MAE news

MECHANICAL AND AEROSPACE ENGINEERING

School of Engineering and Applied Science
PRINCETON

FALL 2021

Dear friends of MAE,

I hope that this note finds you well. You will be pleased to learn that the campus returned to nearly normal operations with the start of the fall semester. Classes and labs meet in person, extracurricular activities are in full swing, and the campus is alive with events, seminars, etc. Indoor activities require masks, but otherwise my first approximation is that we are managing and supporting the on-campus experience that we value at Princeton. Of course, we have learned lessons these past 20 months that can help us as we move forward.

In this newsletter, you will get a glimpse of some of the recent activities in MAE, including new appointments to our faculty of outstanding scholars across many of the disciplines that constitute a modern education in mechanical and aerospace engineering. Also, you will meet a few of our undergraduate and graduate students, and get a glimpse of their talents in research, the classroom, and outside the classroom. We are excited to think about new ways we can further enhance our educational and research activities.

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

Mohamed Hamza:
Olympian and Engineer

Mohamed Hamza's training as a professional fencer prepared him for two of life's greatest privileges and challenges. Representing his home country of Egypt in the Olympic Games. And being an undergraduate at Princeton studying MAE.

"There is a saying that fencing is like a physical game of chess. You are always trying to outplay your opponent. You have to be on your toes and make split-second decisions because the circumstances are constantly changing," explains Mohamed.

Born into a family of fencers, Mohamed picked up his first foil when he was only six years old. In high school, he became one of the youngest fencers to qualify for the 2016 Rio Olympic team. After the 2018-2019 season, he was the

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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

Ryne Beeson:
Optimizing Spaceflight

The airfield was Ryne Beeson's favorite playground growing up. With a father and grandfather who were both pilots, he had the unique opportunity to substitute toy planes and helicopters for real ones.

"What motivated me the most to pursue a career in engineering were all the aviation books my family had laying around," he says. "I would study the cutaway drawings so I could see how the aircrafts were built."

Today, as an Assistant Professor of MAE at Princeton, his goal is to make spaceflight design easier. Professor Beeson's work focuses on "self-optimization"— getting spacecraft from one place to another in the least amount of time, while using as little fuel as possible and doing so with little human oversight.

As advancements in technology make it easier and cheaper to launch satellites and spacecraft, Professor Beeson is trying to break down the barriers that remain in mission planning and operations. "The workload for humans in this area is actually increasing," he explains, "and it is creating a bottleneck."

The solution, Professor Beeson says, is automated mission planning. By leveraging the dynamical structures due to gravitational bodies in the solar system, programs can be designed that find ideal spacecraft trajectories to final destinations without human intervention. For example, a telescope in Earth's orbit can use very little thrust to follow a specific spatial path to reach a point between the Sun and Earth, where it will stay mostly stationary.

In the lab, Professor Beeson is developing probabilistic global optimization algorithms that identify and use these dynamical structures. These algorithms have applications both here and far away—for small satellites using electric propulsion and deep space exploration, such as future missions to Jupiter.

He also brings research in estimation to Princeton. At the University of Illinois at Urbana-Champaign, Professor Beeson's dissertation focused on nonlinear filtering theory for high-dimensional systems with applications towards improving estimation in problems related to weather or climate. As a former collegiate cross-country and track runner, he will also work in an advisory role for the academic-athletic fellow program and teach courses in optimal control, space system design, and estimation theory. ¤

student spotlight *continued*

world's #1 ranked Junior Fencer in Men's Foil.

"That first year, in 2016, being one of the 36 athletes in the world to qualify for the Olympics was such a celebration. I felt so lucky that I was able to represent my country and represent them well," describes Mohamed.

The lessons fencing taught him about how to think on his feet are skills he draws upon every day in engineering. In many ways, completing an engineering task was like winning a strategic fencing match.

But as any world-class athlete knows, the road to greatness is often fraught with challenges. While preparing for the 2020 Tokyo Olympics, the season ended up shutting down due to the coronavirus pandemic. Mohamed decided to stay in Egypt to train and attend college virtually. But he soon became sick with COVID-19 and had to work harder than ever before just to regain his strength.

"At the time, it was very difficult. But when I look back now, I think it boosted my mentality," he says. I When the results were in, Mohamed outperformed his world ranking of 22nd, with a 7th place finish in the Tokyo games.

The challenges Mohamed had to surmount on the fencing strip also sharpened his skills in the lab. With a year off from competition, he was able to intern at Alu Afric—an Egyptian engineering company. The experience inspired him to pursue a certificate in Material Science and Robotics.

Mohamed feels grateful for the opportunity to pursue both passions. After graduation, he plans to find a job in the industry while also working to qualify for the 2024 Paris and 2028 Los Angeles Olympic Games.

"For most other athletes, their job is fencing. But COVID helped me realize that too much fencing is not going to help me get better. I need a balance," he says. In the end, engineering was one of this Olympian's best possible training tools. ¤

a word from the lab

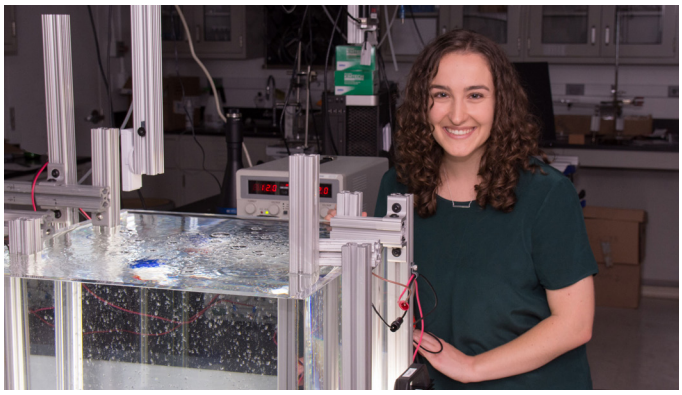
Meghan Booker:
Developing Memory Frameworks for Robots

How much memory does a robot need to complete a task? Are there fundamental tradeoffs between memory and task performance? These are the questions Meghan Booker, a fourth-year PhD student in MAE at Princeton, is trying to answer.

"There is a theoretical importance to understanding memory for robot tasks and that can help us design better, more efficient algorithms and robotic systems," she says. "When we enter the real world with all these uncertainties it becomes even more important to have a clear-cut theoretical framework to guide our expectations of what capabilities robots need for a specific task. Right now, it is very ad-hoc."

As part of Professor Anirudha Majumdar's Intelligent Robot Motion (IRoM) Lab, Meghan is developing memory frameworks that take up minimal amounts of space, while being task-relevant and computationally efficient. She is also investigating memory frameworks that exhibit strong recall so that a robot can complete complex, long-term tasks. Examples of important applications for her work are autonomous cars, which handle an immense amount of data, drones, which are smaller and have limited space for memory, and in-home assistance robots, which are expected to handle many tasks over a long period. ¤

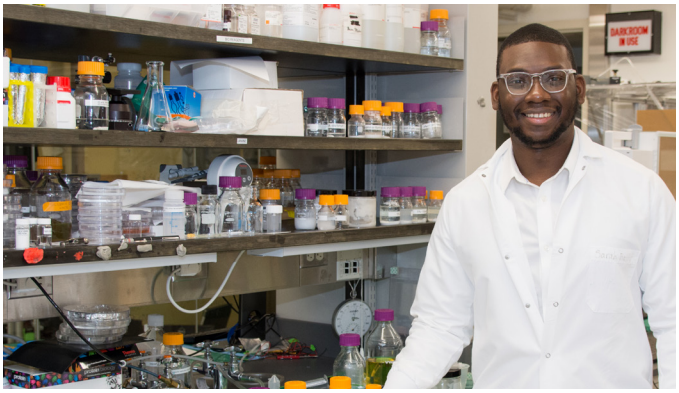
Megan Mazzatenta:
Bubble Bursting Research



Last summer, Megan Mazzatenta spent a month immersed in her dream project at the Air-Sea Interaction Laboratory (ASI) at the University of Delaware conducting large wind-wave tank measurements. As a second-year PhD student in MAE, her research focuses on wave breaking, bubble entrainment, surface bubble behavior, and droplet ejection.

"The ejected droplets or sea spray aerosols can act as cloud condensation nuclei once they enter the atmosphere, and they can also be carried over potentially large distances in the atmospheric boundary layer," she says. By knowing the sizes, compositions, and velocities they can work toward a "mechanistic model of sea spray production" to inform the development of better climate models.

Back at Princeton, Megan has been processing the data. She is also conducting additional experiments in a smaller version of the ASI tank. In the future, she plans to add chemical surfactants and monitor the collective behavior of the bubbles. Her research has implications for improving weather prediction and modeling potentially health-adverse effects, such as dispersants used to break down oil spills. ¤



Marcel Louis:
A Humanitarian Engineer

The most rewarding experience of Marcel Louis's life was serving for a year in Haiti for Engineers Without Borders. Marcel saw his studies come to fruition in real-life. The team used engineering solutions to help a rural community create sustainable filtration systems.

At Princeton, Marcel's research involves using complex fluids to remove bacteria from surfaces—a process that is critical in sterilizing medical equipment. Born in Trinidad and Tobago, the PhD student plans to someday return to his humanitarian roots. ¤

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: fall 2021

SEMINARS SERIES

Friday, September 17, 2021
JULIA M. MIKHAILOVA
PRINCETON UNIVERSITY

Friday, September 24, 2021
ANDREJ KOŠMRLJ
PRINCETON UNIVERSITY

Friday, October 1, 2021
ARTHUR DOGARIU
PRINCETON UNIVERSITY

Friday, October 8, 2021
EMILY C. DAVIDSON
PRINCETON UNIVERSITY

Friday, October 15, 2021
ELIE R. BOU-ZEID
PRINCETON UNIVERSITY

Friday, October 29, 2021
MICHELE L. SARAZEN
PRINCETON UNIVERSITY

Friday, November 5, 2021
GERARD WYSOCKI
PRINCETON UNIVERSITY

Friday, November 12, 2021
GABRIEL A. VECCHI
PRINCETON UNIVERSITY

Friday, November 19, 2021
AMY GLADFELTER
UNIVERSITY OF NORTH CAROLINA

Friday, December 3, 2021
CORINA E. TARNITA
PRINCETON UNIVERSITY

Announcements

MAE RECENTLY WELCOMED NEW ASSISTANT PROFESSORS:

KELSEY HATZELL (*joint with the Andlinger Center; expertise: energy storage; materials and nanoscale phenomena*)

RYNE BEESON (*expertise: astronautics, control and dynamical systems*)

WE WILL SOON WELCOME:

AIMY WISSA (*expertise: adaptive bio-inspired structures and systems for robotic applications*), currently an Assistant Professor at the University of Illinois, Urbana-Champaign, will join us as an Assistant Professor in January 2022.

RADHIKA NAGPAL (*joint with Computer Science; expertise: collective artificial intelligence and robotic systems*) will join us from Harvard University as a Professor in January 2022.

EMILY CARTER (*expertise: quantum mechanical simulation techniques focused on problems of sustainable energy*) will return to the MAE faculty (*joint with the Andlinger Center*) as a Professor starting in January 2022; recently she served as Executive Vice Chancellor and Provost, and Distinguished Professor of Chemical and Biomolecular Engineering, at UCLA.

CHRISTINE ALLEN-BLANCHETTE (*expertise: the intersections of deep learning, geometry and dynamical systems*) will join us as an Assistant Professor in July 2022.