MAE news

MECHANICAL AND AEROSPACE ENGINEERING

School of Engineering and Applied Science
PRINCETON

FALL 2022

Dear friends of Princeton MAE,

Many aspects of campus life have returned to a normal rhythm this academic year, with classrooms and labs once again full of students, and a crowded calendar of in-person events. We've hosted seminar speakers from outside the University and some classes have had visitors from industry to help give perspective to teaching and applications in MAE.

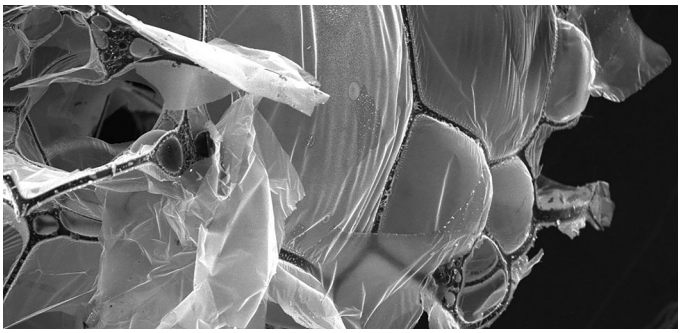
Over the summer we were thrilled to welcome a new faculty member, Christine Allen-Blanchette, who joins us as an assistant professor with expertise in the intersections of deep learning, geometry, and dynamical systems. Christine joins a slew of new MAE faculty members who have joined in the past year or so: Ryne Beeson, Kelsey Hatzel (joint with the Andlinger Center for Energy and the Environment), Radhika Nagpal (joint with Computer Science), and Aimy Wissa.

In September 2022 we welcomed our second cohort of Masters of Engineering students from recent Princeton graduating classes. We also welcomed our largest cohort of first-year Ph.D. students ever. The halls and classrooms of MAE are busy!

In this newsletter, you will get a glimpse of life in the MAE department, including research highlights, awards, and events. We're looking forward to spring semester, and hope you will stop by if you are in Princeton!

Best regards, Howard Stone

a word from the lab



Researchers cook up a new way to remove microplastics from seawater

Researchers at Princeton Engineering have found a way to turn your breakfast food into a new material that can cheaply remove salt and microplastics from seawater.

The researchers used egg whites to create an aerogel, a lightweight and porous material that can be used in many types of applications, including water filtration, energy storage, and sound and thermal insulation. Craig Arnold, the Susan Dod Brown Professor of Mechanical and Aerospace Engineering and vice dean of innovation at Princeton, works with his lab to create new materials, including aerogels, for engineering applications.

One day, sitting in a faculty meeting, he had an idea.

"I was sitting there, staring at the bread in my sandwich," said Arnold. "And I thought to myself, this is exactly the kind of structure that we need." So he asked his lab group

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grad program info

IN OUR PhD PROGRAM

All Ph.D. students are fully supported with tuition and a living expense stipend during the entire program. In year one, a first year fellowship covers tuition and stipend. The remaining years of the program are fully funded through a combination of teaching and research support.

Doctoral students, in consultation with a faculty adviser, develop 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.

Emphasizing both multidisciplinary research and the fundamentals of science and engineering, the department seeks to educate all students to take on future positions of leadership in areas of rapidly evolving technology.

GET MORE INFO

Howard Stone, Department Chair, hastone@princeton.edu

Michael Mueller, Associate Professor & Director of Graduate Studies, muellerm@princeton.edu

Katerina S. Zara, Graduate Administrator, kzara@princeton.edu

faculty spotlight

Radhika Nagpal
Research in robotics and collective intelligence

Radhika Nagpal, an expert in bio-inspired robotic systems and collective behavior, has joined the Princeton faculty as a professor of mechanical and aerospace engineering and computer science. On July 1 she was appointed the Norman R. Augustine ’57 *59 Professor in Engineering.

Nagpal joined Princeton in January from Harvard University, where she was the Fred Kavli Professor of Computer Science and a founding faculty member of the Wyss Institute for Biologically Inspired Engineering, launched in 2009.

Her research has explored the dynamic movements of fish schools, the highly successful collective decision-making of ant colonies, and the complex architectures of cell tissues. Informed by biological systems, Nagpal and her team develop novel hardware and mathematical approaches aimed at illuminating collective intelligence and expanding capabilities of robots for scientific exploration, structural monitoring and construction, and other applications.

Some of Nagpal’s recent work has focused on colonies of army ants, which use their own bodies to build bridges and ladders that are highly adaptable to changing terrain and traffic conditions. In collaboration with biologist Simon Garnier’s Swarm Lab at the New Jersey Institute of Technology, Nagpal’s group used field experiments and simulations to understand how the ants’ self-assembled bridges respond to changes and how individual decisions add up to collective adaptability. Their work was published earlier this year in Nature Communications.

“We’re thinking about ecology as a model for how to do robotics,” said Nagpal. She envisions robot teams that would fit into their environment, minimizing waste and disruption to ecosystems.

Her lab is well-known for the creation of the Kilobots, a swarm of 1,024 coin-sized robots with vibrating motors that can be programmed to self-assemble into particular shapes based on each individual robot’s sensing of its immediate surroundings.

The Kilobots project, published in Science in 2014, was a pioneering demonstration of a low-cost robot collective. “It’s a way of testing ideas for engineered collective intelligence — more real than a simulation, but still an abstraction of a robot,” said Nagpal. These robots have been commercialized and are now used by labs worldwide.

While Kilobots pushed the envelope in manufacturing and coordinating large numbers of robots, the system was “stuck in two dimensions,” said Nagpal. Now, her team is testing schools of 3D-printed, fish-like robots called Blueswarm that can be readily maneuvered in any direction and have a nearly 360-degree view of their surroundings.

“Bigger fish schools are actually more efficient than smaller schools at finding food and evading predators,” said Nagpal. “They get all these group benefits, so we’d like to be able to do that with robots … where each individual is actually doing pretty simple things, but the group itself is so much more powerful than the individual.”

Read the full profile here.

a word from the lab *continued*

to make different bread recipes mixed with carbon to see if they could recreate the aerogel structure he was looking for. None of them worked quite right initially, so the team kept eliminating ingredients as they tested, until eventually only egg whites remained.

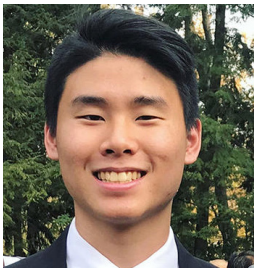
“We started with a more complex system,” Arnold said, “and we just kept reducing, reducing, reducing, until we got down to the core of what it was. It was the proteins in the egg whites that were leading to the structures that we needed.”

Egg whites are a complex system of almost pure protein that — when freeze-dried and heated to 900 degrees Celsius in an environment without oxygen — create a structure of interconnected strands of carbon fibers and sheets of graphene. In a paper published Aug. 24 in Materials Today, Arnold and his coauthors showed that the resulting material can remove salt and microplastics from seawater with 98% and 99% efficiency, respectively.

“The egg whites even worked if they were fried on the stove first, or whipped,” said Sehmus Ozden, first author on the paper. Ozden is a former postdoctoral research associate at the Princeton Center for Complex Materials and now a scientist at Aramco Research Center. While regular store-bought egg whites were used in initial tests, Ozden said, other similar commercially available proteins produced the same results.

Read the full story here.

faculty awards and honors



2022 Tiger Entrepreneurship Award

For the last six years, the Tiger Entrepreneur Award has been given by the Princeton Entrepreneurship Council to celebrate the value of entrepreneurship across the Princeton community and to emphasize the University's commitment to Entrepreneurship the Princeton Way.

One of the 2002 winners is Princeton NuEnergy, a spinout from the labs of Yiguang Ju, Robert Porter Patterson Professor of Mechanical and Aerospace Engineering, and Bruce Koel, professor of chemical and biological engineering. NuEnergy is developing green technologies to recycle and upcycle cathode materials of lithium ion batteries for electric vehicles and energy storage. The team has raised $7.5 million in government and private funding. They will be opening their new cathode recycling plant with a dedication ceremony in McKinney, Texas on October 25th.

"Since the creation of PNE in 2019, the core research team members (all from Princeton University) of Chao Yan (Founder), Xiaofang Yang (CTO) and Jerry Xiang (engineer) has led a very successful technology, product, market, and demonstration plant development," said Ju.

Hultmark wins experimental physics award

The Gordon and Betty Moore Foundation has awarded Marcus Hultmark, professor of mechanical and aerospace engineering, an Experimental Physics Investigators Initiative award. Hultmark's research focuses primarily on turbulent flows, which are chaotic motions in fluid. The Moore Foundation award will support Hultmark's research using a unique new facility that will be housed on Princeton's Forrestal Campus. The Eric and Wendy Schmidt Transformative Technology Fund provided initial funding for the facility.

The Moore Foundation award supports tenured, mid-career faculty doing experimental work in physics. Hultmark is one of sixteen researchers from across the United States to receive the award, which will provide a total of $1,250,000 over the next five years.

Hatzell and Majumdar win early career award from the Office of Naval Research

Professors Kelsey Hatzell and Anirudha Majumdar have received Young Investigator Program awards from the Office of Naval Research.

The Young Investigator Program is a highly competitive and popular early-career award program which recognizes academic achievement and potential for significant scientific breakthrough.

events: fall 2022

Friday, September 9, 2022
SYNCHRONIZATION IN NATURE, TECHNOLOGY, AND MATHEMATICS
STEVEN STROGATZ,
CORNELL UNIVERSITY

Tuesday September 11, 2022
FROM SNAPPING TO BUCKLING: A PATH FOR NEW MULTIFUNCTIONAL MATERIALS
ELEONORA TUBALDI,
UNIVERSITY OF MARYLAND

Thursday, October 6, 2022
USING DELAYS FOR CONTROL
EMILIA FRIDMAN,
TEL AVIV UNIVERSITY

Friday, October 7, 2022
EFFECTIVE PRACTICES FOR TEACHING ENGINEERING UNDERGRADUATES
LAMYAA EL-GABRY,
PRINCETON UNIVERSITY

Friday, October 14, 2022
FLUID INSTABILITIES AND INTERFACIAL MIXING
SNEZHANA I. ABARZHI,
UNIVERSITY OF WESTERN AUSTRALIA

Friday, October 28, 2022
NANO JOINING: THE PAST, TODAY AND BEYOND
ANMING HU,
UNIVERSITY OF TENNESSEE, KNOXVILLE

Friday, November 4, 2022
THE DEATH AND RE-BIRTH OF THE INTERVERTEBRAL DISC CELL
LORI A. SETTON,
WASHINGTON UNIVERSITY IN ST. LOUIS

Friday, November 11, 2022
FROM SNAPPING TO BUCKLING: A PATH FOR NEW MULTIFUNCTIONAL MATERIALS
ELEONORA TUBALDI,
UNIVERSITY OF MARYLAND

In the Media

RADHIKA NAGPAL and AIMY WISSA
featured in Nature for their work on bioinspired robots

EGEMON KOLEMEN featured in Popular Mechanics
for his work on devices that can contain nuclear fusion reactions

Alumna ANNIE YU KLEINMAN featured
in Princeton Alumni Weekly for her work with Afghan refugees

JESSE JENKINS interviewed on the
Ezra Klein Show about decarbonization and climate change