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 fundamnetals 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
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. ♦
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/TXs19Eo4KQ0

**August 2018**
MAE alumni gathering in California
MAE alums, 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 Iiaraldi ’16, Daphne Rein-Weston ’12, Isabel Cleft ’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 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
Yiguang 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.
December 2018
Modeling how New Mexico harvester ants collectively weigh the cost of losing water while foraging for food
The research, published in the Dec. 4, 2018 edition of the journal PLOS Computational Biology, was written by lead author Renato Pagliara Vasquez, the MAE graduate student who spent two summers conducting research in the New Mexico desert. He worked with MAE Prof. Leonard in collaboration with a team from Stanford University that has been studying the ants for the past three decades. The model is a tool for investigating how ant colonies respond to a changing environment and how behavioral differences among colonies affect their long-term survival and reproductive success. The team published their results here: https://doi.org/10.1371/journal.pcbi.1006200

January 2019
From mechanics and materials to robots and rocks, MAE has an outsized “intellectual breadth and impact”
MAE Chair Stone gave an update about the department’s innovative faculty and students, as well as research bridging many fields in science and engineering. (Read more here: https://engineering.princeton.edu/news/2019/01/04/mechanics-and-materials-robots-and-rocks-department-outsized-intellectual-breadth)

How making brooms is like robot engineering
Buse Aktas, who graduated with a Princeton BSE in 2014, 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. (Read more here: https://sheroarspodcast.com/student-profile-buse-aktas)

February 2019
From stone to steel, when do decisions change the most?
Stone gives inaugural lecture at the Leeds Institute for Fluid Dynamics
He spoke on fluid dynamics at the new cross-disciplinary institute at the University of Leeds in Leeds, West Yorkshire, England.

Former MAE student named 2019 Franklin Institute Laureate
Frances H. Arnold (MAE ’79) won the Bower Award and Prize for Achievement in Science for pioneering the development of directed protein evolution. This 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. She received the 2018 Nobel Prize in Chemistry and is the Linus Pauling Professor of Chemical Engineering and Biochemistry at the California Institute of Technology.

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.

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

“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 at 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 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

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

“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.”

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.

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.”

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Zirui Liu has always been interested in rockets, space, travel and “blowing stuff up,” he says with a laugh. In fact, the likeable 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 fire in the lot near my house,” Liu 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?

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,” Liu explains. “My parents weren’t very happy about that.”

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.

“Blowing Stuff Up in Life and the Lab

DEGREE: PHD SPECIALTY: PROPULSION AND ENERGY SCIENCES

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.

“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.

“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
“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 required an introductory physics class. She considered placing out of the class but changed her mind when she called her mom for advice.

“My parents always taught me never to take the short route to anything — that I should take everything slow and use it as an opportunity to learn more,” she says.

Her parents were right, and, much to Dutta’s surprise, she fell in love with physics. “I started to see how physics explains everything around you and how through math you could derive natural phenomena,” she explains. “Physics creates order for the entire world. It gives you unifying laws that explain things seemingly disconnected. I really like when things can be packaged up neatly or follow some kind of pattern.”

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.”
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 physical 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.”

Steyert pursued a broader engineering degree at Harvey Mudd College and gained exposure to as many disciplines as possible through internships and research opportunities. She got a taste of civil engineering at the University of Washington’s Structures Laboratory, constructing welded connections that could be used to build more sound structures. She presented this work at the Northridge 20 Earthquake Symposium. Steyert also investigated ways to reduce noise and drift in the self-contained breathing apparatus (SCBA) used by firefighters for Honeywell.

But it was an internship at NASA Goddard Space Flight Center that first exposed her to the working world of coding and software analysis. Today, at Princeton, she uses computational modeling to find ways to better understand and control fluid systems.

The overarching idea of Steyert’s research is to develop simplified models and algorithms that can explain and control natural processes 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.

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
Egem en Kolem en
Andrej Kosmrlj
Anirudha Majumdar
Julia Mikhailova

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

Associated Faculty
Ilhan Akkaya, Chemical & Biological Engineering
Elie Bou-Zeid, Civil & Environmental Engineering
Nathanial Fisch, Astrophysical Sciences
Bruce Koel, Chemical & Biological Engineering
David Spergel, Astrophysical Sciences
Salvatore Torquato, Chemistry
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

Faculty Research Expenditures Distribution FY19

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<th>Number of Faculty</th>
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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

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

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 2019
Craig Arnold
Luc Deike
Yiguang Ju
Michael Littman
Dan Nosencshuck

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
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
Crecco Colloquium — Burning Issues and Bright Concepts: Some Aspects in Combustion Chemistry Research

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

Lydia Bourouiba, Massachusetts Institute of Technology, University fluid fragmentation

Pierre-Thomas Brun, Princeton University
Building with Fluids, Lazy Design of Functional Materials

Yufeng Chen, Harvard University, Manipulating interfacial physics for novel multimodal and multiphase insect-scale robots

David J Cleary, Aramos Services, Detroit
Global Energy Demand and Opportunities to Reduce the Carbon Footprint of Transportation

Laura Collins, Cornell University
The Role of Atmospheric Turbulence on Cloud Processes

Chiara Daraio, California Institute of Technology
Morphing materials in softform objects, at the micro- and macro-scales

Derek Dunn-Rankin, University of California, Irvine
Electric Field Effects on Laminar Diffusion Flames

V. Reggie Edgerton, University of California, Los Angeles
How can neuromodulation immediately transform the physiological state of the spinal cord from complete to incomplete paralysis?

Patricia Falcone ’79, Lawrence Livermore National Laboratory, Engineering and National Security
New Strategies in Radiation Detection for Nuclear Arms Control and Nonproliferation

Feltui Shi, Stanford University, Structural and interfacial challenges in energy storage systems

Jie Zhao, Northwestern University
Interfacial materials for electrochemical and biomedical devices
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
- Mudhula Baskaran, A Study of Flow Separation in Micro and Milli-Channels
- Nora Bradleys, Injection Molding: Process and Design Principles for 3D Printed Molds
- Daniel Chao, Investigation into Computational Performance of a Multi-Modal Turbulent Combustion Model
- Katherine Dones, Identification of Lithium Depositation 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 Rowe-Aligned Wind Turbines on Power Production
- Dinos Fiorenzo, A New Method for Inducing Strain in Licking Tissue
- Tessa Higgins-Lapte, Vertical Axis Wind Turbine: Analysis of Experimental Data at Full Duramics Similarity
- Suren Jamyanna, Phosphor Crystal Materials: A Design of an Anti-Counterfeiting Feature
- Bartek Kaczmarak, Mechanized Behavior of Pressurized Rods: 3D Shape Transformations of Red Networks via Local Curvature Control
- Hemani Kalucha, Detecting Life on Mars - Analysis of Deep UV Raman Spectrometer with Organics in Martian Soil Matrix
- William Kelly, Gene Ark Design
- Lydon Karsaling, ePilor: An Expandable Pack for Lightweight Outdoor Refuge
- Tanner Kliener, EMITT3D: A Laser Diode Array Approach to Metal Additive Manufacturing
- Jacob Lisson, Development of an Economical Device to Perform Automated Venipuncture
- Larry Loponte, Two Degree of Freedom Motion Simulator Design, Fabrication, and Analysis
- Jackie Machanashwill, Measuring the Acoustic of the Interior of a Tesla 3 Automobile
- Coleman Merchant, Princeton SpaceShot: Analysis, Design & Construction of a High Performance Two-Stage Sounding Rocket
- Nicholas Netsonwood, One-Axis Tracking for Roof-Mounted Residential Solar
- Caleb Owen, Reconstructing the Past: Analysis, Design and Assembly of Aragon’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
- Nikita Turley, ElectroMagnetic Intake Valve Actuation Using a Subwoofer
- Nicolas Viglucci, Design and Construction of an Energy-Efficient Living Space
- Michael Whitman, Analysis and Closures 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 Dimitri, & William Kittler, Fixed-Wing UAV Autonomous Deployment for Search and Rescue Applications
- Tommy Benjaphilav & Victoria Du, One Light Touch: A Simulation of the Sensory Cell Network in the Finger
- Will Hess & Alexander Hua, Parameter Identification and Adaptive Control of a Fixed-Wing UAV in the Longitudinal Mode
- Whitney Huang & Ramesh Gapatra/ELE, Controlling Unmanned Aerial Vehicles in High Wind Speeds using Nano-Scale Thermal Anemometry Probes
- Spencer Kryczka, Connor 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 Puyreray, & Serg Zhelezniak, Dynamic Thrust and Vector Control of a Small Scale Turbojet Engine
- Jeremy Speidel & Mathias Supervieille, 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

MAE supports the education of 179 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 teaming 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 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: Seyyon 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 Magnetoplasmadynamic 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 Smits
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 Keharaj, MEng
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

Wenyu 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

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

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

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: Vignesh 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 Tyha, 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 Kekianian, Harari Postgraduates Fellowship
Udari Madhushani, Athena-Feron Award
Udari Madhushani, Summerfield Second Year Fellowship
Alex Noonoclor, Crouse Award for Teaching Excellence
He Sun, Harari Postgraduates Fellowship

EXTERNAL:
Yingxian (Estella) Yu, PEI Mary and Randall Hack Fellowship
Claudia Brunner, National Defense Science and Engineering Graduate
Kerry Klemmer, National Defense Science and Engineering Graduate
Elizabeth Danzon, National Science Foundation

Daniel Chasse, National Science Foundation
David Feng, National Defense Science and Engineering Graduate

Kelly Huang, National Defense Science and Engineering Graduate
Justice Mason, GEM Fellowship
Samuel Otto, National Science Foundation

Bruce Perry, National Science Foundation
Aric Rousseau, National Defense Science and Engineering Graduate

Anthony Sanchez, National Defense Science and Engineering Graduate

Vivian Stoyert, 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.

Alumni Career Panel

Jing Du ’12, Assistant Professor of Mechanical Engineering, Penn State University; Sandeep Mulgund ’94, Principal Scientist, The Mitre Corporation; Gunter S. Schellenmann ’00, Project Development Manager in the Battery Storage Group, Con Edison Clean Energy Businesses; Barry Zhang ’94, CEO Princeton, 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; Danielle 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 Stellarator Equilibrium with Minimal Unknowns and its use for Numerical Applications; Nicholas Fasano, Graduate Student, Particle-in-cell Simulations of Electron Beam 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, Career Services, Virtual Career Puset; Mapping Your Skills to Careers and Job Descriptions; Brandt Beton, PhD, Tonal, Senior Data Scientist; William Coogan, PhD, Firefly Aerospace, Project Manager; Elisa Krieger, PhD, Physicists, Scientists and Engineers for Healthy Energy, Director, Clean Energy Program; Kenny Klemmer, Graduate Student, Uncertainty Quantification of RANS Closure Models Using Model Error Transport; Courtney Kohut, Business Manager, MAE Business Center; Traveling and Getting Reinforced; Andrej Kosner, Assistant Professor, Mechanical Instabilities in Growing Biological Systems: Wrinkling and Branching; Hyungjun Lee, Graduate Student, Unified Manifold-Based Approach to Modeling 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 Martellini, 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; Julianne Preimesberger, Graduate Student, Piezoelectric/Chemical Effect in Commercial Lithium Ion Batteries; Amy Puczkozowski, Assistant Dean for Professional Development, Graduate School, PhD, 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 Vo, Senior Associate Director, ULP, McGraw Center for Teaching and Learning, Productivity and Time Management; Madeline Vorenkamp, Graduate Student, Aerospace Rocket Nozzle; Jessica Wilson, Graduate Student, Electrolyte Diffusioosmophoresis in One-Dimensional Salt Gradients; Hongtao Zhong, 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 NEtC 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 Arcor (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 ’22), Thomas McBride, Shaylee McBride, and Andrew Yu (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.

Russo receives first prize for the best oral presentation at the 24th International Symposium on Plasma Chemistry

MAE graduate student Aric Russo, who is advised by Prof. Jü, 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 Beige-