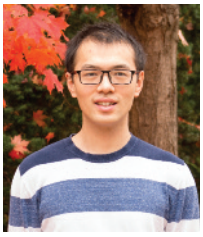
MAE: A YEAR IN REVIEW 2020–2021

Howard A. Stone, Chair

RISING TO EXTRAORDINARY CHALLENGES WITH RESILIENCE AND INNOVATION

MECHANICAL AND AEROSPACE ENGINEERING

CONTENTS



MAE BY THE NUMBERS

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

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

135 Undergraduate Students

1 Lecturer

59 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

23 Full-time Faculty

87 Graduate Students

17 Administrative & Technical Staff

5 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

Rising to Extraordinary Challenges with Resilience and Innovation

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

Resilience and innovation dominated the last year as students, staff, and faculty took on the extraordinary challenges posed by the COVID-19 pandemic. Teamwork was key: it allowed MAE to offer courses and seminars that made our year as normal as possible, given the abnormal conditions we experienced.

We began preparing for the 2020-2021 school year in the summer of 2020. Faculty and staff partnered with 21 MAE undergraduates to test and develop a variety of ways to deliver the best possible teaching and learning experiences remotely, along with the policies, processes, and technology to support them. Several classes with laboratory assignments developed student-tested lab kits for at-home use and/or remote-controlled lab experiments, in addition to exploring various ways technology could enhance the teaching and learning experience. These materials enhanced our fall course offerings.

A majority of students returned to campus for the spring semester, and we were better able to engage with students doing their senior projects, which, consistent with previous years, exhibited a significant amount of hard work and ingenuity.

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 23 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.*

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.

I imagine that some of the innovations from the past year will remain with us wherever they enhance our learning and research environments. I know students have been looking forward to coming back to campus in the fall, and the MAE faculty and staff have been too.

> "I imagine that some of the innovations from the past year will remain with us wherever they enhance our learning and research environments."

NEW FACULTY

In late 2020, MAE and the Andlinger Center for Energy and the Environment were thrilled to hire Kelsey Hatzell, who joined us as an Assistant Professor in July 2021. She is an expert in material science, batteries, and energy storage.

In the spring of 2021, we ran a junior faculty search to continue to strengthen and evolve MAE and in the next report we look forward to introducing new MAE faculty.

The future is bright, and we are looking forward to our next steps, especially as the campus comes back to life following the challenges posed by the pandemic these past 18 months. I look forward to seeing the hallways of MAE again brimming with activity. ♦

YEAR IN REVIEW

Here are some highlights of the many stories about MAE student, faculty, and staff achievements that grace the pages of the MAE website. For more details, please visit https://mae.princeton.edu/about-mae/news.

July 2020

From Princeton to planetary defense: Career Webinar with LLNL's Miller

MAE's Conversations with National Labs Webinar featured MAE alum Paul Miller, PhD, deputy division leader of the Design Physics Division at Lawrence Livermore National Laboratories. He discussed his path to LLNL, the culture and career opportunities there, and his planetary-defense project. (Note: It's against asteroids, not aliens!)

Leonard receives the 2020 John R. Ragazzini Education Award

The American Automatic Control Council recognized Naomi Ehrich Leonard, the Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering, for "outstanding contributions to control education through dedicated mentoring of undergraduate and graduate students, integration of research and education, and innovative curriculum development combining engineering and the arts."

Mueller named to *Combustion and Flame* (CNF) Editorial Board

Michael Mueller, associate professor and director of Graduate Studies, joined the board in January 2021. *CNF* is the flagship journal of the Combustion Institute and the field's premier publication.

August 2020

Kolemen receives 2020 Excellence in Fusion Engineering Award

The nonprofit Fusion Power Associates (FPA) organization honored Professor Egemen Kolemen with the early-career award for showing technical

July 2020

Gallimore '92 wins 2020 AIAA Wyld Propulsion Award

Alec D. Gallimore (MAE '92), the Robert J. Vlasic Dean of the College of Engineering at the University of Michigan, received the American Institute of Aeronautics and Astronautics (AIAA) award for outstanding achievement in the development and application of rocket propulsion systems. Gallimore founded U-M's Plasmadynamics and Electric Propulsion Laboratory (PEPL).

accomplishment and potential to become an exceptionally influential leader in the fusion field.

September 2020

Virtualizing software for remote classes during COVID-19

Irene Kopaliani — the Research Cloud Computing Architect at Princeton Research Computing — worked with a team of MAE and Office of Information Technology (OIT) staff to virtualize the software students needed to take the MAE 321: Mechanical Design class. In two weeks, Kopaliania and her team repackaged the software and files to make it accessible to students over the internet.

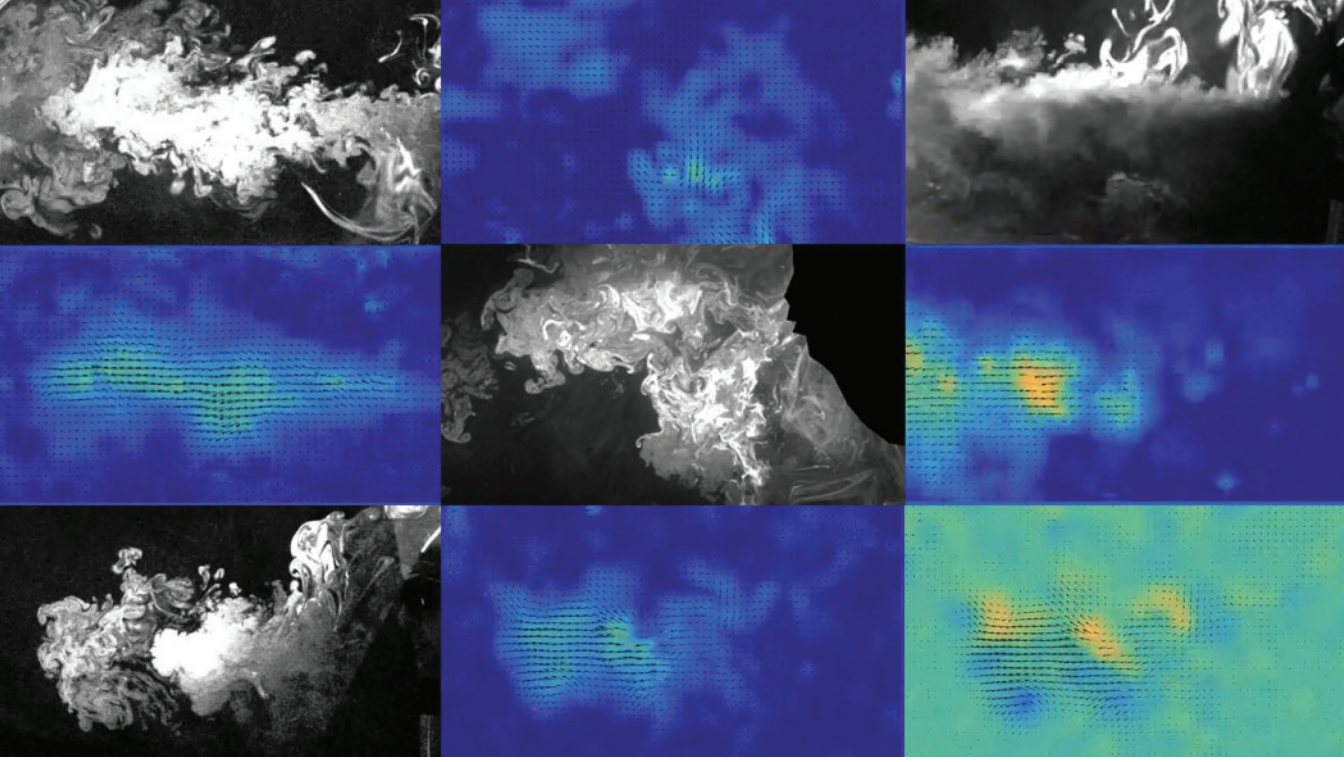
Hands-on learning at home

Over the summer of 2020, MAE faculty teamed up with 21 undergraduates to test and develop a variety of ways to deliver the best possible teaching and learning experiences remotely, along with the policies, processes, and technology to support them. Innovations included creating in-home lab kits of manipulatives for following along in real-time with demonstration lectures and remote-controlled lab experiments.

September 2020

Two alums make Princeton history with Major Gift

Kwanza Jones '93 and Jose E. Feliciano '94 donated $20 million in support of Princeton's goal to expand undergraduate enrollment by 10 percent and support access and inclusion. In recognition, two new dormitory buildings slated to be completed for the 2022-23 school year will be named in their honor at Princeton's two new residential colleges. The donation was the largest gift ever made by Latino and Black donors. Feliciano, co-founder and managing partner of the private investment firm Clearlake Capital Group, graduated with a bachelor's of science in MAE with high honors. Jones is a singer, entrepreneur, and philanthropist who majored in Public and International Affairs at Princeton and earned a law degree from Pepperdine University.



September 2020

Research finds ordinary conversation can spread tiny droplets, increasing COVID-19 risk

Professor Stone's Complex Fluids Group studied the "jet-like" airflow from regular conversation that quickly carries a spray of tiny droplets from a speaker's mouth across meters of an interior space. Stone is the Donald R. Dixon '69 and Elizabeth W. Dixon Professor of Mechanical and Aerospace Engineering and MAE department chair. The research was published in the Proceedings of the *National Academy of Science* (Sept. 25, 2020).

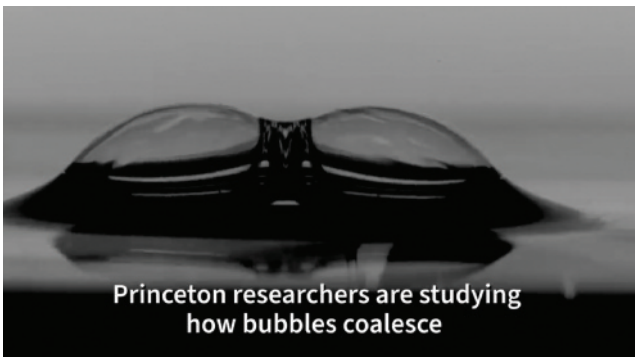
A new NSF award for developing plasma-assisted chemical reactors

The National Science Foundation's Emerging Frontiers & Multidisciplinary Activities program awarded the four-year, $2 million grant to develop smaller, efficient plasma-assisted chemical reactors to convert vented and stranded methane at oil and gas reservoirs into chemicals and liquid fuels. The principal investigator is CBE Professor Michele Sarazen, joined by co-principal investigators MAE Professor Ju, Stanford University Professor Xiaolin Zheng, and University of South Carolina Professors Tanvir Farouk and Lang Yuan. Professors Zheng and Farouk are former MAE combustion group graduates and postdocs.

October 2020

Watch two bubbles merging

In Luc Deike's MAE lab, grad student Daniel Shaw is working with bubbles to better understand what happens when they merge on the ocean's surface. The research provides insights into interactions between the ocean and the atmosphere, which is an important part of understanding the climate. It could also be applied to oil spill mitigation. See the slow-mo video on Princeton Engineering's LinkedIn page.



Hu '18 attends Rising Stars in ME workshop
MAE Alum Jingjie Hu '18 attended the career skills development program, designed for graduate students and postdocs considering academic careers. It lets them connect with a cohort of peers and engage with mentors through the program.

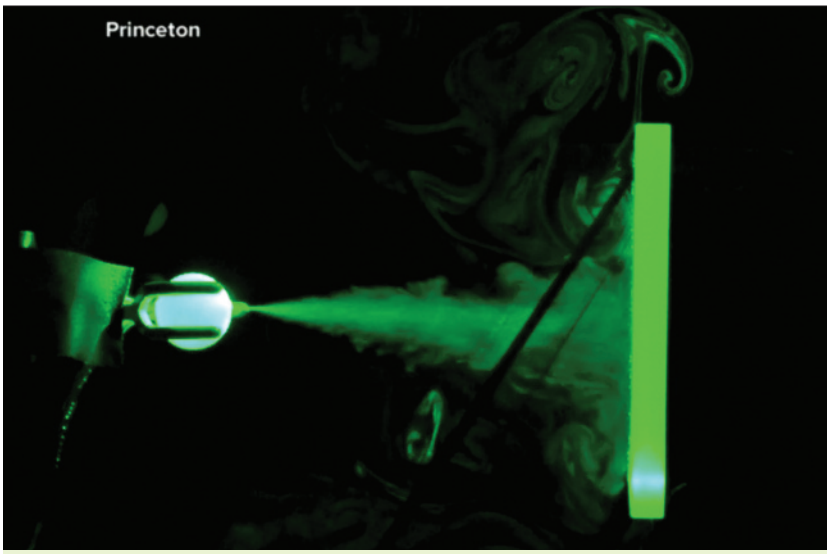
Dogariu named 2021 OSA Fellow
MAE Research Scholar Arthur Dogariu was honored by the Optical Society of America (OSA) for discovering and developing novel nonlinear spectroscopic techniques for remote sensing, with applications from medicine to national security.

New combustion models improve efficiency and accuracy
Professor Mueller's research team has developed a new way to model combustion that combines the rigor and generality of the computationally expensive models with the computational speed and efficiency of the simplified models. Two papers on the work appeared in the *Proceedings of the Combustion Institute*.

November 2020
Giraldo '87 named distinguished professor of applied mathematics at the Naval Postgraduate School
MAE Alum Frank Giraldo '87 also became department chairman of the Monterey, Calif., school in fall 2021 and published a book with Springer-Verlag in their Computational Science and Engineering Series: *An Introduction to Element-Based Galerkin Methods on Tensor-Product Bases*.

Princeton, U.S. Department of Energy formalize clean energy research exchanges
The agreement with the National Renewable Energy Laboratory (NREL) allows for an easy exchange of researchers and students to accelerate the development of clean energy technologies. The lab has been the country's flagship research center for sustainable energy since 1977, producing key breakthroughs in solar photovoltaics, biofuels, wind, and other clean energy areas. Professor Mueller was named faculty researcher and helped facilitate the research exchange agreement.

December 2020
Smits named Royal Aeronautical Society honorary fellow
Alexander Smits, the Eugene Higgins Professor Emeritus of Mechanical and Aerospace Engineering, was recognized with the honorary fellowship for his scientific leadership, most notably his pioneering contributions to the observation and understanding of wall turbulence in extreme Reynolds number and Mach number regimes.



December 2020
MAE team demos airflow patterns on "Good Morning America"
Professor Stone and graduate students Danielle Chase and Nan Xue showed ABC's "Good Morning America" viewers how simulated exhaled breaths passed up and over plexiglass sheets installed to ostensibly protect people in public spaces from COVID-19. While large droplets may be stopped, smaller droplets still circulate up and around the entire room, which is why masks and ventilation are so important.

Large but affordable effort needed for America to reach net-zero emissions by 2050
Princeton's Net Zero America project research shows that the U.S. could reach net-zero greenhouse gas emissions by 2050 using five existing technological pathways to decarbonize the nation's entire economy. The study details the costs (same as historical energy expenses) and how jobs and health would be affected in each state. The study was led by faculty and researchers at Princeton's Andlinger Center for Energy and the Environment in conjunction and High Meadows Environmental Institute (HMEI). MAE Assistant Professor Jesse Jenkins is one of the project leads.

Suckewer elected to National Academy of Inventors
Professor Emeritus Szymon Suckewer was one of the 175 prolific academic innovators from across the world to be honored with NAI Fellow status for inventions contributing to quality of life, economic development, and the welfare of society. His work focuses on laser technology and applications (including biomaterials and medical devices), spectroscopy, atomic processes in plasmas and gases, and development of a more efficient and higher performing ignition system for internal combustion engines.

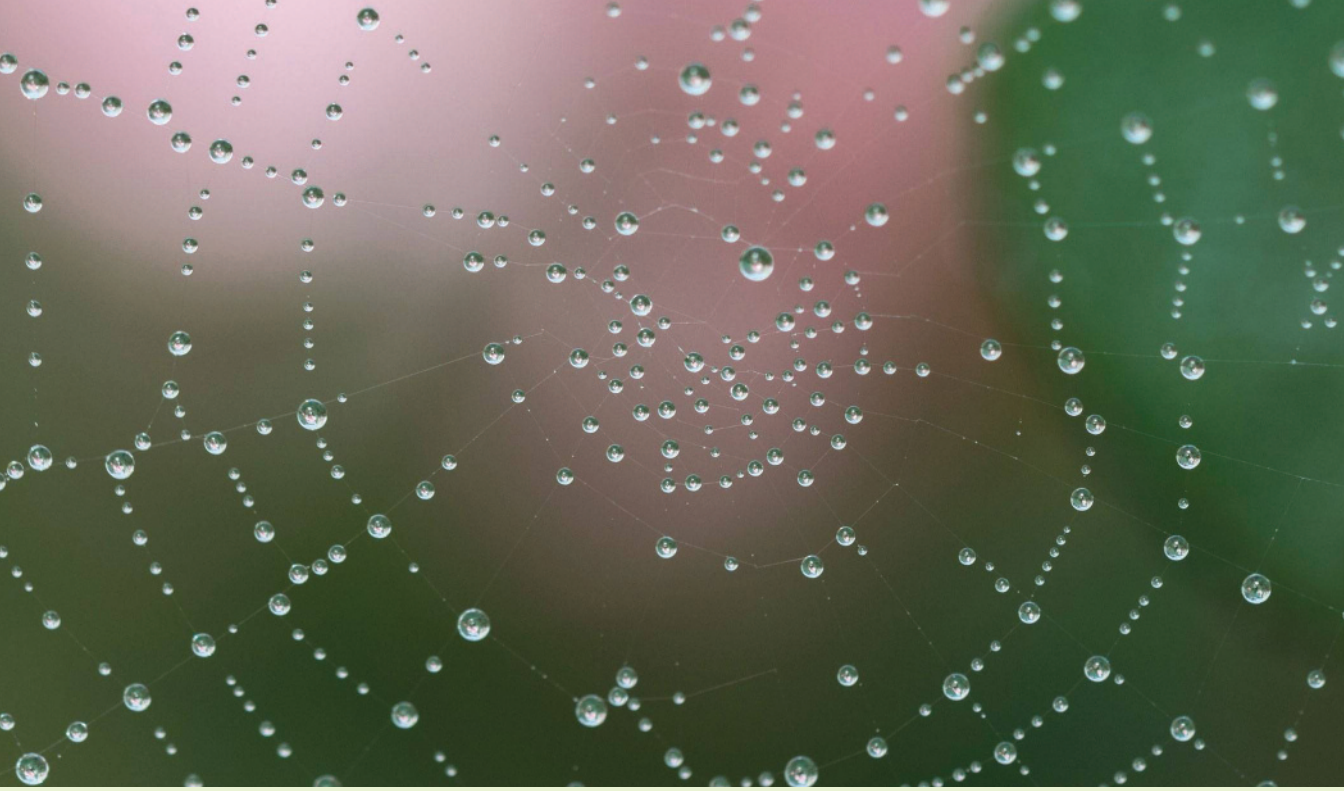
January 2021
Cookies illustrate materials science concepts at 5th grade virtual STEAM event
MAE graduate students demonstrated about different states of matter, diffusion, mixing, reversible mixing, and structure through the process of making meringue cookies. The Riverside Elementary School program was led by Nan Xue, Danielle Chase and Niki Abbasi. The event was planned by Tejas Dethe, Sheetal Ramsurrun and Niki Abbasi.

January 2021
Grasso named Knight of the French Republic
Visiting Professor Francesco Grasso, a global scholar in MAE, was honored with the decoration of Knight of the French Republic. The award is given to foreign individuals who were especially distinguished in their own field and lived in France.

Majumdar receives Young Faculty Researcher Award
Assistant Professor Anirudha Majumdar will receive support from the Toyota Research Institute for research exploring breakthroughs around difficult technological challenges in the areas of automated driving, robotics and machine assisted cognition (MAC).

Yang leads effort to understand carbon storage in soils
Judy Yang, former MAE doctoral fellow, was lead author of a *Nature Communications* report that explored carbon storage in soils. She is now assistant professor at the University of Minnesota, where she heads the Environmental Transport Lab.

Engineering, AI safeguard patient lives
Calibrating ventilator operations to individual patients can be complex. MAE Assistant Professor



February 2021

A spiderweb's dewdrops reveal the physics behind cell structures

The Stone group contributed to new findings that link fluid dynamics to spindle assembly in a cell. The research, entitled, "A hydrodynamic instability drives protein droplet formation on microtubules to nucleate branches," appeared in *Nature Physics*.

Daniel Cohen, Computer Science Professor Elad Hazan, and their team explored how AI can "learn" to adjust the ventilator by uncovering patterns in the data, which would guide its safe and efficient operation and lessen the burden on medical workers. It could also allow ventilators to be deployed in areas with shortages of expert operators.

Three MAE undergrads named Brooke Owens Fellows

Kristen Ahner '23 (Boeing), Christine Ohenzuwa '23 (Virgin Galactic), and An-Ya Olson '22 (Maxar) were named 2021 Brooke Owen Fellows. The program provides paid internships and executive mentorship to exceptional undergraduate women and gender-minority students in the aerospace field.

February 2021

Revolutionary, dirt-cheap sensors will replace $10,000 instruments

Professor Marcus Hultmark and three PhD students in his lab were testing — in water — a high-resolution temperature sensor that they had developed and used successfully for measurements in air. But then-graduate student Clayton Byers saw that the sensor was delivering backwards results: warm registered as cold and vice versa. Disappointment led to discovery as the team realized they were measuring fluid velocity, which has long proven much more difficult to measure than temperature. The team — Hultmark, Byers, Matt Fu, and Yuyang Fan —patented the technology and founded a company to develop the device into a widely available product.

Cohen given NSF CAREER award

Professor Cohen was honored for his work that integrates concepts from bioelectricity and sheepherding to "herd" large groups of living cells. He plans to use the research component of the award toward developing next-gen bioelectric devices for new purposes, such as accelerating injury healing and improved engineering of tissues and organs.

MAE and the election of new members to the NAE
MAE alumnus Lance Collins, Professor (emeritus) Fred Dryer, and former faculty member Wole Soboyejo were elected to the National Academy of Engineering (NAE), which is among the highest professional distinctions accorded to an engineer.

Majumdar given NSF CAREER award
The award will support Assistant Professor Majumdar's Intelligent Robot Motion (IRoM) lab. The research explores how to guarantee safety and generalization for learning-based control of robots such as micro aerial vehicles. The project includes organizing discussion forums about regulation/certification of learning-enabled robots, partnering with teacher preparation programs and others to engage high-school and undergraduate students in robotics, and widely disseminating materials from a new robotics course (MAE 345: Intro to Robotics) that uses hands-on labs with drones.

Jenkins: Future-proofing the Texas power grid
The state's massive blackouts in February 2021 were the result of a long-term, systemic failure to ensure against extreme weather, wrote Jesse Jenkins for the *New York Times* opinion section. Learning the lessons of the unusual event can help Americans prepare for the

March 2021

Ju speaks at the Stop Anti-Asian Crime Rally in Princeton
Professor Yiguang Ju protested the injustice of anti-Asian hate crimes, citing past and current violence against other ethnic and racial groups in the U.S. "Every time it happens, America gets hurt," he said. "Hate crimes and anti-immigrant [crimes] have no place in this country." The entire speech is available on his YouTube channel.

range of extreme weather that a changing climate will bring. Jenkins is an assistant professor with both MAE and the Andlinger Center for Energy and the Environment.

April 2021

Leonard: The "flock logic" of how groups move in nature, by design, and on stage

What do birds, robots, and dancers have in common? Professor Leonard recorded a TEDxKonstanz talk to explain how the choices of individuals produce the beautiful and complex movement seen in nature, design, and on stage. The study of animal groups has informed the design of robot teams, and both inspired the making of the improvisational dance piece entitled, "There Might Be Others." The virtual presentation was shared on the TEDx Talks YouTube Channel.

Dutta receives the MRS Graduate Student Silver Award and the Arthur Nowick Graduate Student Award

Nikita Dutta, a fifth-year MAE student and member of Professor Craig Arnold's lab, is pursuing a joint PhD in Materials Science at the Princeton Institute for the Science and Technology of Materials. Her research establishes cryo-EM as a viable technique to elucidate the nature of colloids in perovskite inks, a vital step toward a fundamental understanding of thin-film crystallization.

Professor Ju's group awarded the Distinguished Paper Award

Hongtao Zhong, Wenbin Xu, Dr. Xingqian Mao, Dr. Aric Rousso, Dr. Chao Yan, Professor Ju and their collaborators won the award for their paper, "Kinetic study of plasma-assisted n-dodecane/O2/N2 pyrolysis and oxidation in a nanosecond-pulsed discharge." The paper was selected from scientific papers presented during the 38th International Symposium on Combustion and was published in the *Proceedings of The Combustion Institute*. Professor Ju's group has received three distinguished paper awards in the last 10 years.

Mueller given Early Career Combustion Investigator Award

Professor Mueller was honored with the biennial award by the U.S. sections of the Combustion Institute (USSCI) at their national meeting.

Hatzell, battery and energy storage expert, joins MAE faculty

MAE announced that Kelsey Hatzell was joining Princeton as an assistant professor of MAE and the Andlinger Center for Energy and the Environment, effective July 1, 2021. She came from Vanderbilt University where she was an assistant professor of mechanical engineering, assistant professor of chemical and biomolecular engineering and led the "Inks and Interfaces" lab.

May 2021

Stone honored for graduate student mentorships

Professor Stone received the Graduate Mentoring Award from the McGraw Center for Teaching and Learning. Nominations made by his current and former students lauded his willingness to work through difficult problems with students in the classroom or the lab, his encouragement of their independence, and excellence in teaching and mentorship.

June 2021

Chang Receives 2021 Electrochemical Society Fellowship

PhD student Wesley Chang was awarded the society's F. M. Becket Fellowship for his work to understand the chemo-mechanical behavior of lithium metal anodes with techniques including operando acoustic transmission.

* * *

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

STUDENT PROFILES

Michael Hauge:

Solving Spacecraft Challenges, From Launch to Interplanetary Travel

DEGREE: BSE SPECIALTY: MAE

On Feb. 18, 2021, Michael Hauge and his student colleagues from around the country were exuberant on their Zoom call as NASA live-streamed the Perseverance rover landing on Mars.

All had worked at NASA's Jet Propulsion Laboratory (JPL) in 2019 and some had worked on the rover that was part of the Mars Exploration Program.

"It was very exciting to witness their work in action," said Hauge, who worked on the JPL's WFIRST Coronagraph Instrument team. He characterized and tested samples of black silicon to improve the manufacturing process of ultra-dark materials that enable coronagraphs to absorb as much unwanted light as possible and help reveal planets orbiting a star.

Spacecraft Fascination: From Theory to Engineering

Hauge, who grew up in Westfield, N.J., became fascinated by space technology after seeing a 1960s-era Mercury one-man space capsule at the National Air and Space Museum in Washington, D.C. during a school visit.

"It looked like a bucket made of bolts, metal and rivets, and I thought, 'This thing right here took a person to space, and I'm standing right in front of it,'" Hauge says. "It was an object of fascination for me."

Before his sophomore year at Princeton, a 10-week MAE summer internship with a research group in the High Contrast Imaging Laboratory (HCI Lab) clinched his decision to major in MAE. Hauge used his programming skills to integrate electrical, optical and mechanical components into a Python-based hardware-in-the-loop simulation of Starshade-telescope alignment and other dynamics.

The Starshade, being developed by JPL and Northrop Grumman, flies thousands of miles in front of a space telescope, unfurling petals to eclipse a star as needed to reveal exoplanets orbiting around it.

Then, early in his sophomore year, Hauge worked on the Princeton ThinSat Team led by Mike Galvin, who met Hauge during the summer internship and became his mentor over the last four years.

The program lets undergraduates develop a launchable ThinSat satellite in less than one year. These devices are about the size of a slice of bread and transmit scientific sensor data from low Earth orbit before burning up in the atmosphere in 4 to 7 days.

Hauge fabricated circuit board components for the electronics payload, which is designed to test the survivability of rapidly prototyped circuits in launch and space environments. The ThinSat he worked on was launched on Feb. 20, two days after the Perseverance rover Mars landing.

Full Tilt Ahead

In 2020, Hauge worked remotely as a summertime engineering intern at Venturi Astrolab, a California-based aerospace startup, through the Matthew Isakowitz Fellowship Program. He used his computational and design skills to analyze power, communications and thermal management systems related to Astrolab's commercial lunar rover and did detailed mechanical design of joints and other rover parts.

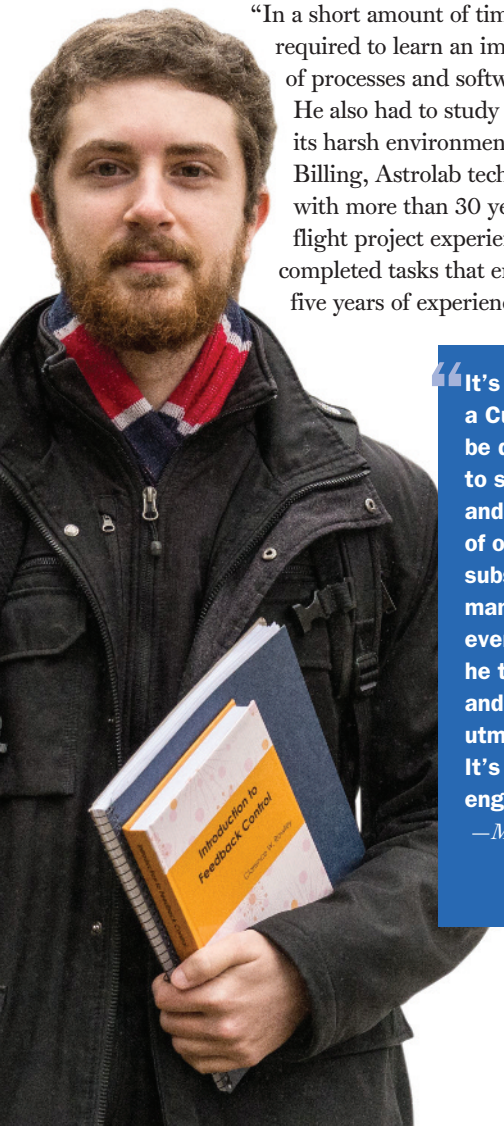
"In a short amount of time, Michael was required to learn an immense number of processes and software tools. He also had to study the moon and its harsh environment," says Rius Billing, Astrolab technical fellow with more than 30 years of space flight project experience. "He completed tasks that engineers with five years of experience would have trouble finishing as quickly and thoroughly as he did, especially in such a short time frame."

"It was an incredible experience to learn from Rius and everyone on the team," Hauge notes. "It's fascinating to see firsthand how decisions are made, the nitty-gritty details, all the trade-offs and how professional engineers work through these problems."

Hauge's independent project was designing a CubeSat frame that could be manufactured in-house by students for a fraction of the commercial cost. CubeSats are miniature satellites that are larger and more advanced than ThinSats.

"It's no easy feat to develop a CubeSat frame that can be demonstrated by analysis to survive a violent launch and also accommodate all of our other CubeSat subsystems in a specified manner," says Galvin. "Like with everything Michael does, he took the bull by the horns and approached it with the utmost professionalism. It's like he's a professional engineer already."

For his undergraduate senior thesis, Hauge created an advanced MATLAB-based software tool to simulate the attitude control of the CubeSat in a novel, low-cost way.



> **"It's no easy feat to develop a CubeSat frame that can be demonstrated by analysis to survive a violent launch and also accommodate all of our other CubeSat subsystems in a specified manner. Like with everything Michael does, he took the bull by the horns and approached it with the utmost professionalism. It's like he's a professional engineer already."**
>
> *—Mike Galvin, technical support staff, HCL Lab, and Hauge's advisor/mentor*

"In one semester, Michael basically wrote his own version of an orbital dynamics simulator that's more advanced than most comparable software packages on the market," says Galvin, who plans to share Hauge's paper as an open-source thesis at CubeSat conferences.

As for his next plans, Hauge is considering graduate school, still intrigued by the stars, moon and planets, but moving forward in aerospace engineering as the vehicle of his passion.

"Theoretical science can be exciting — you're always learning and discovering new things," Hauge says. "But it's very appealing to be able to build something that's real and tangible." ♦

Anvitha Sudhakar:

The Mechanics of Living Shapes

DEGREE: PhD (SECOND YEAR) RESEARCH AREA: MATERIALS SCIENCE

For Anvitha Sudhakar, inspiration and motivation starts at home, more than 8,000 miles away.

She hails from Bangalore, India, where her mother was from "a network of moms" — mothers who pushed daughters who historically had difficulty gaining financial independence.

"This is still a problem in India," says Sudhakar, who expects to complete her MAE PhD in 2024. "Mom was always encouraging me to study harder."

And it worked. After graduating in the 96th percentile at the National Public School Rajajinagar in Bangalore in 2015, Sudhakar gained her bachelor of technology degree with honors in mechanical engineering from the prestigious Indian Institute of Technology (IIT) in Mumbai in 2019.

She took the long trip to the northeastern U.S. after her junior undergraduate year as part of Princeton's International Student Internship Program (ISIP). She could have stayed in India but felt that having graduated from the best school in her homeland, she needed a greater challenge. She liked Princeton's labs and that her program at Princeton is project- rather than syllabus-based.

She had many interests while an undergraduate, including robotics and being on the Technical Team at IIT that developed an unmanned Autonomous Underwater Vehicle. Directed by coding she wrote, the robot competed in the annual Robosub competition conducted by the U.S. Office of Naval Research in San Diego. That transitioned led to an interest in solid mechanics. "I honed in on the mechanics of biological science as what I wanted to pursue my PhD in," she says.

She calls her undergraduate pursuits "random" but valuable: "But it got me to where I ultimately am today."

Her research with Princeton Professor Andrej Košmrlj's group has two broad directions: studying how mechanical processes drive shape-formation in biological systems and using similar mechanical processes to design shape-shifting structures.

One of her current projects was to make a computational model of alveoli formation in lizard lungs during embryonic development. This will help to understand the underlying mechanisms that govern lung development and will be used to build a platform that makes artificial alveoli.

The project is being funded by the Eric and Wendy Schmidt Transformative Technology fund. Schmidt — a Princeton alum and former executive chairman of Alphabet, Google's parent company — and his wife started this fund in 2009 for the invention, development and utilization of cutting-edge technology that has the capacity to transform research in the natural sciences and engineering.

"Anvitha embraced the interdisciplinary nature of her work, and she is always happy to learn new topics from disparate disciplines," says her advisor, Assistant Professor Andrej Košmrlj. "She learned how to effectively communicate with biologists and architects. She also enjoys the computational challenges associated with her work."

Her other project uses the mechanics of biological development to model self-folding of origami/kirigame structures. This model

will be used to design high-performance, self-morphing structures that are made from bio-inspired materials to make them lightweight and energy efficient. The project is funded by the National Science Foundation grant for Future Manufacturing.

There are, of course, always disruptions. Like a global pandemic.

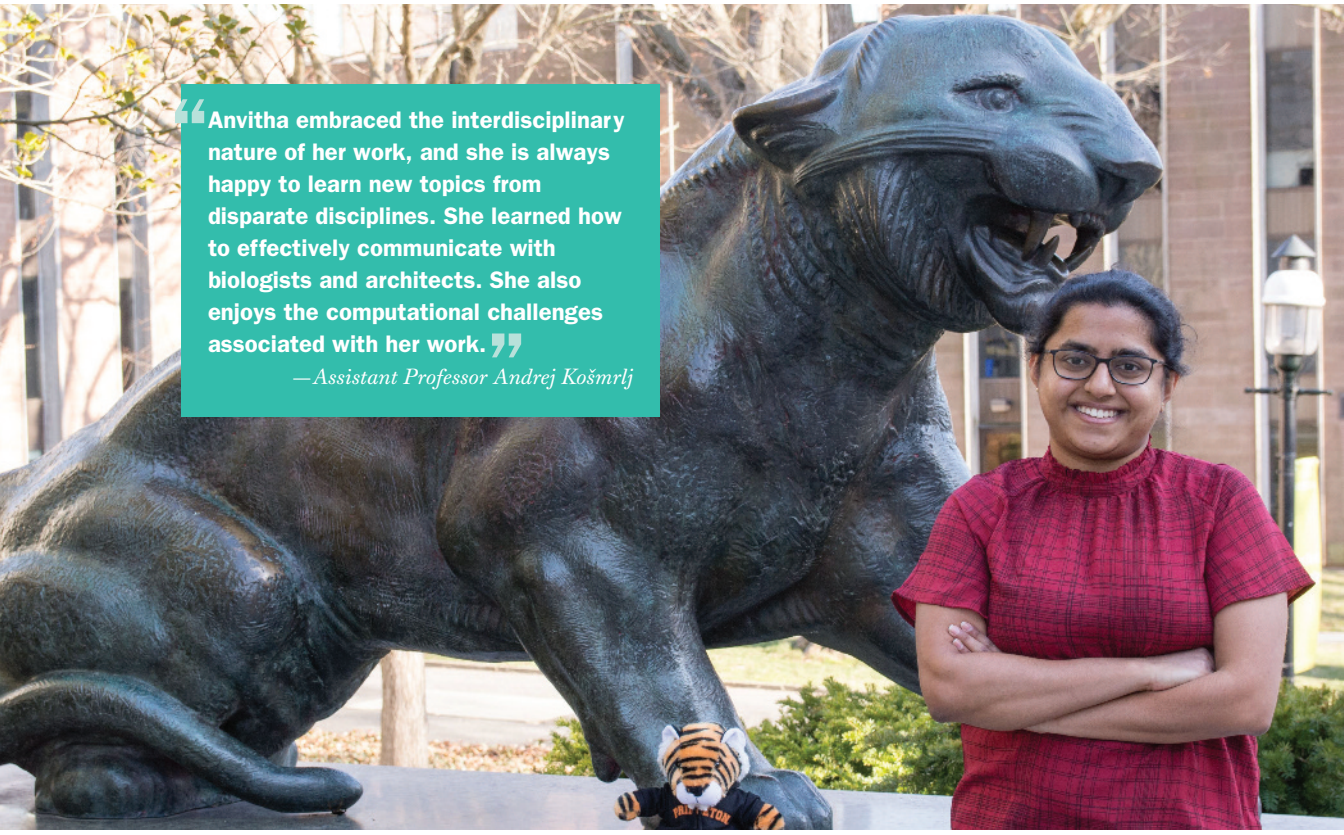
In March of last year, Sudhakar was living in the graduate college but didn't want to stay. When COVID-19 struck, she moved to an apartment on Nassau Street. And, she hadn't seen her family since she started at Princeton in the fall of 2019. (Note: She was able to visit home in the summer of 2020.)

"It was definitely hard," she says, especially since a trip to India had to be canceled. "Then I had exams and I couldn't book a trip." She has figured out the logistics of communicating with her mom, dad, and brother back home. Since they are $9\frac{1}{2}$ hours ahead of her, she called home just before she went to bed, around the time her family starts their day in India. She was homesick, but the calls helped.

After completing her doctorate, Sudhakar plans on a career in industry. She had considered teaching and then becoming a tenured professor but is drawn to the high-quality research she could do in industry, such as computational work with mechanical systems. "I'd like to use software to solve mechanical engineering problems."

But, it mostly comes back to mom. Coming from a family of rural farmers, Sudhakar's mother grew up in a rural area and didn't learn English, which hindered her academically. But she was able to influence Sudhakar and her younger brother, a senior in high school, who, she says, "also has inclinations towards science and engineering."

About her mother and the limitations she grew up with, Sudhakar simply says, "I can't believe she was able to do what she did." ♦



"Anvitha embraced the interdisciplinary nature of her work, and she is always happy to learn new topics from disparate disciplines. She learned how to effectively communicate with biologists and architects. She also enjoys the computational challenges associated with her work."

—Assistant Professor Andrej Košmrlj

Hongtao Zhong:

Search for a Larger World Leads to Pioneering Plasma Chemistry Research at Princeton

DEGREE: PhD (FOURTH YEAR) RESEARCH AREA: PROPULSION AND ENERGY SCIENCES

Hongtao Zhong was raised in a small town in the midst of mountains in Southeastern China by parents who encouraged him to explore his surroundings.

By middle school, he knew he wanted to expand his horizons further through his studies.

After attending one of the most prestigious high schools some 130 miles from his home, he went to Tsinghua University, a world-renowned research school in Beijing and earned two bachelor's degrees: one in energy and power engineering and the other in economics.

"These experiences changed me on so many levels and allowed me to explore a larger world," he says.

While at Tsinghua, he did a summer research program at the University of Cambridge, where he explored laser diagnostics for the first time. His research group used lasers to measure flow variables, such as velocity and temperature, which are important details in understanding and advancing energy conversion for cleaner combustion.

The technology also is a powerful tool for studying chemical kinetics, a subdiscipline of physical chemistry that investigates the rates of chemical reactions.

"Before Princeton, my understanding of chemical kinetics was very limited," he says. "Only when I was exposed to the experimental projects here did I really begin to appreciate the importance of chemical kinetics."

Zhong's chemical kinetics work plays an integral role in Professor Yiguang Ju's lab. He is researching how plasma can optimize combustion and convert carbon dioxide and other gases into value-added chemicals and fuels.

"Hongtao is an immensely talented and outstanding student who has made significant contributions as part of my research team," says Professor Ju, Robert Porter Patterson Professor and Zhong's advisor.

Plasma's Potential

Plasma is ionized gas that is electrically conductive and strongly affected by magnetic fields. The stars, some of the Earth's atmospheric layers, and lightening are composed of naturally occurring plasmas. Manmade plasma is used in many applications, from neon signs and fluorescent lights to electronics and rocket propulsion.

Scientists are increasingly studying plasma's ability to enhance reaction rates, which means that plasma could have a big impact on augmenting renewable energy, vehicle engine efficiency and emission reduction, and sustainable chemical production.

Plasma, also called ionized gas, is the fourth state of matter after solid, liquid, and gas, all of which are based on the transitional phases that rely on temperature. As the temperature in a gas increases, the thermal energy eventually breaks the bonds between the atoms' electrons and nuclei, resulting in free-floating electrons and positive ions.

> **"The idea and the analysis of the plasma chemistry instability are innovative and will open new opportunities to control plasma instability in chemicals and materials processing as well as for advanced engine ignition."**
>
> *—Robert Porter Patterson Professor Yiguang Ju*

Plasmas can be completely ionized, becoming so hot that every molecule dissociates, leading to an equilibrium state in which the thermal energy among all the particles is roughly the same. Others can be "cold" or nonthermal, though still sizzling by human standards. A fluorescent lamp is an example of partially or weakly ionized plasmas that have a range of temperatures.

"The electron temperature is about 10,000 Kelvin [around 17,540 degrees Fahrenheit], while the rest of the gas — ions and neutral atoms — stay barely above room temperature," Zhong explains. "You can touch the [outside of a] fluorescent lamp with no problem."

Plasma Chemical Instability Insights

Zhong's core research focuses on how chemistry impacts weakly ionized plasma and causes the instability that makes it difficult to contain and control. While this instability has largely been attributed to plasma's Joule heating, Zhong recently discovered that chemical interactions also play a role in plasma instability.

In pioneering work with his research team, he developed a theoretical formulation and numerical model for plasma chemistry instability, which was later confirmed by a European research group. He proved that chemical kinetics involving electron attachment, electron-impact reactions, and plasma-assisted low temperature fuel-oxidation reactions can dramatically change when plasma becomes unstable.

Zhong also developed an analysis method, based on computational singular perturbation theory, to identify key chemical species and elementary reactions that contribute to plasma instability.

"The idea and the analysis of the plasma chemistry instability are innovative and will open new opportunities to control plasma instability in chemicals and materials processing as well as for advanced engine ignition," Professor Ju says.

Zhong and his fellow lab collaborators' work has led to exciting U.S.-funded projects. In 2019, Princeton and Ohio State University were awarded $3 million for a U.S. Department of Energy Low Temperature Plasma Science Center, one of only two of its kind in the country. In 2020, Princeton was awarded $2 million from the National Science Foundation's Emerging Frontiers in Research and Innovation program to study interfaces between plasma, catalysts, and reactor design for natural gas conversion to liquid products. ♦

Julienne LaChance:

Sharing Accessible Ventilator Plans with the World

DEGREE: PhD (FIFTH YEAR) RESEARCH AREA: CONTROL, ROBOTICS AND DYNAMICAL SYSTEMS

In the middle of the night during the start of the COVID-19 pandemic, Julienne LaChance hunkered down in an upstate New York garage trying to solve a design problem.

She and her group had not had a full night of sleep since the COVID-19 crisis hit the U.S. but they felt more focused and inspired than ever. Their once-fun DIY workshop for weekend blacksmithing projects became a workshop for designing an easy-to-manufacture ventilator prototype.

"This project has been inspiring in a time of great uncertainty and worry," said LaChance during the height of the project last year. "We read the news every day and hear about how bad it is out there, especially in New York City. We are all consumed with wanting to find some way to help."

When news broke in mid-March 2020 that personal protective equipment (PPE) was in short supply, many Princeton graduate students and professors went to work finding unique ways to manufacture lifesaving equipment for health care workers.

While helping to fabricate face shields, LaChance began discussing the anticipated ventilator shortage with Dan Notterman, MD, Princeton professor of molecular biology and a former pediatrician who worked closely with nearly 150 ICUs in the tri-state area. LaChance refocused her efforts on designing a ventilator that could use off-the-shelf parts and could be made anywhere.

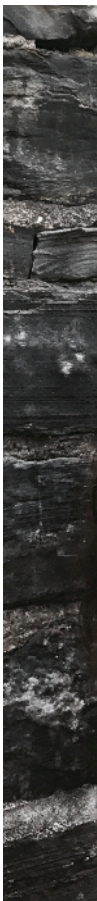
"The project is all about rapid assembly and deployment," she said. "It has been a fast-paced whirlwind involving little sleep. Within two weeks we went from knowing very little about ventilators, to having an automated, breathing prototype."

The project's goal was to create as many ventilators for critical-care patients as possible.

"While a hospital in a wealthy area like Princeton has about 40 ventilators, the facility where my friend in Brazil lives has none," she explained. "My biggest priority is making sure people in other countries will be able to replicate the design. We want to create a low-cost version of our prototype and rapidly deploy these devices so people can start building them immediately."

The framing is made of 80/20, aka "engineering LEGOs." The ventilator design used both off-the-shelf parts and 3D printed components. And, to save time, the team used a Raspberry Pi computer system to operate the ventilator. Instead of writing original code, they can plug and program all of the sensors into an existing operating system. The group repurposed oxygen and flow sensors normally used in automobiles.

Dr. Notterman helped the team understand the design requirements for a critical care ventilator. He also advised the post docs on building and replicating a shadow project of the device. In addition, LaChance and her team met with a senior staff member at ANSI, which controls the ISO engineering standards for the U.S. They provided technical specifications, such as the type of alarms and hospital connectors, that the ventilators need.



LaChance's group poured their hearts and their own money into the passion project until Princeton began to fund it about one month in.

"We knew it would take time to get the funding approved and the longer we waited the more people would suffer. We did not want to waste time, so we decided to pay for it ourselves," she said.

Surprisingly, LaChance did not have any biomedical engineering experience before the ventilator project. Her previous work at Princeton involved machine learning and computer vision. In particular, her lab studies collective behaviors in cells and how they organize themselves into living tissues. By stimulating living tissues with an electrical current, they are learning how to "drive" cells to specific areas, which would allow wounds to heal faster and more cleanly.

Prior to coming to Princeton, LaChance worked in New York City as a firmware engineer and programmer at MakerBot Industries, and then at General Electric's Global Research Center, designing jet engines and building tools for other design engineers. She received her undergraduate and master's degrees from Rensselaer Polytechnic Institute. She also had a variety of engineering internships, working on everything from submarines and helicopters to smart grid optimization.

"Julie is a fantastic researcher who has been pushing the project hard from the beginning, despite needing to do much of the early prototyping in her garage before transitioning it to the lab," said Assistant Professor Daniel Cohen, her advisor. "She really leveraged all of her skillsets and experience in the industry to move things forward, including going to bat for the DIY community by helping to get international agencies to release key design standards for ventilators to the public to help improve the quality, safety, and accessibility of DIY efforts. She even set up a YouTube channel to go through how to spec ventilator parts and what design criteria matter — truly the bread and butter of MAE! This project is a great example of Julie's values as it spans good design, open hardware, and engineering for the public good, and she did a fantastic job here."

Despite her wide-ranging background, the ventilator project was an incomparable learning experience, she said. Every aspect of engineering from flow control to electrical engineering to coding has been involved. The project has pushed her to seriously consider a future in research and design after graduation.

"This has been a unique experience, unlike anything I have ever done before," she said. "Because of the quarantine, there is this sense that nothing else in the world matters but getting this project to work. It is incredible to be a part of something so worthwhile." ♦

"She really leveraged all of her skillsets and experience in the industry to move things forward...This project is a great example of Julie's values as it spans good design, open hardware, and engineering for the public good, and she did a fantastic job here."

—Assistant Professor Daniel Cohen

FACULTY

Meet the People

Every day, the people of MAE harness their vast expertise and insatiable curiosity to improve how human beings interact with the world through the creative science of engineering. Our faculty cultivate the unique matrix of lessons and research through which both discoveries and student potential can thrive.

Professor
Craig Arnold
Edgar Choueiri
Mikko Haataja
Yiguang Ju
Chung (Ed) Law
Naomi Leonard Michael Littman
Luigi Martinelli Clarence Rowley
Howard Stone, *Chair*

Associate Professor Alexander Glaser Marcus Hultmark
Michael Mueller
Daniel Nosenchuck

Assistant Professor
Daniel Cohen
Luc Deike
Jesse Jenkins
Egemen Koleman Andrej Kosmrlj
Ani Majumdar
Julia Mikhailova

Lecturer
Lamyaa El-Gabry
Glenn Northey (part-time)
Christine Allen-Blanchette (part-time)

Visiting Professor
Francesco Grasso (part-time)

Emeritus with Research Appointment
Emily Carter
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*
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
Lamyaa El-Gabry
Yiguang Ju
Andrej Kosmrlj
Luigi Martinelli
Alex Glaser, *Ex-officio*

Seminar Committee:
Mikko Haataja, *Chair*
Edgar Choueiri
Luc Deike
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
Theresa Russo (acting), *Ex-officio*
Howard Stone, *Ex-officio*
Jennifer Widdis, *Ex-officio*
Katerina Zara, *Ex-officio*

Sabbaticals:
Fall 2020: Alex Glaser, Yiguang Ju
Spring 2021: Alex Glaser

Teaching Schedule Coordinators:
Michael Littman
Alex Glaser
Katerina Zara
Theresa Russo (acting), *Ex-officio*
Jo Ann Love, *Ex-officio*

First Year Advisers:
Daniel Cohen
Lamyaa El-Gabry
Mikko Haataja
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 Manager
Jonathan Prevost

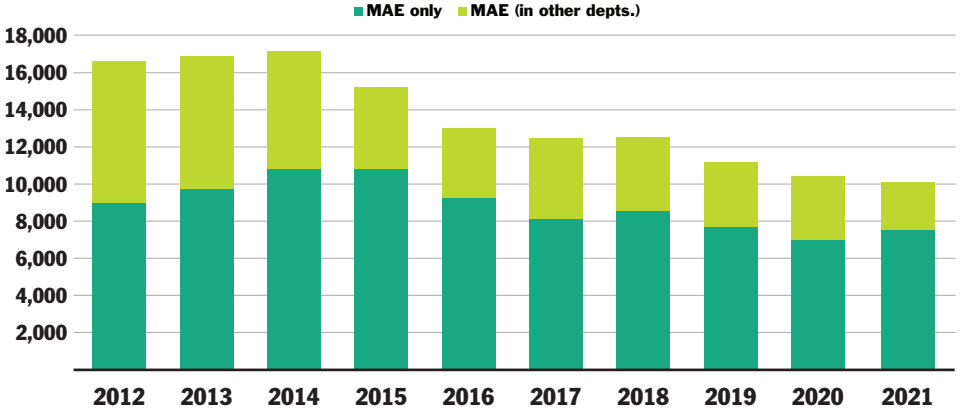
Chemical Hygiene Officer
Michael Littman

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

Craig Arnold (Professor)

- 2021 Reappointed to the National Materials and Manufacturing Board of the National Academies

Emily Carter (Professor, Emeritus)

- 2020 Brumley D. Pritchett Lecturer, Georgia Institute of Technology, School of Materials Science and Engineering

Daniel Cohen (Assistant Professor)

- 2021 NSF Career

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

- 2021 Plenary Lecturer, The 38th International Symposium on Combustion, The Combustion Institute (International)
- 2021 Distinguished Paper Award, The 38th International Symposium on Combustion, The Combustion Institute
- 2021 AIAA Propellants & Combustion Award, the American Institute of Aeronautics and Astronautics (AIAA)

Egemen Kolemen (Assistant Professor, joint with PPPL & the Andlinger Center)

- 2020 David J. Rose Excellence in Fusion Engineering Award

C.K. (Ed) Law (Professor)

- 2021 Distinguished Paper Award, 38th International Symposium on Combustion

Anirudha Majumdar (Assistant Professor)

- 2021 NSF CAREER award
- 2021 Excellence in Teaching Award, Princeton School of Engineering and Applied Science

Michael Mueller (Associate Professor)

- 2020 Princeton Engineering Commendation List for Outstanding Teaching, Spring
- 2021 Early Career Combustion Investigator Award, United States Sections of The Combustion Institute

Alexander Smits (Professor, Emeritus)

- 2020 Honorary Fellow, Royal Aeronautical Society (RAeS)
- 2020 Fellow, American Academy of Arts & Sciences (AAAS)
- 2020 The Batchelor Prize in Fluid Mechanics (IUTAM/CUP)

Howard Stone (Professor & Chair)

- 2020 ASME Fluids Engineering Award, Orlando, FL
- 2021 Graduate Mentoring Award from the McGraw Center for Teaching and Learning, Princeton University
- 2021 Burgers Lecture at the Burgers Symposium 2021 (annual meeting of the JM Burgerscentrum), The Netherlands
- 2021 Warren K. Lewis Lectureship, Department of Chemical Engineering, MIT
- 2021 National Academy of Sciences, Class III Secretary

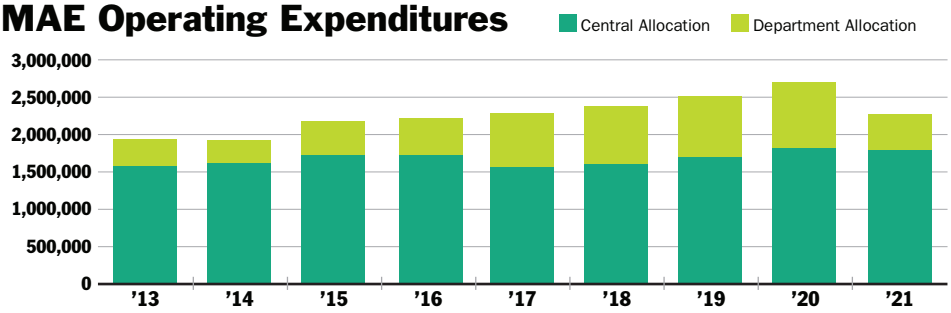
Szymon Suckewer (Professor, Emeritus)

- 2020 Elected to National Academy of Inventors (NAI)

Department Personnel (as of September 1)

Faculty	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Professor	15	13	12	11	11	10
Associate	2	3	4	6	4	4
Assistant	7	6	7	6	7	7
Other			1	1	1	1
Subtotal	**24**	**22**	**24**	**24**	**23**	**22**
Professional Researchers	50	52	43	50	47	45
Visiting Researchers	12	13	19	17	8	14
Technical Research	5.5	5.5	4	4	3	4
Technical Teaching	4	4	4	4	4	4
Administrative	11.5	12	11	11	13	12
TOTAL	**107**	**108.5**	**105**	**110**	**98**	**101**

MAE Operating Expenditures



Department 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.

Kareem Ahmed, University of Central Florida, *High-Speed Compressible Turbulent Combustion from Jet Engines to Exploding Stars*

Achintya Bhowmik, Stanford University, *Transforming Hearing Aids into Multifunctional Health and Communication Devices with Embedded Sensors and Artificial Intelligence*

Jean Botti, VoltAero SA, *Removing the Aviation from the environmental Equation*

Michael Burke, Columbia University, *Unraveling Complex Reacting Systems in Energy and the Environment via Multiscale Data-Driven Approaches*

Chloe E. Dedic, University of Virginia, *Ultrafast Laser Spectroscopy for Reacting Systems and High-Speed Flows*

Mamadou Diagne, Rensselaer Polytechnic Institute, *Control of Multiphase Flow and Phase Transition via PDE Methods*

Catherine Gorlé, Stanford University, *Uncertainty Quantification and Data Assimilation for Predictive Computational Wind Engineering*

Samuel Graham, Georgia Institute of Technology, *Engineering Interfaces To Improve The Thermal Performance of Wide Bandgap Semiconductors*

Grace X. Gu, University of California, Berkeley, *Metamaterials Design and Manufacturing: Perspectives From Biology and Artificial Intelligence*

Egemen Kolemen, MAE, Princeton University, *Engineering Solutions for Fusion Reactors*

Sonia Martinez Diaz, UC San Diego Jacobs School of Engineering, *Multi-Scale Analysis of Multi-Agent Coverage Control Algorithms*

Ioannis Mikellides, Jet Propulsion Lab, California Institute of Technology, *Plasma Physics Modeling and Simulations of Electric Propulsion Over the Last Decade at the Jet Propulsion Laborator*

Karen Mulleners, EPFL *Dynamic Stall Onset and the Road to Recovery*

Kristin M. Myers, Columbia University, *Computational Biomechanical Models of Human Pregnancy – Evaluating the Risk of Preterm Birth*

Rui Ni, Johns Hopkins University, *Fragmentation in turbulence*

Dmitry Savransky, Cornell University, *Engineering the Search for New Worlds*

Aimy Wissa, University of Illinois at Urbana-Champaign, *Bio-inspired Locomotion Strategies across Mediums: From feather-inspired flow control to beetle-inspired jumping*

UNDERGRADUATE

Class of 2021 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 2021 completed the following interesting and exciting year-long projects.

Individual Thesis Projects

Kevin Andrade, *A Deep Learning Approach to AircraftWing Optimization*

Sam Berman, *An Exploration of Reinforcement Learning Through Rocket League*

Gabby Chapman, *A Small Scale Aquaponics System: Proof of Concept*

Douglas Chin, *Design, Development, and Launch of a Canard-Controlled Rocket*

Jens Clausen, *Liquid Lithium Delivery to Capillary Porous Systems for Fusion Experiments*

Cassidy Crone, *Formation and Simulation of Tunable Dimples on the Surface of a Symmetrical Airfoil*

Sarah Dillender, *Message-Passing Structures for Improved Policy Finding in Decentralized Multi-Agent Q-Learning*

Stephanie Domaradsky, *Aquaponics: Data Collection and Monitoring for System Health*

Raiden Evans, *Onboard UAV Navigation Utilizing Limited Sensing*

Chris Ferrigine, *Unsteady Aerodynamics Research of Pinniped Vibrissae for Biomimicry Applications*

Peter Fisher, *Magnetically Actuated Artificial Muscles for Applications in Battery-Powered Robots*

Keith Gabrielson, *Surf's Up: Designing and Manufacturing an Electric Foil-Board*

Ava Goldinger, *Remodeling Robotics: Encouraging Curiosity and Creativity in STEM through Accessible Robotics Content*

Ekin (Ali) Gurgen, *Robust Vision-Based Planning for Quadrotor UAV Using Funnel Libraries*

Michael Hauge, *Simulation and Design of a Novel CubeSat Passive Attitude Stabilization System*

Wenyuan (Roger) Hou, *Design and Test of a Desktop Metal Additive Manufacturing System*

Azmaine Iqtidar, *Predicting and Controlling Plasma Profiles of Tokamaks through an Autoencoder System*

Shalaka Madge, *Understanding Stress Distribution in Cylindrical Lithium-ion Batteries through Finite Element Modeling*

Andres Felipe Montoya, *Design of Princeton Space Physics 'SWAPI' Beam Monitor Testing Equipment*

Alex Preston, *Optical Detection of Lunar Surface Obstacles*

Alex Taylor-Nash, *Investigation of Tools for the Use of Individual CNC Milling Machines in Introductory Level Courses*

Erik Taylor-Nash, *Combustion Stability and Hetero-/Homogeneous Chemistry Interactions for fuel-lean H2/Air Mixtures in Palladium-Coated Microchannels*

Sam van der Jagt, *Understanding the Role and Design Space of Demand Sinks in Low-carbon Power Systems*

Linus Wang, *Using Bioelectric Fields to Sculpt Living Tissue*

David Zamora, *Minimizing Pressure Losses in the Combustor of a Turbocharger Jet Engine*

Team or Group Projects

Colby Chang, Benjamin Giugliano and Alexander Pirola, *Development of a Novel Pursuit-Evasion Path-Planning Algorithm and Generatively Designed Propeller Guards to Avoid Aerial Capture*

Claire Dashe and Colin Tonge, *Investigating the Development of a Smart Home Community Heated and Cooled by a Centralized Geo-Exchange System*

Tomisin Fasawe and Celine Park, *Engineering safer spaces: Using CO2 Sensors to Monitor Ventilation Quality and mitigate the risk of indoor airborne transmission of viruses*

Jonas, Marcus & von Mueller, *Development of Plasma Assisted Active Control for Rotating Detonation Engines*

Noah McGuinness, Nathan Schochet and Noah Spilker, *Design, Analysis, and Flight Test of a Compact, Heavy-Lift VTOL Delivery Drone*

Gargi Sadalagekar, Jacob Walrath and Samarie Wilson, *Decision Making and Task Allocation in a Multi-Robot System*

Ubellacker, Kaley & Wallace, *Sensor-Integrated Unmanned Aerial Vehicle: A Pilot Design for Albedo Monitoring*

Felicia Zhu and Jessica Pan, *Paired Partner Plushies: A Haptic Approach to Long Distance Communication*

Senior Independent Work (One Semester Projects)

Anthony Barnett, *A Numerical Investigation into the Geometric and Kinematic Properties of Incipient Breakers*

Matthew Kolodzik, *Spoke Tension in Motorcycles and Analysis of Wired Wheels*

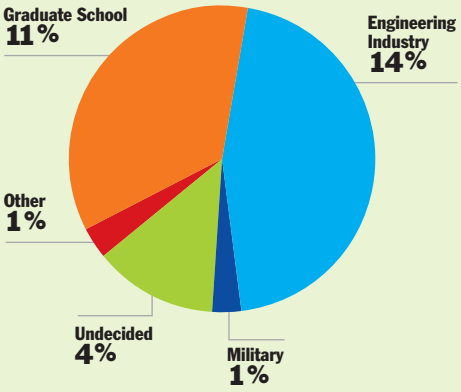
Katherine Mumm, *Bring Lifesaving Medical Advice to Illiterate and at-risk Populations*

Katherine Mumm, *The Research and Development of a Miniaturized Ultrasound Machine*

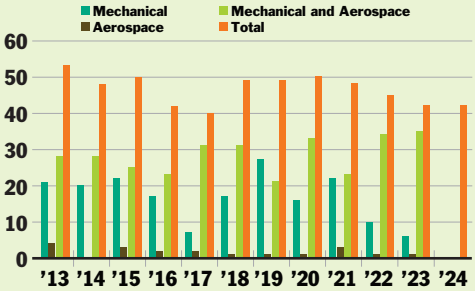
Conor Rachlin, *Active Stability Augmentation Control of a Bicycle with Rider*

Gargi Sadalagekar, *Improving Performance of CEM for Path Optimization Using Manifold Constraints*

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 PhD 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.

2020-21 Graduate Students

Nikita Dutta
Advisor: Craig Arnold
Thesis: Evolution of Structure and Properties in Optical Materials During Solution Processing
Position: Director's Postdoctoral Fellow, National Renewable Energy

David Feng
Advisor: Mikhail Shneider
Thesis: Advancements In Laser Rayleigh Scattering Diagnostics For Selected Gas Properties
Position: Research Scientist, MetroLaser Inc.

Adam Fisher
Advisor: Egemen Kolemen
Thesis: Free surface liquid metal flow for fusion reactors

Mia Hung
Advisor: Jeremy Kasdin and Robert Vanderbei
Thesis: Simulation of Realistic Images and Exoplanet Detection for Starshade Missions
Position: Data Scientist, Microsoft

Katherine Kokmanian
Advisor: Marcus Hultmark
Thesis: Development of a Nanoscale Hot-Wire Probe for Supersonic Flow Applications
Position: Postdoctoral Fellow, Bundeswehr University, Munich

Sebastián Rojas Mata
Advisor: Edgar Choueiri
Thesis: The Active Wave Packet Injection Diagnostic for Measuring Plasma Dispersion Relations
Position: Postdoctoral Fellow, Swedish Institute of Space Physics

Fan Yang
Advisor: Howard Stone
Thesis: Interfacial Flows in Active Matter and Energy Processes
Position: Postdoctoral Fellow, California Institute of Technology

Pierre-Yves Taunay
Advisor: Edgar Choueiri
Thesis: Scaling Laws in Orificed Thermionic Hollow Cathodes
Position: Postdoctoral Fellow, Princeton University

Yaofeng (Desmond) Zhong
Advisor: Naomi Leonard
Thesis: Model-based Investigation of Cascade Dynamics on Multi-layer Networks
Position: Research Scientist, Siemens Corporation

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

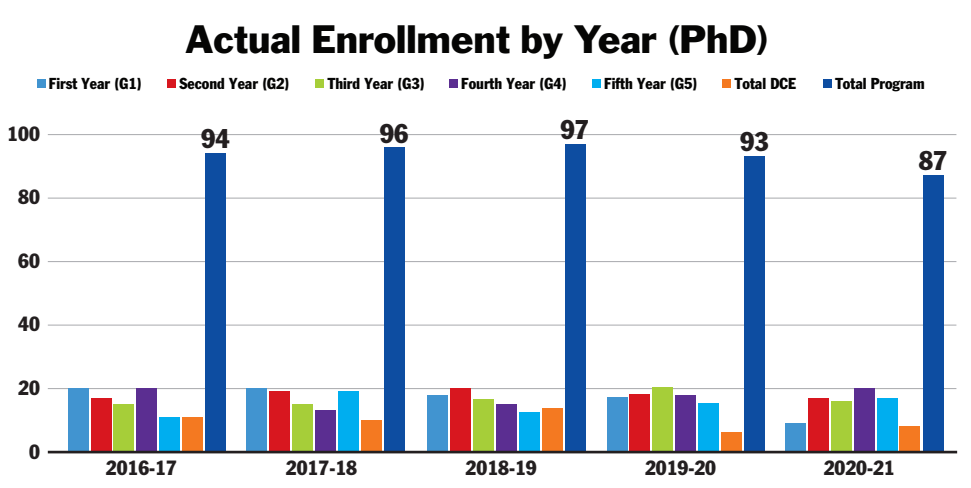
RIPE for Research: Respect, Inclusion, Professionalism, and Equity in Research
Laura Murray, Assistant Director, Learning Programs, McGraw Center for Teaching and Learning

MAE Research Day
MAE Graduate Student Presenters and Speakers:
Daniel Ruth; Nikita Dutta; Nicholas Fasano; Gawoon Shim; Anastasia Bizyaeva; Jinyoung Lee

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

MAE Business Center: Traveling and Getting Reimbursed
Mala Vora, former Business Manager, Mechanical and Aerospace Engineering Department, Princeton University



Graduate Student Fellowships and Awards

DEPARTMENTAL:

Kerry Klemmer, *Larisse Klein Award*

James Roggeveen, *Guggenheim Second Year Fellowship; Sayre Award for Academic Excellence*

Julienne LaChance, *Crocco Award for Teaching Excellence*

Vincent Pacelli, *Crocco Award for Teaching Excellence*

Wenbin Xu, *Phillips Second Year Fellowship*

Jinyoung Lee, *Harari Post Generals Fellowship*

Udari Madhushani, *Harari Post Generals Fellowship*

Tejas Dethe, *Summerfield Second Year Fellowship*

Hongtao Zhong, *Harari Post Generals Fellowship*

Ricardo Shousha, *Harari Post Generals Fellowship*

Daniel Ruth, *MAE Research Day First Prize*

Nikita Dutta, *MAE Research Day Runner Up*

UNIVERSITY:

Nikita Dutta, *Charlotte Elizabeth Proctor Honorific Fellowship*

Nan Xue, *Charlotte Elizabeth Proctor Honorific Fellowship*

Kelly Huang, *2020 Excellence in Teaching Award, Undergraduate and Graduate Engineering Counci*

Jason Liu, *2020 Excellence in Teaching Award, Undergraduate and Graduate Engineering Councill*

Claudia Brunner, *HMEI-STEP Fellowship*

Hongtao Zhong, *School of Engineering and Applied Science Award for Excellence*

Daniel Ruth, *School of Engineering and Applied Science Award for Excellence*

EXTERNAL:

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

Anastasia Bizyaeva, *National Science Foundation*

Claudia Brunner, *National Defense Science and Engineering Graduate Fellowship*

Danielle Chase, *National Science Foundation*

David Feng, *National Defense Science and Engineering Graduate Fellowship*

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

Kelly Huang, *National Defense Science and Engineering Graduate Fellowship*

Jihye Jeon, *Korean Ministry of Education Fellowship*

Eric Lepowsky, *National Science Foundation*

Justin Lidard, *National Defense Science and Engineering Graduate Fellowship*

Samuel Otto, *National Science Foundation*

Anthony Savas, *National Defense Science and Engineering Graduate*

Daniel Shaw, *National Science Foundation*

Nathaniel Simon, *National Science Foundation*

David Snyder, *National Science Foundation*

PRINCETON
UNIVERSITY

MECHANICAL AND
AEROSPACE ENGINEERING
PRINCETON, NJ 08544