MAE news

MECHANICAL AND AEROSPACE ENGINEERING

School of Engineering and Applied Science
PRINCETON

SPRING 2022

Dear friends of MAE,

I hope that this note finds you well. As we mark the beginning of the third year of the pandemic, many aspects of campus life have returned to near normal operations. In MAE, our classes, labs, and hallways are alive, and students are finishing their senior thesis and independent work projects. Our new Assistant Professors Kelsey Hatzell, Ryne Beeson, and Aimy Wissa are teaching and getting their research groups started.

In this newsletter, you will get a glimpse of some of the recent activities in MAE. Also, you will meet a few of our undergraduate and graduate students, spanning bioengineering, advanced propulsion, fluid mechanics, and environmental science, and get a glimpse of their talents in research, the classroom, and outside the classroom. We are looking forward to summer research, including hosting undergraduates in our laboratories, as well as the fall semester when we will welcome everyone back to the Princeton bubble.

On behalf of all of my colleagues, I look forward to welcoming you back to campus when you are in Princeton!

Best regards, Howard Stone

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student spotlight

Navreeta Singh: Embracing Biomechanics, Materials Science, and Research

Research opportunities allow students like Navreeta Singh to grow as scientists and engineers. During her undergraduate career, Navreeta has interned at three different laboratories, co-authored two papers, and is now completing a year-long senior research project at Princeton.

Growing up, Navreeta's interest in engineering evolved from tinkering and constructing things out of erector sets and pieces of wood. She built a Rube Goldberg machine and an automatic tuning device for her violin. When Navreeta came to Princeton, she discovered a love for materials science and biomechanics. She was fascinated by delving into the depths of the very small to study how individual molecules and atoms behave and interact with one another in a variety of biological and other materials.

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grad program info

IN OUR PhD PROGRAM

All PhD students are fully supported with tuition and a living expense stipend during the entire program. A First Year Fellowship covers tuition and stipend in year one. The remaining years of the program are fully funded through a combination of teaching and research support provided by the student's adviser. As a candidate for the doctoral program, the student, in consultation with a faculty adviser, develops an integrated program of study which culminates with a dissertation showing technical mastery of their chosen field and contribution to the advancement of knowledge, followed by a public presentation of the material. Princeton's Department of Mechanical and Aerospace Engineering has played a leading role in propulsion, combustion, aerospace dynamics, and fluid dynamics over the past half century. In recent decades the Department has extended its reach as a leading presence in dynamics and control, robotics, biomechanics, applied physics, and materials science. By exploiting its multi-disciplinary character and stressing science and engineering fundamentals, the Department seeks to educate the very best students – undergraduate and graduate - for future positions of leadership in areas of rapidly evolving technology.

GET MORE INFO

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mae.princeton.edu

faculty spotlight

Aimy Wissa:
Engineering Solutions Inspired by Nature

Ever since Professor Aimy Wissa was six years old, she has been fascinated by the mechanics of airplanes. Today, as the new Assistant Professor in the Department of MAE at Princeton, she builds on that early passion by studying bio-inspired design. This engineering approach is informed by natural systems such as the way birds fly or fish swim and remains unmatched by the most advanced machines and technologies.

Professor Wissa began her research studying bird wings to address problems of limited agility and maneuverability in unmanned aerial vehicles or drones. She noticed that birds—particularly large ones like eagles, and owls—do not flap their wings most of the time because this takes extraordinary amounts of energy. Instead, small local shape changes at the feather level take place to adjust and adapt to airflow.

"That was the 'aha' moment for me," she says. "Rather than thinking about flapping or making large changes, I began to ask: how can we design small local shape changes inspired by the intricate function of feathers to design flow control systems for our engineered aerial vehicles?"

She zoned in on covert feathers, which cover other feathers on the wings and tail. These covert feathers are used to correct for flow reversal over their wings during high-angle-of-attack maneuvers and in strong gusts of winds. Professor Wissa and her team are designing covert-inspired deployable structures on the upper and lower surfaces of a wing.

Her research has expanded to look at many other animals and insects. Click beetles, for example, propel themselves more than 20 times their own height into the air without using their legs. They transfer energy from their muscles into a spring, which is held in place by a mechanical latch in the beetle's thoracic region. In the lab, Professor Wissa is working on transferring this principle into engineering prototypes, such as agile robots that probe inhospitable areas or uneven terrain like inside pipes or on other planets. She has been awarded a Young Investigator Award from the Air Force Office of Scientific Research and a Faculty Early Career Development grant from the National Science Foundation.

student spotlight *continued*

"Biological systems are beautiful and complex, and I enjoy applying principles of physics and mathematics to model and mimic them. I especially enjoy studying and imaging at the microscale, where we can elucidate details that explain large-scale phenomena," says Navreeta, who uses some of the most sophisticated microscopes and imaging tools available at the university.

As part of the Cohen Lab, her senior project involves investigating tardigrade disordered proteins that enable microscopic animals, called "water bears," to withstand extreme drought conditions. Water bears are insect-related organisms that are found in almost any environment that is wet. They are widely used in research because of their amazing ability to survive in harsh environments, such as acute drought, scorching heat, freezing temperatures, and even outer space.

Navreeta's project includes working with hydrogels to emulate how tardigrade disordered proteins thrive in drought conditions. Such research could improve the ability to store stem cells, embryos, and vaccines without the use of refrigeration.

She first started working in biomechanics as an intern in Andrej Košmrlj's lab researching epithelial tissue, which lines nearly every part of the body. She studied viscoelasticity, which has the combined characteristics of viscosity in liquids and elastic properties in solids. Navreeta used computer simulations that involved meshing—the process of dividing an object into thousands or millions of smaller elements so one can see how atoms, molecules, or cells work in conjunction with one another under a variety of conditions and stresses. In her research, Navreeta combined thousands of cells to closely monitor the mechanical properties that a real tissue inside a body would have under mechanical stresses.

Navreeta has also studied vaccine development to combat syphilis as an intern at the University of Connecticut. Last year, Navreeta had the opportunity to conduct research at the Air Force Research Laboratory as an Air Armament Scholar. The experience piqued her interest in defense and policy, and she is now pursuing a certificate in the History and Practice of Diplomacy at Princeton.

a word from the lab

Madeline Vorenkamp:
Drawn to Rocket Science and Space Exploration

A strong passion for space exploration has always driven Madeline Vorenkamp. As a graduate student in MAE, she conducts research on advanced propulsion in the lab headed by her advisor Professor Yiguang Ju.

Throughout her academic journey Madeline has had many unique research opportunities. She was granted an Office of Science Graduate Student Research fellowship, which is awarded through the U.S. Department of Energy (DOE). She spent a year at Sandia National Laboratories as part of a research team that specializes in ultrafast laser diagnostics. Madeline focused on next-generation propulsion engines, such as rotating detonation engines. These engines have the potential to significantly increase burn efficiency, which results in reduced emissions and contributes to overall performance of rockets and aircraft. Her work resulted in three forthcoming peer-reviewed papers and will be the centerpiece of her doctoral thesis.

As an undergraduate, Madeline interned at the DIII-D National Fusion Facility. The opportunity, which was made available through the Princeton Plasma Physics Laboratory, inspired her to apply to graduate school. Madeline worked specifically with a device that injected various elements, such as lithium granules, into the tokamak to test plasma stabilization. She has also conducted research at SpaceX, Astra, and Boeing. ¤

Jiarong Wu:
How Wind Amplifies the Waves

Jiarong Wu has long been marveled by the theories that explain phenomena in nature. The ocean, she says, is one of the most fascinating examples. As a fourth-year PhD student at Princeton, Jiarong's work focuses on understanding how the wind amplifies the waves that cover nearly 71 percent of the Earth's surface. "I am interested in the common, basic principles behind things, more specifically the fluid dynamics that govern everything that flows," she describes. "From one set of equations, an endless complexity emerges."

While the sea is vast, Jiarong's work takes place on a much smaller scale, examining waves of centimeters to meters in scale. She conducts numerical simulation in a "virtual wave tank" to try to analyze the flow more closely and bridge the gap between theories and field observations. Recently, Jiarong co-authored a paper about her research in *Physics Review Fluids*.

Jiarong's work has important applications for both weather prediction and climate change. For example, when there is a tropical cyclone, ocean wave models can predict how tall the waves will become and what coastal regions will be affected. ¤

James Roggeveen:
Intrigued by Space and Surface Phenomena

James Roggeveen is accustomed to trying different things in different places. His many experiences include receiving a Master of Advanced Study at Cambridge in the UK, an internship at NASA where he "became obsessed with space," and serving as captain of the MIT Asian Dance Team. At Princeton, James uses "math to explain things in fluid phenomena observed in nature." He received a Sayre Award for Academic Excellence and a Guggenheim Fellowship for excellence in coursework and research. ¤

faculty awards and honors

Michael Mueller – has been recognized with the Annual Hiroshi Tsuji Early Career Researcher Award from the Combustion Institute.

Craig B. Arnold – has been appointed Princeton University's Vice Dean for Innovation.

Howard A. Stone – has been named a Foreign Member of the Royal Society, the scientific academy of the United Kingdom.

For full stories, visit: http://mae.princeton.edu/about-mae/spotlight

PRINCETON UNIVERSITY

Mechanical & Aerospace Engineering
Engineering Quad - D Wing
Princeton University 08544

Visit **mae.princeton.edu/about-mae/events** for event updates and location information. Events are free and open to the public.

Newsletter Editor: Carolyn Sayre

events: spring 2022

SEMINARS SERIES

Friday, January 28, 2022
MARY CASWELL STODDARD
PRINCETON UNIVERSITY

Friday, February 4, 2022
RALF I. KAISER
UNIVERSITY OF HAWAII AT MANOA

Friday, February 18, 2022
EMILY A. CARTER
PRINCETON UNIVERSITY

Friday, March 11, 2022
YIGUANG JU
PRINCETON UNIVERSITY

Friday, April 1, 2022
ROBERT. J. GOLDSTON
PRINCETON UNIVERSITY

Friday, April 8, 2022
JOHN O. DABIRI
CALIFORNIA INSTITUTE OF TECHNOLOGY

Friday, April 22, 2022
CRAIG ARNOLD
PRINCETON UNIVERSITY

Friday, April 29, 2022
EDGAR CHOUEIRI
PRINCETON UNIVERSITY

Announcements

Graduate Awards and Honors:

Honorific Fellowship Award

CRISTIAN LACEY (G5), Charlotte Procter Fellowship

Advisor: Michael Mueller

This prestigious award supports Ph.D. students whose research shows exceptional promise.

Undergraduate Awards and Honors:

Thesis Project Selected for Philadelphia Art Exhibition

SARAH WITZMAN, ('22), "Rhythm Bots"

Advisors: Naomi Leonard and Maria Santos

Show dates at the Pink Noise Projects gallery are May 6th, 2022 – May 29th, 2022