MAE: A YEAR IN REVIEW 2019–2020

RESPONDING TO EXTRAORDINARY TIMES

Howard A. Stone, Chair

MECHANICAL AND AEROSPACE ENGINEERING

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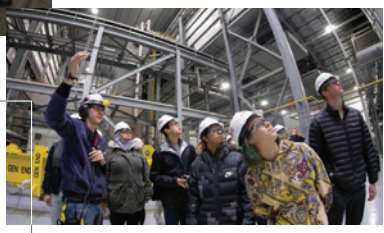
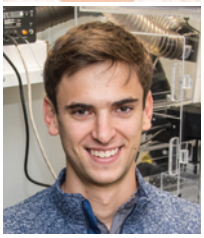




MAE BY THE NUMBERS

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

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

160 Undergraduate Students

2 Visiting Faculty/ Lecturers

71 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

94 Graduate Students

15 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

PRINCETON MAE 2019-20 YEAR IN REVIEW:

Responding to Extraordinary Times

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

The year 2020 needs little introduction. Princeton University shut down all on-campus activities as spring break arrived and then implemented social distancing on-campus and work-from-home policies before the State of New Jersey issued such mandates. Then, the last six weeks of the semester were fully remote for everyone. Our faculty, staff, and students made adjustments in real time, as did others across the U.S. and in most countries. This was especially challenging for seniors completing their thesis, as well as other students pursuing independent work, design courses, projects, etc.

I'm proud to say that the ingenuity, exceptional ability, and hard work of everyone in our MAE community helped make the most of a very difficult situation.

In particular, faculty, staff, and graduate students also applied their creative talents to several MAE initiatives related to fighting COVID-19, including projects focusing on ventilators, personal protective equipment, virus-related research studies, and more. They rose to the challenge, joining their fellow Princeton colleagues and others around the country in finding solutions to beat back a global pandemic. Read more about their achievements in this report's *Year in Review* section.

At the end of May, MAE faculty started to plan laboratories and lectures for the possibility that the fall semester would be in part, or fully, remote. We now know it will be the latter for almost everyone, except perhaps for some small graduate classes.

For eight weeks over the summer, 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.

For example, MAE now has:

- A grading policy for Departmental requirements that offers an option for P/D/F if needed,
- Student-tested lab kits for at-home use,
- At-home manipulatives for following along in real time with lectures,
- Remote-controlled lab experiments,
- A student-tested plan to expand the Zoom app to encourage student collaboration in virtual lounges and enable virtual office hours for faculty,
- And much more.

In addition, we shared our ideas with other Princeton departments and hope that some of the remote teaching ideas will provide long-term educational and organizational benefit.

Thank you to everyone who helped plan for a new educational landscape this fall. It's another example of how the spirit of innovation and collaboration within our MAE community brings out the best in all of us, especially during the challenges of academic life during a pandemic.

In a Zoom demonstration lecture tested this summer, Professor Andrej Kosmrlj used a silicone rubber "dog bone" to show how forms change when different stresses are applied. He provided students with a remote lab kit that included such custom-made items so they could get the full in-person experience.

We look forward to welcoming everyone back on campus, whether remotely or in person!

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 faculty members, and 1 lecturer. The Department has a long history of academic success (currently 5 regular or emeriti faculty are members of the NAE and/or NAS*) and societal impact. In the past year, Professor Robert Stengel retired and Jesse Jenkins joined MAE and the Andlinger Center for Energy and Environment as an Assistant Professor.

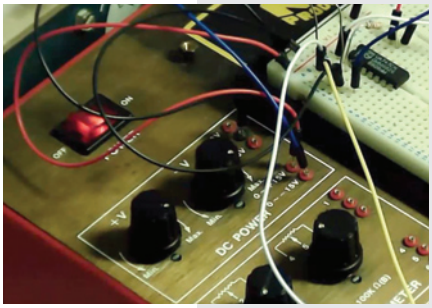
WHAT WE DO

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.



Read more about everyone's achievements in the *Year in Review* section. ♦

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

REMOTE LEARNING SUMMER INTERNSHIP PARTICIPANTS

Students

Anthony M. Barnett
Joshua C. Coleman
Leonardo M. Espinoza Zuniga
Rodrigo Fernandez
Peter A. Fisher
Seth E. Freeman
Grace Gong
Pranav Iyer
Marcus Jonas
Bethwel Kiplimo
Kenalpha Kipyegon
Reese Knopp
Ken Nakamura
Ainil Asyikin Norazman
Alexander C. Preston
Yousuf I. Tariq-Shuaib
Alexander W. Taylor-Lash
Erik W. Taylor-Lash
Linus Wang
Ned Williamson
Alfred Yoon

Faculty/Researchers/ Staff

Howard A. Stone
Craig Arnold
Lamyaa El-Gabry
Alexander E. Gaillard
Michael Galvin
Andrej Kosmrlj
Michael Littman
Anirudha Majumdar
Glenn A. Northey
Jonathan D. Prevost
Michael Vocaturo
Tom Wing

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 2019

Elementary schoolers explore engineering's possibilities

For the seventh year, about 60 Harlem Prep Elementary School students visited Princeton to explore the fields of bioengineering, aerodynamics, fluid mechanics, control systems, and more. They programmed robotic arms, performed "tornado" experiments in the wind tunnel lab, and organized a group "wave" with Baxter, a human-sized research robot. The event was organized by research scholar Tyler Van Buren and graduate student Daniel Floryan and involved 21 MAE student and staff volunteers.

Stengel recalls Apollo 11 moon landing contributions 50 years later

In a Princeton SEAS video on LinkedIn, Professor Robert Stengel recalled developing highly responsive manual controls for the mission's lunar landing module. Astronaut Neil Armstrong was able to steer the vehicle to a perfect landing, with just 20 or 30 seconds of main engine fuel to spare.

July 2019

New era in space exploration: Small but mighty plasma-powered satellite

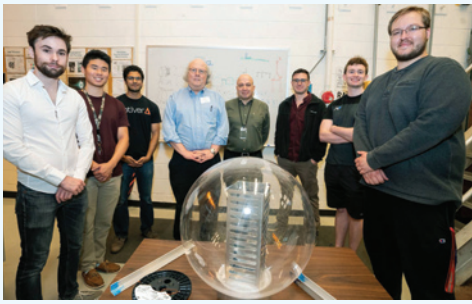


Photo by Elle Starkman, Princeton Plasma Physics Laboratory

About 10 Princeton MAE graduate and undergraduate students are building a cubic satellite or CubeSat at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL), testing a miniaturized rocket thruster design with unique capabilities. Featured with the CubeSat chassis are (from left) third-year graduate student Jacob Simmonds (who worked on thruster development), Jerry Xiang, Nirbhav Chopra, Daniel Marlow (faculty advisor and the Evans Crawford 1911 Professor of Physics), Yevgeny Raitses, undergraduate Seth Freeman (who worked full-time on the project over the summer), Matthew Bledsoe, and Daniel Piatek (Seton Hall student). Not featured is Andrew Redd '20, who led the design and construction.

August 2019

Madhushani wins President's Award for Scientific Research in Sri Lanka

PhD student Udari Madhushani received the prestigious award from her country's National Research Council for co-authoring "Semi-globally Exponential Trajectory Tracking for a Class of Spherical Robots," published in the control systems journal, *Automatica* in 2017.

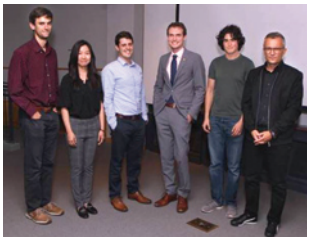
September 2019

New Princeton University-Ohio State University Department of Energy (DOE) Plasma Science Center

Princeton Profs. Yiguang Ju and Bruce Koel are co-principal investigators for the new $3 million Low Temperature Plasma Science Center. The joint universities project will improve understanding of plasma-aided combustion and plasma-assisted catalysis and address the challenges of transitioning from fossil energy to renewable energy.

MAE Research Day 2019

Congratulations to all the speakers who made presentations at the 2019 MAE Research Day on Sept. 13, 2019. Featured (from left) are Matthew Heinrich, who spoke on *Growth Dynamics of Large, Freely Expanding Epithelial Monolayers*; Estella Yu, who spoke on *Speed-dependent Filtration Using the Motion of a Translating Bubble* and was runner up for the Research Day prize; Alex Novoselov, who won the Research Day prize with his presentation on *Turbulent Nonpremixed Cool Flames: Experiments, Simulations, and Models*; Adam Fisher, who spoke on *Liquid Metal Systems for Fusion Reactors*; Sam Otto, who spoke on *Leveraging Dynamics for Near-Optimal, Ultra-Sparse Sensor Placement*, and Alex Glaser, Director of Graduate Studies.



November 2019

50 years ago, MAE grad Pete Conrad '53 commanded Apollo XII's moon mission

On Nov. 19, 1969, Conrad became the third person to walk on the moon, bringing five Princeton flags along on the mission. He later presented one of them to Princeton President Goheen. That flag, with his autograph, now hangs in the Mudd Manuscript Library.

Lessons and advice from Dr. Darden, pioneering NASA mathematician and aerospace engineer

At a Prospect House dinner for MAE students, faculty, and staff, Dr. Christine Darden shared highlights from her 40-year career at NASA, which included crunching numbers for engineers as part of the NASA Langley Research Center's pool of human computers, as featured in the book *Hidden Figures*. She later worked in engineering, focusing extensive work on sonic boom minimization and authoring more than 57 technical articles on the topic. She held numerous leadership positions at NASA and retired in 2007 after eight years in the Senior Executive Services, making her the first African American appointed to the highest rank at Langley.

Seattle MAE alumni mini reunion

MAE alumni had a mini reunion at the November 2019 Annual Meeting of the Division of Fluid Dynamics in Seattle, Wash. Featured (from left) are: Nathan Wei '17 (currently in graduate school at Stanford University), Omkar Shende '18 (currently in graduate school at Stanford University), Professor Howard Stone, Nicole Schiavone '15 (currently in graduate school at Stanford University), Lena Dubitsky '18 (currently in graduate school at Boston University), Emile Oshima '17 (currently in graduate school at Caltech), and Raj Balaji '17 (currently in graduate school at Stanford University).

November 2019

MAE Graduate Engineering Fellowship Dinner

Student fellows included (front row, from left) Cristian Lacey, Paul Kaneelil, Susan Redmond, Simeret Genet, James Roggeveen, Jihye Jeon, and Eric Lepowsky, and (back row, from left) Alec Farid, Jiarong Wu, Rory Conlin, Daniel Shaw, Anastasia Bizyaeva, Professor Luc Deike, and David Snyder. Not pictured are Xiaohan Du, Christopher Galea, Kelly Huang, Katherine Kokmanian, Zirui Liu, Udari Madhushani, Justice Mason, Lena Sabidussi, Fan Yang, Estella Yu, and Desmond Zhong.

December 2019

Emeritus Professor Glassman passed away at 96

Irvin Glassman, a leading authority on combustion and propulsion who served on the Princeton faculty for 49 years, died Dec. 14, 2019 at his home in Princeton. Affectionately known in MAE as the "Grand Old Man of Combustion," Glassman was the Robert H. Goddard Professor of Mechanical and Aerospace Engineering, Emeritus. In addition to teaching, he advised NASA, the National Institute of Standards and Technology, the State of New Jersey, and many industries, notably United Technologies Corporation.

January 2020

Answering the climate call

Jesse Jenkins, MAE assistant professor and the Andlinger Center for Energy and Environment, was featured in an *MIT Technology Review* article about alumni working on climate change. His work has included quantitative models to identify ideas for rapidly, efficiently, and affordably transitioning to a low-carbon electric grid system; testifying before Congress about reducing the carbon footprint of the nation's electric power generation system by using nuclear energy, scrutinizing natural gas with carbon capture and enhanced geothermal systems, and more.

February 2020

Former Professor Grey passed away at 93

Dr. Jerry Grey, a longtime aerospace engineering professor at Princeton, was a pioneer in the field of space nuclear propulsion and power. He founded and edited *Aerospace America* magazine. Among numerous awards and recognition, he also was an honorary fellow of the American Institute of Aeronautics and Astronautics (AIAA).

March 2020

Professor Michael Mueller wins Research Excellence Award from The Combustion Institute

The award is given to registered CI members who, in the opinion of the Executive Committee, have published excellent research papers that have had a major impact on the field of combustion science.

January 2020

Real-life examples bring new energy to core thermodynamics course

Professor Lamyaa El-Gabry redesigned the introductory thermodynamics course to include field trips, guest lectures, and lessons that enhanced students' learning with examples of energy technology and policy from the University campus and surroundings. In one field trip, El-Gabry (second from left) and her students toured the PSEG generating station in Sewaren, N.J., with PSEG engineer Christian Santoro (far left).

Photo by Tori Repp/Fotobuddy

April 2020

Smits elected to the American Academy of Arts & Sciences

The prestigious American Academy of Arts & Sciences was founded in 1780 by John Adams, John Hancock, and others who believed the new republic should honor exceptionally accomplished individuals and engage them in advancing the public good. Professor Alexander Smits' fluid mechanics research spans fundamental turbulence, supersonic and hypersonic flows, bio-inspired flows, sports aerodynamics, and novel energy-harvesting concepts.

Fighting COVID-19 with 3D PPE

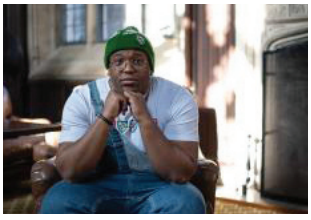
In the spring, Machine Shop Associate Al Gaillard designed and 3D-printed head bands to hold face shields, which he donated to area hospitals to supplement the personal protective equipment (PPE) supplies needed to fight COVID-19.

Kosmrlj on Phase Behavior of Viral Capsids

Professor Andrej Kosmrlj co-authored the Editor's Suggestion paper in the journal *Physical Review Letters*. The researchers proposed a general phase plot for the thermodynamic phases exhibited by the microbiological shells that protect, for example, viruses, bacteria, and most archaea from hostile environments.

Majumdar receives the Alfred Rheinstein Faculty Award

The award recognizes early career Princeton School of Engineering junior faculty such as Professor Ani Majumdar "who have shown exceptional promise and to assist said instructors to further their work in their chosen fields."



May 2020

Artis named one of 10 Spirit of Princeton award winners

Jackson Artis '20 was honored for demonstrating "a strong commitment to the undergraduate experience through dedicated efforts in student organizations, athletics, community service, religious life, residential life, and the arts."

Mikhailova's Group Explains Physics of Coherent Emission from Plasma Mirrors

Professor Julia Mikhailova co-authored a paper in the journal *Scientific Reports* that for the first time generally explained the relationship between the relativistic high-order harmonic generation (RHHG) spectrum and the dynamics of the relativistic electrons accelerated by the laser and plasma fields.

Novoselov receives the Teaching and Service Award

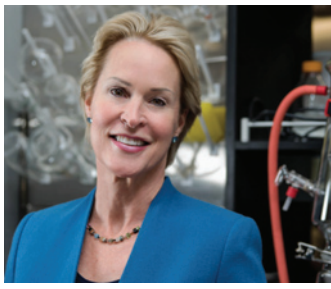
Alex Novoselov, a fifth-year MAE PhD student, has served as a McGraw Center Graduate Teaching Fellow and as secretary of the Graduate Student Government.

Bizyaeva profiled on Princeton website

PhD candidate Anastasia Bizyaeva was featured in an online "Princeton Engineer" profile. She is a member of Professor Naomi Leonard's Dynamical Control Systems Lab and creates models and algorithms of group opinion dynamics, which are inspired by collective behaviors of natural systems, like groups of animals and groups of interconnected neurons.

Nobel Laureate Arnold (MAE '79) received an honorary Doctor of Science degree at Commencement 2020

Frances Arnold, director of the Donna and Benjamin Rosen Bioengineering Center at Caltech, began her career with a BSE from Princeton MAE in 1979. She won the Nobel Prize in Chemistry for the "directed evolution of enzymes" in



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STUDENT PROFILES

Shalaka Madge:
Hard work pays off

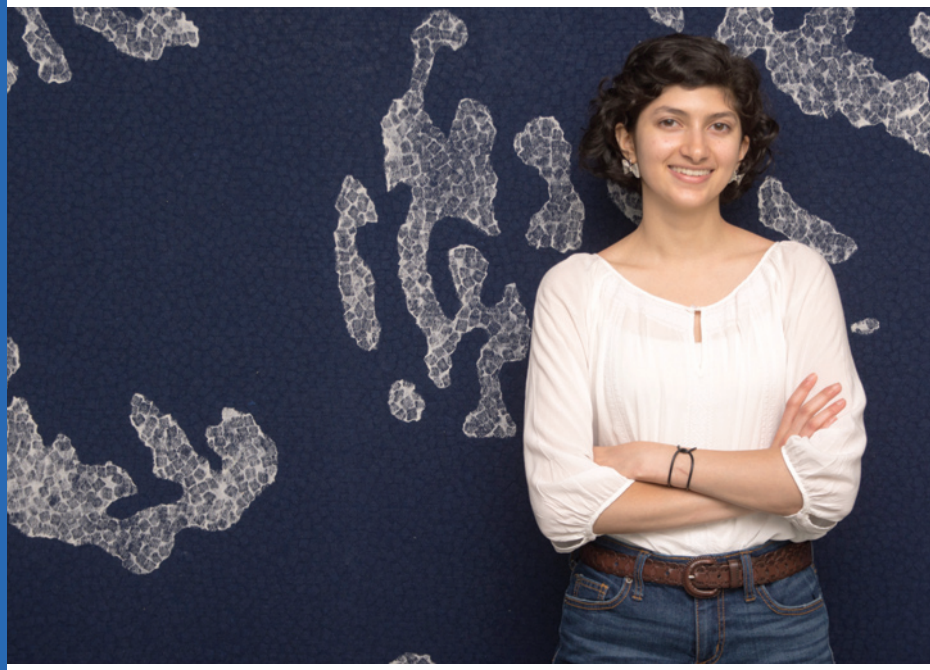
DEGREE: BSE SPECIALTY: MAE

In first grade, Shalaka Madge vowed to someday build a kilometer-long pool in her backyard. It was a giant vision for a small person, but dreaming big always came naturally.

The ambitious project represented two key traits that have defined her academic and athletic career: determination and imagination.

"At the time, I felt my kilometer-long pool displayed my immense love for swimming, although others felt it just displayed my lack of a sense of measurement," jokes Madge, whose hard work and perseverance molded her from a young guppy at the YMCA into a competitive club and high school team swimmer. "The discipline and diligence that I gained during my time at the swim club has been invaluable to my success in other aspects of my life and career."

When she wasn't swimming at the pool, she could be found strumming a tune on the guitar or trying to fix a broken gadget. Her interest evolved from small household do-it-yourself projects in grammar school to designing bridges



with CAD, creating circuits to illuminate bulbs, and printing LEGO blocks on the 3D printer in high school.

Today, her academic pursuits have been as multi-faceted as her hobbies, ranging from tissue engineering to fluid mechanics to spacecraft design.

"Once I learned more about science and technology in school, my love of fixing became more refined with a focus on the world instead of a focus on bookshelves," says Madge. "Engineering gives humans the power to create solutions to the world's greatest problems, which is something I have wanted to do all my life."

One example was in high school when she entered a contest that used engineering to solve real-world problems. Motivated by the Syrian refugee crisis, she devised a plan to place 3D printers and pre-developed shoe designs at major shelters, since displaced people often lose their footwear, which puts them at risk of injury and immobility. She says the contest taught her that "engineering is not simply about fixing, building, or innovating — it requires implementation."

No matter the project, Madge is always thinking about how the solution would fit practically into the real world. With her strong interest in biology, she has worked in Professor Daniel Cohen's Lab, characterizing a stencil cutter for application in the study of tissue expansion and wound healing. She also worked with Professor Sujit Datta in the Chemical and Biology Engineering department to understand the behavior and directionality of flow through aerogels.

In the summer of 2019, she was an aerospace engineering intern for the ThinSat program under the guidance of Michael Galvin, Senior Technical Support in Mechanical and Aerospace Engineering. The program invites teams from universities across the country to design small-scale space exploration missions and build payloads that will go up into space via a thin satellite.

In preparation for the internship, she spent the year modifying and testing the flight software for the satellite, as well as designing a pendulum shock test fixture in Creo to conduct shockwave testing on the satellite. All were designed to ensure that the orbital mission data gets downlinked to the ground successfully, even under all possible contingencies.

"She has also been working on building up our own in-house nanosatellite test facilities, by performing the mechanical design of a fully-custom pendulum shock test fixture, for testing the robustness of all our future nanosatellites to the shock loads that they'll suffer during launch," notes Galvin. "She absorbs new information like a sponge, and brings a great, positive attitude to every challenge. She is a joy to work with!"

> **"She absorbs new information like a sponge, and brings a great, positive attitude to every challenge. She is a joy to work with!"**
>
> *—Mike Galvin, Senior Technical Support in Mechanical and Aerospace Engineering*

Madge also has passion for the arts such as music, comedy, and photography and enjoys taking classes from outside her major whenever possible. She also was a producer of "Princeton Tonight," a campus TV show, was a leader of the Theater Arts trip for Community Action Orientation, and led a fall 2019 backpacking trip as an Outdoor Action Leader.

Always working toward a goal even when the going got tough, Madge came full circle in the fall of 2019 when she worked as an undergraduate course assistant helping other students in Multivariable Calculus for Engineering, a class she herself struggled with during her freshman year.

Given her range of interests and experiences, there is no doubt there will be many more exciting payoffs in the future. And, in case you thought she had forgotten, someday, Madge says, she will build that kilometer-long pool. ♦

Vincent Pacelli:

Writing the equations behind robotics

DEGREE: PHD (SECOND YEAR) SPECIALTY: CONTROL, ROBOTICS AND DYNAMICAL SYSTEMS

Some of Vincent Pacelli's best robotics insights come from playing softball.

While players call it instinct to successfully catch a fly ball, researchers know that it's a simple decision-making strategy called a gaze heuristic — the player fixes their eyes on the ball and runs so that it remains at a fixed point in their vision. This simple rule naturally puts them at the location where the ball will land.

In Pacelli's work at the Intelligent Robots Motion Lab, he designs algorithms that let robots automatically emulate the human "instincts" for doing dexterous tasks, such as picking up a fork or catching a ball.

"Robotics has the power to help many people — my grandmother immediately comes to mind," says Pacelli, a second-year PhD student who was born in the town of Princeton. "She lives alone and has trouble getting around the house. There are plenty of ways robots could be used to help her with chores and remain independent."

"I was drawn to robotics because it was an intersection of so many fields — mechanical engineering, computer science, math, and electrical engineering," he says.

Pacelli's process, which applies to all sorts of robots including drones, quad runners, and autonomous cars, starts with describing a robot's task by developing an algorithm on the computer that helps the robot decide what part of the environment around them is important to their task.

A good example is a self-driving car, which needs to sort through the environmental noise of a busy street to respond to immediate situations — a car right in front of it — as well as identifying situations that don't need an immediate response, such as someone crossing the street several hundred feet away. Throughout the task of driving down the street, though, the car needs to constantly monitor changes, such as if a person in the crosswalk slows down or stops completely.

Sensor technology is one of the biggest challenges in robotics today, says Pacelli, who did a summer internship in a robotics lab startup that built drones to inspect oil rigs.

"The sensors returned more data points than the computers on the robots could process in real time," he says. "As a result, we ended up throwing away a lot of data. My work focuses on using as little sensor information as possible to estimate task-relevant quantities in the environment so the robot can perform dexterous tasks with limited computational resources."

Assistant Professor Anirudha Majumdar says Pacelli has been instrumental in kicking off research in his group.

"Combining research on theory and algorithms with hardware implementation is particularly challenging, and I have been extremely happy to see Vince tackle this challenge head-on," he explains. "Perhaps the most impressive aspect about Vince as a researcher is his ability to make connections to diverse fields of research and bring to bear powerful technical tools from these areas — including information theory, differential privacy, and statistical mechanics — to solve problems in robotics."

"I was drawn to programming because it felt like a mix of a creative outlet and a puzzle," says Pacelli, who taught himself computer programming in high school and wrote a Game Boy emulator for his computer. "When you finally figured something out it felt like a reward that motivated me to get through the next 20 hours of struggle."

"Perhaps the most impressive aspect about Vince as a researcher is his ability to make connections to diverse fields of research and bring to bear powerful technical tools from these areas — including information theory, differential privacy, and statistical mechanics — to solve problems in robotics."

—Anirudha Majumdar, Assistant Professor of Mechanical and Aerospace Engineering

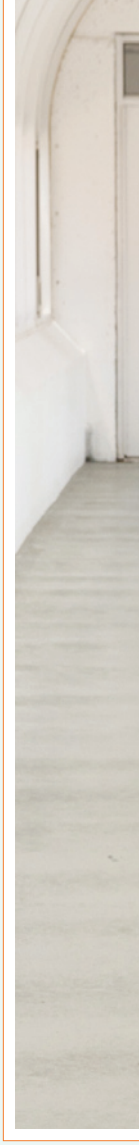
Pacelli majored in electrical engineering at the University of Pennsylvania and then earned a master's degree in robotics. During that time, he developed and filed a patent for xBlox, a type of "smart" building block that's embedded with a tiny circuit board that connects to a computer to show the construction process in real time.

As for his dream project, Pacelli half-jokingly says he would like to create a robot that can fold laundry. Ultimately, though, his goal is for his algorithms to generalize to many applications and make robotics as accessible as possible for everyone. ♦

Kerry Klemmer:

Independent Thinker, Diverse Talents

DEGREE: PHD (THIRD YEAR) SPECIALTY: COMPUTATIONAL FLUID DYNAMICS (CFD)



Kerry Klemmer, a gifted artist who completed a triple major in astronomy, physics, and studio art, chose to pursue a doctorate at Princeton in computational fluid dynamics (CFD) because the field encompasses her many interests and offers a practical career path.

"I thought, engineering is practical and somewhat related to the research I've done in the past. Also, computation became a primary interest of mine," says Klemmer, who grew up in Ossining, just outside of New York City. "As I began looking into engineering subfields such as aeronautics and mechanical engineering — fields that I thought might be highly computational — one of the first things that came up was computational fluid dynamics."

CFD uses computer calculations to discover and analyze the innumerable perplexing problems of fluid dynamics that many researchers work to resolve through simulations around weather patterns, star evolution, blood circulation, and improving gas turbine and spacecraft engine combustion technology.

After completing her bachelor's degree at Wesleyan University, she completed a one-year master's program in CFD at Imperial College London. Then, she joined MAE as part of Associate Professor Michael Mueller's CFD research group that investigates turbulent combustion through simulation and modeling.

While the most detailed and accurate CFD simulations require huge amounts of processing power that take too much time to make their everyday use practical, models simplify the physics so that the simulations run more efficiently. The tradeoff, however, is that more approximations are introduced into the predictive model and errors occur. Klemmer's specialty is estimating and identifying these errors through uncertainty quantification so that researchers can account for them.

"I cannot stress enough how important this research is," says Professor Mueller. "Realistically, we will never be able to develop perfect models to make perfect predictions. But, if we can at least understand and quantify how accurate our simulations are, that would be immensely helpful."

"I wanted the opportunity to be involved in uncertainty quantification, and I find turbulent combustion to be an interesting, multilayered problem," Klemmer says. "Just firing up an engine involves multiple layers of physics."

Her research team focuses on simulations of soot formation in combustion models, assessing how conventional and alternative fuels affect engine performance, and understanding flame stabilization in diesel and gas turbine engines.

To get up to speed on the nature of the work her team is involved in, Klemmer took a graduate combustion course taught by Chung K. Law, the Robert H. Goddard Professor of Mechanical and Aerospace Engineering. She also participates in Princeton's annual Combustion Summer School.

> **"It has been a pleasure to work with Kerry over the last couple of years. She is an independent thinker and prefers to figure things out on her own. And, having an art, astronomy, and physics background definitely offers our group a unique perspective."**
>
> *—Associate Professor Michael Mueller*

All along, Klemmer has continued to make artwork that entails a unique, layered approach. She first constructs an abstract still life using household materials, such as colored tissue paper, honey (as the glue and for surreal liquid and bubble effects), plastic wrap and foil — items that tend to be colorful and shiny. She then photographs the 3D design using various lighting techniques to create distortion. Next, she uses paint to further obscure the identity of the materials to create abstract landscapes.

"The idea is that when you look from a noticeable distance, the painting appears to be concrete with a 3D dimensionality to it," says Klemmer, whose variable styles of artwork reflect her passionate, independent nature while hinting at abstract impressionism and gesturalism.

"Some paintings by these artists are realistic images from a distance, but up close they become abstract," she says. "But, you can't see any tangible brush strokes, which is interesting in its own way. But in my own art, I needed to see those paint strokes. I needed the texture to be a part of the painting."

"It has been a pleasure to work with Kerry over the last couple of years," Professor Mueller says. "She is an independent thinker and prefers to figure things out on her own. And, having an art, astronomy, and physics background definitely offers our group a unique perspective." ♦

Matthew Heinrich:

Fabricating personal protective equipment during the COVID-19 pandemic

DEGREE: PHD (FIFTH YEAR) SPECIALTY: MATERIALS SCIENCE

Finding the answer to a seemingly simple problem is not always easy.

That's one of the many lessons Matthew Heinrich learned after the COVID-19 pandemic started this spring. He, his colleagues, and dozens of volunteers took on the challenge to manufacture 2,000 face shields and another 1,000 disposable covers for Powered Air Purifying Respirators (PAPRs), which were desperately needed for Penn Medicine Princeton Medical Center's front-line healthcare workers.

Throughout the process, the team creatively worked through each challenge: materials were out of stock everywhere, the project team could not meet in person, and they couldn't use the labs that contained high-tech manufacturing equipment because they were closed in accordance with State guidance.

"At the time, we had no idea if our designs would actually get to the people who needed them, but we felt we had a responsibility to try," recalls Heinrich, who studies collective cell migration and tissue engineering and was in a critical phase of his own research project when he first heard about the shortages. "I remember Tom Zajdel, a postdoc in my research group, saying that our data would still be there in three weeks, but that we did not know what those three weeks would hold for the public health crisis."

Manufacturing Face Shields

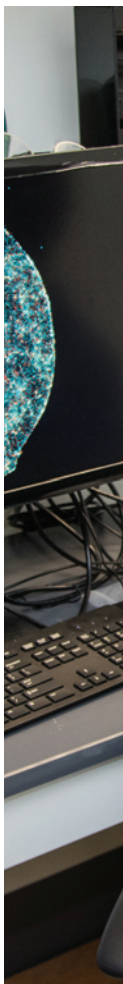
During the early days of the pandemic, Heinrich's co-advisor, Daniel Cohen, Assistant Professor of Mechanical and Aerospace Engineering, brought a speaker from Princeton Medical Center as part of a regular monthly seminar with area physicians. The speaker's estimate of projected PPE shortages inspired Heinrich and his colleagues to take on the design and manufacturing challenge.

"We did not sleep much that first week or so," he says. "I remember waking up at 4 a.m. with an idea for a headband design and not being able to go back to sleep until I tested it. It was how we launched the project so quickly."

But, even if the five research group members worked around the clock over a weekend, they could only make a few hundred shields. "We were never going to meet the need," explains Heinrich. "It became my brainchild to figure out how to scale up."

The team developed an alternative design that could be made at home by a volunteer using an instructional video and no special equipment. Heinrich assembled kits for making 100 shields from clear, pre-cut binder covers, adhesive-backed foam weather stripping, and a head strap attached with VELCRO.

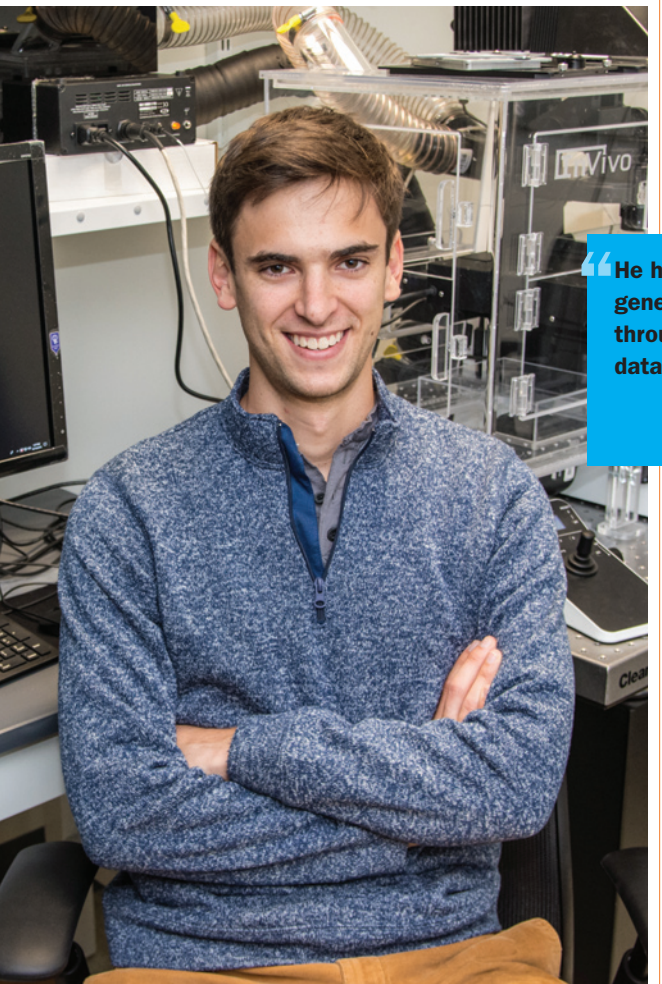
Alex Riordan, a graduate student in neuroscience, and Heinrich recruited about 40 volunteers who were friends, fellow graduate students, and neighbors. Two weeks later, 2,000 face shields were delivered to the hospital.



"Matt really drove through getting our prototypes into full production form by working tirelessly to design our PPE 'kit,' engaging with companies to mass produce components of the kit, coordinating a volunteer network to assemble these kits into PPE, and then getting these items to the hospital," says Professor Cohen. "He has been fantastic and extraordinarily generous with his time and mental energy throughout this process, while also working on data analysis for his primary research area."

Fabricating Precision Covers for PAPRs

While the face shields were being made, Heinrich turned to the issue of making the disposable, air-tight covers for the hospital's crucial respirators. By then, he was able to work in the lab again, where he designed and laser-cut thin pieces of plastic with attachment holes and bonded the covers together using thin silicone rubber.



The prototype was immediately approved by hospital administrators, who said they would need a total of 1,000: 25 immediately because they only had three covers left at the hospital, about 200 within a couple of weeks to get them through mid-June, and then the remainder to last until the end of the year.

Precise sizing and placement of the holes was critical for the covers to work. If they were off by even the slightest bit, they would be either too loose or too small to fit the PAPR helmets.

That's when Heinrich realized that a simple hole puncher was the same size as the hole openings on the cover. He designed a stencil as a guide and ordered hole punchers for the assembly kits.

"It was amazing and ironic that our scalability issue could be solved so simply. But, until we realized that, it was not an easy problem at all," says Heinrich.

The volunteer team met the hospital's deadlines for the 225 immediately needed covers. To speed up manufacture of the remaining shields to serve the hospital for the rest of the year, Heinrich worked with the silicone supplier to pre-cut all the materials at the factory.

> **"He has been fantastic and extraordinarily generous with his time and mental energy throughout this process, while also working on data analysis for his primary research area."**
>
> *—Professor Daniel Cohen, Assistant Professor of Mechanical and Aerospace Engineering*

"Every now and then I stop and think that this graduate student and his labmates have had the opportunity to keep hundreds of doctors and nurses safe," Heinrich explains. "It feels overwhelming and humbling, but it is also a great relief that we could do something to contribute. The project was an incredible community effort and I am so grateful to all the volunteers. We can all look back and know we made a difference during one of the most challenging times in our lives." ♦

FACULTY

Meet the People of MAE

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
Robert Stengel
Howard Stone, *Chair*

Associate Professor
Alexander Glaser
Marcus Hultmark
Michael Mueller
Daniel Nosenchuck

Assistant Professor
Daniel Cohen
Luc Deike
Jesse Jenkins
Egemen Kolemen
Andrej Kosmrlj
Anirudha Majumdar
Julia Mikhailova

Lecturer
Lamayaa El-Gabry
Glenn Northey (part-time)
Amir Pahlavan (part-time)

Visiting Lecturer
Michael Paluszek (part-time)
Stephanie Thomas (part-time)

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:
Alex Glaser, *Chair*
Edgar Choueiri
Daniel Cohen
Luc Deike
Ani Majumdar
Michael Mueller

Director of Graduate Studies:
Alex Glaser (2019-20)
Michael Mueller (2020-21)

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
Jill Ray, *Ex-officio*
Howard Stone, *Ex-officio*
Jenn Widdis, *Ex-officio*

Sabbaticals:
Fall 2019: Marcus Hultmark, Michael Mueller, Rob Stengel
Spring 2020: Marcus Hultmark, Rob Stengel

Teaching Schedule Coordinators:
Michael Littman
Alex Glaser
Jill Ray, *Ex-officio*
Jo Ann Love, *Ex-officio*

Freshman Advisors:
Daniel Cohen
Lamyaa El-Gabry
Mikko Haataja
Andrej Kosmrlj
Ani Majumdar
Gigi Martinelli
Daniel Nosenchuck

Class of 2020
Daniel Cohen
Mikko Haataja
Marcus Hultmark
Yiguang Ju
Andrej Kosmrlj
Michael Littman
Ani Majumdar
Daniel Nosenchuck

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

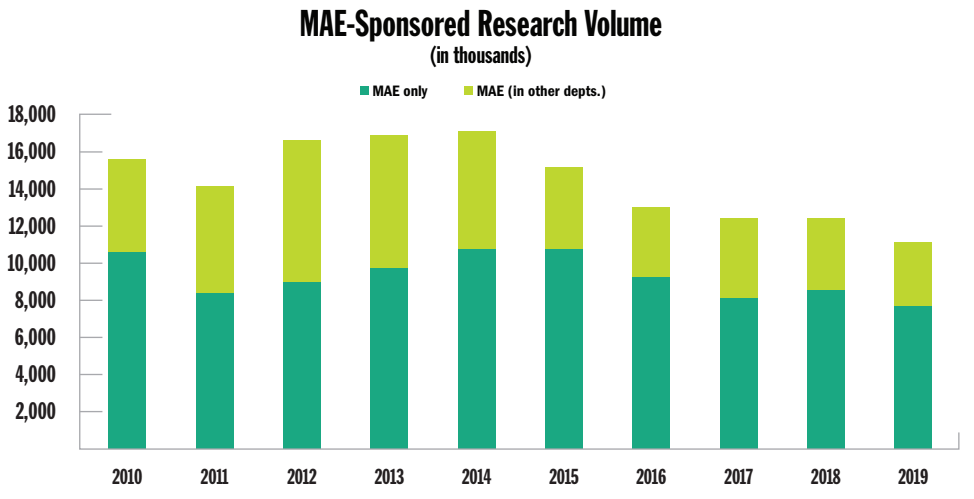
Class of 2022
Craig Arnold
Michael Littman
Gigi Martinelli
Daniel Nosenchuck

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



FACULTY AWARDS, HONORS AND RECOGNITION

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

- 2019 The Presidential Early Career Award for Scientists and Engineers
- 2020 Teaching Award of the Princeton Engineering Council

Craig Arnold (Professor and Director of PRISM)

- 2019 Princeton Engineering Commendation List for Outstanding Teaching

Emily Carter (Professor, Emeritus)

- 2019 John Scott Award, Board of City Trusts, Philadelphia, PA (the oldest science prize in the U.S.)
- 2019 Camille & Henry Dreyfus Lectureship, University of Basel, Switzerland
- 2019 Inaugural WiSE Presidential Distinguished Lecturer, University of Southern California
- 2020 Elected a Member of the European Academy of Sciences
- 2020 UCLA Chemistry & Biochemistry Distinguished Lecturer, University of California, Los Angeles

Lamyaa El-Gaby (Lecturer)

- 2019 ASME Turbo Expo Best Paper

Jesse Jenkins (Assistant Professor)

- 2020 Princeton Engineering Commendation List for Outstanding Teaching, School of Engineering and Applied Science

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

- 2019 Highly Cited Researcher, Web of Science, Clarivate Analytics
- 2019 Plenary Lecturer, "Cool Flames: Dynamics and Impact on Engine and Fuel Design", China National Symposium on Combustion

Naomi Leonard (Professor & Director of the Council on Science & Technology)

- Keynote lecture, 2019 IFAC (International Federation of Automatic Control) Workshop on Distributed Estimation and Control in Networked Systems
- 2020 John R. Ragazzini Education Award, American Automatic Control Council

Anirudha Majumdar (Assistant Professor)

- 2019 Amazon Research Award
- 2019 Google Faculty Research Award
- 2020 Alfred Rheinstein Award

Michael Mueller (Associate Professor)

- 2020 Research Excellence Award, The Combustion Institute

Alexander Smits (Professor, Emeritus)

- 2019 Simpson Distinguished Visiting Professorship, Northwestern University
- 2019 Fluid Dynamics Prize (American Physical Society)
- 2020 The Batchelor Prize in Fluid Mechanics (International Union of Theoretical and Applied Mechanics)
- 2020 Fellow, American Academy of Arts & Sciences (AAAS)

Howard Stone (Professor & Chair)

- 2019 Elected APS Councilor, representative for the Division of Fluid Dynamics and the Topical Group on Climate (4 Year-Appointment)
- 2019 National Academy of Inventors
- 2020 ASME Fluids Engineering Award (Lecture to be delivered in July 2021)
- 2020 Named Co-editor, Annual Review of Fluid Mechanics

Salvatore Torquato (Associated Faculty, Professor of Chemistry)

- 2020 One of the American Physical Society Outstanding Referees
- 2020 Princeton Engineering Commendation List for Outstanding Teaching

Department Personnel (as of September 1)

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Faculty						
Professor	16	15	13	12	11	11
Associate	2	2	3	4	6	4
Assistant	7	7	6	7	6	7
Other				1	1	1
Subtotal	**25**	**24**	**22**	**24**	**24**	**23**
Professional Researchers	45	50	52	43	50	47
Visiting Researchers	13	12	13	19	17	8
Technical Research	6.5	5.5	5.5	4	4	3
Technical Teaching	4	4	4	4	4	4
Administrative	12.5	11.5	12	11	11	13
TOTAL	**106**	**107**	**108.5**	**105**	**110**	**98**







The MAE 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.

Leslie Kaelbling, MIT Computer Science and Engineering
Crocco Collquium—Doing for Our Robots What Nature Did for Us

John Brophy, Nasa, *Electric Propulsion's Present and Future Impact on Space Exploration*

Christopher Hart, Former Chairman of the National Safety Transportation Board, *Benefits and Challenges of Increasing Flight Deck Automation*

Isabel Houghton, University of San Francisco, *Physical and Biogeochemical Impacts of Migrating Zooplankton Aggregations*

Joseph Katz, Johns Hopkins University, *On the Breakup and Transport of Crude Oil by Surface Waves and Subsurface Plumes*

John Kolinski, EPFL, *Crack Path Selection in Dynamic Fracture*

Sungyon Lee, University of Minnesota, *Pattern Formation in Suspension Flows*

Dionisios Margetis, University of Maryland, *Modeling Epitaxial Growth: From Atomistic Motion to Macroscopic Laws*

Julia Mikhailova, Princeton University, *Plasma Optics for Novel Sources of Bright Light: Expanding the Frontiers of Achievable Light Intensities*

Radhika Nagpal, Harvard University, *Collective Intelligence, from Nature to Robots*

Jacqueline O'Connor, Penn State University, *Gas Turbine Combustion Instability: Connecting Fundamental Processes to Combustor Design*

Jeffrey Rickman, Lehigh University, *Using Materials Informatics to Quantify Complex Correlations Linking Structure, Properties and Processing in Materials*

Leif Ristroph, New York University, *Sculpting with Flow: Mudballs, Meteorites, and Candy Landscapes*

UNDERGRADUATE

Class of 2020 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 2020 completed the following interesting and exciting year-long projects.

Individual Thesis Projects

Nina Arcot, *Laser-based Additive Manufacturing of Lightweight Metal Alloys*

Jackson Artis, *Development of A Megawatt Class alpha^2+ Magnetoplasmadynamic Thruster and Beginning Steps for Accompanying Control System for Autonomous Monitoring of Operational Envelope*

Morgan Baker, *Engineering Metal Additives in Lubrication Oil to Control Low Speed Preignition in Advanced Gasoline*

Justin Calimlim, *Additive Advancements in Medical Technology: Easing 3D-Printable Instruments Into Orthopedic*

Julian Castellon, *[Bring] Instax Back*

Nick Chen, *Design of a Wind-Powered Helmholtz Resonance-Driven Thermoacoustic Refrigerator*

Samuel Dale, *Developing a Consumer Product that Mechanically Shields a Bicycle Seat from Rain and Snow*

Justice Dixon, *Developing An Anthropomorphic Biomimetic Hand for Robotics Application*

Jessica Fan, *Designing a Transitional NuFlex Element for Orthopedic Walker Boots for Better Recovery of Lower Leg Injuries*

Melissa Fan, *Digging Deeper into Enhanced Geothermal Systems: Techno-Economic Simulation of EGS Electricity*

Meredith Hooper, *Characterization of a Xanthan Gum — Cetylpyridinium Chloride Microfluidic System*

Hassaan Khan, *Mechanical Characterization of Self-Folding Thermoplastic Polystyrene Sheets*

Tristan LaCombe, *Volt Wagon*

Xerxes Libsch, *Carly: The Miniature Autonomous Vein Injection Robot*

Gregory Luck, *Design of a Low-Cost Solar-Powered Direct-Air-Capture and CO2 Sequestration (DACCS) Plant for Deployment in MENA Countries*

Emily McDonnell, *Designing Child-Safe Quadcopter Rotors: A Study in Low Reynolds Number Propeller Design*

Michael Rodriguez, *Kingfisher: An Unmanned Hybrid Vehicle for Emergency Response Missions*

Alex Rogers, *Processing Optical Observation Data to Efficiently Verify Maneuver History and Orbital Tolerances of Geostationary and Geosynchronous Satellites*

Matthew Timo, *Auto Pot Autonomous Agricultural System*

Andrew Witmer, *Development of a Robot Navigation System*

Jerry Xiang, *Gradient Ion Doping for High Performance Nickel-Rich Cathode Materials in Lithium-Ion Batteries*

Jose Yanez, *Autonomous Land Surveying Using Ground Penetrating Radar (GPR)*

Team or Group Projects

Kate Andre and Matt Hetrick, *Drink Up: A Smart, Hydration-Focused Water Bottle*

John Bachek, Christopher Lawrie, Ofek Peres, and Gabriel Roth, *EverFly: An Autonomous Drone Battery Exchange System*

Jeb Banavige, Connor Matthews, and Adhitya Raghavan, *Waste to Work: Powering Cold Storage Systems Using Biomass and Solar Power*

Alex Caldwell and Cutter Esson, *Power Optimization System*

Nicholas Callegari, Maya Naphade, and Dominic Saunders, *TigerBoard: Creating the Next Generation of Hoverboards*

Julian Castellon and Jerry Xiang, *Design and Additive Manufacturing of an Active Damped Tatoo Machine*

Matthew Helm and Alexis Rysewyk, *Dynamic Thrust and Vector Control of a Small Scale TurboJet Engine*

Milo Hughes and Andrew Redd, *Development and Optimization of Ball Bearing Race Geometry and Ferrofluid Pressure Seals for EVA Space Suits*

Sneha Iyer and Abby Breitfeld/ELE, *The Design and Control of an Economical Autonomous Surface Vehicle for Object Detection*

Alexandra Koskosidos and Nick Ng, *Design of Safe & Robust Aerial Co-Drone for Human Collaboration*

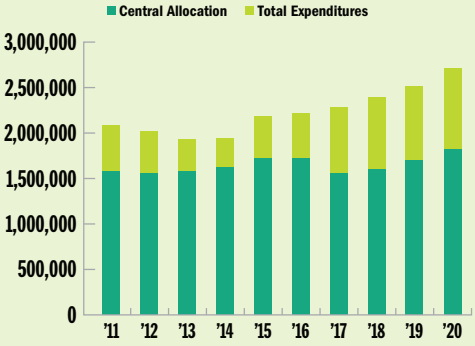
Divyanshu Pachisia, Evan Quinn, Beimnet Shitaye and Jocelyn Wang, *Soft Eversion Robots in Application of Minimally Invasive Subsurface Drip Irrigation*

Senior Independent Work (One Semester Projects)

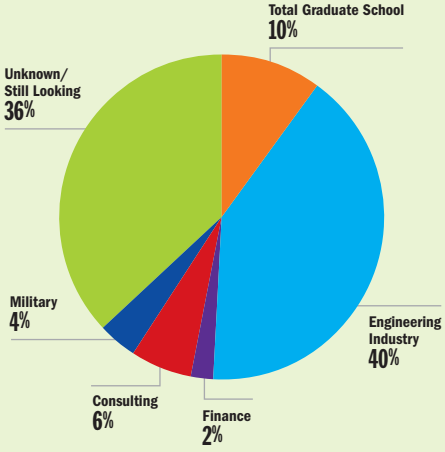
Satchel Joseph, *Fish are Friends and Food (Aquaponics System)*

Bora Kiyan, *Machine Learning Methods such as Neural Networks to Control the Dynamics of a Tokamak*

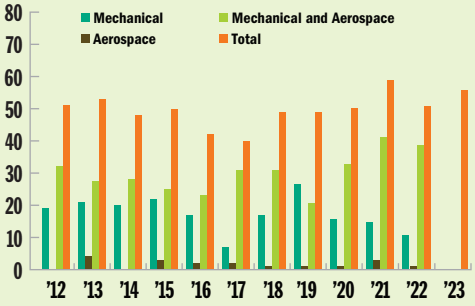
MAE Operating Expenditures



MAE Post-Graduate Plans for Graduating Seniors



MAE Undergraduate 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 in MAE

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.

2019-20 Graduate Students

Soha Aslam, M.Eng.
Advisor: Alexander Glaser
(June 2020)

Julien de Troullioud de Lanversin, Ph.D.
Advisor: Alexander Glaser
Thesis: ONIX: an Open-Source Burnup Code for Nuclear Archaeology (August 30, 2019)
Position: Stanford University, Postdoctoral Fellow

Rebecca Gray, Ph.D.
Advisor: Naomi Leonard
Thesis: Designing Collective Decision-making Dynamics for Multi-agent Systems, with Inspiration from Honeybees (July 19, 2019)
Position: Data Scientist Olvin, London

Nathan Grube, Ph.D.
Advisor: Pino Martin
Thesis: Shock Wave--Turbulence Interactions (January 29, 2020)
Position: Postdoctoral Associate, University of Maryland Aerospace Engineering (short-term postdoc), then Dridam Flight, Maryland

Michael Hepler, Ph.D.
Advisor: Alexander Glaser
Thesis: Zero-knowledge Isotopic Discrimination for Nuclear Warhead Verification (May 7, 2020)
Position: Basel, Switzerland

Thomas Hodson, Ph.D.
Advisor: Daniel Steingart
Thesis: Probing of the Evolution of Electrochemical Systems using Non-Destructive Techniques (May 14, 2020)
Position: Columbia University, Postdoctoral

Xinyi Minnie Liu, Ph.D.
Advisor: Craig Arnold
Thesis: Localization Phenomenon Due to Mechanically Induced Transport Non-uniformities in Lithium-ion Batteries (February 10, 2020)
Position: Walmart Labs, Hoboken

Ying Liu, Ph.D.
Advisor: Howard Stone
Thesis: Manipulating Multiphase Flows using Physical or Chemical Mechanisms (January 21, 2020)
Position: Radix Trading LLC, Quantitative Researcher

Justice Mason, M.S.E.
Advisor: Naomi Leonard
Thesis: Application of Model Reference Adaptive Control to Leader-Follower Systems for 6DOF Control of Starshade-Telescope Formation Concepts (September 2019)
Position: Princeton University Ph.D. candidate

Alex Novoselov, Ph.D.
Advisor: Michael Mueller
Thesis: Manifold-Based Modeling of Turbulent **Reacting Flows:** Cool Flames and Multi-Modal Combustion (May 19, 2020)
Position: ETH Zurich, Postdoctoral

Renato Pagliara Vasquez, Ph.D.
Advisor: Naomi Leonard
Thesis: Mechanisms and Opportunities for the Design of Robust and Flexible Collective Behavior in Dynamic Multi-Agent Systems with Interactions (July 18, 2019)
Position: Boston Consulting Group (Seattle, WA), Consultant

Christopher Peters, Ph.D.
Advisor: Richard Miles
Thesis: Considerations for Femtosecond Laser Electronic Excitation Tagging in High-Speed Flows (July 1, 2019)
Position: Research Aerospace Engineer, Inlets and Nozzles Branch, NASA Glenn Research Center

Leonid Pogorelyuk, Ph.D.
Advisor: Clancy Rowley
Thesis: Non-linear Reduced-order Estimation and Control of Space-based Coronagraphs (January 20, 2020)

Aric Rousso, Ph.D.
Advisor: Yiguang Ju
Thesis: Plasma-Assisted Combustion: Kinetics and Control (September 9, 2019)
Position: Lawrence Livermore National Laboratory, Mechanical Engineering Analyst

He Sun, Ph.D.
Advisor: Jeremy Kasdin
Thesis: Efficient Wavefront Sensing and Control for Space-based High-contrast Imaging (September 10, 2019)
Position: Caltech, Postdoctoral

Weiqi Sun, Ph.D.
Advisor: Yiguang Ju
Thesis: Developments of Efficient Numerical Methods for Combustion Modeling with Detailed Chemical Kinetics (May 11, 2020)
Position: Bloomberg LP, Software Developer

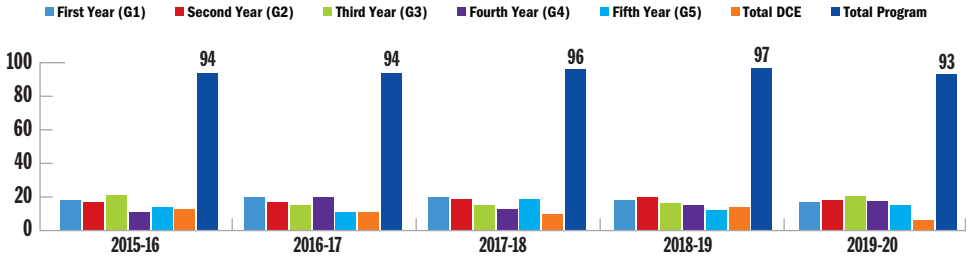
Chuck Witt, Ph.D.
Advisor: Emily Carter
Thesis: Quantum Mechanics Without Wave **Functions:** Advancing Orbital-Free Methods for Materials Research (July 16, 2019)
Position: University of Cambridge, Postdoctoral

Estella Yu, Ph.D.
Advisor: Howard Stone
Thesis: Thin Films and Interfacial Dynamics for Environmental Applications (May 11, 2020)
Position: Princeton University, Postdoctoral

Hao Zhang, Ph.D.
Advisor: Clancy Rowley
Thesis: Data-driven Modeling for Fluid Dynamics and Control (February 28, 2019)
Position: Bloomberg L.P. NLP, Researcher

Hao Zhao, Ph.D.
Advisor: Yiguang Ju
Thesis: Oxidation of Hydrocarbons and Oxygenated Fuels with Chemical Sensitization by Ozone/Nox/Radicals (August 12, 2019)
Position: Chemical Engineering, Princeton University, Postdoc

MAE Graduate Actual Enrollment by Year (PhD)



Graduate Student Fellowships and Awards

DEPARTMENTAL:

Anastasia Bizyaeva, *Larisse Klein Award*
Rory Conlin, *Guggenheim Second Year Fellowship*
Xiaohan Du, *Crocco Award for Teaching Excellence*
Alec Farid, *MAE Department Second Year Fellowship*
Simeret Genet, *Guggenheim Second Year Fellowship*
Kelly Huang, *Crocco Award for Teaching Excellence*
Paul Kaneelil, *Phillips Second Year Fellowship*
Cristian Lacey, *Guggenheim Second Year Fellowship; Sayre Award for Academic Excellence*
Zirui Liu, *Harari Post Generals Fellowship*
Udari Madhushani, *Larisse Klein Award*
Susan Redmond, *Summerfield Second Year Fellowship*
Jiarong Wu, *MAE Department Second Year Fellowship*
Desmond Zhong, *Harari Post Generals Fellowship*
Alex Novoselov, *MAE Research Day First Prize*
Estella Yu, *MAE Research Day Runner Up*

UNIVERSITY:

Fan Yang, *Wallace Memorial Graduate Honorific Fellowship*
Katherine Kokmanian, *2019 Excellence in Teaching Award, Undergraduate and Graduate Engineering Council*
Tasman Powis, *PEI-STEP Fellowship*
Christopher Galea, *School of Engineering and Applied Science Award for Excellence*
Estella Yu, *School of Engineering and Applied Science Award for Excellence*
Zirui Liu, *School of Engineering and Applied Science Award for Excellence*

EXTERNAL:

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*
Kelly Huang, *National Defense Science and Engineering Graduate Fellowship*
Jihye Jeon, *Korean Ministry of Education Fellowship*
Katherine Kokmanian, *Amelia Earhart Fellowship*
Samuel Otto, *National Science Foundation*
Anthony Savas, *National Defense Science and Engineering Graduate*
Daniel Shaw, *National Science Foundation*
Vivian Steyert, *National Science Foundation*

Graduate Program Professional Development

Complementing academic offerings, the department provides programming to promote student success in research, teaching, career development and professionalism. Students can participate in a number of workshops to develop skills in areas such as public speaking, writing, research and explore post-graduation possibilities.

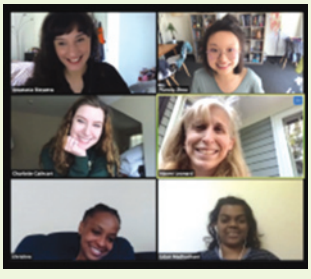
Niki Abbasi, *Graduate Student, Nonequilibrated Aqueous Two-phase Systems for Generation of Biomaterials;* Meghan Booker, *Graduate Student, Active Memory Reduction in Task-Centric Controller Design;* Rory Conlin, *Graduate Student, Machine Learning Fusion Plasma;* Alec Farid, *Graduate Student, Using PAC-Bayes Bounds to Learn Policies that Provably Generalize to Novel Environments;* Simeret Genet, *Graduate Student, Modelling of Non-Equilibrium Wall Bounded Turbulent Flows;* Jesse D. Jenkins, *Assistant Professor, Getting to Zero: New MAE faculty Jesse Jenkins on the Transition to a Carbon-free Electricity System;* Yiguang Ju, *Professor, The Role of Plasma Chemistry in Transition to Electron Energy;* Paul Kaneelil, *Graduate Student, Two-phase Flow Instability at a Channel Outlet;* Egemen Kolemen, *Assistant Professor, Engineering for Fusion: Lasers, Fluids, Control and Machine Learning;* Cristian Lacey, *Graduate Student, Computationally Efficient Data-Enhanced Manifold Modeling of Multi-Modal Turbulent Combustion;* Christine Murphy, *Assistant Dean for Academic Affairs, The Adviser/Advisee Relationship How to Find the Right Adviser for You;* Laura Murray, *Assistant Director, Learning Programs, McGraw Center for Teaching and Learning, RIPE for Research: Respect, Inclusion, Professionalism, and Equity in Research;* Susan Redmond, *Graduate Student, Focal Plane Wavefront Control for Direct Exoplanet Imaging;* Dan Shaw, *Graduate Student, Surface Bubble Coalescence*
Gawoon Shim, Graduate Student, Accelerated Wound Healing by Galvanotactic Migration of Keratinocyte Tissues; Ricardo Shousha, *Graduate Student, Improving real-time equilibrium reconstruction by including pressure constraints and tracking MHD stability using Relay Feedback Methods;* Amlan Sinha, *Graduate Student, Verifiable, Control-Oriented Learning on the Fly a Toy Problem;* Josiah Wai, *Graduate Student, Model Predictive Control of the X-Divertor in ITER;* Kristina Watters, *Manager, Procurement Operations, Finance and Treasury, Concur Overview;* Jiarong Wu, *Graduate Student, Numerical Investigation of Wind Wave Growth;* Roy Zhang, *Graduate Student, Physical Modeling of Pathological Protein Fibrillization*

2018, becoming the first female Princeton graduate to win a Nobel Prize. She is known for pioneering the technique of "directed evolution," which guides genetic code development in successive generations of bacteria to allow for more environmentally friendly manufacturing of chemical substances, including medicines and renewable fuels. Among her many honors, Arnold is a member of the National Academy of Sciences, the National Academy of Medicine, and the National Academy of Engineering.

June 2020

Faces of Princeton Engineering in a snapshot of Research life during the quarantine

In May, Professor Naomi Leonard's research group met for twice-weekly "coffee breaks" on Zoom during the Pandemic shutdown. Featured are half of the Leonard research group: Presidential Postdoctoral Research Fellow Christine Allen-Blanchette, PhD students Anastasia Bizyaeva, Yunxiu Zhou, Charlotte Cathcart, and Udari Madhushani, and Professor Naomi Leonard.



Shneider receives 2020 AIAA Plasmadynamics and Lasers Award

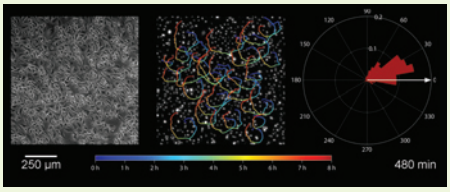
Mikhail N. Shneider, MAE senior research scholar, received the award at the June 2020 American Institute of Aeronautics and Astronautics (AIAA) Aviation and Aeronautics Forum and Exposition. The award recognized his "seminal contributions to the theory and modeling of electric discharges and theoretical foundations of diagnostics based on coherent microwave and laser scattering."

Majumdar receives Faculty Advancement Award

Professor Ani Majumdar was one of six SEAS junior faculty members to receive the E. Lawrence Keyes, Jr./Emerson Electric Co. Faculty Advancement Award for early-career excellence in research and teaching. He leads MAE's Intelligent Robot Motion Lab. The award will support research into approaches for learning control policies that provably generalize well to novel environments.

Mezhericher appointed to International Journal of Chemical Engineering

Dr. Maksim Mezhericher, Associate Research Scholar in Professor Stone's Complex Fluids Group, has been appointed Academic Editor and Editorial Board Member for the *International Journal of Chemical Engineering*.



Researchers use electric fields to herd cells like flocks of sheep

Princeton researchers have created a device called SCHEEPDOG (Spatiotemporal Cellular HErding with Electrochemical Potentials to Dynamically Orient Galvanotaxis) that can "herd" groups of cells like sheep, precisely directing the cells' movements by manipulating electric fields to mimic those found in the body during healing. The technique opens new possibilities for tissue engineering, including approaches to promote wound healing, repair blood vessels, or sculpt tissues. Senior author Dr. Daniel Cohen and his team published the report in the journal *Cell Systems*.

Emeritus Professor Brown awarded the status of an Officer of the Order of Australia (AO)

Garry Brown was awarded the AO in June as part of the 2020 Queen's Birthday Honors List, in recognition of his distinguished service to aerospace and mechanical engineering, to education and research, and as a mentor to young scientists. In addition to serving as a Princeton MAE professor and department chair, he directed Australia's Aeronautical Research Laboratory for nine years.

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