

Table of Contents

Mechanical Engineering at Northwestern University	1
The Graduate Program in Mechanical Engineering	3
MS Degree Requirements	4
1. Thesis Option.....	4
Course Requirements	4
Research	4
Residency	4
Master’s Thesis and Examination	4
MS Thesis	4
2. Non-thesis Option for Terminal MS Degree	5
Course Requirements	5
Project	5
PhD Degree Requirements	6
Course Requirements	6
TA and English Requirements	6
Residency	6
Qualifying Examination/Admission to Candidacy/PhD Prospectus	6
GPA Requirement	7
PhD Thesis Dissertation	7
Final Examination/Dissertation Defense	7
PhD Student Assessment and Feedback.....	7
ME Sub-Area Specializations – Course Information.....	8
Specialization in Design/Manufacturing/Tribology	8
Faculty Research Interests.....	8
Course Work	8
Contact	8
Specialization in Dynamics, Control, Robotics, and Neural Engineering.....	9
Faculty Research Interests.....	9
Course Work	9
Contact	9
Specialization in Solid Mechanics	10
Faculty Research Interests.....	10
Course Work	10
Contact	11

Specialization in Fluid Dynamics	12
Faculty Research Interests.....	12
Course Work	12
Contact	12
Specialization in Nanotechnology/MEMS	13
Faculty Research Interests.....	13
Course Work	13
Contact	14
Other Important Graduate Study Information.....	15
Course Levels.....	15
Grades	15
Financial Aid and Registration.....	15
Registration as a Full-Time Student.....	15
Continuous Registration Requirement	16
Where and When to Register	16
Finding an Advisor.....	16
PhD Advisory Committee Guidelines.....	16
Mechanical Engineering Department Information	17
Support Staff	17
Duplicating Machine.....	17
Fax Machine.....	17
Paychecks.....	17
Eligibility to Work in the U.S.	17
Mailboxes.....	17
Phones	17
Emergency	17
E-Mail	17
Purchasing.....	18
Travel Reimbursement.....	18
Mechanical Engineering Department Facilities.....	18
Mechanical Engineering Faculty and Their Research	19
Around Northwestern University	24
Norris Center Bookstore.....	24
Bursar's Office	24

Campus Parking Office	24
University Career Services.....	24
Counseling and Psychological Services (CAPS)	24
Ryan Field and McGaw Hall.....	24
ID Cards	24
Math Library	24
Norris University Center	24
Off-Campus Housing Office	24
Patten Gym.....	24
Seeley G. Mudd Library.....	24
Sports and Aquatic Center.....	24
Student Health Center	25
Student Loans Office.....	25
University Library.....	25
Evanston Information	25
Evanston Police/Fire	25
Housing (On-and Off-Campus).....	25
Transportation	25
Public	25
CTA (Chicago Transit Authority)	25
Amtrak	26
Greyhound.....	26
NU Shuttle.....	26
Getting to O’Hare and Midway Airports	26
Parking on Campus	26
Parking in the City of Evanston	27

The ME Graduate Handbook

Information about the Graduate Program in

Mechanical Engineering

McCormick School of Engineering and Applied Science

Northwestern University

2009

MECHANICAL ENGINEERING AT NORTHWESTERN UNIVERSITY

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

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

with new emphases on

- Small-Scale and Multi-Scale Systems Science and Engineering
- Energy Production and Utilization
- Biological and Human Interface Engineering

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

THE GRADUATE PROGRAM IN MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers programs leading to the MS and PhD degrees. Superior 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 Quality Engineering and Failure Prevention, the Center for Intelligent Processing of Composites, and the Program in Theoretical and Applied Mechanics.

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

MS DEGREE REQUIREMENTS:

1 Thesis option

(All students receiving departmental support-TAs, RAs, any fellowships- must take this option)

Course Requirements:

- **Number of courses:** Nine course units are required, excluding project units.
- **Breadth:** Students must take at least one course each from four of the seven subareas: (1) Solids, (2) Fluids, (3) Dynamics/Controls, (4) Design/Manufacturing/Tribology, (5) MEMS/Nanotechnology, (6) Biomedical/Biology, and (7) Mathematics/Sciences. The following courses are suggested:
 - Solids:* ME 362 or CEE 415, ME 365, CEE 318, CEE 417-1, CEE 417-2 CEE 426-1, ME 426-2, and ME 466
 - Fluids:* ME 420, ME 421, ME 422, ME 423, ME 424, ME 425, ME 427, ME 428, and ME 429
 - Dynamics/Control:* ME 314, ME 391, and ME 460
 - Design/Manufacturing/Tribology:* ME 319, ME 320, ME 341, ME 346, ME 366, ME 439, ME 441, ME 442, ME 443, ME 445, and ME 446
 - MEMS/Nanotechnology:* ME 381, ME 382, ME 385, ME 451, ME 453, ME 317 and ME 318
 - Biomedical/Biology:* BME 317, BME 380, BME 477, BioSci 301, BioSci 309, and BioSci 354
 - Mathematics/Sciences:* ESAM 311, ESAM 322, ESAM 346, ESAM 411, ESAM 420, ESAM 424, ESAM 426, ESAM 427, ESAM 429, ESAM 430, ESAM 446, EECS 328, and ME 432
- **Level:** A minimum of 5 credited course units (excluding project units) must be 400-level or above.
- **ME courses:** A minimum of 5 course units must be ME courses.
- **Seminar:** Registration and regular attendance for the non-credit ME512 Seminar is required for all quarters.
- **Approval:** Students must obtain approval for all courses in advance from their advisor or Graduate Study Chair before an advisor is identified and submit a signed course form each quarter to the ME graduate program assistant before registration.

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.

Residency: Three quarters of full-time registration (3-4 courses or project units per quarter) are required.

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

MS thesis: The thesis should be based on original research that is of publishable quality and should have a quantity of material equivalent to at least one journal paper. It should be prepared according to the Graduate School format for PhD dissertations.

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

2 Non-thesis option for terminal MS degree

Course Requirements:

- **Number of courses:** Eleven course units plus one project unit ME 499 are required.
- **Breadth:** Students must take at least one course each from four of the eight subareas: (1) Solids, (2) Fluids, (3) Dynamics/Controls, (4) Design/Manufacturing/Tribology, (5) MEMS/Nanotechnology, (6) Biomedical/Biology, (7) Mathematics/Sciences, and (8) Engineering Management. The following courses are suggested:
 - Solids:* ME 362 or CEE 415, ME 365, CEE 318, CE 417-1, CEE 417-2, CEE 426-1, ME 426-2, and ME 466
 - Fluids:* ME 420, ME 421, ME 422, ME 423, ME 424, ME 425, ME 427, ME 428, and ME 429
 - Dynamics/Control:* ME 314, ME 391, and ME 460
 - Design/Manufacturing/Tribology:* ME 319, ME 320, ME 341, ME 346, ME 366, ME 439, ME 441, ME 442, ME 443, ME 445, and ME 446
 - MEMS/Nanotechnology:* ME 381, ME 382, ME 385, ME 451, ME 453, ME 317 and ME 318
 - Biomedical/Biology:* BME 317, BME 380, BME 477, BioSci 301, BioSci 309, and BioSci 354
 - Mathematics/Sciences:* ESAM 311, ESAM 322, ESAM 346, ESAM 411, ESAM 420, ESAM 424, ESAM 426, ESAM 427, ESAM 429, ESAM 430, ESAM 446, EECS 328, and ME 432
 - Engineering Management*:* IEMS 402, IEMS 407, IEMS 415, IEMS 426, IEMS 427, IEMS 428, and IEMS 486
- **Level:** A minimum of 5 credited course units (excluding project units) must be 400-level or above.
- **ME courses:** A minimum of 7 course units (excluding project units) must be ME courses.
- **Seminar:** Registration and regular attendance for the non-credit ME512 Seminar is required for all quarters.
- **Approval:** Students must obtain approval from the ME Assistant Chair or the Graduate Studies Chair for all courses before registration.

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 faculty advisor must be completed.

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

** Admission to the Engineering Management Minor program through the IEMS department is required in order to enroll in any of these IEMS courses. The certificate requires IEMS 402, IEMS 407, and one additional IEMS course from the list.*

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 PhD. Nine (9) course units within this 15 course units must satisfy the MS course requirements.
- **MS from another school:** Students admitted with a MS degree from elsewhere may transfer a maximum of six (6) course units from the post-bachelor's degree study toward the 15-course requirement. A course credit transfer form must be completed by the student, the advisor and approved by the Graduate Study Chair.
- **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 for the non-credit ME512 Seminar is required for all quarters.
- **Professional Essentials:** Registration for the non-credit ME513 Seminar is required for one quarter within the first two years. It is strongly recommended that this seminar course be taken before PhD candidacy.
- **Approval:** Students must obtain approval from their advisor for all courses in advance and submit a signed course form each quarter to the ME graduate program assistant before registration.
- **Timeline.** The course requirement for the Ph.D. program shall be fulfilled within the first 12 and 8 quarters of full-time registration for students matriculating with BS and MS, respectively.

TA and English requirements: It is suggested that each student conduct at least one quarter of Teaching Assistance. International students whose first language is not English must pass the Test of Spoken English (TSE) with a minimum score of 50 or complete 3 quarters of English (Linguistics 380 or approved equivalent from the "English as a Second Language" (ESL) program offered by the linguistics department at Northwestern).

Residency: Eight quarters of full-time registration consecutively over two years, including summers, are required. Full-time registration requires enrollment in a combination of course units and ME-590 (research) units for a total of 3-4 units each quarter.

After residency has been obtained, full-time registration is maintained by registering for TGS 500 (Advanced Doctoral Study). Courses related to the student's area of study may be taken in addition to TGS 500, up to a maximum of 4 course units per quarter subject to the approval of the advisor.

Qualifying Examination / Admission to Candidacy / PhD Prospectus:

Students are admitted to candidacy for the PhD degree by passing an oral qualifying exam. The oral qualifying examination will be based on (but not restricted to) a written research proposal (no more than 30 pages in total length, double spaced) prepared by the student and administered by the examination committee appointed by the department chair.

Students are eligible to take the qualifying exam when all but three of the courses required for PhD have been taken. (See GPA requirement below, however)

Students must take the oral qualifying examination no later than the end of the second year of full time study beyond the MS degree or the end of the third year of full time study beyond the BS degree. Students who fail the examination may, upon the recommendation of their committee, retake it within one quarter. Students who do not pass the re-examination shall not continue in the PhD program.

The examination committee is also the advisory committee of a student. Each committee should consist of at least three faculty members who are also members of graduate faculty. At least one of the members must be from outside of the ME department. The committee normally conducts the final examination for the PhD at a later date. The chairperson of the committee must be a graduate faculty member of the ME department and is generally the

student's advisor. Any faculty member may request the privilege of serving on the committee for a particular student.

GPA requirement. GPA is determined by all post BS courses taken at Northwestern towards satisfying the course requirements above, excluding research and seminar units. All but one ME 499 may be used towards the overall GPA. Students whose GPA falls short of a 3.5 average, shall be required to take an oral and/or written preparatory examination prior to the oral qualifying examination. These examinations will be administered by a committee consisting of at least three faculty members appointed by the department chair. The student's advisor shall not serve on the preparatory examination committee. The committee will inform the students involved as to the form and content of the examination beforehand. The result of the examination will be decided by the committee in consultation with the student's advisor and the department chair. Students who fail the preparatory examination 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 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.

PHD STUDENT ASSESSMENT AND FEEDBACK

Objective: 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.

- 1) Each PhD student will establish an evaluation committee consisting of at least three professors by the end of the summer of year 1. This committee may become the thesis committee of the student. The advisor is the chair of this committee.
- 2) 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 report following the specific departmental required format and obtain faculty advisor's written comments on the annual report
 - b. The annual report and comments will be kept in the student's file.
 - c. Notification of good academic standing/student progress will be communicated to each student by the ME program assistant.
- 3) 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 improvement, students may be advised to leave, pursue a terminal MS, or continue with the PhD program.

**ME SUB-AREA SPECIALIZATIONS –
COURSE INFORMATION**

SPECIALIZATION IN DESIGN/MANUFACTURING/TRIBOLOGY

Faculty research interests:

Jian Cao	Metal and Composite Forming
Wei Chen	Design Methodology and Computational Design Methods
Yip-Wah Chung	Surface Science; Coating; Tribology
Kornel Ehmann	Metal Cutting; Machine Dynamics, Accuracy and Control; Automation
Elizabeth Gerber	Human Centered Design Methodology and Innovation Practices
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 317,318	Molecular Modeling & Interface to Micromechanics I and II
ME 319,320	Applications of Surface Science to Nanomechanics and Nanotribology I and II
ME 341	Computational Methods for Engineering Design
ME 346	Introduction to Tribology
ME 359	Reliability Engineering
ME 363	Mechanical Vibrations
ME 366	Finite Elements in Design
CEE 415-1,2	Elasticity I and II
ME 416	Non-Destructive Evaluation
CEE 417-1,2	Continuum I and II
ME 420,421,422	Micro-/Nano-scale Fluid Dynamics I, II, and III
ME 423,424	Computational Fluid Dynamics, I and II
CEE 426 1,2	Advance Finite Element Methods I and II
ME 439	Computer Control in Manufacturing
ME 441	Engineering Optimization for Product Design and Manufacturing
ME 442	Metal Forming
ME 443	Metal Cutting
ME 445	Micromanufacturing
ME 446	Advanced Tribology
ME 448	Flexible Automation and Robotics
ME 460	Advanced Engineering Dynamics
ME 497(0.5 credits)	Rapid Product Innovation
	Intellectual Property in Manufacturing

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 graduate students without an advisor should see Professor Jian Cao to discuss their initial course of study.

SPECIALIZATION IN DYNAMICS, CONTROL, ROBOTICS, AND NEURAL ENGINEERING

Faculty research interests:

J. Edward Colgate	Robotics; human-machine interaction; actuator design and control, automatic control
Dean Ho	Nanomedicine, bionanotechnology, drug delivery, biosensing and diagnostics
Kevin Lynch	Robotics and automation; robot manipulation and motion planning; human-robot interaction; multi-agent systems; bio-inspired sensing and locomotion
Todd Murphey	Robotics; control; overconstrained mechanical systems; manipulation; friction-dominated mechanics and nonsmooth mechanics
Michael Peshkin	Robotics and intelligent mechanical systems; cobots; sensors and actuators, human robot interaction rehabilitation robotics
James Patton	Human motor control, rehabilitation robotics
Mitra Hartmann	Neurobiology and biomechanics of active sensing behaviors
Malcolm Maciver	Biomechanics and the nervous system: neuromechanics, neuroethology, robotics, and simulation,

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
ME 391	Fundamentals of Control Systems
or EECS 360	Introduction to Feedback Systems
ME 433	Advanced Mechatronics
EECS 374	Introduction to Digital Control
EECS 410	System Theory
EECS 422	Random Processes Comm and Control

Instrumentation; Data Analysis

EECS 353	Digital Microelectronics
EECS 359	Digital Signal Processing
EECS 418	Advanced Digital Signal Processing
PHYS 359-1,2	Modern Physics Laboratory

Mathematics

EECS 302	Prob Systems and Random Signals
----------	---------------------------------

EECS 328	Numerical Methods for Engineers
EECS 479	Nonlinear Optimization
ESAM 311-1,2,3	Methods of Applied Math

Robotics; Computing

ME 448	Flexible Automation and Robotics
ME 449	Robotic Manipulation
ME 450	Geometry in Robotics
EECS 311	Data Structures and Data Management
EECS 317	Data Management & Info Processing
EECS 325	Artificial Intelligence Programming
EECS 330	Human Computer Interaction
EECS 332	Digital Image Analysis
EECS 333	Intro to Communication Networks
EECS 336	Design And Analysis Of Algorithms
EECS 348	Introduction to Artificial Intelligence
EECS 351	Introduction to Computer Graphics
EECS 390	Intro to Robotics

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. In addition, students must meet the requirements for the MS degree. These requirements are detailed in the ME Graduate Handbook, but key stipulations include:

- Core Course Requirement (two courses outside of main research area)
- Minimum of **five** 400-level courses (excluding research credits)
- Minimum of **five** ME courses
- **Seminar:** ME students must register for and attend ME 512 *Mechanical Engineering Seminars*

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

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

Contact:

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

SPECIALIZATION IN SOLID MECHANICS

Faculty research interests:

Jan Achenbach	Nondestructive evaluation, fracture mechanics
Oluwaseyi Balogun	Optical techniques for materials characterization; nondestructive evaluation
Ted Belytschko	Computational mechanics, finite elements
Cate Brinson	Polymeric, composite and smart materials, micromechanics
Jian Cao	Mechanics of forming, instability analysis
Wei Chen	Stochastic multiscale analysis, model validation
Isaac Daniel	Experimental mechanics, composites, nondestructive evaluation
Horacio Espinosa	Nanomechanics, dynamic response of materials, cell mechanics
Yonggang Huang	Mechanics of materials; nanomechanics; mechanics of stretchable electronics
Leon Keer	Stress analysis, fracture, elasticity, tribology
Sridhar Krishnaswamy	Intelligent structural health management; smart structures and materials; sensors; photoacoustic materials characterization
Wing Kam Liu	Nanoengineering; multi-scale analysis; materials design; nonlinear finite elements
Jianmin Qu	Micromechanics, interface mechanics, and quantitative nondestructive evaluation
John Rudnicki	Fracture and inelastic behavior, particularly geomaterials

Course work:

A typical list of mechanics courses follows:

Fall Quarter		Winter Quarter		Spring Quarter	
CEE 417-1 CEE 415-1	Continuum I Elasticity I	CEE 313 CEE 417-2 CEE 414-1 ME 366	Expt. Stress Analysis Continuum II Composites I Finite Elements for Design	CEE 318 CEE 411 CEE 414-2 CEE 415-2	Fracture Mechanics Micromechanics Composites II Elasticity II
ME 365 CEE 327 ME 381	Finite Elements for Stress Analysis Introduction to MEMS	ME 385 CEE 426-1 ME 426-1 ME 465 ME 466	Nanotechnology Advanced FEM I Advanced FEM II Wave Propagation Inelastic Constitutive Relations	CEE 426-2 ME 426-2 CEE 429 CEE 418	Advanced FEM II Comp. Mech. II Comp. Mech. Fracture Continuum Theory of Fracture
Offered any quarter: CE/ME 495 Special Topics – look for special mechanics courses of interest					
Offered every other year: ME 456 usually in Winter					

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

- Engineering Science and Applied Mathematics offers many excellent courses, including ESAM 311-1,2,3 series, suggested for students who have not had mathematics beyond sophomore level differential equations. The series ESAM 411-1,2,3 covers more advanced topics.
- Note that all ME students must satisfy a *Core Requirement* (for MS) and a *Minor Requirement* (for PhD) – check Class Schedule for availability of relevant classes each term.
- 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:** Mechanics students should register for *Structural Mechanics Seminar* CEE-512 each quarter and attend all seminars (typically on specific Thursdays at 11 am; send email address to Effie Fronimos at i-fronimos@northwestern.edu) to receive announcements of all 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 graduate students without an advisor should see Professor Sridhar Krishnaswamy to discuss their initial course of study.

SPECIALIZATION IN FLUID DYNAMICS

Faculty research interests:

Sandip Ghosal	Fluid mechanics at micro and nano scales
Elmer Lewis	Reliability engineering and nuclear engineering
Seth Lichter	Turbulent mixing; vorticity dynamics, Hamiltonian and molecular dynamics
Rich Lueptow	Granular, filtration & Taylor-Couette flows, physical acoustics, design
Neelesh A. Patankar	Computational fluid dynamics; Micro/nano-scale flows; bio-applications
Siavash Sohrab	Combustion; turbulent reactive flows; physico-chemical thermodynamics

Course work:

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

Fall	Winter	Spring
ME 425 ¹	One or more of ME 420, 421, 422, 427, 428, 429	One or more of ME 420,421, 422, 427, 428, 429
Elective or MS Core Reqt	Elective or MS Core Reqt	Elective
Mathematics Elective	Mathematics Elective	ME 499 or Elective
Elective	ME 499 or Elective	ME 499
Seminar Series: ME 512	Seminar Series: ME 512	Seminar Series: ME 512

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

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

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

- Suggested courses:

ME 420	Micro- and Nanoscale Fluid Dynamics
ME 421	Design and Analysis of Microfluidic Systems
ME 422	Molecular Scale Fluid Dynamics
ME 423, 424	Computational Fluid Dynamics
ME 425	Fundamentals of Fluid Dynamics
ME 427	Viscous Fluid Dynamics
ME 428	Compressible and Inviscid Fluid Dynamics
ME 429	Turbulent Flows
ME 432	Optimization Methods in Science and Engineering
ME 434	Random Data and Spectral Analysis
ME 379, 478	Combustion
ME 489	Selected Topics in Cellular-Level Transport
ChBE 404	Advanced Thermodynamics
ChBE 424-1,2	Transport Phenomena
CEE 356	Transport Processes in Porous Media
CEE 455	Computational Methods in Subsurface Hydrology
ESAM 322	Applied Dynamical Systems
ESAM 346	Modeling and Computation in Science & Engineering
ESAM 424-1,2	Mathematical Topics in Combustion
ESAM 426, 427	Flows with Small Inertia and Small Viscosity
ESAM 429-1,2	Hydrodynamic Stability
ESAM 430-1,2,3	Wave Propagation

Contact: Please see your graduate advisor to discuss your program of study. New graduate students without an advisor should see Professor Neelesh A. Patankar to discuss their initial course of study.

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

SPECIALIZATION IN NANOTECHNOLOGY / MEMS

Faculty research interests:

Horacio Espinosa	Micro and Nano Mechanics, MEMS, NEMS, Biotechnology
Dean Ho	Nanomedicine, bionanotechnology, drug delivery, biosensing and diagnostics
Chang Liu	Sensors and sensing technology, micro and nanofabrication
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 451: Micromachining
 - ME 453: Micro Systems Design
 - ME 495: Advanced Topics in Nanotechnology
- Other possible courses are listed below:
 - A. Solid State Physics:
 - Basics:*
 - PHYS 339 Quantum Mechanics
 - PHYS 332 Statistical Mechanics
 - PHYS 422-1,2,3 Solid-State Physics
 - EECS 388 Microelectronic Technology
 - Theory and Fabrication:*
 - EECS 381 Electronic Properties of Materials
 - MSc 355 Electronic Materials
 - EECS 384 Solid State Electronic Devices
 - EECS 401 Fundamentals of Electronic Devices
 - ChBE 367 Fabrication of Microelectronic Devices
 - B. Fluid Mechanics:
 - Mechanical Engineering:*
 - ME 420 Micro- and Nanoscale Fluid Dynamics
 - ME 425 Fundamentals of Fluid Dynamics
 - ME 423, ME 424 Computational Fluid Dynamics
 - ME 427 Viscous Fluid Dynamics
 - Biomedical Engineering:* (choose one)
 - ME 395 Molecular Machines
 - ME 489 Protein Dynamics
 - BME 477-1,2 Advanced Fluid Mechanics in Engineering and Biology
 - ESAM 426 Flows with Small Inertia
 - C. Biotechnology & Biotransducers:
 - BME 317-0 Biochemical Sensors
 - BME 380-0 Biomedical Transducers and Instrumentation
 - BioSci 301-0 Biochemistry
 - BioSci 309-0 Principles of Biochemistry
 - BioSci 354-0 Biochemistry Laboratory
 - D. Material and Surface Science:
 - MSc 415 Fundamentals of Thin Film Materials
 - MSc 316-1,2 Microstructural Dynamics
 - MSc 312 Interfaces in Crystalline Solids
 - MSc 361 Crystallography and Diffraction
 - MSc 380 Introduction to Surface Science and Spectroscopy
 - Chem 329 Analytical Chemistry
 - ME 346 Introduction to Tribology
 - CEE 411 Micromechanics

E. Control and Sensors:

Basics:

- ME 390 Introduction to Dynamics Systems
- ME 391 Fundamentals of Control Systems
- EECS 360 Introduction to Feedback Systems

Applications:

- EECS 410 Introduction to Robotics
- ME 333 Introduction to Mechatronics
- ME 433 Advanced Mechatronics

F. Computational and Applied Science and Engineering:

- ME 317/318 Molecular Modeling and the Interface to Micromechanics
- ME 365 Finite Elements for Stress Analysis
- 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. The up to 3 project courses will be taken from the list above and *only when activities outside campus will take place*. No more than 2 courses per quarter will be allowed. Approval for taking the courses will be given by the ME Graduate Committee chair 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 graduate students without an advisor should see Professor Horacio D. Espinosa 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 and Registration

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

Several types of financial aid are available. Fellowships generally provide a monthly stipend and tuition for full-time study and research. Most fellowships are only available to US citizens and are awarded on a competitive basis by the department. Research assistantships involve participation in ongoing funded research projects and are awarded at the discretion of the faculty advisor. Research assistantships provide a monthly stipend out of which the student pays a tuition fee. 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. 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.

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 Projects. Preferable registration is for a total of 4 units per quarter for three quarters to meet the residency requirement and to fulfill the 12 required units for the MS degree within three quarters. Students who need to continue their research after having completed the required 12 units should register for TGS-588 Resident Masters Study, described below.

PhD candidates who have not achieved candidacy (passed the qualifying exam) should maintain a full-time registration of 3-4 units of courses and ME-590 Research. Full-time registration for 5 quarters beyond the MS degree or 8 quarters beyond the BS is necessary to meet the residency requirement and to fulfill the course requirements (9 courses beyond MS degree). Students who need to continue their research but take no classes prior to candidacy may register for TGS-500 Resident Doctoral Study at a reduced tuition level. 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* should be discussed with your advisor.

MS research/project registration is summarized below:

ME-499 Projects --Available to master's degree students to pursue research for their MS project. Typical registration is for 1 to 3 499 units in addition to courses to achieve a total of 4 units for full-time registration. A maximum of 3 499 units may be used for fulfilling the MS degree requirements. 499 units may not be used toward the requirements of a PhD.

TGS-588 Residents Master's Study--Available to master's degree students who have completed residency requirements and are pursuing research, need to use university facilities, are receiving financial aid, or hold F-1 or J-1 visa status. Requests for more than one 588 registration will be reviewed by The Graduate School. Provides full-time status, but allows no accumulation of credit or residency toward the master's degree. No courses including ME-512 Seminar may be taken with 588 registration. Tuition is substantially lower for 588 registration than for full-time registration.

PhD research/project registration is summarized below:

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

TGS-500 Advanced Doctoral Study--Available to doctoral students who have completed all residency requirements, been admitted to candidacy, and need to use University facilities to complete a dissertation. Also appropriate for students receiving financial aid or on F-1 and J-1 visas. Provides full-time status, but is not a required registration. Tuition is substantially lower for 500 registration than for full-time registration.

PhD research registration summary:

	Resid. Credit	Candidacy	Tuition rate	Use
ME 590	yes	pre	full	In 1st few(1-3) years while satisfying residency requirements
TGS 500	no	post	reduced	As needed after 8 quarters to maintain student status until thesis 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/studentsvcs/generaldegreereq/registration/continuousregistration/>

Where and When to Register

Registration information can be obtained on the web at: <http://www.registrar.northwestern.edu/registration/>

Finding an Advisor

Students should seek out a research advisor to work with on his/her graduate research within one to two quarters 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 oral 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.

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 follow and 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 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. A final thesis presentation (several weeks prior to the examination date) to a larger audience is 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.

MECHANICAL ENGINEERING DEPARTMENT INFORMATION

1. Support Staff:

Mary Erickson	Business Administrator	Room B223	mary-erickson@northwestern.edu
Beltran, Michael	Lab Instructor/Manager	Room AG28	mbeltran@northwestern.edu
Dyess, Pat	Graduate Program Asst	Room B224	j-dyess@northwestern.edu
Fiocchi, Shirl	CSET Assistant	Room L196	Shirlf@northwestern.edu
Flannery, Nancy	Sr. Editorial Assistant	Room A214	n-flannery@northwestern.edu
Herman, James	Program Assistant	Room A214	j-herman@northwestern.edu
Hilliard, Marcia	CQEFP Assistant	Catalysis 324	m-hilliard@northwestern.edu
Kulanda, Sinta	Financial Assistant	Room B224	s-kulanda@northwestern.edu
Marzec, Rick	Technical Support	Room LG96	r-marzec@northwestern.edu
Masters, Amy	Program Assistant	Room B224	amy-masters@northwestern.edu
Miranda, Amy	Payroll Assistant	Room B224	a-miranda2@northwestern.edu

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

2. Duplicating Machine: In Room B224 there is a duplicating machine that you may use. See your advisor to obtain a copy code number. For personal copies pay the office staff directly.

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 in the Payroll Office (720 University Place, Evanston).

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-LAC-XXX-XXXX, where LAC is the local area code (312 or 773-Chicago, 708 or 630-suburbs). Long distance calls require the use of an authorization code as follows *89-AUTHCD-9-1-LDC-XXX-XXXX, where AUTHCD is the 6-digit authorization code and LDC is the long distance area code. See your advisor to obtain an authorization code.

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**.

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 items for research, fill out a form indicating the number of items, item number, item description, item cost, total cost, supplier name, address, phone number, fax number, and FEIN (Federal Employer Identification Number), and research account number (available from your advisor). Provide the form to Financial Assistant Sinta Kulanda, who will place the order. Electronic copies of the form are available from Sinta. 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.

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

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

Oluwaseyi Balogun, Assistant Professor; BSc, University of Lagos, Nigeria; MS, PhD, Boston University.
Optical techniques for materials characterization; nondestructive evaluation of micro- and nanoscale structures; photoacoustic and photothermal microscopy; fiber optic sensors for structural health monitoring.
Office Catalysis Bldg. 325, email: o-balogun@northwestern.edu.

Ted Belytschko, Walter P. Murphy Professor; BS, PhD, Illinois Institute of Technology.
Computational mechanics; finite elements; multiscale methods; computational nanomechanics.
Office B222, email: tedbelytschko@northwestern.edu.

L. Catherine Brinson, Jerome B Cohen Professor of Engineering and Chair; BS, Virginia Polytechnic Institute and State University; MS, PhD, California Institute of Technology.
Polymers, nanocomposites, biomaterials and smart materials; micromechanics and characterization.
Office B222, email: cbrinson@northwestern.edu.

Debbie Burton, Lecturer and Assistant Chair; AB Harvard University; MEng University of California at Berkeley; PhD, Northwestern University.
Office B226, email: durton@northwestern.edu

Jian Cao, Professor and Director of Graduate Studies; BS, Shanghai Jiaotong University; SM, PhD, Massachusetts Institute of Technology.
Mechanics and process optimization of manufacturing processes at multi-scales; instability analysis; laser texturing.
Office A217, email: jcao@northwestern.edu.

Wei Chen, Professor and Director of Predictive Science & Engineering Design Cluster; BS, Shanghai Jiaotong University; MS, Univ. of Houston; PhD, Georgia Institute of Technology.
Design theory and methodology; design optimization; computational methods for design under uncertainty; stochastic multiscale analysis, consumer preference modeling; engineering decision making.
Office A216, email: weichen@northwestern.edu.

J. Edward Colgate, Pentair-Nugent Professor; Co-Director, Segal Design Institute; BS, MS, PhD, Massachusetts Institute of Technology.
Robotics; human-machine interaction; haptic interface; cobots.
Office B225, email: colgate@northwestern.edu.

Isaac M. Daniel, Walter P. Murphy Professor; Director, Center for Intelligent Processing of Composites; BS, MS, PhD, Civil Engineering, Illinois Institute of Technology.
Applied mechanics; composite materials; nondestructive evaluation.
Office Catalysis Bldg. 326, email: imdaniel@northwestern.edu.

Kornel F. Ehmann, James N. and Nancy J. Farley Professor of Manufacturing and Entrepreneurship; BS, MS, University of Belgrade, Yugoslavia; PhD, University of Wisconsin-Madison.
Machine-tool dynamics and control; metal-cutting processes; automation and robotics.
Office A215, 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.
In situ electron microscopy testing of nanomaterials, novel NEMS architectures, tip-based nanofabrication, cell mechanics, dynamic failure, continuum and atomistic modeling.
Office L286, email: espinosa@northwestern.edu.

Elizabeth Gerber, Assistant Professor; BA, Dartmouth College, MS, PhD, Stanford University.
Human centered design methodology and innovation practices
Office Ford Building 2-329, email: e-gerber@northwestern.edu.

Sandip Ghosal, Associate Professor; BS, Presidency College, Calcutta, India, PhD, Columbia University.
Fluid mechanics; micro and nanoscale flows.
Office M312; email: s-ghosal@northwestern.edu.

Mitra Hartmann, Associate Professor, BS, Cornell University; PhD, California Institute of Technology.
Neural engineering; computational neuroscience; sensorimotor control and sensory acquisition; hardware models of neuromechanical systems; modulation of rhythmic motor activity.
Office D153; email: m-hartmann@northwestern.edu.

Walter B. Herbst, Clinical Professor; Director, Master of Product Development Program; BFA, University of Illinois, MS, Northwestern University.
The totality of the issues related to product development.
Office Ford 2-313, w-herbst@kellogg.northwestern.edu

Dean Ho, Assistant Professor; B.S. M.S., Ph.D., University of California, Los Angeles.
Fabrication of novel devices for targeted and controlled therapeutic release, nanodiamond-based chemotherapeutic hydrogels, polymeric biomembranes for diagnostic applications
Office D155, email: d-ho@northwestern.edu.

Yonggang Huang, Joseph Cummings Professor; BS, Peking University; MS, PhD, Harvard University.
Mechanics of materials; Nanomechanics; mechanics of stretchable electronics.
Office: A116, email: y-huang@northwestern.edu

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

Sridhar Krishnaswamy, Professor; Director, Center for Quality Engineering and Failure Prevention; BTech, Indian Institute of Technology, Madras; MS, PhD, California Institute of Technology.
Intelligent structural health management; smart structures and materials; sensors; photoacoustic materials characterization.
Office Catalysis Bldg. 323, email: s-krishnaswamy@northwestern.edu.

Elmer E. Lewis, Professor; BS, MS, PhD, University of Illinois.
Radiation transport; reliability and risk analysis.
Office A213, email: e-lewis@northwestern.edu.

Seth Lichter, Professor; AB, Harvard University; PhD, Massachusetts Institute of Technology.
Fluid mechanics; contact-line physics; vorticity dynamics.
Office L396, email: s-lichter@northwestern.edu.

Chang Liu, Professor, BS, Tsinghua University, MS, Ph.D. California Institute of Technology.
Sensors and sensing technology, micro and nanofabrication.
Office: L288, email: changliu@northwestern.edu

Wing Kam Liu, Walter P. Murphy Professor; BS, University of Illinois at Chicago; MS, PhD, California Institute of Technology.
Nanoengineering; multi-scale analysis; materials design; nonlinear finite elements.
Office A326, email: w-liu@northwestern.edu.

Richard M. Lueptow, Professor; Senior Associate Dean, McCormick School; Co-Director, Master of Product Development Program; BS, Michigan Technological University; SM, ScD, Massachusetts Institute of Technology.
Granular flow; filtration; Taylor-Couette flow; design.

Office Ford Building 2-321, email: r-lueptow@northwestern.edu.

Kevin M. Lynch, Professor and Associate Chair, PhD, Carnegie Mellon University.
Robotics and automation; robot manipulation and motion planning; human-robot interaction; multi-agent systems; bio-inspired sensing and locomotion.
Office B221, email: kmlynch@northwestern.edu.

Malcolm MacIver, Assistant Professor; BS, MA, University of Toronto; PhD, University of Illinois.
Neurobiology; neuroethology; behavior; active sensory systems; modeling and simulation; biomechanics; robotics.
Office D157, email: maciver@northwestern.edu.

Ann McKenna, Research Associate Professor; BS, MS, Drexel University; PhD, University of California at Berkeley.
Engineering Education.
Office Ford Building G-319, email: mckenna@northwestern.edu

Todd Murphey, Assistant Professor; BS, University of Arizona; PhD, California Institute of Technology.
Robotics; control; overconstrained mechanical systems; coordinated manipulation; manipulation in the presence of uncertainty; friction-dominated mechanics and nonsmooth mechanics.
Office L192, email: t-murphey@northwestern.edu

Neelesh A. Patankar, Associate Professor, BTech, Indian Institute of Technology, Bombay, MS, PhD, University of Pennsylvania.
Computational fluid dynamics; multiphase flows; submicron/nanoscale fluid dynamics; surface-roughness-induced drop motion; biological applications.
Office M310, email: n-patankar@northwestern.edu.

Michael A. Peshkin, Professor; BS, University of Chicago; MS, Cornell University; PhD, Carnegie-Mellon University.
Robotics and intelligent mechanical systems; cobots; sensors and actuators.
Office B227, email: peshkin@northwestern.edu.

John W. Rudnicki, Professor; BS, MS, PhD, Brown University.
Fracture and inelastic behavior of solids, particularly geomaterials.
Office A333, email: jwrudn@northwestern.edu.

Siavash H. Sohrab, Associate Professor; BSc, University of California, Davis; MSc, San Jose State University; PhD, University of California, San Diego.
Combustion; turbulent reactive flows; physical-chemical thermodynamics.
Office LG94, email: s-sohrab@northwestern.edu.

Cheng Sun, Assistant Professor; BS, MS, Nanjing University; PhD, Pennsylvania State University.
Micro-nano scale science and engineering; novel micro/nano 3D fabrication technologies; design and manufacturing for metamaterials and devices (energy; bio-sensing)
Office L292, email: c-sun@northwestern.edu.

Q. Jane Wang, Professor; BS, Shaanxi Institute of Mechanical Engineering; MS, Northern Illinois University; PhD, Northwestern University.
Contact and interfacial mechanics; nanotribology; surface design and engineering; machine elements.
Office A219, email: qwang@northwestern.edu.

Professors with Courtesy Appointments in the Mechanical Engineering Department:

Jose E. Andrade, Assistant Professor (Home Department CEE); BS, Florida Tech; MS, PhD, Stanford University. Mechanics; computational poromechanics; computational inelasticity.
Office A124; email: j-andrade@northwestern.edu; URL: geomechanics.civil.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.

James G. Conley, Clinical Professor (Home Department Kellogg-Economic Decision Science), BS, University of Virginia; MM, PhD, Northwestern University.
Strategic use of intangible assets, intellectual properties on competitive advantage.
Office Jacobs Center 5249, email j-conleya@kellogg.northwestern.edu

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

Bernard J. Matkowsky, John Evans Professor (Home Department – ESAM); PhD, Courant Institute of Mathematical Science.
Combustion synthesis of advanced materials; nonlinear dynamics and pattern formation; analytical and comp. methods.
Office L497, email: b-matkowsky@northwestern.edu.

Michael J. Miksis, Professor (Home Department – ESAM); BS, Drexel University, MS, PhD, Courant Institute of Mathematical Sciences.
Theoretical and computational fluid mechanics, especially multiphase flow and free boundary problems; wave propagation.; asymptotic and perturbation methods.
Office M426, email: miksis@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 E168, email: jm-ottino@northwestern.edu.

Aaron Packman, Associate 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, Research Assistant 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 345 E. Superior St, Suite 1406, j-patton@northwestern.edu

Jianmin Qu, Walter P. Murphy Professor and Chair of Civil and Environmental Engineering; BS, Jilin University; MS, PhD, Northwestern University.
Micromechanics, interfacial fracture and adhesion, fatigue and creep damage in solder alloys, defects and transport in crystalline solids, thermomechanical reliability of microelectronic packaging, and quantitative nondestructive evaluation.
Office A234, email: j-qu@northwestern.edu

Emeritus Professors:

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

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

Arthur A. Kovitz, BSE, MS, University of Michigan; PhD, Princeton University.
Fluid dynamics; heat transfer; interfaces.
email: akovitz@northwestern.edu.

David A. Mintzer, BS, PhD, Massachusetts Institute of Technology.
Acoustic wave propagation; rarefied gas dynamics.

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

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

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

Man-Chuen Yuen, BS, Purdue University; MS, Massachusetts Institute of Technology; PhD, Harvard University.
Heat transfer; fluid mechanics; multiphase flow.
email: hmcy58@ yahoo.com.

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 Services

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

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: 847-491-7070. The stadium is the site of football games, while McGaw Hall contains Welsh-Ryan arena, home of the basketball team. Tickets may be purchased at the game or at Norris University Center.

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: 1915 Maple Ave. 847-491-3015. Provides listings of available off-campus housing.

Patten Gym: 2407 Sheridan Rd. 847-491-7313; 847-491-4099 (evenings and weekends). 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. See your advisor for a research account copy card.

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.

University Library: 1970 Campus Drive, 847-491-7568. 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.

EVANSTON INFORMATION

Evanston Police/Fire:

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

Regular business: Fire 847-866-5900
 Police 847-866-5000

Housing

ON-CAMPUS

Engelhart Hall (1915 Maple Avenue, 847-491-5127) is the only on-campus housing available for graduate students. Single students share a two bedroom apartment, with a kitchen and bath, but no common areas. Married students can rent one or two 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 building is located next to the Foster El stop (about a 15 minute walk to Tech.), so noise can be a problem. 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 Engelhart Hall, 1915 Maple Ave., 847-491-3015, <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, and free use of telephones for local calls to landlords. 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 \$2.00 per ride + \$.25 for a transfer. If you'll also be riding a bus, you are allowed to transfer an additional 2 times within a 2-hour period. Graduate students in possession of an activated U-Pass will incur no cost on the El system and all Pace buses.

During 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 at the Davis Street stop, at 901 Davis St., or call 312-972-7000.

Amtrak (1-800-USA-RAIL) trains leave from Union Station, downtown, at Adams and Canal St. The downtown **Greyhound** (312-781-2900) terminal is at 630 W. Harrison.

NU Shuttles

Purple Express - For schedules see <http://www.univsvcs.northwestern.edu/shuttles/evanston.html>

Intercampus - <http://www.univsvcs.northwestern.edu/shuttles/evanston.html>

Ryan Field - <http://www.univsvcs.northwestern.edu/shuttles/evanston.html> - This service operates from 6:50am to 7:56pm and runs between the Evanston campus and the parking lots at Ryan Field and the Research Park (behind the Hilton).

For questions or comments about the shuttles, please contact the Transportation Office of University Services at 312-503-8129 or via email at shuttle@northwestern.edu. For automated message regarding service updates, call 847-467-5284. For Lost & Found and after hours dispatch, call 708-474-7474.

Getting to O'Hare and Midway Airports

To get to O'Hare on the El, take the Howard/Dan Ryan to Washington St. station, and transfer to the O'Hare/Congress/Douglas line (the blue line). Follow the signs - you'll go down a flight of stairs and walk through an underground tunnel to the blue line station. The connection is free. You want to head northwest to O'Hare (don't worry - there are lots of signs!), and O'Hare is the last stop. Time: 1-1.5 hours. Cost: \$2.00.

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 \$2.00. 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: ~\$30 (Norsshore (847-864-7500) or 303 Cab (847-468-0303)). Taxi service to Midway is quite expensive--about \$40.

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

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 who live on campus can purchase 'Resident parking sticker and may only park in 'R' lots. Students who live off campus outside of a restricted area near the campus may purchase a 'Commuter parking sticker to park in 'C' lots.

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 (<http://cityofevanston.org/departments/parking.snow/shtml>) and on the Snow Hotline, 847-864-SNOW.
- **Meters** - Do not assume that you can keep feeding quarters and park in a two hour metered spot for six hours. They will mark your tire with chalk, and even if your meter has money, you will receive a ticket for parking greater than two hours.
- **Public Lots** - Many residential neighborhoods have lots available to the public with purchase of a sticker from the City of Evanston's Parking System Department, 847-866-2923.