulence in the Lower Atmosphere
Position: Postdoctoral Fellow, University of Notre Dame

Kerry Klemmer
Advisor: Michael Mueller
Thesis: Physics-Based Uncertainty Quantification for Turbulent Flows
Position: Postdoctoral Associate, Massachusetts Institute of Technology

Julienne LaChance
Advisor: Daniel Cohen
Thesis: Machine Learning and Statistical Analysis of the Collective Behaviors of Large Tissues
Position: AI Research Scientist, II, SonyAI

Jinyoung Lee
Advisor: Michael Mueller
Thesis: Unified Manifold-Based Approach to Modeling Combustion-Affected Turbulence
Position: Postdoctoral Research Associate, Center for Exascale-enabled Scramjet Design, University of Illinois Urbana-Champaign, Illinois

Aaron Lemmer
Advisor: Jeremy Kasdin
Thesis: A Ferrofluid Deformable Mirror for Adaptive Optics
Position: Adaptive Optics Research Staff Member, Lawrence Livermore National Laboratory

Zirui Liu
Advisor: Chung Law
Thesis: Dynamics and Statistics of Cellular Instability in Laminar and Turbulent Expanding Flames
Position: Quantitative Researcher, Citadel Securities

Matthew New-Tolley
Advisor: Mikhail Shneider
Thesis: Modeling laser-gas interactions for aerospace applications
Position: Sensing HW Engineer, Apple Inc.

Sam Otto
Advisor: Clarence Rowley
Thesis: Advances in Data-Driven Modeling and Sensing for High-Dimensional Nonlinear Systems
Position: Postdoctoral Fellow, Princeton University

Tasman Powis
Advisor: Igor Kaganovich and Mikhail Shneider
Thesis: Particle Methods for Modeling Magnetospheric Diagnostics and Low-Temperature Plasma Physics
Position: Computational Research Associate, Princeton Plasma Physics Laboratory, Princeton, New Jersey

Juliane Preimesberger
Advisor: Craig Arnold
Thesis: Studying the Piezoelectrochemical Phenomenon Using Lithium-Ion Batteries
Position: Postdoctoral Researcher, National Renewable Energy Lab, Golden, Colorado

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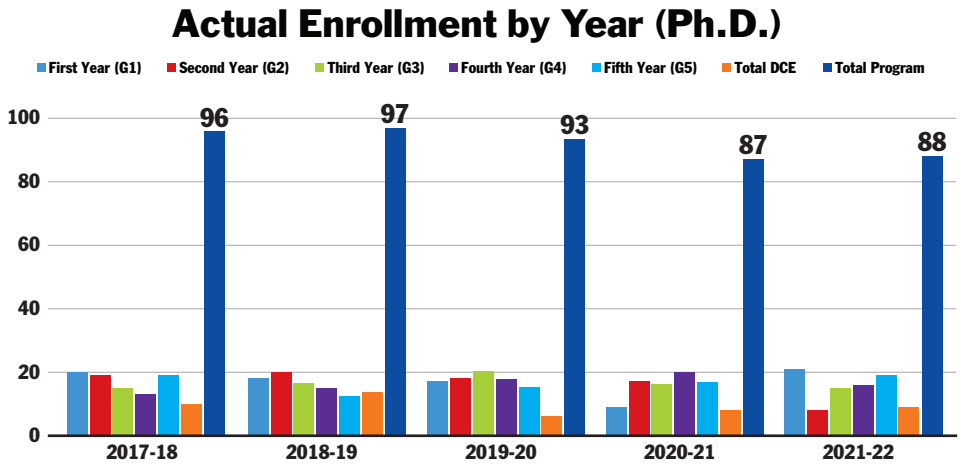

Lena Rosendahl
Advisor: Jonathan Cohen and Naomi Leonard
Thesis: The Multi-Particle Multi-Well (MPMW) Framework: A Quantum Framework Incorporating Attentional Capture, Representational Generality, and Arousal to Perceptual Choice Problems
Position: Senior Data Scientist, Mathematica Policy Research, Princeton, NJ

Daniel Ruth
Advisor: Luc Deike
Thesis: Bubble motion and break-up in turbulence: fluid mechanics affecting bubbles entrained by breaking waves
Position: Postdoctoral Fellow, ETH Zürich, Zürich, Switzerland

Jacobs Simmonds
Advisor: Yevgeny Raitses and Masaaki Yamada
Thesis: Studies of Thrust Density Limits in Hall Thrusters
Position: Technologist, NASA Jet Propulsion Laboratory

Vivian Steyert
Advisor: Clarence Rowley
Thesis: Uncovering Structure with Data-driven Reduced-order Modeling
Position: Robotics Technologist, Jet Propulsion Laboratory, Pasadena, CA

Yang Xia
Advisor: Mikko Haataja
Thesis: Computational study of structural phase transformations in ultrathin materials
Position: Associate Professor, Hunan University, Changsha, China

Nan Xue
Advisor: Howard Stone
Thesis: Gravity-induced flows: buoyancy-driven flows and interfacial thin-film flows
Position: Postdoctoral Fellow, ETH Zürich, Zürich, Switzerland

Professional Development Offerings and Programming

The Advisor/Advisee Relationship: How to Find the Right Advisor For You
Workshop for MAE First Year Graduate Students
Christine Murphey, Assistant Dean for Academic Affairs, The Graduate School, Princeton University

RIPE for Research: Respect, Inclusion, Professionalism, and Equity in Research
Laura Murray, Assistant Director, Learning Programs, McGraw Center for Teaching and Learning

MAE Research Day
MAE Graduate Student Presenters and Speakers:
Eric Lepowsky; Anvitha Sudhakar; Susan Redmond; Jiarong Wu; Xiaohan Du; Wilson Ricks

Long-Term Ph.D. Career Outcomes Data
Amy Pszczolkowski, Assistant Dean for Professional Development, The Graduate School, Princeton University

Center for Career Development: 101 for Grad Career Development
Gaeun Seo, Senior Associate Director, Graduate Student Career Development, Center for Career Development

Graduate Student Fellowships and Awards

DEPARTMENTAL:

Meghan Booker, *Crocco Award for Teaching Excellence*

Alec Farid, *Crocco Award for Teaching Excellence*

Cristian Lacey, *Crocco Award for Teaching Excellence*

Francisco Saenz, *Guggenheim Second Year Fellowship; Sayre Award for Academic Excellence*

Nathaniel Simon, *Guggenheim Second Year Fellowship; Sayre Award for Academic Excellence*

Gawoon Shim, *Britt and Eli Harari Fellowship*

Jiargong Wu, *Britt and Eli Harari Fellowship*

Kathleen VanderKam, *Phillips Second Year Fellowship*

Justin Lidard, *Summerfield Second Year Fellowship*

UNIVERSITY:

Kerry Kelmmer, *Charlotte Elizabeth Proctor Honorific Fellowship*

Udari Madhushani, *Harold W. Dodds Honorific Fellowship*

Daniel Shaw, *Mary and Randall Hack '69 Graduate Award for Water and the Environment*

Jiarong Wu, *Mary and Randall Hack '69 Graduate Award for Water and the Environment*

Niki Abbasi, *2020 Excellence in Teaching Award, Undergraduate and Graduate Engineering Counci*

Charlotte Cathcart, *2020 Excellence in Teaching Award, Undergraduate and Graduate Engineering Councill*

Anastasia Bizyaeva, *School of Engineering and Applied Science Award for Excellence*

Jinyoung Lee, *School of Engineering and Applied Science Award for Excellence*

EXTERNAL:

Niki Abbasi, *Natural Sciences and Engineering Research Council of Canada Graduate Fellowship*

Ian Gunady, *Department of Defense National Defense Science and Engineering Graduate Fellowship*

Eric Lepowsky, *National Science Foundation Graduate Research Fellowship Program*

Justin Lidard, *National Science Foundation Graduate Research Fellowship Program*

Megan Mazzatenta, *National Science Foundation Graduate Research Fellowship Program*

Daniel Pardo Medina, *National Science Foundation Graduate Research Fellowship Program*

Valeria Saro-Cortes, *National Science Foundation Graduate Research Fellowship Program*

Daniel Shaw, *National Science Foundation Graduate Research Fellowship Program*

Nathaniel Simon, *National Science Foundation Graduate Research Fellowship Program*

David Snyder, *National Science Foundation Graduate Research Fellowship Program*

Katie Wu, *National Science Foundation Graduate Research Fellowship Program*

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