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 in the Swanson School of Engineering's Undergraduate Catalog, which is the official source of information about the School's academic programs and degree requirements. 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

Undergraduate Program Description

1.1 Undergraduate Program Rationale

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.

In their career and professional activities, we expect our graduates to (a) demonstrate successful application of materials science and engineering knowledge and skills for industry, public sector organizations, or their profession, (b) pursue life-long learning through advanced professional degrees, graduate studies in engineering, professional training, or engineering certification, and (c) demonstrate professional and intellectual growth as leaders in their profession and/or community.

1.2 Materials Science and Engineering Curriculum

The requirements for obtaining a Bachelor of Science (B.S.) degree in Materials Science and Engineering are described below. Refer to the MEMS Department's Student Resources web- page or Appendix C to see one possible 4-year, semester-by-semester sequence through the curriculum. Mechanical engineering students can monitor their own progression through the curriculum using the **MSE Curriculum Checklist** in Appendix A, which is also available on the Student Resources webpage.

Minors, Certificates, and Dual Degrees

We encourage our students to take full advantage of University of Pittsburgh resources and educational opportunities. Many of our students obtain Minors and/or Certificates that add value to their education and distinguish them as they move forward in their careers. Some of our students also seek a Dual Degree that augments the materials science and engineering experience—sometimes another engineering degree, sometimes a degree in Arts & Sciences. For additional information, please refer to the MEMS Department's Undergraduate Degree Options webpage.

1.2.1 Required Mathematics (5 Courses)

We require that students master basic mathematical skills in analytic geometry, calculus, linear algebra, and differential equations as preparation for mastery of materials science and engineering applications. The required math courses are:

- MATH 0220 Analytic Geometry & Calculus 1 (4 credits)
- MATH 0230 Analytic Geometry & Calculus 2 (4 credits)
- MATH 0240 Analytic Geometry & Calculus 3 (4 credits)
- Linear Algebra:
  - MATH 0280 Introduction to Matrices & Linear Algebra (3 credits), or
  - MATH 1180 Linear Algebra 1 (3 credits), or
  - MATH 1185 Honors Linear Algebra (3 credits)
- Differential Equations:
  - MATH 0290 Differential Equations (3 credits), or
  - MATH 1270 Ordinary Differential Equations 1 (3 credits)

Students interested in a **Math Minor** should consider taking MATH 1270 instead of MATH 0290 and either MATH 1180 or MATH 1185 instead of MATH 0280. Current MATH course descriptions can be found at PeopleSoft Mobile.

1.2.2 Required Basic Sciences (4 Courses, 1 Lab)

Engineering practice is frequently described as *applied science*. Materials science and engineering requires knowledge of and ability to use basic physics and chemistry. The required basic sciences courses are:

- Two semesters of introductory chemistry
  - First semester:
    - CHEM 0110 General Chemistry 1 (4 credits), or
    - CHEM 0410 General Chemistry 1 (3 credits), or
    - CHEM 0710 Honors General Chemistry 1 (4 credits), or
    - CHEM 0760 Honors General Chemistry for Engineers 1 (3 credits), or
    - CHEM 0960 General Chemistry for Engineers 1 (3 credits)
  - Second semester:
    - CHEM 0120 General Chemistry 2 (4 credits), or
    - CHEM 0420 General Chemistry 2 (3 credits), or
    - CHEM 0720 Honors General Chemistry 2 (4 credits), or
    - CHEM 0770 Honors General Chemistry for Engineers 2 (3 credits), or
    - CHEM 0970 General Chemistry for Engineers 2 (3 credits)

  Note: the CHEM 0410/CHEM 0420 sequence also requires CHEM 0430 General Chemistry 1 Laboratory (1 credits).

- Two semesters of calculus-based physics
  - First semester:
    - PHYS 0174 Basic Physics for Science & Engineering 1 (4 credits), or
    - PHYS 0475 Honors Physics 1 (4 credits)
  - Second semester:
    - PHYS 0175 Basic Physics for Science & Engineering 2 (4 credits), or
    - PHYS 0476 Honors Physics 2 (4 credits)

Current PHYS and CHEM course descriptions can be found at PeopleSoft Mobile.

1.2.3 Required Humanities and Social Sciences (6 Courses)

The Swanson School of Engineering (SSoE) requires all undergraduates to complete **at least six** humanities and social science (H/SS) elective courses that adhere to the SSoE Guidelines and Requirements in order to satisfy SSoE and ABET accreditation requirements for breadth and depth. Please make sure that you adhere to the requirements for **breadth** and **depth**. While only approved humanities and social sciences courses can be used to satisfy the H/SS requirements, the approved list is not static. New courses are added frequently. 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 on the MEMS Department's Student Resources webpage. 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 ap- proximately 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.

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.
- 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:
  - The language(s) must be other than English.
  - The language(s) must be other than the student's mother tongue.
  - The course(s) must be a bona fide language course.
- Dietrich School of Arts & Sciences (DSAS) courses cross-listed with College of General Studies (CGS) courses that are designated as self-paced (self), online (www), or hybrid online (hybrid) **or not** acceptable for fulfilling the H/SS requirements.

Current course descriptions for H/SS courses can be found at PeopleSoft Mobile.

1.2.4 Required Communication Skills (1 Course)

To satisfy the Communication Skills Elective requirement, students must satisfactorily complete one of the following courses. Note that a course can either be used as a Humanities and Social Sciences Elective or as the Communication Skills Elective, but not both. 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 credits)
- COMMRC 0520 Public Speaking (3 credits)
- COMMRC 0540 Discussion (3 credits)
- ENGCMP 0400 Written Professional Communication (3 credits)
- ENGCMP 0401 Written Professional Communication: Topic in Diversity (3 credits)
- ENGCMP 0412 Engineering Communication in a Professional Context (3 credits)
- ENGCMP 0600 Introduction to Technical Writing (3 credits)

1.2.5 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.

- Students should refer to **PeopleSoft** (in the **Class Search** screen, choose **Writing Option** from the **Requirement Designation** field) each term to determine whether a course is being offered as a W-designated course (i.e., courses with the **Writing Requirement Course** attribute). Note that there are courses that may have a writing option, but not for all their sections.

- The writing requirement will normally be fulfilled by ensuring that either one of the six required Humanities and Social Sciences Electives or the Communications Skills Elective is a W-course. It will not typically require a student to take an additional course.

- ENGCMP 0200 Seminar in Composition is *not* a W-course and does not satisfy the writing requirement.

Required first year writing courses:

- ENGCMP0210 Seminar in Composition for Engineers (3 credits)
  Seminar in Composition is a course taken by almost all undergraduates at the University of Pittsburgh. Seminar in Composition: Engineering undertakes the goals of Seminar in Composition within a first year (and beyond) engineering context. First-year Swanson School of Engineering (SSOE) students in Seminar in Composition: Engineering will explore engineering disciplines, practices, methods, ethics, and education and will analyze their own views and goals as engineering students and as future engineers as they are learning about and practicing writing as a rigorous, disciplined form of critical inquiry and a responsible form of communication. In Seminar in Composition: Engineering, students will strengthen their knowledge and practice of the textual conventions required of university- and professional-level writing and will, via drafting and revision, regularly reexamine the clarity and effects of their writing processes and outcomes.

- ENGCMP0412 Engineering Communication in a Professional Context (3 credits) (W-course)
  Engineering Communication in a Professional Context is a required course for all Swanson School of Engineering first-year students enrolled in ENGR 0012. In ENGCMP 0412 students write a significant research paper for the Swanson School of Engineering's Annual Conference on Sustainability, held near the end of the spring term. Students compose this paper in teams of 3; students also compose individual papers reporting and reflecting on their experience with teamwork and with researching, composing, assessing, and presenting written work within a context of maximum personal and professional responsibility and integrity. In ENGCMP 0412 students undertake intensive research into a current engineering innovation/technology. Students expand upon that research as they move through a multi-step process of writing and revising a conference paper that includes considerable technical content as well as intensive analyses of the social value and ethical applications of that technology. Through ENGCMP 0412, students will continue to increase their experience and success with major teamwork projects, will practice best

policies and procedures for professional communication and presentation, will continue to learn about and practice communication modes and expectations in engineering, science, and technology, and will continue with an academically and intellectually rigorous process (begun in ENGCMP 0210, Seminar in Composition: Engineering), of understanding and communicating what it means personally, educationally, professionally, socially, and globally to "be an engineer." Prerequisite: ENGCMP 0210 Corequisite: ENGR 0012

1.2.6 Required Basic Engineering (4 Courses)

The required basic engineering courses are:

- Freshman Engineering, first semester:
  - ENGR 0011 Introduction to Engineering Analysis (3 credits), or
  - ENGR 0015 Introduction to Engineering Analysis (3 credits), or
  - ENGR 0711 Honors Engineering Analysis and Computing (3 credits)

  Note: Transfer students can substitute any engineering course for the first semester Freshman Engineering requirement.

- Freshman Engineering, second semester:
  - ENGR 0012 Introduction to Engineering Computing (3 credits), or
  - ENGR 0016 Introduction to Engineering Computing (3 credits), or
  - ENGR 0712 Advanced Engineering Applications for Freshmen (Honors) (3 credits), or
  - ENGR 0716 Art of Hands-On System Design and Engineering (Art of Making) (3 credits)

  Note: Students who take ENGR 0016 must also take ENGCMP 0200 Seminar in Composition (3 credits).

- ENGR 0135 Statics & Mechanics of Materials 1 (3 credits)
  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 credits)
  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.

1.2.7 Required Core Materials Science & Engineering (17 Courses)

The required core mechanical engineering courses are:

- MEMS 0023 Introduction to Materials Science and Engineering
  This is an introductory class for students majoring in materials science and engineering. It begins by focusing on fundamentals of structure including bonding, crystal structures and defect in crystals and microstructure. It then addresses the relationship between structure and properties, including mechanical, thermal, electrical, magnetic, and optical properties. It concludes by introducing thermodynamic and kinetic principles of materials especially those pertinent to materials processing.

- MEMS 0024 Introduction to Mechanical Engineering Design (3 credits)
  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 credits)
  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 credits)
  Manufacturing and processing of ceramics, semiconductors, metals, and polymers covering refining, product formation, and control of properties. Prerequisite: MEMS 0023 (or ENGR 0022).

- MEMS 0048 Thermodynamics of Materials (3 credits)
  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 credits)
  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: MEMS 0022 (or ENGR 0022).

- MEMS 1011 Structures & Properties Laboratory (3 credits)
  This laboratory will build on the student's 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 credits)
  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 credits)
  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: MEMS 0023 (or ENGR 0022), MEMS 1028.

- MEMS 1043 Senior Design Project (3 credits)
  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 credits)
  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 credits)
  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: MEMS 0023 (or ENGR 0022).

- MEMS 1058 Electromagnetic Properties of Materials (3 credits)
  Review of basic principles—quantum theory, band and zone theory. Transport, electrical, and thermal properties; semiconductors and semiconductor devices; magnetic materials—hard and soft; dielectric and optical properties. Prerequisite: MEMS 0023 (or ENGR 0022).

- MEMS 1059 Phase Equilibria in Multi-Component Materials (3 credits)
  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: MEMS 0023 (or ENGR 0022), MEMS 0048.

- MEMS 1063 Phase Transformations & Microstructure Evolution (3 credits)
  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 credits)

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: MEMS 0023 (or ENGR 0022), ENGR 0145.

- MEMS 1079 Senior Materials Research Project (3 credits)

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 credits)

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.

- MEMS 1086 MSE Seminar (0 credits)

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.

1.2.8 Required MSE Technical Electives (3 Courses)

Students are required to satisfactorily complete three of the following Materials Science and Engineering Technical Elective courses. Current course descriptions for these courses can be found at PeopleSoft Mobile. Some suggested sequences include:

Bulk Engineering Materials (3 of the following courses)

MEMS 1033 Fracture Mechanics for Product Design and Manufacturing
MEMS 1080 Powder Processing of Materials
MEMS 1087 Sustainable Materials Production
MEMS 1102 Principles and Applications of Steel Alloy Design
MEMS 1103 Principles and Applications of Steel Processing
MEMS 1130 Introduction to Additive Manufacturing of Materials
MEMS 1163 Ceramic Materials

Nanomaterials (3 of the following courses)

MEMS 1048 Analysis & Characterization at Nanoscale
MEMS 1057 Micro/Nano Manufacturing
MEMS 1080 Powder Processing of Materials
MEMS 1111 Materials for Energy Generation and Storage
MEMS 1130 Introduction to Additive Manufacturing of Materials
MEMS 1163 Ceramic Materials
MSE 2061 Tribology: adhesion, friction, lubrication, and wear
ENGR 0240 Nanotechnology and Nanoengineering
ENGR 1066 Introduction to Solar Cells and Nanotechnology

Advanced Manufacturing (3 of the following courses)

MEMS 1057 Micro/Nano Manufacturing
MEMS 1080 Powder Processing of Materials
MEMS 1087 Sustainable Materials Production
MEMS 1103 Principles and Applications of Steel Processing
MEMS 1130 Introduction to Additive Manufacturing of Materials
MEMS 1165 Materials Design

Computational Materials Science (3 of the following courses)

MEMS 1012 Computational Materials Science
MEMS 1165 Materials Design
MSE 2112 Nanoscale Modeling and Simulation
ENGR 1452 Exploratory Data Science
ENGR 1453 Data Science: Statistical Learning, Modeling and Prediction
Polymers (3 of the following courses)
CHE 1754 Principles of Polymer Engineering
CHEM 0310 Organic Chemistry 1
CHEM 0320 Organic Chemistry 2

Biomaterials (3 of the following courses)

BIOENG 1070 Introduction to Cell Biology 1
BIOENG 1071 Introduction to Cell Biology 2
BIOENG 1075 Introduction to Cell and Molecular Biology Laboratory Techniques
BIOENG 1810 Biomaterials and Biocompatibility
IE 1202 Introduction to Medical Product Development

Energy (3 of the following courses)

MEMS 1111 Materials for Energy Generation and Storage
MEMS 1122 Fundamentals of Magnetic Materials and Applications
ENGR 1066 Introduction to Solar Cells and Nanotechnology
ENGR 1700 Introduction to Nuclear Engineering
ENGR 1701 Fundamentals of Nuclear Reactors
ENGR 1702 Nuclear Plant Technology

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[1]BIOSCI 0105 and BIOSCI 0106 can be substituted for BIOENG 1070 and BIOENG 1071. CHEM 0310 Organic Chemistry 1 is also recommended, but not required, for this option.

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.

1.2.9 Required Engineering Elective (1 Course)

Students are required to complete one Engineering Elective course. 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.

- 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.

1.3 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. 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.

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.

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. 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 1.3.1 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.

1.3.1 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 Depart- ment, 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.

1.4 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 2

Academic Policy

2.1 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–."

2.1.1 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

2.1.2 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. Stu- dents 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).

2.2 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.

2.3 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.

2.3.1 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 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 Associate Dean for Aca- demic 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.

2.4 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.

2.4.1 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.

2.4.2 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.

2.5 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.

2.5.1 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.

2.5.2 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.

2.5.3 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.

2.5.4 Dismissal

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

2.6 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.

2.7 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 1, for a total of at least 128 credits.

   (a) All 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.

   (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, to make sure everything is in order. It is the students' responsibility to meet all 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 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.

2.7.1 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 3

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.

3.1 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.

3.2 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.

3.3 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.

3.4 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 the following certificates at the undergraduate level:

- Nuclear Engineering
- Engineering Simulations in Design
- Innovation, Product Design and Entrepreneurship
- Sustainability
- Engineering for Humanity
- International Engineering Studies
- Public Communication of Science and Technology

3.5 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.

3.6 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.

3.7 Frederick Honors College

The Frederick Honors College is something of a paradox: Though headquartered in a newly renovated suite at the University of Pittsburgh's Cathedral of Learning, it's not really a bricks-and-mortar school within the University. And although FHC 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.

3.8 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.

3.9 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.

3.10 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.

3.11 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*
ENGCMP0210	3 _____	Seminar in Composition	
ENGCMP0412	3 _____	Engr. Communication	
_____	3 _____	Humanity Elective	Student has fulfilled
_____	3 _____	Social Science Elective	□ Breadth
_____	3 _____	Humanity/Soc. Sci. Elective	□ Depth
_____	3 _____	Humanity/Soc. Sci. Elective	□ W-course
_____	3 _____	Communication Skills Elective	
ENGR0011	3 _____	Intro. to Engr. Analysis	
ENGR0012	3 _____	Engr. Computing	ENGR0011
ENGR0135	3 _____	Statics & Mech. of Mater. 1	MATH0230, PHYS0174
ENGR0145	3 _____	Statics & Mech. of Mater. 2	ENGR0135
_____	3 _____	Engineering Elective	
MEMS0023	3 _____	Intro. to MSE	MATH0230, PHYS0174
MEMS0024	3 _____	Intro. to ME Design	ENGR0011
MEMS0031	3 _____	Electrical Circuits	PHYS0175, *MATH0290*
MEMS0040	3 _____	Materials & Manufacturing	MEMS0023
MEMS0048	3 _____	Thermodynamics of Materials	PHYS0174, CHEM0960, *MATH0290*
MEMS1010	3 _____	Experimental Methods in MSE	MEMS0023
MEMS1011	3 _____	Struct. & Prop. Lab	MEMS1010
MEMS1028	3 _____	Mechanical Design 1	ENGR0145
MEMS1030	3 _____	Material Selection	MEMS0023, MEMS1028
MEMS1043	3 _____	Senior Design Project	*Senior Standing*
MEMS1052	3 _____	Heat and Mass Transfer	MEMS0048
MEMS1053	3 _____	Struct. of Crystals & Diffract.	MEMS0023
MEMS1058	3 _____	Electromagnetic Prop. Mater.	MEMS0023
MEMS1059	3 _____	Phase Equilibria	MEMS0023, MEMS0048
MEMS1063	3 _____	Phase Transformations	MEMS1053, MEMS1059
MEMS1070	3 _____	Mech. Behavior of Materials	MEMS0023, 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
ENGR0135	●	●	●
ENGR0145	●	●	●
Engr. Electives	●	●	●
MEMS0023	●		
MEMS0024	●		
MEMS0031		●	●
MEMS0040		●	●
MEMS0048		●	
MEMS1010	●		
MEMS1011		●	
MEMS1028	●	●	
MEMS1030	●		
MEMS1043	●	●	●
MEMS1052	●		
MEMS1053	●		
MEMS1058	●		
MEMS1059	●		
MEMS1063		●	
MEMS1070		●	
MEMS1079	●	●	●
MEMS1085	●	●	
MEMS1086	●	●	
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 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
ENGCMP0210	Seminar in Composition	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
ENGCMP0412	Engr. Communication	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
MEMS0023	Intro. to MSE	3
MEMS0024	Intro. to ME Design	3
MEMS1085	Departmental Seminar	0
MEMS1086	MSE 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
MEMS1086	MSE 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
MEMS1086	MSE 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
MEMS1086	MSE Seminar	0
		15

SEVENTH TERM

Subject		Credits
MEMS1030	Material Selection	3
MEMS1070	Senior Mater. Research Proj.	3
	MSE Technical Elective	3
	Humanity/Soc. Sci. Elective	3
	Humanity/Soc. Sci. Elective	3
MEMS1085	Departmental Seminar	0
MEMS1086	MSE 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
MEMS1086	MSE Seminar	0
		15

Students must enroll in both MEMS 1085 Departmental Seminar and MEMS 1086 MSE Seminar each semester

Appendix D: Co-op Schedule Form

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

Current Semester Status (circle one): **4th** **5th** **6th** **7th**

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

Appendix D: Co-op Schedule Form

MATERIALS SCIENCE AND ENGINEERING CO-OP SCHEDULE A

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

Current Semester Status (circle one): **4th** **5th** **6th** **7th**

	Fall	*Spring*	*Summer*
Year 1	CHEM0960 MATH0220 PHYS0174 ENGR0011 ENGCMP0210	CHEM0970 MATH0230 PHYS0175 ENGR0012 ENGCMP0412	
Year 2	MATH0240 MATH0280 ENGR0135 MEMS0023 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.	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____

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 schedule without departmental approval.

Appendix D: Co-op Schedule Form

MATERIALS SCIENCE AND ENGINEERING CO-OP SCHEDULE B

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

Current Semester Status (circle one): **4th** **5th** **6th** **7th**

	Fall	*Spring*	*Summer*
Year 1	CHEM0960 MATH0220 PHYS0174 ENGR0011 ENGCMP0210	CHEM0970 MATH0230 PHYS0175 ENGR0012 ENGCMP0412	
Year 2	MATH0240 MATH0280 ENGR0135 MEMS0023 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	MEMS1030 MEMS1043 MEMS1079 *MSE Tech. Elec.* Soc. Sci./Hum.	_____ _____ _____ _____ _____	_____ _____ _____ _____ _____