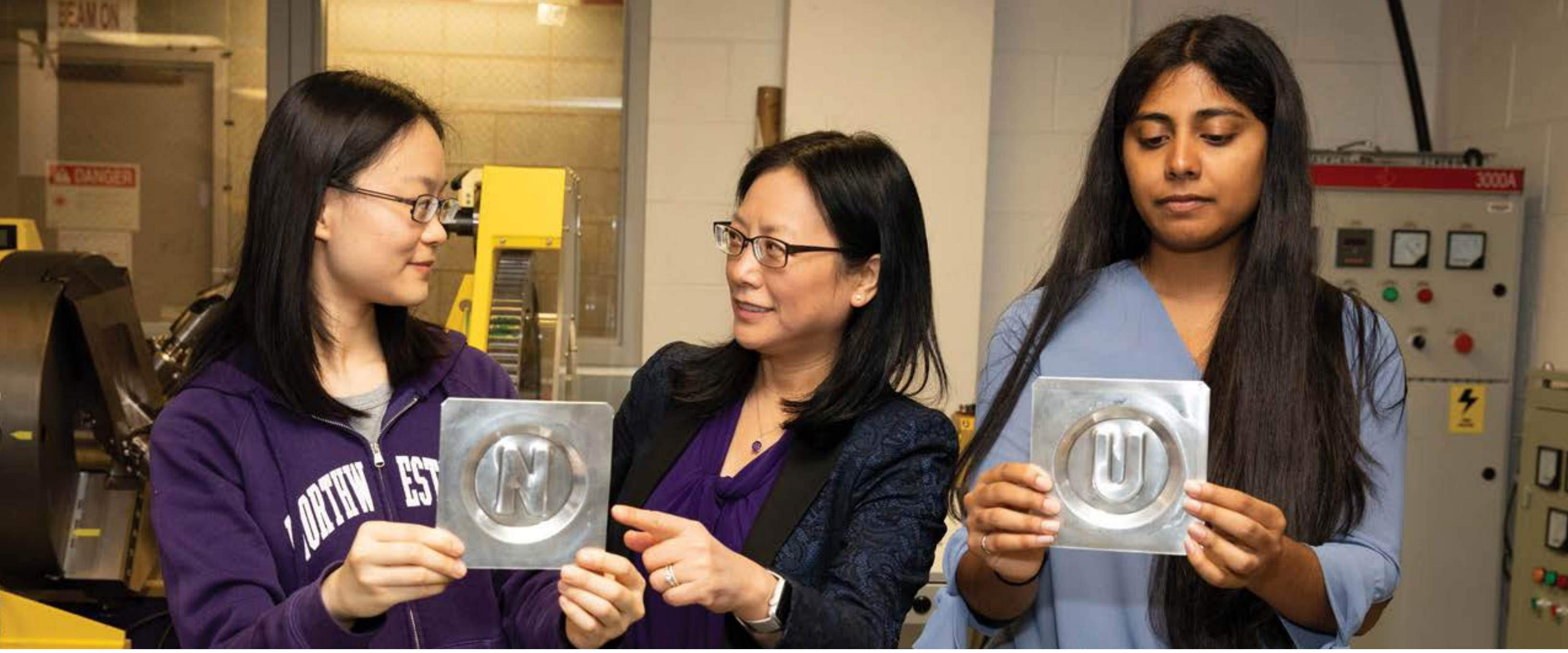
Northwestern | McCORMICK SCHOOL OF ENGINEERING

Mechanical Engineering

Integrating mechanical sciences, computation, and design to shape the future

Strategic Plan: *educational and research priorities for the department*



Who We Are

Mission Statement

We train the next generation of ‘whole-brain’ mechanical engineers to lead with both creativity and analytical thinking. We pursue fundamental principles at the core of mechanical sciences and their interface with other scientific disciplines, and we generate new products, processes, and systems that create lasting societal impact.

Diversity, Equity, and Inclusion

Diverse perspectives and recognizing the needs of a diverse society are critical to prioritizing our research initiatives and maximizing the impact of our teaching. We thrive by ensuring that students, faculty, and staff of all ages, backgrounds, religions, races, ethnicities, gender identities/expressions, national origins, sexual orientations, physical abilities, and all other identities feel welcome and respected, are treated equitably, and are able to fully engage with our learning and research communities.

30 tenure-track (including 6 women), **7 teaching,** and **10 courtesy faculty** members

1/3 of faculty have joint appointments with another department

9 members of the National Academy of Engineering (NAE)

3 members of the National Academy of Sciences (NAS)

4 members of the National Academy of Inventors (NAI)

8 editors-in-chief of international research journals

1/3 of faculty are among top 1%
3/4 of faculty are among top 10% of most cited researchers (Clarivate Analytics 2016-2020)

Graduate Education

COLLABORATIVE AND INTERDISCIPLINARY

Our faculty and students are engaged in collaborative projects with researchers from every other engineering department and from around the University. Interdisciplinary cluster programs provide opportunities to work with colleagues with different technical perspectives.

FLEXIBLE

Graduate students are encouraged to take courses from across engineering and science disciplines to build a program that accommodates their own research interests and talents. MS concentrations are available in energy and sustainability, simulation-driven engineering, robotics, and other in-demand specialization areas.

DIVERSE

Among top engineering schools, McCormick is highly ranked in our percentage of female and underrepresented minority students. Northwestern, McCormick, and the Mechanical Engineering department have developed numerous initiatives to ensure that students of all backgrounds feel welcome, respected, and fully engaged in the learning and research community.

SUPPORTIVE

Work-life balance is essential to a fulfilling graduate education experience. The ME Graduate Student Society (MEGSS) plans social events and provides mentoring and guidance, and Northwestern offers services and benefits to nurture students' mental, emotional, and physical well-being. Outside the classroom and lab, student life is enriched by the cultural diversity and social opportunities provided by Northwestern, Evanston, and the Chicago area.

BENEFITS

Fully-funded tuition, stipend, and health insurance for PhD students

Paid parental leave and childcare grants for eligible graduate students

RANKINGS

#13 by U.S. News and World Report (2021)

Top 5 in latest National Research Council ranking (2010)

PhD CAREER PATHS

1/3 go into **academia**

1/3 go into **industry**

1/3 go into **other positions** (e.g., consulting or government labs)

DIVERSE CLASSES

32% **female, 9% underrepresented minority,** and from **22 countries**

Research

Building on our three core disciplines of Design and Manufacturing, Mechanics and Materials, and Robotics and Biosystems, we address pressing current and future needs of our society through seven cross-cutting research areas.

Leaders of Research Centers

Faculty in Mechanical Engineering play leadership roles in 14 cutting-edge research centers that address national priorities in robotics, future manufacturing, advanced materials, clean water, renewable energy, health and medicine, artificial intelligence, and space technology.

Ultra-precision single point diamond turning for advanced optical surfaces

Advanced Manufacturing

Creating manufacturing processes, equipment, controls, predictive capabilities, and connectivity for enhanced productivity, precision, and sustainability

Manufacturing has the largest economic multiplier effect of all industries. Through the platform offered by the Northwestern Initiative for Manufacturing Science and Innovation (NIMSI), we integrate both ideas and technologies across multiple disciplines, aiming for the creation of processes and systems with a lasting positive environmental and societal impact.

ADDITIVE MANUFACTURING PROCESSES AND SYSTEMS

Inventing, characterizing, and improving additive manufacturing processes from the micro- to the macro-scale for a wide range of engineering materials

DEFORMATION-BASED MANUFACTURING PROCESSES AND SYSTEMS

Creating flexible and predictable forming processes through innovative process and machine system design

MICRO/NANO AND PRECISION MANUFACTURING

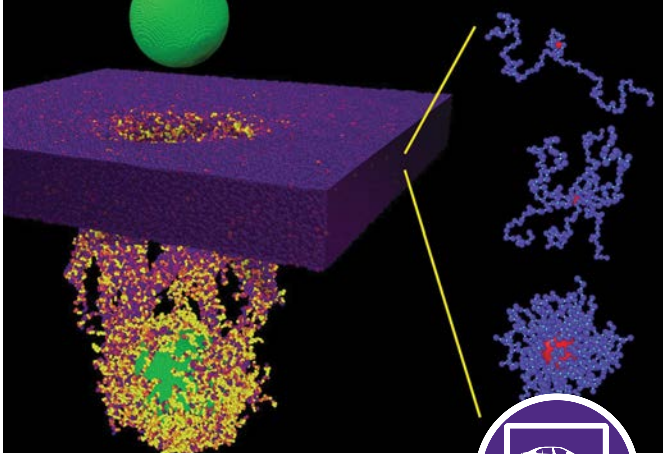
Pushing the limits of precision and resolution to enable scalable micro/nano-manufacturing processes through new system design and process innovation

PHYSICS-BASED, DATA-DRIVEN PROCESS DESIGN AND CONTROL

Establishing understanding of process mechanics and linking that understanding with in situ process sensing for robust process monitoring and control

DIGITAL TWINS IN THE CONNECTED WORLD

Building and integrating digital twins of physical manufacturing systems and human operators for advanced AI analytics and process planning



Molecular simulation of impact response of a star polymer thin film

Computational Engineering

Advancing computational simulation to understand and predict phenomena across the natural and technological world

Computational simulation gives researchers the power to explore complex engineering problems that cannot be easily approached through theory and experiment alone. We are creating solutions using high-performance computing platforms and advanced algorithms to impact all our cross-cutting research areas.

NOVEL FORMULATIONS AND ALGORITHMS
Developing mathematical and computational tools to solve complex, multifaceted, multiscale engineering problems

MULTISCALE MODELING AND DESIGN FOR MATERIALS AND MANUFACTURING
Discovering, creating, and building new forms of matter through computational simulation and design, from atoms to structures to devices

BIOSIMULATION: ORGANS, TISSUES, MOLECULES, AND DEVICES
Enabling breakthroughs in medicine and health using physics-based modeling and design

MECHANISTIC MACHINE LEARNING
Building knowledge-driven models that combine deep-learning networks with physical principles and engineering insight

Bio-inspired frost patterning (left: natural, right: artificial)

Energy and Sustainability

Developing efficient energy conversion, energy utilization, water management, and pollution mitigation solutions

Sustainable access to energy and clean water using low-carbon-emission technologies is essential to address climate change. We are inventing new technological solutions using integrated approaches rooted in computational mechanical-material science, surface engineering, thermo-fluids science and engineering, design, and manufacturing.

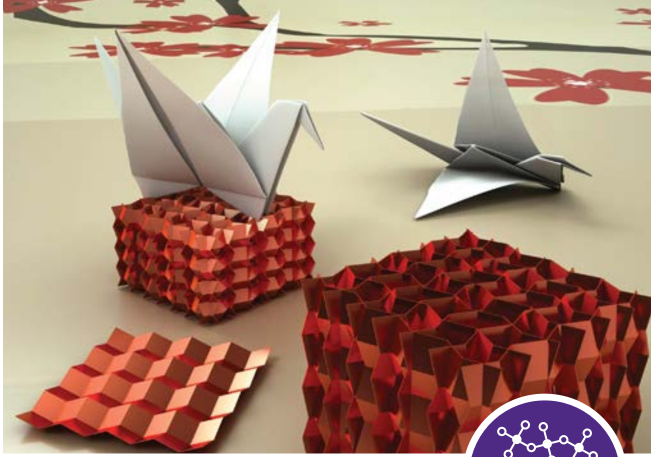
ENERGY CONVERSION AND STORAGE
Designing, fabricating, and testing novel materials for more sustainable solar, thermal, geothermal, and chemical energy conversion and storage systems

EFFICIENT ENERGY UTILIZATION
Reducing carbon footprint by mitigating icing and fouling, reducing friction and wear at surfaces in contact, and improving efficiency of thermal transport systems

WATER MANAGEMENT
Creating collection, filtration, and purification technologies to reduce water use in energy, agricultural, and manufacturing sectors

POLLUTION MITIGATION
Capturing pollutants from air and water, and developing safe and efficient carbon sequestration to address the pollution challenge

CRADLE-TO-CRADLE SUSTAINABILITY ANALYSIS
Evaluating the energy and environmental effects of energy, water, and material systems to guide technology development



Origami engineering – inspiration for designing metamaterials

Micro/ Nanoengineering

Probing, understanding, and manipulating matter at small scales to achieve unique functions in materials, mechanical systems, and biological systems

Micro- and nanoengineering provide tools for the characterization and design of nanostructured materials and metamaterials with novel electronic, photonic, and mechanical properties to address critical societal needs. Innovations in probing bio/nano interfaces and cell gene editing and analysis address key biological questions and help us better diagnose and cure diseases.

QUANTUM AND ARCHITECTED METAMATERIALS AND DEVICES
Breaking new ground in multi-functional quantum devices and architected materials through advances in theory, simulations, and high-throughput experiments

CELL MANIPULATION AND ANALYSIS
Advancing microfluidics coupled with genetic engineering and enabling unprecedented capabilities in cell analysis and manipulation, targeting disease modeling and therapeutics

MULTI-SCALE CHARACTERIZATION AND MODELING
Establishing novel in situ experiments and in silico approaches coupled with machine-learning algorithms to accelerate the design of new nanomaterials and devices

NANO/MICROSCALE FABRICATION AND 3D PRINTING
Developing the science and technology of multiscale, multiphase fabrication with applications ranging from smart structures to metamaterials to classical and quantum photonics

SURFACE AND INTERFACE ENGINEERING
Investigating novel properties and mechanisms at solid-fluid interfaces across nano/microscales for breakthroughs in manufacturing, tribology, desalination, chemical reactions, and energy conversion

Collaborative mobile manipulators

Robotics and Autonomy

Creating machines that interact with complex environments, make decisions, take action, and collaborate with humans and one another

On land, in air, in space, and underwater, as individuals and as teams, autonomous machines increasingly impact infrastructure, healthcare, security, manufacturing, and the environment. Research in the Center for Robotics and Biosystems (CRB) drives fundamental advances in materials, actuation, and sensing and control; sensorimotor integration; locomotion, manipulation, and swarm behavior; machine perception and cognition; and human-robot interaction.

BIOINSPIRATION, NEUROMECHANICS, AND NEUROSCIENCE
Using robotics to understand sensorimotor integration in animals and using animal models to inspire novel robotic systems

HUMAN-MACHINE SYSTEMS
Developing interfaces that augment human perception and human-robot systems that enhance capabilities via shared autonomy

SWARM ROBOTICS AND DECENTRALIZED COMPUTATION
Creating teams of robots that, without centralized planning or control, can exhibit complex emergent behaviors such as self-assembly and locomotion

AUTONOMOUS SYSTEMS
Investigating new ways for robots and vehicles (underwater, ground, and aerial) to perform sophisticated, dynamic behaviors in complex environments

SOFT ROBOTICS
Developing techniques to fabricate soft 3D robotic structures with embedded sensors, artificial muscles, and control

Patient with spinal cord injury controls an assistive robotic arm

AI and Design

Developing human-centered, physics-based, and AI-enabled design methods for creating engineering products and systems that address societal challenges

Design combines engineering, business, the arts, and the social sciences to tackle complex societal challenges. Designers use machine learning and artificial intelligence (AI) to work at the interface between technology and society. In collaboration with the Segal Design Institute and the Center for Human-Computer Interaction+Design, we develop human-centered design principles, collective-innovation platforms, and AI-enabled computational design methods.

HUMAN-CENTERED DESIGN

Blending engineering and social sciences to build novel socio-technical systems to augment human behavior and develop theories of society and technology interactions

AI FOR PHYSICAL HUMAN-MACHINE INTERACTION

Enhancing machine learning and AI techniques in design of surface haptic technology, human-robot co-adaptation, swarm robots, and learning and rehabilitation devices

PHYSICS-BASED MACHINE LEARNING

Combining machine learning with physics-based simulations and experiments for predictive multiscale modeling and design, manufacturing process control, and creation of cyber-physical systems

DESIGN OF ENGINEERED MATERIALS SYSTEMS

Developing novel design representations and data-driven design synthesis approaches to accelerate the design of materials and structures in emerging materials systems

BIOINSPIRED DESIGN AND SYNTHESIS

Translating biological knowledge into design of innovative products and processes such as underwater robots, metamaterials, optics, and 3D materials syntheses

Skin-like wireless sensor for health monitoring

Biosystems and Health

Advancing basic and translational research to address critical healthcare issues and answer fundamental biological questions at scales from molecules to systems

From molecular mechanics to multiscale physiological simulations to the control of prosthetic limbs, mechanical engineering helps develop technologies that improve human health and offers insights into fundamental biological processes. In close collaboration with the Feinberg School of Medicine and the Shirley Ryan AbilityLab, the nation's No. 1 rehabilitation research hospital, we address pressing healthcare challenges.

HUMAN-ROBOT SYSTEMS

Designing robots to augment human capabilities (prosthetics and assistive robots), aid recovery from injury (rehabilitation robots), and revolutionize human-computer interaction (haptic interfaces)

BIOELECTRONICS

Creating devices that interface biological tissue with electronics, with applications including wireless skin-like wearable sensors and actuators, resorbable electronics, and drug delivery

CELL THERAPY

Advancing microfluidic platforms for gene editing and live cell analysis, with specific applications in disease modeling, drug screening, immunology, and cell therapies

MECHANICS OF BIOSYSTEMS

Understanding the functions and mechanical properties of biomolecules and biosystems such as cells and organs

SENSORIMOTOR CONTROL

Revealing the sensorimotor foundations for perception, action, and cognition in humans and other animals

Education

We provide students with a strong foundation in mechanical engineering, prepare them for leadership and innovation by emphasizing independent thinking and teamwork, instill a systematic approach to problem solving, and promote a keen awareness of the role of engineering in modern society.

Undergraduate Education

HOLISTIC

We train whole-brain engineers. Our curriculum integrates a solid foundation in technical subjects with multiple opportunities for creative problem solving, plus experience in design, entrepreneurship, and leadership.

CUTTING EDGE

Curricular flexibility is provided in the form of nine state-of-the-art concentrations such as aerospace, design, manufacturing, energy, and robotics, reflecting rapidly emerging areas of mechanical engineering. Our curriculum can be customized to suit a student's interests and professional goals.

EXPERIENTIAL

We emphasize design thinking and hands-on learning through our flagship Engineering First® and capstone sequences. Outside the classroom, many students engage in research with world-renowned professors for academic credit. Entrepreneurial and leadership opportunities are available in the innovation space at The Garage and the Farley Center for Entrepreneurship and Innovation.

AWARD-WINNING

Our department has received the largest number of university-level teaching awards at Northwestern. We are also innovators of teaching tools such as the lab-in-a-backpack and the Northwestern Lightboard. Students are advised by faculty members one-on-one through graduation, creating continued and long-lasting relationships.

300+

undergraduates
27% female / 27% Hispanic or Black

#9

National University ranking by **U.S. News and World Report** (2021)

9

ME-led student organizations
(ACME, ASME, SAE Formula Car, Mini-Baja, Solar Car, Pi Tau Sigma, NUSTARS, Design for America, NU Robotics)

2021 GRADUATION CLASS STATS

25%
in **Pi Tau Sigma** National Honor Society

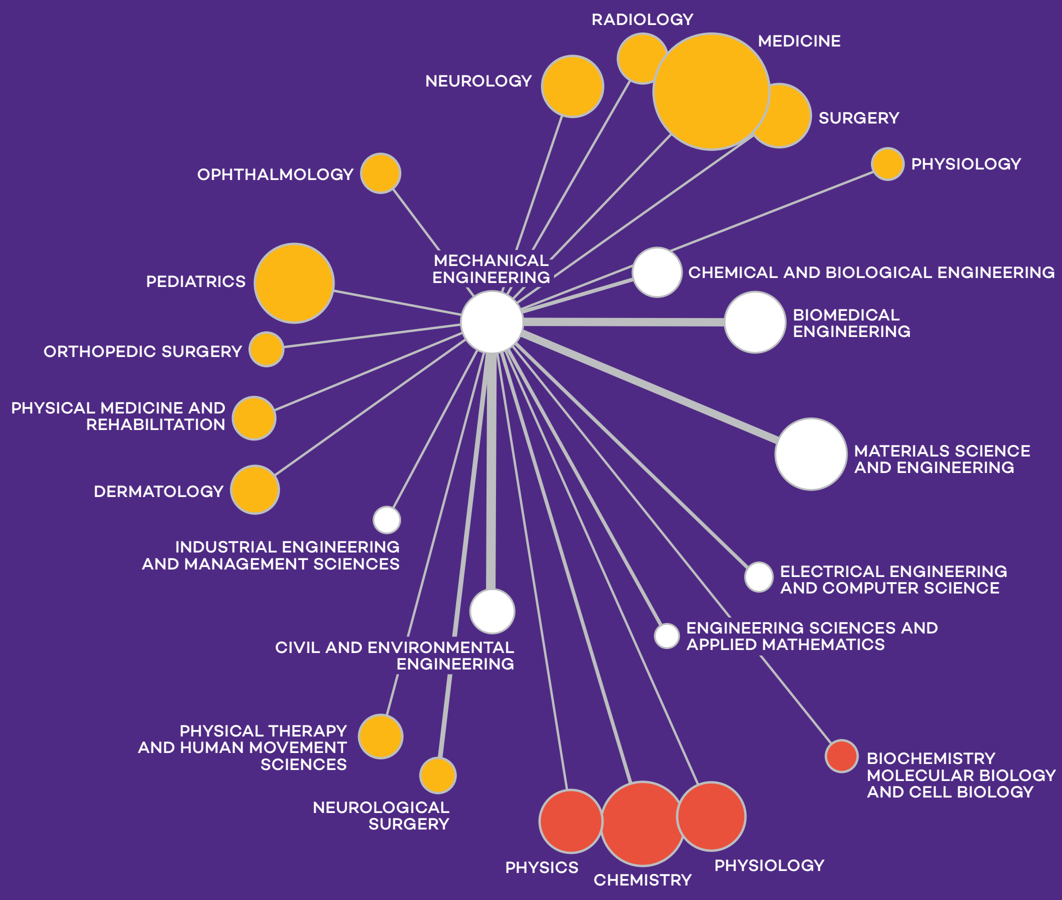
15%
graduated with **double majors**

40%
admitted into the **integrated BS/MS program**

15%
graduated with **a minor**

Interdisciplinary Collaboration

Mechanical Engineering, located in Evanston, Illinois, engages in research collaborations across many schools and departments at Northwestern, including Feinberg School of Medicine in downtown Chicago, as well as external partners such as Argonne National Laboratory.



Collaborations with 24 other departments across Northwestern.

Circle area is proportional to the number of papers. Line width is proportional to the number of coauthored papers.

Northwestern University, Evanston Campus

Feinberg School of Medicine, Chicago Campus

Argonne National Laboratory

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Whole-brain engineering starts here.
Find out more.

WWW.MECH.NORTHWESTERN.EDU

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