MECHANICAL ENGINEERING
UNIVERSITY of WASHINGTON

Spring 2014

The MEssenger

Engineering Innovative Solutions *to* Clinical Challenges

Healthcare is a huge part of our nation's economy, and innovation in healthcare has improved care for millions of people around the world. Many of these innovations come from collaboration between engineers and healthcare practitioners. The current climate necessitates that the quality and safety of care continue to improve, and that the economics of these improvements help reduce the overall cost of healthcare. The Department of Mechanical Engineering is taking steps to address these challenges through the Engineering in Medicine initiative.

In 2012, ME Professor and Chair Per Reinhall and Bryan T. McMinn Endowed Associate Professor Jonathan Posner, with help from a dedicated subcommittee of experienced engineers and physicians from the ME External Advisory Board, developed the Engineering in Medicine initiative. Engineering in Medicine aims to improve healthcare outcomes and reduce the cost of delivery by identifying important clinical challenges and engineering transformative solutions. The initiative also aims to train the next generation of students, fellows, and faculty in medical device development and innovation, establishing an interdisciplinary culture of engineers and health practitioners. "I saw the disconnect between engineers and clinicians as directly impacting healthcare costs and innovation in medical technology," says Professor Reinhall, "Professor Posner and the members of our external advisory committee shared the opinion that this was an opportunity for a change in the culture." The committee met several times and decided that the first efforts of the initiative should be a year-long capstone design sequence.

The sequence began with the Engineering Innovation in Medicine course for third and fourth year ME undergraduates, focused on medical device and technology development. The intention was to introduce students to the issues surrounding healthcare that are important for engineers. It featured guest lectures from local biomedical entrepreneurs, UW physicians, designers, engineers, and attorneys, speaking about issues such as medical terminology, cost containment, the FDA and regulation, funding, and

Professor Posner works with an Engineering in Medicine capstone design team's prototype.

reimbursement. Local entrepreneurs lectured on their experiences in healthcare ventures, including the challenges of setting up a healthcare company and getting funding. A series of physicians lectured on how technology impacts healthcare in specializations such as cardiology, gastroenterology, the emergency room, neurosurgery, and intensive care.

The students were also invited to tour several medical facilities, including UW's Intensive Care Unit and Swedish Heart and Vascular, as well as the Institute for Simulation and Interprofessional Studies' medical simulation laboratory at UW Medicine. The course was very well received by the students, and many continued on to to the capstone design portion of the sequence. In the design course,

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IN THIS ISSUE

Chair's CORNER

Per Reinhall, ME Chair

Welcome to the Spring 2014 issue of the MEssenger! I'm eager to share some exciting updates from around the ME Department in this issue. First of all, in Fall 2013, the College of Engineering welcomed our new Dean, Michael Bragg. ME also welcomed two new faculty members, Nicholas Boechler and Kat Steele, and a research faculty member, Brian Polagye, to the tenure track. These outstanding junior faculty will provide new expertise in the department in the areas of health and renewable energy.

In the past two years, ME has led the effort to establish the Engineering Innovation in Medicine Initiative, building on partnerships between all engineering disciplines, UW Medicine, the VA, and Seattle Children's hospital. From the beginning, Engineering in Medicine has been supported by a dedicated subcommittee of our External Advisory Board. The group has been instrumental in advancing the Engineering in Medicine initiative by establishing connections between clinicians and engineers, and engaging students by developing seminars and capstone design courses. I am excited to share this year's successes and our future plans for the Engineering Innovation in Medicine Initiative with you in the cover story of this issue.

This edition of the MEssenger also explores some of the exciting ways our students apply their mechanical engineering education both before and after graduation. Participation in project-based learning, such as the FSAE and EcoCAR2 team, helps our students become better engineers, communicators, entrepreneurs and professionals. Many of our students are interested in commercializing their inventions developed during their time in ME, and even starting companies as Thomas Larson (BSME '13) did. Our students lead the university in patent applications and issued patents.

For more news from the ME department, please visit our website and follow our Facebook page. As always, feel free to contact me with any questions or for more information, or stop by the department to have a look around.

Awards, Honors and Acknowledgements

Graduate student **Chris Bassett** was awarded the 2013 UW Graduate School Medal.

Professor Joyce Cooper was named a UW Presidential Entreprenuerial Faculty Fellow.

Professor Santosh Devasia was appointed Associate Dean of Research and Graduate Studies for the College of Engineering.

Professor Brian Fabien was awarded the DOE Applied Automotive Engineering Fellowship.

Graduate student **Shirin Feghhi** was awarded a trainee position on the Bioengineering Cardiovascular Training Grant.

Graduate student **Shirin Feghhi** and current Research Associate **Lucas Ting** took home 1st place awards in their respective groups for their papers presented at the ASME Summer Bioengineering Conference.

Thomas Larson, BSME '13, won 1st place for his presentation at the WW-ASME annual Student Presentation Competition.

Graduate student **Chi Hou Lei** won the 2013 UW Excellence in Teaching Award.

Professor Ramulu Mamidala was named the College of Engineering Boeing-Pennell Professor. He was also awarded the 2013 ASEE Isadore T. Davis Award.

Professor Jonathan Posner was named the Bryan T. McMinn Endowed Associate Professor.

Professor Jim Riley was elected to the National Academy of Engineering.

Professor Nate Sniadecki was named the Albert Kobayashi Associate Professor of Mechanical Engineering.

Professor Minoru Taya was elected to the Washington State Academy of Science.

Research Associate **Lucas Ting** won the WAGS/UMI Innovation in Technology Award for his Ph.D. dissertation.

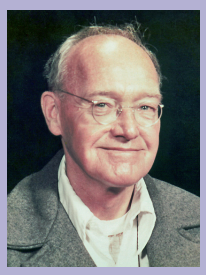
Graduate student **Scott Wilcox** won the best student paper award at the 2013 ASME Dynamic Systems and Control Conference.

ME Welcomes Three Outstanding New Faculty

Nicholas Boechler joins ME from the Massachusetts Institute of Technology, where he was a Postdoctoral Associate in the Department of Mechanical Engineering. He began his appointment at the UW as an Assistant Professor in September 2013. He earned his PhD in Aeronautics and his MS in Aerospace Engineering from the California Institute of Technology. His research focuses on the study and design of new materials that affect wave propagation. This includes novel materials such as metamaterials and phononic crystals with nonlinear, periodic, and locally resonant elements. Recent projects have included the study of nonlinear localized modes and tunable acoustic rectification in granular crystals, and the photoacoustic characterization of microscale granular metamaterials. Because of the importance of wave propagation in many engineering applications, his research is applicable to a broad range of areas including sound and vibration management, signal processing, biomedical devices, and energy conversion and storage. His honors have included a NASA Institute for Advanced Concepts Fellowship, and the Coles, Hornung, and Sechler Prizes, which were awarded by the Graduate Aerospace Laboratories of the California Institute of Technology for work done during his graduate studies.

Brian Polagye is the co-Director of the Northwest National Marine Renewable Energy Center, leading marine renewable energy research, development, and testing at the University of Washington. His research areas encompass multiple aspects of power generation from marine renewable energy resources including, resource characterization, systems to identify and mitigate environmental impacts, and optimization of energy converter design. He is the principal investigator for a National Science Foundation Sustainable Energy Pathways grant related to large-scale deployment of tidal energy converters and participates in the development of international standards for resource assessment and power performance of tidal energy converters. Dr. Polagye holds a BSME (2000) from Princeton University and MSME (2005) and PhD (2009) from the University of Washington.

Kat M. Steele arrived in Seattle to join the Department of Mechanical Engineering as an Assistant Professor in September 2013, after spending a year working at the Rehabilitation Institute of Chicago. She received her BS in engineering from the Colorado School of Mines and MS and PhD in mechanical engineering from Stanford University. Her research focuses upon using dynamic simulation, medical imaging, and device design to improve treatment and mobility for individuals with neurological disorders. Currently, her lab is working on projects to evaluate altered neuromuscular control among individuals with cerebral palsy, utilize novel ultrasound techniques to measure altered muscle properties after brain injury, and optimize orthotic design using musculoskeletal simulation. Dr. Steele has a strong background in human-centered design, which has also led to the creation of a compact catheter for individuals with urinary incontinence and compost latrines being tested in the developing world. Dr. Steele's research bridges engineering and medicine and she has previously worked at multiple hospitals, including The Children's Hospital Denver, Lucile Packard Children's Hospital, and the Cleveland Clinic.



In Memoriam **Professor Emeritus Joseph Firey** passed away in December 2013. Professor Firey joined the ME Faculty in 1958 and retired in 1978, yet remained very active in the department for many years after his retirement. Professor Firey received his BSME from the University of Washington in 1940, and his MSME from the University of Wisconsin in 1941. He was an expert in combustion and holds over two dozen combustion process patents. Professor Firey was also an avid mountaineer and skier, known as a legend in the mountaineering community for his many first ascents and discoveries of new routes in the North Cascades and BC coast mountains.

FSAE, EcoCAR2 stand out in competitions

FSAE's 2013 eCar and cCar on campus. UW FSAE

Controls team captain, Trevor Fayer, takes the team faculty adviser, Professor Brian Fabien, for a ride in the EcoCAR. UW EcoCAR2

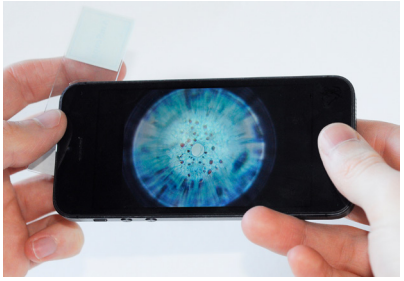
This was a great year for the Formula SAE (FSAE) and EcoCAR2 student teams! The FSAE team, which designs, manufactures, tests, and races a small formula-one style race car against competitors from around the world, built an electric racecar in addition to their combustion racecar for the first time last year. Their 1st place finish at FSAE West with the combustion car, 2nd place finish at the same competition with the electric car, and 7th place finish with the combustion car at Formula Student Germany-which is considered to be the premier Formula Student competition- has gained them a world ranking of 6th overall. This summer, they plan to compete in both Lincoln and Germany again.

The UW EcoCAR 2 team has been competing against 15 other universities to re-engineer a 2013 Chevy Malibu in order to reduce the environmental impact of the vehicle without sacrificing safety, customer appeal and driving performance. The mission of the competition is to provide practical, invaluable experience to the next generation of automotive engineers. The team performed well last spring at the year 2 competition, as the only vehicle to complete the Emissions and Energy Consumption Event as a hybrid. The team's Through-The-Road (TTR) Plug-in Hybrid Electric Vehicle (PHEV) ranked fourth overall.

Now in the final year of the competition, the UW EcoCAR 2 team is focused on making improvements prior to the final leg of the competition. The team is focused on software optimization to improve overall power and efficiency as well as optimizing the serviceability of the high voltage system. Overall, the team aims to refine the exhaust-after treatment system to reduce emissions.

The ME Department is very proud of the FSAE and EcoCAR2 teams for the exceptional work they have done!

Successful Kickstarter funds BSME grad's cell phone microscope



Thomas Larson

The simple but powerful microscope lens for cell phones magnifies up to 150x.

Last summer, recent BSME grad Thomas Larson launched a campaign on the crowdfunding website Kickstarter.com to fund the production of his invention: a tiny silicon lens that self-adheres to a cell phone camera to provide 15x magnification. Thomas developed the microscope lens as a student in the ME department, working in Professor Nate Sniadecki's Cell Biomechanics lab. He presented the idea at conferences, winning several prizes, including 3rd Place at the UW SEBA Science and Technology Showcases and 1st Place in the Western Washington ASME Student Presentation Competition.

Thomas asked for just $5,000 to fund the project, but in a few weeks, his Kickstarter campaign had raised over $90,000! Thomas was able to use the funds to manufacture the simple but powerful microscope lens, which is now sold for $15 on Amazon.com. In March 2014, Thomas launched a second Kickstarter campaign to fund the production of a lens that magnifies 150x, comparable to conventional microscopes. In just a few weeks, the funding surpassed his goal of $50,000. The 150x lens promises many exciting new applications, such as the ability to rapidly detect harmful microorganisms in water or soil samples in the field rather than the lab, and providing affordable and accessible microscopes for classrooms.

With his newfound knowledge of the world of commercialization, Thomas has been working with the UW Entreprenuership Club to get more engineering students intererested in entrepreneurship. It's safe to say that life after college has been exciting for Thomas!

10th Annual ME Scholarship and Fellowship Luncheon

Karen Orders

Recipients of the James B. Morrison Endowed Scholarships in Mechanical Engineering, with the family of Professor Morrison and Henry Schatz (BSME '64).

Karen Orders

Ron (BSME '62) and Wanda Crockett, with recipients of the Ron Crockett Endowed Fellowships and Scholarships in Mechanical Engineering.

ME Leadership Seminar Series 2013

ME wishes to thank the following alumni and friends for participating in our leadership seminar series:

Richard "Dick" Sandaas, BSME '60
Former Vice President, CH2MHill

Ron Prosser, BSME '70
Chairman & CEO, Green Charge Networks

Tom Loutzenheiser, BSME '83
Technology Executive & Entrepreneur

Herbert Roeser
Chairman, Trans Marine Power Systems

Allan Stephan, BSME '82
CEO, Stratos Group

Jill McCallum
President, Pacific Rim Aerospace

Sean Newsum, BSME '90, MBA '02
Director of Environmental Strategy
Boeing Commercial Airplanes

Anders Brown, BSME '92
Managing Director, Radius Inc.

John Premo, BSME '90
Senior Manager for Noise Preliminary Design & Acoustic Technology
Boeing Commercial Airplanes

Mike Sekins, PhD '81
Medical Director, Applications
Siemens Medical Solutions

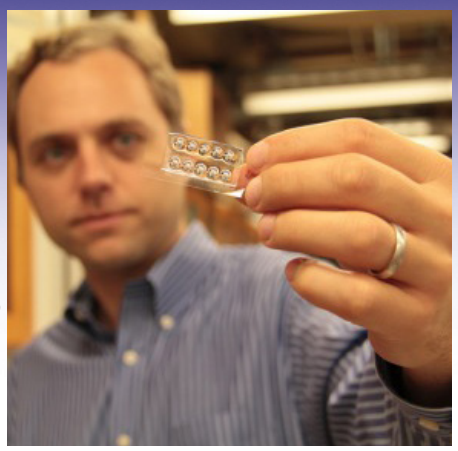
Jesse Cherian, BSME '01, MBA '04, MSME '05
Principal Product Manager, Kindle Direct Publishing

Brian Carver, BSME '97
President/CEO, Jabex Construction/ST Fabrication

Peder Fitch, PhD '04
Director of Product Quality, TSI/Nova-Tech Engineering

Brett VanVoorhis, BSME '06
Design Engineer, Kenworth Trucking Company

Research CENTERS



McKenna Princing

Rising healthcare costs mean that practitioners are increasingly searching for ways to automate or streamline expensive and time consuming processes. Here we spotlight two ME professors who have engineered tiny, low cost devices to aid clinicians in rapid diagnoses, providing accurate data to patients in minutes.

Nate Sniadecki

Associate Professor Nate Sniadecki is a lead investigator on a project to develop a small plastic and silicon card that can be used to rapidly detect blood-clotting deficiency in trauma patients. Professor Sniadecki and his team of postdoctoral scholars and graduate students in the Cell Biomechanics Lab coordinated with Dr. Nathan White, an Assistant Professor in the Department of Emergency Medicine at UW, to develop the device.

The surface of the card contains tiny protein coated posts, onto which a blood sample is placed. Platelets, a type of blood cell, adhere to the posts, initiating a clot. Technicians are able to monitor how much force the clot generates as it forms and contracts against the posts, and use that data to determine the strength of the clot and how long it will take to break down. They can also watch the formation of the clot under a microscope.

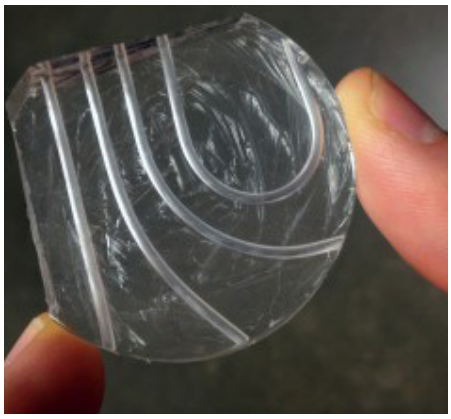
The ability to provide immediate and accurate test results on a patient's blood clotting ability is vital to successfully treating severe injuries. One-fourth of trauma patients have impaired blood clotting ability and thus face an increased risk of dying from their injuries. Therefore, it is critical for physicians to detect blood-clotting deficiency in trauma patients quickly. Currently, devices used in emergency rooms to test blood-clotting ability were not developed specifically for trauma patients, and are thus less useful in trauma care.

The device will undergo clinical trials at Harborview Medical Center in 2015. Professor Sniadecki expects that the card will be commercially available in about three years.

Eric Seibel

Research Professor Eric Seibel is working with a team in the Human Photonics Laboratory to develop a small, low cost device that could help pathologists diagnose pancreatic cancer earlier and faster. The device can perform the basic steps for processing a biopsy, relying on fluid transport instead of human hands to process the tissue.

Currently, in order to biopsy tissue, a pathologist sends the sample to the lab where it's cut into thin slices and analyzed optically in 2-D for abnormalities. The microfluidic device allows the tissue to pass intact through tiny seamless curved and straight channels, undergoing a series of steps that replicate what happens on a much larger scale in a pathology lab. Researchers say this is the first time material larger than a single-celled organism has successfully moved in a microfluidic device. The device is able to process and analyze whole tissue biopsies for 3-D imaging, which offers a more complete picture of the cellular makeup of a tumor.



U of Washington

The prototype of a microfluidic device has both curved and straight channels for transporting tissue biopsies.

Postdoctoral researcher Ronnie Das and ME undergraduate Chris Burfeind designed the device, made from lightweight, flexible silicon, to be simple to manufacture and use. They plan for it to be used overseas as an over-the-counter kit to process biopsies and convey information from remote areas to pathologists. They say that it has the potential to reduce the time it takes to diagnose cancer to a matter of minutes.

Professor Kat Steele's research priority is to improve mobility and quality of life for individuals with neuromuscular disorders through biomedical computation, muscle physiology, and device design. New experimental and computational tools have provided a pathway to understand, evaluate, and treat movement disorders. Professor Steele's lab aims to develop and harness these tools to empower patients and clinicians and improve mobility.

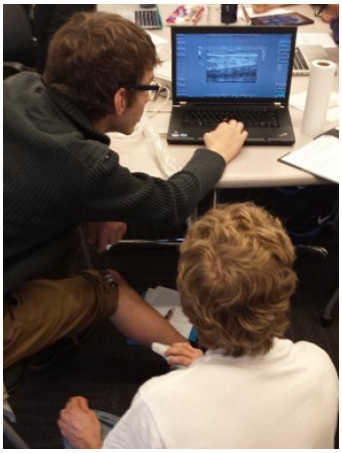
Musculoskeletal Modeling & Simulation

Computational modeling and simulation provide a powerful tool to examine complex systems and perform studies that cannot be done experimentally. The neuromuscular and musculoskeletal systems are incredibly complex; enabling the versatility of human movement. However, the same complexity that makes the human body so versatile also makes it difficult to treat when something goes awry. For individuals with movement disorders, such as stroke and cerebral palsy, neuromuscular and musculoskeletal limitations compromise mobility and are challenging to treat.

Musculoskeletal simulation with ankle foot orthosis.

Better tools and methods are required to understand the causes of gait pathologies and to design innovative treatment strategies. Musculoskeletal modeling and simulation provides a tool that can be used to examine gait pathologies, analyze hypotheses, and perform 'what-if' scenarios. Dr. Steele has previously used these methods to examine the underlying mechanisms of crouch gait, a common gait pathology in individuals with cerebral palsy. Crouch gait is not only inefficient but if left untreated can lead to joint pain, the formation of bone deformities, and eventually the loss of the ability to walk independently.

Using musculoskeletal simulations, Dr. Steele investigated how individual muscles contribute to movement during crouch gait, how tibiofemoral contact forces change with crouch severity, and how muscle weakness may contribute to crouch gait. Tight feedback loops between experimental and simulation research is critical for examining clinical questions. In her analysis of crouch gait, Dr. Steele also used meta-analysis of post-treatment outcomes, motion analysis of individuals with instrumented total joint replacements, and imaging of cartilage thickness to compliment results from simulation.



Students in Dr. Steele's lab learning to ultrasound muscle.

Musculoskeletal modeling and simulation will make the greatest clinical impact if research results are readily shared between researchers and clinicians, new methodologies are made widely available, and interdisciplinary collaborations are forged. To facilitate the growth and impact of musculoskeletal simulation, Dr. Steele and her colleagues use and help develop free, open-source biomechanics software. Simulations, tools, and new methods are posted on-line for other researchers to evaluate, use, and build upon. These tools can also be combined with other research modalities such as ultrasound, MRI, and finite element modeling to examine complex systems and create subject-specific clinical tools.

Dr. Steele is working with colleagues at University of Washington and other insitutions to pursue other applications of simulation in the treatment of movement disorders including: how to tune the stiffness of orthotics to optimize gait, how to evaluate changes in muscle properties after active and passive stretching programs, and how to predict changes in motion using electrical stimulation. The aim of all of these projects is to not only improve current abilities to model human movement, but to develop the tools and devices required to improve treatment and quality of life for individuals with movement disorders.

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The MEssenger

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Engineering in Medicine

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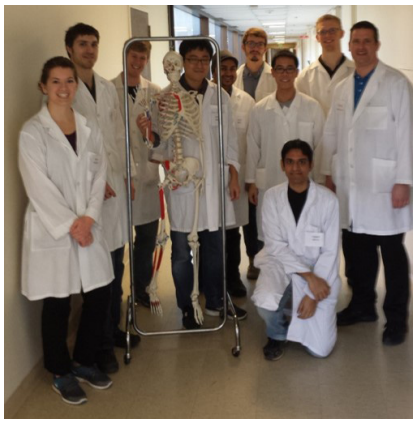
Dr. Fred Silverstein

student teams were paired with engineering faculty, physicians, intellectual property managers, medical device designers, and FDA experts to work on projects such as developing an anchor for catheter based heart surgery and monitoring delirious ICU patients. Dr. Fred Silverstein, an Engineering in Medicine subcommittee member and UW Clinical Professor of Medicine who was crucual in getting the initiative off the ground, says that the course was an opportunity for the students "to be actively involved in solving a series of real medical problems, and to learn about innovation in the healthcare environment, effectiveness, safety and cost containment." The projects resulted in functional prototypes, with several student groups exploring commercialization options.

Also in 2013, Engineering in Medicine, led by Professor Posner, teamed with Molecular Medicine to organize a spring seminar series for Engineering graduate students titled "Opportunities for Innovative Applications of Technology to Disease," in which teams of medicine and engineering faculty discussed unsolved challenges in medicine and opportunities for engineering innovation. The seminar was very well attended by students across the college.



Engineering students from the neurological disorders journal club visit the anatomy lab.

Future plans for the Engineering in Medicine initiative include continuing the undergraduate capstone design sequence and adding courses for graduate students in health sciences. In order to continue to increase collaboration between engineers and physicians to solve problems in healthcare, the committee plans to partner with the departments of Bioengineering and Electrical Engineering, and a team of Radiology residents led by Dr. Keith Chan. According to Dr. Silverstein, "The opportunities for collaboration to improve healthcare are real and extensive. The next decade will be very exciting."