GW | Engineering

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

Improving human life through innovations in energy, mobility, health and beyond

THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

LETTER FROM THE DEPARTMENT CHAIR

From bioinspired robotic design to sustainable energy solutions, the technologies that are vital to human life and prosperity rely on engineering innovations. GW Engineering creates a collaborative, interdisciplinary environment for students, faculty, and community stakeholders to innovate and create together – all while leveraging our dynamic location in Washington, DC.

The Department of Mechanical and Aerospace Engineering embodies this spirit of collaborative innovation. Our "Engineering and…" approach connects mechanical and aerospace engineering with the many aspects of our diverse, complex lives. With a deep understanding of how thermal and fluid sciences, manufacturing, materials science, robotics, and design form a foundation for infrastructure and technologies that touch all aspects of our lives, our department's faculty and students build on that foundation to impact business, law, policy, and health. It is common to see us collecting data in the hospital, developing frameworks for technology regulation in the law school, analyzing scientific frontiers with government agencies, and creating global solutions with international NGOs. We share a few representative examples here to demonstrate how our partnerships with doctors, companies, and even the National Zoo allow us to create relevant, meaningful solutions that impact human life.

I welcome you to explore our commitment to leveraging engineering research and education to improve human life and serve our global society by reading the profiles and stories that follow.

Michael Plesniak, Ph.D.
Chair, Department of Mechanical and Aerospace Engineering

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FACULTY

DR. LIJIE GRACE ZHANG

Dr. Zhang is a Professor and Associate Dean for Research in the School of Engineering and Applied Science at the George Washington University. She obtained her Ph.D. in Biomedical Engineering at Brown University. Dr. Zhang joined GW after finishing her postdoctoral training at Rice University and Harvard Medical School. She is the director of the Bioengineering Laboratory for Nanomedicine and Tissue Engineering at GW.
She has received many prestigious awards including the ASME Sia Nemat-Nasser Early Career Award, NIH Director's New Innovator Award, Society of Engineering Science Young Investigator Medal, Young Innovator in Cellular and Molecular Bioengineering, and John Haddad Young Investigator Award by the American Society for Bone and Mineral Research, etc. Her lab is focused on applying advanced 3D/4D bioprinting, nanotechnology, and stem cells for complex tissue regeneration and various disease treatments.

As a leader in the field of 3D/4D bioprinting, she has authored 152 publications including 111 peer-reviewed journal papers in top journals in her field such as Science Advances, Advanced Materials, Biomaterials, Advanced Science, Materials today, Nano today, Biofabrication, ACS Applied Materials & Interfaces, Advanced Healthcare Materials, Small Methods, Acta Biomaterialia, Nano Research, and Tissue Engineering, 22 conference proceedings, and 19 book chapters. Her lab has given over 360 presentations at various international/national conferences and universities. Dr. Zhang is an American Institute for Medical and Biological Engineering (AIMBE) Fellow.

She serves as the Editor-in-Chief of Biomedical Engineering Advances and Associate Editor for several high-impact international journals. Dr. Zhang was also elected to the American Society for Engineering Education (ASEE) Engineering Research Council Board of Directors and the International Society for Biofabrication (ISBF) Board of Director.

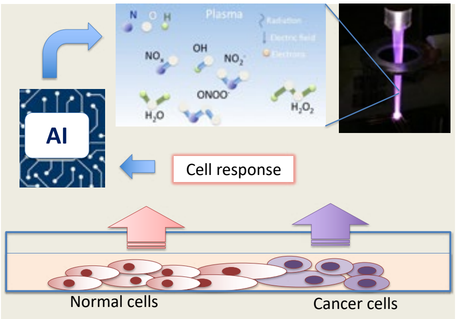
DR. PENG WEI

Dr. Wei is an associate professor in the Department of Mechanical and Aerospace Engineering at the George Washington University, with courtesy appointments in the Department of Electrical and Computer Engineering Department and the Department of Computer Science. By contributing to the intersection of control, optimization, machine learning, and artificial intelligence, he and his team develop autonomy and certification tools for aviation, aeronautics and aerial robotics. His current focus is on safety, efficiency, and scalability of decision-making systems in complex, uncertain and dynamic environments.

Dr. Wei is leading the Intelligent Aerospace Systems Lab (IASL), where his team works in air traffic control, air traffic management, airline operations, UAS traffic management, urban air mobility, and autonomous drone racing. He is an associate editor for AIAA Journal of Aerospace Information Systems, and he serves as the chairman of the AIAA Air Transportation Systems Technical Committee. He received the NSF CAREER Award in 2021.

Dr. Wei received his Ph.D. degree in Aerospace Engineering from Purdue University in 2013 and his bachelor's degree in Control Theory from Tsinghua University in 2007.

RE-ENGINEERING LIVING SYSTEMS



Adaptive plasmas and artificial intelligence for biomedical applications.

Engineered materials and novel biological processes have the potential of addressing global challenges, ranging from hunger to life-threatening diseases. SEAS faculty that will tackle the fundamental aspects, engineering and techniques to demonstrate and implement the novel concept of adaptive plasma systems that are able to adjust their delivery of reactivity to produce a desired cellular and tissue response and real-time surface monitoring.

Creating a plasma-based platform capable of engineering biological systems is a complex undertaking that requires advances in several fields including plasma chemistry, novel surface architectures, and biomedical, chemical, agriculture and computer science & engineering. Designed biological processes and living systems will enable radical reductions in the production cost of critical biological compounds, including engineered tissues, artificial joints & hormones, antibodies, cancer-specific markers, autoimmune serums, etc., as well as combating diseases and aging.

Currently, this project is supported by an NSF Industry-University Cooperative Research Center directed by Michael Keidar, a pioneer in cold plasma research and the A. James Clark Professor of Engineering in the School of Engineering and Applied Science. In addition, in 2020, George Washington University entered a $3.2 million corporate research agreement with US Patent Innovations, LLC (USPI) to support further development of adaptive cold plasma devices for cancer therapies and explore using these devices to combat the spread of COVID-19. University-corporate partnerships like this expand research and its real-world impact by creating a bridge between basic and translational research.

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Designed biological processes and living systems will enable radical reductions in the production cost of critical biological compounds, including engineered tissues, artificial joints & hormones, antibodies, cancer-specific markers, autoimmune serums etc. as well as combating diseases (cancer, HIV etc.) and aging. Low-temperature plasma interactions with biological surfaces and living tissues provide unique engineering platforms which enable real-time adaptation of plasma's biological-controlling capabilities while selectively enhancing biological functions.

ENERGY INNOVATION

Energy innovation impacts some of the most pressing issues of our time: quality of life, climate change, security, economic stability and growth, and equity. GW has an established, strong, collaborative research foundation in energy innovation. There are active interdisciplinary research projects across core focus areas such as energy as an equity enabler, multi-length scale materials for efficiency, next generation networks for electricity, heating, and cooling.

A key activity of our energy innovation research is to create high-profile demonstrations of research in action. For example, Saniya LeBlanc, Associate Professor within GW Engineering, is using the campus's combined heat and power plant, rooftop solar power systems, and solar water heating as a "living laboratory" to build a framework that can determine how an urban energy system will hold up to challenges like a major heatwave that taxes the system or a storm that causes grid outage. Her interdisciplinary research team uses modeling and hardware-in-the-loop laboratory demonstrations to determine the system's reliability, resiliency and vulnerability. Mansi Talwar, a GW graduate and now GW's Executive Director of Engineering, Utilities and Energy, said the beauty of this partnership is that it combines the university's core missions of teaching and research with its ambitious sustainability goals.

Students experienced the living lab approach to learning by doing case studies of utility scale solar photovoltaic power generation in the mid-Atlantic region. Through a site visit to GW's solar farm that supplies electricity onto the PJM grid, students gathered data to inform their technoeconomic and environmental impact analyses.

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Students engaged in a site visit to the Capital Partners Solar Project, a renewable energy power purchase agreement project that supplies almost half the university's electricity.

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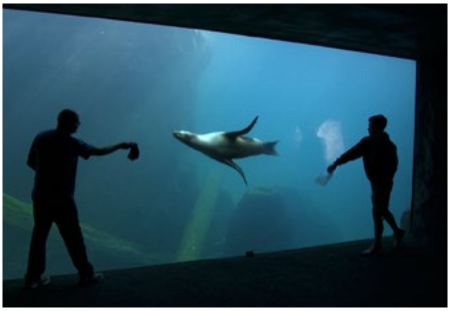
THE SCIENCE OF SWIMMING

Sea lions glide through the ocean with amazing grace. Not only are they fast swimmers—reaching speeds of 25 miles per hour—but they also are capable of extraordinary maneuvers. These playful animals back flip and spin with ease, like ballerinas of the sea.

In Dr. Megan Leftwich's lab, she and her team of researchers work in a field called fluid dynamics, the study of how objects and animals travel through liquids, gasses and plasmas in order to explain phenomena of the natural world.

Sea lions immediately piqued her interest because they move through the water unlike any other animals on Earth. While fish and other swimming mammals thrust forward with their tails or caudal fins, sea lions rely on their fore flippers, which are analogous to human arms, for underwater movement. They sweep downward, clap their large flippers into their bodies and glide forward, producing jet propulsion. Sea lions are able to cruise the length of an Olympic-size pool with a single clap. Other animals that use jets to propel forward, like octopi and squid, cannot sustain high speeds or manipulate their bodies with the sea lions' impressive agility. Sea lions' hardly traceable wake structure—the disturbance a solid causes in a fluid—also differs significantly from other swimming mammals.



Collaboration with Smithsonian's National Zoo allows GW researchers to gather data on sea lions swimming.

As part of an ongoing research partnership, Dr. Leftwich and her team visited the National Zoo's California sea lions, using high-definition video cameras to digitize their unique flipper motions. After analyzing the videos, Dr. Leftwich and post-doctoral scientist Chen Friedman quantitatively compared differences in the sea lions' claps and body maneuvers in order to highlight correlations in features such as angular velocity and flipper curvature.

When one of the zoo's sea lions died last year, Dr. Leftwich's lab obtained her flipper. Josh Waldron, one of six undergraduates working in Dr. Leftwich lab, spent the summer taking high-resolution, micro-scale images of the flipper's skin using a high-powered scanning electron microscope.

For future studies, Dr. Leftwich hopes to collaborate with the SLEWTHS program (Science Learning and Exploration With the Help of Sea Lions) based in California, where her team would be able to experiment directly with the animals in their natural habitats. One potential application for Dr. Leftwich's research is to provide models for underwater vehicles, such as the autonomous ones used by the Navy for disarming underwater bombs.

REPRODUCIBILITY AND OPEN SCIENCE

A movement for open science and reproducibility has been growing across fields of research. Reproducibility and replicability are part of the ways in which science self-corrects but are not the sole concern. Professor Lorena Barba was a member of the National Academies of Sciences, Engineering and Medicine (NASEM) Reproducibility and Replicability in Science study committee. This committee conducted an in-depth study looking across all of science to better understand what, if any, improvements are needed.

The committee held a series of briefings leading up to the release of their report in 2019 with the White House Office of Science and Technology Policy, the National Science Foundation (NSF) and other stakeholders. It aimed to identify any issues of replication and reproducibility in scientific and engineering research. The report made recommendations for improving rigor and transparency in scientific and engineering research, and identified and highlighted good practices.

The study was commissioned by the National Science Foundation, in response to congressional mandate. Public Law 114-329 cites "growing concern that some published research findings cannot be reproduced or replicated…" and directs the NSF to produce a report with an assessment and recommendations on the matter.

The committee's study found that improvements are needed—more transparency of computational workflows, code and data, for example, and adjusting the incentive structure to value reproducible research. Other findings include the need for greater fluency with statistics, and training of early career researchers on computational tools and methods. The study has been influential in policy changes and new programs, including the new NASA Transform to Open Science (TOPS) mission.

PREPARING GRADUATES FOR IMMEDIATE SUCCESS AT THEIR FIRST JOB

We prepare our graduates for success at their first jobs by fostering the development of knowledge, skills and capabilities that evince the GW ethos of career preparation and passion by engaging all students in authentic engineering design projects with external sponsors.

Capstone Senior Design is a two semester sequence where students work in teams to design, fabricate, and verify solutions for customer-driven problems. Students hone their technical capabilities and develop proficiency in teamwork, communication, project management, among others. They grow success-apposite character and grit by persisting through failure toward a desired outcome.

Our program capitalizes on our location in the heart of Washington DC that is surrounded by powerhouse government labs in addition to headquarters and offices of top national and international companies and organizations. Some of our recent capstone project sponsors include NASA, Naval Surface Warfare Center, Department of Energy, Mitre Corporation, Noblis Corporation, MC Dean, Inc., and QL Plus. Students also have the opportunity to work on national competitions such as Mini-baja sponsored by the Society of Automotive Engineers, Design-Build-Fly sponsored by the American Institute of Aeronautics and Astronautics, and the Rocket Engineering Competition.

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