

UNIVERSITY OF PITTSBURGH

Mechanical Engineering

Undergraduate Academic Program Manual

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Forward

This *Mechanical Engineering Undergraduate Academic Program Manual* is a supplement to the information provided on the *University of Pittsburgh Swanson School of Engineering Web Site* (www.engineering.pitt.edu), which is the official source of information about the School's academic programs and degree requirements. This supplemental manual provides specific information about departmental policies, procedures, and programs that is not included in the Swanson School of Engineering Web Site, as well as some relevant information from the Swanson School of Engineering Web Site.¹ It is provided so that you will be better informed about your department and for your convenience in monitoring your progress towards completion of your degree.

¹If there are any discrepancies between the *Mechanical Engineering Undergraduate Academic Program Manual* and the *Swanson School of Engineering Web Site*, then the ultimate authority is the *Swanson School of Engineering Web Site*.

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Chapter 1

About Mechanical Engineering

Prospective students often ask, “What is mechanical engineering? What do mechanical engineers do, exactly?” In an attempt to answer these questions, the American Society of Mechanical Engineers (ASME) offers the following:

Mechanical engineering plays a dominant role in enhancing safety, economic vitality, enjoyment and overall quality of life throughout the world. Mechanical engineers are concerned with the principles of force, energy, and motion. The men and women who work as mechanical engineers are professionals with expert knowledge of the design and manufacturing of mechanical systems and thermal devices and processes. Some examples of products and processes developed by mechanical engineers include engines and control systems for automobiles and aircraft, electric power generation plants, lifesaving medical devices and consumer products ranging from air conditioners to personal computers and athletic equipment. They also design the machines that mass-produce these products. Virtually every aspect of life is touched by mechanical engineering. If something moves or uses energy, a mechanical engineer was probably involved in its design or production.¹

The breadth and diversity of the profession requires an undergraduate curriculum that provides a solid foundation in the basic sciences, computational skills including the use of the latest sophisticated software tools, and the fundamentals of engineering and engineering design. The curriculum provides a base for future professional growth and is also an excellent background for those who wish to pursue careers in other professions, such as management, law, or medicine.

The Bachelor of Science programs in this department are fully accredited by the Accreditation Board for Engineering and Technology (ABET), which is the accreditation organization for engineering and technology programs in the United States.

¹ASME Brochure MP0398, *What is a Mechanical Engineer?*

1.1 Program Educational Objectives

Consistent with the criteria set by ABET, the overall educational objective of the undergraduate program in the Department of Mechanical Engineering and Materials Science is to educate students with excellent technical capabilities in the mechanical engineering discipline and related fields, who will be responsible citizens and continue their professional advancement through life-long learning.

In their career and professional activities, we expect our graduates to:

- Demonstrate successful application of mechanical engineering knowledge and skills for industry, public sector organizations, or their profession.
- Pursue life-long learning through advanced professional degrees, graduate studies in engineering, professional training, or engineering certification.
- Demonstrate professional and intellectual growth as leaders in their profession and/or community.

1.2 Curriculum Overview

The curriculum is designed to educate in four years a professional engineer who has, and will continue to have, a wide range of career options. In the first two years, the Mechanical Engineering curriculum concentrates on the fundamentals of the sciences, mathematics, and engineering. The last two years provide increased depth in the engineering sciences, including thermodynamics, fluid mechanics, heat transfer, and systems analysis, and in engineering applications such as mechanical measurements, manufacturing, mechanical design, and thermal systems. Students have the freedom to pursue areas of personal interest in mechanical engineering via their choice of technical elective courses.

Course work in the humanities and social sciences is included for the enhancement of the student's awareness of the importance of social, political, and economic problems in the practice of engineering. Where appropriate, the upper-level Mechanical Engineering courses introduce consideration of human values, social benefits, and social constraints to prepare future practicing engineers to be responsive to such concerns.

The following undergraduate programs are available in our department:

- Bachelor of Science in Mechanical Engineering (Chapter 2, page 7)
- Bachelor of Science in Mechanical Engineering via the 3/2 Program (Section 5.12, page 38)
- Combined CAS-Engineering Joint Degree (Section 5.1, page 35)
This program requires *all* of the requirements for two degrees, such as Computer Science and Mechanical Engineering, to be fulfilled. This program usually takes 5–6 years to complete.

In addition, each of the departments in the School of Engineering offers minors in such diverse areas as bioengineering, petroleum engineering, and environmental engineering (Section 5.7,

page 37). A student may earn a minor along with a Bachelor of Science in Mechanical Engineering. Each of the above degrees can be obtained in conjunction with the Cooperative Education Program (Section 5.6, page 36).

1.2.1 Mechanical Engineering Design

Design is central to mechanical engineering. The design experience begins in the freshman year through the design of computer programs. This introduces the student to the concept of problems that have more than one valid solution and to methods for generating parametric solutions to problems. Ill-defined problems are also introduced in the freshman year, so that the student begins to learn the necessity of restating problems and how to deal with insufficient information.

In the sophomore year, the design experience is expanded to include the construction of physical models. During the same year, students learn to use computer-aided engineering design tools. The students also address design problems and problems in manufacturing, mechanisms, and thermo-fluids engineering.

In the junior year, students continue to expand their knowledge of design by addressing problems and projects in courses on mechanical design, applied thermodynamics, and applied fluid mechanics. During this year, students are also introduced to the finite element method and learn how to use ANSYSTM, a commercial implementation of the finite element method, as a tool in mechanical design.

Design is a large part of the senior year. Design problems in heat transfer and a second course in mechanical design are included in the first term. All seniors are also required to take a capstone design course in which small groups of students work with a faculty member to design, manufacture, and test a product or some aspect of a product. Often, problems of interest to local industry are used. Students are given a modest budget and objectives to meet, and are required to create a project plan, develop drawings, procure parts and materials, manufacture parts to assemble and operate the device, and report on the results in a manner that is common in industry.

1.2.2 Teamwork

Small groups of students usually work together on design projects. The objective behind employing this approach is to help students learn how to work as part of a team. Students also learn about other important facets of mechanical engineering, including ethical issues and meeting budget and schedule constraints.

1.2.3 Written and Oral Communication

A mechanical engineer must be able to communicate effectively to be successful. The engineering admission requirements include a verbal SAT score of at least 500. All freshmen are tested during orientation for proficiency in English writing and literacy. If they score below a satisfactory level, they are required to take a basic writing course, which does not count toward the degree requirements. Students are also required to take a Communication Skills Elective (Section 2.6, page 21). Subsequent laboratory and project reports reinforce the

skills learned in this elective. The senior design project course includes a written report and an oral presentation during a symposium held near the end of the term. Each presentation is videotaped and students are required to view the video of their talk.

1.2.4 Computer Experience

Computer experience is distributed throughout the Mechanical Engineering curriculum. In the freshman year, students are introduced to computer programming, the use of spreadsheets, and word processors. Students perform programming assignments, illustrating selected numerical methods applied to problems in engineering analysis. Students receive instruction in the computer application MatlabTM in addition to the programming languages C and HTML.

In the sophomore year, mechanical engineering students learn to use a proprietary solid modeling application, an integrated software package that allows development of parametric models in two and three dimensions and generates design drawings. Students are also exposed to programming of CNC machines.

In addition, many of the technical electives involve extensive use of computers. For example, the digital control courses involve machine language programming of microcomputer boards.

1.2.5 Laboratory Experience

The Mechanical Engineering program has long emphasized a balanced theoretical/experimental curriculum in its undergraduate program. To accomplish this balance, traditional mechanical engineering courses are supplemented by an experimental mechanical measurements sequence. This sequence consists of three courses, which begin in the second term of the junior year.

MECHANICAL MEASUREMENTS 1 consists of 12 one-week experiments covering a wide range of topics from flow measurements to strain measurements and touching on practically all of the major areas of mechanical engineering. This is a hands-on course, where the students are exposed to a wide variety of measuring instruments and various recording, signal processing, and readout techniques and devices. Each student is required to prepare a laboratory report for every experiment, describing the experimental procedure, results and conclusions.

MECHANICAL MEASUREMENTS 2 is a laboratory course that teaches students how to properly design and perform experiments on complex mechanical systems, in order to determine specific characteristics or performance of that system. Included within this framework is knowledge of instrumentation, data acquisition, and data analysis. Students are required to give technical presentations.

The SENIOR DESIGN PROJECT is the senior capstone project. The objective of this course is to expose the students to real world engineering problems and situations. Many of the projects performed consist of integrated product and process development, system analysis, design, and manufacturing problems suggested by industry. The students are divided into small groups and work for the full term under the direction of a faculty advisor and, in most instances, an industrial advisor. The results of their investigations are reported

in a formal written report, a poster display, and by an oral presentation at the Technical Symposium at the end of the term.

1.2.6 Student Development in Engineering Professional Practice

Ethics and professionalism are presented to students by example in most courses and by the actions and attitudes of the faculty. Each year, as a part of the required departmental seminar, speakers on ethics and professionalism are invited to give a presentation. Also, the senior technical symposium in which all students make presentations is conducted in the manner of a professional meeting.

There are two student chapters of professional societies in the department, the American Society of Mechanical Engineers (ASME) and the Society of Automotive Engineers (SAE). Both regularly participate in national or regional activities. Each year, SAE student members design and build a formula car, which they enter into a national competition. Pi Tau Sigma, the National Honorary Mechanical Engineering Fraternity, is also active in the department.

Chapter 2

Undergraduate Curriculum

The requirements for obtaining a Bachelor of Science (B.S.) degree in Mechanical Engineering are described below. In addition to required courses within and outside of the Mechanical Engineering and Materials Science Department, students are also required to take four (4) Mechanical Engineering Technical Electives, one (1) Engineering Elective, six (6) Social Science and Humanities Electives, and one (1) Communication Skills Elective. There are a total of 128 passed units required for graduation, all of which must be taken with the letter grade option.

2.1 Required Mechanical Engineering Courses

Students must satisfactorily complete the following sixteen (16) Mechanical Engineering courses, for a total of forty-five (45) units.

MEMS 0024 INTRODUCTION TO MECHANICAL ENGINEERING DESIGN (3 units)
Provides knowledge of design graphics and manufacturing processes by conventional and computer-aided methods. Prerequisite: ENGR 0011.

MEMS 0031 ELECTRICAL CIRCUITS (3 units)
The study of linear circuit networks, including constitutive equations for circuit elements and Ohm's and Kirchoff's laws. Mesh and node equations, Thevenin/Norton equivalents, maximum power transfer, transient and AC analyses, and operational amplifiers. Prerequisite: PHYS 0175. Corequisite: MATH 0290.

MEMS 0040 MATERIALS & MANUFACTURING (3 units)
Manufacturing and processing of ceramics, semiconductors, metals, and polymers covering refining, product formation, and control of properties. Prerequisite: ENGR 0022.

MEMS 0051 INTRODUCTION TO THERMODYNAMICS (3 units)
Synthesis of the basic concepts from thermodynamics and fluids, including: properties of pure substances, first law analysis, and introduction to the second law; fluid statics, kinematics, stress, and viscosity; and control volume analysis of the conservation equations. Prerequisites: PHYS 0174, CHEM 0960. Corequisite: MATH 0290.

MEMS 0071 INTRODUCTION TO FLUID MECHANICS (3 units)

Fundamental of fluid mechanics, with emphasis on inviscid and linearly viscous, incompressible fluids. Basic physical phenomena of fluid mechanics. Fluid kinematics. Governing equations (both integral and local forms). Exact solutions. Internal flows. Dimensional analysis and modeling. Prerequisites: PHYS 0174, CHEM 0960. Corequisite: MATH 0290.

MEMS 1014 DYNAMIC SYSTEMS (3 units)

Modeling and analysis of physical systems. Time and frequency domain analysis. Transient and steady-state system response to various excitations. Transfer function and state space model representations. Laplace and Fourier transforms. Prerequisites: MATH 0280, ENGR 0012, MEMS 0031.

MEMS 1015 RIGID-BODY DYNAMICS (3 units)

Dynamics of rigid bodies including energy methods, conservation of momentum, problems of varying forces and constraints, relationship of motion to different reference frames and Euler's equations. Prerequisites: MATH 0240, ENGR 0135.

MEMS 1028 MECHANICAL DESIGN 1 (3 units)

Stress and deflection analysis; survey of mechanical design criteria; selection and application of working stresses for ductile and brittle materials; static, fatigue, and impact loading and combination of stresses. Prerequisite: ENGR 0145.

MEMS 1029 MECHANICAL DESIGN 2 (3 units)

Design and selection of various machine components including bearings, belts, gears, chains, screws, brakes, clutches, shafts and springs. Emphasis is placed on how these components are incorporated into various machines. Case studies, laboratory mini-projects and an open ended design project are also included. Prerequisites: MEMS 0024, MEMS 1028.

MEMS 1041 MECHANICAL MEASUREMENTS 1 (3 units)

Fundamentals of mechanical measurement, including steady-state measurement, but stressing dynamic signal inputs, detector-transducer elements, signal conditioning, and readout systems. Standards, instrument calibration, data treatment, error analysis. Prerequisites: ENGR 0145, MEMS 0031. Corequisite: MEMS 1014.

MEMS 1042 MECHANICAL MEASUREMENTS 2 (3 units)

Design of experiments, instrumentation, data acquisition, data analysis, and data presentation techniques as applied to complex mechanical systems. Prerequisite: MEMS 1041.

MEMS 1043 SENIOR DESIGN PROJECT (3 units)

A major project involving literature search, planning, design, fabrication, experimentation, analysis, and technical report writing is performed by a small team of students under the guidance of a faculty director and culminates in an oral presentation at a technical symposium. Prerequisite: *senior standing*.

MEMS 1051 APPLIED THERMODYNAMICS (3 units)

Thermodynamic processes, energy and entropy changes in real and ideal gases, vapors, and liquids, and mixtures of those fluids. Basic thermodynamic cycles (vapor and gas power, refrigeration, and heat pumps). Thermodynamic property relations. Prerequisite: MEMS 0051.

MEMS 1052 HEAT & MASS TRANSFER (3 units)

One and two-dimensional steady and unsteady-state conduction, empirical and practical relations for forced and natural convection. Principle of radiation using “radiation network” method. Heat exchangers and special topics. Prerequisite: MEMS 0051.

MEMS 1071 APPLIED FLUID MECHANICS (3 units)

Basic principles of computational fluid dynamics (CFD). Hands-on experience using a commercial CFD package. Students will use this tool to solve a design problem. External flows with particular emphasis on aerodynamics. Fluid machinery. Experimental fluid mechanics. Prerequisite: MEMS 0071.

MEMS 1085 DEPARTMENTAL SEMINAR (0 units)

Seminars are designed to acquaint the student with aspects of mechanical engineering not normally encountered in classes and include a wide range of topics such as the significance of engineering as a profession and the relation of engineering to current social problems.

2.2 Other Required Courses

Students must satisfactorily complete each of the following courses from outside of the Mechanical Engineering and Materials Science Department. There are fourteen (14) of these courses for a total of forty-seven (47) units.

CHEM 0960 GENERAL CHEMISTRY FOR ENGINEERS 1 (3 units)

The courses CHEM 0960 and 0970 comprise a two-term introduction to the fundamental properties of matter. The courses emphasize applications to industrial and environmental chemistry and biochemistry. CHEM 0960 covers stoichiometry; the properties of solids, liquids, and gases; thermochemistry; and the electronic structure of atoms and molecules. It includes three hours of lecture per week and one hour of recitation per week. Enrollment is limited to School of Engineering students. An Honors Section is available. (If a student has difficulty enrolling in CHEM 0960, then CHEM 0110 is an acceptable substitute.)

CHEM 0970 GENERAL CHEMISTRY FOR ENGINEERS 2 (3 units)

The course emphasizes applications to industrial and environmental chemistry and biochemistry, building upon material presented in CHEM 0960 or 0110. Enrollment is limited to School of Engineering students. An Honors Section is available. (If a student has difficulty enrolling in CHEM 0970, then CHEM 0120 is an acceptable substitute.) Prerequisite: CHEM 0110 or CHEM 0960.

ENGR 0011 INTRODUCTION TO ENGINEERING ANALYSIS (3 units)

Introduction to engineering analysis and engineering design. Includes units and conversion factors, graphs, data analysis and curve fitting. Use of spreadsheets. Introduction to engineering analysis, including statics, strength of materials, electrical circuits, heat transfer, fluid mechanics, and introduction to rate phenomena. Applications to engineering design. Fundamentals of report writing.

ENGR 0012 ENGINEERING COMPUTING (3 units)

Course is designed to teach students the fundamentals of computing and the concept of engineering design as applied to the design of software. Fundamentals include basic computer organization, formulation of algorithms, basic data structures, pseudo-code, and top-down iterative refinement. In the concurrent laboratory, proficiency is developed in a high-level language and a text editor/word processor. Prerequisites: ENGR 0012.

ENGR 0022 MATERIAL STRUCTURE & PROPERTIES (3 units)

An introduction to the basic concepts of materials science and engineering. The concepts of atomic, crystal, micro- and macrostructure; and their control and effects on chemical, electrical, magnetic, optical, and mechanical properties. Modification of properties by heat treatment and control of processing. Fundamental considerations in materials selection. Prerequisites: MATH 0230, PHYS 0174.

ENGR 0135 STATICS & MECHANICS OF MATERIALS 1 (3 units)

A basic course in statics and mechanics of materials. Topics covered include the effect of external forces acting on particles and deformable bodies. The free-body diagram is emphasized. Use is made of computers for problem solving. Prerequisites: MATH 0230, PHYS 0174.

ENGR 0145 STATICS & MECHANICS OF MATERIALS 2 (3 units)

An introductory course in the mechanics of deformable solids. Material covers the internal stresses, strains, and displacements that occur when a structure is subjected to applied loads. Open-ended design problems are presented and discussed. Prerequisite: ENGR 0135

MATH 0220 ANALYTIC GEOMETRY & CALCULUS 1 (4 units)

First of a sequence of three basic calculus courses intended for all engineering, mathematics, statistics, and science students. It covers the derivative and integral of functions of one variable and their applications. Honors Section is also available. Prerequisite: MATH 0032 or MATH 0200.

MATH 0230 ANALYTIC GEOMETRY & CALCULUS 2 (4 units)

Second of a sequence of three basic calculus courses intended for engineering, mathematics, statistics, and science students. It covers the calculus of transcendental functions, techniques of integration, series of numbers and functions, polar coordinates, and conic sections. Honors Section is also available. Prerequisite: C or better in MATH 0220.

MATH 0240 ANALYTIC GEOMETRY & CALCULUS 3 (4 units)

Third of a sequence of three basic calculus courses intended for engineering, mathematics, statistics, and science students. It covers vectors and surfaces in space and the calculus of functions of several variables including partial derivatives and multiple integrals, Stokes theorem, and first-order differential equations. Honors Section is also available. Prerequisite: C or better in MATH 0230.

MATH 0280 INTRODUCTION TO MATRICES & LINEAR ALGEBRA (3 units)

The topics which this course cover include: vectors, matrices, determinants, linear transformations, eigenvalues and selected applications. Prerequisite: MATH 0220.

MATH 0290 DIFFERENTIAL EQUATIONS (3 units)

The course presents an introduction to the theory of differential equations from an applied perspective. Topics covered include linear and nonlinear ordinary differential equations, Laplace transforms, and introduction to partial differential equations. Prerequisite: MATH 0230.

PHYS 0174 BASIC PHYSICS FOR SCIENCE & ENGINEERING 1 (4 units)

First of a sequence of two basic physics courses for science and engineering students. Subjects covered include: kinematics; Newton's laws of motion; energy; momentum, rotational motion, rigid body motion, angular momentum, simple harmonic motion, gravitation, mechanical waves, sound waves, and the kinetic theory of gases. Recitation sections are for discussion of difficult points from the lecture and for reviewing homework assignments. Check time schedule of classes for associated recitation sections. The lecturer may use one of the lecture hours for student teamwork such as computer exercises, dependent on availability of suitable rooms. Corequisite: MATH 0220.

PHYS 0175 BASIC PHYSICS FOR SCIENCE & ENGINEERING 2 (4 units)

Second of a sequence of two basic physics courses for science and engineering students. Subjects covered include: electrostatics, electric currents, magnetism, induction, simple AC circuits, Maxwell's equations, electromagnetic waves, geometric and wave optics, followed by an introduction to quantum physics, including photons, the Bohr atom and spectra, and elementary wave mechanics. Recitation sections are for discussion of difficult points from the lecture and for reviewing homework assignments. Check time schedule of classes for associated recitation sections. The lecturer may use one of the lecture hours for student teamwork such as computer exercises, dependent on availability of suitable rooms. Prerequisite: PHYS 0174. Corequisite: MATH 0230.

2.3 Mechanical Engineering Technical Electives

Students are required to satisfactorily complete four (4) of the following Mechanical Engineering Technical Elective courses, for a total of twelve (12) units. The courses are first presented by general subject area, to assist students who wish to choose courses from an area of personal interest (note that some courses are listed under more than one subject area). *At least one* of the four technical electives must be from the Dynamics Systems subject area. The courses are then listed in numerical order with course descriptions. Included is a selection of 2000-level (i.e., Masters-level) courses that students may use to satisfy the technical elective requirements.

Note also the following:

- Co-op students can earn three (3) units for a written report on their co-op experience, which may be substituted for one of the technical electives. However, the Dynamic Systems Technical Elective requirement must still be satisfied.
- Upper-level engineering courses from other engineering departments may be substituted for Mechanical Engineering Technical Electives, subject to the approval of the Undergraduate Director. To request approval for such a substitution, the student must submit a *Technical Elective Approval Request* form to the Undergraduate Director. This is typically associated with the pursuit of a minor (Section 5.7, page 37).
- Technical electives are usually not offered during the Summer Term.
- Students must have completed the proper prerequisites before enrolling in any of the technical electives and should have acquired senior standing.

2.3.1 Technical Electives by Subject Area

Dynamic Systems

MEMS 1020 MECHANICAL VIBRATIONS

MEMS 1045 AUTOMATIC CONTROLS

MEMS 1049 MECHATRONICS

ME 2027 ADVANCED DYNAMICS

ME 2045 LINEAR CONTROL SYSTEMS

ME 2046 DIGITAL CONTROL SYSTEMS

ME 2080 INTRODUCTION TO MICROELECTROMECHANICAL SYSTEMS (MEMS)

ME 2082 PRINCIPLES OF ELECTROMECHANICAL SENSORS AND ACTUATORS

Engineering Mathematics & Computation

MEMS 1047 FINITE ELEMENT ANALYSIS

MEMS 1055 COMPUTER AIDED ANALYSIS IN TRANSPORT PHENOMENA

ME 2001 DIFFERENTIAL EQUATIONS

ME 2002 LINEAR AND COMPLEX ANALYSIS

ME 2060 NUMERICAL METHODS

Fluid/Thermal Systems

MEMS 1055 COMPUTER AIDED ANALYSIS IN TRANSPORT PHENOMENA
MEMS 1065 THERMAL SYSTEMS DESIGN
ME 2003 INTRODUCTION TO CONTINUUM MECHANICS
ME 2056 INTRODUCTION TO COMBUSTION THEORY

Materials Science & Engineering

MEMS 1010 EXPERIMENTAL METHODS IN MATERIALS SCIENCE & ENGINEERING
MEMS 1030 MATERIAL SELECTION IN MECHANICAL DESIGN
MEMS 1053 STRUCTURE OF CRYSTALS & DIFFRACTION
MEMS 1058 ELECTROMAGNETIC PROPERTIES OF MATERIALS
MEMS 1059 PHASE EQUILIBRIA IN MULTI-COMPONENT MATERIALS
MEMS 1063 PHASE TRANSFORMATIONS & MICROSTRUCTURE EVOLUTION
MEMS 1070 MECHANICAL BEHAVIOR OF MATERIALS
MEMS 1101 FERROUS PHYSICAL METALLURGY
MEMS 1102 PRINCIPLES & APPLICATIONS OF STEEL ALLOY DESIGN
MEMS 1103 PRINCIPLES & APPLICATIONS OF STEEL PROCESSING & DESIGN
MEMS 1162 COMPUTER APPLICATIONS IN MATERIALS SCIENCE & ENGINEERING
MEMS 1163 CERAMIC MATERIALS
MEMS 1172 PHYSICAL METALLURGY
MEMS 1174 CERAMIC PROCESSING
MEMS 1180 ADVANCED MECHANICAL BEHAVIOR OF MATERIALS

Manufacturing

MEMS 1030 MATERIAL SELECTION IN MECHANICAL DESIGN
MEMS 1033 FRACTURE MECHANICS FOR MANUFACTURING & PERFORMANCE
MEMS 1045 AUTOMATIC CONTROLS
MEMS 1047 FINITE ELEMENT ANALYSIS
MEMS 1049 MECHATRONICS
MEMS 1057 MICRO/NANO MANUFACTURING

Nuclear Engineering

ENGR 1700 INTRODUCTION TO NUCLEAR ENGINEERING
ENGR 1701 FUNDAMENTALS OF NUCLEAR REACTORS
ENGR 1702 NUCLEAR PLANT TECHNOLOGY

Solid Mechanics

MEMS 1030 MATERIAL SELECTION IN MECHANICAL DESIGN
MEMS 1033 FRACTURE MECHANICS FOR MANUFACTURING & PERFORMANCE
MEMS 1047 FINITE ELEMENT ANALYSIS
ME 2003 INTRODUCTION TO CONTINUUM MECHANICS
ME 2022 APPLIED SOLID MECHANICS

2.3.2 Technical Elective Course Descriptions

ENGR 1700 INTRODUCTION TO NUCLEAR ENGINEERING (3 units)

Overview course that provides broad subject-area coverage to introduce students to application of theory to practical aspects of nuclear science and technology in the world today with special emphasis on commercial nuclear power. Prerequisites: PHYS 0175; CHEM 0970.

ENGR 1701 FUNDAMENTALS OF NUCLEAR REACTORS (3 units)

Covers the nuclear reactor core and other components inside the reactor pressure vessel. Reactor core physics, energy removal from the core, heat transfer and fluid mechanics, reactor mechanical design, and selection of materials that can withstand the high temperature, high radiation environment of the reactor. Prerequisite: PHYS 0175; CHEM 0970.

ENGR 1702 NUCLEAR PLANT TECHNOLOGY (3 units)

Covers practical applications of nuclear energy to produce power for the generation of electricity or propulsion of mobile systems. Aspects of a nuclear power plant beyond the reactor vessel and the reactor core, prominent types of existing and future nuclear power plants with emphasis on the design and operating characteristics, primary systems and balance of plants systems, standards used in design of nuclear plants. Prerequisite: PHYS 0175; CHEM 0970.

MEMS 1010 EXPERIMENTAL METHODS IN MSE (3 units)

This laboratory will give the student practical experience of the experimental methods used in modern materials science and engineering. The first set of experiments will introduce the common methods for analyzing material structure including: optical microscopy, X-ray diffraction, and scanning electron microscopy (SEM). The second part of the course will concentrate on methods used to measure material properties such as the tensile test, hardness test, impact testing as well as electrical and magnetic property measurement methods. Prerequisite: ENGR 0022.

MEMS 1020 MECHANICAL VIBRATIONS (3 units)

Review of free and forced vibrations of single-degree-of-freedom systems with and without damping, multi-degree-of-freedom systems, vibration isolation, nonlinear vibrations, Lagrange's equations, and vibration of continuous systems. Prerequisite: MEMS 1014.

MEMS 1030 MATERIAL SELECTION IN MECHANICAL DESIGN (3 units)

Methodology for materials selection in mechanical design processes. Includes: (i) design process and consideration, (ii) criteria for materials and their shape selection, and (iii) design case study. Mechanical components have mass; they carry loads; they conduct heat and electricity; they are exposed to wear and to corrosive environments; they are made of one or more materials; they have shape; and they must be manufactured. This course provides knowledge on how these activities are related. Prerequisites: ENGR 0022, MEMS 1028.

MEMS 1032 AUTOMOTIVE DESIGN & FABRICATION (3 units)

Covers the basics of automotive fabrication. Students working as one team have the opportunity to experience hands-on application of both classical and modern manufacturing techniques while adhering to a very strict externally imposed deadline. The team effort culminates in the production of a high-performance automobile. Special permission required.

MEMS 1033 FRACTURE MECHANICS FOR MANUF. & PERFORM. (3 units)
An introduction to the principles of fracture mechanics; the essential concepts underlying appropriate materials selection including the effects of shape selection for maximum performance; and the strengths and weaknesses inherent in the choice of, say, metals versus ceramics versus polymers, etc. Prerequisites: ENGR 0022, MEMS 1028.

MEMS 1045 AUTOMATIC CONTROLS (3 units)
Modeling of mechanical systems and classical feedback control theory for single-input-single-output systems. Prerequisite: MEMS 1014.

MEMS 1047 FINITE ELEMENT ANALYSIS (3 units)
The finite element method applied to solid mechanics, fluid dynamics, and heat transfer. Prerequisites: MEMS 1028, MEMS 1052, MEMS 1072.

MEMS 1049 MECHATRONICS (3 units)
An introduction to Mechatronics, or the interfacing of mechanical and electrical systems. Focus is on embedded controllers (Motorola 68HC11 and PIC 16F84) and their programming, power and interfacing electronics, actuators, sensors, and integration of these components to create a complete functional mechatronic system. Prerequisite: MEMS 1014.

MEMS 1053 STRUCTURE OF CRYSTALS & DIFFRACTION (3 units)
Crystallography of materials; Bravais lattices, crystal systems, and crystal structures. Diffraction methods; X-ray, electron, and neutron scattering; atomic scattering factor; structure factor; powder techniques; Laue method; reciprocal lattice; electron diffraction; amorphous materials; thermodynamics of crystals and crystal defects; polymorphism; order-disorder phenomena. Prerequisite: ENGR 0022.

MEMS 1055 COMPUTER AIDED ANALYSIS IN TRANSPORT PHENOMENA (3 units)
Provides an introduction to implementation of some of the numerical/computational methods for solving problems in transport phenomena. Fluids described by linear and nonlinear ordinary differential equations (initial and boundary value problems), and partial differential equations (elliptic, parabolic, and hyperbolic) will be considered by means of various examples from fluid dynamics, heat and mass transfer, and combustion. Numerical discretization techniques based on finite difference methods (FDM) will be the main subject of discussions. Prerequisites: ENGR 0012, MEMS 0051.

MEMS 1057 MICRO/NANO MANUFACTURING (3 units)
Explores different micro/nano manufacturing options, material choices, and a variety of applications. The goal is to gain an understanding of various micro/nano fabrication techniques, learn major applications and principles of micro/nano systems, and develop an ability to design and fabricate new micro/nano systems.

MEMS 1058 ELECTROMAGNETIC PROPERTIES OF MATERIALS (3 units)
Review of basic principles—quantum theory, band and zone theory. Transport, electrical, and thermal properties; semiconductors and semiconductor devices; magnetic materials hard and soft; dielectric and optical properties. Prerequisite: ENGR 0022.

MEMS 1059 PHASE EQUILIBRIA IN MULTI-COMPONENT MATERIALS (3 units)
Thermodynamics of solutions with applications to materials systems; heterogeneous phase equilibria; relations between free energy and phase diagrams; electrochemistry; rate processes; thermodynamics of surfaces. Prerequisites: ENGR 0022, MEMS 0051.

MEMS 1063 PHASE TRANSFORMATIONS & MICROSTRUCTURE EVOLUTION (3 units)
Phase equilibria; binary and ternary system; phase rule; thermodynamics and phase diagrams; diffusion in materials; phase transformations; nucleation and growth kinetics; precipitation reactions; solidification; glass-forming systems; phase separation; displacive or martensitic transformations; microstructural development in metallic and non-metallic systems; electron theory of solids; zone theory; electrical and magnetic properties of materials. Prerequisites: MEMS 1053, MEMS 1059.

MEMS 1065 THERMAL SYSTEMS DESIGN (3 units)
Design, analysis, and optimization of thermal systems. Systems analysis applied to heat exchanger, power conversion, air conditioning, refrigeration, and heat recovery systems. Economics, equation fitting, and thermal property evaluation are integrated into simulation and optimization of thermal system designs. Prerequisites: MEMS 0071, MEMS 1051, MEMS 1052.

MEMS 1070 MECHANICAL BEHAVIOR OF MATERIALS (3 units)
Theory of elasticity, stress, strain, constitutive equations, isotropic and anisotropic elasticity, wave propagation in brittle solids, time dependent deformation, viscoelasticity, vibrations, damping, anelasticity, creep, design of creep resistant microstructures, deformation of polymers, physics of fracture, fracture mechanisms, brittle fracture, ductile fracture, design of fracture-resistant microstructures. Prerequisites: ENGR 0022, ENGR 0145.

MEMS 1097 SPECIAL PROJECTS (1–3 units)
Investigation and research embodying testing; original design or research on an approved subject; or individual course of study guided by an approved departmental faculty member.

MEMS 1098 SPECIAL PROJECTS 2 (1–3 units)
Investigation and research embodying testing; original design or research on an approved subject; or individual course of study guided by an approved departmental faculty member.

MEMS 1101 FERROUS PHYSICAL METALLURGY (3 units)
This course will introduce the student to the thermomechanical processing of austenite in plain carbon, high strength low alloy steels, high formability sheet steels and high alloy and special steels. The course will also present the use of hot rolling as a thermomechanical treatment. The importance of thermomechanical treatment, microstructural control and mechanical properties will be presented. Prerequisites: ENGR 0022, MEMS 0051, MEMS 1010.

MEMS 1102 PRINC. & APPL. OF STEEL ALLOY DESIGN (3 units)

This course will present the students with a discussion of the properties that are required of engineering alloys for a given commercial application. The alloy design, thermomechanical processing and required package of mechanical properties for plate, strip, bar, rod, wire and tubular products will be reviewed. These include: strength, toughness, formability, weldability, fatigue resistance, and corrosion/oxidation resistance. Prerequisite: MEMS 1101.

MEMS 1103 PRINC. & APPL. OF STEEL PROCESSING AND DESIGN (3 units)

This course will present case studies of actual components used in commercial applications in the automotive, construction, oil and gas and nuclear industries. This course will guide the student from the alloy selection, microstructural processing, mechanical properties to the final fabrication steps. Prerequisite: MEMS 1102.

MEMS 1162 COMPUTER APPLICATIONS IN MSE (3 units)

Applications of computer programming, computer software, and databases for materials science and engineering. Students will first apply computing and statistics fundamentals to solve materials science and engineering problems. Review recently developed software packages such as those of diffraction, thermodynamics, electronic materials, etc. The students will also learn about the techniques for using computerized databases for obtaining information on engineered materials. Prerequisites: MEMS 1052, MEMS 1054, MEMS 1056.

MEMS 1163 CERAMIC MATERIALS (3 units)

Structure of ceramics and glasses. Microstructures and their development. Properties, processing, and applications. Prerequisite: MEMS 1064.

MEMS 1172 PHYSICAL METALLURGY (3 units)

Concepts introduced in Materials Science I, energetics and materials processing are used to provide an understanding of the development of structure in metals and alloys, and the dependence of properties on structure. Specific topics include dislocations and slip phenomena; twinning; the nature of the cold-worked state; annealing-recovery, recrystallization, and grain growth; textures; grain boundaries and other interfaces; and strengthening mechanisms. Prerequisite: MEMS 1054. Corequisite: MEMS1064.

MEMS 1174 CERAMIC PROCESSING (3 units)

Raw materials, powder, preparation, characterization of powders; forming processes: powder pressing, slipcasting, plastic forming; drying and firing, sintering, and vitrification; special processes. Prerequisites: MEMS 1163.

MEMS 1180 ADVANCED MECHANICAL BEHAVIOR OF MATERIALS (3 units)

Fracture mechanics, design of tough microstructures, fatigue behavior, S-N curves, role of surface condition, statistical approach, strain-life curves, high cycle fatigue, low cycle fatigue, design of fatigue resistant microstructures, creep of materials, processing and properties of composite materials. Prerequisite: MEMS 1070.

- ME 2001 DIFFERENTIAL EQUATIONS (3 units)
 Ordinary differential equations; series solutions of differential equations; introduction to partial differential equations. Prerequisite: MATH 0290.
- ME 2002 LINEAR AND COMPLEX ANALYSIS (3 units)
 Linear algebra; vector analysis; complex variables; introduction to calculus of variations. Prerequisite: MATH 0290.
- ME 2003 INTRODUCTION TO CONTINUUM MECHANICS (3 units)
 The fundamental concepts of continuum mechanics are necessary for studying the mechanical behavior of solids and fluids. Includes a review of vectors and tensors; stress; strain and deformation; general principles in the form of balance laws; constitutive equations and their restrictions; and specialization to the theories of linearized elasticity and fluid mechanics.
- ME 2022 APPLIED SOLID MECHANICS (3 units)
 Stress and strain transformations; applied elasticity problems in torsion and plane problems; thermal stresses and elementary plasticity; energy methods; fundamentals of finite element methods. Prerequisites: MATH 0290, MEMS 1028.
- ME 2027 ADVANCED DYNAMICS (3 units)
 Variational principles, Lagrangian and Hamiltonian formalisms, kinematics and dynamics of rigid bodies, first integrals, Routh's method, stability, canonical transformations, the Hamilton-Jacobi theory. Prerequisite: MEMS 1015.
- ME 2045 LINEAR CONTROL SYSTEMS (3 units)
 This course builds upon the foundation laid in a classical feedback control course. The tools will be developed for analyzing and designing controllers for multi-input, multi-output dynamic systems. Ideas of controllability and observability will be discussed, as well as modern control design techniques such as pole-placement. Prerequisite: MEMS 1045.
- ME 2046 DIGITAL CONTROL SYSTEMS (3 units)
 This course provides the student with the tools necessary to analyze and design discrete-time (digital computer) control systems for real time control of dynamic systems. It builds upon the background of classical control topics including Nyquist, Bode, and root locus. Transform ideas will be used extensively for design and analysis to give the student an understanding of how discrete-time and classical control systems are related. State-space representations will be used for MIMO systems, so a prior understanding of modern control ideas is important. Prerequisite: MEMS 1045.
- ME 2056 INTRODUCTION TO COMBUSTION THEORY (3 units)
 Covers the general solution techniques associated with combustion phenomena as well as chemical thermodynamics, heat and mass transfer, laminar flame theory, one-dimensional reactive flow, heterogeneous combustion, and turbulent combustion.

ME 2060 NUMERICAL METHODS (3 units)
Introduction to numerical techniques for the solution of linear and nonlinear equations, numerical integration and differentiation, interpolation, ordinary and partial differential equations, and eigenvalue problems.

ME 2080 INTRO. TO MICROELECTROMECHANICAL SYSTEMS (MEMS) (3 units)
This course aims to provide basic understanding of microfabrication processes, fundamentals of microelectromechanical systems (MEMS) technologies. The first part of the course emphasizes thin film deposition, photolithography, and etching. The second part deals with micromachining processes including LIGA, RIE/DEEP, RIE, and other processes commonly used in MEMS fabrication. The third part covers the physical mechanisms of MEMS devices. The final part of the course gives some commercial application examples of MEMS technologies.

ME 2082 PRINC. OF ELECTROMECHANICAL SENSORS AND ACTUATORS (3 units)
The objective of this course is to provide a thorough understanding of the various mechanisms that can be exploited in the design of electromechanical sensors and actuators. These transduction mechanisms include: 1) transduction based on changes in the energy stored in the electric field, 2) transduction based on changes in the energy stored in the magnetic field, 3) piezoelectricity and pyroelectricity, 4) linear inductive transduction mechanisms, and 5) resistive transduction mechanisms. Various transduction materials, sensors, and actuators from a wide range of applications will be discussed. Prerequisites: MEMS 1014, MEMS 1020, MEMS 2001.

2.4 Engineering Elective

Students are required to complete one (1) Engineering Elective course, for a total of at least three (3) units. Any course offered by the School of Engineering may be used to satisfy this requirement (e.g., ENGR 0020 PROBABILITY & STATISTICS FOR ENGINEERS or IE 1040 ENGINEERING ECONOMIC ANALYSIS). It *does not* have to be an upper-level course. For students pursuing a minor from another department (Section 5.7, page 37), one of the courses required for the minor can be used to fulfill this requirement (in contrast, recall that only upper-level courses from other departments can be used as Mechanical Engineering Technical Electives).

2.5 Humanities and Social Science Electives

All School of Engineering undergraduates must complete at least six (6) humanities and social science elective courses, for a total of eighteen (18) units. These courses must be on the School's list of approved humanities and social science elective courses. A link to this list can be found on the department's undergraduate resources webpage at

www.engineering.pitt.edu/MEMS/Undergraduate/Resources/

Additionally, all Mechanical Engineering undergraduate students must fulfill the following requirements when choosing their six elective classes:

Depth Requirement

- Students must complete at least two courses from the *same* department or program within the School of Arts and Sciences.
- Alternatively, a student may satisfy the Depth Requirement by completing two or more courses with a related theme, e.g., courses that focus on a geographic region, historic period, or ideological perspective.
- At least one of these courses must be a non-introductory course. Introductory courses are designated by an asterisk [*] on the School's list of approved courses.

Breadth Requirement

- Students must select courses from at least three different School of Arts and Sciences humanities and social science departments.
- Students must select courses from both humanities and social science departments.

Writing Requirement

- All School of Engineering students must also complete at least one “W”-designated course in which the “W” indicates that a course has a substantial writing component, as approved by the School of Arts and Sciences. Students should refer to the Registrar's website each term to determine whether a course is being offered as a “W”-designated course. Note that every School of Arts and Sciences department offers “W”-designated courses, which may or may not satisfy School of Engineering humanities or social science requirements.

Departmental Requirement

- Students must include either PHIL 0300 INTRODUCTION TO ETHICS or PHIL 0302 INTRODUCTION TO ETHICS/WRITING PRACTICUM as one of the six Humanities and Social Science Electives.

The humanities and social science courses on the School's list of approved courses satisfy the School of Engineering's requirements. However, students may petition the Senior Associate Dean for Academic Affairs to have a course added to the list of approved courses by submitting an *Approval Request for Humanities/Social Science Elective* form, available in the Mechanical Engineering and Materials Science Undergraduate Program Office (636 Benedum Hall). The form must be turned in to the Senior Associate Dean for Academic Affairs Office (147 Benedum Hall) for approval. Students can contact the Undergraduate Program Office approximately one week later to see if the course was approved. It is helpful to include a copy of a course description for the course. Courses that are deemed sufficiently relevant and academically appropriate generally are approved. Broad survey courses (typically below the 100 level that are generally taught in large lecture sections) are usually not approved. Skills courses (courses that focus more on acquiring a skill than on conveying intellectual knowledge) are also usually not approved.

Notes and Restrictions on Selecting Courses

- No more than two of the required six elective courses can be satisfied via high school Advanced Placement credit.
- If a student has obtained elective credit from a community college prior to enrolling in the School of Engineering, no more than three of the six elective courses can be satisfied via community college credit.
- Courses that are cross-listed with other departments may be taken under either course number (i.e. ANTH 1524 is equivalent to HAA 1650) and may be used to satisfy the depth requirement in either department.
- Students are strongly encouraged to use language courses to partially satisfy the humanities and social science elective requirements. Three out of five, or six out of ten, first-year language course units are acceptable toward fulfilling the humanities and social science requirements. However, the following restrictions apply:
 1. The language(s) must be other than English.
 2. The language(s) must be other than the student's mother tongue.
 3. The course(s) must be a bona fide language course.

No more than two of the required six elective courses can be satisfied by language courses.

- Only an officially listed School of Arts and Sciences course may be used to fulfill a humanities and social science requirement. Courses from the College of General Studies (including External Studies courses), the College of Business Administration, or the School of Information Sciences cannot be used to fulfill the humanities and social science requirements.

2.6 Communication Skills Elective

To satisfy the Communication Skills Elective requirement, students must satisfactorily complete one of the following courses offered by the School of Engineering (ENGR), the Communication Department (COMMRC), and the English Department (ENGCMP). The Communication Skills Elective should be taken as soon as possible, in order that a student might benefit from it in other courses.

COMMRC 0500 ARGUMENT (3 units)

This course introduces students to fundamental principles of argument, and develops argument skills through in-class debates.

COMMRC 0520 PUBLIC SPEAKING (3 units)

This course is designed to develop rhetorical understanding and increased skill in public speaking. Students will learn to research, organize, compose and deliver public speeches.

COMMRC 0540 DISCUSSION (3 units)

The purpose of this course is to learn and sharpen discussion and critical thinking skills, which are absolutely essential elements in the process of group decision making. There is a clear trend in the modern world to reduce the decision making power of individuals and increase the influence of groups. This is a hands-on course that will give students practical experience in the process of group decision-making, a valuable and highly marketable skill.

ENGCMP 0400 WRITTEN PROFESSIONAL COMMUNICATION (3 units)

Written Professional Communication prepares students to develop effective plans, written documents and presentations for a variety of professional audiences. Classes are interactive workshops in which students assess and respond to realistic writing scenarios and sample texts. Each student creates a personalized writing portfolio that may be used on the job market. Note that most sections of this class are “W” designated.

ENGR 1010 COMMUNICATION SKILLS FOR ENGINEERS (3 units)

Utilizing a variety of spoken, written, and audio-video activities, students learn how to give instructions, use feedback, listen, conduct a job and appraisal interview, conduct meetings, make use of groups, make presentations, manage crises most of the skills they need to strengthen their personal, interpersonal, group, and organizational communicative skills. The instructing-learning process emphasizes motivation, concentration, participation, organization, comprehension, repetition, articulateness, and confidence.

2.7 Advanced Standing and Transfer Credit

Students transferring into the Mechanical Engineering and Materials Science Department from other college-level programs will have their academic records reviewed for advanced standing credit after they have been accepted for admission (see Section 4.4 on page 33 for more information on how to apply for transfer to the School of Engineering from another college or university). Only the units will transfer for the equivalent class, not the grade or grade point average.

The determination of advanced standing is made by the Undergraduate Director, in accordance with School of Engineering policy and criteria established by the Accreditation Board for Engineering and Technology (ABET). Only courses in which the applicant received at least 2.00 on a 4.00 scale will be considered for transfer, and then only if the courses are an integral part of the proposed degree program. In general, advanced standing for engineering or engineering science courses will be given only if the courses were taken from an ABET-approved engineering program. Advanced standing for mathematics, science, humanities, and social sciences courses will be awarded to the extent that those courses match University of Pittsburgh School of Arts and Sciences courses that are required by the School of Engineering. In particular, humanities and social sciences courses must correspond to those

on the School of Engineering's approved list of humanities and social science electives. A maximum of 96 units of transfer credit may be applied towards the degree.

Students transferring from either a college maintaining a 3/2 program with the School of Engineering, a community college having an articulation agreement with the School of Engineering, or a pre-engineering program at a University of Pittsburgh regional campus will receive advanced standing in accord with those agreements.

2.7.1 Advanced Placement (AP) Credit

The School of Engineering encourages students to take advantage of college prep courses offered at their high schools. This allows students to start ahead in the freshman curriculum and can create openings in future terms, which can be used for courses toward a minor or dual degree. We do, however, caution students that core courses such as Calculus, Chemistry, and Physics are building blocks for future success, and so credit should only be used if a student is truly confident in their retention of the material.

2.7.2 Transfer Credit for Courses Taken After Enrollment

Students enrolled in the School of Engineering may take courses at other universities to satisfy graduation requirements only if those courses are approved in advance by the Undergraduate Director. Such courses must be taken at a college or university that offers a full four-year degree program. Specifically, once a student is enrolled in the Mechanical Engineering and Materials Science Department, he/she is not permitted to take courses at a community college or other two-year institution as part of his/her engineering education. Students residing in the Pittsburgh area are expected to take all of their courses at the University of Pittsburgh, unless there is a special course offered at one of the other area four-year colleges that is not available at the University of Pittsburgh. See Section 4.2 on page 32 for more information on cross-registering at PCHE-member institutions. Students may take courses at the Greensburg and Johnstown campuses of the University of Pittsburgh. Engineering and engineering science courses must have been taken from an ABET-approved engineering program.

Only the units will transfer for the equivalent class, not the grade or grade point average, and credit will only be given if the student receives at least 2.00 on a 4.00 scale. It is the student's responsibility to have their transcript sent to the Undergraduate Program Office, 636 Benedum Hall, at the completion of the class.

2.8 Academic Advising

- The Undergraduate Director will be your initial transfer advisor when you apply for admission to the Mechanical Engineering and Materials Science Department. The Undergraduate Administrator will assist you with your initial registration. After the transitional period, you will be notified of your permanent academic advisor.
- If you decide to enroll in the co-op program, you must see the Undergraduate Administrator in Room 636 Benedum to be assigned to a co-op advisor (Section 5.6,

page 36).

- An alphabetical listing of all the mechanical engineering students along with their assigned advisor's name is available on the MEMS Undergraduate Resources web page.
- All of the department advisors' office hours and room numbers are available on the MEMS Undergraduate Resources web page.
- Students must make an appointment with their advisors for registration at least one week before the registration period begins.

2.8.1 Undergraduate Resources Web Page

A broad range of information, including information on student advisors and faculty office hours is available at www.engineering.pitt.edu/MEMS/Undergraduate/Resources/. Many of the forms needed for registration, graduation, etc. can also be downloaded from this web page.

Chapter 3

Academic Policy

3.1 Grading System

The University of Pittsburgh has a standard letter grade system, as described below. All of the courses taken for fulfillment of the requirements for a B.S. in Mechanical Engineering must be taken with the Letter Grade Option—the H/S/U and S/NC Grade Options are not allowed. The only exception is for study abroad courses.

3.1.1 Letter Grades

The University's letter grade system identified below will be followed without exception.

Grades	Grade Points
A+ =	4.00
A =	4.00 Superior
A- =	3.75
B+ =	3.25
B =	3.00 Meritorious
B- =	2.75
C+ =	2.25
C =	2.00 Adequate
C- =	1.75
D+ =	1.25
D =	1.00 Minimal
D- =	0.75
F =	0.00 Failure

3.1.2 Other Grades: Incomplete, Withdrawn, Resigned

Upon a student's completion of a course, one of the grades listed below may appear on the student's transcript in lieu of the letter grades discussed above.

- G - The “G” grade signifies unfinished course work due to extenuating circumstances. Students assigned “G” grades are required to complete course requirements within the next term of registration or within the time specified by the instructor. The instructor of the course will complete a grade change authorization form and send it to the School of Engineering Office of Administration for processing. If a “G” grade is not removed within one year, the instructor may change it to an “F” grade for the course.
- I - The “I” grade signifies incomplete course work due to the nature of the course, clinical work, or incomplete research work in individual guidance courses or seminars. It is not typically used for undergraduates.
- R - The “R” grade signifies that a student resigned from the University.
- W - The “W” grade signifies that a student has withdrawn from a course (see Withdrawal below).
- Z - The “Z” grade indicates that an instructor has issued an invalid grade.

3.2 Withdrawal

To receive a refund, a student must officially drop a course during the term’s add/drop period. This is done by processing an Enrollment form, signed by the student’s academic advisor, through the Undergraduate Program Office, 648 Benedum Hall.

Through the ninth week of the term, a student may withdraw from a course by completing a Monitored Withdrawal form available in the Undergraduate Program Office, 636 Benedum Hall. The course instructor must sign the form. Withdrawal forms for courses offered by the School of Engineering must be processed through the Engineering Office of Administration, 253 Benedum Hall. Withdrawal forms for courses offered by the School of Arts and Sciences, the Faculty of Arts and Sciences, or the College of General Studies must be processed through their respective dean’s office. A “W” grade will then be assigned for the course.

Withdrawal from a School of Engineering course after the ninth week of the term is permitted only for extremely extenuating circumstances. It requires the approval of the Associate Dean for Academic affairs.

3.3 Calculation of the Grade Point Average

Each unit carried for a letter grade towards a student’s degree is awarded grade points as shown in the grading system table. A student’s term grade point average (term GPA) is the total grade points earned for the term divided by the total units assigned letter grades. A student’s cumulative grade point average (cumulative GPA) is determined by dividing the total number of grade points by the total number of units assigned letter grades. Only units that are taken at the University of Pittsburgh and count towards a student’s degree are used in the calculation of the grade point averages. In particular, preparatory writing, preparatory mathematics, PEDC, and AFROTC units are not included in the calculation of a student’s GPA.

3.3.1 Course Repeats

A course resulting in a grade of “C–” or lower may be retaken within one calendar year. When calculating the cumulative GPA, the letter grade assigned for the later course will then replace the previously assigned grade, though the original grade will not be removed from the student’s transcript. No sequence course may be repeated for credit after a higher-numbered sequence course has been satisfactorily completed with a “C” or better. For the purpose of this rule, grades of “R” or “W” do not count as repeats. Students are only permitted to repeat a course twice.

3.4 Academic Honors

At the end of each term, the academic records of all undergraduate degree students in the School of Engineering are reviewed to determine eligibility for the Term Honor List and the Dean’s Honor List. Students who qualify for both honor lists will appear only on the Dean’s Honor List.

3.4.1 Term Honor List

To be eligible for the Term Honor List, a student must have (1) earned a term grade point average of at least 3.25, (2) completed a minimum of 15 units of academic work for letter grades at the University of Pittsburgh, and (3) completed a minimum of six units of work for letter grades in the term of eligibility.

3.4.2 Dean’s Honor List

To be eligible for the Dean’s Honor List, a student must have (1) earned cumulative and term grade point averages of at least 3.25, (2) completed a minimum of 30 units of academic work for letter grades at the University of Pittsburgh, and (3) completed a minimum of six units of work for letter grades in the term of eligibility.

3.5 Academic Discipline

To be considered in good academic standing, a student’s cumulative GPA must be at least 2.00 and the student must be making satisfactory progress toward earning an engineering degree. Each engineering student’s academic record is reviewed at the end of each term.

3.5.1 Warning

If a student’s *term* GPA is less than 2.00, but his/her *cumulative* GPA is still greater than or equal to 2.00, then the student will receive a warning letter from the School of Engineering that he/she is in academic difficulty, which could eventually lead to probation if academic performance does not improve. The student is still in good academic standing.

3.5.2 Probation

A student whose *cumulative* GPA drops below 2.00 is no longer in good academic standing and will be placed on academic probation. A student is subject to suspension or dismissal if his/her cumulative GPA remains below 2.00 for two consecutive terms.

3.5.3 Suspension

After being suspended, students are not eligible to reenroll for one calendar year, after which they are required to apply for reinstatement through the School of Engineering Office of Administration. Students returning from academic suspension are reinstated on academic probation and their academic performance will be reviewed after each subsequent term. If the student's cumulative GPA remains below 2.00 for two consecutive terms, he/she will be subject to dismissal.

3.5.4 Dismissal

Dismissal is a final action. Dismissed students are not eligible for future enrollment in the School of Engineering.

3.6 Graduation Requirements

1. To graduate with a Bachelor of Science in Engineering, a student must have satisfactorily completed all required courses and earned the total number of units required by the department in which the student is enrolled. The student must also have obtained a minimum cumulative GPA of 2.00 for (a) all courses completed at the University of Pittsburgh and (b) all departmental courses.
2. Students who have a cumulative GPA of 2.00, but have not obtained the minimum 2.00 departmental GPA, can only be certified for graduation by the department by repeating all departmental courses in which a grade of "D+" or worse was awarded and earning a grade of "C" or better for each repeated course. Such students must maintain a cumulative GPA of 2.00 for all courses taken at the University.
3. Students must complete the 128-unit course requirement. Only units approved by the Mechanical Engineering and Materials Science Undergraduate Director count towards this requirement. In particular, remedial writing, remedial mathematics, PEDC, and AFROTC units will not count towards this requirement.
4. Advanced standing credit accepted by the School of Engineering may partially fulfill course requirements for graduation, but grades and units earned in such courses are not included in the GPA calculations.
5. No course in which an "F" or a non-letter grade was received can be used to satisfy the 128-unit requirement. A minimum "D-" letter grade is required.

6. Students must complete an Application for Graduation form in the term that they are graduating. These forms are available in the Undergraduate Program Office and online at www.engineering.pitt.edu/MEMS/Undergraduate/Resources/. After completing the form, students turn it in to the Office of Administration, 253 Benedum Hall. Students need to pay attention to the application deadlines to avoid late fees. The deadlines are posted outside of the Undergraduate Program Office and throughout Benedum Hall.
7. It is suggested that students schedule an appointment with their advisor to review their records in the term preceding the term in which they plan to graduate, in order to make sure everything is in order. It is the students' responsibility to meet all of the department's requirements for graduation.
8. In the term that the student is graduating, he/she must make an appointment to see the Undergraduate Director before the add/drop period ends. The Undergraduate Director will sign off on their final academic graduation folder and verify that graduation requirements will be satisfied.
9. The work of the senior year (a minimum of 26 units) must be completed while in residence at the School of Engineering, University of Pittsburgh. Exceptions to this regulation may be granted for a limited number of units through petition to the department.
10. To be considered for honors at graduation, a student must earn at least 68 letter grade units at the University of Pittsburgh. The minimum cumulative GPA for graduation cum laude is 3.25, for magna cum laude is 3.50, and for summa cum laude is 3.75.

3.6.1 Statute of Limitations

All required academic work for the Bachelor of Science degree in Engineering, including courses for which advanced-standing credit has been granted, must be completed within 12 consecutive calendar years. Under unusual circumstances a student may, with the approval of the Undergraduate Director, request a waiver of this policy. This policy means that part-time students must progress toward the degree at a minimum of 10.67 units per calendar year.

3.6.2 Reinstatement

An engineering student in good academic standing who has not attended the University of Pittsburgh for three consecutive terms, and has attended no other institution in the intervening period, will be considered for reinstatement after making an application to the Undergraduate Director. If the student has attended another institution and completed more than 12 units, then the student must reapply through the University's Office of Admission and Financial Aid in accordance with the procedure for transfer applicants from other colleges or universities.

Chapter 4

Registration

A lot of useful information and many of the necessary forms associated with registration can be found on the MEMS Undergraduate Resources Web Page:

www.engineering.pitt.edu/MEMS/Undergraduate/Resources/

These and other forms are also available in the Undergraduate Program Office, 648 Benedum Hall.

4.1 Self-Enrollment

Students enroll for courses on-line. There is an interactive video on the Student Services Portal on my.pitt.edu that provides step-by-step instructions on how to register and process add/drops.

- Prior to each term, students will be provided with an Enrollment Appointment, which is the date and time at which they may begin registering for courses. The Enrollment Appointments are based on seniority (seniors first, then juniors, etc.).
- All students will initially have an “Academic Advisement Required” hold on their account, which will prevent them from self-enrolling. Students should meet with their advisors to resolve questions regarding their curricular schedules. After it has been documented that a student has been advised, we are authorized to manually remove the student’s hold. Ideally a student’s hold should be removed before his/her Enrollment Appointment.

All full-time engineering students are expected to register for a normal full term of academic courses. No student shall be allowed to register for more than 18 units without specific written permission from the Undergraduate Director and approval by the Associate Dean for Academic Affairs. Such permission is given selectively and only after a review of the student’s record and planned course work suggests that such an overload is academically justifiable. All units over 18 will be billed over and above the full-time tuition rate at the prevailing per-unit tuition charge.

4.2 PCHE Cross-Registration

Cross-college and cross-university registration is a program designed to provide for enriched educational opportunities for undergraduates at any of the ten institutions that comprise the Pittsburgh Council on Higher Education (PCHE): Carnegie Mellon, Carlow College, Chatham College, Community College of Allegheny County, Duquesne University, Point Park College, LaRoche College, Robert Morris College, Pittsburgh Theological Seminary, and the University of Pittsburgh. Under the terms of this program, full-time students at any one of these institutions are granted the opportunity to enroll for a maximum of six units per term at any of the other institutions. Each institution provides the others with lists of those courses approved by department chairpersons as being open to cross-registration. Such courses must be selected from those regularly accredited toward baccalaureate programs, and a student registering for them must meet all prerequisites. Priority in registration goes to the students of the host college. Units and grades are transferred.

The following limitations apply:

- Cross-registration is available only during the Fall and Spring Terms.
- Undergraduates and post-baccalaureate students must be registered for a total of at least 12 units (including the cross-registration units).
- Students may not cross-register for courses available at the home institution.
- Students cannot use cross-registration to repeat courses taken at the University of Pittsburgh.
- Once a student is enrolled in the Mechanical Engineering and Materials Science Department, he/she is not permitted to take courses at the Community College of Allegheny County or any other two-year institution as part of his/her engineering education.
- Students may not use cross-registration to take courses that are not acceptable for an Engineering degree.
- The grading system for a cross-registered course is determined by the college or university that offers the course. The student must also follow that school's procedures and deadlines for add/drop, etc.

Cross-registration takes place during the add/drop period, ending the last day of the University of Pittsburgh's add/drop period. Interested students should go to the Office of Administration, 253 Benedum Hall, for a PCHE registration form and additional instructions.

4.3 Interdepartmental Transfers

A student whose academic record satisfies the minimum requirements for continued registration may apply for transfer from the Mechanical Engineering program to another engineering discipline. An Undergraduate Academic Program Change form, available in the

Undergraduate Office, should be completed to initiate a change of departmental status. The Undergraduate Director must initial the form, and the student then returns the form to the Office of Administration, 253 Benedum. The student's academic records will be sent to the requested department. The acceptance of a change-of-status request must have the approval of the department to which the student desires to transfer. It is the prerogative of that department to approve or reject a change-of-status transfer request.

4.4 Transfer Students from Other Universities

An applicant for transfer to the School of Engineering from another college or university should request an Application for Admission with Advanced Standing from the Office of Admissions and Financial Aid, 2nd Floor, Bruce Hall, Pittsburgh, PA 15260. Applicants for the Spring Term should apply by November 15; for the Summer Term by March 15; and for the Fall Term by July 15. A transfer applicant will typically not be admitted to the School of Engineering without a grade point average of 2.50 on a 4.00 scale at the institution previously attended. Advanced standing credit will be granted for college course work at another accredited institution depending on the relevance to the applicant's proposed program in the School of Engineering and on grades received. Only courses in which the applicant received at least 2.00 on a 4.00 scale will be considered for transfer, and then only if the courses are an integral part of the proposed degree program. See Section 2.7 on page 22 for more information on the transfer of credit.

Students transferring from the School of Arts and Sciences and the College of General Studies of the University of Pittsburgh should initiate the request for transfer in their academic dean's office. To be considered for transfer, a minimum cumulative grade point average of 2.75 is required. All the freshman-level engineering courses should be completed before applying for transfer.

4.4.1 Regional Transfers

Request forms for relocation from the pre-engineering program at Bradford, Greensburg, Johnstown, or Titusville are available at each regional campus. The student must initiate the request for relocation in accordance with the regulations at the regional campus. The regional campus sends the request for relocation to Pittsburgh and the student's records to the Engineering Office of Administration for review and action by the School of Engineering. Students who have a grade point average of 2.75 or higher in the required engineering curricula are guaranteed relocation to the Oakland campus.

Chapter 5

Degree Options

Brief descriptions of some of the degree options available to students in the Mechanical Engineering and Materials Science Department are given below. More information, including links to specific web sites for each of the degree options listed below, is available online at www.engineering.pitt.edu/MEMS/Undergraduate/Degree_Options/.

5.1 Arts and Sciences-Engineering Joint Degree Program

The School of Arts and Sciences (A&S) and the School of Engineering have developed an undergraduate joint degree program that permits students to combine a major in arts and sciences with a program in engineering and then receive degrees from both A&S and the School of Engineering. Students can apply for admission into the program through either A&S or the School of Engineering and must be admitted into both schools.

5.2 Engineering-School of Education Certification Program

Engineering students may apply for a fifth-year program that leads to mathematics, general science, or physics teaching certification from the School of Education. Students who complete the program are qualified to teach in the Commonwealth of Pennsylvania. Students interested in pursuing this option should apply prior to the start of their junior year.

5.3 Certificate Programs

School of Engineering undergraduate students are encouraged to broaden their educational experience by electing to take one of the certificate programs currently offered by A&S, the University Center for International Studies, or the School of Engineering. Typically, the certificate programs may be used by engineering students to partially fulfill the humanities/social sciences or technical elective requirements, thereby allowing specialization in an

area of interest while pursuing an engineering degree. The requirements for each certificate vary, and students should contact the appropriate certificate program director.

The School of Engineering offers seven certificates at the undergraduate level.

- Energy Resource Utilization
- Fessenden Honors in Engineering Program
- International Education
- Mining Engineering
- Nuclear Engineering
- Product Realization
- Sustainable Engineering

5.4 University Honors College

The University Honors College is something of a paradox: Though headquartered in a newly renovated suite at the University of Pittsburgh's Cathedral of Learning, it's not really a bricks-and-mortar school within the University. And although UHC offers specific courses and the bachelor of philosophy degree, the options are available to any student (in any major) who demonstrates an extraordinary ability to pursue independent scholarship.

5.5 PCHE Cross-Registration Program

The Pittsburgh Council on Higher Education (PCHE) cross-registration program provides opportunities for enriched educational programs by permitting full-time undergraduate and graduate students to cross-register at any other PCHE school (Section 4.2, page 32).

5.6 Cooperative Education Program

The Co-Op Education Program at Pitt is one of the most exciting opportunities available to engineering students. By alternating work and school terms, co-op education provides students with relevant, challenging, paid work assignments with local, national, or international employers.

The program integrates a rotation of school and employment terms that enables the cooperative education student to complement his or her formal classroom training with additional technical knowledge, hands-on experience, and financial remuneration. The co-op graduate possesses the maturity and assurance of a more seasoned employee and the ability to incorporate academic knowledge and theory into practice. During co-op sessions, students earn competitive salaries, which makes this program also financially rewarding.

Mechanical Engineering and Materials Science students have the option of using their co-op units (ENGR 1090) towards one of the technical electives in the curriculum, provided that a technical paper is submitted to the department. The guidelines and due dates for the co-op paper are available in the Undergraduate Program Office, 648 Benedum Hall.

The co-op option is available to all engineering undergraduates. Students must be in good academic standing (minimum 2.00 GPA), and must be eligible to complete a minimum of three work terms. Most students begin during the sophomore year and complete the program during the senior year. Students who are interested in participating in the co-op program should contact the Cooperative Education Program Office, located in B77/78 Benedum Hall or call (412) 624-9882 or 9883.

5.7 School of Engineering Minors

Undergraduate students in the Mechanical Engineering and Materials Science department can choose to enhance their education by minoring in another engineering area of interest. Each of the departments in the School of Engineering offers at least one minor. Descriptions of these minors and their requirements are available online.

5.8 School of Arts & Sciences Minors

Twenty-one departmental minors are available in programs offered by the A&S. The minors are applied statistics, chemistry, classics, economics, English literature, French, German, history, Italian, Japanese, linguistics, music, neuroscience, philosophy, physics, political science, religious studies, Slovak studies, sociology, studio arts, and theatre arts. Students must complete at least half of the units earned for a minor at the University of Pittsburgh and must complete a minor with at least a 2.00 GPA.

5.9 Emerging Leaders Program

Emerging Leaders introduces participants to four fundamentals of leadership; self-knowledge, valuing others, personal accountability, and integrity. Learners explore these topics while building skills in group dynamics, conflict management, power and influence, diversity, ethics, and life-work planning. This 10-week program provides learners with opportunities to:

- Explore and assess your leadership skills and style.
- Practice and experiment with new leadership behavior.
- Receive feedback on your style and behavior.
- Plan for your on-going leadership development.

5.10 International Education

The School of Engineering is making a concerted effort to expand students' knowledge through international education. As the world becomes increasingly interconnected and globalization is a way of life, Engineering students must understand how to operate in a global manner to remain competitive. The school's programs provide opportunities for students to broaden their horizons in numerous ways.

5.11 Receiving Graduate Credit

An undergraduate student who intends to continue towards an advanced degree may arrange to schedule a limited number of courses for graduate credit during the next to the last term or final term of registration for the B.S. degree. Approval will be granted only if the student's total program for the term does not exceed 18 units. A maximum of 6 units can be applied to a master's degree program. These units will only apply to graduate degree requirements.

5.12 Combined Liberal Arts & Engineering 3/2 Programs with Other Universities

The University of Pittsburgh School of Engineering has developed combined liberal arts and engineering joint-degree programs with a number of accredited liberal arts colleges. These programs are typically referred to as 3/2 programs, since the student initially enrolls at the liberal arts college, completing a three-year structured program. Those first three years usually include the general education requirements for the liberal arts degree, specific courses in areas of concentration required for all engineering programs, and the courses necessary for acceptance to the University of Pittsburgh School of Engineering. With the recommendation of the review committee at the liberal arts college, the student then applies for transfer to the University of Pittsburgh School of Engineering. If accepted, the student spends the final two years in the Mechanical Engineering program.

At the request of the student, his or her University of Pittsburgh School of Engineering academic record will be forwarded to the liberal arts college for evaluation, and a liberal arts degree will be awarded in accordance with the policy of the liberal arts college. The engineering degree will be awarded upon completion of the engineering requirements.

Interested students should be referred to the Director of Freshman Programs, B-80 Benedum Hall for specific information and requirements. The 3/2 agreements and articulation agreements should be followed very closely. If students take courses that are not listed on the 3/2 agreement, the classes most likely will not transfer.

APPENDICES

Appendix A - ME Curriculum Checklist

Name: _____

Date: _____

Course	Credits	Course Title	Prerequisites/Corequisites
CHEM0960	3 _____	Gen. Chem. for Engr. 1	
CHEM0970	3 _____	Gen. Chem. for Engr. 2	CHEM0960
MATH0220	4 _____	Anal. Geometry & Calc. 1	
MATH0230	4 _____	Anal. Geometry & Calc. 2	MATH0220 (C or better)
MATH0240	4 _____	Anal. Geometry & Calc. 3	MATH0230 (C or better)
MATH0280	3 _____	Matrices & Linear Algebra	MATH0220
MATH0290	3 _____	Differential Equations	MATH0230
PHYS0174	4 _____	Phys. for Sci. & Engr. 1	<i>MATH0220</i> ¹
PHYS0175	4 _____	Phys. for Sci. & Engr. 2	PHYS0174, <i>MATH0230</i>
PHIL0300	3 _____	Intro. to Ethics (Humanity)	
_____	3 _____	Humanity/Soc. Sci. Elective	
_____	3 _____	Humanity/Soc. Sci. Elective	
_____	3 _____	Humanity/Soc. Sci. Elective	
_____	3 _____	Humanity/Soc. Sci. Elective	
_____	3 _____	Humanity/Soc. Sci. Elective	
_____	3 _____	Communication Skills Elective	
ENGR0011	3 _____	Intro. to Engr. Analysis	
ENGR0012	3 _____	Engr. Computing	ENGR0011
ENGR0022	3 _____	Mater. Struct. & Properties	MATH0230, PHYS0174
ENGR0135	3 _____	Statics & Mech. of Mater. 1	MATH0230, PHYS0174
ENGR0145	3 _____	Statics & Mech. of Mater. 2	ENGR0135
_____	3 _____	Engineering Elective	
MEMS0024	3 _____	Intro. to ME Design	ENGR0011
MEMS0031	3 _____	Electrical Circuits	PHYS0175, <i>MATH0290</i>
MEMS0040	3 _____	Materials & Manufacturing	ENGR0022
MEMS0051	3 _____	Intro. to Thermodynamics	PHYS0174, CHEM0960, <i>MATH0290</i>
MEMS0071 ²	3 _____	Intro. to Fluid Mechanics	PHYS0174, CHEM0960, <i>MATH0290</i>
MEMS1014	3 _____	Dynamic Systems	MATH0280, ENGR0012, MEMS0031
MEMS1015	3 _____	Rigid-Body Dynamics	MATH0240, ENGR0135
MEMS1028	3 _____	Mechanical Design 1	ENGR0145
MEMS1029	3 _____	Mechanical Design 2	MEMS0024, MEMS1028
MEMS1041	3 _____	Mechanical Measurements 1	ENGR0145, MEMS0031, <i>MEMS1014</i>
MEMS1042	3 _____	Mechanical Measurements 2	MEMS1041
MEMS1043	3 _____	Senior Design Project	<i>Senior Standing</i>
MEMS1051	3 _____	Applied Thermodynamics	MEMS0051
MEMS1052	3 _____	Heat and Mass Transfer	MEMS0051
MEMS1071 ³	3 _____	Applied Fluid Mechanics	MEMS0071
_____	3 _____	ME Technical Elective	
_____	3 _____	ME Technical Elective	
_____	3 _____	ME Technical Elective	
_____	3 _____	Dynamic Systems Elective	

¹Italicized courses indicate corequisites, that is, courses that must be taken before or concurrently.

²May be replaced by MEMS1072 Applied Fluid Dynamics, if taken prior to September, 2013.

³May be replaced by MEMS1065 Thermal Systems Design, if taken prior to September, 2013.

Appendix B - ME Course Offerings by Term

To assist you in long term schedule planning, a term-by-term listing of course offerings is provided below. This schedule will be especially helpful to students who decide to enroll in the co-op program.

Course Number	Fall Term	Spring Term	Summer Term
ENGR0022	•	•	•
ENGR0135	•	•	•
ENGR0145	•	•	•
Engr. Electives	•	•	•
MEMS0024	•		
MEMS0031		•	•
MEMS0040		•	•
MEMS0051		•	•
MEMS0071	•	•	
MEMS1014	•	•	
MEMS1015		•	•
MEMS1028	•	•	
MEMS1029		•	•
MEMS1041	•	•	
MEMS1042	•	•	•
MEMS1043	•	•	•
MEMS1051	•	•	
MEMS1052	•		•
MEMS1071		•	•
MEMS1085	•	•	
Tech. Electives	•	•	
Dyn. Sys. Elec.	•	•	

- Note that, in general, Mechanical Engineering Technical Electives are only offered during the Fall and Spring Terms.
- This is a tentative schedule that is subject to change. However, changes will not be made without appropriate accommodation for students' existing plans.

Appendix C - ME Sample Schedule

Shown below is an example of a schedule of courses that leads to a B.S. in Mechanical Engineering in four years. It satisfies all of the relevant course prerequisites and the Mechanical Engineering degree requirements.

FIRST TERM

Subject		Credits
CHEM0960	Gen. Chem. for Engr. 1	3
MATH0220	Anal. Geometry & Calc. 1	4
PHYS0174	Phys. for Sci. & Engr. 1	4
ENGR0011	Intro. to Engr. Analysis	3
	<i>Humanity/Soc. Sci. Elective</i>	3
ENGR0081	Freshman Seminar	<u>0</u>
		17

SECOND TERM

Subject		Credits
CHEM0970	Gen. Chem. for Engr. 2	3
MATH0230	Anal. Geometry & Calc. 2	4
PHYS0175	Phys. for Sci. & Engr. 2	4
ENGR0012	Engr. Computing	3
	<i>Humanity/Soc. Sci. Elective</i>	3
ENGR0082	Freshman Seminar	<u>0</u>
		17

THIRD TERM

Subject		Credits
MATH0240	Anal. Geometry & Calc. 3	4
MATH0280	Matrices & Linear Algebra	3
ENGR0022	Mater. Struct. & Properties	3
ENGR0135	Statics & Mech. Mater. 1	3
MEMS0024	Intro. to ME Design	3
MEMS1085	Departmental Seminar	<u>0</u>
		16

FOURTH TERM

Subject		Credits
MATH0290	Differential Equations	3
ENGR0145	Statics & Mech. Mater. 2	3
MEMS0031	Electrical Circuits	3
MEMS0040	Materials & Manufacturing	3
MEMS0051	Intro. to Thermodynamics	3
	<i>Communication Skills Elective</i>	3
MEMS1085	Departmental Seminar	<u>0</u>
		18

FIFTH TERM

Subject		Credits
MEMS0071	Intro. to Fluid Mechanics	3
MEMS1014	Dynamic Systems	3
MEMS1028	Mechanical Design 1	3
	<i>Engineering Elective</i>	3
	<i>Humanity/Soc. Sci. Elective</i>	3
MEMS1085	Departmental Seminar	<u>0</u>
		15

SIXTH TERM

Subject		Credits
MEMS1015	Rigid-Body Dynamics	3
MEMS1029	Mechanical Design 2	3
MEMS1041	Mechanical Measurements 1	3
MEMS1051	Applied Thermodynamics	3
	<i>Humanity/Soc. Sci. Elective</i>	3
MEMS1085	Departmental Seminar	<u>0</u>
		15

SEVENTH TERM

Subject		Credits
MEMS1042	Mechanical Measurements 2	3
MEMS1052	Heat and Mass Transfer	3
	<i>ME Technical Elective</i>	3
	<i>Dynamic Systems Elective</i>	3
	<i>Humanity/Soc. Sci. Elective</i>	3
MEMS1085	Departmental Seminar	<u>0</u>
		15

EIGHTH TERM

Subject		Credits
MEMS1043	Senior Design Project	3
MEMS1071	Applied Fluid Mechanics	3
	<i>ME Technical Elective</i>	3
	<i>ME Technical Elective</i>	3
	<i>Humanity/Soc. Sci. Elective</i>	3
MEMS1085	Departmental Seminar	<u>0</u>
		15

Appendix D - Co-op Schedule Form

Student Name: _____

Department: _____

Anticipated Co-op Start Date: _____

Current Status (circle one): Sophomore 2 Junior 1 Junior 2 Senior 1

	<i>Fall</i>	<i>Spring</i>	<i>Summer</i>
<i>Year 1</i>	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
<i>Year 2</i>	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
<i>Year 3</i>	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
<i>Year 4</i>	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____
<i>Year 5</i>	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____

Co-op Advisor's Signature: _____

Date: _____

Student's Signature: _____

Date: _____

Any changes in scheduling *must* be approved by your faculty advisor. The co-op office will not be responsible for students who deviate from their schedules without departmental approval.

Appendix E - ME Co-op Schedule A

Student Name: _____

Department: _____

Anticipated Co-op Start Date: _____

Current Status (circle one): Sophomore 2 Junior 1 Junior 2 Senior 1

	<i>Fall</i>	<i>Spring</i>	<i>Summer</i>
<i>Year 1</i>	CHEM0960 MATH0220 PHYS0174 ENGR0011 <i>Soc. Sci./Hum.</i>	CHEM0970 MATH0230 PHYS0175 ENGR0012 <i>Soc. Sci./Hum.</i>	
<i>Year 2</i>	MATH0240 MATH0280 ENGR0022 ENGR0135 MEMS0024	MATH0290 ENGR0145 MEMS0031 MEMS0040 MEMS0051	Work Rotation
<i>Year 3</i>	MEMS0071 MEMS1014 MEMS1028 MEMS1051 <i>Engr. Elective</i>	Work Rotation	MEMS1015 MEMS1029 MEMS1052 <i>Soc. Sci./Hum. Comm. Skills</i>
<i>Year 4</i>	Work Rotation	MEMS1041 <i>ME Tech. Elec. ME Tech. Elec. Dyn. Sys. Elec. Soc. Sci./Hum.</i>	MEMS1042 MEMS1043 MEMS1071 <i>Soc. Sci./Hum. Soc. Sci./Hum.</i>
<i>Year 5</i>	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____

Co-op Advisor's Signature: _____

Date: _____

Student's Signature: _____

Date: _____

Any changes in scheduling *must* be approved by your faculty advisor. The co-op office will not be responsible for students who deviate from their schedules without departmental approval.

Appendix F - ME Co-op Schedule B

Student Name: _____

Department: _____

Anticipated Co-op Start Date: _____

Current Status (circle one): Sophomore 2 Junior 1 Junior 2 Senior 1

	<i>Fall</i>	<i>Spring</i>	<i>Summer</i>
<i>Year 1</i>	CHEM0960 MATH0220 PHYS0174 ENGR0011 <i>Soc. Sci./Hum.</i>	CHEM0970 MATH0230 PHYS0175 ENGR0012 <i>Soc. Sci./Hum.</i>	
<i>Year 2</i>	MATH0240 MATH0280 ENGR0022 ENGR0135 MEMS0024	Work Rotation	MATH0290 ENGR0145 MEMS0031 MEMS0040 MEMS0051
<i>Year 3</i>	Work Rotation	MEMS0071 MEMS1014 MEMS1028 <i>Engr. Elective Comm. Skills</i>	Work Rotation
<i>Year 4</i>	MEMS1041 MEMS1051 MEMS1052 <i>ME Tech. Elec. Soc. Sci./Hum.</i>	MEMS1015 MEMS1029 <i>ME Tech. Elec. Dyn. Sys. Elec. Soc. Sci./Hum.</i>	MEMS1042 MEMS1043 MEMS1071 <i>Soc. Sci./Hum. Soc. Sci./Hum.</i>
<i>Year 5</i>	_____ _____ _____ _____	_____ _____ _____ _____	_____ _____ _____ _____

Co-op Advisor's Signature: _____

Date: _____

Student's Signature: _____

Date: _____

Any changes in scheduling *must* be approved by your faculty advisor. The co-op office will not be responsible for students who deviate from their schedules without departmental approval.