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 biotechnology, energy production and distribution, 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 2018-19 YEAR IN REVIEW:
Capitalizing on Synergy

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

Welcome to the 2018-19 edition of the annual report of the Department of Mechanical and Aerospace Engineering (MAE). Each year, we celebrate the accomplishments of the people of MAE and share how we are meeting the challenges faced in our field to develop a better, safer, and more productive world.

Looking back at the 2018-19 accomplishments and milestones set out in these pages, one theme continues to be evident: our faculty and students are capitalizing on synergy to advance knowledge and discoveries not only in our own disciplines but also in other fields, at Princeton and around the world.

MAE operates under the auspices of Princeton University’s School of Engineering and Applied Science (SEAS) and supports two of Princeton’s five ABET-accredited undergraduate degree programs in SEAS. We are unique in that MAE represents a variety of disciplines recognized at most universities in separate departments.

The driving force of our department and its accomplishments is our faculty. We have 22 faculty members and one lecturer (19 FTEs total). Together, we build on a long history of academic success and societal impact. For example, five regular or emeriti faculty (Carter, Law, Miles, Smits, and myself) are members of the NAE and/or the NAS.

BEYOND BOUNDARIES
Our faculty conduct active, world-leading research programs in many areas, including some research topics that stretch the traditional boundaries of MAE. As such, collaboration is one of our greatest strengths. Our MAE faculty work with colleagues around the globe and in many departments at Princeton in areas as diverse as:
- Chemical and Biological Engineering
- Civil and Environmental Engineering
- Computer Science
- Ecology and Evolutionary Biology
- Mathematics
- Molecular Biology
- Neuroscience
- Operations Research and Financial Engineering
- Physics
- Woodrow Wilson School of Public and International Affairs

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, we are actively involved in:
- Robotics and dynamical systems, and its modern variants of cyberphysical systems
- Materials sciences—including problems from engineering materials to biomechanics
- 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, and fusion energy

We hope you enjoy learning through this publication about our community of faculty, researchers and students who explore new ideas and challenge old ones every day, contributing to science and real-world applications from mechanical to aerospace engineering — and beyond.

The Complex Fluids Group (with some visitors).
Each year, many stories about student and faculty achievements grace the pages of the MAE website. Here is a summary of some highlights in one easy-to-read place. To read more details about the stories below, please visit the MAE news pages at https://mae.princeton.edu/about-mae/news.

July 2018

Foam offers greener option for petroleum drillers
Princeton researchers, led by Prof. Howard Stone, described in the July 2018 edition of the journal PNAS how a compressible foam can reduce the amount of fresh water and resulting wastewater typically involved in the hydraulic fracturing (fracking) process. Lead author Ching-Yao Lai, PhD '18, reported that foam fracturing would use only about 10 percent of water by volume. Additional authors include Princeton researchers Bhargav Rallabandi, Antonio Perazzo, Zhong Zheng, and Samuel Smiddy (an undergraduate in Chemical and Biological Engineering). Stone is the Donald R. Dixon '69 and Elizabeth W. Dixon Professor of Mechanical and Aerospace Engineering, and Chair, Department of Mechanical and Aerospace Engineering.

Building fish-inspired robots
Former MAE graduate student Derek Paley '07 has long been fascinated by how fish flap their way efficiently through water and how they swim cohesively in a group by using a strip of sensors on their sides to detect water flow and obstacles. He is leading researchers at the University of Maryland in developing a fish-inspired submarine to explore fish-sensing and propulsion in the context of developing autonomous robots. He is UMD's Willis H. Young Jr. Professor of Aerospace Engineering Education and the Director, Collective Dynamics and Control Laboratory in Department of Aerospace Engineering. See a video of the fish-submarine here: https://youtu.be/TXs19EotErQ

August 2018

MAE alumni gathering in California
MAE alumni, who are all engineers at Virgin Space Companies, gathered for dinner in Los Angeles: (from left) George Whitesides (WWS) and MAE's Josh Ellis '15, Brittany Ilardi '16, Daphne Rein-Weston '12, Isabel Clerf '18, Carter Green '20, and Scott Ostrem '89.

September 2018

Leonard presents 2018 Marsden Memorial Lecture
Naomi Ehrich Leonard, the Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering, gave the annual award lecture at the Pacific Institute for the Mathematical Sciences in Vancouver, British Columbia. Her topic was nonlinear dynamics for distributed decision-making that derive from principles of symmetry and bifurcation. Her work is inspired by studying animal groups such as house-hunting honeybees and schooling fish to demonstrate how they can be both flexible and stable in response to a changing environment.

October 2018

Video shows a particle surfing in its own wave
Check out this video (at https://engineering.princeton.edu/news/2018/10/02/riding-wave) showing a marble-sized sphere falling through a tank of silicone oil, a viscous, honey-like liquid, alongside a thin rubber sheet. At the beginning, the sheet and marble are almost touching, but as the sphere falls, the two grow further apart. This behavior (a particle surfing its own wave) was identified by a team of researchers from Prof. Stone’s MAE lab, along with their counterparts at the Flatiron Institute in New York and the Center for Soft Matter Research at New York University. The team hopes this research will help measure elastic properties of biological membranes or help learn how to separate particles.

Passing of Professor Emeritus Lam
Sau-Hai (Harvey) Lam, who developed influential theories in fluid mechanics, combustion and plasma dynamics and helped shape engineering education at Princeton, died Oct. 29 in Plainsboro, N.J., at age 87. He served on the University’s Mechanical and Aerospace Engineering faculty for four decades and was the Edwin Wilsey '04 Professor Emeritus of Mechanical and Aerospace Engineering. He earned his PhD in aeronautical engineering from Princeton in 1958.

November 2018

Prof. Ju wins 2018 International Prize of the Combustion Society of Japan
Viguong Ju, the Robert Porter Patterson Professor of Mechanical and Aerospace Engineering and Director, Program in Sustainable Energy, was honored for making distinguished contributions to the international and Japanese combustion research communities.

At the intersection of nonlinear dynamics and improvisational dance
Prof. Leonard and her team collaborated with Princeton dance and music colleagues to study how a collective, in-the-moment creative process such as improvisational dance is a valuable model for studying social decision-making. The rule-based improvisational work was entitled, “There Might Be Others.” Her team uses mathematical model-based investigations of complex group dynamics to explain and explore collective behavior in nature and art and to inform the design of control systems for robot teams operating in challenging environments. The research was published in the Nov. 20, 2018 edition of the journal Interdisciplinary Science Reviews. It represents a new application of an evolutionary theory examining this tension in the context of different survival strategies within a population of individuals. Learn more here: https://doi.org/10.1080/030 80188.2018.1544806

August 2018

Glassman receives the 2018 Daniel Guggenheim Medal
Irvin Glassman, the Robert H. Goddard Professor of Mechanical and Aerospace Engineering, Emeritus, was recognized for his work as a legendary combustion expert who has enhanced understanding of fundamental combustion processes. His contributions have enabled engineers and scientists to improve the performance of propulsion and power generation systems, while minimizing their adverse environmental effects.
Dying bacteria absorb antibiotic, allowing others to survive and grow

MAE Assistant Prof. Andrej Kosmrlj collaborated with a team from California State University-Northridge (CSUN) to develop a mathematical model to more fully explain the “self-sacrifice” phenomenon and aid further investigations. They created the model by observing what happens when a population of E. coli bacteria is treated with a particular antimicrobial antibiotic, allowing their neighbors to survive and continue growing. The team published their results here: https://doi.org/10.1371/journal.pcbi.1006200

Majumdar receives Amazon Research Award

Assistant Prof. Anirudha Majumdar’s research focuses on the control of highly agile robotic systems such as unmanned aerial vehicles with formal guarantees on their safety and performance. The discovery allowed chemists to engineer biological catalysts that mimic natural evolution in a laboratory setting, thus enabling greener, less energy-intensive and less polluting manufacturing processes.

Buse Aktas receives Amazon Research Award

Buse Aktas, who graduated with a Princeton BSE in 2012, was profiled by Harvard University’s School of Engineering and Applied Sciences, where she is pursuing her PhD. As an engineer and artist, she noted the similarities between working on her engineering degree and the two years she spent as a broom-maker’s apprentice in her native Turkey, which resulted in a sculpture project. While at Princeton, for her senior thesis she developed a device to help individuals with physical and mental disabilities build objects on an assembly line at an Easter Seals workshop.

MAE alumnus honored as Distinguished Lecturer at AIAA Science and Technology Forum

Virginia Tech Prof. Joseph Schets (Princeton MAE ’62) gave the 2019 American Institute of Aeronautics and Astronautics (AIAA) Dryden Lecture in Research on “Truss-Braced Wing Designs for High-Speed Transport Aircraft.” He currently is the Fred D. Durham Endowed Chair in the Kevin T. Crofton Department of Aerospace and Ocean Engineering at Virginia Tech.

Majumdar receives Amazon Research Award

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Kokmanian receives Excellence in Teaching Award

Katherine Kokmanian (MAE ’92) received the Excellence in Teaching Award presented by the Undergraduate and Graduate Engineering Councils.

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As a kid, I loved television shows like ‘MythBusters’ and ‘How It’s Made,’” he says. “By watching the Discovery Channel, I learned what engineering was in an ideological sense—which is taking the world into your hands and changing it for the better. That really spoke to me.”

Fierros pursued his interest in science in middle school and high school, even spending a summer as a high school researcher on Villanova University’s Autonomous Surface Vehicle Team. His team competed in the AUVSI Roboboat competition and later in the international RobotX competition and he gained an appreciation for the work that goes into designing and building robotic systems, he says.

In high school, he also discovered another passion: technical theater.

Diego Fierros knew he wanted to be an engineer early on.

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Diego Fierros
Bringing engineering to the world stage
DEGREE: BSE
SPECIALTY: DYNAMICS AND CONTROLS

“My specialty is sound design, setting up speakers in the performance space, programming the sound board, and making sure that every actor’s microphone is working properly,” he explains. “Plus, I mix in the music from our pit orchestra so that every sound is balanced in the theater. My goal is for the audience to hear every line and have the best possible time at our shows.”

Fierros’ love of theater carried over to Princeton, where he joined the Triangle Club in 2016. Founded in 1891, the Triangle Club is America’s oldest touring college musical-comedy theater group, with productions written and performed by the students. Fierros uses advanced theater hardware to create and adjust a live theater soundscape. He has directed several teams of technicians in setting up and breaking down the theater sound system at tour venues and is mentoring incoming students about theater sound design.

When Fierros was considering universities to attend, he visited many institutions, including schools that were purely technical. “However, they seemed like competitive pressure cookers where people have learned to become addicted to the stressful environment,” he notes. “Princeton is competitive as well, but by contrast, the atmosphere is more relaxed. Plus, it provides a good liberal arts education, which is important for STEM majors. A great engineer who can’t properly express their ideas is doomed to failure.”

In his freshman year, one of his courses involved authenticating and repairing two antique Triumph motorcycles. “I learned a lot about mechanical design and how to machine things,” says Fierros.

Later, he participated in the Fluid Mechanics Transport Phenomena Group, where he used PTC Creo design software to develop laboratory equipment such as a sensor test bench and a wind tunnel pitot traverse.

He developed procedures for injection molding low-cost sensor interfaces for medical fluid tubing.

His internship at the Siemens Corporate Technology Future of Automation Lab gave him experience learning practical robotic programming using the Robotic Operating System and Linux. He collaborated with a team of researchers to develop an autonomous robotic farming system.

He is now pursuing certificates in Computer Science and Robotics and Intelligent Systems along with his degree.

In Prof. Daniel Cohen’s bioengineering lab, he studied how the shape of wounds affects how fast they heal. He also started pondering how to create a device that maps asymmetric strain fields onto wounded tissue to determine how the cells act when subjected to these conditions.

Under the supervision of Prof. Luigi Martinelli, Fierros also volunteers as an Interactor, a resource for undergraduate engineers or those interested in the BSE program.

“I talk to them about my experiences, hoping it will help them as they are starting out,” he says. “It can be daunting, especially during the first two years in engineering, to get all the classes under your belt while acclimating to what Princeton expects of you as a student. It’s important to me, even in a minor way, to help alleviate some of that stress and let them know that someone cares.”

Looking ahead, Fierros is weighing his options for the future, which could include a master’s degree. “But I may want to get some industry experience first, just to get an idea of what that scene is like. I’m interested in learning more about automation and robotics, particularly as it relates to autonomous vehicles,” he says. “I think robotics is an aspect of engineering that has the potential to do a lot for our society.”

©

Diego is very personable, well organized and willing to go the extra mile to help. His personality is multifaceted. And from our talks about CAD and robotics in particular, I find him to be technically knowledgeable and engaging.

—Prof. Luigi Martinelli
Zirui Liu has always been interested in rockets, space, travel and “blowing stuff up,” he says with a laugh. In fact, the likable third-year PhD student initially became interested in the engineering and aerospace fields as a result of his voracious reading habit.

As a child, he loved science biographies: Isaac Newton inspired his love of mathematics and science, while Albert Einstein and Marie Curie deepened his interests in physics and chemistry, respectively. Somewhere along the way he read about combustion. He began conducting experiments while reading M.M. Pattison Muir’s page-turner “The Story of the Chemical Elements,” which mentioned using flame to heat up salt and bones. It was a great idea—until his parents found out, that is.

His interest in fire goes back to around age 8. “I would buy matches and light the grass on fire in the lot near my house,” Lui explains. “My parents weren’t very happy about that.” But, he did it a few more times after that. How else is a budding scientist supposed to learn about combustion, right?

Liu comes from Fuxin, China, also called the “Agate City,” since roughly 90 percent of the country’s agate products are mined in the agricultural region. “Fuxin is a nice city with mountains, rivers, and one main street, similar to Princeton,” he says.

Liu traveled frequently in China with his parents and caught the sightseeing bug. He enjoyed the skyscrapers in the big city of Shanghai and the desert and mountains of western China.

He also inherited his parents’ sense of honor and duty to country. His mother works in China’s environmental protection department, which safeguards forests and wild animals. Her appreciation for nature seeped into family life and gave Liu his fondness for the outdoors.

While Liu and his classmates were hard at work studying for the very competitive college entrance exams, he eagerly followed the news about SpaceX launching the first flight of the reusable cargo spacecraft called the Dragon. This solidified his desire to combine his interests in math, science, combustion, and space into a major. His hard work paid off when he was accepted into the Aerospace Engineering program at Beijing’s Tsinghua University.

He still found time to satisfy his wanderlust during his undergraduate years, traveling to Tibet, Beijing and Shanghai. “We saw many beautiful mountains, lakes, and went into the sacred mountains of Mount Nojin Kangsang. It was a life-changing experience to see new cultures and become immersed in them,” he says.

So, how exactly does one from China hear about Princeton University in New Jersey?“It’s the best school for combustion and the professors are the best,” he says, noting that the university’s reputation is world-renowned.

“This is the leading research department with a long history of studies into combustion. Combustion is very important if you are interested in space.”

At Tsinghua University, he took second place in the Aeronautic and Aerospace Design Competition and won the National Academic Scholarship, also in China.

At Princeton, Liu was awarded the MAE Second Year Fellowship in 2017. Humble by nature, he wanted to share his knowledge and spent the Fall 2018 semester as a Teaching Assistant helping students with Mathematical Methods of Engineering Analysis I (MAE-APC 501).

He has continued his passion for sightseeing since arriving in the Western Hemisphere. He’s been to Iceland and Alaska, where he missed seeing the Aurora Borealis because it was snowing. “But the mountains were very beautiful,” he adds. Since starting at Princeton, he’s been to New York several times and also drove from LA to San Francisco.

As for his research, his project for Prof. C.K. Law’s group is called “Laminar and Turbulent Flame Propagation Under the Effect of Flame Instability,” which has application to automobile and airplane engines.

“I am trying to see the interaction between flame instability and turbulence,” says Liu, who would like eventually to teach at a U.S. university to continue his combustion research or work at a national lab or in industry. “This could be applied to real engines because the flame instability appears when the pressure is high and in engines the flow is turbulent.”

For now, this talented young man is sharing his curiosity and insights at Princeton…by blowing things up in a lab.

“Zirui’s discovery and analysis on the structure and propagation of laminar and turbulent flames, with and without the occurrence of cells over the flame surface, not only is a major advance in flame theory, but it also offers strategies towards increasing the combustion efficiency and reducing the undesirable emissions from burning petroleum fuels.”

— Prof. C.K. Law
When Nikita Dutta was a child, she invented a cutter that sliced through her EGGO waffle ridges faster, crafted a penny and nickel sorter from a cereal box to organize her loose change, and created a long straw that reached from her room to the sink, to avoid the walk downstairs for a drink of water.

“I always liked inventing and creating things,” says Dutta. “It combines my enjoyment for making projects with my hands and my need to make life around the house more efficient.”

During childhood, she took apart old toys and sifted through the recycling to find spare parts. Today, as a materials scientist, she finds ways to repurpose materials by changing their properties and structures to make them work in new or more efficient ways.

When she started her undergraduate studies at Yale University, her first preference was to be a biology major, which would be truly transformative for a major branch of materials science.

In a junior year particle physics project, she developed an algorithm to reconstruct muon events coincident between the Ice-Cube Neutrino Observatory and the DM-Ice 17 dark matter detector. Her goal was to reduce background noise for both experiments and it was the first time she saw herself pursuing a research career.

“Repairing implies an endpoint,” she explains. “When the job is done, the device works one way, and there is nowhere to go from there. Research, on the other hand, builds off existing science, but there is no fixed endpoint. Even after a successful study, there is somewhere new to go.”

Also, projects that make people’s daily lives better appealed to her, as did materials science, which seemed a nice combination of fundamental science and impactful, real-world applications.

“In any kind of engineering you need materials that behave efficiently and with the right kinds of properties. Materials science often fuels innovation in other areas. Some of my work can be used in solar energy, some in medicine for laser surgery, and some in information storage,” she says.

Dutta is developing new ways to understand and control how processing materials in various solvents will generate desired properties for use in a device and make them work better. In particular, she works with chalcogenide glasses, which are very responsive to light and are used in fiber optic networks, chemical sensors, and other applications that transmit information or store energy using light.

Previous approaches have involved solution processing of materials, seeing what happens, and then going back to tweak the process. Instead, Dutta developed a process that creates a solution with parameters that lead to a certain structure with desired properties.

“This gives you more control than the reverse technique [where you] go backwards to tweak your result without really understanding how the properties arose,” she says.

“Solution processing is useful because it is very simple — you do not need high temperatures or expensive equipment. You can simply add things to the solution that change the structure of the material. It is also very flexible, so it allows for a variety of deposition methods, like inkjet printing or filling a mold,” she says.

Her research has developed new characterization methods, notes Prof. Craig Arnold, that have “revealed the first-ever experimental validation of the molecular structure of this material in solution. This is an initial stage to the formation of bulk material and a critical missing link in our current understanding of amorphous materials.”

Even today, Dutta’s mind is always conceiving new inventions, including a focus on how material science could be applied to women’s health issues. “What I love most about science is that it is never stagnant,” she says. “Science is constantly evolving and growing. It is a real privilege to be a part of this field and know that you can have a practical impact on the world around you.”

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Vivian Steyert’s lifelong passion for learning — and imparting that knowledge to others — was evident from the start. From twirling pirouettes and viola scales to science fair experiments and algebra equations, she has long been enamored with both the arts and sciences. But, figuring out puzzles and finding ways to demonstrate concepts ultimately captivated her extensive curiosity.

“From very early on, I loved school and was interested in learning everything,” she recalls. “Growing up I spent a lot of free time pursuing my interests in ballet and viola. I loved the artistry and teamwork involved in orchestra and ballet performances. I was also a voracious reader. Over the years, my interests gradually narrowed more towards math, physics, engineering, and computer science.”

As a child, she “taught” her younger sister in pretend art or math school, later helping her sibling with homework. She was a teen SAT tutor for the National Honors Society and continued tutoring in college. As a fourth-year PhD student at Princeton, Steyert was an assistant instructor for the undergraduate automatic control systems lab course.

“Teaching has been a great way for me to help other students and, at the same time, deepen my understanding of the material,” says Steyert. “My favorite part of teaching is watching a concept click into place for a student. It is an incredible process to witness.”

Steyert’s favorite part of the course is the culminating pendulum project, in which students piece together the concepts they have learned all semester and balance an upside-down pendulum using a control system they design.

The wonderment Steyert sees so often in her students’ eyes reminds her of a defining personal moment. Her fluid mechanics professor asked the class to describe what would happen to an adiabatic subsonic flow in the presence of friction. They all assumed it would slow down. Even though Steyert understood every step, she didn’t predict the result.

“Situations like this one, where the mechanical world is shown to be more complicated than I had previously imagined, are exciting. Understanding why and how the strange behavior occurs is thrilling to me,” she explains.

Observing the physical world was a common topic of conversation in her Maryland home growing up. Both Steyert’s mother and father have PhDs in chemistry and microbiology, respectively.

“My mother would always talk about work at home. It gave me insight into what it was like to conduct research,” says Steyert. “They were very hands-on with my science fair projects and made me think more deeply about the subjects, while still giving me the space to make the experiment my own.”

The overarching idea of Steyert’s research is to develop simplified models and algorithms that can explain and control natural processes and allow predictions to be made. For example, researchers obtain a copious amount of velocity data when studying the flow of fluids within a system. Her approach separates the data about structured behavior from the random, chaotic behavior, letting her develop a simple model and algorithm that can explain the flow, which can ultimately help control the fluid in a desired way.

“If we better understand the limits and capabilities of these algorithms, we can develop new, more efficient methods,” says Steyert, whose approach could be applied not just in fluid mechanics but also in disease modeling or even finance.

While teaching has been a defining part of the researcher Steyert has become, she says she will likely pursue a career in industry first, where there will undoubtedly be countless opportunities to fuel her first love — learning — and perhaps even become a mentor and teacher again someday.
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.

**FACULTY**

**Professor**
- Craig Arnold
- Emily Carter
- Edgar Choueiri
- Mikko Haataja
- Yiguang Ju
- N. Jeremy Kasdin
- Chung (Ed) Law
- Naomi Leonard
- Michael Littman
- Clarence Rowley
- Robert Stengel
- Howard Stone, Chair

**Associate Professor**
- Alexander Glaser
- Marcus Hultmark
- Luigi Martinelli
- Michael Mueller
- Daniel Nosencshuck
- Daniel Steingart

**Assistant Professor**
- Daniel Cohen
- Luc Deike
- Egemen Kolemen
- Andrej Kosmrlj
- Anirudha Majumdar
- Julia Mikhailova
- Lamyaa El-Gabry
- Ankur Gupta (part-time)
- Glenn Northey (part-time)
- Suin Shim (part-time)

**Lecturer**
- Lamyaa El-Gabry
- Ankur Gupta (part-time)
- Glenn Northey (part-time)
- Suin Shim (part-time)

**Associated Faculty**
- Ilhan Aksay, Chemical & Biological Engineering
- Elie Bou-Zeid, Civil & Environmental Engineering
- Nathaniel Fisch, Astrophysical Sciences
- Bruce Koel, Chemical & Biological Engineering
- David Spergel, Astrophysical Sciences
- Salvatore Torquato, Chemistry Research & Financial Engineering
- Claire White, Civil & Environmental Engineering

**DEPARTMENTAL COMMITTEES**

**Graduate Committee:**
- Alex Glaser, Chair
- Edgar Choueiri
- Marcus Hultmark
- Ani Majumdar
- Michael Mueller

**Director of Graduate Studies:**
- Alex Glaser, Chair

**Undergraduate Committee:**
- Michael Littman, Chair
- Craig Arnold
- Marcus Hultmark
- Yiguang Ju
- Andrej Kosmrlj

**EEO Officer:**
- Michael Mueller

**Chemical Hygiene Officer:**
- Michael Vocaturo

**Department Safety Manager:**
- Jonathan Prevost

**SEAS Lab Safety Committee Representatives:**
- Michael Littman
- Jonathan Prevost
- Michael Vocaturo

**Student Organization Representatives:**
- AIAA: Michael Mueller
- SAE: Yiguang Ju
- MRS: Craig Arnold

**Tau Beta Pi (SEAS-wide):**
- Michael Mueller, Howard Stone

**Freshman Advisors:**
- Marcus Hultmark
- Michael Mueller
- Andrej Kosmrlj
- Gigi Martinelli
- Dan Nosencshuck

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

**Class of 2021**
- Craig Arnold
- Michael Littman
- Gigi Martinelli
- Daniel Nosencshuck

**Faculty Leaves**
- Fall 2018: Ed Law
- Spring 2019: Naomi Leonard

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**Faculty Research Expenditures Distribution FY19**

**Number of Faculty**
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

**Research Expenditures (In 1,000s)**
- 0.0
- 500
- 1000
- 1500
- 2000

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**Class of 2019**
- Craig Arnold
- Luc Deike
- Yiguang Ju
- Michael Littman
- Dan Nosencshuck
- Clancy Rowley
- Daniel Steingart

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**Class of 2021**
- Craig Arnold
- Michael Littman
- Gigi Martinelli
- Daniel Nosencshuck
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.

Katharina Kohse-Höinghaus, University of Bielefeld
Cresco Colloquium—Burning Issues and Bright Concepts: Some Aspects in Combustion Chemistry Research

Molly Stevens, Imperial College London
Bactier Colloquium—Bio-responsive hybrid materials for regenerative medicine and biosensing

Ana Jones, University of Maryland, Fundamentals of vortex formation on high advance ratio rotors

Eva Kanno, University of Southern California
Cilia-driven Flows: From Mechanics to Biological Function

Scott Kemp, Massachusetts Institute of Technology
How Do You Solve a Problem Like North Korea?

Chris Klinever, Sandia National Laboratories
Ultrafast Nonlinear Optical Diagnostics: Cross-Cutting Innovations for the Study of Combustion, Fluid Dynamics, and Catalytic Materials

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Tian Li, University of Maryland, Wood for energy and high temperature emerging technology

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The MAE Department Seminar Series

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Class of 2019 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 2019 completed the following interesting and exciting year-long projects.

Individual Thesis Projects
Emily Achterkirch, Analysis of Hockey Skate Blade Holders: An Investigation into Broken Skates by Reverse Engineering
Billy Andrews, Aerodynamic Analysis and Simulation of Drag Racing Motorcycle Bodywork
Dylan Baroody, Analysis of Soft Phononic Crystals: Using Machine Learning to Predict Compression using Transmission Data
Mrudhula Baskaran, A Study of Flow Separation in Micro and Milli-Channels
Sami Belkadi, Agriflow: The Application of Elastic Filament Velocimetry to Water Flow Measurement and Control in Hydroponic Vertical Farms
Katherine Denner, Learning to Predict Compression using Transmission Data
Bartek Kaczmarski, Phosphor Crystal Materials: A Design of an Injection Molding: Process and Design Principles for 3D Printed Molds
Daniel Chan, Investigation into Computational Performance of a Multi-Modal Turbulent Combustion Model
Katherine Deonier, Identification of Lithium Deposition and Characterization of State of Charge and State of Health in Extreme Fast Charge Cells using Ultrasonic Methods
William England (Oxford), Investigating the Effect of Separation of Row Aligned Wind Turbines on Power Production
Diego Fierros, A New Method for Inducing Strain in Lacing Tissue
Tessa Nguyen-Lopez, Vertical Axis Wind Turbines: Analysis of Experimental Data at Full Dynamics Similarity
Suren Jamiyan, Phosphor Crystal Materials: A Design of an Anti-Counterfeiting Feature
Bartek Kaczmarski, Mechanical Behavior of Pressurized Rods: 3D Shape Transformations of Rod Networks via Local Curvature Control
Hemant Kalucha, Detecting Life on Mars – Analysis of Deep UV Raman Spectrometer with Organics in Martian Soil Matrix
William Kelly, Gene Ark Design
Lydon Kersting, nPLOR: An Expandable Pack for Lightweight Outdoor Refuge
Tanner Kileweir, FMITD3D: A Laser Diode Array Approach to Metal Additive Manufacturing

Jacob Lissen, Development of an Economical Device to Perform Automated Venipuncture
Larry Lopate, Two Degree of Freedom Motion Simulator Design, Fabrication, and Analysis
Jackie Macharashvili, Measuring the Acoustics of the Interior of a Tesla 3 Automobile
Coleman Merchant, Princeton SpaceShot: Analysis, Design & Construction of a High Performance Two-Stage Sounding Rocket
Nicholas Nelsenwood, One-Axis Tracking for Roof-Mounted Residential Solar
Caleb Owen, Reconstructing the Past: Analysis, Design and Assembly of Apollo’s Disk
Kendall Ratter, TAG Lens Laser Experimentation
Jorge Reyes, An Affordable Navigation and Weed Detection System for Farming Robot
Beni Snow, Design, Simulation, and Testing of an ABS/GOX Hybrid Rocket Engine
Nihita Turley, ElectroMagnetic Intake Valve Actuation Using a Subwoofer
Nicholas Viglucci, Design and Construction of an Energy-Efficient Living Space
Michael Whittemore, Analysis and Closure of Dissipation Rates in a Physically Derived Reduced-Order Manifold for Turbulent Combustion
David Wu, Intelligent Audio Beam Locking for Source-Listener Isolation (one-semester)

Team or Group Projects
Ashley Barnes, Adele Dimituli, & William Kittler, Fixed-Wing UAV Autonomous Deployment for Search and Rescue Applications
Tammy Benjipahal & Victoria Du, One Light Touch: A Simulation of the Sensory Cell Network in the Finger
Will Hess & Alexander Hui, Parameter Identification and Adaptive Control of a Fixed-Wing UAV in the Longitudinal Mode
Whitney Huang & Ramesh Gpatra/ELE, Controlling Unmanned Aerial Vehicles in High Wind Speeds using Nano-Scale Thermal Anemometry Probes
Spencer Nyczka, Conor Roettig, Joshua Teves, & Max Veronneau, Hybrid Performance Golf Cart: Examining the Feasibility of Low-Budget Hybrid Engines
Mario Liu & Nadir Noordin, Autonomous Quadcopter Navigation using Depth Camera and Real-Time Kinematic GPS
Curtis Merrill, Joseph Puryear, & Serg Zheloniak, Dynamic Thrust and Vector Control of a Small Scale Turbojet Engine
Jeremy Spiezio & Matias Supervielle, The Sound of Silence: A Preliminary Investigation into the Effects of Blade Row Spacing in Counter-Rotating Propellers on the Sound Intensity in the Near-Field

Mechanical & Aerospace Engineering

Undergraduate Actual Enrollment by Concentration by Class Year

MAE Report 2018 Page 21
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 101 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.

2018-19 Graduate Students

Qiang Chen, PhD
Advisor: Seymon Suckewer
Thesis: Stimulated Raman Back-Scattering and Self-Guiding of Femtosecond Laser Pulses

William Coogan, PhD
Advisor: Edgar Choueiri
Thesis: Thrust Scaling in Applied-Field Magnetoplasma-dynamic Thrusters
Position: Project Manager, Orbital Transfer Vehicle, Firefly Aerospace, Cedar Park, Texas

Elizabeth Davison, PhD
Advisor: Naomi Leonard
Thesis: Synchronization and Phase Locking in Networks of Heterogeneous Model Neurons
Position: Data Scientist, The Aerospace Corporation, El Segundo, California

Matthew Edwards, PhD
Advisor: Julia Mikhailova
Thesis: Ultrafast Sources of Intense Radiation
Position: Lawrence Fellow, Lawrence Livermore National Laboratory, Livermore, California

Daniel Floryan, PhD
Advisor: Clarence Rowley, Alexander Smith
Thesis: Hydromechanics and Optimization of Fast and Efficient Swimming
Position: Postdoctoral Research Associate, University of Wisconsin, Madison, Wisconsin

Matthew Fu, PhD
Advisor: Marcus Hultmark
Thesis: Measuring and Modifying the Near-wall Behavior of Wall-bounded Turbulence
Position: Postdoctoral Researcher, University of Melbourne, Melbourne, Australia (7/2019); Postdoctoral Research Associate, Mechanical and Aerospace Engineering, Princeton University

Renli Kahwaji, MEing
Advisor: Alexander Glaser
Position: Engineering Project Manager, Dassault Falcon Jet Corporation, Little Ferry, New Jersey

Ching Yao Lai, PhD
Advisor: Howard Stone
Thesis: Fluid-Structure Interactions for Energy and the Environment
Position: Lamont Postdoctoral Fellow, Lamont-Doherty Earth Observatory, Columbia University, Earth Institute, Palisades, New York

Peter Landgren, PhD
Advisor: Naomi Leonard
Thesis: Distributed Multi-agent Multi-armed Bandits

Wenli Li, MSE
Advisor: Yiguang Ju
Thesis: Flame Dynamics in Supercritical Conditions

Mark Miller, PhD
Advisor: Marcus Hultmark
Thesis: High Reynolds Number Horizontal and Vertical Axis Wind Turbine Experiments
Position Assistant Professor of Aerospace Engineering at the Pennsylvania State University, University Park, Pennsylvania (8/2019); Postdoctoral Research Associate, Mechanical and Aerospace Engineering, Princeton University

Codlu Nunn, PhD
Advisor: Michael Mueller
Position: Postdoctoral Research Associate, Argonne National Laboratory, Lemont, Illinois

Bruce Perry, PhD
Advisor: Michael Mueller
Thesis: Computationally Efficient Large Eddy Simulation of Multi-Stream Partially Premixed Turbulent Combustion
Position: Postdoctoral Researcher, National Renewable Energy Laboratory, Golden, Colorado

Christopher Reuter, PhD
Advisor: Yiguang Ju (Michael Mueller will comment)
Thesis: Chemistry and Dynamics of Counterflow Cool Flames
Position: Postdoctoral Fellow, Air Force Research Lab, Wright Patterson Air Force Base, Dayton, Ohio

Sandra Sewah, MSE
Advisor: Howard Stone, Michael Mueller
Thesis: Laminar and Turbulent Secondary Flow Profiles for Curved Pipes of Constant Radius of Curvature

Emre Turkaz, PhD MAEMS
Advisor: Craig Arnold
Thesis: High-Resolution Printing of Complex Fluids Using Blister-Actuated Laser-Induced Forward Transfer
Position: Research Physicist, Exxon Mobil Corporate Strategic Research, Clinton, New Jersey

Joseph Tylka, PhD
Advisor: Edgar Choueiri
Thesis: Virtual Navigation of Ambisonics-Encoded Sound Fields Containing Near-Field Sources

Graduate Student Fellowships and Awards

DEPARTMENTAL:
Anastasia Bizyeva, Phillips Second Year Fellowship
Xiaohan Du, Guggenheim Second Year Fellowship
Kerry Klemmer, Guggenheim Second Year Fellowship
Katherine Kekmanian, Harari Post Graduates Fellowship
Udari Madhusuthan, Athena-Feron Award
Udari Madhusuthan, Summerfield Second Year Fellowship
Alex Novoselov, Croucher Award for Teaching Excellence in Hong Kong

He Sun, Harari Post Graduates Fellowship

Nan Yue, Harari Post Graduates Fellowship
Omar Yehia, Harari Post Graduates Fellowship

Yingxian (Estella) Yu, PEI Mary and Randall Hack Fellowship

EXTERNAL:
Claudia Brunner, National Defense Science and Engineering Graduate

Danielle Chase, National Science Foundation

Elizabeth Denison, National Science Foundation

David Feng, National Defense Science and Engineering Graduate

Katie Huang, National Defense Science and Engineering Graduate

Justice Mason, GEM Fellowship

Samuel Otto, National Science Foundation

Bruce Perry, National Science Foundation

Aric Rousse, National Defense Science and Engineering Graduate

Anthony Sanz, National Defense Science and Engineering Graduate

Vivian Steyert, National Science Foundation

Yingxian (Estella) Yu, PEI Mary and Randall Hack Fellowship

REFERENCES:
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.

Alumni Career Panel
Jing Du ’12, Assistant Professor of Mechanical Engineering, Penn State University; Sandeep Mulgund ’94, Principal Scientist, The Mitre Corporation; Gunter H. Schiemann ’00, Project Development Manager in the Battery Storage Group, Con Edison Clean Energy Businesses; Barry Zhang ’94, CEO Princetel, Inc.; Anastasia Bizyaeva, Graduate Student, Flexible Task Allocation Dynamics for Multiple Agents; Claudia Brunner, Graduate Student, Dynamic Effects on Airfoil Performance Under Unsteady Inflow Conditions at High Reynolds Numbers; Christopher Burger, Graduate Student, Solid-gas Reactions of Copper-Oxide Particles with Hydrocarbons; Wesley Chang, Graduate Student, Understanding Structural Development of Electrodeposited Lithium Metal; Daniella Chase, Graduate Student, Fluid Driven Fracture in a Porous Medium; Xiaohan Du, Graduate Student, Modeling and Optimization of the TAG lens; Daniel Dudt, Graduate Student, Definition of Starrerar Equilibrium with Minimal Unknowns and its use for Numerical Applications; Nicholas Fasano, Graduate Student, Particle-in-cell Simulations of Electron Bunch Formation During Relativistic Laser Plasma Interactions; Alexander Glazer, Associate Professor, Trying to Save the World from the Nuclear Apocalypse: Research Opportunities in MAE’s Laboratory for Science and Global Security; Susanne Killian, Ph.D., Senior Associate Director of Graduate Student Career Development, Carrier Services, Virtual Career P小额, Mapping Your Skills to Careers and Job Descriptions; Brandt Belton, Ph.D, Tonal, Senior Data Scientist; William Coogan, Ph.D, Firefly Aerospace, Project Manager; Elina Krieger, Ph.D, Physicians, Scientists and Engineers for Healthy Energy, Director, Clean Energy Program; Kerry Klemmer, Graduate Student, Uncertainty Quantification of RANS Closure Models Using Model Error Transport; Courtney Kohut, Business Manager, MAE Business Center; Traveling and Getting Reimbursed; Andrej Kosmrlj, Assistant Professor, Mechanical Instabilities in Growing Biological Systems: Wrinkling and Branching; Imyoung Lee, Graduate Student, Unified Manifold-Based Approach to Modulating Turbulent Combustion in LES; Jason Liu, Graduate Student, Confined Crystallization of Polymers; Uday Madhushani, Graduate Student, Multi-agent Dynamics in Multi-armed Bandit Problem with Heterogeneous Stochastic Interactions; Gigi Martineili, Professor, CFD: Engineering at the Intersection of Numerical Mathematics, Scientific Computing and Fluid Dynamics; Julia Mikhailova, Assistant Professor, Waveforms of Light; Michael Mueller, Associate Professor, So You Want to be a Professor…; Alberto Padovan, Graduate Student, Understanding and Modelling Nonlinear Mechanisms in Flow Separation; Juliane Preimesberger, Graduate Student, Piezoelectrochemical Effect in Commercial Lithium Ion Batteries; Amy Puszkowska, Assistant Dean for Professional Development, Graduate School, Ph.D, Long-term Career Outcomes – Where do grad alumni go? How can I find them?; Daniel Ruth, Graduate Student, Bubble Dynamics in Turbulence; Robert Stengel, Professor, Project Apollo: Origins, Missions, and the Legacy; Nic Vog, Senior Associate Director, ULP, McGraw Center for Teaching and Learning, Productivity and Time Management; Madeline Vorenkamp, Graduate Student, Aerospike Rocket Nozzle; Jessica Wilson, Graduate Student, Electrolyte Diffusiophoresis in One-Dimensional Salt Gradients; Hongtao Zhang, Graduate Student, Plasma-Assisted Low-Temperature Combustion: Kinetics and Stability

Year in Review continued from page 7
June 2019
Princeton team participates in NASA’s Micro-g NeXt Competition
The annual NASA design competition challenges undergraduate students to design, build and test a tool or device to function in microgravity environments over the course of a year. The Princeton Rocketry Team, which is competing in the Mini-Arm End-Effector challenge, designed and built a device that uses a granule-filled bag that can go between malleable and rigid states to achieve grip. It is designed to interface with a robotic arm that has been designed by NASA Jet Propulsion Laboratory (JPL) scientists and engineers. The winning device will be used to handle samples underwater on missions to ocean worlds like Europa and Enceladus. The team is comprised of team leader Nina Arcot (MAE) and Alex Rogers (MAE), Whitney Huang (MAE), Kyle Johnson (ELE), Cindy Li and Hoang Le (Prospective ELE ’22), Alexander Essig (Woodrow Wilson), Jacob Essig and Elizabeth Petrov (Prospective COS ’29), Thomas McBride, Shaylee McBride, and Andrew Xu (Prospective MAE ’22).

Witt wins the 2019-B MolSSI Seed Software Fellowship
Chuck Witt, PhD, was named one of the Molecular Sciences Software Institute’s seven fellowship winners. Recipients receive six months of support and mentoring by the MolSSI’s Software Scientist team.

Roussos receives first prize for the best oral presentation at the 24th International Symposium on Plasma Chemistry
MAE graduate student Aric Roussos, who is advised by Prof. Ju, spoke on “Kinetic Effect of Hydrocarbon Oxidation on Filamentary Instabilities in Nanosecond-pulsed Plasma Discharges” at the symposium held in Naples, Italy.

Brunner awarded 2019 PEI-Step Graduate Fellowship
Graduate student Claudia Brunner’s topic is “Offshore Wind Energy in the United States – From Begeoning