UNIVERSITY OF PITTSBURGH
MECHANICAL ENGINEERING DEPARTMENT
Undergraduate Academic Program Manual

Dr. Minking Chyu
Chairman

Dr. William S. Slaughter
Undergraduate Coordinator

University of Pittsburgh
Mechanical Engineering Department
Undergraduate Office
648 Benedum Hall
3700 O'Hara Street
Pittsburgh, PA 15261
Phone: (412)624-9780
Fax: (412)624-4846

Web Address: `www.engr.pitt.edu/mechanical`

For information regarding admissions and financial aid, see
`www.engr.pitt.edu/admissions/undergraduate.html`

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Forward

This *Mechanical Engineering Undergraduate Academic Program Manual* is a supplement to the information provided on the *University of Pittsburgh School of Engineering Web Site* (`www.engr.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 School of Engineering Web Site, as well as some relevant information from the 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.

[1] If there are any discrepancies between the *Mechanical Engineering Undergraduate Academic Program Manual* and the *School of Engineering Web Site*, then the ultimate authority is the *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 program in this department is 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.

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 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.

As practicing engineers, our graduates should be able to:

- Apply sound design methodology in multidisciplinary fields of mechanical engineering.
- Competently use mathematical methods, engineering analysis, and measurement and instrumentation techniques.

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

- Employ effective oral and written communication skills.

- Understand the environmental, ethical, diversity, cultural, and contemporary aspects of their work.

- Work collaboratively and effectively in engineering and manufacturing industries.

- Assume positions of professional leadership in industry and government.

1.2 Curriculum Overview

The Mechanical Engineering program is a day program. Although a few courses are offered in the late afternoon or early evening to provide access to students working in local industry, a bachelor's degree cannot be achieved by these courses alone. There is no academic distinction between classes taught at various times of the day.

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 dynamics, 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 (see page 6)

- Bachelor of Science in Mechanical Engineering via the 3/2 Program (see page 29)

- Combined CAS-Engineering Joint Degree (see page 28)
  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 (see page 27). 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 co-op engineering program (see page 27).

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-assisted engineering design tools. The primary tool introduced is Pro/ENGINEER^{TM}, an integrated software package that allows development of parametric tools in two and three dimensions. The student also addresses 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 dynamics. During this year, students are also introduced to the finite element method and learn how to use ANSYS^{TM}, 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 a 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. During the sophomore year, students are required to take a Communication Skills Elective (see page 16). Subsequent laboratory and project reports reinforce the skills learned in this elective. The senior project course includes a written report and an oral presentation during a symposium held near the end of the term. Each presentation is video taped 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 Matlab™ in addition to the programming languages C and HTML.

In the sophomore year, mechanical engineering students learn to use Pro/ENGINEER™, 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 Department 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.

Mechanical Measurements 3 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 Department, students are also required to take (4) Mechanical Engineering Technical Electives, six (6) Social Science and Humanities Electives, and one (1) Communication Skills Elective. There are a total of 125 passed credits 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) credits.

ME 0022 Kinematics of Machinery (3 cr.)

Fundamental theory of motion as applied to basic mechanisms. Analytical, computer, and graphical methods for determining displacements, velocities, and accelerations. Gears and gear trains are studied and cams and linkages are synthesized. Prerequisites: MATH 0240, ENGR 0135, ME 0024.

ME 0024 Introduction to Mechanical Engineering Design (3 cr.)

Provides knowledge of design graphics and manufacturing processes by conventional and computer-aided methods. Prerequisite: ENGR 0011.

ME 0031 Electrical Circuits (3 cr.)

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.

ME 0051 Introduction to Thermo-Fluids Engineering (3 cr.)

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 0175, CHEM 0960. Corequisite: MATH 0290.

ME 1014 Dynamic Systems (3 cr.)

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 0290, PHYS 0175, ME 0031.

ME 1015 KINETICS (3 cr.)
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. Prerequisite: ME 0022.

ME 1028 MECHANICAL DESIGN 1 (3 cr.)
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.

ME 1029 MECHANICAL DESIGN 2 (3 cr.)
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: ME 0024, ME 1028.

ME 1041 FUNDAMENTALS OF MECHANICAL MEASUREMENTS 1 (3 cr.)
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, ME 0031. Corequisite: ME 1014.

ME 1042 MECHANICAL MEASUREMENTS 2 (3 cr.)
Design of experiments, instrumentation, data acquisition, data analysis, and data presentation techniques as applied to complex mechanical systems. Prerequisite: ME 1041.

ME 1043 MECHANICAL MEASUREMENTS 3 (3 cr.)
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.*

ME 1051 APPLIED THERMODYNAMICS (3 cr.)
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: ME 0051.

ME 1052 HEAT TRANSFER (3 cr.)
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: ME 0051.

ME 1065 THERMAL SYSTEMS DESIGN (3 cr.)
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: ME 1052, ME 1072.

ME 1072 Applied Fluid Dynamics (3 cr.)
Kinematics of fluids. Navier-Stokes equations. Flow of incompressible, inviscid fluids. Dimensional analysis and similarity. Internal flows in pipes. Boundary layer theory. External flow past bodies. Prerequisite: ME 0051.

ME 1085 Departmental Seminar (0 cr.)
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 Department. There are fourteen (14) of these courses for a total of forty-five (47) credits.

CHEM 0960 General Chemistry for Engineers 1 (3 cr.)
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 cr.)
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 cr.)
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 cr.)
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. This course is closely linked to ENGR 0011.

ENGR 0022 Material Structure & Properties (3 cr.)
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 0175.

ENGR 0135 Statics and Mechanics of Materials 1 (3 cr.)
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: PHYS 0175, ENGR 0012.

ENGR 0145 Statics and Mechanics of Materials 2 (3 cr.)
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 and Calculus 1 (4 cr.)
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 and Calculus 2 (4 cr.)
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: MATH 0220.

MATH 0240 Analytic Geometry and Calculus 3 (4 cr.)
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: MATH 0230.

MATH 0280 Introduction to Matrices and Linear Algebra (3 cr.)
The topics which this course cover include: vectors, matrices, determinants, linear transformations, eigenvalues and selected applications. Prerequisite: MATH 0220.

MATH 0290 Differential Equations (3 cr.)
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, MATH 0280.

PHYS 0174 Basic Physics for Science and Engineering 1 (4 cr.)
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 and Engineering 2 (4 cr.)
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 Technical Electives

Students are required to satisfactorily complete four (4) of the following Mechanical Engineering Technical Elective courses, for a total of twelve (12) credits. 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) credits 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 Coordinator. To request approval for such a substitution, the student must submit a *Technical Elective Approval Request* form to the Undergraduate Coordinator. This is typically associated with the pursuit of a minor (see page 27).
- 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

ME 1020 Mechanical Vibrations
ME 1045 Automatic Controls
ME 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

ME 1047 Finite Element Analysis
ME 1055 Computer Aided Analysis in Transport Phenomena
ME 2001 Differential Equations
ME 2002 Linear and Complex Analysis
ME 2060 Numerical Methods

Fluid/Thermal Systems

ME 1055 Computer Aided Analysis in Transport Phenomena
ME 2003 Introduction to Continuum Mechanics
ME 2056 Introduction to Combustion Theory

Manufacturing

ME 1033 Fracture Mechanics for Manufacturing & Performance
ME 1037 Manufacturing Quality Assessment
ME 1038 Design for Manufacturing
ME 1045 Automatic Controls
ME 1047 Finite Element Analysis
ME 1049 Mechatronics

Solid Mechanics

ME 1033 Fracture Mechanics for Manufacturing & Performance
ME 1047 Finite Element Analysis
ME 2003 Introduction to Continuum Mechanics
ME 2022 Applied Solid Mechanics

2.3.2 Technical Elective Course Descriptions

ME 1020 Mechanical Vibrations (3 cr.)
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: ME 1014.

ME 1032 Automotive Fabrication (3 cr.)
By special permission only.

ME 1033 Fracture Mechanics for Manufacturing & Performance (3 cr.)
Failure of manufactured products in service, implications for design. Energy release rates, toughness, evaluation of experimental tests. Fracture mechanisms in different material systems. Damage tolerance. Fracture control. Design studies.

ME 1037 Manufacturing Quality Assessment (3 cr.)
Statistical quality control and statistical process control as related to manufacturing. Measurement of quality related parameters. Design of quality assessment systems for manufacturing. Prerequisites: ME 1041.

ME 1038 Design for Manufacturing (3 cr.)
Manufacturing design process (independent of the final item that is being designed), design strategies, economic aspects of design/manufacturing alternatives, design synthesis; considerations in the minimization of total cost (development costs, production costs, and life-cycle costs), methods of meeting goals (optimal design techniques, axiomatic design), and coupling of the design process, manufacturing process, and material properties. Prerequisites: ENGR 0022, ME 1041. Corequisites: ME 1029, ME 1052, ME 1072.

ME 1045 Automatic Controls (3 cr.)
Modeling of mechanical systems and classical control theory. Prerequisite: ME 1014.

ME 1047 Finite Element Analysis (3 cr.)
The finite element method applied to solid mechanics, fluid dynamics, and heat transfer. Prerequisites: ME 1028, ME 1052, ME 1072.

ME 1049 Mechatronics (3 cr.)
Digital logic, register, RAMs, ALUs, and microprocessor operation with typical applications. Prerequisite: ME 1014.

ME 1055 Computer Aided Analysis in Transport Phenomena (3 cr.)
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, ME 0051.

ME 1097 Engineering Research Special Projects (1–3 cr.)

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.

ME 2001 Differential Equations (3 cr.)

Ordinary differential equations; series solutions of differential equations; introduction to partial differential equations. Prerequisite: MATH 0290.

ME 2002 Linear and Complex Analysis (3 cr.)

Linear algebra; vector analysis; complex variables; introduction to calculus of variations. Prerequisite: MATH 0290.

ME 2003 Introduction to Continuum Mechanics (3 cr.)

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 cr.)

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, ME 1028.

ME 2027 Advanced Dynamics (3 cr.)

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: ME1015.

ME 2045 Linear Control Systems (3 cr.)

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: ME 1045.

ME 2046 Digital Control Systems (3 cr.)

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. Transforms 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: ME 1045.

ME 2056 Introduction to Combustion Theory (3 cr.)
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 cr.)
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 cr.)
This course aims to provide basic understanding of microfabricaton 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 cr.)
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: ME 1014, ME 1020, ME 2001.

2.4 Humanities and Social Science Electives

Students must satisfactorily complete a minimum of six (6) Humanities and Social Science courses, for a total of eighteen (18) credits, to satisfy the degree requirements for Mechanical Engineering. All courses selected must be on the list of approved Social Science and Humanities courses that has been prepared by the Associate Dean's Office. External studies courses[1] are not acceptable and neither are English Composition 0150 and 0200.[2] A copy of the list of approved Social Science and Humanities courses can be obtained from the Mechanical Engineering Department Undergraduate Office (647 Benedum Hall).

Students must additionally satisfy the following requirements:

- Students must include PHIL 0300 Introduction to Ethics as one of the six Humanities/Social Science courses. If there is a compelling reason, the Undergraduate Coordinator may waive this requirement.

- Students must satisfactorily complete two (2) Humanities/Social Science courses from the same department or program, only one of which may be an introductory course (indicated by an asterisk "*" on the list of approved Social Science and Humanities courses). This meets ABET's requirement for depth in the Humanities and Social Sciences.

- Students must satisfactorily complete at least two (2) Humanities courses (PHIL 0300 counts as one of these) and at least two (2) Social Science courses. For example, it is not acceptable for five of the six Humanities/Social Science courses to be in the Humanities. This meets ABET's requirement for breadth in the Humanities and Social Sciences.

- The University of Pittsburgh requires that all students complete at least one "W" designated course—the "W" indicates that a course has a substantial writing component, with students revising their written work after receiving feedback from the instructor. Students should refer to the *Schedule of Classes* each term to determine whether a course is being offered as a "W" designated course. Note that "W" designated courses are offered by every CAS department, not just the Humanities/Social Science departments.

Course descriptions for the Humanities and Social Science electives are available in the College of Arts and Sciences Dean's Office (140 Thackeray Hall), and there is also a desk copy available in the Mechanical Engineering Undergraduate Office (647 Benedum Hall).

If a student would like to take a Humanities or Social Science elective which is not on the approved list, then the student must complete an *Approval Request for Humanities/Social Science Elective* form, available in the Mechanical Engineering Undergraduate Office (647

[1] External studies courses are denoted by an "X" in the "Special Indicators" column of the *Schedule of Classes*.

[2] All engineering students complete an examination upon entry into the University and if it is determined that a student needs additional instructon in written communication, then either ENGCMP 0150 Basic Writing or ENGCMP 0200 General Writing is required as an additional course beyond the normal requirements.

Benedum Hall). The form must be turned in to the Associate Dean's Office (323 Benedum Hall) for approval. Students can contact the Undergraduate Office approximately one week later to see if the course was approved. It is helpful if you include a copy of a course description for the course.

2.5 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, preferably in the third term of a student's course of study.

COMMRC 0500 Argument (3 cr.)

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

COMMRC 0520 Public Speaking (3 cr.)

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 cr.)

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 cr.)

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 cr.)

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 crisesmost 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.

2.6 Academic Advising

- The Undergraduate Coordinator will be your initial transfer advisor when you apply for admission to the Mechanical Engineering 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 647 Benedum to be assigned to a co-op advisor (see page 27).

- All of the department advisors' office hours and room numbers are posted on the front door of the Undergraduate Office, as well as on various bulletin boards on the 5th and 6th floors of Benedum Hall.

- If you forget who your advisor is, there is an alphabetical listing of all the mechanical engineering students along with their assigned advisor's name located on the Undergraduate Bulletin Board outside 622 Benedum Hall.

- Students must make an appointment with their advisors for registration at least one week before the registration period begins.

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/N Grade Options are not allowed.

3.1.1 Letter Grades

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

Grades		Quality 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 Add/Drop form, signed by the student's academic advisor, through the Office of the Registrar, G-1 Thackeray Hall.

Through the ninth week of the term, a student may withdraw from an engineering course by completing a Monitored Withdrawal form available in the Undergraduate Office, 647 Benedum Hall. The course instructor must sign the form. Withdrawal forms for courses offered by the College 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 Quality Point Average

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

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 QPA, 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 quality point average of at least 3.25, (2) completed a minimum of 15 credits of academic work for letter grades at the University of Pittsburgh, and (3) completed a minimum of six credits 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 quality point averages of at least 3.25, (2) completed a minimum of 30 credits of academic work for letter grades at the University of Pittsburgh, and (3) completed a minimum of six credits 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 QPA 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* QPA is less than 2.00, but his/her *cumulative* QPA 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* QPA 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 QPA 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 QPA 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 credits required by the department in which the student is enrolled. The student must also have obtained a minimum cumulative QPA of 2.00 for (a) all courses completed at the University of Pittsburgh and (b) all departmental courses.

2. Students who have a cumulative QPA of 2.00, but have not obtained the minimum 2.00 departmental QPA, 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 QPA of 2.00 for all courses taken at the University.

3. Students must complete the 125-credit course requirement. Only credits approved by the Mechanical Engineering Undergraduate Coordinator count towards this requirement. In particular, remedial writing, remedial mathematics, PEDC, and AFROTC credits will not count towards this requirement.

4. Advanced standing credits accepted by the School of Engineering may partially fulfill course requirements for graduation, but grades and credits earned in such courses are not included in the QPA calculations.

5. No course in which an "F" or a non-letter grade was received can be used to satisfy the 125-credit 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 Office. 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 on the door of the Undergraduate 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 Coordinator before the add/drop period ends. The Undergraduate Coordinator 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 credits) 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 credits through petition to the department.

10. To be considered for honors at graduation, a student must earn at least 68 letter grade credits at the University of Pittsburgh. The minimum cumulative QPA 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 Coordinator, request a waiver of this policy. This policy means that part-time student must progress toward the degree at a minimum of 10.42 credits 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 Coordinator. If the student has attended another institution and completed more than 12 credits, 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

4.1 Registration Procedure

- Students should attend the registration seminar on the designated date, as specified during the first undergraduate seminar of the term. The registration seminar will be extended by one hour to accommodate students whose schedule conflicts with the regularly schedule undergraduate seminar. The Undergraduate Administrator and academic advisors will be present during these registration seminars. Students will not have to register at Thackeray Hall—the Undergraduate Administrator will process the registration forms immediately after these sessions.

  Students who do not register during the above-designated time must not expect to be given special consideration should course sections be closed or canceled. Students who do not attend the registration seminar must register during the make-up period assigned during the first seminar for the term.

- Exceptional situations will be handled by the Undergraduate Administrator in 647 Benedum Hall.

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 credits without specific written permission from the Undergraduate Coordinator 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 credits over 18 will be billed over and above the full-time tuition rate at the prevailing per-credit tuition charge.

4.2 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 credits 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. Credits 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 credits (including the cross-registration credits).
- 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.
- Students who have earned more than 60 credits toward a college degree may not take courses at the Community College of Allegheny County or any other two-year institution.
- 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 Department to another engineering discipline. A Change of Status form, available in the Undergraduate Office, should be completed to initiate a change of departmental status. The Undergraduate Coordinator 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 & Advanced Standing for Courses Taken Outside of the University

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; 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 4.0 scale at the institution previously attended. Advanced standing credits 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 2.0 on a 4.0 scale will be considered for transfer, and then only if the courses are an integral part of the proposed degree program.

Students transferring from the College 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 quality point average of 2.50 is required. All the freshman-level engineering courses should be completed before applying for transfer.

Students transferring into the Mechanical Engineering Department from other college-level programs will have their academic records reviewed for advanced-standing credit after they have been accepted for admission. The determination of advanced standing is made by the Undergraduate Coordinator, in accord with School of Engineering policy and criteria established by the Accreditation Board for Engineering and Technology (ABET). 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 College 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.

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.

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 Coordinator. Such courses must be taken at a college or university that offers a full four-year degree program. Engineering and engineering science courses must have been taken from an ABET-approved engineering program.

4.4.1 Community College Courses

Specifically, once a student is enrolled in the Mechanical Engineering 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 who are not residing in the Pittsburgh area may be given permission to take arts and sciences courses at legitimate, four-year institutions (ABET approved). 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. Students may take courses at the Greensburg and Johnstown campuses of the University of Pittsburgh.

4.4.2 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 quality point average of 2.50 or higher in the required engineering curricula are guaranteed relocation to the Oakland campus.

4.4.3 Transfer of Summer Courses

Many students prefer to take classes at a college located near their homes during the summer months. Students should provide their advisor with a course description for each course they wish to transfer. If the course is approved, the advisor should put the approval in writing and place it in the student's academic file. Only the credits will transfer for the equivalent class, not the grade or quality point average. Credit will only be given for course work of C or higher. It is the student's responsibility to have the transcript sent to the Engineering Office of Administration, 253 Benedum Hall, at the completion of the class.

Typically, courses are used to fulfill the Humanities/Social Sciences component. Advisors must be sure that the proposed course is equivalent to a course on the School's approved Humanities/Social Science list.

Chapter 5
Curricular Options

5.1 Co-op Program

The Cooperative Education Program (or Co-op Program) is a partnership among the employer, university, and student that provides relevant work assignments for the students while at the undergraduate level. The employers benefit from the expertise and enthusiasm of the student, and find the program a cost-effective means of completing projects. Many employers also utilize the program as a recruitment tool for post-graduate employment.

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.

Designated faculty members from each participating department approve students' co-op schedules and remain in the capacity of advisor throughout the students' tenure in the program. Faculty and co-op staff members also visit the work sites. The co-op office works with students individually to try and place them in appropriate assignments; although placement is not guaranteed, in most cases students can find appropriate positions, particularly if they are willing to look beyond the Pittsburgh region. The average starting salary for a first term co-op during 2001 was $2100 per month. Students who complete the program requirements are honored at a luncheon each year. Employers, staff and faculty, and parents are invited to attend. Each student is presented with a certificate of program completion by the Dean.

Mechanical Engineering students have the option of using their co-op credits (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 Office, 647 Benedum Hall.

The co-op option is available to all engineering undergraduates. Students must be in good academic standing (minimum 2.0 QPA), 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. Also, there is a wealth of additional information on the co-op program web site (`www.engr.pitt.edu/coop`).

5.2 Engineering Minors

Undergraduate students in the Mechanical Engineering department can choose to enhance their education by minoring in one of the following areas: bioengineering, chemical engineering, electrical engineering, environmental engineering, industrial engineering, materials science and engineering, petroleum engineering, or polymer engineering. Descriptions of these minors and their requirements are available in the Undergraduate Office, 647 Benedum Hall, and on the department's web site (`www.engr.pitt.edu/mechanical`).

5.3 International Education

The School of Engineering is making a concerted effort to expand students knowledge through international education. Engineering students must understand how to operate in a global manner. The schools programs provide opportunities for students to broaden their horizons in numerous ways.
www.engr.pitt.edu/students/InternationalEducation.html

5.3.1 Study Abroad

The School of Engineering has designed several study aboad programs and/or affiliates with particular institutions of higher learning specifically for the benefit of its students. Students are encouraged to participate in overseas study and/or internship programs for academic credit during a semester, summer, or academic year.
www.pitt.edu/~abroad/engrng/

5.3.2 Semester at Sea

Manufacturing in the Pacific Rim is one of the first Semester at Sea programs designed speicifically for engineering and business students. In addition to visiting interport lecturers, the program will includes site visits to manufacturing facilities to better enable students to learn about the manufacturing cultures, issues and challenges in each of the seven countries—Russia, Korea, Taiwan, China (Shanghai), Hong Kong, Vietnam, and Japan. Students will meet with manufacturing company representatives to discuss differences in manufacturing culture between the county being visited and other countries where that company operates.
www.semesteratsea.com

5.3.3 Engineers Without Frontiers

Engineers Without Frontiers is student organization within the School of Engineering that helps to coordinate service learning opportunities for engineers. Students use their engineering skills to help better development of third-world countries. Contact jmhughes11@juno.com for more information.

5.4 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 credits. A maximum of 6 credits can be applied to a master's degree program. These credits will only apply to graduate degree requirements.

5.5 College of Arts & Sciences Joint Degree Program

The College of Arts and Sciences (CAS) and the School of Engineering have developed a joint-degree program that permits a student to combine a major in Arts and Sciences with a program in engineering and receive degrees from both CAS and Engineering. The student

must be admitted to into both schools.

While the form of the program is dependent upon the individual student's interests, the first year's curriculum is typically the standard engineering program. During the next three years the student may complete the specific requirements for his or her engineering degree while fulfilling certain College of Arts and Sciences requirements. The fifth year is then used to complete the CAS requirements. Students must complete a minimum of 90 CAS credits, including all CAS Skills and General Education Requirements and a CAS major (but not a related area). Students may also complete all the degree requirements of their chosen engineering program, usually consisting of 70 or more School of Engineering credits. Each program is developed with an adviser in the College of Arts and Sciences and an adviser in the School of Engineering, and tailored to the student's special interests. Students in this program have combined engineering with behavioral neuroscience, philosophy, economics, and music.

Students must satisfy both schools' normal progress requirements and criteria for academic standing as long as they remain in the joint-degree program. Students also must apply for graduation from both schools. CAS students earn a B.A., B.S. or B.Phil. degree, depending upon the CAS program of study. The student's QPA for graduation from CAS is calculated based solely upon the credits earned for the CAS degree. For further information, students may contact one of the following: the Freshman Engineering Program Office, B-80 Benedum Hall; the CAS Dean's Office, 140 Thackeray Hall; or the CAS Advising Center, 252 Thackeray Hall.

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

The University of Pittsburgh School of Engineering has developed combined liberal arts-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. 3/2 agreements or articulation agreements are in place with the following institutions:

Allegheny College
California University of PA
Clarion University of PA
Community College of Allegheny County
Duquesne University
Edinboro University
Gannon University
Indiana University of PA
Jamestown Community College
Saint Francis College
Saint Vincent College
Seton Hill College
Thiel College
Valley Forge Military College

APPENDICES

Appendix A - Curriculum Checklist

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
MATH0240	4 ____	Anal. Geometry & Calc. 3	MATH0230
MATH0280[1]	3 ____	Matrices & Linear Algebra	MATH0220
MATH0290[1]	3 ____	Differential Equations	MATH0280
PHYS0174	4 ____	Phys. for Sci. & Engr. 1	*MATH0220*[2]
PHYS0175	4 ____	Phys. for Sci. & Engr. 2	PHYS0174, *MATH0230*
PHIL0300	3 ____	Intro. to Ethics (Humanity)	
_____	3 ____	Humanity Elective	
_____	3 ____	Social Science Elective	
_____	3 ____	Social Science 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, PHYS0175
ENGR0135	3 ____	Statics & Mech. of Mater. 1	PHYS0175, ENGR0012
ENGR0145	3 ____	Statics & Mech. of Mater. 2	ENGR0135
ME0022	3 ____	Kinematics of Machinery	MATH0240, ENGR0135, ME0024
ME0024	3 ____	Intro. to ME Design	ENGR0011
ME0031	3 ____	Electrical Circuits	PHYS0175, *MATH0290*
ME0051	3 ____	Intro. to Thermo-Fluids	PHYS0175, CHEM0960, *MATH0290*
ME1014	3 ____	Dynamic Systems	MATH0290, PHYS0175, ME0031
ME1015	3 ____	Kinetics	ME0022
ME1028	3 ____	Mechanical Design 1	ENGR0145
ME1029	3 ____	Mechanical Design 2	ME0024, ME1028
ME1041	3 ____	Mechanical Measurements 1	ENGR0145, ME0031, *ME1014*
ME1042	3 ____	Mechanical Measurements 2	ME1041
ME1043	3 ____	Mechanical Measurements 3	*Senior Standing*
ME1051	3 ____	Applied Thermodynamics	ME0051
ME1052	3 ____	Heat Transfer	ME0051
ME1065[3]	3 ____	Thermal Systems Design	ME1052, ME1072
ME1072	3 ____	Applied Fluid Dynamics	ME0051
_____	3 ____	Technical Elective	
_____	3 ____	Technical Elective	
_____	3 ____	Technical Elective	
_____	3 ____	Dynamic Systems Elective	

[1]MATH0280 and MATH0290 may be replaced with MATH0250 Matrix Theory and Differential Equations, if it was taken *before* the Fall Term of 2006–07 (2071).

[2]Italicized courses indicate corequisites, that is, courses that must be taken prior to or concurrently with the subject course.

[3]ME1065 Thermal Systems Design may be replaced with ME1038 Design for Manufacturing, if it was taken *before* the Spring Term of 2004–05.

Appendix B - 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
	Humanity/Soc. Sci. Elective	3
ENGR0081	Freshman Seminar	0
		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
	Humanity/Soc. Sci. Elective	3
ENGR0082	Freshman Seminar	0
		17

THIRD TERM

Subject		Credits
MATH0240	Anal. Geometry & Calc. 3	4
MATH0280	Matrices & Linear Algebra	3
ENGR0135	Statics & Mech. Mater. 1	3
ME0024	Intro. to ME Design	3
	Communication Skills Elective	3
ME1085	Departmental Seminar	0
		16

FOURTH TERM

Subject		Credits
MATH0290	Differential Equations	3
ENGR0145	Statics & Mech. Mater. 2	3
ME0022	Kinematics of Machinery	3
ME0031	Electrical Circuits	3
ME0051	Intro. to Thermo-Fluids	3
ME1085	Departmental Seminar	0
		15

FIFTH TERM

Subject		Credits
ENGR0022	Mater. Struct. & Properties	3
ME1014	Dynamic Systems	3
ME1028	Mechanical Design 1	3
ME1052	Heat Transfer	3
	Humanity/Soc. Sci. Elective	3
ME1085	Departmental Seminar	0
		15

SIXTH TERM

Subject		Credits
ME1015	Kinetics	3
ME1029	Mechanical Design 2	3
ME1051	Applied Thermodynamics	3
ME1072	Applied Fluid Dynamics	3
	Humanity/Soc. Sci. Elective	3
ME1085	Departmental Seminar	0
		15

SEVENTH TERM

Subject		Credits
ME1041	Mechanical Measurements 1	3
ME1065	Thermal Systems Design	3
	ME Technical Elective	3
	Dynamic Systems Elective	3
	Humanity/Soc. Sci. Elective	3
ME1085	Departmental Seminar	0
		15

EIGHTH TERM

Subject		Credits
ME1042	Mechanical Measurements 2	3
ME1043	Senior Design Project	3
	ME Technical Elective	3
	ME Technical Elective	3
	Humanity/Soc. Sci. Elective	3
ME1085	Departmental Seminar	0
		15

Appendix C - Course Offerings by Term

To assist you in long term schedule planning, a *tentative* 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	•	•	•
ME0022		•	•
ME0024	•		
ME0031		•	•
ME0051		•	•
ME1014	•	•	
ME1015	•	•	
ME1028	•	•	
ME1029		•	•
ME1041	•	•	
ME1042		•	•
ME1043	•	•	•
ME1051	•	•	
ME1052	•		•
ME1065	•		•
ME1072	•	•	
ME1085	•	•	
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 without notice.

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

	Fall	*Spring*	*Summer*
Year 1			
Year 2			
Year 3			
Year 4			
Year 5			

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 - Co-op Schedule A

Student Name: _____
Department: _____
Anticipated Co-op Start Date: _____

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

	Fall	*Spring*	*Summer*
Year 1	CHEM0960 MATH0220 PHYS0174 ENGR0011 *Soc. Sci./Hum.*	CHEM0970 MATH0230 PHYS0175 ENGR0012 *Soc. Sci./Hum.*	
Year 2	MATH0240 MATH0280 ENGR0135 ME0024 *Comm. Skills*	MATH0290 ENGR0145 ME0022 ME0031 ME0051	**Work Rotation**
Year 3	ME1014 ME1015 ME1028 ME1051 ME1072	**Work Rotation**	ENGR0022 ME1029 ME1052 *Soc. Sci./Hum.* *Soc. Sci./Hum.*
Year 4	**Work Rotation**	ME1041 *ME Tech. Elec.* *ME Tech. Elec.* *Dyn. Sys. Elec.* *Soc. Sci./Hum.*	ME1042 ME1043 ME1065 *Soc. Sci./Hum.*
Year 5	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____

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 - Co-op Schedule B

Student Name: _____
Department: _____
Anticipated Co-op Start Date: _____

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

	Fall	*Spring*	*Summer*
Year 1	CHEM0960 MATH0220 PHYS0174 ENGR0011 *Soc. Sci./Hum.*	CHEM0970 MATH0230 PHYS0175 ENGR0012 *Soc. Sci./Hum.*	
Year 2	MATH0240 MATH0280 ENGR0135 ME0024 *Comm. Skills*	**Work Rotation**	MATH0290 ENGR0145 ME0022 ME0031 ME0051
Year 3	**Work Rotation**	ENGR0022 ME1014 ME1015 ME1028 *Soc. Sci./Hum.*	**Work Rotation**
Year 4	ME1041 ME1051 ME1052 *ME Tech. Elec.* *Soc. Sci./Hum.*	ME1042 ME1072 *ME Tech. Elec.* *Dyn. Sys. Elec.* *Soc. Sci./Hum.*	ME1029 ME1043 ME1065 *Soc. Sci./Hum.*
Year 5	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____

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.