Autumn 2020

MESSENGER

MECHANICAL ENGINEERING | UNIVERSITY of WASHINGTON

YouTubing math for engineers, *Pages 6-7*

CHAIR'S MESSAGE

THANK YOU

For me personally, the worst aspect of the COVID-19 pandemic has been the distancing measures. As advanced as our virtual tools have become, and as much as I admire the creativity and resilience with which we've carried on during these past months, remote collaboration is simply no substitute for the real thing. That's why, as I close out my time as ME department chair, I want to express how grateful I am to everyone who has supported me, and more importantly ME, over the past ten years. To our students, faculty, staff, alumni, donors, our partners in research, education, industry and in all other endeavors – it is our collective, hands-on effort that make us great. In good times and difficult ones, thank you for your collegiality, your generosity and your friendship. Though this will be my last MEssenger issue as chair, I look forward to carrying on our work and watching ME continue to grow and thrive in the decade to come.

Per Reinhall
Mechanical Engineering Chair

ME External Advisory Board

The board provides counsel to the department, mentoring to students, and advocacy and vital connections to industry.

Thanks to the following alumni and friends for participating on the 2019-20 board:

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Department news

Professor **Philip Malte** retired and was named professor emeritus. A leader in all aspects of combustion and renewable energy, we congratulate him on his retirement and thank him for his many contributions as a mentor, teacher and scholar.

Doctoral student **Laurel Morgan Miller Marsh** was awarded a Fulbright Scholarship to conduct dissertation work on flow-diverting stents in Germany.

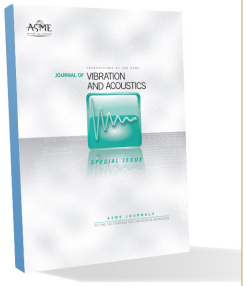
Incoming assistant professor **Michelle DiBenedetto** received the American Physical Society's 2020 Andreas Acrivos Dissertation Award in Fluid Dynamics.

Professor **Jonathan Posner** was named to the Population Health Initiative executive council by UW President Ana Mari Cauce.

Professor **Nate Sniadecki** was appointed as an associate director of UW's Institute for Stem Cell and Regenerative Medicine.

Acting assistant professor **Ayokunle Olanrewaju** was awarded a UW/ Fred Hutch Center for AIDS Research New Investigator Award.

In five years serving as editor for the *ASME Journal of Vibrations and Acoustics*, professor **Steve Shen** doubled the impact factor of the journal. ASME recognized his achievement with a certificate of appreciation.



New faculty

Welcome to our new faculty joining ME this academic year.

Michelle DiBenedetto
Assistant Professor

Michelle DiBenedetto will join the department this winter as an assistant professor. DiBenedetto's research lies at the intersection of environmental fluid mechanics and particle-laden flows. At the UW, she plans to continue studying particle dynamics in the ocean to improve microplastics degradation and transport modeling.

Krithika Manohar
Assistant Professor

Krithika Manohar will start as an assistant professor in ME this winter. Manohar specializes in data-driven prediction and control of complex, large-scale dynamical systems. These systems occur and have applications in fluid dynamics, atmospheric science, biology, engineering and manufacturing.

Ayokunle Olanrewaju
Acting Assistant Professor

Ayokunle (Ayo) Olanrewaju was hired into the department this summer as an acting assistant professor. His research is focused on developing rapid and user-friendly tests for monitoring medication drug levels right in the settings visited by patients to improve global disease treatment and prevention.

Eli Patten
Assistant Teaching Professor

Eli Patten joined ME this autumn as an assistant teaching professor. With experience in materials and design for medical and renewable energy devices, Patten will lead the development of a new mechanical engineering capstone design program. He will teach and mentor students and coordinate with industry on capstone projects.

Aniruddh Vashisth
Assistant Professor

Aniruddh Vashisth will join the department this winter as an assistant professor. Vashisth works on fabrication, design and analysis of advanced composite materials using theoretical and experimental approaches. His research also focuses on data-driven manufacturing, reactive molecular dynamics and nanostructure properties.

Research roundup

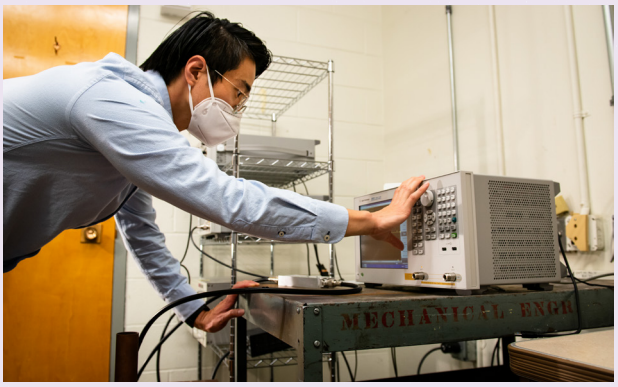
Advancing cryopreservation technology

Dayong Gao is the Origincell Endowed Professor of Mechanical Engineering and an internationally recognized scientist in the field of cryopreservation. His lab investigates all aspects of preserving biological materials in cryogenic conditions, including research on why cells live or die during the process and what new technologies could improve their survival.

One important part of cryopreservation is safely bringing a material that's stored in liquid nitrogen back to room temperature. Gao's team recently demonstrated a promising new system for rewarming biomaterials with better control of the speed and uniformity of heat. They believe the technology is well suited to future use in hospitals for cellular therapy and organ transplants.

"Cryopreservation and biobanking have already become indispensable in modern medicine and across industries like healthcare, agriculture, environmental conservation and biotech," says Gao. "We're developing new technology to meet urgent needs in cellular and gene therapy, regenerative medicine, tissue engineering, stem cell and organ transplantation, new vaccine and drug development, disease screening, and fertility treatments. It's an exciting time."

Read more about Gao's work at **me.uw.edu/news/cryopreservation**



Above: ME doctoral student Shen Ren is part of the research team advancing technology for preserving human and biological samples. Photo by Olivia Hagan / University of Washington

Top right: ME faculty and students will play a key role in UW's new CREATE center. Photo by Mark Stone / University of Washington

ME is ready to CREATE a more accessible world

Fueled by a $2.5 million investment from Microsoft in May, the newly launched UW Center for Research and Education on Accessible Technology and Experiences (CREATE) is led by an interdisciplinary team whose mission is to make the world accessible through technology.

CREATE's leadership team hails from six different UW units. Kat Steele, the Albert S. Kobayashi Endowed Professor in Mechanical Engineering, is an associate director of the new center and is leading projects focused on using technology to amplify human abilities and expanding inclusion of people with disabilities in engineering. She is hosting a series of conversations throughout 2021 called "Reimagining Mobility" with thought leaders at the intersection of engineering, rehabilitation and assistive technology to examine how technology helps and hinders the ways we move and explore our world.

"Assumptions of how people move and interact with the world are literally cemented into our daily lives," says Steele. "As engineers, we have a responsibility to examine these assumptions and challenge ourselves to design and envision new futures that are more inclusive of people with diverse abilities. With CREATE we aim to both make technology more accessible and use technology to make the world more accessible."

Learn more about the "Reimagining Mobility" series and CREATE at **create.uw.edu**

Researchers demonstrate 'acoustic forceps'

A team of UW researchers recently published their experiments using ultrasound to noninvasively control a solid object within a living body. Their technique shows promise for a variety of medical applications, such as steering cameras or manipulating kidney stones to help them pass through the urinary tract.

The research builds on the groundbreaking "optical tweezers" work that was awarded the 2018 Nobel Prize in Physics, but in this case uses acoustic waves instead of light. Compared to current technologies, the method allows much greater control of objects in three dimensions. Researchers were able to move a one-eighth-inch glass sphere both in water and in the urinary tracts of pigs. The team has formed a company to help commercialize the technology for use in kidney stone treatments.

"Acoustic forceps show great promise to lift, reposition, remove or rotate an object in the body without incision or injury," says ME associate professor and Applied Physics Lab principal engineer Michael Bailey, one of the members of the research team. "We've done a lot of work to specifically apply this to kidney stones, but we're also very enthusiastic about the array of opportunities it presents for other new noninvasive procedures."

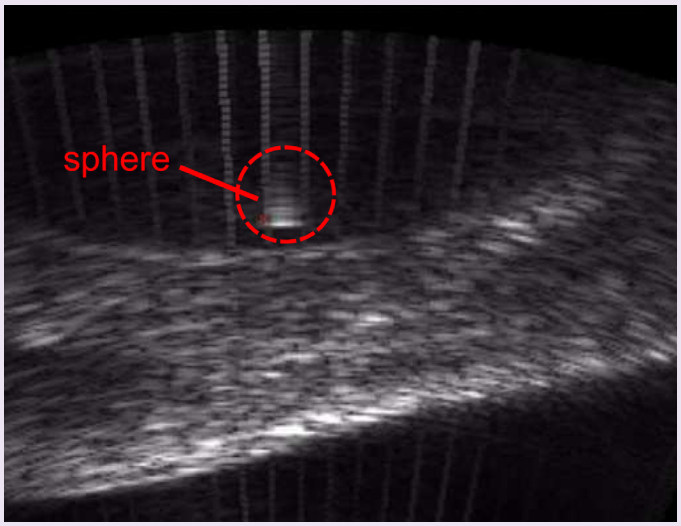


Image: An ultrasound shows the location of a small glass sphere that was navigated noninvasively in a live body using the new "acoustic forceps" technique. Image by Mohamed Ghanem / University of Washington

The latest in insect cybernetics

The Autonomous Insect Robotics (AIR) Laboratory has been busy. In July the team published a paper describing a tiny, steerable camera, small enough to be mounted on the back of a beetle. The camera weighs around 250 milligrams, streams video at 1 to 5 frames per second and sits on a mechanical arm that allows it to pivot 60 degrees. The team believes this bug-scale GoPro will be useful for insect behavioral studies and is currently modifying it to attach to Asian giant hornets, also known as "murder hornets," to track their activities.

Meanwhile, another team from AIR Lab has been developing a small bio-hybrid drone that uses a moth antenna for a sensor. Inspired by the moths' keen odor detection ability, this "smellicopter" can be programmed to autonomously sniff out chemical signatures, such as explosives or gas leaks. The smellicopter measures the tiny electrical signals coming from the moth antenna, which read out faster than commercially available chemical sensors.

"Insects still leave human engineered systems in the dust," says ME assistant professor Sawyer Fuller, director of AIR Lab. "They can find their way to mates by sensing pheromones at a concentration of less than one in a quadrillion, exploit unsteady airflow to flit away from a flyswatter, or navigate a windy forest to return to particularly tasty flowers. Sometimes biological machinery is so much better than manmade machinery that you have to say, 'If you can't beat 'em, join 'em.'"

Learn more at **depts.uw.edu/airlab**

Above: ME doctoral student Melanie Anderson holds the "smellicopter," a small drone modified to use a moth antenna as an odor sensor. Photo by Mark Stone / University of Washington

Left: A pinacate beetle carries a tiny camera developed by researchers in the AIR Lab. Photo by Mark Stone / University of Washington

‘EIGENSTEVE’ BRUNTON

Professor Steve Brunton’s popular YouTube channel teaches mathematical fundamentals to engineers from all around the world.

In his small video studio tucked away in the Mechanical Engineering Building, ME professor Steve Brunton cleans his lightboard and prepares to record a lesson.

“People tend to trash everything on the internet, so I’ve been surprised by how overwhelmingly positive the reception has been,” remarks Brunton, known by his online followers as “Eigensteve” (a reference to the linear algebra terms eigenvalue and eigenvector).

Brunton’s comments are an understatement. With over four million views and 90,000 subscribers, the Eigensteve YouTube channel has very few haters. Most of the videos have a consistent style: Brunton draws figures and equations on a colorful lightboard set against a black backdrop. His tone is casual and accessible, but also measured and expedient.

The videos fill an important niche, simplifying the fundamentals of applied math for engineers around the world who are grappling with data-driven concepts like machine learning and dynamical systems. They’ve been so successful that Brunton gets 20 to 50 comments every day and now finds himself recognized by graduate students at conferences who treat him as a minor celebrity.

Flipping the classroom

Brunton began recording lessons after joining the UW as an acting assistant professor in applied mathematics. He and Nathan Kutz, professor of applied math, were responsible for teaching AMATH301: Beginning Scientific Computing, one of engineering’s core classes taken by over a thousand students a year.

Because the class was taught repeatedly without much change to the curriculum, they decided to flip the class. The strategy of a flipped classroom is to reverse the typical lecture-then-homework model. Instead, students watch lecture material online ahead of class, and class time is spent engaged in problem solving activities.

In a two-day period they filmed every lecture for the entire course. The class was a success. To Brunton, it showed that recorded lessons were better at reaching more students. He also noticed how much students benefited from being able to watch the lectures at times that worked for them and being able to re-watch certain portions, spending as much or as little time as needed on a lesson.

A few years later, with seed funding from MathWorks, the creators of MATLAB, Kutz and Brunton set up a shoestring video studio in Lewis Hall. “It was tiny, cramped, had no windows and in the middle of summer would get to 120 degrees,” says Brunton. “But that was our beta version of the lightboard studio and we had a ton of fun.”

Engineering in a data-driven world

These days, lessons are filmed in the new MEB studio (shown in the photo below) that Brunton’s team designed and built in 2019 with support from The Boeing Company. With upgraded equipment and hundreds of videos now under his belt, the production value of the series has increased dramatically since the early days.

Back in the classroom, Brunton has also been key to bringing modern, data-driven concepts into the ME curriculum. Last year, ME added the option for students to take a data science degree track through the UW eScience Institute, where Brunton is a fellow.

Yet he also takes a very pragmatic approach to the kinds of math that are useful to a career in engineering. “Ninety-nine percent of the people learning math are going to use the math in practice as engineers, not as pure math professors. So that’s the perspective we take,” he says.

The approach is working. The videos that first helped his YouTube channel take off were a "boot camp" series on controls. Brunton has heard from students who use the videos to brush up and prepare for tests and from professionals who watch them to help extend their knowledge.

For those interested in where to start among the channel's hundreds of videos, Brunton recommends picking a playlist on a topic that interests them and watching the first video, which typically starts with a high-level overview.

Simplifying the math

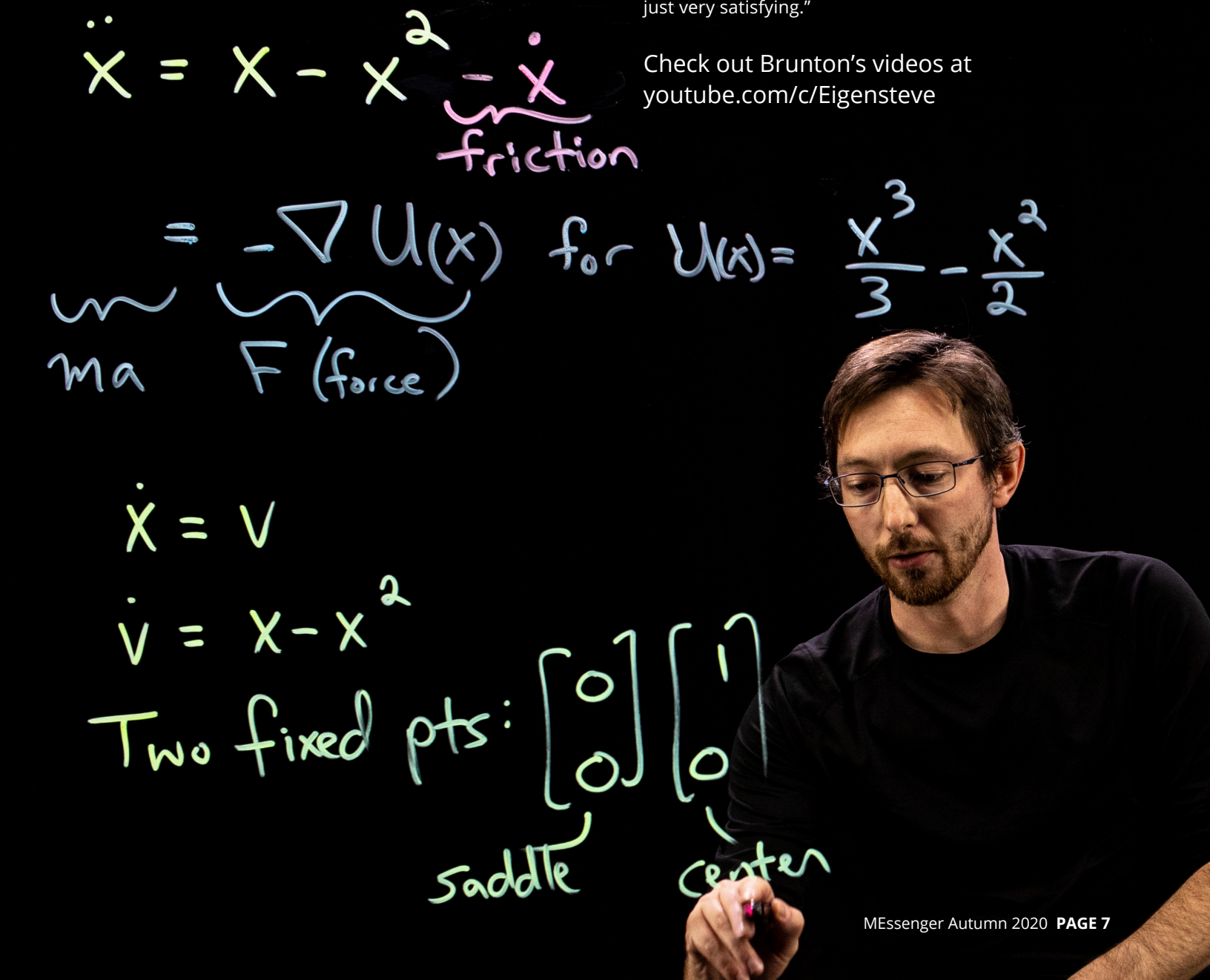
"I think one of the reasons the YouTube videos have gone so well is because I'm very simple myself," he says. "I have a hard time understanding complicated concepts, so by the time I grasp it enough to explain it to someone else, it has to be simplified."

It's a humble statement coming from the James B. Morrison Endowed Professor of Mechanical Engineering and a 2019 winner of a Presidential Early Career Award for Scientists and Engineers, but Brunton insists the YouTube videos are largely a selfish pursuit.

"Part of what I enjoy about it is the immediate gratification," says Brunton. "On one hand, most of what we do in research has a very long timeframe. With the online medium you get immediate feedback and you know you're making an impact. People appreciate it and they ask fantastic questions."

Brunton says one of his favorite parts of the YouTube channel is looking at the audience demographics and seeing how far it reaches globally. "There are kids in rural India learning control theory, and that's awesome," he says. "My entire life and career have been defined by the great teachers who have invested their time to help me. I wouldn't want to do anything in my life that doesn't involve teaching and sharing knowledge, for me that's just very satisfying."

Check out Brunton's videos at youtube.com/c/Eigensteve



PROMISE DURING PANDEMIC

ME innovations confront COVID-19

The global spread of COVID-19 has brought health care to the front and center of society's problems, and ME has stepped up to the task. "COVID-19 has created many challenges for our health care system and clinicians are coming to us to develop technical solutions to address those unmet needs," explains ME and chemical engineering professor Jonathan Posner, who was recently named ME's Richard and Victoria Harrington Professor in Engineering Innovation in Health (EIH).

Through EIH and other university collaborations, many ME researchers are currently focusing on work related to the pandemic. Included here is a sampling of those projects.

Engineering Innovation in Health

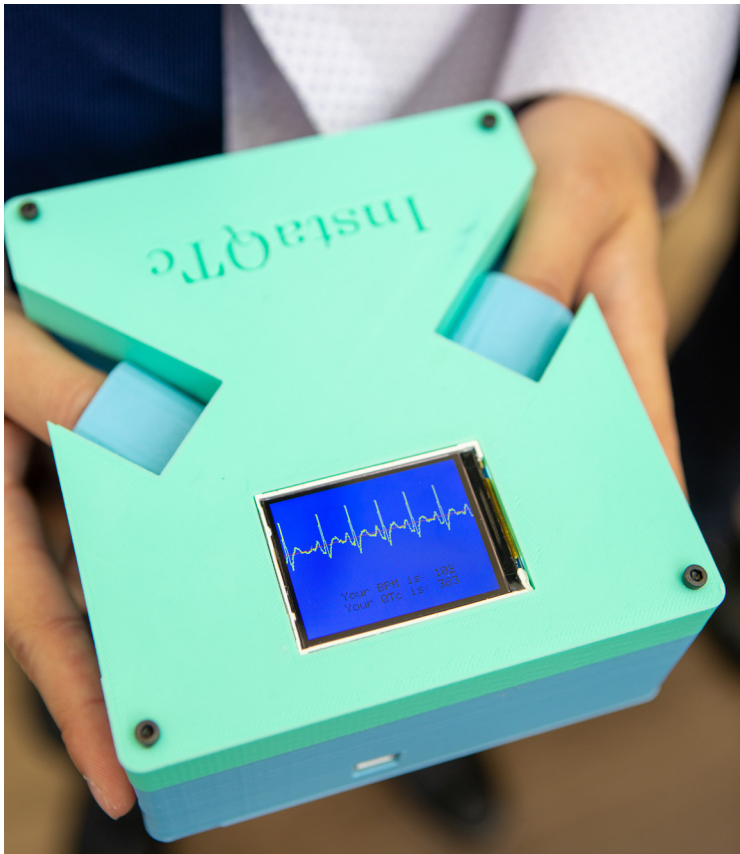
Decontamination boxes for N95 masks

The N95 respirator mask is one of the most important protections for keeping first responders, such as emergency medical services (EMS) staff and firefighters, defended against COVID-19. Now, thanks to a unique and innovative Washington partnership, first responder stations across the region have UW-designed, locally manufactured boxes to decontaminate these high-demand masks needed to protect staff while carrying out their essential duties.

A UW-led team designed a plug-in N95 mask decontamination box that uses ultraviolet (UVC) light to destroy viruses – including the SARS-CoV-2 virus that causes COVID-19. The boxes are roughly the size of a small refrigerator and allow essential staff at fire, police, maritime and EMS stations to quickly decontaminate their own masks. The team plans to manufacture around 100 boxes for King County and has already built and distributed more than 50 of them throughout the region.

InstaQTc: Peace of mind for prescriptions

InstaQTc is a portable device for reading QT intervals, an electrical measurement of the heart that indicates a risk of irregularities in a patient's heart rhythm. With many medications, monitoring the QT interval serves as a key gauge of safety and, in the case of COVID-19, QT intervals entered the spotlight as doctors raced to test various drug treatments.



Valley Medical Center faculty physician Jon Neher brought the idea for InstaQTc to EIH as an alternative to electrocardiogram (EKG) tests. Compared to EKGs, InstaQTc allows cheaper and more efficient access to QT interval readings across a broader array of clinical settings. The InstaQTc team, led by ME students Nanye Du and Trinh Vo and mentored by ME assistant teaching professor Soyoung Kang, has received a CoMotion Innovation Gap Fund award, a provisional patent and approval for clinical testing.

Sensit-IV: Taking the guesswork out of giving fluids

Ordering intravenous (IV) fluids for patients who have low blood pressure is one of the most common medical interventions worldwide. The team behind Sensit-IV is developing a custom-designed monitor to guide IV fluid management. This is an important consideration partly due to a phenomenon known as capillary leak, where the IV fluids leak from veins into the surrounding tissue, causing a cascade of potential side effects. In the case of COVID-19, capillary leakage can cause fluids to spill into the lungs, preventing patients from getting oxygen.

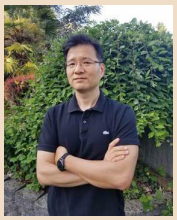
Sensit-IV was proposed by UW Medicine surgical fellow Catherine Beni. The team includes students Aman Garg, Nelson Warner and Syndey Yeh of ME and Kenneth Shim of Electrical & Computer Engineering, with faculty mentorship from Jonathan Posner.

In addition, a quarter of EIH's new projects this fall have ties to COVID-19. Visit eih.uw.edu to learn more.

Opposite left: ME-designed boxes use UV to decontaminate N95 masks between uses. Photo courtesy of EIH

Opposite right: InstaQTc is one of several student-led EIH projects with ties to the current pandemic. Photo by Matt Hagen / University of Washington

FACULTY CONTRIBUTIONS



Prototyping a carbon nanotube sensor for at-home screening

Carbon nanotubes have emerged as an exciting new technology for medical sensors and diagnostic tests. Associate professor Jaehyun Chung's lab won an NIH grant to prototype an inexpensive nanotube-based sensor that could be used for rapid point-of-care and at-home screening of COVID-19. Their goal is to be able to detect low concentrations of the novel coronavirus from nasal swab samples in 15 minutes.

Tracking aerosols in the operating room

Research associate professor Igor Novosselov, an expert in aerosol sensors, is working with the Department of Environmental & Occupational Health Sciences and Harborview Medical Center on a study to track the movement of aerosols in hospital environments using state-of-the-art sensor networks. By characterizing the way air moves in these rooms, the medical facilities can improve the effectiveness of ventilation systems and other air control strategies to help prevent airborne transmission of viruses, such as SARS-CoV-2. This research is supported through the UW CoMotion Director's Award.

UV sterilization for ventilator breathing tubes

Among its many impacts, COVID-19 has caused a rise in the need for ventilators to treat patients with the most severe cases of the disease. Unfortunately, one side effect of ventilators can be a condition known as Ventilator Associated Pneumonia (VAP), which occurs when bacteria colonize the surfaces on and around the breathing tube that's inserted into a patient's windpipe. Research professor Eric Seibel, an expert in medical optics and photonics, is exploring whether UV light could be used to help reduce the biofilm buildups that cause VAP. His work is supported by an NSF grant.

COVID-19's impact on engineered heart tissues

Professor Nate Sniadecki and colleagues have been studying the effects of the SARS-CoV-2 virus on engineered heart tissues made from human stem cells. Their tests show direct damage from the virus to cardiac function with the heartbeats of engineered tissues diminishing greatly within days after infection and then a steady decline to cell death. The team is now using their techniques for screening studies to identify drugs that could help prevent the virus from replicating.

Lessons from a decade as ME chair

The defining events of the 2010s are still up for debate, but in the UW Department of Mechanical Engineering, there's little question that it will be the Per Reinhall decade.

Per Reinhall has served as the chair of the ME department since Autumn 2010. At the end of this year Reinhall, whose first name is pronounced "pair," will conclude his second term as "Chair Per" and return to research and teaching. ME's Andy Freeberg spoke with Reinhall about his time leading the department and what stands out to him from his decade as chair.

What were your goals for ME when you first became chair?

When I became chair I'd already been in ME for over 25 years, so I knew the department well. I liked the department culture a lot – it was wonderfully collegial and geared toward excellent research and teaching, but I knew we could improve its standing both at UW and against peer institutions. So when I took the role I came in with a lot of ideas and energy to take on new initiatives.

First, I wanted to change the way the department looked to outsiders. There was this idea that mechanical engineering was just that, mechanical, only dealing with traditional mechanical systems consisting of nuts, bolts, gears and the like. I wanted to make it clear that ME addresses all the grand challenges of today and the future. Even at that time we were doing diverse research – working on medical devices, 3D printing, renewable energy, advanced robotics and all kinds of exciting stuff, but the word wasn't getting out. My message was, and still is, that if you want to change society, ME is the way to go.

I also wanted to encourage ME faculty to become more proactive about leading programs and initiatives. I felt that if we could increase our presence and improve our standing in the college it'd benefit us in a lot of ways.

Of all that's been accomplished in the past 10 years, what do you see as having the most impact?

Everything we've accomplished has been a team effort. So to me, the most important thing has been all of the excellent people who have joined the department. Over half of our current faculty have joined since I became chair and I'm very, very proud of the caliber of those hires. They've brought fresh ideas and energy and are great leaders and collaborators.

We've also found ways to make a bigger impact by building infrastructure around our key teams. For example, with Engineering Innovation in Health we've cemented our ties to UW Medicine and built a program

that provides a top-notch educational experience to students. Nearly half of our core faculty now have ties to health-related research, and I'm proud of the game-changing innovations we've been a part of in that area.

The Boeing Advanced Research Center is another good example. It's led to award-winning research, but also helps us keep a finger on the pulse of industry. We learn what research is most needed to support commercial sectors and, in turn, our students graduate better prepared to go into engineering careers. The new PACCAR Advanced Research Center will do the same.

How has the department changed?

I would like to think we've held on to ME's collegial and positive atmosphere while growing much more interdisciplinary and problem-focused than we once were. Compared to a decade ago, we're doing a better job stepping up to tackle society's toughest challenges. This has changed the way we're viewed around the university and made more units want to work with us. Our faculty are core contributors to major UW centers in nanoengineering, molecular engineering, clean energy and other topics.

The other big change I've seen is in the quality of our hands-on educational experience. When I first started only the Formula Motorsports student team was organized and competing at a national level. As a department we've come to see how valuable these clubs and competitions are for giving our students a chance to apply and enhance their engineering and business skills. Today we have seven well-run and nationally recognized teams and numerous prizes from the UW Buerk Center for Entrepreneurship competitions. The students on these teams are among our most sought-after by employers when they graduate.

What have been your favorite parts of the job?

More than anything I enjoy talking with staff and going out to coffee with faculty to hear about what they've been doing. I get a lot of energy from working with all the people in ME who really care, who want to keep improving the department and serving the students. Those kinds of personal interactions have been most fun for me. It's also why the pandemic has been so hard this year.

I've also tremendously enjoyed getting to know alumni and donors. Talking to them and seeing how much the department means to them is humbling. I've always been so grateful to donors, but I had no clue before I became chair just how devoted our alumni are and how much they care about supporting our students.

What are your plans once your term comes to a close?

The short answer is that I don't know! I do want to get back to research. I want to work with more faculty across the UW. I have a few startups that I want to spend more time nurturing and spend more time with my family.

Opposite: Reinhall has helped many new initiatives grow and flourish during his time as ME chair. Among them are the Amplifying Movement & Performance Lab (upper left) and Boeing Advanced Research Center (lower right)

Above: Per Reinhall with his golden retriever Molly. Photo courtesy of Per Reinhall

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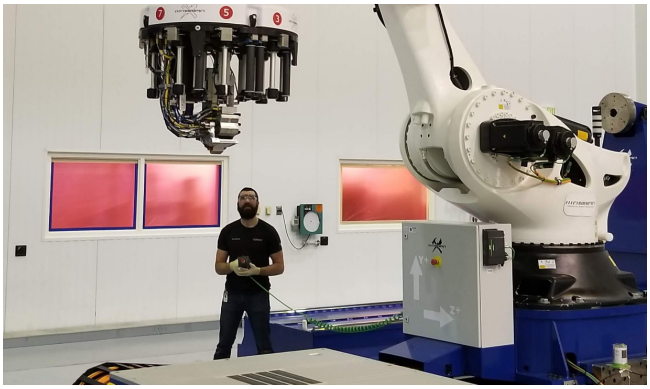
COMING SOON: NEW FACILITIES FOR RESEARCH AND COLLABORATION

Advanced Composites Center

Currently under construction in a 16,000 square foot facility at Magnuson Park in the Sand Point neighborhood north of campus, the Advanced Composites Center (ACC) will be an innovation hub for data-driven methods of composites manufacturing. The ACC will include an automated fiber-placement system for robotic manufacturing of composites, design and test facilities for additive manufacturing, and a suite of other research, education and office spaces. The equipment will be available to both UW and industry partners.

Visit **depts.washington.edu/uwacc** to learn more.



Interdisciplinary Engineering Building

A top priority for the College of Engineering is constructing the new Interdisciplinary Engineering Building (IEB) on Stevens Way. Envisioned as an academic "home" for all undergraduate engineering students, the IEB will provide more space for cross-disciplinary programs, hands-on learning facilities, student clubs, research labs and informal gathering and study. While many of the details are still in discussion, IEB's goal is to grow UW Engineering not only in numbers, but to become more inclusive, collaborative, innovative and adaptable.

Learn more about the plans and how you can help at **engr.uw.edu/facilities**