UNIVERSITY OF PITTSBURGH

Materials Science & Engineering

Undergraduate Academic Program Manual

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Forward

This *Materials Science and Engineering Undergraduate Academic Program Manual* is a supplement to the information provided on the University of Pittsburgh Swanson School of Engineering's website (https://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's website. It is provided so that you will be better informed about your department and for your convenience in monitoring progress towards completion of your degree. The latest version of this manual can be found on the MEMS Department's student resources webpage.

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Chapter 1

About Materials Science & Engineering

Materials limitations often impede technological and social progress. The materials engineer applies special knowledge of the structure, behavior, and properties of materials to solve these materials problems. The engineer may be concerned with developing and improving processes for producing materials, developing new materials or improving existing materials, and/or achieving better utilization of materials. New materials must be designed for a variety of functions (e.g., structural, aesthetic, electrical, or magnetic) and operating environments. Materials are dealt with in forms so minute that the work is done under a microscope and so large that special handling cranes are required.

Materials Science and Engineering (MSE) is a relatively new and very interdisciplinary field. MSE is for students who genuinely want to be involved with using engineering science at the cutting edge of today's technological world. Modern MSE creates the "stuff" out of which we fabricate our society, using concepts of engineering design from the microscopic level of atoms, molecules, and electrons to the macroscopic scale of bridges, machines, motors, turbine engines, and supersonic aircraft.

A major attraction of this major is the breadth of career opportunities available to graduates because of the impact and influence of materials on an ever-greater number of critical manufacturing and processing technologies and because of their critical role in vital areas such as transportation, energy, and communications. Materials scientists and engineers are heavily recruited by the primary metallurgical, aerospace, and electronics industries. Moreover, opportunities are growing in the emerging biomedical/bioengineering technologies.

The MSE 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 MSE program in the Department of Mechanical Engineering and Materials Science is to educate students with excellent technical capabilities in the materials science and 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 materials science and 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 Materials Science and Engineering 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 Materials Science and Engineering curriculum concentrates on the fundamentals of the sciences, mathematics, and engineering. The last two years provide increased depth in the engineering sciences, including heat and mass transfer, energetics, and the structure and properties of materials, and in engineering applications such as experimental methods, mechanical design, and material selection. Students have the freedom to pursue areas of personal interest in materials science and 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 Materials Science and Engineering courses introduce consideration of human values, social benefits, and social constraints to prepare future practicing engineers to be responsive to such concerns.

1.2.1 Engineering Design

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 student also addresses design problems in mechanics, manufacturing, 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, heat and mass transfer, and expermental methods.

Design is a large part of the senior year. Design problems in material selection 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 materials science and engineering, including ethical issues and meeting budget and schedule constraints.

1.2.3 Written and Oral Communication

A materials scientist and 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). 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.

1.2.4 Computer Experience

Computer experience is distributed throughout the Materials Science and 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, 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, Computer Applications in MSE utilizes software packages developed for applications such as diffraction, thermodynamics, and electronic materials.

1.2.5 Laboratory Experience

Laboratory experience is an important component of the Materials Science and Engineering undergraduate curriculum. This experience comes primarily through three courses, beginning in the junior year.

Experimental Methods in MSE gives students practical experience of the experimental methods used in modern materials science and engineering. The first set of experiments introduces the common methods for analyzing material structure including: optical microscopy, X-ray diffraction, and scanning electron microscopy (SEM). The second part of the course concentrates 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.

Structures & Properties Laboratory builds on the students experience of experimental methods by applying them to processing-structure-property relationships in materials from the different material classes. Examples include: the effect of mechanical work and heat treatment on the properties of metal alloys, the effect of ceramic powder characteristics on the pore structure of sintered ceramics, and the effect of temperature on the extent of crosslinking in a thermosetting polymer.

The Senior Materials Research Project is a major project involving literature search, planning, experimentation, analysis, an oral presentation, and a final technical report. The project is either sponsored by the department or a local company and is conducted by an individual or a small team of students with a faculty adviser.

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 is a student chapter of the American Society for Metals (ASM) International, a professional society for materials scientists and engineers whose mission is to gather, process, and disseminate technical information. ASM fosters the understanding and application of engineered materials and their research, design, reliable manufacture, use, and economic and social benefits. This is accomplished via a unique global information-sharing network of interaction among members in forums and meetings, education programs, and publications and electronic media.

Chapter 2

Undergraduate Curriculum

The requirements for obtaining a Bachelor of Science (B.S.) degree in Materials Science and 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 three (3) Materials Science and Engineering Technical Electives, six (6) Social Science and Humanities Electives, and one (1) Communication Skills Elective. There are a total of 128 passed credits required for graduation, all of which must be taken with the letter grade option.

2.1 Required Materials Science & Engineering Courses

Students must satisfactorily complete the following seventeen (17) Materials Science and Engineering courses, for a total of forty-seven (47) credits.

MEMS 0024 Introduction to Mechanical Engineering Design (3 cr.)
Fundamentals of the design process, basic techniques of graphic communication, and an introduction to the most common mechanical components and manufacturing processes. Prerequisite: ENGR 0011.

MEMS 0031 Electrical Circuits (3 cr.)
Fundamental laws, principles, and analysis techniques for DC and AC linear circuits whose elements consist of passive and active components used in modern engineering practice, including the determination of steady-state and transient responses. Prerequisite: PHYS 0175. Co-requisite: MATH 0290.

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

MEMS 0048 THERMODYNAMICS OF MATERIALS (3 cr.)
This course teaches the essentials of thermodynamics of materials, which concerns the basic concepts and principles of thermodynamics, and the application of thermodynamic principles to the analysis of a multitude of phenomena related to the behavior of materials. The course covers topics on the laws of thermodynamics, relation between work, heat and energy, entropy, free energy, phase equilibrium in one-component systems, chemical reactions involving gases, and chemical reactions involving both solids and gases. Prerequisites: PHYS 0174, CHEM 0960. Co-requisite: MATH 0290.

MEMS 1010 EXPERIMENTAL METHODS IN MSE (3 cr.)
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 1011 STRUCTURES & PROPERTIES LABORATORY (3 cr.)
This laboratory will build on the students experience of the experimental methods introduced in MEMS 1010 by applying them to processing-structure-property relationships in materials from the different material classes. Examples include: the effect of mechanical work and heat treatment on the properties of metal alloys, the effect of ceramic powder characteristics on the pore structure of sintered ceramics and the effect of temperature on the extent of cross-linking in a thermosetting polymer. Prerequisite: MEMS 1010.

MEMS 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.

MEMS 1030 MATERIAL SELECTION IN MECHANICAL DESIGN (3 cr.)
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 1043 SENIOR DESIGN PROJECT (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.*

MEMS 1052 HEAT & MASS 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: MEMS 0048 or MEMS 0051.

MEMS 1053 STRUCTURE OF CRYSTALS & DIFFRACTION (3 cr.)
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 1058 ELECTROMAGNETIC PROPERTIES OF MATERIALS (3 cr.)
Review of basic principles—quantum theory, band and zone theory. Transport, electrical, and thermal properties; semiconductors and semiconductor devices; magnetic materialshard and soft; dielectric and optical properties. Prerequisite: ENGR 0022.

MEMS 1059 PHASE EQUILIBRIA IN MULTI-COMPONENT MATERIALS (3 cr.)
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 0048.

MEMS 1063 PHASE TRANSFORMATIONS & MICROSTRUCTURE EVOLUTION (3 cr.)
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 1070 MECHANICAL BEHAVIOR OF MATERIALS (3 cr.)
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 1079 SENIOR MATERIALS RESEARCH PROJECT (3 cr.)
A major project involving literature search, planning, experimentation, analysis, an oral presentation, and a final technical report. The project is either sponsored by the department or a local company and is conducted by an individual or a small team of students with a faculty adviser. Prerequisite: *senior standing.*

MEMS 1085 DEPARTMENTAL SEMINAR (0 cr.)
Seminars are designed to acquaint the student with aspects of 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 fifteen (15) of these courses for a total of fifty-one (51) 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. (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. (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.)
Introduces students to basic topics in engineering, the role of the computer in engineering, ill-structured problem solving, and report writing. The course includes material on the use of Unix, HTML, spread sheets, and MATLAB. Data analysis and curve fitting is done in both MATLAB and Excel. The writing component includes four detailed reports and includes an oral presentation. The course goals are: to introduce the fundamentals of what engineering is, what engineers do, why a diverse work force is needed, and what values come with working in a group environment; to introduce the required library research skills and communication skills used by all engineers; to introduce the role of the computer in engineering problem solving, including the basic analytical, programming design, graphical, and problem solving skills used by most engineers in their profession; and to provide an overview of how material in the basic sciences and mathematics is applied by engineers to solve practical problems of interest to society.

ENGR 0012 Introduction to Engineering Computing (3 cr.)
Introduces students to social topics in engineering, the role of the computer in engineering, ill-structured problem-solving and report writing. The course includes material on the use of MATLAB and C++. Students learn the fundamentals of computing in engineering, including program design, program development, and debugging. Applications to problems in engineering analysis with topics selected from ENGR 0011. The writing component includes four detailed reports and includes an oral presentation. Prerequisites: ENGR 0012.

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 0174.

ENGR 0135 Statics & Mechanics of Materials 1 (3 cr.)
First of a two course sequence covering statics and mechanics of materials. Topics covered include: concurrent force systems, equilibrium, axial loading, stress, strain, deformation, moments, equivalent systems, centroids, centers of mass and distributed loads, free-body diagrams, equilibrium of rigid and deformable bodies, plane trusses, frames and machines, equilibrium in 3D, torsion, and friction. Prerequisites: MATH 0230, PHYS 0174.

ENGR 0145 Statics & Mechanics of Materials 2 (3 cr.)
Second of a two course sequence covering statics and mechanics of materials. Topics include: flexure; second moment of areas, shear force and bending moment diagrams, composite beams, shearing stresses, beam deflections, energy methods, combined static loading, and buckling of columns. Prerequisite: ENGR 0135

MATH 0220 Analytic Geometry & 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.

MATH 0230 Analytic Geometry & 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. Prerequisite: C or better in MATH 0220.

MATH 0240 Analytic Geometry & 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. Prerequisite: C or better in MATH 0230.

MATH 0280 Introduction to Matrices & Linear Algebra (3 cr.)
The topics which this course cover include: vectors, matrices, determinants, linear transformations, eigenvalues and eigenvectors, and selected applications. Prerequisite: C or better in 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: C or better in MATH 0230.

PHYS 0174 Basic Physics for Science & Engineering 1 (4 cr.)

The integrated curriculum version of PHYS 0104, the first part of a two-term sequence that introduces students to the basic principles of mechanics. An effort has been made to achieve a better integration of physics with the first term of calculus, engineering, and chemistry. The theory of waves and the kinetic theory of gases will be discussed. Co-requisite: MATH 0220.

PHYS 0175 Basic Physics for Science & Engineering 2 (4 cr.)

The integrated curriculum version of PHYS 0105, the second part of a two-term sequence that introduces students to the basic principles of physics. An effort has been made to achieve a better integration of physics with the first term of calculus, engineering, and chemistry. Modern physics (special relativity, elementary quantum mechanics, and atomic structure) will be discussed. Prerequisite: C or better in PHYS 0174. Co-requisite: MATH 0230.

2.3 Technical Electives

Students are required to satisfactorily complete three (3) of the following Materials Science and Engineering Technical Elective courses, for a total of nine (9) credits. Some suggested sequences include:

Bulk Engineering Materials (3 of the following courses)

MEMS 1101 Ferrous Physical Metallurgy
MEMS 1102 Principles and Applications of Steel Alloy Design
MEMS 1103 Principles and Applications of Steel Processing
MEMS 1162 Computer Applications in MSE
MEMS 1163 Ceramic Materials
MEMS 1174 Ceramics Processing

Nanomaterials (3 of the following courses)

MEMS 1048 Analysis and Characterization at the Nano-scale
MEMS 1057 Micro/Nano Manufacturing
MEMS 1111 Materials for Energy Generation and Storage
MEMS 1162 Computer Applications in MSE
MEMS 1163 Ceramic Materials
ENGR 0240 Introduction to Nanotechnology and Nanoengineering
ENGR 1066 Introduction to Solar Cells and Nanotechnology

Polymers

CHEM 0310 Organic Chemistry 1
CHEM 0320 Organic Chemistry 2
CHEM 1600 Synthesis and Characterization of Polymers
CHE 1754 Principles of Polymer Engineering

Biomaterials (3 of the following courses)

BIOENG 1070 Introduction to Cell Biology 1
BIOENG 1071 Introduction to Cell Biology 2
BIOENG 1810 Biomaterials and Biocompatibility
IE 1201 Biomaterials and Biomanufacturing
(BIOSCI 0105 and 0106 can be substituted for BIOENG 1070 and 1071. CHEM 0310 Organic Chemistry 1 is also recommended, but not required, for this option.)

Energy

ENGR 1700 Introduction to Nuclear Engineering
ENGR 1701 Fundamentals of Nuclear Reactors
ENGR 1702 Nuclear Plant Technology

Note also the following:

- MSE technical electives can include 2000-level (i.e., Masters-level), subject to the approval of the MSE Program Director.
- 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 MSE technical electives.
- Upper-level engineering courses from other engineering departments may be substituted for Materials Science and Engineering Technical Electives, subject to the approval of the MSE Program Director.
- 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 junior standing.

Students wishing to pursue other technical elective choices must obtain the approval of the MSE Program Director.

2.3.1 Technical Elective Course Descriptions

BIOENG 1070 Introduction to Cell Biology 1 (3 cr.)
Principles of cell biology in higher organisms: structure, function, biosynthesis, and macromolecular organization with a focus on macromolecular organization and function from a quantitative systems perspective. Prerequisite: ENGR 0012.

BIOENG 1071 Introduction to Cell Biology 2 (3 cr.)
Continuation of BIOENG 1071. Principles of cell biology in higher organisms: structure, function, biosynthesis, and macromolecular organization with a focus on macromolecular organization and function from a quantitative systems perspective. Upon completing the two course sequence, BIOENG 1070 and BIOENG 1071, students should be able to (1) demonstrate understanding of the principles of cell structure and function, (2) describe the

experimental tools used to understand cellular function such as molecular genetic techniques, biochemical analysis, and microscopy, and (3) use systems approaches to understand how cellular processes are integrated. Prerequisite: BIOENG 1070.

BIOENG 1810 Biomaterials and Biocompatibility (3 cr.)
Undergraduate students are introduced to an advanced understanding of biomaterials and the use of biomaterial in areas such as tissue engineering, artificial organs, and implantable devices. Throughout the course, ties are made between the topic of study and clinically relevant biomaterial performance. The course introduces various biomaterials, such as polymers, metals, and ceramics, with the focus on biomaterial synthesis, characterization, structure-property relationship and surface modification. Biocompatibility issues of biomaterials will be discussed from different aspects such as protein adsorption, foreign body reaction, immune and inflammatory response, and sterilization. Finally, examples of clinical applications are discussed. Upon completing the course, the student should be able to: state the basic principles behind human tissue response to artificial surface implantation, describe the general types of materials used in soft and hard tissue replacements, drug delivery devices, and extracorporeal devices, describe techniques utilized to control the physiologic response to artificial surfaces, and identify various design strategies and clinical applications of biomaterials. Prerequisite: CHEM 0320.

CHE 1754 Principles of Polymer Engineering (3 cr.)
This course deals with the elements of polymer science and engineering necessary for entry-level understanding of polymer technology. While the chemistry determines macromolecular microstructure, an understanding of polymer manufacture and processing requires the addition of physical chemistry and transport phenomena. The essential material covered in this class includes the elements of polymers thermodynamics, rheology, mechanical behavior, and equipment design. Prerequisite: MEMS 1056.

CHEM 0310 Organic Chemistry 1 (3 cr.)
An introduction to theory and practice of organic chemistry through study of structural principles, reaction mechanisms, and synthesis leading toward end of second term, when complex molecules of biological interest are discussed. Basic goals of course are to develop appreciation and skill in methods of molecular analysis which have made organic chemistry such a powerful intellectual discipline. Course will prepare student for work in advanced topics of organic chemistry, biochemistry, chemical engineering and health related sciences. Prerequisite: CHEM 0970.

CHEM 0320 Organic Chemistry 2 (3 cr.)
An introduction to theory and practice of organic chemistry through study of structural principles, reaction mechanisms, and synthesis leading toward end of second term, when complex molecules of biological interest are discussed. Basic goals of course are to develop appreciation and skill in methods of molecular analysis which have made organic chemistry such a powerful intellectual discipline. Course will prepare student for work in advanced topics of organic chemistry, biochemistry, chemical engineering and health related sciences. Prerequisite: CHEM 0310.

CHEM 1600 Synthesis and Characterization of Polymers (3 cr.)
Synthesis and characterization of polymers is focus of course. Current methods of polymer synthesis will be surveyed, practical implementation of reactions and kinetic consequences of reaction strategies in homopolymer, copolymer and block copolymer synthesis. Techniques for characterization of polymer molecular weight, chemical composition, and stereochemistry (Ft-IR, NMR, other spectroscopic and chemical methods) will be discussed. Brief treatment of polymer solution thermodynamics and selected topics in polymer chemistry will be discussed. Prerequisites: CHEM 0320 and CHEM 1420.

ENGR 0240 Introduction to Nanotechnology and Nanoengineering (3 cr.)
This research-oriented course is a multidisciplinary course taught by a faculty team including a professor of electrical engineering and a professor of chemistry. The course introduces nanoscale devices created from a range of nanomaterials including carbon nanotubes (CNTS), nanoparticles (NPS), and nanowires (NWS). Theories of operation, fabrication techniques and applications of Nano devices will be discussed. The course combines lecture, laboratory work, and web-supported project-based learning. Prerequisites: MATH 0230; PHYS 0175.

ENGR 1066 Introduction to Solar Cells and Nanotechnology (3 cr.)
Introduction to solar cells and nanotechnology this course aims to prepare Undergraduate students in the design and development of low-cost, high-efficiency solar cells. Students will learn the basics of solar cells, introduce themselves to nanotechnology and how this may enable next-generation solar cells, learn how to use instruments for synthesis and characterization of nanomaterials and solar cells, examine the social implication of nanotechnology and solar cells, and practice problem solving and engineering design skills within a collaborative team. Portions of the class will be flipped (video lectures at home and assignments in class) in order to facilitate an active and engaged learning process. Prerequisite: PHYS 0175.

ENGR 1700 Introduction to Nuclear Engineering (3 cr.)
Introduction to nuclear science and technology; applications of nuclear engineering; careers in nuclear industry; nuclear history; reactor types; elementary nuclear and reactor physics; nuclear radiation and safety; fuel cycle; regulations and sustainability. Prerequisites: PHYS 0175; CHEM 0970.

ENGR 1701 Fundamentals of Nuclear Reactors (3 cr.)
Nuclear physics, fission and fusion; cross-sections; neutron flux and slowing-down; diffusion and transport; criticality condition and calculations; reactor kinetics and shielding; heat generation, transfer and cooling; reactor materials; reactor structure. Prerequisite: PHYS 0175; CHEM 0970.

ENGR 1702 Nuclear Plant Technology (3 cr.)
Current and future reactor systems; nuclear power plants; balance of plant configuration; fuel cycle management; reactor operation principles; reactor plant economics; analysis and design of nuclear systems; design projects. Prerequisite: PHYS 0175; CHEM 0970.

IE 1201 Biomaterials and Biomanufacturing (3 cr.)
The purpose of this course is to provide students having a background in biomaterials and biomanufacturing with an opportunity to learn about the many modern aspect of biomaterials from basic science to clinical applications, across the formulations and chemistry of polymers, ceramics, metals and their use in various biomedical devices and implants, as well as their clinical performance and host responses. Students will also gain knowledge and experiences with designing and manufacturing biomedical devices through team projects. This one-semester, graduate course is intended for students majoring in the industrial engineering, or those who contemplating such a major (or minor). Students enrolled in the class should have an understanding of various biomaterials, and the ability to understand biological phenomena and manufacturing processes.

MEMS 1048 Analysis and Characterization at the Nano-scale (3 cr.)
This course offers a survey of micro-analytical, microscopy and diffraction methods that are widely used for the analysis of composition, chemistry, structure, scale and morphology of advanced materials. It introduces the most basic concepts required to understand experimental data obtained with these modern techniques. The main objectives of the course are to enable students to interpret and evaluate relevant data sets presented in the research literature and to identify experimental tools to solve a given Nano-research characterization problem. Some prerequisite basic knowledge of the structure of solid matter (e.g. crystals and amorphous materials), diffraction methods (e.g. X-ray diffraction) and processing-property-structure relationships in materials is expected. Prerequisite: MEMS0040.

MEMS 1057 Micro/Nano Manufacturing (3 cr.)
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. Prerequisite: MEMS0040.

MEMS 1101 Ferrous Physical Metallurgy (3 cr.)
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 cr.)
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 cr.)
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 1111 MATERIALS FOR ENERGY GENERATION AND STORAGE (3 cr.)
The objective of this course is to provide an overview of the important renewable energy resources and the modern technologies to harness and store them. After taking MEMS 1111, students are expected to develop a solid scientific and technological understanding of new alternative energy technologies. This course will give an overview on harnessing renewable energy resources and storing collected energy. In each topic, issues relevant to basic principles and technological barriers limiting the use of non-fossil energy will be discussed.

MEMS 1162 COMPUTER APPLICATIONS IN MSE (3 cr.)
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 1053, MEMS 1059.

MEMS 1163 CERAMIC MATERIALS (3 cr.)
Structure of ceramics and glasses. Microstructures and their development. Properties, processing, and applications. Prerequisite: MEMS 1063.

MEMS 1174 CERAMIC PROCESSING (3 cr.)
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.

2.4 Engineering Elective

Students are required to complete one (1) Engineering Elective course, for a total of at least three (3) credits. Any course offered within the Swanson School of Engineering may be used to satisfy this requirement, provided only that it does not substantially replicate another course in a student's curriculum. The purpose of the Engineering Elective is to allow students the flexibility to explore possible areas of interest outside of materials science and engineering (e.g., CEE 1210 Green Building Design and Construction or IE 1040 Engineering Economic Analysis).

- In contrast to the requirements for a MSE Technical Elective, the Engineering Elective *can* be from another engineering program's sophomore curriculum (i.e., it does not have to be an "upper-level" course).
- A fourth MSE Technical Elective may be used to fulfill this requirement.
- For students pursuing an engineering minor (Section 5.2) or certificate (Section 5.4), one of the courses required for the minor or certificate can be used to fulfill this requirement.

2.5 Humanities and Social Science Electives

All Swanson School of Engineering undergraduates must complete six (6) humanities and social science elective courses, for a total of at least eighteen (18) credits. 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 MEMS Department's student resources webpage.

Additionally, all Materials Science and Engineering students must fulfill the following requirements when choosing their six humanities and social science elective courses:

Depth Requirement

- Students must complete at least two courses from the *same* department or program within the Dietrich 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 departments in the Dietrich School of Arts and Sciences.
- Students must choose classes from both humanities and social science departments.

The humanities and social science courses on the School's list of approved courses satisfy the Swanson 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

- Transfer students may be required to take ENGCMP 0200 Seminar in Composition. This does not count as one of the six required elective courses.
- No more than two of the six required elective courses can be satisfied via advanced standing credit from AP exam scores.
- If a student has obtained transfer credit from a community college prior to enrolling in the Swanson School of Engineering, no more than three of the six required elective courses can be satisfied via community college credit.
- Courses that are cross-listed with other departments may be taken under either course number (e.g., 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 credits are acceptable toward fulfilling the humanities and social science elective 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 six required 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 elective requirement. Courses from the College of General Studies (including External Studies courses), the College of Business Administration, and 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 Swanson 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 cr.)

This course is designed to acquaint students with fundamental principles of argumentation through the use of elementary debating techniques and strategies. Students will participate in several in-class debates on a question of policy.

COMMRC 0520 Public Speaking (3 cr.)

This course is designed to help students develop increased skill in public speaking by means of theory and practice. This course covers research, organization, style, delivery, and criticism of informative, deliberative, and ceremonial speeches.

COMMRC 0540 Discussion (3 cr.)

This course is designed to increase skills in critical thinking, decision making, and small group discussion. Students are introduced to theories of group process and practice step-by-step group problem solving related to contemporary issues.

ENGCMP 0400 Written Professional Communication (3 cr.)

This course explores the methods of inquiry, analysis and composition characteristic of written communication in professional settings. The course will examine such writing's specialized use of language, conventions and formats, premises, motives, and purposes. By preparing letters, resumes, proposals, reports, etc. Students will get a feel not only for what "professional" communication is, but also for how and why it does, or can, or should function. Prerequisite: ENGCMP 0200 or ENGR 0012.

ENGCMP 0600 Introduction to Technical Writing (3 cr.)

This introductory course is for students in various technical fields. Representative technical reports will be studied, as well as abstracts, the presentation of visuals and oral communication. Writing assignments will emerge from case studies reflecting on-the-job challenges.

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.

2.7 Writing Requirement

All Swanson School of Engineering students must complete at least one writing intensive course (referred to from now on as a W-course), as certified by the Dietrich School of Arts and Sciences. When viewing the Class Detail for courses online, W-courses are distinguished by having "Writing Requirement Course" listed as one of their Class Attributes. Only courses that have this Class Attribute can be used to satisfy the writing requirement.

- The writing requirement will normally be fulfilled by ensuring that either one of the six required humanities and social science electives or the communications skills elective is a W-course. It will not typically require a student to take an additional course.
- The Dietrich School of Arts and Sciences maintains a Course Descriptions webpage (http://www.courses.as.pitt.edu) that can be used to find W-courses. Under the *General Education Requirements* dropdown menu, choose W - Writing Intensive and click on the semester to see a list of W-courses being offered that term.
- There are a variety of W-courses offered each term to choose from, particularly from the English Literature Department. Note that ENGCMP 0400 Written Professional Communication and ENGCMP 0600 Introduction to Technical Writing are normally offered as W-courses.
- ENGCMP 0200 Seminar in Composition is *not* a W-course and does not satisfy the writing requirement.

2.8 Advanced Standing and Transfer Credit

Students transferring into the Mechanical Engineering and Materials Science Department from other colleges and universities will have their academic records reviewed for advanced standing after they have been accepted for admission (see Section 4.4 for more information on how to apply for transfer to the Swanson School of Engineering from another college or university). Advanced standing for a University of Pittsburgh course means that a student receives transfer credit for that course. Only the credits will transfer for the course, not the grade received at the previous institution, but in all other respects it as if the student took the course at the University of Pittsburgh.

The determination of advanced standing is made by the MEMS Undergraduate Director, in accordance with Swanson School of Engineering policy and criteria established by the Accreditation Board for Engineering and Technology (ABET).

- Only courses in which the applicant received a grade of at least 2.00 on a 4.00 scale will be considered for advanced standing, and then only if the course can be used to satisfy degree requirements.
- Advanced standing for engineering or engineering science courses will be given only if the courses were taken from an ABET accredited engineering program.

- Advanced standing for mathematics and science courses will be awarded to the extent that those courses match Dietrich School of Arts and Sciences courses.
- Humanities and social science courses must either correspond to those on the Swanson School of Engineering's approved list of humanities and social science electives or meet the Swanson School of Engineering's requirements for an acceptable humanities and social science elective, as determined by the Undergraduate Director.
- A maximum of 96 transfer credits may be applied towards the degree (75% of the 128 credits required for graduation).

Students transferring from either an institution maintaining a 3/2 program with the Swanson School of Engineering or a community college having an articulation agreement with the school will receive advanced standing in accordance with those agreements.

2.8.1 Advanced Placement (AP) Credit

The Swanson 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. Please see the freshman engineering web page (`https://www.engineering.pitt.edu/freshman`) for the current Swanson School of Engineering policy relating AP scores with advanced standing credit.

2.8.2 Transfer Credit for Courses Taken After Enrollment

Students enrolled in the Swanson 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 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 credits 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 2.0 on a 4.0 scale. It is the student's responsibility to have their transcript sent to the Undergraduate Office, 636 Benedum Hall, at the completion of the class.

2.8.3 Undergraduate Resources Web Page

A variety of resources is available on the Undergraduate/Student Resources page of the department's website. Here you will find:

- The latest versions of this Academic Program Manual, the Curriculum Checklist, the Schedule of Course Offerings by Term, etc.
- Semester course schedules.
- Departmental information regarding co-op participants, the departmental seminar, graduation, humanities and social science electives, etc.
- Various university forms for Anticipated Graduation Date, Graduation Application, Permission to register for more than 18 credits, etc.

Chapter 3

Academic Policy

3.1 Grading System

The University of Pittsburgh uses a standard letter grade system, as described below. All of the courses taken for fulfillment of the requirements for a Bachelor of Science in 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 courses through University of Pittsburgh International Programs, which are taken pass/fail (S/U). The minimum grade for satisfactory completion of a course is a "D−."

3.1.1 Letter Grades and Grade Points

The University's letter grades and their associated grade points are as follows:

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.

- A "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.

- An "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.

- A "R" grade signifies that a student resigned from the University.

- A "W" grade signifies that a student has withdrawn from a course (see Withdrawal below).

3.2 Withdrawal

To receive a refund, a student must officially drop a course during the term's add/drop period. 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. The course instructor must sign the form. Withdrawal forms for courses offered by the Swanson School of Engineering must be processed through the Engineering Office of Administration. Withdrawal forms for courses offered by the Dietrich School of Arts and Sciences must be processed through that school's dean's office. A "W" grade will then be assigned for the course. Withdrawal from a 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 credit carried for a letter grade is awarded grade points as shown in the table above. A student's term grade point average (term GPA) is the total grade points earned for the term divided by the total credits 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 credits assigned letter grades. Only credits that are taken at the University of Pittsburgh are used in the calculation of the grade point averages.

3.3.1 Course Repeats

If a student receives a grade of "C−" or lower in a course, repeats the course within one calendar year, and receives a better grade the second time, then the second grade will replace the previously assigned grade when calculating the cumulative GPA.

- The time limit can be extended if a student is not able to repeat a course within one calendar year due to extenuating circumstances (e.g., the course was only offered when the student was on a co-op rotation). Such an extension must be approved by the Senior Associate Dean for Academic Affairs.

- No sequence course may be repeated for credit after a higher-numbered sequence course has been satisfactorily completed with a "C" or better.

- Students are only permitted to repeat a course twice. For the purposes of this rule, grades of "R" or "W" do not count as repeats. If a student receives a better grade the third time, then that grade will replace the two previously assigned grades when calculating the cumulative GPA. Special permission from the Senior Associate Dean for Academic Affairs is required to take a course for a fourth time and will granted only for extremely extenuating circumstances.

- Grades for courses that have been repeated will remain on a student's transcript, even if they are not used in determining the GPA.

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 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 grade 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 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 Swanson 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 Swanson School of Engineering.

3.6 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 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.

3.7 Graduation Requirements

In order to graduate with a Bachelor of Science in Engineering in the Materials Science and Engineering program:

1. A student must have satisfactorily completed all required courses, as defined in Chapter 2, for a total of at least 128 credits.
   (a) All of the courses taken for fulfillment of the degree requirements must be taken with the Letter Grade Option. The only exception is for courses through University of Pittsburgh International Programs, which are taken pass/fail (S/U).
   (b) Advanced standing credit accepted by the Swanson School of Engineering may partially fulfill degree requirements, up to a maximum of 96 credits.
   (c) Only credits approved by the Mechanical Engineering and Materials Science Undergraduate Director count towards the 128-credit requirement. In particular, remedial writing, remedial mathematics, PEDC, and AFROTC credits will not count towards this requirement.
   (d) No course in which an "F" or a non-letter grade was received can be used to satisfy the 128-credit requirement. A minimum "D−" letter grade is required.
2. A student must have a cumulative GPA of at least 2.00.
3. The work of the senior year (a minimum of 26 credits) must be completed while in residence at the Swanson School of Engineering. Exceptions to this regulation may be granted for a limited number of credits through petition to the department.

Students must complete an Application for Graduation form in the term that they are graduating. This form is available in the Undergraduate Program Office and on the Undergraduate/Student Resources page of the department's website. After completing the form, students turn it in to the Engineering Office of Administration. Students should pay attention to the application deadlines to avoid late fees. The deadlines are posted online.

- 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.
- During the add/drop period of the term that a student is planning to graduate, students must notify the MEMS Department's Undergraduate Academic Administrator. The MEMS Undergraduate Director will then review each student's records and communicate to the student what needs to be done in order to complete his/her graduation requirements. It is important that this happens during the add/drop period, in case there are any changes required to a student's academic schedule.

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 GPA for graduation cum laude is 3.25, for magna cum laude is 3.50, and for summa cum laude is 3.75.

3.7.1 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.

Chapter 4

Registration

A lot of useful information and many of the necessary forms associated with registration can be found on the Undergraduate/Student Resources page of the department's website. These and other forms are also available in the Undergraduate Program Office, 636 Benedum Hall.

4.1 Self-Enrollment

Students enroll for courses on-line. There is an interactive video on the Student Services Portal on `https://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 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 (i.e., 12–18 credits). No student will be allowed to register for more than 18 credits 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 credits over 18 will be billed over and above the full-time tuition rate at the prevailing per-credit 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 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.
- 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 Engineering Office of Administration, 151 Benedum Hall, for a PCHE registration form and additional instructions.

4.3 Internal Transfers

Students wishing to transfer into the Swanson School of Engineering from another University of Pittsburgh undergraduate school or college, or from a University of Pittsburgh regional campus, should consult the information page for internal transfer students on the Swanson School of Engineering website.

A student in another Swanson School of Engineering program, whose academic record satisfies the minimum requirements for continued registration, may apply for transfer into the Materials Science and Engineering program by submitting an Undergraduate Academic Program Change form to their current program's administration office. Once approved by the current program's Undergraduate Director, the student's records will be sent to the MEMS department for evaluation. It is then the prerogative of the MEMS department to either approve or reject the change-of-status transfer request.

4.4 External Transfers

Students wishing to transfer into the Swanson School of Engineering from another college or university should consult the information page for external transfer students on the Swanson School of Engineering website. To be considered for admission, a student must:

- Have a GPA of at least 3.0. Community college students must have a GPA of at least 3.25.
- Have completed at least 24 credits appropriate for engineering, including two semester sequences of calculus, chemistry, calculus-based physics, and computer programming in C or C++.

If a student has fewer that 24 credits, then his/her high school record will also be evaluated in the admissions decision.

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 Swanson 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 2.8 for more information on the transfer of credit.

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 https://www.engineering.pitt.edu/mems.

5.1 Cooperative Education Program

The Cooperative Education (Co-op) Program at Pitt is one of the most exciting opportunities available to engineering students. By alternating work and school terms, the co-op program 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 rotations, 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 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 on the Undergraduate/Student Resources page of the department's website.

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 on the first floor of Benedum Hall.

5.2 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.

5.3 Arts and Sciences Minors

Many departmental minors are available in programs offered by the Dietrich School of Arts and Sciences, including architectural studies, computer science, economics, history, mathematics, and physics. Students must complete at least half of the credits earned for a minor at the University of Pittsburgh and must complete a minor with at least a 2.00 GPA.

5.4 Certificate Programs

Swanson School of Engineering undergraduate students are encouraged to broaden their educational experience by electing to take one of the certificate programs currently offered by the Dietrich School of Arts and Sciences, the University Center for International Studies, and the Swanson 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 Swanson School of Engineering offers thirteen certificates at the undergraduate level:

- Civil Engineering and Architectural Studies
- Conceptual Foundations of Medicine
- Energy Resource Utilization
- Engineering for Humanity
- Engineering Simulation
- Fessenden Honors Engineering
- Health Systems Engineering
- Innovation, Product Design, and Entrepreneurship
- International Engineering Studies
- NanoScience and Engineering
- Nuclear Engineering

- Supply Chain Management
- Sustainable Engineering

5.5 Arts and Sciences-Engineering Joint Degree Program

The Dietrich School of Arts and Sciences and the Swanson 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 the Dietrich School of Arts and Sciences and the Swanson School of Engineering. Students can apply for admission into the program through either the Dietrich School of Arts and Sciences or the Swanson School of Engineering and must be admitted into both schools.

5.6 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.

5.7 University Honors College

The University Honors College is something of a paradox: Though headquartered in a newly renovated suite at the University of Pittsburghs 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.

5.8 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.

5.9 International Education

The Swanson 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.

5.10 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.

5.11 Combined Liberal Arts & Engineering 3/2 Programs with Other Colleges and Universities

The Swanson School of Engineering has developed combined liberal arts and engineering joint-degree programs with a number of accredited liberal arts colleges and universities. These programs are typically referred to as 3/2 programs, since the student initially enrolls at the liberal arts institution, 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 Swanson School of Engineering. With the recommendation of the review committee at the liberal arts institution, the student then applies for transfer to the Swanson 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 Swanson School of Engineering academic record will be forwarded to the liberal arts institution for evaluation, and a liberal arts degree will be awarded in accordance with the policy of the liberal arts institution. The engineering degree will be awarded upon completion of the engineering requirements.

Interested students should be referred to the Director of Freshman Programs 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 - MSE 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
MATH0240	4 ____	Anal. Geometry & Calc. 3	MATH0230
MATH0280	3 ____	Matrices & Linear Algebra	MATH0220
MATH0290	3 ____	Differential Equations	MATH0230
PHYS0174	4 ____	Phys. for Sci. & Engr. 1	*MATH0220*[1]
PHYS0175	4 ____	Phys. for Sci. & Engr. 2	PHYS0174, *MATH0230*
________	3 ____	Humanity Elective	
________	3 ____	Social Science Elective	Student has fulfilled
________	3 ____	Humanity/Soc. Sci. Elective	☐ Breadth
________	3 ____	Humanity/Soc. Sci. Elective	☐ Depth
________	3 ____	Humanity/Soc. Sci. Elective	☐ W-course
________	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, *MATH0290*
MEMS0040	3 ____	Materials & Manufacturing	ENGR0022
MEMS0048	3 ____	Thermodynamics of Materials	PHYS0174, CHEM0960, *MATH0290*
MEMS1010	3 ____	Experimental Methods in MSE	ENGR0022
MEMS1011	3 ____	Struct. & Prop. Lab	MEMS1010
MEMS1028	3 ____	Mechanical Design 1	ENGR0145
MEMS1030	3 ____	Material Selection	ENGR0022, MEMS1028
MEMS1043	3 ____	Senior Design Project	*Senior Standing*
MEMS1052	3 ____	Heat and Mass Transfer	MEMS0048
MEMS1053	3 ____	Struct. of Crystals & Diffract.	ENGR0022
MEMS1058	3 ____	Electromagnetic Prop. Mater.	ENGR0022
MEMS1059	3 ____	Phase Equilibria	ENGR0022, MEMS0048
MEMS1063	3 ____	Phase Transformations	MEMS1053, MEMS1059
MEMS1070	3 ____	Mech. Behavior of Materials	ENGR0022, ENGR0145
MEMS1079	3 ____	Senior Mater. Research Proj.	*Senior Standing*
________	3 ____	MSE Technical Elective	
________	3 ____	MSE Technical Elective	
________	3 ____	MSE Technical Elective	

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

Appendix B - MSE 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	•	•	•
Engr. Electives	•	•	•
MEMS0024	•		
MEMS0031		•	•
MEMS0040		•	•
MEMS0048		•	
MEMS1010	•		
MEMS1011		•	
MEMS1028	•	•	
MEMS1030	•		
MEMS1043	•	•	•
MEMS1052	•		•
MEMS1053	•		
MEMS1058	•		
MEMS1059	•		
MEMS1063		•	
MEMS1070		•	
MEMS1079	•	•	•
MEMS1085	•	•	
Tech. Electives	•	•	

- Note that, in general, Materials Science and 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 - MSE Sample Schedule

Shown below is an example of a schedule of courses that leads to a B.S. in Materials Science and Engineering in four years. It satisfies all of the relevant course prerequisites and the Materials Science and 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
ENGR0022	Mater. Struct. & Properties	3
ENGR0135	Statics & Mech. Mater. 1	3
MEMS0024	Intro. to ME Design	3
MEMS1085	Departmental Seminar	0
		16

FOURTH TERM

Subject		**Credits**
MATH0290	Differential Equations	3
ENGR0145	Statics & Mech. Mater. 2	3
MEMS0031	Electrical Circuits	3
MEMS0040	Materials & Manufacturing	3
MEMS0048	Thermodynamics of Materials	3
	Communication Skills Elective	3
MEMS1085	Departmental Seminar	0
		18

FIFTH TERM

Subject		**Credits**
MEMS1010	Experimental Methods in MSE	3
MEMS1052	Heat and Mass Transfer	3
MEMS1053	Struct. of Crystals & Diffract.	3
MEMS1058	Electromagnetic Prop. Mater.	3
MEMS1059	Phase Equilibria	3
MEMS1085	Departmental Seminar	0
		15

SIXTH TERM

Subject		**Credits**
MEMS1011	Struct. & Prop. Lab	3
MEMS1028	Mechanical Design 1	3
MEMS1063	Phase Transformations	3
MEMS1070	Mech. Behavior of Materials	3
	Engineering Elective	3
MEMS1085	Departmental Seminar	0
		15

SEVENTH TERM

Subject		**Credits**
MEMS1030	Material Selection	3
MEMS1079	Senior Mater. Research Proj.	3
	MSE Technical Elective	3
	Humanity/Soc. Sci. Elective	3
	Humanity/Soc. Sci. Elective	3
MEMS1085	Departmental Seminar	0
		15

EIGHTH TERM

Subject		**Credits**
MEMS1043	Senior Design Project	3
	MSE Technical Elective	3
	MSE Technical Elective	3
	Humanity/Soc. Sci. Elective	3
	Humanity/Soc. Sci. Elective	3
MEMS1085	Departmental Seminar	0
		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

	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 - MSE 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 ENGR0022 ENGR0135 MEMS0024	MATH0290 ENGR0145 MEMS0031 MEMS0040 MEMS0048	**Work Rotation**
Year 3	MEMS1010 MEMS1053 MEMS1058 MEMS1059 *Comm. Skills*	**Work Rotation**	MEMS1052 *Engr. Elective* *Soc. Sci./Hum.* *Soc. Sci./Hum.* *Soc. Sci./Hum.*
Year 4	**Work Rotation**	MEMS1011 MEMS1028 MEMS1063 MEMS1070 *MSE Tech. Elec.*	**Work Rotation (Optional)**
Year 5	MEMS1030 MEMS1043 MEMS1079 *MSE Tech. Elec.* *Soc. Sci./Hum.*	____________ ____________ ____________ ____________ ____________	____________ ____________ ____________ ____________ ____________

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 - MSE 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 ENGR0022 ENGR0135 MEMS0024	**Work Rotation**	MATH0290 ENGR0145 MEMS0031 MEMS0040 *Soc. Sci./Hum.*
Year 3	**Work Rotation**	MEMS0048 MEMS1028 MEMS1070 *Engr. Elective* *Comm. Skills*	**Work Rotation**
Year 4	MEMS1010 MEMS1030 MEMS1053 MEMS1058 MEMS1059	MEMS1011 MEMS1063 *MSE Tech. Elec.* *MSE Tech. Elec.* *Soc. Sci./Hum.*	MEMS1043 MEMS1052 MEMS1079 *Soc. Sci./Hum.* *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.