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

events: spring 2017

March 30 3:30 p.m.
"Soft Robotics: Design and Fabrication of Intelligent Material Systems"
REBECCA KRAMER, PURDUE UNIVERSITY

April 7 3:30 p.m.
"Overview of the DOE Co-Optimization of Fuel and Engines (Co-Optima) Initiative"
JOHN FARRELL, NATIONAL RENEWABLE ENERGY LAB

April 14 3:30 p.m.
"Order and Chaos": Collective Behavior of Crowded Drops in Microfluidic Systems"
SINDY TANG, STANFORD UNIVERSITY

April 21 3:30 p.m.
BAETJER COLLOQUIUM
"Socially Assistive Robotics: Creating Robots That Care"
MAJA MATARIC, UNIVERSITY OF SOUTHERN CALIFORNIA

April 28 3:30 p.m.
"PyFR: High-Order Accurate Cross-Platform Petascale Computational Fluid Dynamics with Python"
FREDDIE WITHERDEN, STANFORD UNIVERSITY

May 5 3:30 p.m.
"Materials by Design: 3-Dimensional Nano-Architected Meta-Materials"
JULIA R. GREER, CALIFORNIA INSTITUTE OF TECHNOLOGY

events: fall 2017

Friday, September 15
Research Day

Friday, September 22
KEN KAMRIN, MIT

Friday, September 29
PADMINI RANGAMANI, UC SAN DIEGO

Friday, October 13
MICHAEL MUELLER, PRINCETON UNIVERSITY

Friday, October 20
MARCUS HULTMARK, PRINCETON UNIVERSITY

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

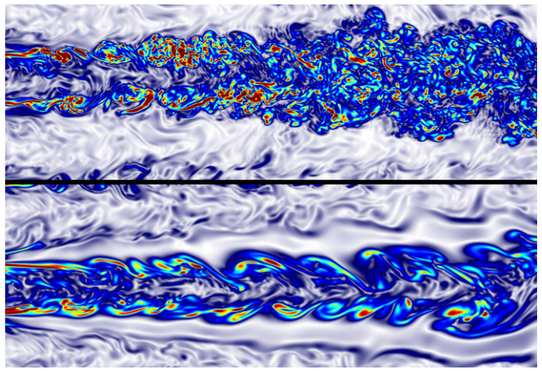
Newsletter Editor: Carolyn Sayre

MAE**news**
MECHANICAL AND AEROSPACE ENGINEERING
SPRING 2017

School of Engineering and Applied Science
PRINCETON

Welcome to the premier issue of MAE News, the bi-annual newsletter from Princeton University's Department of Mechanical and Aerospace Engineering, featuring faculty and graduate student spotlights and highlights from research projects from our labs. For more information about what's new in MAE, please visit our website at mae.princeton.edu.

—Howard Stone, MAE Chair



Direct numerical simulations of turbulent combustion: vorticity magnitude in a non-reacting jet flow and in a reacting jet flame, non-reaction jet flow (top) and reacting jet flame (bottom). Courtesy of Professor Michael Mueller's group, ctrfl.princeton.edu

In this issue...

student spotlight

Fitsum Petros
Being a Part of Ethiopia's Rebirth

There are three groups of people who inspire Fitsum (Fits) Petros, '18: her parents, her countrymen, and of course—super-heroes. As a little girl growing up in Ethiopia, her passion for designing high-tech gadgets came from watching action movies and TV shows like American Inventor.

"The first time I watched Ironman, I kept thinking 'I want to build that suit,'" she says. "My friends and I were obsessed with the scene in James Bond when the car drives into the water, turns into an airplane, and flies. We tried to construct one using paper and an empty carton."

...continued p. 2

grad program info

JOIN 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 in preparation for a comprehensive general exam, which is normally taken in January of the second year. Subsequent to passing the exam, the student prepares 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, 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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faculty spotlight

Marcus Hultmark
Learning about Fluid Mechanics can Influence Everything

Marcus Hultmark has been tinkering with fluid mechanics since he was six years old. Growing up by the shore in Sweden, the open water was his neighborhood playground—and sailing and wind surfing were his childhood pastimes. "Sailing is sort of a nerdy sport," he jokes. "There is an incredible amount of aerodynamics and fluid mechanics involved."

From those early voyages developed an unquenchable curiosity for understanding how forces in nature act on the world around him. As an Assistant Professor of MAE, his research focuses primarily on turbulent flows, which involve large, chaotic fluctuations. From wind turbines to underwater vehicles, and sensor technology, Hultmark's wide project scope has resulted in patented hardware and one-of-a-kind testing facilities while contributing to the basic understanding of fluid mechanics.

"It is hard to think of anything that exists in nature or was man-made that has not been affected by fluids in their various states at some point," he says. "That means if you can learn something fundamental about fluid mechanics, then essentially, you can have an impact on everything."

Photo: www.vestas.com

That impact can already be seen in one of Professor Hultmark's key projects: testing wind turbines. With ever increasing portions of our electricity being provided by wind power, it has become more important than ever to maximize efficiency and reduce the maintenance and production costs of developing new wind turbines. For the first time, Hultmark has developed a scaled-down wind tunnel model to test turbine designs. "We basically had to find a way to compress the whole world down," he explains.

And then there are the projects he never intended to work on. During his experiments, Hultmark could never find sensors that obtained accurate measurements. So he decided to make them. "We became sensor people out of necessity," he laughs. The sensors his team developed have since spun into two start-up companies. "Most of what I have achieved in life has been counter to my plans," he says. "But that is what I appreciate about this job—and science. You can make it whatever you want it to be."

student spotlight *continued*

Their design, Fits jokes, was pretty bad. But from those first scrap pieces of paper sparked a lifelong passion for creating and building. As Fits grew, she recognized even more how technology had the power to impact the world for the better. For example, many rural parts of Africa still cook with open fire. A simple stove, she says, could transform many lives.

"What motivates me to work hard every day is the burning desire to see my nation's evolution," she says. "I want to be a leading part of the generation that brings about my country's rebirth. I need to learn and invent. It is a responsibility I carry with great pride."

As a junior at Princeton, majoring in Mechanical & Aerospace Engineering (MAE), Fits is on her way to being part of that rebirth. Someday, she hopes to combine her interests in anatomy and mechanics and start a biotech company back home. Fits is also interested in expanding the Ethiopian Space and Science community, perhaps by designing and building airplanes.

"What fascinates me about building in any type of context is that tiny things can do extraordinary things," she says. "You start with something that is small and slow, and replicate it into something big and fast, something that you never thought was possible."

Last summer, Fits worked on building a receiver that would optimize the process of acoustically testing batteries. She also interned in the Planet Finders Lab setting up the tests for the star-shade prototype—a project funded by NASA.

"Fitsum has a quiet, sincere drive that imbues all of her work, and perhaps the best balance between an open mind and critical thinking I have seen in an undergraduate student," says Dan Steingart, PhD, Assistant Professor of MAE.

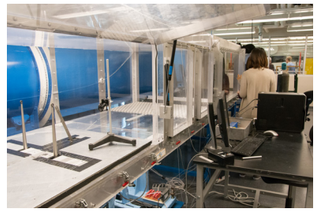
A couple of weeks ago, Fits had a reminder of how far her early designs have come. Her professor joked that building a hybrid car/plane was a useless pursuit.

"Of course, I had to tell him the story and explain what materials we used for our James Bond prototype," she laughs. "He thought the idea was genius."

a word from the lab

APPLIED PHYSICS • DYNAMICS & CONTROLS • FLUID MECHANICS • MATERIALS SCIENCE • PROPULSION & ENERGY SCIENCES

Welcome to the New MAE Lab



It is the first day of class in the newly renovated Thermodynamics and Fluid Mechanics laboratory whose redesign was led by Professors Dan Steingart and Marcus Hultmark. The sophomores quickly learn their first lesson: the world is not as perfect as it seems in textbooks.

"In the real world, a small mistake can either lead to a new discovery or cause you to completely rethink your steps," says Marcus Hultmark, Assistant Professor of MAE.

Take a seat for MAE 221/224. The place where the equations students have neatly solved in their freshman notebooks suddenly have to hold up against the realities of the physical world. "The course is a tasting menu for mechanical engineering," Hultmark says. "Our new design creates a synergy between the lecture hall and the laboratory bench.

The students begin to test the concepts they have learned about and apply them to real world problems."

From turbulent flows in pipelines and aerodynamic forces pushing up on an airplane wing, such real-world engineering typically comes with a great deal of uncertainty that needs to be well understood. Says Hultmark: "Students develop an appreciation for this uncertainty. Suddenly, it is not enough to read about engineering—instead, they are itching to test it."

Greg Davies: Preserving Our Natural World

Back in Australia, Greg Davies called it bushwalking. Being raised in a city that was surrounded by national parks, he spent many days hiking with friends.

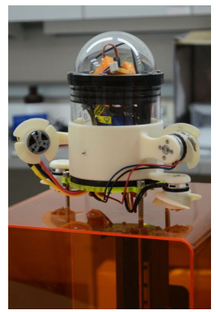
Since then, Greg has carried his passion for the environment across the globe. Today, he works on developing renewable energy solutions.

For nearly a century, the electric power grid has been powered by fossil fuels; and even today, only a small fraction comes from green sources. Professor Dan Steingart's team is trying to increase that percentage by working on large-scale battery storage systems.

The goal, he says, is to find a way to make these battery systems cheap enough to be adopted on a wide scale. In the laboratory, Greg manipulates the architecture of various battery designs using different materials and forms that change the energy density, power, and longevity of the product.

"Energy storage solutions like batteries could increase the reliability of wind and solar power," he explains. "Capturing excess energy while the sun is shining and the wind is blowing, storing it on the grid system, and then releasing it at a later time when generation is low, is one important step towards a grid with an increased proportion of renewable energy."

Peter Landgren: Exploring the Science of Decision-Making



Imagine a group of friends want to buy the best burrito. Collectively, they have to answer many questions. Which opinion do you trust? Who has the most experience?

Peter Landgren's research explores this type of thinking. His work involves cooperative multi-agent decision-making in noisy environments,

which explores the intersection of mathematics and group decision-making among both animals and humans. One practical application of Landgren's research is in connected devices, such as smart home devices, robots or self-driving cars.

awards

Naomi Leonard is the recipient of 2017 Hendrik W. Bode Lecture Prize of the IEEE Control System Society

Craig Arnold is elected into the 2017 class of OSA Fellows

Graduate student **Aric Russo** wins Best Presentation Award and graduate student **Ching-Yao Lai** wins 1st Place Award

Lex Smits awarded the 90th Anniversary Medal from the Fluids Engineering Division of ASME

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