**The Bachelor of Science Degree**

**in**

# MECHANICAL ENGINEERING

**at**

# NORTHWESTERN UNIVERSITY

## September 2009

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# Mechanical Engineering

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**April 2009**

## INTRODUCING MECHANICAL ENGINEERING AT NORTHWESTERN UNIVERSITY

Mechanical engineering today is a rapidly diversifying field, encompassing areas such as robotics, automated manufacturing, biological molecular machines, thermodynamics, fluid dynamics, computational mechanics, composite materials, and tribology. Mechanical engineering plays a dominant role in a wide spectrum of industries, among them the transportation industry (automotive, rail, air, and marine), heavy machinery (machines producing other machines), the power industry, the environmental industry (heating, ventilation, and air-conditioning), the light precision-machine enterprises (optical and prosthetic devices, mechanical instruments, and the like), and numerous commercial product industries. Preparation for a career in mechanical engineering requires a basic understanding of the mathematical, physical, and engineering principles essential to planning, designing, and manufacturing new equipment. Mechanical engineering students also go on to professional schools in medicine, law, and business, and the mechanical engineering program at Northwestern gives students the flexibility to tailor their academic program to their own interests.

## ***Mechanical Engineering Undergraduate Mission:***

*To educate undergraduates in the basic principles underlying the field of mechanical engineering, to train students to think independently and to work in teams, to instill a systematic approach to problem solving, and to promote a keen awareness of the role of engineering in a modern society.*

## EDUCATIONAL OBJECTIVES:

The Educational Objectives of the Northwestern University Mechanical Engineering undergraduate curriculum are to provide a student with:

1. A cornerstone knowledge and understanding of fundamental mathematics and physical science
2. A set of core experiences providing fundamental background and understanding of engineering science necessary for mechanical engineering
3. Experience in engineering design
4. Skill and expertise in practical tools used by practicing mechanical engineers
5. Practical, hands-on experiences in design, manufacturing, and engineering science
6. The opportunity to specialize within the field of mechanical engineering
7. Experience and training in interpersonal skills, communication, and team skills
8. Stimulation to foster an ongoing intellectual curiosity and professional development
9. A liberal education to provide a well-rounded and multi-dimensional educational experience, particularly with regard to an understanding of the societal, ethical, and professional implications of engineering decisions
10. The ability to think critically, formulate problems, and reason solutions with regard to mechanical engineering situations
11. Experience in identifying engineering problems and then applying engineering science to the formulation, analysis, interpretation, and solution of those problems

## THE PROGRAM IN MECHANICAL ENGINEERING

The curriculum in Mechanical Engineering at Northwestern University provides a broad, fundamental education preparing a student for direct entry into industry as well as further professional study. The first part of the curriculum is devoted to mathematics, physics and chemistry. With this background, fundamental mechanical engineering subjects are studied. These include dynamics, solid mechanics, fluid mechanics and thermodynamics followed by specialized subjects such as manufacturing, heat transfer and automatic control. During the final two years, design courses, laboratory courses and project courses allow students to acquire a taste for the complex task of designing, analyzing and building a piece of hardware. In particular, students become aware of the coupling between conceptual design, subsequent analysis (mathematical modeling), manufacturing, systematic experimentation and final testing. Supporting courses in allied fields of science and engineering broaden the technical proficiency of mechanical engineering, while the elective courses in social sciences, fine arts, history and philosophy enlarge their background in the problems of humanity. Details of the requirements for a Bachelor of Science in Mechanical Engineering degree are as follows:

**MECHANICAL ENGINEERING CURRICULUM**

Total requirement - 48 courses

MATHEMATICS - 4 courses

Math 220,224,230 Calculus

Math 234 Multiple Integration and Vector Calculus

ENGINEERING ANALYSIS AND COMPUTER PROFICIENCY - 4 courses

Gen Eng 205-1,2,3,4 Engineering Analysis

BASIC SCIENCES - 4 courses

Phys 135-2,3 General Physics

Chemistry through Chem 102 General Inorganic Chemistry or Chem 171 Accelerated General Inorganic Chemistry

DESIGN AND COMMUNICATIONS - 3 courses

Dsgn 106-1,2 Engineering Design and Communication and English 106-1,2 Writing in Special Contexts

Gen Comm 102 or 103

BASIC ENGINEERING - 5 courses

Thermodynamics:

ME 220 Thermodynamics

Fluids and Solids:

ME 241 Fluid Mechanics I

CEE 216 Mechanics of Materials

Materials Science:

MSc 201 Principles of the Properties of Materials

Electrical Science:

ME 233 Electronics Design

(Students planning to take advanced EECS courses as electives may substitute EECS 221 Fundamentals of Circuits)

SOCIAL SCIENCES/HUMANITIES THEME REQUIREMENT - 7 courses

UNRESTRICTED ELECTIVES - 5 courses

MECHANICAL ENGINEERING DEPARTMENTAL PROGRAM - 16 courses

Required - 7 courses

ME 202 Mechanics II
ME 224 Experimental Engineering I
ME 240 Intro. to Mech. Design and Manufacturing
ME 315 Theory of Machines - Design of Elements
ME 340-1 Computer Integrated Manufacturing
ME 377 Heat Transfer
ME 390 Introduction to Dynamic Systems

Advanced Study - 4 courses

One course from

ME 314 Theory of Machines – Dynamics
ME 363 Mechanical Vibrations
ME 391 Fundamentals of Control Systems I or EECS 360 Introduction to Feedback Systems

One course from

ME 362 Stress Analysis
ME 365 Finite Elements for Stress Analysis
CEE 327 Finite Element Methods in Mechanics

One course from

ME 370 Thermodynamics II
ME 373 Engineering Fluid Mechanics

One design course from

ME 340-2 Computer Integrated Manufacturing
ME 366 Finite Elements for Design & Optimization
ME 398 Engineering Design

Electives - 5 courses (no more than 2 units of 399 are allowed)*

2 300-level Mechanical Engineering courses
1 200- or 300-level engineering, science or mathematics technical elective
2 300-level engineering, science or mathematics technical electives

*One elective must be in mathematics or the basic sciences. It may be any 300 level course in Mathematics, Applied Mathematics or Statistics; IEMS 201 or IEMS 202; or any 200 or 300 level course in Physics and Astronomy, Chemistry, Earth & Planetary Sciences or Biological Sciences with the following exceptions: PHYS 301, CHEM 393, BIOL 307.

Students are encouraged to concentrate technical electives in an area of interest. Seven areas of concentration, including appropriate courses and descriptions, are listed on pages 6-8. In the case that the student wishes to count as technical electives five courses that do not satisfy the conditions above, the student must file a petition with the department listing the five courses to be counted toward the technical electives. If the five courses satisfy the requirements of one of the suggested areas of concentration and meet the basic science requirement, the petition will be granted automatically.

## COURSE SCHEDULING

| | FALL | WINTER | SPRING |
|---|---|---|---|
| **Freshman** | Chem 101<br>Math 220<br>Gen Eng 205-1<br>Elective | Chem 102<br>Math 224<br>Gen Eng 205-2<br>DSGN 106-1 | Math 230<br>Gen Eng 205-3<br>DSGN 106-2<br>Elective |
| **Sophomore** | Math 234<br>Gen Eng 205-4<br>CEE 216 or MSc 201<br>Elective | Phys 135-2<br>MSc 201 or CEE 216<br>ME 202<br>Elective | Phys 135-3<br>ME 220<br>ME 240<br>Elective |
| **Junior** | ME 241<br>ME 233 or Elective<br>ME 315* or ME Req.<br>ME 340-1 | ME 377 or ME Req.<br>ME Req. or Tech. Elective<br>Tech. Elective<br>Elective | ME 315 or ME Req.<br>ME 377 or ME Req.<br>Elective<br>Elective |
| **Co-Op Junior** | ME 241<br>ME 340-1<br>ME 233<br>Elective | ME Req.<br>ME Req. or Tech. Elective<br>Tech. Elective<br>Elective | CO-OP |
| **Co-Op Pre-Senior** | ME 340-1<br>ME 390<br>ME 224 or ME Req.<br>Elective | CO-OP | ME 315<br>ME 377<br>ME Req. or Tech. Elective<br>Elective |
| **Co-Op Senior** | CO-OP | Design Course<br>ME Req. or Tech. Elective<br>Tech. Elective<br>Elective | ME 224 or ME Req.<br>Tech. Elective<br>Elective<br>Elective |
| **Senior** | ME 390<br>ME 224 or Tech. Elective<br>ME 233 or Elective<br>Elective | Design Course<br>ME Req. or Tech. Elective<br>Tech. Elective<br>Elective | ME 224 or Tech. Elective<br>Tech. Elective<br>Elective<br>Elective |

In addition to the required courses listed explicitly above, students must complete 4 mechanical engineering advanced study courses, 5 technical electives, 7 theme electives and 5 unrestricted electives.

**ME Req. = Mechanical Engineering Advanced Study (4 courses).**
**Elective = Theme (7 Courses), unrestricted electives (5 courses), or speaking course. (13 courses total)**
**Tech. Elective = (5 courses).**

| ME Required (Adv. Study) (4) | Tech Elective (5) | Theme, unrestricted electives, speaking course (13) |
|---|---|---|
| ME 314, 363 or 391 (or EECS 360) | | |
| ME 362, 365 or CEE 327 | | |
| ME 370 or 373 | | |
| ME 340-2, 366 or 398 | | |
| | | |

A number of the required mechanical engineering courses are only offered one quarter per year as indicated above. Courses typically offered in more than one quarter include ME 220 (every quarter), ME 224 (fall, spring), ME 241 (fall, spring), ME 315 (fall, spring), and ME 377 (winter, spring). For the advanced study courses, note that normally ME 314 and ME 370 are offered in the fall, ME 373 and ME 391 (EECS 360) in the winter, ME 362 in the spring, and the design courses in the winter. Check current time tables for possible exceptions.

**Elective Concentrations**

The program in Mechanical Engineering is designed to appeal to students with a wide variety of interests and professional goals. By an appropriate choice of elective courses, students can develop a highly personalized curriculum.

Some suggested areas of concentration are biomedical engineering, design, energy, intelligent mechanical systems, computer-aided design/computer-aided manufacturing, MEMS/nanotechnology, and solid mechanics. The *biomedical engineering* concentration is open to students interested in the biological and medical application of mechanical engineering procedures. Students in this concentration can also satisfy the entrance requirements of medical schools. The *design* concentration focuses on product design with related conceptual and manufacturing processes. The *energy* concentration emphasizes the mechanical aspects of energy conversion and management. The *intelligent mechanical systems* concentration focuses on robotics and the design of microprocessor-controlled electromechanical systems. The *manufacturing* concentration is directed toward planning and selecting manufacturing methods, design for manufacture, computer-aided flexible automation and robotics, and increasing the efficiency and productivity of current and emerging manufacturing technologies. The *solid mechanics* concentration focuses on the study of stress and strain in solid bodies along with the application of computational methods for stress analysis.

**Technical electives chosen according to the suggested concentrations below may not satisfy the requirements of 2 300-level ME courses, 1 200- or 300-level technical elective, and 2 300-level technical electives, as outlined on page 4. In this case, the student must file a petition with the department listing the five courses to be counted as technical electives. If these five courses satisfy the requirements of one of the areas of concentration below, the petition will be granted automatically.**

**Biomedical Engineering – 5 courses**

Requirements for admission to medical and dental schools vary from one school to another. Students should be aware of these differences and use the technical electives and/or unrestricted electives to fulfill particular requirements. Students may elect to take Chem 342-1 instead of ME 220.

Recommended design course:

- ME 398 Engineering Design

Three courses from the following:

- Chem 210-1,2 Organic Chemistry
- Biol 210-1 Biology
- BME 301,302,303 Systems Physiology

Two courses from the following:

- Any 300-level ME or BME course (including BME 301,302,303 Systems Physiology if not included as a part of the above three courses)

**Design - 5 courses**

Design courses (one to count as an Advanced Study design course, one to count as a Technical Elective):

- ME 340-2 Computer Integrated Manufacturing
- ME 398 Engineering Design

Four courses from the list:

- CEE 327 Finite Element Methods in Mechanics
- ME 333 Introduction to Mechatronics
- ME 340-3 Computer Integrated Manufacturing
- ME 341 Computational Methods for Engineering Design
- ME 346 Introduction to Tribology
- ME 359 Reliability Engineering
- ME 362 Stress Analysis (if not included as an ME Advanced Study course)
- ME 365 Finite Elements for Stress Analysis (if not included as an ME Advanced Study course)
- ME 366 Finite Elements for Design and Optimization
- MSc 318 Materials Selection
- Dsgn 3xx Any 300-level Dsgn course

Recommended unrestricted electives or theme electives:

- ART 124 Essentials of Design
- ART 125 Basic Drawing

**Energy - 5 courses**

Recommended design course:
- ME 398 Engineering Design

ME 370 Thermodynamics II or ME 373 Engineering Fluid Mechanics (whichever is not included as an ME Advanced Study course)

Four courses:
- ME 362 Stress Analysis
- ME 379 Elements of Combustion Engineering
- ChBE 323 Mass Transfer

**Intelligent Mechanical Systems – 5 courses**

ME 333 Introduction to Mechatronics

ME 391 Fundamentals of Control Systems or EECS 360 Introduction to Feedback Systems (if not included as an ME Advanced Study Course)

One or two programming courses 200-level or higher; the following courses are suggested:
- EECS 211 Fundamentals of Computer Programming 2
- EECS 311 Data Structures and Data Management
- EECS 205 Fundamentals of Computer System Software
- EECS 230 Programming for Computer Engineers

One or two 300-level technical electives; suggested:
- EECS 390 Introduction to Robotics

**Manufacturing - 5 courses**

Recommended design course:
- ME 340-2 Computer-Integrated Manufacturing: CAD/CAM
- ME 340-3 Computer-Integrated Manufacturing: Automation

Four courses, at least one from each of the following groups:

Group 1
- ME 342 Mechanics of Cutting and Forming
- ME 346 Introduction to Tribology
- ME 362 Stress Analysis
- MSc 316-1 Microstructural Dynamics
- MSc 316-2 Microstructural Dynamics
- MSc 317 Materials in Manufacturing
- MSc 331 Physical Properties of Polymers
- MSc 332 Mechanical Behavior of Solids (MSc 316-1,2 are prerequisites)
- MSc 340 Ceramic Processing

Group 2
- ME 341 Computational Methods for Engineering Design
- ME 365 Finite Elements and Stress Analysis
- ME 366 Finite Elements in Design Optimization
- EECS 314 Applied Artificial Intelligence
- EECS 390 Introduction to Robotics

Group 3
- ME 359 Reliability Engineering
- IEMS 201 Introduction to Statistics
- IEMS 305 Statistical Methods for Quality Improvement
- IEMS 310 Operations Research
- IEMS 326 Economics and Finance for Engineers
- IEMS 382 Production Planning and Scheduling

**MEMS/Nanotechnology – 5 courses**

ME 381 Introduction to MEMS
ME 382 Experiments in Micro/Nano Science and Engineering
ME 385 Nanotechnology
Two courses from the list below and only one for each subgroup:
- Materials and Characterization:
  - ME 317 Molecular Modeling and the Interface to Micromechanics
  - ME 319 Applications of Surface Science to Nanomechanics and Nanotribology
  - ChBE 361 Introduction to Polymers
  - MSc 395 Special Topics: Biomaterials
  - MSc 395 Special Topics: Colloids
  - MSc 395 Special Topics: Nano-materials
  - MSc 360 Introduction to Electron Microscopy
  - MSc 380 Introduction to Surface Science and Spectroscopy
- Devices and Control:
  - ME 389 Molecular Machines in Biology
  - ME 391 Fundamentals of Control Systems or EECS 360 Introduction to Feedback Systems
  - EECS 388 Microelectronic Technology
  - BME 317 Biochemical Sensors
  - BME 321 Theory and Control of Biological Systems
  - BME 343 Biomaterials and Medical Devices

**Solid Mechanics – 5 courses**

Recommended design course:
- ME 366 Computer-Aided Engineering II – Design or ME 398 Engineering Design

ME 362 Stress Analysis (if not included as an ME Advanced Study course)
Four courses (five courses if ME 362 is included as an ME Advanced Study course) from the list:
- CEE 318 Mechanics of Fracture
- CEE 319 Theory of Structures II (CEE 221 is a prerequisite)
- CEE 320 Structural Analysis
- CEE 322 Structural Design (CEE 222 is a prerequisite)
- ME 327 (CEE 327) Finite Element Methods in Mechanics
- ME 365 Finite Elements for Stress Analysis (if not included as an ME Advanced Study course)
- CEE 413 Experimental Stress Analysis
- CEE 417 Mechanics of Continua I

## OTHER INFORMATION ABOUT COURSES

### Electives and Non-Technical Courses

In addition to the required math, science, and engineering courses, all students take a number of non-technical and elective courses to satisfy the McCormick School requirements.

#### Social Science - Humanities Requirements

Students must take seven courses chosen according to either of the following two options:

**Option A**

At least two courses must be chosen in each of three areas:

**Social and Behavioral Science (SBS)**
**Historical Studies and Values (HSV)**
**Fine Arts, Language and Literature (FAL)**

Of the seven courses, only three 100-level introductory courses may be taken and three courses must be "thematically related" to provide depth of study in a particular area.

**Option B**

Five of the seven courses must clearly have a "thematic relatedness." For breadth, no more than five courses may come from a single area (SBS, HSV, or FAL).

The courses taken for a student's social science-humanities requirement must be approved in advance by filling out a *theme declaration form*. Forms for either option are available either in the Academic Services Office (L269). Once filled out and signed by a student's advisor, they should be returned to this office for approval.

#### Unrestricted Electives

Unrestricted electives can be selected from any course offered for credit in the University. These are very valuable in permitting the student to concentrate in a particular area. For example, the student may utilize some or all of these in conjunction with the 7 Social Science-Humanities Requirements to achieve an in-depth undergraduate preparation in a particular non-engineering discipline, such as music or business. As a second example, the student may utilize the unrestricted electives in conjunction with the 5 technical electives to attain an undergraduate specialization in a particular area of Mechanical Engineering. With suitable advanced placement credit, summer work, or a fifth year, it is possible in this manner to structure a curriculum, which achieves two B.S. Degrees, one in Mechanical Engineering and one in another curriculum. Students should interact closely with their advisors to plan their unrestricted electives to achieve the maximum benefit from their undergraduate program.

### Communications Requirement

All McCormick School students are required to develop proficiency in writing and speaking before graduation, since effective communication is essential in any career in engineering, management, or academia. Accordingly, students must demonstrate proficiency or take one unit in both writing and speech. Courses that will satisfy the communications requirement are:

| | | |
|---|---|---|
| **Writing** | IDEA 106-1,2 | Engineering Design and Communication and |
| | English 106-1,2 | Writing in Special Contexts |
| **Speaking** | Gen Comm | Public Speaking |
| | Gen Comm | Analysis and Performance of Literature |

These courses are usually taken during the freshman year. High-level courses may satisfy this requirement and are approved on an individual basis.

**Transfer into Mechanical Engineering**

Since the course requirements for the freshman year are very similar in all engineering curricula, transferring into Mechanical Engineering during the freshman year usually requires no catching up with required Mechanical Engineering courses. Often transfers during a student's sophomore year can be accomplished with minimal problem as well, especially if the student has AP (Advanced Placement) credit. Transfer into Mechanical Engineering after the sophomore year is usually more difficult and may require extra coursework to complete the departmental requirements. Students may change departments by filling out the appropriate form in the Academic Services Office (Room L269).

**Grade Requirements for BS in Mechanical Engineering**

Students must earn a grade average of not less than 2.0 for all courses presented for the degree. Students must also earn a grade average of not less than 2.0 for all 16 Mechanical Engineering Departmental Program courses. Further, no more than two of these courses may carry a grade of D.

**P/N (Pass/No Credit) Grade Option**

A maximum of eight quarter courses may be taken under the P/N option and used toward the degree. During the Freshman and Sophomore years, only one course may be taken under the P/N option in any quarter. Junior, Pre-Senior, and Senior students are not subject to this limitation. The P/N option rules are as follows for the Mechanical Engineering undergraduate program:

**Social Sciences/Humanities**

P/N may be used here for any 300 level course and a maximum of four 100-200 level courses applied toward the nine required Social Science/Humanities Theme and the Communications courses.

**Unrestricted Electives**

P/N may be used for any unrestricted electives.

**Other Courses**

No other courses may be taken P/N.

**Course Levels**

Courses are labeled with three-digit numbers. The first digit represents the course level as follows:

**100 - Introductory (Freshman level)**

**200 - Intermediate (Sophomore level)**

**300 - Advanced (Junior, Senior, and Graduate level)**

**400 & 500 - Graduate level**

Our undergraduate curriculum (i.e., 100, 200, and 300 level courses) is designed to provide the student with adequate breadth in their field. 400 & 500 level courses are primarily for graduate students, but may be open to undergraduate students with permission.

**ME 399 Projects Credit**

Students may work on special projects with a particular faculty advisor for credit. Before registering for ME 399, students should contact a professor to coordinate an appropriate project and confirm that the professor is able to serve as faculty advisor. Often students participating in the McCormick Design Competition register for ME 399 or an equivalent 399 course from another department to receive credit for their project. 399 credit is subject to the following restrictions and criteria:

1) 399 credit will be provided in the home department of the faculty advisor for the project. Thus, ME students working with an EECS advisor will receive EECS 399 credit.

2) 399 may not be substituted for the design requirement in the ME curriculum. Only ME 340-2, ME 366, or ME 398 fulfill the ME design requirement.

3) ME 399 may be used as a 300 level mechanical engineering technical elective or a 300 level mechanical engineering course in fulfilling the ME curriculum requirements.

4) 399 in a department other than ME may be used as a 300 level technical elective course in fulfilling the ME curriculum requirements.

5) Students may not use more than two 399 courses to fulfill the ME curriculum requirements. The remaining technical electives should be formal structured courses.

6) To obtain 399 credit for the McCormick Design Competition, the 399 project must culminate in a written report that documents the work done and the resulting design. The report should include a clear statement of the design problem, the approaches used in solving the problem along with any related analysis and calculations, the resulting design, and any supporting material (mechanical drawings, component data sheets, program listings, schematics, etc.) This report should be sufficiently detailed that the design competition entry can be re-created from the information in the report. Individual reports from each student are not necessary. A group report will suffice.

7) A maximum of one 399 credit per quarter may be obtained for the McCormick Design Competition.

**AP (Advanced Placement) Credit**

Many engineering students enter Northwestern with Advance Placement (AP) credit, usually in mathematics or chemistry, granted on the basis of College Entrance Examination Board (CEEB) advanced placement tests. AP credits directly substitute for equivalent required Theme courses and unrestricted elective courses. As a result, AP credit will reduce the course requirements for the BS by the number of AP credits, thereby reducing the total number of classes required for a degree. Most students take advantage of Advanced Placement Credit to take required courses earlier than the scheduled quarter or to take additional unrestricted elective courses.

**ABET Accreditation**

The Mechanical Engineering program is accredited by the Accreditation Board for Engineering and Technology (ABET). Fulfilling the requirements set forth in the Mechanical Engineering Curriculum automatically satisfies ABET requirements.

**Petitions**

Students may petition to substitute courses to fulfill curriculum requirements or transfer courses from other universities. The petition form, which is available from the McCormick Academic Services Office (Room L269), requires an explanation of the request and the reasons for the request. After filling out the petition, the student should deliver it to his or her advisor for a signature. The advisor delivers the petition to the department chair who, along with a committee set up for this purpose, decides on the action for the petition and delivers it to the Dean's Office. Upon final action by the Dean's Office, the student and the advisor receive copies of the original petition and, if approved, the petition is incorporated into the student's record.

**SPECIAL PROGRAMS FOR MECHANICAL ENGINEERING STUDENTS**

**Cooperative Engineering Education Program**

Many mechanical engineering undergraduates elect to participate in the five-year Cooperative Engineering Education Program (Co-op), which provides alternate periods of on-the-job industrial experience with regular classwork at Northwestern. Typically, such students work in industry for two quarters (summer and one academic quarter) during each of their last three years after completing two years (six academic quarters) of study. During the 18 months of industrial employment, a student is afforded the opportunity of applying theory while gaining practical experience. The perspective gained enables students to develop an understanding of the responsibilities of their future professional career.

Students in good academic standing normally elect the Co-op program in the Fall of the Sophomore year by contacting the McCormick Cooperative Engineering Education Office, Ford Engineering Building, 2nd Floor Room 350. The office works with students to obtain a cooperative work assignment related to the student's professional objectives.

Generally, the first work experience for Co-op students occurs during the summer between their Sophomore and Junior years. Co-op experience for Junior transfer students and others with two years of academic credit begins in the spring of their Junior year. If necessary, special schedules can be worked out with the help of the student's academic advisor that will enable the student to fulfill special academic requirements as well as Co-op. These include four-year Co-op programs for students with advanced placement, and combined BS/MS programs. Co-op students are required to register at Northwestern for their work quarters, but no tuition or fee is charged.

Although emphasis is placed upon the experience gained from Co-op work rather than upon the income, Co-op students may earn a sizable portion of their educational expenses.

In addition to the academic degree, the faculty of the McCormick School awards the Co-op student a certificate in recognition of successful completion of the Cooperative Engineering Education Program.

**Two BS Degrees**

Students with a wide range of interests may work toward two Bachelor of Science degrees in engineering, or a BS in engineering and a second bachelors degree from one of Northwestern's other schools. In either case all requirements for both degrees must be satisfied, double counting courses that apply to both degrees. In the case of two engineering degrees, at least 54 course units must be completed, along with the 12 quarter Undergraduate Residency Requirement (URR). If one of the degrees is outside of engineering then the student must meet a 15 quarter URR. Advanced placement, transfer credit, or other means may be used to reduce the URR as described in detail in the undergraduate catalog. The catalog may be found at
http://www.registrar.northwestern.edu/nucatalog/

**BS/MS Program**

An option open to mechanical engineering undergraduates is the combined BS/MS program. Integrated planning of course work allows simultaneous study in undergraduate and graduate courses and early entrance into project or research work. Advanced placement, course exemption, and/or demonstrated proficiency may make it possible to complete the combined program in less than the normal five years. Students seeking a Bachelor of Science degree and a Master of Science degree should contact the Mechanical Engineering Department Chair, and the Associate Dean for Undergraduate Affairs.

**McCormick School of Engineering and Applied Science Scholars Program**

A high school student admitted into this program is almost immediately involved in the research program of an active faculty. Generally, the student will engage in research both during the academic year and during the summer, when he or she would be supported by the faculty or the McCormick School. Students in this program follow an accelerated academic curriculum, capitalizing upon advanced placement credits. Depending upon the advanced standing and record at Northwestern the student might be admitted to the Graduate School in the Ph.D. program as early as the third academic year. Support for the student (full tuition and stipend) would then be provided by the university through a Cabell or Murphy Fellowship. This program provides an opportunity for outstanding high school students to obtain their Ph.D. degrees in as little as six years after their high school graduation. The students are provided with continuous opportunities to interact directly with active researchers and to publish in recognized scientific journals at an early age.

**Undergraduate Honors Program**

A student with a good scholastic record may be admitted to the Undergraduate Honors Program anytime during the junior or pre-senior year. At the time of admission, the student must have a cumulative grade point average of 3.5 or better. An honors student participating in the program must complete at least three units of approved advanced study (including courses normally accepted at the graduate level) with an average grade of B or better, and complete an extended independent study project (at least two quarters on the same topic) leading to an acceptable report. Successful completion of the Honors program will be noted on the student's transcript. Recognition will also be given in the commencement program. If a student's individually evaluated performance is not judged to meet the standards of success, the student will receive course grades and credit as earned.

**Business Basics Certificate**

Since many McCormick graduates choose to enter the business world, McCormick offers a Business Basics Certificate for Engineers. The requirements for non co-op students include course work (six courses from a list of approved courses), six months of work experience, and an Industry Experience Report on the student's preparation for a business-oriented career. A total of 52 course units are required (four in addition to the degree requirements). The requirements for co-op students includes course work (four courses from a list of approved courses) and a co-op certificate. A total of 50 course units are required (two courses in addition to the degree requirements). For additional information see

http://www.mccormick.northwestern.edu/undergraduate/businessbasics.html.

**Certificate in Engineering Design**

The Certificate in Engineering Design program helps McCormick undergraduates develop a set of design skills that will prove valuable in their careers. The program focuses on innovative engineering design in a team-based, cross-disciplinary setting. "Innovative design" here implies both identifying and solving real-world problems. The Certificate in Engineering Design requirements include 2.5 course units in required IDEA courses, 3.5 units from a list of approved courses, and the preparation of an Engineering Design Portfolio. At least five of the courses needed for the Certificate in Engineering Design may not also be used to fulfill the requirements in the "Major Program" of your BS degree as described in the undergraduate catalog. No certificate courses may be taken P/N. For additional information see http://www.idea.northwestern.edu/programs/cert.html

**STUDENT ADVISING**

Each student is assigned a faculty member as an advisor. Students meet with their advisors on a regular basis at least once each quarter, usually during the fifth or sixth week of the quarter. Advisors help students select appropriate courses to satisfy both the departmental and McCormick requirements, and the student's own interests. In the Spring Quarter, the student and advisor design a tentative schedule of courses for the following academic year. In each of the remaining quarters, the advisor and student discuss the student's progress and verify or modify the schedule for the next quarter. Students are also invited to meet with their advisors at any time during the year to discuss academic problems, academic goals, professional development, and career goals. Advisors are assigned by the department, however, students can request a change of advisor by filling out a form in the Academic Services Office (Room L269). The Dean may require a student having academic difficulties to meet with his or her advisor to discuss those difficulties.

Certain faculty have been designated as resources regarding undergraduate curriculum questions in each listed program. Contact the Academic Services Office (L269) for contact information.

**PEOPLE AND PLACES TO KNOW**

**Undergraduate Engineering:**

| | | |
|---|---|---|
| Stephen H. Carr, Associate Dean | Room L268 | 491-7379 |
| Betty Modlin, Department Assistant | Room L268 | 491-7379 |

The McCormick Office of Undergraduate Engineering works as a liaison between students and the engineering faculty.

**Counseling:**

| | | |
|---|---|---|
| Ellen Worsdall, Assistant Dean | Room L291 | 491-5173 |
| Joseph Holtgreive, Assistant Dean | Room L270 | 491-3332 |
| Gwen Murphy, Coordinator of Student Involvement | Room L291 | 491-5195 |

In addition to the University's Counseling and Guidance Office, McCormick has its own counseling offices, augmented by faculty advisors, the Freshman Program Office, and Dean Carr's office. Interest (career) testing can also be arranged by McCormick counselors.

**McCormick Academic Services Office:**

| | | |
|---|---|---|
| Donna Tobias, McCormick Registrar | Room L269 | 491-3120 |
| Mary Stanton, Freshman/Sophomore Program Coordinator | Room L269 | 491-5261 |
| Joanna Foley, Classroom Scheduling | Room L269 | 491-4363 |

The Academic Services Office keeps track of all academically-related data on McCormick students.. The office maintains check-off sheets (forms used to record classes already taken, still required, and grades received); maintains current lists of locations and meeting times for classes; handles change-of-majors, petitions to take course work at other institutions, drop/adds, etc.

**Walter P. Murphy Cooperative Engineering Education Program Office:**

| | | |
|---|---|---|
| Helen Oloroso, Director | Ford Bldg., 2-350 | 491-8669 |
| Thy Nguyen, Associate Director | Ford Bldg., 2-350 | 491-2613 |
| Michelle Bledsoe, Recruitment Coordinator | Ford Bldg., 2-350 | 491-5994 |
| Bradley Baker, Program Assistant | Ford Bldg., 2-350 | 491-3366 |

The Co-operative Education Program Office provides information and arranges contacts with potential employers for students participating in the Co-op program.

**Student Activities:**

| | | |
|---|---|---|
| Ellen Worsdall, Assistant Dean | Room L291 | 491-5173 |
| Gwen Murphy, Coordinator of Student Involvement | Room L291 | 491-5195 |

The Coordinator of Student Activities serves as a counselor, consultant and facilitator to assist engineering organization officers in planning various student activities. These diverse activities are designed primarily to provide professional information to members of the organization as well as personal development for future career choices.

**Study Abroad:**

Joseph Holtgreive, Assistant Dean Room L270 491-3332

Students interested in studying abroad for a quarter or more should see Dean Holtgrieve. Students must complete a petition and have their plans approved prior to starting any program of study at another institution.

**Tech Tutoring Program:**

Coordinator of Student Involvement Room L291 491-5195

McCormick offers free tutoring which is available in the afternoon and in the evening to undergraduate engineering students. The program is conducted in an informal manner with a flexible approach to insure individual needs are met. Students work one-on-one with a tutor, or, when appropriate, will work together in groups led by a tutor. Tutors are available to help with math, chemistry, physics, computer, and basic engineering courses. A schedule of tutoring times and subjects covered is posted outside Room LG52, where tutoring takes place.

**Counseling and Psychological Services (CAPS)**

633 Emerson Street 2nd floor 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.

## CAREER PLANNING AND INFORMATION RESOURCES

Mechanical Engineering graduates from Northwestern University are well prepared for employment in a wide spectrum of industries, ranging over transportation, heavy and light machinery, machine and precision tools, construction equipment, heating and refrigeration, power and energy, and robotics. Engineering and consulting firms and government laboratories and agencies also offer many career opportunities. Typical assignments involve work in product development, design, production, or sales, all utilizing the scientific and engineering background obtained on campus. New problem areas relating to energy, materials, pollution control, electronic packaging, medicine, and aerospace offer challenges for the future as well.

Many graduates continue their education as graduate students on a part-time or full-time basis. Medical, dental, law and business schools readily accept a mechanical engineering degree as a firm basis for further professional study. In addition, graduate programs leading to the Master's or Doctoral degree in mechanical engineering provide opportunities for preparation in research and teaching in mechanical engineering, in universities and industrial or government laboratories.

**UNIVERSITY CAREER SERVICES**:

**Lonnie Dunlap, Director - URL: http://www.northwestern.edu/careers**

620 Lincoln Street, (847) 491-3700, fax: (847) 491-2573

The mission of University Career Services is to support Northwestern University's academic programs by designing, implementing and managing services, programs and systems that meet the career development and employment needs of students and that meet the staffing needs for University students and graduates of local, regional, national and international employers. You are encouraged to register early since many employers seeking engineers visit campus during the Fall Quarter. As you engage in the transition from student to employed engineer, it is recommended that you take full advantage of the following resources to strengthen your career plans and to enhance your employment options:

Services include:

- Campus Interviews, resume referral service, and job listings via JOBTRAK - http://www.jobtrak.com
- Individual career and employment counseling/Express advising hours
- Resume & cover letter development
- Employer research tools including: Career Search database, employer videos, brochures and annual reports
- Job Search workshops and special events such as Class Conferences and the Career Expo job fair
- GETAJOB and PhD listservs/Engineering & Science web site: http://www.stuaff.nwu.edu/ucs/engineering
- Campus interviews and job listings via JOBTRAK - http://www.jobtrak.com
- Internships, part-time and temporary jobs
- CDC/NUSEP listserv

## MECHANICAL ENGINEERING DEPARTMENT FACILITIES

The facilities of the newly reconstructed mechanical engineering laboratories provide many opportunities for undergraduates to explore quantitatively the implication of fundamental laws through application to practical problems in heat transfer, fluid flow, vibration, dynamics and control, manufacturing processes and engineering design. The undergraduate instrumentation laboratory uses state-of-the-art computers and associated electronics for investigations requiring sophisticated mechanical measurements and data acquisition. The prototyping shop provides space and equipment, including machine tools, for prototyping designs and building experimental apparatus. The laboratories shared with the Manufacturing Engineering Program contain powerful workstations for computer-aided design and a variety of modern computer-controlled machine tools and a workstation lab.

## STUDENT ORGANIZATIONS

The American Society of Mechanical Engineers (ASME), the Society of Automotive Engineers (SAE), and Pi Tau Sigma (mechanical engineering honor society) have student sections at Northwestern University. For further information see the faculty advisors:

| | |
|---|---|
| ASME | Dr. W. Chen |
| SAE | TBA |
| Pi Tau Sigma | Dr. Mitra Hartmann |

## 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.*
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**Oluwaseyi Balogun,** Assistant Professor; BSc, University of Lagos, Nigeria; MS, PhD, Boston University.
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**Ted Belytschko**, Walter P. Murphy Professor; BS, PhD, Illinois Institute of Technology.
*Computational mechanics; finite elements; multiscale methods; computational nanomechanics.*
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**L. Catherine Brinson**, Jerome B Cohen Professor of Engineering and Chair; BS, Virginia Polytechnic Institute and State University; MS, PhD, California Institute of Technology.
*Polymesr, nanocomposites, biomaterials and smart materials; micromechanics and characterization.*
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**Jian Cao**, Professor and Director of Graduate Studies; BS, Shanghai Jiaotong University; SM, PhD Massachusetts Institute of Technology.
*Mechanics and optimization of manufacturing processes at multi-scales; instability analysis; solid mechanics.*
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**Wei Chen**, Professor; 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; consumer preference modeling; engineering decision making*.
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**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.*
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**Isaac M. Daniel**, Walter P. Murphy Professor; Director, Center for Intelligent Processing of Composites, Theoretical and Applied Mechanics Program; BS, MS, PhD, Civil Engineering, Illinois Institute of Technology.
*Applied mechanics; composite materials; nondestructive evaluation.*
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**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.
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**Horacio D. Espinosa**, Professor, BS, Northeast National University, Argentina, MS, PhD Brown University.
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**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.*
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**Walter B. Herbst**, Clinical Professor; Co-Director, Master of Product Development Program; BFA, University of Illinois, MS, Northwestern University.
*The totality of the issues related to product development.*
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**Leon M. Keer**, Walter P. Murphy Professor, Director, Center for Surface Engineering and Tribology; BS, MS, California Institute of Technology, PhD, University of Minnesota.
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**Wing Kam Liu**, Walter P. Murphy Professor; BS, University of Illinois at Chicago; MS, PhD, California Institute of Technology.
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**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.
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**Kevin M. Lynch**, Professor and Associate Chair, PhD, Carnegie Mellon University.
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**Malcolm MacIver**, Assistant Professor; BS, MA, University of Toronto; PhD, University of Illinois.
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**Todd Murphey**, Assistant Professor; BS, University of Arizona; PhD, California Institute of Technology.
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**Neelesh A. Patankar**, Associate Professor, BTech, Indian Institute of Technology, Bombay, MS, PhD, University of Pennsylvania.
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**Michael A. Peshkin**, Professor; BS, University of Chicago; MS, Cornell University; PhD, Carnegie-Mellon University.
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**Cheng Sun**, Assistant Professor; BS, MS, Nanjing University; PhD, Pennsylvania State University.
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**Q. Jane Wang,** Professor; BS, Shaanxi Institute of Mechanical Engineering; MS, Northern Illinois University; PhD, Northwestern University.
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## Professors with Courtesy Appointments in the Mechanical Engineering Department:

**Jose E. Andrade**, Assistant Professor (Home Department CEE); BS, Florida Tech; MS, PhD, Stanford University.
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**Yip-Wah Chung**, Professor (Home Department – MSE); BS, University of Hong Kong; PhD, University of California, Berkeley.
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**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.*
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**Stephen H. Davis,** Walter P. Murphy Professor (Home Department ESAM); BEE, MS, PhD, Rensselaer Polytechnic Institute
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**Bernard J. Matkowsky**, John Evans Professor (Home Department – ESAM); PhD, Courant Institute of Mathematical Science.
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**Michael J. Miksis**, Professor (Home Department – ESAM); BS, Drexel University, MS, PhD, Courant Institute of Mathematical Sciences.
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**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.*
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**Julio M. Ottino**, Walter P. Murphy Professor (Home Department – ChBE); Dean, McCormick School; BS, MS, National University of LaPlata, Argentina; PhD, University of Minnesota.
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J**ames L. Patton**, Research Assistant Professor (Home Department – MED – Physical Med & Rehab); BS, University of Michigan; MS, Michigan State University; PhD, Northwestern University.
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## Emeritus Professors:

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**Alan L. Kistler**, BS, MS, PhD, Johns Hopkins University.
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**Arthur A. Kovitz**, BSE, MS, University of Michigan; PhD, Princeton University.
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**David A. Mintzer**, BS, PhD, Massachusetts Institute of Technology.
*Acoustic wave propagation; rarefied gas dynamics.*

**Toshio Mura**, Professor Emeritus; MS, PhD, University of Tokyo.
*Fracture and fatigue; nondestructive measurement; composite materials; thin films.*

**Henry W. Stoll**, Professor; BS, Valparaiso University; MS, University of Michigan; PhD, University of Illinois.
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**Man-Chuen Yuen**, BS, Purdue University; MS, Massachusetts Institute of Technology; PhD, Harvard University.
*Heat transfer; fluid mechanics; multiphase flow.*