

The ME Graduate Handbook

All about the Graduate Program

in

Mechanical Engineering

in

**The McCormick School of Engineering and
Applied Science**

at

Northwestern University



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The ME Graduate Handbook

Information about the Graduate Program in Mechanical Engineering McCormick School of Engineering and Applied Science Northwestern University

2018

MECHANICAL ENGINEERING AT NORTHWESTERN UNIVERSITY

Northwestern University's Department of Mechanical Engineering is a leader in fundamental research in several cutting edge technologies that are relevant to today's society. Our programs provide a solid foundation for careers in academia, industry and research labs. Northwestern's tradition of interdisciplinary research provides students with exciting new opportunities in the broad areas of:

- Design, Manufacturing and Tribology
- Dynamics, Control, Robotics, and Neural Engineering
- Fluid Mechanics and Energy □ Nanotechnology and MEMS
- Solid Mechanics

with new emphases in

- Design
- Biosystems and Health
- Nano/Microscience and Technology
- Energy and Sustainability
- Data-Driven Multiscale Simulation in Science and Engineering

You will find updated information about the current research activities of the department on our website: <http://www.mccormick.northwestern.edu/mechanical/>.

THE GRADUATE PROGRAM IN MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers programs leading to the MS and PhD degrees. Outstanding students may be admitted for graduate study directly from the bachelor's to the doctoral degree.

Students arrange their study and research in association with individual faculty members and often with the various interdepartmental and special programs associated with the Center for Surface Engineering and Tribology, the Center for Smart Structures and Materials, Northwestern Institute on Complex Systems, the Segal Design Institute, Northwestern Initiative for Manufacturing Science and Innovation (NIMSI), the Program in Theoretical and Applied Mechanics, and the Predictive Science & Engineering Design (PS&ED) Cluster.

Graduate students are not required to follow a rigid curriculum; each student may arrange a curriculum that accommodates individual needs, talents, and interests while satisfying the basic degree requirements. The basic degree requirements are designed to ensure that the students develop a rigorous appreciation of mathematics, and have a broad exposure to fields of engineering and science outside of their immediate area of interest.

MS DEGREE REQUIREMENTS:

1 Thesis option

Course Requirements:

- **Number of courses:** Nine course units are required, excluding ME 590 research units. (12 total units)
- **General program breadth requirement:** General program students must take at least one course each from four of the eight subareas:
(1) Solids, (2) Fluids/Thermodynamics/Energy, (3) Robotics/Dynamics/Controls,
(4) Design/Manufacturing/Tribology, (5) MEMS/Nanotechnology, (6) Biomedical/Biology,
(7) Mathematics/Sciences, and (8) Engineering Management.

The following courses are suggested in each category, while other courses may be considered in consultation with the MS Program Director:

Solids: ME 327, ME 362, ME 416, ME 417, ME 418, CEE 413^c, CEE 414-1^c, CEE 414-2^c, CEE 415^c, CEE 417-1^c, ME 426-1, ME 426-2, ME 456, and relevant ME 495 courses (eg: wave propagation, thin films, etc.)

Fluids/Thermo/Energy: ME 322, ME 367, ME 395 (combustion), ME 380, ME 418, ME 420, ME 422, ME 423, ME 424, ME 425, ME 427, ME 467, ME 470, CEE 440, ESAM 426, ESAM 429-1, ESAM 429-2

Dynamics/Control: ME 314, ME 333, ME 363, ME 390, ME 433, ME 448, ME 449, ME 450, ME 451, ME 454, ME 495 (comp. nanodynamics), EECS 360, EECS 374

Design/Manufacturing/Tribology: ME 319, ME 320,, ME 340-3, ME 341, ME 346, ME 439, ME 441, ME 442, ME 445, ME 446, ME 495 (comp stat for design), ME 495 (manuf process mech), ME 495 (sustainable manuf systems)

MEMS/Nanotechnology: ME 381, ME 382, ME 385, ME 416, ME 417, ME 418, ME 445, ME 451, ME 453, ME 495 (comp nanodynamics), ME 495 (mech of cell and bioMEMS)

Biomedical/Biology: ME 495 (mech of cell and bioMEMS), BME 462, BME 463, BME 464, BME 465, BME 467, BME 475, BME 495-01,02 (medical innovation)

Mathematics/Sciences: ESAM 311-1,2,3, ESAM 322, ESAM 346, ESAM 370, ESAM 411-1,2,3, ESAM 420-1,2,, ESAM 421-1,2,, ESAM 424-1,2, ESAM 426, ESAM 429-1,2, ESAM 430-1,2,3, ESAM 445, ESAM 446-1,2, EECS 328, ME 432

Engin. Management: ME 495 (Tech Innovation), ME 467, MEM 402*, MEM 407*, MEM 415*, MEM 417*, MEM 426*, IEMS 486*, IEMS 490*

* Registration in MEM courses requires permission from the MEM Program or IEMS department.

- **Energy and Sustainability program requirements:** ISEN 410 is required plus one course from each of four topic areas (course can count for only one area even if qualifies for two):
Energy: ME 367, ME 395 (Nuclear), ME 395 (Energy Systems), ME 467, MatSci 382^c (Energy materials & devices)
Environment: CEE 363, CEE 364, CEE 368, CEE 395-23 (Environmental Justice), CEE 440^c, ESAM 495 (Math modeling for Earth Sci)
Core Principals of Energy Systems: ME 322, ME 346, ME 380, ME 445, ME 446, ME 467, CEE 414-1^c, CEE 414-2^c, MatSci 381^c, MatSci 382^c (Energy materials & devices)
Economics and Policy: ISEN 420, ISEN 430, CEE 303, ChE 365, CEE 395-23 (Environmental Justice)

###^c (superscript-c): These are considered ME courses

- **Level:** A minimum of 5 credited course units (excluding research units) must be 400-level or above.
- **ME courses:** A minimum of 5 course units (excluding research units) must be ME courses or qualifying courses marked as ###^c.
- **Seminar:** Registration and regular attendance at the non-credit ME512 Seminar is required for all quarters. Only those doing MS with thesis option should register for ME 512.
- **Approval:** There are no advisor holds. Thus, the students are free to choose courses that accommodate individual needs, talents, and interests while satisfying the basic degree requirements. Students are encouraged to talk with the MS Program Director for any questions or consultation. Note that if you register for four units in any given quarter the tuition will be charged only for three units. That is a 25% savings in tuition for that quarter.
- **Continuous Registration:** Occasionally when more time is needed to complete a thesis, a student may be permitted, in consultation with the research advisor, to register for TGS 512 Continuous Registration. TGS 512 is considered full-time and costs about \$100 for the quarter. The restrictions are that the student must have completed 12 units prior to TGS 512 registration and must not be taking any other courses.

Research: Three credit units of ME 590 are required in which a suitable thesis under the direction of a faculty advisor must be completed and defended. When registering for the very first time, only one unit of ME 590 is permitted.

GPA requirement: GPA is determined by all BS/MS qualifying courses or post BS courses taken at Northwestern towards satisfying the course requirements above. A minimum GPA of 3.0 is required by The Graduate School to earn a MS degree. If after fulfilling the course requirements, a student's GPA is below the minimum it may be necessary to take additional classes to raise the GPA to the required minimum.

Master's Thesis and Examination: The Mechanical Engineering Department requires a written thesis to be approved at a final examination. The final examination shall include a presentation by the student of the thesis material and examination by the Examining Committee. The Examining Committee is comprised of at least two full-time members of the Northwestern University faculty, who must also be a member of the Graduate Faculty. Coursework and core courses must be filled out on the "ME MS Degree Requirements" form, signed by the advisor and the MS Program Director. This form must be presented prior to the final examination. Upon successful completion of the final examination, the Examining Committee signs the *Master's Degree Completion form*, which is then submitted to the Graduate School.

MS thesis: The thesis should be based on original research that is of publishable quality and should have a quantity of material equivalent to at least one journal paper. It should be prepared according to the Graduate School format for PhD dissertations (<http://www.tgs.northwestern.edu/documents/policies/dissertation-format-guidelines.pdf>).

An *Application for Degree* must be submitted to The Graduate School by the relevant published deadline for June, August, December or March graduation.

Transferring from MS to PhD:

Occasionally, an outstanding MSME student may want to continue their studies for a PhD. Completion of MS is not a requirement for being in the PhD program. Since our PhD program is fully supported, the student will need to work effectively with his (her) MS research advisor who may sponsor the student for a PhD provided the funding is available. After you have identified a sponsoring professor, please contact the ME Director of Graduate Studies who will make the final admission decisions, which will be subject to approval by The Graduate School. Note that there is no separate application to fill out; only a one-page Program Transfer form should be submitted (to the Graduate Program Assistant for processing) at least six weeks before the PhD enrollment.

If you are awarded an external Doctoral Fellowship (for example, NSF) please contact the Director of Graduate Studies right away. If you are pursuing a McCormick Professional MS (for example MSR), the above procedure does not apply. You will need to complete the TGS application for a PhD admission by the December 15th deadline and await the evaluations.

2 Non-thesis option for terminal MS degree

Course Requirements:

- **Number of courses:** Eleven course units plus one project unit ME 499 are required. (12 total units)
- **General program breadth requirement:** General program students must take at least one course each from four of the eight subareas:
(1) Solids, (2) Fluids/Thermodynamics/Energy, (3) Robotics/Dynamics/Controls,
(4) Design/Manufacturing/Tribology, (5) MEMS/Nanotechnology, (6) Biomedical/Biology,
(7) Mathematics/Sciences, and (8) Engineering Management.
The following courses are suggested in each category, while other courses may be considered in consultation with the MS Program Director:
Solids: ME 327, ME 362, ME 416, ME 417, ME 418, CEE 413 ^c, CEE 414-1 ^c, CEE 414-2 ^c, CEE 415 ^c, CEE 417-1 ^c, ME 426-1, ME 426-2, ME 456, and relevant ME 495 courses (eg: wave propagation and thin films, etc.)
Fluids/Thermo/Energy: ME 322, ME 367, ME 395 combustion, ME 380, ME 418, ME 420, ME 422, ME 423, ME 424, ME 425, ME 427, ME 467, ME 470, CEE 440, ESAM 426, ESAM 429-1, ESAM 429-2
Dynamics/Control: ME 314, ME 333, ME 363, ME 390, ME 433, ME 448, ME 449, ME 450, ME 451, ME 454, ME 495 (comp. nanodynamics), EECS 360, EECS 374
Design/Manufacturing/Tribology: ME 319, ME 320, ME 340-3, ME 341, ME 346, ME 439, ME 441, ME 442, ME 445, ME 446, ME 495 (comp stat for design), ME 495 (manuf process mech), ME 495 (sustainable manuf systems)
MEMS/Nanotechnology: ME 381, ME 382, ME 385, ME 416, ME 417, ME 418, ME 445, ME 451, ME 453, ME 495 (mech of cell and bioMEMS)
Biomedical/Biology: ME 495 (mech of cell and bioMEMS), BME 462, BME 463, BME 464, BME 465, BME 467, BME 475, BME 495-01,02 (medical innovation)
Mathematics/Sciences: ESAM 311-1,2,3, ESAM 322, ESAM 346, ESAM 370, ESAM 411-1,2,3, ESAM 420-1,2,, ESAM 421-1,2,, ESAM 424-1,2, ESAM 426, ESAM 429-1,2, ESAM 430-1,2,3, ESAM 445, ESAM 446-1,2, EECS 328, ME 432
Engineering Management: ME 495 (Tech Innovation), ME 467, MEM 402*, MEM 407*, MEM 415*, IEMS 417*, MEM 426*, IEMS 486*, IEMS 490*
* Registration in MEM courses requires permission from the MEM Program or IEMS department.
- **Energy and Sustainability program requirements:** ISEN 410 is required plus one course from each of four topic areas (course can count for only one area even if qualifies for two):
Energy: ME 395 (Nuclear), ME 395 (Energy Systems), ME 367, ME 467, MatSci 382 ^c (Energy materials & devices)
Environment: CEE 363, CEE 364, CEE 368, CEE 395-23 (Environmental Justice), CEE 440 ^c, ESAM 495 (Math modeling for Earth Sci)
Core Principals of Energy Systems: ME 322, ME 346, ME 380, ME 445, ME 446, ME 467, CEE 414-1 ^c, CEE 414-2 ^c, MatSci 381 ^c, MatSci 382 ^c (Energy materials & devices)
Economics and Policy: ISEN 420, ISEN 430, CEE 303, ChE 365, CEE 395-23 (Environmental Justice)

###^c (superscript-c): These are considered ME courses
- **Level:** A minimum of 5 credited course units (excluding the one required project unit) must be 400-level or above.
- **ME courses:** A minimum of 7 course units (excluding project units) must be ME courses or qualifying courses marked as ###^c).
- **Seminar:** Regular attendance at the non-credit ME 512 Seminar is encouraged but students with MS non-thesis option should not register for it.
- **Approval:** There are no advisor holds. Thus, the students are free to choose courses that accommodate individual needs, talents, and interests while satisfying the basic degree requirements. Students are encouraged to talk with the MS Program Director for any questions or consultation. Note that if you register for four units in any given quarter the tuition will be charged only for three units. That is a 25% savings in tuition for that quarter.

Project: One credit unit of ME 499 or an approved project course is required in which a suitable research project under the direction of a ME faculty advisor must be completed. Students may also petition to complete an additional unit of ME 499 credit for a more involved project in lieu of one course credit, resulting in a total of 10 course and 2 research units (12 units total).

GPA requirement: GPA is determined by all BS/MS qualifying courses or post BS courses taken at Northwestern towards satisfying the course requirements above. A minimum GPA of 3.0 is required by The Graduate School to earn a MS degree. If after fulfilling the course requirements, a student's GPA is below the minimum it may be necessary to take additional classes to raise the GPA to the required minimum.

Master's Completion: Coursework and core courses must be filled out on the "ME MS Degree Requirements" form and signed by the MS Program Director. This form must be submitted to the ME graduate program assistant.

An *Application for Degree* must be submitted to The Graduate School by the relevant published deadline for June, August, December, or March graduation.

PHD DEGREE REQUIREMENTS:

Course Requirements:

- **Number of courses taken at NU:** 9 graded courses must be taken at NU.
- **Number of post-BS courses:** A total of fifteen (15) course units (excluding project/research units) are required towards the PhD. Nine (9) course units within this 15 course units must satisfy the MS course requirements (including breadth requirement and minimum number of ME/core courses).
- **MS from another school:** Students admitted with a MS degree from elsewhere may submit a petition for a waiver of up to a maximum of six (6) course units towards the 15-course requirement, based on post-bachelor's degree study. A MS course waiver form must be completed by the student and the advisor and be approved by the Director of Graduate Studies (Graduate Chair). Students admitted with an MS degree in Mechanical Engineering may request to be exempt from the MS course requirements, subject to approval from the Director of Graduate Studies.
- **Level:** At least one half (1/2) of the credited course units satisfying the post-MS requirement must be 400-level or above courses.
- **Seminar:** Registration and regular attendance at the non-credit ME512 Seminar is required for all quarters.
- **Professional Essentials:** Registration for the non-credit ME513 Seminar is required for one quarter within the first two years. It is strongly recommended that this seminar course be taken before PhD candidacy.
- **Approval:** Students must obtain approval from their advisor for all courses in advance and submit a signed course form each quarter to the ME graduate program assistant before registration.
- **Timeline.** The course requirements for the PhD program shall be fulfilled within the first 12 and 8 quarters of full-time registration for students matriculating with BS and MS, respectively.

Teaching Experience: All PhD students must meet one of the following requirements: (1) serve as an instructor of an undergraduate course, (2) serve as a full-time teaching assistant (20 hours a week) in an undergraduate course for at least one quarter, and (3) serve as a part-time teaching assistant (6-8 hours a week) in an undergraduate course for at least three quarters. The student must register for GEN_ENG 546-0 "Teaching Experience" (0 units) for activities that fall under (1) and (2); register for GEN_ENG 545-0 "Teaching Experience" (0 units) for activities that fall under (3).

English requirement: All international PhD students whose primary language is not English should pass the Engineering proficiency requirement after arriving at Northwestern. International students must pass the English proficiency requirement before being eligible for a teaching assistantship. Students whose countries of origin are Australia, Canada, New Zealand, or the United Kingdom are exempt. Students can satisfy the English proficiency requirement by passing the Versant test (scoring 65 or higher out of a possible 80) or SPEAK test (scoring 50 or higher out of a possible 60). There are three additional ways students may fulfill this requirement: (1) A score of 26 or higher (out of a possible 30) on the Speaking Section of the TOEFL internet-based test; (2) Two Versant test scores of 63 or 64; and (3) Teaching demonstration in LING 480 (The Language of Teaching and Teachers). More details of English proficiency requirement can be found at <http://www.tgs.northwestern.edu/funding/assistantships/graduate-andteaching.html>. The lowest scoring students will be assigned to participate in a mandatory supplemental English language curriculum called CLINIC (Culture and Language Intensive for the Northwestern International Community).

Residency: Eight quarters of full-time registration consecutively over two years, including summers, are required. Full-time registration requires enrollment in a combination of course units and ME 590 (research) units for a total of 3 or more units each quarter. After residency has been obtained, full-time registration is maintained by registering for TGS 500 (Advanced Doctoral Study). Courses related to the student's area of study may be taken in addition to TGS 500, up to a maximum of 4 course units per quarter subject to the approval of the advisor.

Qualifying Examination / Admission to Candidacy / PhD Prospectus:

Students are admitted to candidacy for the PhD degree by passing (1) a research qualification exam before the end of the fifth quarter (entering with MS degree) or the seventh quarter (entering with BS degree) of full-time graduate study and (2) a dissertation proposal exam by the end of the second year of full-time study beyond the MS degree or the end of the third year of full-time study beyond the BS degree.

Research Qualification Exam:

All PhD students shall pass an oral research qualification exam that tests their research ability. Students who enter with MS degree or BS degree shall take the exam before the end of the fifth or seventh quarter of full-time graduate study, respectively. Taking the exam sooner is encouraged. With the consensus of advisor, PhD students who enter with BS degree may consider to first obtain an MS degree and use the MS thesis exam as a substitute for the PhD research qualification exam. Any requests for changes to the

regular deadline require prior approval of the Committee of Graduate Studies. The exam consists of a 30-minute presentation by the student and 30 minutes of questions by the faculty committee. The purpose of the exam is to demonstrate the ability to define a research problem, explain its relevance in scientific terms, and articulate current research challenges and a methodology to address such challenges, as well as for the student to demonstrate an understanding of the underlying fundamental concepts related to the research topic. A two-page abstract should be provided to the committee a week before the exam.

Students should register for at least three units of ME 590 before the exam. A student who does not pass the exam on the first attempt may (1) continue with the same advisor and retake the exam the next quarter, if agreed to by the advisor; (2) switch advisors if needed, and retake the exam after two more quarters; or (3) leave the program. No more than two attempts of taking the exam may be made.

The examination committee will consist of at least three faculty members who are members of the graduate faculty. A student's faculty advisor will serve on the committee but will not be its chair. At least one member of the committee should be from a subdiscipline outside the student's area of specialization. The composition of the examination committee is subject to the final approval by Graduate Studies Committee. The examination committee's recommendation to fail students will be voted on by the entire tenure-track ME faculty, whose decision will be final.

Dissertation Proposal Exam:

Students are eligible to take the dissertational proposal exam when all but no more than three of the courses required for PhD have not been taken (also see GPA requirement below). The oral dissertation proposal examination will be based on (but not restricted to) a written research proposal (recommend to be less than 30 pages in total length, double spaced) prepared by the student, a proposal presentation made by student, and an oral examination administered by the examination committee.

Students must take the dissertation proposal examination no later than the end of the second year of full time study beyond the MS degree or the end of the third year of full time study beyond the BS degree. Students who fail the examination may, upon the recommendation of their committee, retake it within one quarter. Students who do not pass the re-examination shall not continue in the PhD program. The examination committee is normally the advisory committee of a student. Each committee should consist of at least three faculty members who are also members of graduate faculty. At least one of the members must be from outside of the ME department. The committee normally conducts the final examination for the PhD at a later date. The chairperson of the committee must be a graduate faculty member and is generally the student's advisor. If the chairperson is not a ME faculty member, a ME faculty member must be identified to serve as the co-chair of the committee. Any faculty member may request the privilege of serving on the committee for a particular student. Formation of an examination committee is subject to the approval of both the ME department and The Graduate School.

GPA requirement. GPA is determined by all post BS courses taken at Northwestern towards satisfying the course requirements above, excluding research and seminar units. At most one ME 499 credit can be used in the overall GPA calculation. Students whose GPA falls short of a 3.5 average, shall be required to take a preparatory examination prior to the Dissertation Proposal Exam. These examinations will be administered by a committee consisting of at least three faculty members. The committee can consist of the same members in the examination committee for research defense. The exam can be either written or oral or a combination of these two. Based on the research contents, the committee decides what subject(s) will be tested and informs the student the form and the content of the exam at least two months in advance. The result of the examination will be decided by the committee. Students who fail the preparatory examination will be given another chance to be re-examined in two months following the same rule described above. Students who fail both attempts shall not continue in the PhD program.

PhD Thesis Dissertation: A written dissertation on the research project that is satisfactory to the student's faculty advisor, the advisory (examination) committee, and meets the University's requirements, is required.

Final Examination / Dissertation Defense: An oral examination by the examination committee of faculty including the student's advisor addressing the research is required. The written dissertation must be given to the members of the student's examination committee at least one week before the date of the scheduled examination. The dissertation should be prepared according to the Graduate School format for PhD dissertations (<http://www.tgs.northwestern.edu/documents/policies/dissertation-formatguidelines.pdf>).

PHD STUDENT ASSESSMENT AND FEEDBACK

The objective of the annual PhD student evaluation is to provide early and ongoing feedback to students regarding their performance during their PhD studies, and to provide guidance and advice for their work and progress. Annual evaluation is required by the Graduate School.

- 1) Each PhD student should be evaluated annually before the end of the summer quarter of each year. This evaluation should consist of the following:
 - a. Each student will submit an annual progress report following the required format in the online Graduate Student Tracking System ([//gsts.northwestern.edu/](http://gsts.northwestern.edu/)).
 - b. A face-to-face meeting between the advisor and student is highly recommended before the faculty advisor finalizes the advisor evaluation.
 - c. If a student disagrees with the advisor's evaluation, the student should contact the Director of Graduate Studies to request a reevaluation.
- 2) Students with low GPA and/or unsatisfactory research progress will be put on probation. Such cases will be carefully discussed and handled individually with the evaluation committee. Depending on subsequent improvements, students may be advised to leave, pursue a terminal MS, or continue with the PhD program.

ME SUB-AREA SPECIALIZATIONS – COURSE INFORMATION

SPECIALIZATION IN DESIGN/MANUFACTURING/TRIBOLOGY

Faculty research interests:

Jian Cao	Flexible Manufacturing Processes; Cyber Physical Systems; Surface Engineering
Wei Chen	Computational design methods; Data science; Consumer preference modeling
Yip-Wah Chung	Surface Science; Coating; Tribology
Kornel Ehmann	Metal Cutting; Machine Dynamics, Accuracy and Control; Automation
Elizabeth Gerber	Design Methodology and Collective Intelligence
Ping Guo	Micro-manufacturing, surface texturing, process micro-mechanics, miniature machine tools, micro-additive manufacturing
Wing Kam Liu	Additive Manufacturing; Jointing Technology; Multi-functional Metamaterials; Composites, polymers, Design and Manufacture of Biomedical Devices, Data-driven materials and process design, biomechanics of Scoliosis, finite elements and numerical methods
Eric Masanet	Sustainable Manufacturing Systems; Technology Assessment
Cheng Sun	Design and Manufacturing for Metamaterials and Devices
Greg Wagner	Process and Material Microstructure Simulation
Q. Jane Wang	Mechanical Design and Engineering Tribology

Course work:

Students should follow and satisfy the general course requirements for a graduate degree in ME as outlined in the preceding sections of this Handbook. In addition, students should attend departmental seminars regularly.

Additional courses are determined in conjunction with the advisor and may typically include some of the following courses:

ME 327	Finite Element Methods in Mechanics
ME 340	Computer Integrated Manufacturing I: Manufacturing Processes
ME 341	Computational Methods for Engineering Design
ME 346	Introduction to Tribology
ME 363	Mechanical Vibrations
ME 366	Finite Elements for Design and Optimization
ME 395	Computational Forensics and Failure Analysis
CEE 415	Theory of Elasticity
CEE 417	Mechanics of Continua I
ME 416	Computational Nanodynamics
ME 417	Multi-scale Modeling and Simulation in Mechanics I (Solids)
ME 418	Multi-scale Modeling and Simulation in Mechanics II (Fluids)
ME 420	Micro and Nano-scale Fluid Dynamics
ME 423, 424	Computational Fluid Dynamics, I and II
ME 425	Fundamentals of Fluid Dynamics
ME 426 1,2	Advance Finite Element Methods I and II
ME 432	Optimization Methods
ME 439	Computer Control in Manufacturing
ME 441	Engineering Optimization for Product Design and Manufacturing
ME 442	Advanced Metal Forming
ME 445	Micromanufacturing
ME 446	Advanced Tribology
ME 448	Flexible Automation and Robotics
ME 495	Multifunctional Materials
ME 495	Advanced Computational & Statistical Methods for Engineering Design
ME 495	Mechanics of Manufacturing Processes
ME 495	Sustainable Manufacturing Systems
ME 470	High Performance Computing for Multi-Physics Applications

DSGN 410-0	Design Research
DSGN 420	Design Communication and Methods
DSGN 450	Differentiation by Design
DSGN 495	Design Strategy

Additional courses offered by other departments are also likely to be recommended.

Contact: Please see your graduate advisor to discuss your program of study. New PhD students without an advisor should see Professor Wei Chen to discuss their initial course of study.

SPECIALIZATION IN DYNAMICS, CONTROL, ROBOTICS, AND NEURAL ENGINEERING

Faculty research interests: (for most recent information, visit the NxR website <http://nxr.northwestern.edu/>)

Brenna Argall	Robotics autonomy, machine learning, shared control between humans and robots, human rehabilitation
J. Edward Colgate	Haptics, robotics; human-machine interaction; actuator design and control, automatic control
Mitra Hartmann	Biomechanics of active sensing behaviors; the neuromechanical basis for touch perception; ethology; robotic models and simulations
Kevin Lynch	Robotics and automation; robot manipulation and motion planning; human-robot interaction; multi-agent systems; bio-inspired sensing and locomotion
Malcolm MacIver	High agility bio-inspired robotics, sensing, neural circuits underlying behavior.
Todd Murphey	Large-scale complex systems, autonomy in uncertain environments, software-enabled human-robot interaction, rehabilitation robotics
Michael Peshkin	Physical human-robot interaction, Surface haptics, Cobots, Biomedical mechatronics, Sensors and actuators
Michael Rubenstein	Control and design of multi-robot systems
Paul Umbanhowar	Granular materials mixing and flow, segregation, self assembly/organization and pattern formation; Robo-physics; Frictional transport; Legged devices and animals

Course work:

Courses listed below are appropriate for first year MS and MS/PhD program. Courses in **bold** are considered fundamental. Unless taken at the undergraduate level, these should be treated as requirements. Check the Class Schedule at <http://www.registrar.northwestern.edu/> to confirm availability of any course.

Dynamics & Control

ME 314 Theory of Machines — Dynamics
ME 333 Intro to Mechatronics
ME 390 Intro to Dynamic Systems
EECS 360 Intro to Feedback Systems
ME 433 Advanced Mechatronics
ME 454 Numerical Methods in Optimal Control of Nonlinear Systems
 EECS 374 Introduction to Digital Control
 EECS 410 System Theory
 EECS 422 Random Processes Comm and Control

Instrumentation; Data Analysis

EECS 353 Digital
 EECS 359 Digital Signal Processing
 EECS 418 Advanced Digital Signal Processing

Mathematics

EECS 302 Prob Systems and Random Signals
 EECS 328 Numerical Methods for Engineers
 EECS 479 Nonlinear Optimization
 ESAM 311-1,2,3 Methods of Applied Math

Robotics; Computing

ME 449 Robotic Manipulation
 ME 454 Optimal Control of Nonlinear Systems
 ME 495 Applied Mechatronics:Quadrotor Design and Control

ME 395/EECS 301 Introduction to Robotics Laboratory
 ME 495/EECS 469 Machine Learning and Artificial Intelligence for Robots
 ME 495 Haptics
 EECS 311 Data Structures and Data Management
 EECS 317 Data Management & Info Processing
 EECS 325 Artificial Intelligence Programming
 EECS 330 Human Computer Interaction
 EECS 332 Digital Image Analysis
 EECS 333 Intro to Communication Networks
 EECS 336 Design and Analysis of Algorithms
 EECS 348 Introduction to Artificial Intelligence
 EECS 351 Introduction to Computer Graphics
 EECS 390 Intro to Robotics
 EECS 457 Advanced Algorithms
 EECS 495 Special Topics in Swarms and Multi-Robot Systems

Biological Systems

BME 365 Control of Human Limbs and Their Artificial Replacements
 ESAM 370 Intro to Comp Neuroscience
 BME 401 Neurophysiology
 BME 461 Sensory Acquisition
 BME 462 Computational Neuromechanics and Neuroethology
 BME 463 Systems Neuropathophysiology
 BME 467 Biomedical Robots

A typical program consists of no more than **four** courses each term plus a non-credit, one day per week seminar (ME 512). Students supported on research assistantships sometimes take 2 classes per term. Exceptions to the required

number of ME and 400 level courses are frequently granted (by advisor approved petition to the Graduate Studies Committee) in this specialization for well-designed interdisciplinary programs of study.

Considerable variation exists among individual programs and special topics courses (395, 495) are frequently available. Course availability and scheduling change periodically, so confirm your intended schedule with the official Class Schedule for any given quarter. There are other relevant courses in ME, EECS, and BME as well as in other departments that may interface well with your research study. Take advantage of these courses.

Contact:

Please see your graduate advisor to discuss your program of study. New PhD students may see any of the above faculty.

SPECIALIZATION IN SOLID MECHANICS

Faculty research interests:

Jan Achenbach	Nondestructive evaluation, fracture mechanics
Oluwaseyi Balogun	Optical techniques for materials characterization; nondestructive evaluation
Zdenek Bazant	Mechanics of materials and structures
Jian Cao	Constitutive modeling, process mechanics
Wei Chen	Stochastic multiscale analysis, model validation, design of emerging material systems
Isaac Daniel	Experimental mechanics, composites, nondestructive evaluation
Horacio Espinosa	Nanomechanics, dynamic response of materials, cell mechanics
Yonggang Huang	Mechanics of materials; nanomechanics; mechanics of stretchable electronics
Leon Keer	Stress analysis, fracture, elasticity, tribology
Sinan Keten	Molecular dynamics, biological materials, soft matter mechanics, materials failure, chemistry-mechanics interaction
Sridhar Krishnaswamy	Multifunctional materials; smart structures; 3D nanolithography of soft matter
Victor Lefevre	Mechanics of soft materials, smart materials, composites, analytical and computational homogenization methods
Wing Kam Liu	Finite element and meshfree methods. Additive Manufacturing; Joining Technology; Multi-functional Metamaterials; Composites, polymers, Design and Manufacture of Biomedical Devices, Data-driven materials and process design, biomechanics of Scoliosis
John Rudnicki	Fracture and inelastic behavior, particularly geomaterials
Greg Wagner	Multi-scale modeling; fluid-structure interaction; advanced manufacturing simulations
Q. Jane Wang	Contact and interfacial mechanics

Course work:

A typical list of mechanics courses follows:

Fall Quarter		Winter Quarter		Spring Quarter	
CEE 413	Experimental Mech.	CEE 414-1	Composites I	CEE 414-2	Composites II
CEE 417	Continuum I	CEE 415	Theory of Elasticity	ME 362	Stress Analysis
ME 327	Finite Elements for Stress Analysis	ME 426-1	Advanced FEM I	ME 363	Vibrations
ME 381	Introduction to MEMS	ME 385	Nanotechnology	ME 382	Micro-Nano Science
ME 417	Multi-scale Modeling and Simulation in Solid Mechanics	ME 456	Mechanics of Advanced Materials	ME 426-2	Advanced FEM II
ME 417	Multi-scale Modeling and Simulation in Solid Mechanics	ME 466	Inelastic Constitutive Relations	ME 470	High Performance Computing for Multi-physics Applications
ME341 or 441	Computational Methods for Engineering Design	ME 495	Adv. Fracture Mech.	ME 416	Computational Nanodynamics
Offered any quarter: CEE/ME 495 Special Topics – look for special mechanics courses of interest Offered every other year: ME 456 usually in Winter					

For a first year MS or MS-PhD student, a typical program consists of 4 classes each term for fellowship students, 2-3 classes per term for RAs, 3 classes per term for TAs. Also note:

- Engineering Science and Applied Mathematics offers many excellent courses, including ESAM 311-1,2,3 series, suggested for students who have not had mathematics beyond sophomore level differential equations. The series ESAM 411-1,2,3 covers more advanced topics.

- For the MS program, a minimum of 5 courses (excluding 499) must be 400-level and a minimum of 5 courses (excluding 499) must be ME courses or the CEE courses listed here.
- By spring term, first year students generally register for 1-2 units of 499 *Project Research* in addition to coursework.
- **Seminars:** ME students must register for and attend ME-512 *Mechanical Engineering Seminars*.

The courses listed here are provided as guidelines. Course availability and scheduling change periodically, so confirm your intended schedule with the official Class Schedule for any given quarter. There are many other relevant courses both in CE and ME as well as in other departments that may interface with your research study. Take advantage of these courses.

Contact: Please see your graduate advisor to discuss your program of study. New PhD students without an advisor should see Professors Sridhar Krishnaswamy or Sinan Keten to discuss their initial course of study.

SPECIALIZATION IN FLUID MECHANICS AND ENERGY

Faculty research interests:

Sandip Ghosal	Fluid mechanics at micro and nano scales
Seth Lichter	Statistical mechanics; molecular-scale fluid mechanics; dynamics of proteins
Wing Kam Liu	Multiscale drug delivery modeling, simulation and design; additive manufacturing processing for biomedical devices, data-driven analysis and design, polymers
Rich Lueptow	Granular, filtration & Taylor-Couette flows, physical acoustics, design
Kyoo-Chul (Kenneth) Park	Interfacial fluid mechanics, mass and heat transfer
Neelesh A. Patankar	Computational fluid dynamics; Micro/nano-scale flows; bio-applications
Siavash Sohrab	Combustion; turbulent reactive flows; physico-chemical thermodynamics
Greg Wagner	Computational fluid dynamics and heat transfer; fluid-structure interaction
Q. Jane Wang	Lubrication

Course work:

- Recommended MS and first-year MS-PhD Program in Fluid Mechanics
-

Fall	Winter	Spring
ME 423, 425 ¹	One or more of ME 420, 424	One or more of ME 420, 424
Elective or MS Core Reqt	Elective or MS Core Reqt	Elective
Mathematics Elective	Mathematics Elective	ME 499 or Elective
Elective	ME 499 or Elective	ME 499
Seminar Series: ME 512	Seminar Series: ME 512	Seminar Series: ME 512

Many students elect to cover the MS program in Fluid Dynamics over four to six quarters instead of three quarters. Students with research assistantships typically take two courses per quarter. Excluding ME 499, a minimum of five courses must be 4-level, and a minimum of five courses must be ME courses.

- At least two electives should be in mathematics. For students who have not had mathematics beyond undergraduate differential equations, ESAM 311-1,2 is suggested. Other appropriate mathematics electives are:

ESAM 311-1,2,3	Methods in Applied Mathematics
ESAM 411-1,2,3	Differential Equations of Mathematical Physics
ESAM 420-1,2,3	Asymptotic & Perturbation Method in Appl. Math.
ESAM 446-1,2,3	Numerical Solution of Partial Differential Eqns.

- Suggested courses:

ME 420	Micro- and Nanoscale Fluid Dynamics
ME 422	Statistical Mechanics for Applications
ME 423, 424	Computational Fluid Dynamics
ME 425	Fundamentals of Fluid Dynamics
ME 432	Optimization Methods in Science and Engineering
ME 395	Combustion/Energy Systems
ME 467	Industrial Energy Management and Utilization
ME 470	High Performance Computing for Multi-physics Applications
ME 417	Multiscale Modeling and Simulations for Solids
ME 418	Multiscale Modeling and Simulations for Fluids
ChBE 404	Advanced Thermodynamics
ESAM 322	Applied Dynamical Systems

¹ If ME425 is not offered, students may enroll in ChE 424-1.

ESAM 346	Modeling and Computation in Science & Engineering
ESAM 424-1,2	Mathematical Topics in Combustion
ESAM 426	Theory of Flows with Small Inertia
ESAM 429-1,2	Hydrodynamic Stability
ESAM 430-1,2,3	Wave Propagation

Contact: Please see your graduate advisor to discuss your program of study. New PhD students without an advisor should see Professor Seth Lichter to discuss their initial course of study.

SPECIALIZATION IN NANOTECHNOLOGY / MEMS

Faculty research interests:

Horacio Espinosa	Micro and Nano Mechanics, MEMS, NEMS, Biotechnology
Cheng Sun	Micro/nano 3D fabrication technologies, design and manufacturing for metamaterials and devices

Course work:

In addition to the general requirements placed by the Graduate School and the ME department, students specializing in Nanotechnology/MEMS must satisfy the following:

- Core Courses: Take any four of these core courses.
ME 381: Introduction to MEMS
ME 382: Experiments in Micro/Nano Science and Engineering
ME 385: Nanotechnology
ME 495: Advanced Topics in Nanotechnology

Other possible courses are listed below:

A. Solid State Physics:

Basics:

- PHYS 339-1,2 Quantum Mechanics
- PHYS 332 Statistical Mechanics
- PHYS 422-1,2,3 Condensed Matter (Solid-State) Physics
- EECS 388 Nanotechnology Theory and Fabrication:
- EECS 381 Electronic Properties of Materials
- MSc 355 Electronic Materials
- EECS 384 Solid State Electronic Devices
- EECS 401 Fundamentals of Electronic Devices

B. Fluid Mechanics:

Mechanical Engineering:

- ME 420 Micro- and Nanoscale Fluid Dynamics
- ME 425 Fundamentals of Fluid Dynamics
- ME 423, ME 424 Computational Fluid Dynamics
- ME 418 Multiscale Modeling and Simulations for Fluids

Biomedical Engineering:

- ESAM 426 Flows with Small Inertia

C. Biotechnology & Biotransducers:

- BioSci 301-0 Biochemistry
- BioSci 309-0 Principles of Biochemistry
- ME 495 Mechanics of the Cell and BioMEMS

D. Material and Surface Science:

- MSc 415 Fundamentals of Thin Film Materials
- MSc 316-1,2 Microstructural Dynamics
- MSc 361 Crystallography and Diffraction
- MSc 380 Introduction to Surface Science and Spectroscopy
- Chem 329 Analytical Chemistry
- ME 346 Introduction to Tribology
- ME 446 Advanced Tribology
- ME 416 Computational Nanodynamics
- ME 417 Multiscale Modeling and Simulations for Solids

E. Control and Sensors:

Basics:

- ME 390 Introduction to Dynamics Systems
- EECS 360 Introduction to Feedback Systems
- Applications:*
- ME 333 Introduction to Mechatronics
- ME 433 Advanced Mechatronics

F. Computational and Applied Science and Engineering:

- ME 417 ME 418 Multi-scale Modeling and Simulation in Mechanics I & II

ME 327 Finite Elements for Stress Analysis
ME 341 or 441 Computational Methods for Engineering Design
CHEM 448 Computational Chemistry
ChBE 379 Intro to Computational Biology
ESAM 495 Interdisciplinary Nonlinear Dynamics
ESAM 346 Modeling and Computation in Science and Engineering

G. Project Courses*:

ME 499-1: MEMS Microfabrication
ME 499-2: MEMS/Nano Instrumentation
ME 499-3: Nanofabrication Methods I

* Project courses taught by the advisor will consist in a series of activities outlined at the beginning of the quarter. A final report documenting the materials and techniques learned by the student will be required. Upon grading of the final report, the advisor will submit a final grade. Up to 3 project courses can be taken from the list above and *only when activities outside campus will take place*. No more than 2 project courses per quarter will be allowed. Final approval for taking the courses will be given by the ME Director of Graduate Studies on an ad-hoc basis.

Seminars: Students should register for *ME-512 Mechanical Engineering Seminars* each quarter and attend all seminars.

Contact: Please see your graduate advisor to discuss your program of study. New PhD students without an advisor should see Professor Cheng Sun to discuss their initial course of study.

OTHER IMPORTANT GRADUATE STUDY INFORMATION

Course Levels

Courses are labeled with letter prefixes having the following meaning:

- 1 - Introductory (Freshman level)
- 2 - Intermediate (Sophomore level)
- 3 - Advanced (Junior, Senior, and Graduate level)
- 4, 5- Graduate level

Grades

Credit for the MS or PhD degree will be given only for courses in which a grade of A, B, or C has been received. No P/N registration will be accepted. A student whose overall grade average is below B is not meeting academic standards and will be placed on probation. Failure to remedy that situation may lead to dismissal by The Graduate School.

An incomplete grade (Y) for any course except Projects (499) must be removed within one year of the official ending of the course. Research (590) may be graded as incomplete (K) until the research is finished. All K grades must be changed by the time the dissertation is submitted to The Graduate School.

Financial Aid, Fellowships, and Registration

Recipients of financial aid must be fully registered. Full registration, according to The Graduate School regulations, means 3-4 courses per quarter.

Students enrolled in the MS program are not eligible for financial aid and assistantships except for the GEM Fellowship for under-represented minority students.

Several types of financial aid are available for PhD students. The Walter P. Murphy and Royal E. Cabell Fellowships are endowed fellowships that enable outstanding students to pursue their first year of graduate study with no teaching obligations. Information on merit-based fellowships offered by the Graduate School at Northwestern University can be found at <http://www.tgs.northwestern.edu/funding/fellowships-and-grants/index.html>. The terminal year Cabell Fellowships are available on a competitive basis for students completing their PhD studies to enable them to focus entirely on their dissertation during their final year. The Department of Mechanical Engineering offers the Martin Outstanding Doctoral Fellowship to mid-career PhD students. Examples of external fellowships that are suitable to ME PhD students include the NSF Graduate Research Fellowship, the National Defense Science & Engineering Graduate Fellowship, and the HHMI International Student Research Fellowship. Fellowships generally provide a monthly stipend and tuition for full-time study and research.

Fellowships for underrepresented minority group members are available for new and continuing students. General information on fellowship opportunities for encouraging diversity can be found at <http://www.tgs.northwestern.edu/diversity/fellowship-opportunities/>.

Research assistantships involve participation in ongoing funded research projects and are awarded at the discretion of the faculty advisor. Some new students and most continuing students are supported through research assistantships. Research assistantships provide a monthly stipend and tuition for full-time study and research. A limited number of teaching assistantships are available. A teaching assistant has responsibility for running the laboratory portion of a course or for grading papers and holding office hours. Teaching assistantships cover tuition, provide a monthly stipend, and are arranged by the department with the endorsement from faculty advisor. Students whose native language is not English must pass the English proficiency requirement (see pg. 9) to be considered for a teaching assistantship. Fellowship, research assistantships, and teaching assistantships are subject to income tax.

Full-time graduate students in good academic standing are eligible to apply for low-cost student loans. More information is available at the Student Loan Office, 555 Clark Street, 3rd Floor.

PhD students who receive financial support in the form of NU fellowships, research, and teaching fellowships are strongly discouraged from terminating PhD study with an MS degree. When such situation happens and with the approval of the faculty advisor, the student must take the thesis option for MS degree (see section on “MS Degree Requirements”).

Registration as a Full-Time Student

All students using departmental facilities in any quarter must be registered or must be employees of the University. During the fall, winter or spring quarters, a full-time registration of 3-4 units of courses and research normally should be elected. For MS students this is achieved by registering for a combination of course units and ME-499 Research Project or ME-590 Thesis Research. Preferable registration is for a total of 4 units per quarter for three quarters to meet the residency requirement and to fulfill the 12 required units for the MS degree within three quarters. Students who

need to continue their research after having completed the required 12 units should register for TGS-512 Continuous Registration, described below.

PhD candidates who have not achieved candidacy (passed the qualifying exam) should maintain a full-time registration of 3-4 units of courses and ME-590 Research. Full-time registration for 5 quarters beyond the MS degree or 8 quarters beyond the BS is necessary to meet the residency requirement and to fulfill the course requirements (9 courses beyond MS degree and 15 courses beyond BS degree). Students who need to continue their research (but take no classes) prior to candidacy may register for TGS-500 Advanced Doctoral Study, as described below. Courses related to the student's area of study may be taken in addition to TGS 500, up to a maximum of 4 course units.

Registration for the *summer quarter* is required for students who work on research. Registration for a summer internship is optional (see section on "Summer Internship" in "Other Important Graduate Student Information"). Students are strongly encouraged to discuss summer registration with your advisor.

MS research/project registration is summarized below:

ME-499 Research Project or ME-590 Thesis Research --Available to master's degree with thesis option students to pursue research for their MS project. One unit of ME-499 is required for the "non-thesis option" and three units of ME-590 are required for the "thesis option". Typical registration is for 1 to 3 research units in addition to courses to achieve a total of 3-4 units for full-time registration. A second unit of ME-499 may be used to fulfill the MS degree requirements by petition. 499 units may not be used toward the requirements of a PhD.

TGS-512 Continuous Registration--Available to master's degree students who have completed all course and residency requirements, and have previously registered for the required number of ME-499 or ME-590 units, and are continuing research, need to use university facilities, are receiving financial aid, or hold F-1 or J-1 visa status. Requests for more than one 512 registration will be reviewed by The Graduate School. Provides fulltime status, but allows no accumulation of credit or residency toward the master's degree. No courses excluding the ME-512 Seminar may be taken with TGS-512 registration. Only a registration fee is required rather than tuition for regular registration.

PhD research/project registration is summarized below:

ME-590 Research--Available to PhD students to pursue research for their PhD prior to candidacy and completing residency requirements. Typical registration is for 1 to 4 590 units in addition to courses to achieve a total of 3-4 units for full-time registration until residency is completed.

TGS-500 Advanced Doctoral Study--Available to doctoral students who have completed all residency requirements, been admitted to candidacy, and need to use University facilities to complete a dissertation. Also appropriate for students receiving financial aid or on F-1 and J-1 visas. TGS 500 provides full-time status. For self-supporting students, tuition is substantially lower for 500 registration than for full-time registration.

PhD research registration summary:

	Resid. Credit	Candidacy	Tuition rate	Use
ME 590	yes	pre	full	In 1st few(1-3) years while satisfying residency requirements. Minimum three units required before taking the research qualification exam
TGS 500	no	post	reduced	As needed after 8 quarters to maintain student status until dissertation is handed in

Continuous Registration Requirement

All doctoral students in years one through nine and master's students in years one through five must be registered at Northwestern University in each of the fall, winter and spring terms. Explanation of the policy is available at: <http://www.tgs.northwestern.edu/about/policies/general-registration-policies.html>

Where and When to Register

Register on CAESAR www.caesar.northwestern.edu

Finding an Advisor

Students are recommended to seek out a research advisor to work with on his/her graduate research within the first quarter of beginning graduate study. The research advisor directs the student's research by providing research guidance, background information, computer resources, laboratory facilities, and often, research assistantship support. The advisor is on the student's examination committee and is usually the chair of the committee. The advisor also closely reviews the research report, thesis, or dissertation and is co-author on publications arising from the research project.

Changing an Advisor

In rare instances, a change of advisor may be necessary due to loss of funding, mismatch of research interests, or other reasons. PhD students are encouraged to contact the Director of Graduate Studies regarding concerns related to changing advisors, while the MS students are encouraged to contact the Director of MS Program. If DGS or MS Director are advisors themselves then the student is encouraged to contact the Department Chair.

PhD Advisory Committee Guidelines

The role of the PhD advisory committee is one of guidance as well as examination. Members of the advisory committee will help direct the PhD student's research efforts and will also serve as the examining committee for the qualifying exam and the thesis exam. Any faculty member who requests membership on this committee will be granted that privilege. In order to enhance the student's progress the following guidelines should be followed:

- The advisory committee for the student should be formed as soon as the general direction of research is identified, ideally no later than the end of the second quarter after the MS degree; or the end of the second year after the BS degree.
- The student should meet individually and collectively with the members of the advisory committee on a regular basis: quarterly or bi-annually is suggested.
- In addition to the regular meetings, the student should meet with all the advisory committee members before the proposal exam and thesis exam are scheduled; consultation 2-3 months prior to the exam date will allow time for advice to be incorporated into research before the exam.
- It is strongly recommended that the student give presentations on their work at every opportunity. Conference presentations and the practice of a final thesis presentation to a larger audience are particularly advised.
- The thesis proposal and the thesis should be completed and distributed to the advisory committee at least one week prior to each scheduled exam date.

Academic and Research Integrity

Academic dishonesty (e.g., cheating or plagiarism) is a serious matter for graduate students committed to intellectual pursuits, and will be adjudicated in accordance with procedures approved by the Graduate Faculty. Sanctions may involve a letter of warning, suspension, or exclusion from the university. Detailed description can be found at <http://www.tgs.northwestern.edu/about/policies/academic-integrity.html>. All graduate students who participate in funded research will need to complete the Responsible Conduct of Research (RCR) compliance training (<http://www.researchintegrity.northwestern.edu/responsible-conduct-of-research-rcr-training/>).

Family Leave Policy

Family leave includes both parental leave and medical leave. TGS provides 12 weeks of parental accommodation for students of all gender identities and gender expressions who become new parents (whether by childbirth or adoption). Family medical leave may be taken in addition to the parental accommodation. Details can be found at <http://www.tgs.northwestern.edu/campus-life/child-and-family-resources/>.

Summer Internship

Students may seek internships during the summer term to gain practical experience in industry or at national laboratories in areas closely related to their research. The summer term is suitable time for an internship since no courses are offered by the ME department in the summer. Students seeking a summer internship should contact the McCormick Career Development office and begin the process in the winter quarter, although they may also find an internship on their own. Students may choose to register their summer internship through the McCormick Career Development office as CRDV 411 for MS students or CRDV 510 for PhD students. CRDV courses are non-credit, non-tuition-bearing courses. The CRDV registration enables international students with F-1 visas to qualify for CPT work authorization, allows health benefits to be maintained (if the student desires them and pays the appropriate fees), permits loans to be deferred, and provides evidence of the internship on transcripts.

The **Crown Family Internship** program is open to all doctoral students in the McCormick School. International students may participate by using a part or all of their practical traineeship visa during the internship. However, the total

term of work experience (pre-graduation internship plus post-graduation work) may not exceed one year. Participants in this program register for CRDV 510. Up to three registrations of CRDV 510 are allowed, but no more than two registrations may be consecutive. Details and the application process of the Crown Family Internship are provided at the website <http://www.mccormick.northwestern.edu/students/graduate/fellowships-internships/crown-family.html> .

Conference Travel Grant

The Conference Travel Grant (CTG) offered by The Graduate School provides funds to assist PhD and MFA students traveling to conferences and/or seminars to make presentations on behalf of the University. Students are eligible for a maximum of **two grants** up to \$600 over the entire course of their graduate career. Details can be found at <http://www.tgs.northwestern.edu/funding/fellowships-and-grants/internal-grants/conference-travel-grant/index.html> .

New Computer Initiative

ME department subsidizes a new computer for any full-time PhD student within three months of passing their PhD dissertation proposal exam, provided the exam occurs within two years of full-time study after the MS degree or three years of full-time study after the BS degree. The department will cover a laptop (or desktop) purchase up to \$1,500 through IBuyNU. If the cost is more than \$1,500, the student will be responsible for the difference. Please contact Sinta Kulanda (s-kulanda@northwestern.edu) with any questions.

Academic Probation

A student who is not making satisfactory academic progress will be placed on academic probation by The Graduate School and/or the ME department. When a decision to place a student on probation is made, the student will be given at most two quarters (not including summer quarter) to resume satisfactory academic standing. Detailed guidelines can be found at <http://www.tgs.northwestern.edu/about/policies/satisfactory-academic-progress.html> .

Exclusion (Dismissal) and Appeals Process

If a student cannot re-establish satisfactory academic standing during the two probationary quarters, the student will become ineligible to receive financial aid and will be excluded (dismissed) from TGS.

Students wishing to appeal an exclusion decision should follow the procedure specified by The Graduate School under “Appeal Process”. Student should send a copy of appeal to his (or her) academic advisor and the Director of Graduate Studies when submitting the appeal to The Graduate School.

Visit the Graduate School Policy page

(<http://www.tgs.northwestern.edu/about/policies/index.html>) for a complete description of graduate school policies at Northwestern University.

MECHANICAL ENGINEERING DEPARTMENT INFORMATION

1. Support Staff:

Dyess, Pat	Graduate Program Asst	Room B224	j-dyess@northwestern.edu
Kulanda, Sinta	Financial Assistant	Room B224	s-kulanda@northwestern.edu
Latham, John	Financial Assistant	Room B224	john.latham@northwestern.edu
Marzec, Rick	Technical Support	Room AG24	r-marzec@northwestern.edu
Santos, Tami	Administrative Assistant	Room B224	tami.santos@northwestern.edu
Smith, Vanessa	Financial Coordinator	Room B225	vanessa.smith@northwestern.edu
Sparks, Hillary	Business Administrator	Room B223	h-sparks@northwestern.edu

The above rooms are located in the Technological Institute unless otherwise indicated.

2. Photocopier/Scanner: In Room B224 there is a duplicating machine that you may use.

3. Fax Machine: There is a fax machine in Room B224. If you need to send a fax long distance, your advisor will provide you with a phone code. The cost of sending a fax is \$0.60/page. Incoming faxes have no cost. Faxes may also be received through this machine - the number is 847-491-3915.

4. Paychecks: For those students on payroll (fellowships, teaching assistantships or research assistantships), paychecks will be directly deposited to your bank account on the last working day of the month.

5. Eligibility to Work in the U.S: If you are on the payroll (including fellowships, teaching assistantships or research assistantships), and you have not been on any Northwestern payroll during the last six months, you are required by law to complete an I-9 form - Employment Eligibility Verification Form. You will not receive your September paycheck unless this form is completed.. After completing Section I here <https://northwestern.i9servicecenter.com/Login.aspx> , take your documentation to the Payroll Office, 720 University Place, 2nd Floor (Office hours 8:30am-5:00pm, Monday-Friday), to complete Section 2.

E-Verify FAQs Electronic I9 Access and Section 1 Questions and Electronic I9 Section 2 Processors
<http://www.northwestern.edu/hr/payroll/e-verify/index.html>

How does E-Verify work regarding the 3 days of hiring an employee?

<http://www.northwestern.edu/hr/payroll/payment/index.html>

6. Mailboxes: Graduate student and faculty mailboxes are located to the left as you enter the department office, Tech. B224. *The departmental mailboxes should not be used for receiving personal mail.* The proper mailing address to receive mail is:

Your Name
Department of Mechanical Engineering
2145 Sheridan Road
Northwestern University
Evanston, IL 60208-3111

7. Phones: Telephones are available in most graduate laboratories or offices. The phones are equipped to handle only campus and local calls. Campus calls, including the medical school, require only the last 5 digits of the phone number. Calls in the 847 (Chicago north shore) require dialing 9-XXX-XXXX. Local calls in the Chicago area require 9-LACXXX-XXXX, where LAC is the local area code (312 or 773-Chicago, 708 or 630-suburbs).

8. Emergency: For emergencies such as fire or injury dial **456** from any campus phone to directly connect to campus police. For life-threatening events, call **911** from a campus phone or your mobile phone.

9. E-Mail: Graduate students may obtain an email account that is accessible from any networked computer. E-mail accounts may be obtained at the Computing Center, 1800 Sherman Avenue. A valid NU identification card is needed to obtain an e-mail account.

10. Purchasing: To purchase non IBuyNU items, fill out the form located on the Resources webpage of the department website.

You can also request the form from the ME Department Financial Assistant, Sinta Kulanda, s-kulanda@northwestern.edu. Fill in all information, with chart-string provided by your advisor and signed by him/her, and submit to Sinta. When the requested items arrive, you will receive an email to pick up the package from the ME Department Mail Room, Tech B214. When items arrive, the packing slip should be provided to Sinta to notify her that the items were received and payment should be made.

11. Travel Reimbursement: Before planning your business travel, review the university's travel reimbursement policy at <http://www.northwestern.edu/userservices/> and see Sinta Kulanda, the department Financial Assistant, to review the key points of the policy. Be sure to keep all your itemized and credit card receipts to prevent your reimbursement from being delayed. Travel reimbursement forms should be filled out and signed by the traveler and then signed by your advisor. Give the signed form to Sinta within 30 days of return.

MECHANICAL ENGINEERING DEPARTMENT FACILITIES

The facilities of the mechanical engineering laboratories provide many opportunities for graduate students to conduct their research. The prototyping shop provides space and equipment, including machine tools, for prototyping designs and building experimental apparatus. For engineering computer use, the department maintains a PC/workstation lab in Room AG21.

MECHANICAL ENGINEERING FACULTY AND THEIR RESEARCH

Brenna Argall, Assistant Professor; BS, MS and PhD, Carnegie Mellon University.
Robotics autonomy and machine learning within human assistive and rehabilitation domains.
Office: M194, email: brenna.argall@northwestern.edu

Oluwaseyi Balogun, Associate Professor, BSc, University of Lagos, Nigeria; MS, PhD, Boston University. Ultrasonic Near Field Optical Microscopy; Optical Sensors; Nondestructive Materials Characterization; Dynamic Deformation of Materials; and Nanomechanical Resonators.
Office Catalysis Bldg. 325, email: o-balogun@northwestern.edu

Michael Beltran, Lecturer, Department of Mechanical Engineering and Segal Design Institute. BS, Massachusetts Institute of Technology; MS, Northwestern University.
Director, Rapid Prototyping Lab, Instructor in CAD, CAM, Engineering Design Capstone, & Advanced Manufacturing courses.
Office: Tech, AG28, email: mbeltran@northwestern.edu

Jian Cao, Cardiss Collins Professor, Director of Northwestern Initiative on Manufacturing Science and Innovation, and Associate VP for Research; Assistant: Maegen Gregory, B224, maegen.gregory@northwestern.edu ; BS, Shanghai Jiao Tong University; MS, PhD, Massachusetts Institute of Technology.
Mechanics and process innovation of manufacturing processes at multi-scales; failure analysis; surface texturing; composite forming; rapid and flexible processes such as dieless forming and additive manufacturing processes.
Office A214, email: jcao@northwestern.edu

Wei Chen, Wilson-Cook Professor in Engineering Design; Director of Predictive Science & Engineering Design Cluster; Co-director of Design Cluster; BS, Shanghai Jiao Tong University; MS, University of Houston; PhD, Georgia Institute of Technology.
Design optimization; simulation-based design under uncertainty; data science and artificial intelligence in design and manufacturing; stochastic multiscale analysis and materials design; topology optimization and metamaterial design; design of complex and multidisciplinary systems; consumer preference modeling; model validation; engineering decision making.
Office A216, email: weichen@northwestern.edu

J. Edward Colgate, Breed University Professor, Director of the MS Program in Engineering Design and Innovation; BS, MS, PhD, Massachusetts Institute of Technology.
Robotics; human-machine interaction; haptic interface; haptic perception.
Office B282, email: colgate@northwestern.edu

Isaac M. Daniel, Professor; Director, Center for Intelligent Processing of Composites; BS, MS, PhD, Illinois Institute of Technology.
Processing; characterization; micromechanics; fracture; fatigue; dynamic behavior; environmental effects; damage mechanics; nondestructive evaluation; life prediction.
Office Catalysis Bldg. 326, email: imdaniel@northwestern.edu

Kornel F. Ehmman, Professor, BS, MS, University of Belgrade, Yugoslavia; PhD, University of Wisconsin-Madison. Micro/meso-scale manufacturing; precision engineering; machine tool dynamics and control; material removal processes; automation and robotics.
Office L288, email: k-ehmann@northwestern.edu

Horacio D. Espinosa, James N. and Nancy J. Farley Professor of Manufacturing and Entrepreneurship; Director, Theoretical and Applied Mechanics Program; BS, Northeast National University, Argentina, MS, Milan Polytechnic, Italy, PhD, Brown University.
Micro-electro-mechanical systems; nano-electro-mechanical systems; thin films and MEMS materials; mechanics of biomaterials; dynamic failure of advanced materials.
Office A212, email: espinosa@northwestern.edu

Elizabeth Gerber, Associate Professor, Allen K. and Johnnie Cordell Breed Junior Professor of Design; BA, Dartmouth College, MS, PhD, Stanford University.
Design and innovation; human-computer interaction; crowdsourcing; motivation.
Office Ford Building 2-327, email: e-gerber@northwestern.edu

Sandip Ghosal, Associate Professor; BS, Presidency College, Calcutta, India, PhD, Columbia University.
Fluid mechanics; micro-scale flows near changed interfaces; mathematical biology.
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Ping Guo, Assistant Professor, BS, Tsinghua University; PhD, Northwestern University.
Advanced manufacturing; ultra-precision machining; 3D printing; acoustic levitation; vibration and dynamics.
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Mitra Hartmann, Professor, BS, Cornell University; PhD, California Institute of Technology.
Sensorimotor integration; robots as tools for studying neuroscience; sensory acquisition behaviors; neuroethology.
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Walter B. Herbst, Clinical Professor; Director, Master of Product Design and Development Management Program; BFA, University of Illinois; MS, Northwestern University.
Product design and development to include marketing
Office Ford 2-313, email: w-herbst@kellogg.northwestern.edu

Greg W. Holderfield, Director of the Segal Design Institute; Co-Director of the MMM Program; Clinical Associate Professor, ME; Pentair-D. Eugene and Bonnie L. Nugent Professor
Design Innovation.
Office Ford 2-315, email: g-holderfield@northwestern.edu

Yonggang Huang, Walter P. Murphy Professor; BS, Peking University; MS, PhD, Harvard University.
Mechanics of stretchable electronics.
Office A116, email y-huang@northwestern.edu

Sinan Keten, Associate Professor; Director of Graduate Studies; BS, Bogazici University; MEng, PhD, Massachusetts Institute of Technology.
Atomistic modeling and simulation of biological and bioinspired materials and dynamics of nano-scale phenomena; modeling interdependence of material chemistry, structure, mechanics at multiple scales.
Office A133, email: s-keten@northwestern.edu

Manohar Kulkarni, MS Program Director and Clinical Professor; BTech ME, Indian Institute of Technology, Madras; MSME, University of Iowa; PhD, University of Missouri.
Energy Optimal Control of Thermal Systems; Thermal Systems Design and Modeling; Industrial Energy Management and Utilization; and Sustainability.
Office B226, email: manohar.kulkarni@northwestern.edu

Sridhar Krishnaswamy, Professor; Director, Center for Smart Structures and Materials; BTech, Indian Institute of Technology, Madras; MS, PhD, California Institute of Technology.
Multifunctional materials and systems and intelligent structural health management of safety-critical structures.
Office Catalysis Bldg. 323, email: s-krishnaswamy@northwestern.edu

Victor Lefevre, Assistant Professor; BSc, Ecole Polytechnique, France; MS, Imperial College London; PhD, University of Illinois at Urbana-Champaign.
Mechanics of soft materials, smart materials, composites, analytical and computational homogenization methods.
Office Catalysis Bldg. 320, email: victor.lefevre@northwestern.edu

Seth Lichter, Professor; AB, Harvard University; PhD, Massachusetts Institute of Technology.
Statistical mechanics; molecular-scale fluid mechanics; dynamics of proteins.
Office L493, email: s-lichter@northwestern.edu

Wing Kam Liu, Walter P. Murphy Professor; BS, University of Illinois at Chicago; MS, PhD, California Institute of Technology.
Finite element and meshfree methods. Additive Manufacturing; Joining Technology; Multi-functional Metamaterials; Composites, polymers, Design and Manufacture of Biomedical Devices, Data-driven materials and process design, biomechanics of Scoliosis.
Office A326, email: w-liu@northwestern.edu

Richard M. Lueptow, Professor; Senior Associate Dean, McCormick School; BS, Michigan Technological University; SM, ScD, Massachusetts Institute of Technology.
Granular flows; fluid mixing; granular mixing and segregation; Taylor-Couette flows; chaos; reverse osmosis and filtration.
Office L258, email: r-lueptow@northwestern.edu

Kevin M. Lynch, Professor and Chair; BSE, Princeton University; PhD, Carnegie Mellon University.
Motion planning and control for robotic manipulation and under-actuated systems; decentralized control of multirobot systems; physical human-robot interaction.
Office B222, email: kmlynch@northwestern.edu

Malcolm MacIver, Professor; BS, MA, University of Toronto; PhD, University of Illinois.
Neurobiology; neuroethology; behavior; active sensory systems; modeling and simulation; biomechanics; robotics.
Office B292, email: maciver@northwestern.edu

Nick Marchuk, Senior Lecturer; BS, Johns Hopkins University; MS, Northwestern University.
Electromechanical design, Mechatronics.
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Eric Masanet, Associate Professor; BS, University of Wisconsin-Madison; MS, Northwestern University; PhD, University of California-Berkeley.
Sustainable Manufacturing Systems; Energy Systems Analysis; Life-Cycle Assessment; Technology Assessment.
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Todd Murphey, Professor; BS, University of Arizona; PhD, California Institute of Technology.
Modeling and control of complex mechanical and biological systems.
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Kyol-Chul (Kenneth) Park, Assistant Professor, BS, Seoul University; MS, PhD, Massachusetts Institute of Technology.
Biologically-inspired interfacial thermofluidics; surface design for new functions and a sustainable future.
Office M411, email: k-park@northwestern.edu

Neelesh A. Patankar, Professor and Associate Chair, BTech, Indian Institute of Technology, Bombay, MS, PhD, University of Pennsylvania.
Fast and efficient algorithms for fully resolved simulation of immersed bodies in fluids; biological application - esophageal transport and aquatic locomotion; superhydrophobicity and surface engineering for phase control.
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Michael A. Peshkin, Charles Deering McCormick Professor of Teaching Excellence, Professor; BS, University of Chicago; MS, Cornell University; PhD, Carnegie-Mellon University.
Robotics and intelligent mechanical systems; cobots; sensors and actuators.
Office B288, email: peshkin@northwestern.edu

Michael Rubenstein, Assistant Professor; BS, Purdue University; MS, University of Southern California; PhD, University of Southern California.
Control and design of robotic swarms.
Office Ford Building 2-221, email: rubenstein@northwestern.edu

John W. Rudnicki, Professor; BS, MS, PhD, Brown University.

Inelastic behavior and failure of solids, especially geomaterials; coupling of deformation with pore fluid diffusion.
Office A333, email: jwrudn@northwestern.edu

Siavash H. Sohrab, Research Professor; BSc, University of California, Davis; MSc, San Jose State University;
PhD, University of California, San Diego.

Combustion; thermodynamics; fluid mechanics; statistical mechanics; quantum mechanics; gas dynamics; applied mathematics.

Office B121, email: s-sohrab@northwestern.edu

Cheng Sun, Associate Professor; BS, MS, Nanjing University; PhD, Pennsylvania State University.

Scalable 3D nano-fabrication of integrated nano-systems.

Office B392, email: c-sun@northwestern.edu

Paul B. Umbanhowar, Research Professor; BA, Carleton College; PhD, The University of Texas at Austin. Granular materials mixing, segregation and flow; robotic locomotion on yielding substrates; robotic manipulation; self-assembly/organization and pattern formation.

Office B227, email: umbanhowar@northwestern.edu

Gregory J. Wagner, Associate Professor; BS, Boston University; MS, PhD, Northwestern University.

Multi-scale and multi-physics simulation methods; computational fluid dynamics; high-performance computing. Office L492, email: gregory.wagner@northwestern.edu

Q. Jane Wang, Professor; BS, Shanxi Institute of Mechanical Engineering; MS, Northern Illinois University; PhD, Northwestern University.

Contact and interfacial mechanics; tribology; tribological design of mechanical systems.

Office A219, email: qwang@northwestern.edu

Professors with Adjunct/Courtesy Appointments in the Mechanical Engineering Department:

Zdenek P. Bazant, McCormick Institute Professor, Walter P. Murphy Professor; (Home Department CEE) CE, Czech Technical University, Prague, PhD, Czechoslovak Academy of Science, Prague.
Mechanics of materials and structures, fracture, plasticity, creep and hygrothermal effects, nanoporous materials, probabilistic strength characterization, scaling, size effect, fiber composites, quasibrittle materials, impact.
Office: A135, email: z-bazant@northwestern.edu

J. Alex Birdwell, Assistant Professor of Instruction, co-Director of Lightboard Studio; BS, Georgia Institute of Technology; MS, PhD, Northwestern University.
Robotics; Biomechanics; Human-Machine Interfaces; Prosthetics & Rehabilitation Engineering; Manufacturing, Design, & Engineering Education.
Office Ford Building 1-204, email: j-birdwell@northwestern.edu

L. Catherine Brinson, Professor, Mechanical Engineering and Materials Science, Duke University; BS, Virginia Polytechnic Institute and State University; MS, PhD, California Institute of Technology.
Multiscale mechanics of advanced materials, including shape memory alloys, polymer nanocomposites, and biomaterials: synthesis, characterization and modeling.
email: cbrinson@northwestern.edu ; <http://mems.duke.edu/faculty/catherine-brinson>

Yip-Wah Chung, Professor (Home Department – MSE); BS, University of Hong Kong; PhD, University of California, Berkeley.
Surface science; tribology; design and characterization of hard coatings and thin films.
Office Catalysis Bldg. 205, email: ywchung@northwestern.edu

James G. Conley, Clinical Professor (Home Department Kellogg-Economic Decision Science), BS, University of Virginia; MM, PhD, Northwestern University.
Strategic use of intangible assets and intellectual properties to build and sustain competitive advantage.
Office Global Hub 3169, email: j-conleya@kellogg.northwestern.edu

Stephen H. Davis, Walter P. Murphy Professor (Home Department ESAM); BEE, MS, PhD, Rensselaer Polytechnic Institute.
Theoretical fluid mechanics, especially hydrodynamic stability and interfacial phenomena. Material science, especially thin films and crystal growth; asymptotic and variational methods; interfacial dynamics and stability.
Office M440, email: sdavis@northwestern.edu

Kuniaki Dohda, Research Professor; BS, MS, Toyama University; PhD, Nagoya University.
Tribology in metal forming; microforming.
Office: B119, email: dohda.kuni@northwestern.edu

Mark Fleming, Lecturer; BS, University of Nebraska-Lincoln; MS, PhD, Northwestern University
Finite element analysis and meshless methods for nonlinear mechanics, dynamics, and fracture mechanics; failure analysis; product testing and design evaluation
Office A217, email: mark.fleming@northwestern.edu

David W. Gatchell, Clinical Associate Professor, Segal Design Institute; AB Bowdoin College, PhD Boston University.
Engineering Design
Office Ford Building G-319, email: d-gatchell@northwestern.edu

Mark Johnson, Professor (Home Department – Biomed.); BS, Purdue University; MS, PhD, Massachusetts Institute of Technology
Cellular mechanics and the hydrodynamics of glaucoma; the role of lipids in age-related macular degeneration; transport through connective tissues; esophageal transport; chaos and diffusion.
Office E378, email: m-johnson2@northwestern.edu

Bernard J. Matkowsky, John Evans Professor (Home Department – ESAM); PhD, Courant Institute of Mathematical Science.

Combustion synthesis of advanced materials; nonlinear dynamics and pattern formation; analytical and comp. methods.
Office M438, email: b-matkowsky@northwestern.edu

Michael J. Miksis, Professor (Home Department – ESAM); BS, Drexel University, MS, PhD, Courant Institute of Mathematical Sciences.

Theoretical and computational fluid mechanics, especially multiphase flow and free boundary problems; wave propagation; asymptotic and perturbation methods.
Office M462, email: miksis@northwestern.edu

Ferdinando (Sandro) Mussa-Ivaldi, Professor (Home department: Physiology) PhD Biomedical Engineering, Polytechnic of Milan, Italy.

Neural Engineering, Motor System Neuroscience, Computational Neuroscience, Motor Control and Learning, Neurorehabilitation, Biomedical Robotics.
Office RIC, 345 E. Superior, Room 1304, email: sandro@northwestern.edu

Julio M. Ottino, Walter P. Murphy Professor (Home Department – ChBE); Dean, McCormick School; BS, MS, National University of LaPlata, Argentina; PhD, University of Minnesota.

Granular flows; mixing and segregation; chaos; materials processing.
Office L262, email jm-ottino@northwestern.edu

Aaron Packman, Professor (Home Department – CEE); BS, Washington University; MS, PhD, California Institute of Technology.

Environmental and microbial transport processes, Fundamentals of interfacial transport in aquatic systems and the coupling of physical transport processes with biological and biogeochemical processes.
Office A314, email: a-packman@northwestern.edu

James L. Patton, Adjunct Associate Professor (Home Department – MED – Physical Med & Rehab); BS, University of Michigan; MS, Michigan State University; PhD, Northwestern University.

Robotics for therapeutic neuron-rehabilitation. Robotic teaching. Control of human movement. Haptics. Human-machine interfaces.
Office Abbott, 710 N. Lake Shore, Room 1014, email: j-patton@northwestern.edu

John A. Rogers, Querrey Professor (Home Department – Materials Science and Engineering); Director, Center for

Bio-Integrated Electronics (CBIE); BS Physics, BA Chemistry, The University of Texas at Austin; SM, Physics and Chemistry, PhD, Massachusetts Institute of Technology.

Soft materials for conformal electronics, nanophotonic structures, microfluidic devices, and microelectromechanical systems.
email: jrogers@northwestern.edu

Seth Snyder, Adjunct Professor, (Home Department ChBE) BA, Penn; MS, PhD, U of Virginia.

Advanced biofuels conversion and separations technologies, water treatment, environmental sustainability, and the role of policy and technology transfer to achieve energy and environmental goals.
email: seth.snyder@northwestern.edu

Petia M. Vlahovska, Associate Professor (Home Department ESAM); MS, Sofia University, Bulgaria; PhD, Yale University.

Fluid dynamics, membrane biophysics, and soft matter.
Office M426, petia.vlahovska@northwestern.edu

Emeritus Professors:

Jan D. Achenbach, Walter P. Murphy Professor and Distinguished McCormick School Professor; Kand Ir, Technological University of Delft, Netherlands; PhD, Stanford University.
Mechanics of solids; quantitative nondestructive evaluation; fracture mechanics.
Office Catalysis Bldg. 324, email: achenbach@northwestern.edu

Herbert S. Cheng, BS, Univ. of Michigan; MS, Illinois Institute of Technology; PhD, University of Pennsylvania.
Contact fatigue; thin-film lubrication; tribology of engine and transmission components.
email: hsc@northwestern.edu

Leon M. Keer, Walter P. Murphy Professor, Director, Center for Surface Engineering and Tribology; BS, MS, California Institute of Technology; PhD, University of Minnesota.
Engineering mechanics.
Office A319, email: l-keer@northwestern.edu

Alan L. Kistler, BS, MS, PhD, Johns Hopkins University. Turbulent flow; rotating machinery; acoustics; energy conservation.
email: a-kistler@northwestern.edu

Elmer E. Lewis, Professor; BS, MS, PhD, University of Illinois.
Radiation transport; reliability and risk analysis.
email: e-lewis@northwestern.edu

David A. Mintzer, BS, PhD, Massachusetts Institute of Technology.
Acoustic wave propagation; rarefied gas dynamics.
email: dmin@northwestern.edu

Henry W. Stoll, BS, Valparaiso University; MS, University of Michigan; PhD, University of Illinois. Design theory and methodology; design for manufacturability; mechanical system design and analysis.
email: hstoll@northwestern.edu

Richard S. Tankin, BS, Johns Hopkins University; MS, Massachusetts Institute of Technology; PhD, Harvard University.
Combustion; heat transfer; fluid flow.
email: r-tankin@northwestern.edu

John A. Walker, BS, University of Delaware; PhD, University of Texas.
Stability analysis and dynamic behavior.
email: jwalker@northwestern.edu

AROUND NORTHWESTERN UNIVERSITY

Norris Center Bookstore: 847-491-3990. This is the main on-campus bookstore, located in Norris University Center. Other bookstores are in downtown Evanston.

Bursar's Office: 619 Clark. 847-491-5343.

Campus Parking Office: 1819 Hinman. 847-491-3319. On campus parking is only available to those who live beyond a certain distance from campus. Details, and permits, are available at this office.

Campus Police Department: **Emergency: 456.** Regular business: 847-491-3254.

University Career Advancement

620 Lincoln
847-491-3700

The goal of University Career Services is to help students make informed decisions about career-related issues - from exploring their own interests and talents to choosing a major to investigating graduate study and career possibilities. UCS is available to assist students in finding employment for graduating students at the bachelor's, master's and PhD/Post Doc level, and all alumni for the balance of their working lives. UCS is open the year around, with a special emphasis on on-campus recruiting from early fall through late spring of each school year. Each year 300-400 employers recruit on campus. Another several thousand positions are faxed, mailed, or called in each year.

Counseling and Psychological Services (CAPS)

633 Emerson Street, 2nd floor
847-491-2151, After-hours emergency service - 847-491-8100 (Ask to speak with CAPS staff on call)

The Counseling and Psychological Services staff are the University's primary counseling staff. The team of counselors, social workers, psychologists, and psychiatrists provide counseling and psychotherapy services to students with emotional and personal concerns. Services include individual counseling, groups, workshops, and firesides for a wide range of concerns including homesickness, academic motivation, test anxiety, personal relationships, family problems, eating behavior, sexuality, loss of a loved one, and depression.

Ryan Field and McGaw Hall: Ticket Office: 888-467-8775. The stadium is the site of football games, while McGaw Hall contains Welsh-Ryan arena, home of the basketball team. Football tickets may be purchased online at NUSports.com, by telephone or in person at the Ryan Field Ticket Office.

ID Cards: 847-467-6843. The NU identification card is known as the WildCard. This may be obtained in the WildCard office in the basement of the Norris University Center. Bring a photo ID to get your WildCard. The WildCard can be used as a library card, copy account card, bank machine card, and debit card.

Math Library: 847-491-7627. Located in Lunt Hall, this library houses the math collection.

Norris University Center: Information: 847-491-2300. This is Northwestern's student center, and it contains the school bookstore, a cafeteria, a convenience store, postal services, a reading library, as well as many other services. The information desk on the first floor is a great source for answers to many and varied questions about Northwestern, and available services.

Off-Campus Housing Office: Scott Hall, 601 University Place, Rm. 41, 847-491-8430. Provides listings of available off-campus housing.

Patten Gym: 2407 Sheridan Rd. 847-491-4099. This gym contains a free-weight room, as well as basketball and volleyball courts.

Seeley G. Mudd Library: 847-491-3362. This is the Tech. Library, where most of the science and engineering books and journals are located. The WildCard is used as a library card and personal copy card. [Group study rooms](#) on

the second floor of Mudd Library may be reserved locally or [online](#) for up to three hours for **student groups of 4 or more (10 or more if booking Room 231)**.

Sports and Aquatic Center (SPAC): 847-491-4300. This facility houses an Olympic size swimming pool, an indoor track, various Nautilus and Cybex weight machines, treadmills and Stairmasters, and basketball, squash, racquetball and tennis courts.

Student Health Center: 633 Emerson Street. 847-491-8100 This is the student clinic.

Student Loans Office: 555 Clark Street, 3rd Floor. 847-491-3125.

TGS Commons: 2122 Sheridan Road, 1st Floor. <http://www.tgs.northwestern.edu/campus-life/TGScommons/index.html> A space for general use by TGS graduate students and postdocs to study, to host small group gatherings, to reserve for formal academic presentations. Access is with wildcard.

University Library: 1970 Campus Drive, 847-491-7658. The three towers and associated buildings contain the majority of Northwestern's collection of works in the humanities, social sciences, and history. The business collection is located here.

DINING OPTIONS

Sargent Hall, next door to Tech Institute, 2245 Sheridan Road
Tech Express, 1st Floor Tech Institute, 847-467-2243
Kellogg Global Hub, The Marketplace, 2211 Campus Drive, A state-of-the art dining and gathering place featuring global cuisine and lake views.
Norris University Center, 2122 Sheridan Road

Off Campus

Noyes Street: Tomate Fresh Kitchen (914 Noyes St., #1, 847-905-0194); Mandarin House (819 Noyes St., 847-869-4344); Dave's New Kitchen (815 Noyes St., 847-864-6000); D&D Dogs (825 Noyes St., 847-864-1909, <http://dddogs.net/>)
Downtown Evanston: Smylie Brothers Brewing Co. (1615 Oak Ave., 224-999-7320, <http://www.smyliebros.com/>); Bat 17 (1709 Benson Ave., 847-733-7117, <http://bat17evanston.com/>); Celtic Knot Public House (626 Church St., 847-864-1679, <http://www.celticknotpub.com>); Prairie Moon (1502 Sherman Ave., 847-864-8328 <http://www.prairiemoonrestaurant.com/v4/>); La Principal (700 Main St., 224-307-2444, <https://laprincipalevanston.com/>); Naf Naf Grill (1629 Orrington Ave., 847-866-8470, <http://www.nafnafgrill.com/>); Flat Top Grill (707 Church St., 847-570-0100, <http://www.flattopgrill.com>) and many more...see <http://downtownevanston.org/eat-drink>

EVANSTON INFORMATION

Evanston Police/Fire:

Emergency Only: 911 (use **456** for on-campus emergencies)

Regular business: Fire 847-448-4311

Police 847-866-5000

Housing

ON-CAMPUS

Engelhart Hall (1915 Maple Avenue) and Seabury Apartments (605-615 and 621-623 Garrett Place) are the only on-campus housing available for graduate students. The Graduate Housing office is located at 1915 Maple Avenue (847467-4663). In Engelhart, single students share a "twin studio" which is a two bedroom apartment, with a kitchen and bath, but no common areas. In Seabury, single students can rent an "efficiency/studio apartment" which has a single room for a combined bedroom with kitchenette area, and a private bath. Married students can rent one, two, or three bedroom apartments, with kitchen, bath, and living room. All apartments are furnished with bed, desk, bookshelves and lamps. Utilities are included in the rent and each bedroom has an air conditioner. The kitchens are tiny with little counter space. The Engelhart building is located next to the Foster El stop (about a 15 minute walk to Tech.), so noise can be a problem. The Seabury building is quite close to Tech. Nicer, more spacious apartments can be found off campus at lower rents. OFF-CAMPUS

There are many apartment options available. Rent is primarily influenced by location - the closer you are to campus, the higher the rent. Lower rents can be found in areas a mile or two from campus and in the Rogers Park section of Chicago. Some students choose to live in the Wrigleyville/Lincoln Park areas of Chicago. These areas of Chicago are an easy commute to Northwestern on the El (30-45 min.). Rents vary widely, but reasonable apartments can be found.

Most apartments in Evanston are in converted private houses or in apartment buildings. Most apartments become available at the end of the summer (Aug. 1 or Sept. 1). Apartment hunting in the winter can be difficult since listings are scarce. It is difficult to find anything other than a one-year lease, resulting in many people trying to sublet their apartment for the summer. If you want to live alone, studios and one-bedrooms are available, but are typically more expensive than multi-bedroom apartments. Finding a roommate(s) can reduce your rent dramatically: either find a friend or check the listings for apartments to share. A third option is renting a room in a private home. Rooms are usually furnished with a bed, chair, desk, bookshelves, etc. Some rooms will have private entrance, private bath, kitchen and laundry facilities.

The **Off-Campus Housing Office** (in Scott Hall, 601 University Place, Rm. 41, 847-491-8430), <http://www.northwestern.edu/offcampus/>) provides computerized apartment listings - including apartments to rent, apartments to share, and rooms to rent. This is the best place to start your apartment search. The office provides maps of Evanston and Chicago, local newspapers, copies of the Evanston Landlord and Tenant Ordinance. Other apartment listings can be found in the *Evanston Review* and the *Chicago Reader* (both of which are published on Thursdays), the *Chicago Tribune*, the *Daily Northwestern* and posted in the Norris University Center.

Transportation

Public

The **CTA (Chicago Transit Authority)** offers 24 hour service between Chicago and Evanston via the El (which is short for elevated trains). The Purple Line runs between the Howard Street station (on the border of Chicago and Evanston) and the Linden Street Station, in Wilmette, with no service between 2:00-4:30a.m. At Howard you must switch to a Howard/Dan Ryan (Red Line) train to head south to Wrigleyville/Lincoln Park, the Loop, or anywhere south (e.g. Cellular Field or Chinatown). Purple line trains run every 5 to 20 minutes (depending on the time of day). Red line trains run every 5-15 minutes. CTA maps are available at the Davis Street stop in downtown Evanston, online at <http://www.transitchicago.com> or by calling the CTA (312-836-7000). The El stops closest to Northwestern are:

Noyes Street, between Sherman Avenue and Ridge Avenue (best stop for Tech)

Foster Street, between Sherman Avenue and Ridge Avenue

Davis Street, at Davis Street and Benson Avenue

The cost is \$2.25 per ride. If you'll also be riding a bus, you are allowed to transfer an additional 2 times within a 2-hour period. Graduate students in possession of an activated U-Pass will incur no cost on the El system and all Pace buses. During the academic year, September 1-June 30, you may board the #201 bus using your Wildcard.

During morning and evening rush hours, the **Evanston Express** runs between Linden and the Loop. These trains make all stops between Linden and Howard, but then run express to Belmont, Fullerton, and around the Loop. The Express trains can reduce travel times between Evanston and the Loop considerably (approximately 30 minutes between Foster and the Merchandise Mart). Alternatively, if you are not heading to the Loop, you can ride the Express to Howard and switch to a Howard/Dan Ryan train.

Evanston Express hours (Monday through Friday only):

Southbound: 6:25 a.m.-9:20 a.m.

3:00 p.m.-5:30 p.m.

Northbound: 7:05 a.m.-10:00 a.m.

3:40 p.m.-6:05 p.m.

During rush hour the CTA also runs the Skokie Swift between Howard Street and downtown Skokie. Look for the trains with the bright yellow signs.

In addition to the El, the double-decker **Metra** trains also run between Evanston and Chicago. This is primarily a commuter line - carrying suburbanites to and from the Loop. The Evanston stops are along the Chicago-Kenosha line, which runs between the Chicago NorthWestern Station downtown and Kenosha, Wisconsin. Trains stop at Main Street, Davis Street, and Central Street in Evanston. At NorthWestern Station, downtown, you can switch to any of the eleven other lines to various suburbs. Trains run on a fixed schedule, and fares vary according to destination and day of travel (in general, the Metra is more expensive than the El for trips into Chicago). A detailed schedule with fare information can be obtained here <https://metrarail.com/maps-schedules/train-lines/UP-N/fares> or at the Davis Street stop, 901 Davis St., Evanston, or call 312-322-6777.

Amtrak (1-800-872-7245) trains leave from Union Station, downtown Chicago, at Adams and Canal St. The downtown **Greyhound** (312-408-5821) terminal is at 630 W. Harrison, Chicago.

NU Shuttles

Evanston and Campus Loop - For schedules see <http://www.shuttle.northwestern.edu>

Intercampus - <http://www.shuttle.northwestern.edu>

Ryan Field (#201 CTA) - <http://www.shuttle.northwestern.edu> - This service connects the Central Street Metra station and the Ryan Field parking lot to the main Evanston campus.

For questions or comments about the shuttles, please contact the Transportation Office of University Services at 312503-8129 or via email at shuttle@northwestern.edu. For automated message regarding service updates, call 847467-5284. For Lost & Found and after hours dispatch, call 708-474-7474.

NU-Argonne National Lab Carpool - <http://www.northwestern.edu/userservices/transportation/shuttles/argonne.html>
The Northwestern-Argonne Carpool is a user-run service that travels daily between the Northwestern Evanston Campus and the Argonne National Lab Campus. Students, professors and researchers affiliated with Northwestern are encouraged to take advantage of this carpool, which is fully funded by the Northwestern University Office for Research. Contact the carpool coordinator, Mark Seniw (m-seniw@northwestern.edu), for access to the online reservation system.

Getting to O'Hare and Midway Airports

The Pace #250 Bus runs to O'Hare parking lot; board at the Davis Street El stop or along Dempster Street in Evanston.

To get to O'Hare on the El, take the Howard/Dan Ryan to Washington St. station, and transfer to the O'Hare/Congress/Douglas line (the blue line). Follow the signs - you'll go down a flight of stairs and walk through an underground tunnel to the blue line station. The connection is free. You want to head northwest to O'Hare (don't worry - there are lots of signs!), and O'Hare is the last stop. Time: 1-1.5 hours. Cost: \$2.25.

To get to Midway airport, take the Howard/Dan Ryan to the Roosevelt station and transfer to the Midway line (the orange line). Time: 1-2 hours. Cost \$2.25. See also www.transitchicago.com.

Airport vans run from the Hotel Orrington or the Foster Walker Complex at NU to O'Hare. Time: 1-2 hours. Cost: \$15-\$20. For more information call 1-800-654-7871.

Taxi service to and from O'Hare is also available. Time: Usually less than an hour. Cost: Norshore (847-8647500), \$35 (includes MPEA Airport Tax and tolls) or 303 Cab (847-303-0303), \$31 + **\$2.00 MPEA Airport Tax**). Taxi service to Midway is quite expensive--about \$55 & \$51, respectively.

Rental Cars

Enterprise Rent-A-Car, 1810 Maple Ave., Evanston, b/t University Place & Clark Street, 847-332-2550 **Zipcar** <http://www.northwestern.edu/fm/services/motor-pool/resources/car-sharing.html> Garret parking lot; downtown Evanston

Divvy Bikeshare <https://www.divvybikes.com/>

<https://www.northwestern.edu/wildcard/services/businesses/divvy-bikes.html>

Locations closest to Tech Institute: Sheridan Road and Noyes Street; University Library
Student Wildcard discount \$75 rate for Annual Membership

Parking on Campus

In order to park in a university parking lot or restricted street, a permit must be displayed in the rear bumper or rear window. Permits may be purchased from the Parking Office at 1819 Hinman Ave. (847-491-3319). Students must live outside the "walking zone" to be eligible to buy a parking permit.

Parking in the City of Evanston

Evanston has many rules and special regulations. Make it a habit to read the signs posted for the entire block each and every time you park. Some restrictions include:

- **Street Cleaning** - Street cleaning on alternate sides of the street, from 1 a.m.-8 a.m. or 9 a.m.-4 p.m. on various weekdays. During this period, parking is forbidden and violators will be ticketed or towed. See posted signs for specific dates when this occurs.

- Beware of special street cleanings (these will be posted three to four days prior to towing).
- **Two Hour Parking** – Some streets allow parking for up to two hours without a permit. For extended parking, a permit is required (available at the Evanston Civic Center, 2100 Ridge Ave., from the City Collectors Office on the 1st floor).
- **Snow Emergency** - During snow emergencies, street parking is restricted to specific areas. Signs for snow emergency areas are posted year round. Familiarize yourself with the affected streets in your neighborhood before the snow falls. Many routes are "No Parking 11 p.m.-Complete Removal". Most residential streets are "No Parking

9 a.m.-6 p.m., alternating odd/even days". "Snow emergencies" are announced on the Evanston city website <https://www.cityofevanston.org/residents/parking> and on the Snow Hotline, 847-864-SNOW (7669) or 847-866-2917 (recorded message available 24/7) To Sign up for text message alerts text **COE SNOW YourEmailAddress** to **468311**.

- **Meters** - Do not assume that you can keep feeding quarters and park in a two hour metered spot for six hours. They will mark your tire with chalk, and even if your meter has money, you will receive a ticket for parking greater than two hours.
- **Public Lots** - Many residential neighborhoods have lots available to the public with purchase of a sticker from the City of Evanston's Parking Services Department, 3-1-1 or 847-448-4311.