

The ME Graduate Handbook

All about the Graduate Program

in

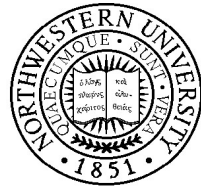
Mechanical Engineering

in

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

at

Northwestern University



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Disclaimer: Northwestern University reserves the right to change without notice any statement in this publication concerning, but not limited to, rules, policies, tuition, fees, curricula, and courses.

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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

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 core disciplines of:

- Design & Manufacturing
- Robotics & Biosystems
- Mechanics & Materials

with cross-cutting research areas in:

- Advanced Manufacturing
- AI and Design
- Biosystems and Health
- Computational Engineering
- Energy and Sustainability
- Micro/Nanoengineering
- Robotics and Autonomy

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

COVID-19 INFORMATION AND RESOURCES

In the 2021-2022 academic year, some aspects of the graduate program, including classes and research in the Mechanical Engineering department, may be affected by the COVID-19 pandemic. Because the situation is constantly changing, students are encouraged to consult the COVID-19 and Campus Updates web site for full and latest information:

<https://www.northwestern.edu/coronavirus-covid-19-updates/>

NONDISCRIMINATION STATEMENT

Northwestern University does not discriminate or permit discrimination by any member of its community against any individual on the basis of race, color, religion, national origin, sex, pregnancy, sexual orientation, gender identity, gender expression, parental status, marital status, age, disability, citizenship status, veteran status, genetic information, reproductive health decision making, or any other classification protected by law in matters of admissions, employment, housing, or services or in the educational programs or activities it operates. Harassment, whether verbal, physical, or visual, that is based on any of these characteristics is a form of discrimination. Further prohibited by law is discrimination against any employee and/or job applicant who chooses to inquire about, discuss, or disclose their own compensation or the compensation of another employee or applicant.

Northwestern University complies with federal and state laws that prohibit discrimination based on the protected categories listed above, including Title IX of the Education Amendments of 1972. Title IX requires educational institutions, such as Northwestern, to prohibit discrimination based on sex (including sexual harassment) in the University's educational programs and activities, including in matters of employment and admissions. In addition, Northwestern provides reasonable accommodations to qualified applicants, students, and employees with disabilities and to individuals who are pregnant.

Any alleged violations of this policy or questions with respect to nondiscrimination or reasonable accommodations should be directed to Northwestern's Office of Equity, 1800 Sherman Avenue, Suite 4-500, Evanston, Illinois 60208, 847-467-6165, equity@northwestern.edu.

Questions specific to sex discrimination (including sexual misconduct and sexual harassment) should be directed to Northwestern's Title IX Coordinator in the Office of Equity, 1800 Sherman Avenue, Suite 4-500, Evanston, Illinois 60208, 847-467-6165, TitleIXCoordinator@northwestern.edu.

A person may also file a complaint with the Department of Education's Office for Civil Rights regarding an alleged violation of Title IX by visiting www2.ed.gov/about/offices/list/ocr/complaintintro.html or calling 800-421-3481. Inquiries about the application of Title IX to Northwestern may be referred to Northwestern's Title IX Coordinator, the United States Department of Education's Assistant Secretary for Civil Rights, or both.

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, the Center for Robotics and Biosystems, 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.

Graduate Program Goals/Mission Statement:

The graduate program in mechanical engineering aims to discover new knowledge and technologies, and train mechanical engineers that will shape our future. We strive to transform students to outstanding scholars, teachers and engineering professionals who will become the future leaders in science and engineering. Our graduate curriculum aims to enable students to learn the fundamentals of mechanical engineering by focusing on core disciplines in mechanics, manufacturing, and systems, together with essential areas of mathematics and physical sciences. Teaching and research experiences promote personal and professional growth while developing technical aptitude, while gaining creative thinking and communication skills that are necessary for crafting a better future.

The learning objectives and assessment strategies followed by our department for our graduate programs are listed below:

MS Program Learning Objectives, Milestones, and Assessment

| Learning objective(s) <i>Students should be able to...</i> | Milestone/ Requirement/Capacity | Assessment Strategies and Criteria* <i>How do we know this objective has been achieved?</i> <i>What criteria do we have to measure success?</i> |
|-----------------------------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Make original research contributions to science, engineering and technology management fields. | Research Project Planning and Execution | Assessment Strategy: Advisor evaluates planned research project, provides feedback for improvement. Criteria: Formulate a research plan with proper methodology, write an original thesis or project report, and as feasible publish research progress in journals or file patents/IP. |
| Demonstrate command over basic knowledge in the field and effective scholarly communication skills. | MS Thesis Defense or MS Research Project Report | Assessment Strategy: Thesis committee (or the advisor for research project) review of student's basic knowledge in the field, research skills, and presentation skills. Criteria: A research presentation summarizing key accomplishments. |
| Establish a career plan | Semi-Annual Meeting for MS Thesis Candidates | Student shares plan semi-annually with advisor at semi-annual progress review and individual meetings; student and advisor craft a plan for appropriate training and identify necessary resources for post-graduate success. |
| Enact ethical research methodologies and practices. | RCR Training/ Research | Criteria: Fosters ethical problem-solving skills; increase the ability to recognize ethical issues in design and conduct of research; identify and understand clinical ethics regulations, policies, and resources. |

PhD Program Learning Objectives, Milestones, and Assessment

| <p>Learning objective(s) <i>Students should be able to...</i></p> | <p>Milestone/ Requirement/Cap acity</p> | <p>Assessment Strategies and Criteria* <i>How do we know this objective has been achieved?</i> <i>What criteria do we have to measure success?</i></p> |
|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Make original research contributions to science, engineering and technology management fields.</p> | <p>Thesis Proposal Defense/ Dissertation/ Publications/ Patents</p> | <p>Assessment Strategy: Committee evaluates thesis defense, provides feedback for improvement. Criteria: Formulate a research plan with proper methodology, write an original thesis, publish research progress in journals or file patents/IP.</p> |
| <p>Demonstrate command over basic knowledge in the field and effective scholarly communication skills.</p> | <p>Research Qualification Exam</p> | <p>Assessment Strategy: Committee review of student's basic knowledge in the field, research skills, presentation skills. Criteria: A research presentation summarizing key accomplishments from the first year and a half.</p> |
| <p>Design a classroom activity and gain teaching experience</p> | <p>TA fulfilled / other teaching experience</p> | <p>Assessment Strategy: Course instructor evaluates outcomes, students provide formative assessment (e.g. CTECs, surveys). Designed classwork or homework serves as a summative assessment that measures students' success in acquiring the new skills and knowledge.</p> |
| <p>Establish a career plan</p> | <p>Annual Meeting</p> | <p>Student shares plan annually with advisor at annual progress review and individual meetings; student and advisor craft a plan for appropriate training and identify necessary resources for post-graduate success.</p> |
| <p>Enact ethical research methodologies and practices.</p> | <p>RCR Training/ Research</p> | <p>Criteria: Fosters ethical problem-solving skills; increase the ability to recognize ethical issues in design and conduct of research; identify and understand clinical ethics regulations, policies, and resources.</p> |

MS PROGRAM INFORMATION

(The following pages, 10-13, are applicable for the MS degree)

MS DEGREE REQUIREMENTS:

TGS minimum course requirements: TGS policy requires, as a minimum for master's degrees: Nine quality letter-graded (ABC, not P/NP) courses approved for TGS credit (i.e., courses with a career of TGS, as designated in CAESAR). 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. **The ME graduate program has further course requirements for MS degrees as detailed below.**

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, CEE 413^c, CEE 414-1^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, heterogeneous materials, etc.)

Fluids/Thermo/Energy: ME 322, ME 367, ME 373, ME 377, ME 378, 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

Robotics/Dynamics/Control: ME 314, ME 333, ME 363, ME 390, ME 433, ME 448, ME 449, ME 450, ME 454, ME 495 (comp. nanodynamics), EE 360, EE 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 451, 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/Science/Data Science: 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, EE 475, IEMS 304, IEMS 308, IEMS 455

Engineering 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.

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

Specializations: The following *optional* specializations are currently available for MS:

- Advanced Manufacturing**
- Energy and Sustainability**
- Simulation-Driven Engineering (SDE)**
- Robotics and Control**
- Nanotechnology**
- Biology and Bio-inspired Engineering**

For specialization requirements visit,

<https://www.mccormick.northwestern.edu/mechanical/academics/graduate/student-resources/masters-curriculum.html>

- **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 committee must satisfy the TGS requirements specified for Master's students: (<https://www.tgs.northwestern.edu/about/policies/masters-degree-requirements.html#degree>). 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*. The results of the exam are then submitted to the Graduate School via GSTS: TGS Forms.

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, CEE 413^c, CEE 414-1^c, CEE 415^c, CEE 417-1^c, ME 426-1, ME 426-2, ME 456, and relevant ME 495 courses (e.g., wave propagation and thin films, heterogeneous materials, etc.)

Fluids/Thermo/Energy: ME 322, ME 367, ME 373, ME 377, ME 378, 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

Robotics/Dynamics/Control: ME 314, ME 333, ME 363, ME 390, ME 433, ME 448, ME 449, ME 450, ME 454, ME 495 (comp. nanodynamics), EE 360, EE 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 451, 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/Science/Data Science: 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, EE 475, IEMS 304, IEMS 308, IEMS 455

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.

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

Specializations: The following *optional* specializations are currently available for MS:

Advanced Manufacturing

Energy and Sustainability

Simulation-Driven Engineering (SDE)

Robotics and Control

Nanotechnology

Biology and Bio-inspired Engineering

For specialization requirements visit,

<https://www.mccormick.northwestern.edu/mechanical/academics/graduate/student-resources/masters-curriculum.html>

- **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 PROGRAM INFORMATION

(The following pages, 15-17, are applicable only for the PhD degree)

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:** There are no advisor holds. Thus, 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 their advisor for any questions or consultation.
- **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.
- **Full-time registration:** Funded PhD students may register for TGS 500 or research 590s during summers in their first and second year, or whenever they are not taking a full-time load of courses to maintain full-time registration.

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).

Proposal Writing Experience

All PhD students who do not already have a major external fellowship* are required to apply for at least one such fellowship sometime during the first two years of their PhD study. If a major fellowship opportunity cannot be identified for which the student is eligible, the student may instead apply for another research award or fellowship or contribute to a research proposal, as approved by his or her advisor.

* A major external fellowship is defined as one that provides tuition and a stipend for two or more years, such as the NSF Graduate Research Fellowship, NDSEG fellowship, DOE fellowships, Ford Foundation, NASA Research Fellowship, Hertz Foundation Fellowship, Microsoft PhD Fellowship, Microsoft Ada Lovelace Fellowship, etc.

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 <https://www.tgs.northwestern.edu/funding/assistantships/graduate-and-teaching.html>. The lowest scoring students will be assigned to participate in a mandatory supplemental English language curriculum offered by English Language Programs <https://www.elp.northwestern.edu/index.html>.

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 proposal examination committee is normally the advisory committee of a student until completion of the PhD degree, and also conducts the final examination for the PhD at a later date. The committee should satisfy the TGS requirements (<https://www.tgs.northwestern.edu/about/policies/phd-degree-requirements.html>). In addition to TGS requirements, the ME program requires that one committee member must have a primary appointment outside of the department. 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 (<https://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-AREAS– COURSE INFORMATION

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; Mechanistic Data Science; Joining 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 |
| Cheng Sun | Design and Manufacturing for Metamaterials and Devices |
| Ryan Truby | Soft, polymeric, and nanoscale materials; Additive and digital manufacturing methods; Soft robots; Soft matter |
| 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 |
| ME 395 | Mechanistic Data Science for Engineering |
| ME 395 | Industry 4.0 Manufacturing |
| 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 | Advanced Finite Element Methods I and II |
| ME 432 | Calculus of Variations |
| 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 470 | High Performance Computing for Multi-Physics Applications |
| ME 495 | Multifunctional Materials |
| ME 495 | Advanced Computational & Statistical Methods for Engineering Design |
| ME 495 | Mechanics of Manufacturing Processes |
| ME 495 | Sustainable Manufacturing Systems |
| 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 Ping Guo to discuss their initial course of study.

DYNAMICS, CONTROL, ROBOTICS, AND NEURAL ENGINEERING

Faculty research interests

(for most recent information, visit the Center for Robotics and Biosystems website <https://robotics.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 |
| Ryan Truby | Soft, polymeric, and nanoscale materials; Additive and digital manufacturing methods; Soft robots; Soft matter |
| 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 |
| EE 360 | Intro to Feedback Systems |
| ME 433 | Advanced Mechatronics |
| ME 454 | Numerical Methods in Optimal Control of Nonlinear Systems |
| EE 374 | Introduction to Digital Control |
| EE 410 | System Theory |
| EE 422 | Random Processes Comm and Control |

Instrumentation; Data Analysis

| | |
|--------|------------------------------------|
| EE 359 | Digital Signal Processing |
| EE 418 | Advanced Digital Signal Processing |

Mathematics

| | |
|--------------|---------------------------------|
| EE 302 | Probabilistic Systems |
| EECS 328 | Numerical Methods for Engineers |
| EECS 479 | Nonlinear Optimization |
| ESAM 311-1,2 | Methods of Applied Math |

Robotics; Computing

| | |
|--------|----------------------------------------------------|
| ME 410 | Applied Mechatronics: Quadrotor Design and Control |
|--------|----------------------------------------------------|

| | |
|---------------|---------------------------------------------------------|
| ME 301/CS 301 | Introduction to Robotics Laboratory |
| ME 409/CS 409 | Swarms and Multi-Robot Systems |
| ME 469/CS 469 | Machine Learning and Artificial Intelligence for Robots |
| ME 495 | Haptics |
| EECS 311 | Data Structures and Data Management |
| EECS 317 | Data Management & Info Processing |
| CS 325-1 | Artificial Intelligence Programming |
| CS 330 | Human Computer Interaction |
| EECS 332 | Digital Image Analysis |
| EE 333 | Intro to Communication Networks |
| CS 336 | Design and Analysis of Algorithms |
| CS 348 | Introduction to Artificial Intelligence |
| CS 351-1 | Introduction to Computer Graphics |
| EECS 390 | Intro to Robotics |
| EECS 457 | Advanced Algorithms |

Biological Systems

| | |
|----------|----------------------------------------------------------|
| BME 365 | Control of Human Limbs and Their Artificial Replacements |
| ESAM 370 | Intro to Comp Neuroscience |
| BME 401 | Neurophysiology |
| BME 461 | Computational Neuromechanics and Neuroethology |
| BME 462 | Sensory Acquisition |

| | | | |
|--------|--------------------------------------|---------|------------------------------|
| ME 449 | Robotic Manipulation | BME 463 | Systems Neuropathophysiology |
| ME 454 | Optimal Control of Nonlinear Systems | 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 sub-area 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, EE, CS, 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.

SOLID MECHANICS

Faculty research interests:

| | |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Oluwaseyi Balogun | Nondestructive materials characterization; elastic wave propagation; mechanics of soft materials |
| 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 |
| Horacio Espinosa | Nanomechanics, dynamic response of materials, cell mechanics |
| Yonggang Huang | Mechanics of materials; nanomechanics; mechanics of stretchable electronics |
| 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; Mechanistic Data Science; . Additive Manufacturing; Jointing 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 of geomaterials and mechanics of porous media; Mechanics of rat whiskers |
| 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 415 | Theory of Elasticity | ME 362 | Stress Analysis |
| CEE 417 | Continuum I | ME 426-1 | Advanced FEM I | ME 363 | Vibrations |
| ME 327 | Finite Elements for Stress Analysis | ME 385 | Nanotechnology | ME 382 | Micro-Nano Science |
| ME 381 | Introduction to MEMS | ME 456 | Mechanics of | ME 426-2 | Advanced FEM II |
| ME 395 | Mechanistic Data Science | ME 466 | Advanced Materials | ME 470 | High Performance |
| ME 414-1 | Mechanics of Composite Materials | ME 341 or 441 | Inelastic Constitutive Relations | ME 416 | Computing for Multi-physics Applications |
| ME 417 | Multi-scale Modeling and Simulation in Solid Mechanics | ME 495 | Computational Methods for Engineering Design | | Computational Nanodynamics |
| | | ME 495 | Theory of Heterogeneous Materials | | |
| | | ME 495 | Adv. Fracture Mech. | | |
| 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 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 Ketten to discuss their initial course of study.

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 | Mechanistic Data Science for systems simulation and design; additive manufacturing processing for biomedical devices, polymeric material systems |
| 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 | 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 | Numerical Solution of Partial Differential Eqns. |

Suggested courses:

| | |
|-------------|------------------------------------------------|
| ME 395 | Mechanistic Data Science for Engineering |
| 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 | Calculus of Variations and its Applications |
| ME 395 | Combustion/Energy Systems |
| ME 467 | Industrial Energy Management and Utilization |
| ME 417 | Multiscale Modeling and Simulations for Solids |

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

| | |
|--------------|-----------------------------------------------------------|
| ME 418 | Multiscale Modeling and Simulations for Fluids |
| ME 470 | High Performance Computing for Multi-Physics Applications |
| ChBE 404 | Advanced Thermodynamics |
| ESAM 322 | Applied Dynamical Systems |
| 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 Theory |
| ESAM 430 | Wave Propagation |

Contact:

Please see your graduate advisor to discuss your program of study. New PhD students without an advisor should see Professor Greg Wagner to discuss their initial course of study.

NANOTECHNOLOGY / MEMS

Faculty research interests:

| | |
|-------------------|---------------------------------------------------------------------------------------------------------------------|
| Oluwaseyi Balogun | Heat transport in nanoscale materials and devices |
| Horacio Espinosa | Micro and Nano Mechanics, MEMS, NEMS, Biotechnology |
| Sinan Keten | Molecular dynamics, biological materials, soft matter mechanics, materials failure, chemistry-mechanics interaction |
| 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
- EE 388 Nanotechnology
- EE 381 Electronic Materials: Properties and Applications
- MSc 355 Electronic Materials
- EE 384 Solid State Electronic Devices
- EE 401 Fundamentals of Electronic Devices
- ME 495 Nanoscale Thermal Transport

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:

- BME 377 Intermediate Fluid Mechanics

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
EE 360 Introduction to Feedback Systems
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
ME 395 Mechanistic Data Science for Engineering
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/funding-resources/index.html>.

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 the 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 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. 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 their 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 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 full-time status, but allows no accumulation of credit 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. 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 TGS course requirements are completed.

TGS-500 Advanced Doctoral Study--Available to doctoral students who have completed all TGS course 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:

| | Credit | Candidacy | Tuition rate | Use |
|---------|--------|-----------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| ME 590 | yes | pre | full | In 1st few (1-3) years while satisfying TGS course requirements. Minimum three units required before taking the research qualification exam |
| TGS 500 | no | post | reduced | As needed or 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. Upon matching with an advisor, the student must notify the department by entering their advisor's name in the GSTS (<http://gsts.northwestern.edu>). PhD students that are unable to find an advisor by the end of their first quarter will be put on academic probation by the program and must contact the Director of Graduate Studies immediately. The Director of Graduate Studies will determine a deadline by which the student must identify an advisor to avoid exclusion from the program due to unsatisfactory academic progress.

Student Wellness, Conflict Resolution and Changing an Advisor

Students are encouraged to consult the Director of Graduate Studies (DGS) at any point regarding their academic progress, potential conflicts with their advisor or others in the program, or other concerns that relate to their well-being. In rare instances, a change of advisor may be necessary due to loss of funding, mismatch of research interests, or other reasons. If the student and/or primary research advisor believe at any point that the student would be better served by a different advisor, the student must immediately contact the DGS. Under these circumstances, the DGS will work with the faculty and student to determine a deadline by which the student must identify a new advisor to avoid exclusion from the program due to unsatisfactory academic progress. PhD students are encouraged to contact the DGS regarding concerns related to changing advisors, while MS students are encouraged to contact the Director of MS Program. If the DGS or Director of the MS Program are themselves the student's advisor, 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. 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

<https://www.tgs.northwestern.edu/funding/about-graduate-funding/paid-medical-leave-and-parental-accommodations.html>

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

A student who fails to resume good academic standing after at most two quarters after the quarter of being notified of their placement on probation by either The Graduate School or the program will be excluded from The Graduate School. Program exclusion requires approval from both the Director of Graduate Studies and the Chair of the department.

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. Students wishing to appeal a program's decision to exclude must first appeal directly to the program by contacting the Director of Graduate Studies. The program must inform both the student and TGS of the outcome of the student's appeal(s) in writing. A student may subsequently appeal program decisions to TGS.

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 Assistant | Tech B224 | j-dyess@northwestern.edu |
| Kulanda, Sinta | Financial Assistant | Tech B224 | s-kulanda@northwestern.edu |
| Latham, John | Research Administrator | Tech B225 | john.latham@northwestern.edu |
| Martin, Mady | Program Assistant | Tech B224 | madison.martin1@northwestern.edu |
| Marzec, Rick | Technical Support | Tech AG24 | r-marzec@northwestern.edu |
| Smith, Vanessa | Financial Coordinator | Tech B225 | vanessa.smith@northwestern.edu |
| Sparks, Hillary | Business Administrator | Tech B223 | h-sparks@northwestern.edu |
| Syeda, Amreen | Financial Assistant | Tech B224 | amreen.syeda@northwestern.edu |
| Wells, Jeremy | Administrative Assistant | Tech B224 | jeremywells@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, Associate Professor; BS, MS and PhD, Carnegie Mellon University.
Robotics autonomy and machine learning within human assistive and rehabilitation domains.
Office: A219, email: brenna.argall@northwestern.edu

Oluwaseyi Balogun, Associate Professor, BSc, University of Lagos, Nigeria; MS, PhD, Boston University.
Nondestructive materials characterization; biomechanics of soft materials; elastic wave propagation; thermal transport in nanoscale materials and devices.
Office Catalysis Bldg. 325, email: o-balogun@northwestern.edu

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

Michael Beltran, Senior 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; Chair, Department of Mechanical Engineering; 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; customer 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

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, Professor, Co-Director, Center for Human Computer Interaction + Design; BA, Dartmouth College, MS, PhD, Stanford University.
Design and innovation; human-computer interaction; crowdsourcing
Office Ford Building 2-327, email: e-gerber@northwestern.edu

Sandip Ghosal, Associate Professor; BS, Presidency College, Kolkata, 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; Pentair-D. Eugene and Bonnie L. Nugent Clinical Professor of ME
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

Mark Johnson, Professor; BS, Purdue University; MS, PhD, Massachusetts Institute of Technology
Cellular mechanics and the hydrodynamics of glaucoma; transport through connective tissues; biological transport processes; chaos and diffusion.
Office E378, email: m-johnson2@northwestern.edu

Sinan Keten, Professor; June and Donald Brewer Professor; 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

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

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

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. 326, 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.
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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; Jointing 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.
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Kevin M. Lynch, Professor; Director, Center for Robotics and Biosystems; 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.
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Malcolm MacIver, Professor; BS, MA, University of Toronto; PhD, University of Illinois.
Neurobiology; neuroethology; behavior; active sensory systems; modeling and simulation; biomechanics; robotics.
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Nick Marchuk, Senior Lecturer; BS, Johns Hopkins University; MS, Northwestern University.
Electromechanical design, Mechatronics.
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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.
Office B286, email: t-murphey@northwestern.edu

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.
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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.
Office L490, email: n-patankar@northwestern.edu

Michael A. Peshkin, Professor, Breed Senior Professor of Design; BS, University of Chicago; MS, Cornell University; PhD, Carnegie-Mellon University.
Physical human-robot interaction; surface haptics; cobots; biomedical mechatronics; sensors and actuators.
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Michael Rubenstein, Assistant Professor; BS, Purdue University; MS, University of Southern California; PhD, University of Southern California.
Control and design of robotic swarms.
Office A294, email: rubenstein@northwestern.edu

John W. Rudnicki, Professor; BS, MS, PhD, Brown University.
Fracture and inelastic behavior of geomaterials and mechanics of porous media; Mechanics of rat whiskers.
Office A333, email: jwrudn@northwestern.edu

Cheng Sun, Professor; BS, MS, Nanjing University; PhD, Pennsylvania State University.
Scalable 3D nano-fabrication of integrated nano-systems.
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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

Ryan Truby, Assistant Professor; BS, University of Texas at Austin; PhD, Harvard University.
Soft, polymeric, and nanoscale materials; Additive and digital manufacturing methods; Soft robots; Soft matter.
Office Cook 1131, email: rtruby@northwestern.edu

Gregory J. Wagner, Associate Professor, Director of Graduate Studies, Bette and Neison Harris Chair in Teaching Excellence; 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.
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Professors with Adjunct/Courtesy Appointments in the Mechanical Engineering Department:

Ange-Therese Akono, Assistant Professor (Home Department – CEE); BS, Ecole Polytechnique; MS, PhD, Massachusetts Institute of Technology
Nano-mechanics; fracture analysis; nanotechnology; advanced experimental testing; multiscale modeling
Office: A236, email: ange-therese.akono@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 ; cate.brinson@duke.edu ; <http://mems.duke.edu/faculty/catherine-brinson>

Daniel P Brown, Clinical Professor, Segal Design Institute; BS St. Xavier University, MS Northwestern University, PhD Coventry University.
Engineering Design, Manufacturing Design, Product Development, Intellectual Property, & Entrepreneurship, areas of research include “How Design Creates Value and Competitive Advantages in the Marketplace”.
Office Ford Building G-327, email: dan-brown@northwestern.edu

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

Kuniaki Dohda, Research Professor; BS, MS, Toyama University; PhD, Nagoya University.
Tribology in metal forming; microforming.
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Jennifer Dunn, Associate Professor (Home Department: ChBE), Co-director, Center for Engineering Sustainability and Resilience; BS, Purdue University, MS, PhD, University of Michigan.
Energy and environmental impacts of emerging technologies; life cycle analysis; air pollutant and greenhouse gas emissions; water and energy consumption.
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Matthew Elwin, Assistant Professor of Instruction; BS, Dartmouth College; MS, PhD, Northwestern University.
Robotics, Mechatronics, Multi-robot Systems, Decentralized Estimation and Control.
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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 L497, email: mark.fleming@northwestern.edu

Zhengtao Gan, Research Assistant Professor; BS, Chongqing University; PhD, Chinese Academy of Sciences, Beijing;
Multiscale and multiphysics modeling for advanced manufacturing.
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David W. Gatchell, Clinical Associate Professor, Segal Design Institute; AB Bowdoin College, PhD Boston University.
Engineering Design
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Netta Gurari, Research Assistant Professor, (Home Department - Physical Therapy and Human Movement Sciences, Feinberg School of Medicine); BSE, University of Pennsylvania; MS, PhD The Johns Hopkins University
Robotics, haptics, human-machine interaction, human perception and rehabilitation, stroke
Office: Suite 1100, 645 N Michigan Ave, Chicago 60611, email: netta.gurari@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 SRA, 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

José Pons, Professor (Home Department – Shirley Ryan AbilityLab) BS, University of Navarra; PhD, University of Madrid
Wearable robotics; neuroprosthetics; mobility devices
Office Abbbtt, 701 N. Lake Shore, Suite 1022, email: jose.pons@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, Professor (Home Department ESAM); MS, Sofia University, Bulgaria; PhD, Yale University.
Fluid dynamics, membrane biophysics, and soft matter.
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Emeritus Professors:

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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 2-8** <http://www.library.northwestern.edu/muddlibrary> .

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. <https://www.tgs.northwestern.edu/campus-life/TGS-commons/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

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

Sargent Hall, next door to Tech Institute, 2245 Sheridan Road

Off Campus

Noyes Street: Tomato Fresh Kitchen (914 Noyes St., #1, 847-905-0194); Dave's New Kitchen (815 Noyes St., 847-864-6000); D&D Dogs (825 Noyes St., 847-864-1909, <http://dddogs.net/>); Al's Deli (914 Noyes St., 847-475-9400)

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 (1635 Chicago Ave., 847-864-8328 <https://www.prairiemoonrestaurant.com/>); La Principal (700 Main St., 224-307-2444, <https://www.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 (847-467-4663). 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 \$2.50 per ride. If you'll also be riding a bus, you are allowed to transfer an additional time 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. Head northwest to O'Hare (don't worry - there are lots of signs!); O'Hare is the last stop. Time: 1-1.5 hours. Cost: \$2.50.

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 \$2.50. 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 : <https://www.zipcar.com/universities/northwestern-university>

Divvy Bikes (<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 and Pay Stations** – Most commercial areas in Evanston, including downtown, require paid street parking. Evanston is currently transitioning away from single-space parking meters to pay-by-license-plate pay stations – be sure to look for these. There is no need to display a payment receipt on a vehicle's dashboard. Alternatively, drivers can pay using the ParkEvanston mobile app. Paid parking is in effect from 8am-9pm, Monday through Saturday; parking is free on Sundays and major holidays.
- **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.