

PENNS^TATE



Department of Engineering Science and Mechanics

Undergraduate Student Guide 2005-2006

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Foreward

The purpose of this document is to assist Engineering Science undergraduates in the planning of their academic programs and to enable them to derive maximum benefit from their affiliation with the Department. This guide also contains information regarding academic matters of interest to students, and provides a means for students to keep a record of their curriculum plans and courses taken.

The Department of Engineering Science and Mechanics is the departmental title resulting from the merger of the long-established Department of Engineering Mechanics and the Engineering Science Program, the College of Engineering Honors curriculum. Through this lineage the Department has had a continuous existence for over seventy-five years. It has offered master's and doctoral degrees since 1940.

The baccalaureate major in Engineering Science was established in 1952 to provide an enriched interdisciplinary program for students with special aptitude for graduate study and the pursuit of careers in creative aspects of engineering, including research and development. The first class of Engineering Science students graduated in 1956, and in 1963 the Engineering Science major was certified by the University as an Honors program. Since its inception, the Engineering Science program has graduated more than 1,000 students.

In 1974, as a result of economic considerations, the baccalaureate programs in Engineering Mechanics and Engineering Science, both highly regarded nationally, were merged under a single department with a new departmental name. The existing program in Engineering Science became the baccalaureate major for the Department, and it continues to be very highly regarded.

Because of its depth, breadth, and flexibility, the Engineering Science major provides an excellent opportunity for students who are interested in interdisciplinary training. Yet because of its flexibility, it can also be used to give tailored, focused training in engineering

mechanics, electrical science, solid state and materials sciences, computer science, and bioengineering, to mention just a few possibilities.

It is interesting to note the results of a recent survey of Engineering Science undergraduates. They were asked to list their principal motivation for enrolling in Engineering Science. Almost equal numbers listed either the program's flexibility in planning a learning schedule or the program's extensive and practical applied science and mathematics background as their primary consideration. In (close) third place was the appreciation that the curriculum provides excellent training for a career in research and development. Some students listed the fact that the major is the official Honors program for the College of Engineering while others cited the excellent preparation for graduate school that it provides as their principal motivation for enrolling in Engineering Science.

We are excited that in February 2005 an integrated undergraduate/graduate (IUG) program of study in the Engineering Science and Mechanics department was approved. The Schreyer Honors College also has an IUG program. These combined or integrated undergraduate/graduate programs offers students a number of scholastic advantages, not the least of which is a savings of time and money while obtaining a graduate degree. Details of the program are provided in Appendix B.

It is hoped that you will retain this guide, read it carefully, and refer to it for assistance when the occasion arises. Along with your adviser, the entire faculty is ready to offer assistance when needed; do not hesitate to approach us.

Chapter I: E SC Curriculum Description

I. 1 —Engineering Science

Engineering Science is the discipline devoted to creating and optimizing engineered solutions through enhanced understanding and integrated application of mathematical, scientific, statistical, and engineering principles. Engineering Science provides the knowledge and motivation necessary to merge multidisciplinary resources, and propose enduring solutions that meet the profession's most demanding challenges.

I. 2 —The Engineering Scientist

The Penn State Engineering Science graduate obtains a solid understanding of the analytical, interpretive and extrapolative aspects of engineering. This unique knowledge enables a graduate to bridge the gap between theoretical science and practical engineering. The engineering scientist forgoes specialization in a single discipline for a broader perspective of engineering and the ability to interact with a team of allied professionals. Thus the Engineering Science graduate in industry often finds himself/herself functioning in a consultative capacity among other engineers.

I. 3 —The Engineering Science Curriculum

Engineering Science is a multidisciplinary honors program that emphasizes enhanced understanding and integrated application of engineering, scientific, and mathematical principles. The program is unique because it provides a broad foundation in the sciences and associated mathematics that underlie engineering and provides students the opportunity to obtain a depth of knowledge in an area of their choosing through technical electives and an honors thesis. The curriculum is designed for students who seek to link the engineering disciplines with science. In addition to taking core courses in mathematics, physics, chemistry, and biology, students study thermody-

namics, heat transfer, electromagnetics, solid and fluid mechanics, electrical devices, materials science, and failure analysis. During the senior year, all students select a focus area of study, complete a capstone project and write a thesis that integrates the scientific principles of research, design and analysis and applies them to engineering. Focus areas of study include, but are not limited to, electrical, mechanical, civil, bioengineering, and materials and are typically interdisciplinary. Hence, Engineering Science students achieve both depth and breadth in engineering and science, are able to function across disciplines, and graduate well prepared for advanced studies as well as professional employment.

1. 4 —Program Outcomes

At the time of graduation, Engineering Science graduates are expected to:

1. Be prepared for advanced study and lifetime learning. (a, i)
2. Recognize multi-faceted issues of technical problems, comprehend the importance of each, interact in diverse teams necessary to their solution, and effectively communicate these solutions across disciplines. (a, b, c, d, e, g, j)
3. Identify, analyze, and solve independently a technical problem, in particular the research aspect of their senior thesis. (a, b, c, d, e, k)
4. Communicate through written reports and papers and explain their work clearly in oral presentations. (d, g)
5. Select, proficiently apply, and interpret results of state-of-the-art engineering tools. (a, b, c, d, k)
6. Understand from a global perspective technology and its impact on societies, ethics and its impact upon the profession, citizenship and its impact on humanity, and act responsibly. (f, h, j)

The letters a-k above refer to educational outcomes required by ABET, the organization that accredits engineering programs.

1. 5 —Program Educational Objectives

The expected accomplishments of Engineering Science graduates in the first several years following graduation are:

1. Participate in lifelong learning activities including but not limited to masters, doctorate, medical, and law degrees, continuing education, leadership development, management training, and global involvement/awareness.
2. Engage in practice in a wide variety of fields including but not limited to electrical systems, electronics, mechanical systems, materials development, forensics, biomaterials, medicine, law, and business.
3. Research, develop, design and/or utilize new products, processes, materials, devices, systems, and/or tools.
4. Communicate findings and best practices at conferences and meetings, by filing patents, in technical publications (journals, reports, memoranda), and to the general public.
5. Use state-of-the-art tools for the benefit of society.
6. Participate in and promote the value of diversity in society.
7. Encourage and foster future generations of engineers through mentoring, service, and outreach.

I. 6 —Keywords and Phrases in Engineering Science

- create and optimize engineered solutions
- integrated application of mathematical, scientific, statistical, and engineered principles
- integrate scientific principles of research, design and analysis with the applied art of engineering
- knowledge components: analytical to solve problems, interpretive to understand physics and reach conclusions, extrapolative to make decisions
- broad perspective of engineering and ability to interact with a team of allied professionals
- able to bridge the gap between theoretical science and practical engineering
- merge multidisciplinary resources, propose enduring solutions, meet demanding challenges
- work as a consultant among other engineering disciplines

- independently perform a capstone project in a timely manner
- multidisciplinary
- focus area of study
- honors and quality
- capstone project
- breadth with depth
- independent research
- consultant
- good communicator

1. 7 —Course Plans (University Park and Commonwealth Campuses)

The curriculum in Engineering Science has been designed so that a student in this major can attend a Commonwealth Campus for the complete freshman and sophomore year before transferring to the University Park Campus, without delaying graduation.

The following flowchart shows the typical semester-by-semester placement of courses at University Park Campus. At a Commonwealth Campus, the differences are (1) that E MCH 011 plus E MCH 013 (6 credits) will replace E MCH 110H (5 credits) and (2) it is recommended that students complete their Health and Physical Activity requirement during their freshman and sophomore years. Course descriptions appear in Sections 1.9 and 1.10.

It should be noted that the 12 credits of senior technical electives and the two senior project courses, E SC 410H and 411H, constitute 19 credits in an engineering area of the student's choice. This degree of flexibility enables students to gain excellent preparation for a career orientation of their choosing. *At least two of the technical elective credits must be engineering design and at least three must be engineering science.* The table in section 1.11 lists the engineering design/engineering science category content of many upper level engineering courses. It is in the student's best interest to select technical electives that support her or his senior project. Students should work with their project advisor and their academic advisor to plan to take the most appropriate technical electives.

I. 8 —Course Descriptions (Department Courses)

E MCH 110H: Equilibrium Mechanics, Honors (5). Equilibrium of particles and rigid bodies; stresses, strains, and displacements in elastic; rods, torsion bars, beams, trusses, frames, and columns. Prerequisite: or concurrent: MATH 141 [alternate course: E MCH 210 or E MCH 011 and E MCH 013]

E MCH 112H: Mechanics of Motion (3). Kinematics of a particle; relative motion; kinetics of a mass-point; kinetics of a rigid body; work-energy; impulse-momentum. Prerequisite: E MCH 011, E MCH 110H, or E MCH 210; MATH 141 [alternate course: E MCH 12]

E MCH 210: Statics and Strength of Materials (5). Equilibrium of particles, rigid bodies, frames, trusses, beams, columns; stress and strain analysis of rods, beams, pressure vessels. Prerequisite: or concurrent: MATH 141 [preferred alternate course: E MCH 110H]

E SC 261M: Computational Methods in Engineering (3). Modeling, solving engineering problems using FORTRAN, software libraries, graphics. Reports on root search, curve fitting, finite differences, algebraic equations. Prerequisite: or concurrent: MATH 141 [alternate course: CMPSC 201]

E SC 314: Engineering Applications of Materials (3). Basic concepts of material structure and their relation to mechanical, thermal, electrical, magnetic, and optical properties, with engineering applications. Prerequisite: PHYS 212 [preferred alternate course: E MCH 416H]

E SC 400H: Electromagnetic Fields (3). Irrotational and solenoidal fields, potentials, vector and scalar field and wave equations, harmonic and wave functions in various coordinates, radiation. Prerequisite: E E 210, MATH 250

E SC 404H: Analysis in Engineering Science (3). Unified application of coordinate transformations; Laplace's, heat, and wave equations to boundary value problems and problems of continua in engineering. Prerequisite: MATH 250 or MATH 251

E SC 407H: Computer Methods in Engineering Science, Honors (3). Application of numerical methods to problems in engineering science. Algebraic and differential equations; integration; interpola-

tion; eigenvalue problems; linear programming. Students who have passed E MCH 407 may not schedule this course for credit. Prerequisite: CMPSC 201C, CMPSC 201F, or E SC 261M. Prerequisite or concurrent: E MCH 012 or E MCH 112H

E SC 410H: Senior Design Project, Honors (3). Design and synthesis in the context of a specific design project undertaken during the senior year. Prerequisite: E SC 407H

E SC 411H: Senior Design Project, Honors (4). Design and synthesis in the context of a specific design project undertaken during the senior year. Prerequisite: E SC 410H

E SC 414M: Elements of Material Engineering (3). Structure and imperfections in engineered materials; their influence on properties, behavior, and processing. Applications of metals, ceramics, polymers, and composites. Prerequisite: E MCH 013, E MCH 110H, or E MCH 210; PHYS 237

E MCH 416H: Failure and Failure Analysis of Solids (3). Examination and analysis of the various modes of failure of solid materials. Prerequisite: E MCH 013, E MCH 210, or E MCH 110H [alternate course: E SC 314]

Department courses required for students who attend first two years at Commonwealth Campuses:

E MCH 011: Statics (3). Equilibrium of coplanar force systems; analysis of frames and trusses; noncoplanar force systems; friction; centroids and moments of inertia. Prerequisite: or concurrent: MATH 141

E MCH 012: Dynamics (3). Motion of a particle; relative motion; kinetics of translation, rotation, and plane motion; work-energy; impulse-momentum. Prerequisite: E MCH 011 or E MCH 210 ; MATH 141

E MCH 013: Strength of Materials (3). Axial stress and strain; torsion; stresses in beams; elastic curves and deflection of beams; combined stress; columns. Prerequisite: E MCH 011

I. 9 —Course Descriptions (Other Required Courses)

AERSP 308: Mechanics of Fluids (3). Kinetics and dynamics of fluids; perfect fluid theory using complex variables; introduction to viscous flow theory; fundamentals of compressible flow. Prerequisite: E MCH 012 or E MCH 112H; MATH 251

CAS 100A(GWS) Effective Speech (3).

Principles of communication, implemented through presentation of speeches, with some attention to group discussion and message evaluation.

CAS 100B(GWS) Effective Speech (3).

Principles of communication, implemented through group problem solving, with some attention to formal speaking and group discussion.

CHEM 012 (GN): Chemical Principles (3).

Basic concepts and quantitative relations.

CHEM 013 (GN): Chemical Principles (3).

Continuation of CHEM 012 including an introduction to the chemistry of the elements.

CHEM 014: (GN) Experimental Chemistry (1).

An introduction to quantitative experimentation in chemistry.

ED&G 100: Introduction to Engineering Design(3):

Introduction to engineering design through team-oriented design projects supported by communication skills: graphical, verbal, written.

E E 210H: Circuits and Devices (4). Introduction to electrical circuit analysis, electronic devices, amplifiers, and time-domain transient analysis. Prerequisite: PHYS 202 or PHYS 212 . Prerequisite or concurrent: MATH 250

E E 340: Electronic Devices and Circuits (3). Theoretical study of electronic devices, active and passive circuit elements, linear and nonlinear active circuit analysis. Intended for students in engineering science. Prerequisite: E E 203 or E E 210

ENGL 202C(GWS) Effective Writing: Technical Writing (3):

Writing for students in scientific and technical disciplines. (A student may take only one course for credit from ENGL 202A, 202B, 202C

and 202D) Prerequisite: ENGL 015 or ENGL 030; fourth-semester standing.

IE 424: Process Quality Engineering (3). Statistical methods for engineering process characterization and improvement. For non-Industrial Engineering majors. Prerequisite: MATH 141, MATH 220 [alternate course: NUC E 307]

MATH 140 (GQ): Calculus with Analytic Geometry I (4). Functions, limits; analytic geometry; derivatives, differentials, applications; integrals, applications. Students may only take one course for credit from MATH 110, 140, 140A, and 140B. Prerequisite: MATH 022, MATH 026; or MATH 040 or MATH 041 or satisfactory performance on the mathematics proficiency examination

MATH 141 (GQ): Calculus with Analytic Geometry II (4). Derivatives, integrals, applications; sequences and series; analytic geometry; polar coordinates. Students may take only one course for credit from MATH 141 and 141B. Prerequisite: MATH 140, MATH 140A, or MATH 140B

MATH 220 (GQ): Matrices (2). Systems of linear equations; matrix algebra; eigenvalues and eigenvectors; linear systems of differential equations. Prerequisite: MATH 110 or MATH 140

MATH 230: Calculus and Vector Analysis (4). Three-dimensional analytic geometry; vectors in space; partial differentiation; double and triple integrals; integral vector calculus. Students who have passed either Math 231 or 232 may not schedule Math 230 for credit. Prerequisite: MATH 141

MATH 251: Ordinary and Partial Differential Equations (4). First and second-order equations; special functions; Laplace transform solutions; higher order equations; Fourier series; partial differential equations. Prerequisite: MATH 141

ME 120: Engineering Thermodynamics (4). Engineering thermodynamics and heat transfer, with pertinent applications to devices important in mechanical engineering. For students in engineering science. Prerequisite: CHEM 013, PHYS 211, and MATH 230 or MATH 231

NUC E 307: Statistical and Transport Description of Matter (3): Particle statistical distributions; transport descriptions of matter; energy, momentum, mass transfer; particle diffusion; thermodynamic

equilibrium and nonequilibrium spectra. Prerequisite: MATH 251, PHYS 237 [alternate course: I E 424]

PHYS 211 (GN): General Physics: Mechanics (4). Calculus-based study of the basic concepts of mechanics: motion, force, Newton's laws, energy, collisions, and rotation. Concurrent: MATH 140

PHYS 212 (GN): General Physics: Electricity and Magnetism (4). Calculus-based study of the basic concepts of electricity and magnetism. Prerequisite: MATH 140, PHYS 211. Concurrent: MATH 141

PHYS 213 (GN): General Physics: Fluids and Thermal Physics (2). Calculus-based study of the basic concepts of fluids and sound, heat, kinetic theory, and entropy. Prerequisite: MATH 140, PHYS 211. Concurrent: MATH 141

PHYS 214 (GN): General Physics: Wave Motion and Quantum Physics (2). Effective Date: SP2004 Calculus-based study of the basic concepts of wave motion, geometrical optics, interference phenomena, photons, wave mechanics, and the structure of matter. Prerequisite: MATH 140, PHYS 211. Concurrent: MATH 141

PHYS 237: Introduction to Modern Physics (3). Relativity and quantum theory applied to selected topics in atomic, molecular, solid state, and nuclear physics. Prerequisite: PHYS 202 or PHYS 212. Concurrent: PHYS 203 or PHYS 204 or PHYS 214

I. 10 —Elective Department Courses

E SC 405H: Engineering Applications of Field Theory, Honors (3) :

Field concepts in engineering, derivation of field equations, mathematical solutions, applications stressing universality of approaches to all fields of engineering. Prerequisite: MATH 250

E SC 433H: Engineering Science Research Laboratory Experience (1). Student "hands-on" experiences spanning ESM Research laboratories: environmental degradation, fatigue, MEMS, neural networking, smart materials, ultrasonics, etc. Prerequisite: E E 203, E SC 414M

E SC 445: Semiconductor Optoelectronic Devices (3). The course will present the basic engineering science and technology involved in modern semiconductor optoelectronic devices. Prerequisite: E E 340, E E 368, or E SC 314

E SC 450 (MATSE): Synthesis and Processing of Electronic and Photonic Materials (3). The materials science of applying thin film coatings, etching, and bulk crystal growth; includes materials transport, accumulation, epitaxy, and defects. Prerequisite: CHEM 013, MATSE 400, MATSE 401, MATSE 402

E SC 455 (MATSE): Electrochemical Methods in Corrosion Science and Engineering (3). The objective of the course is to give students hands-on experience in assessing environmental degradation of engineering materials. Prerequisite: E SC 414M or MATSE 259; MATSE 420 or MATSE 421

E SC 475 (MATSE): Particulate Materials Processing (3). Fundamentals of processing particulate materials including production, characterization, handling, compaction, and sintering of metal, carbide, intermetallic, and composite powders. Prerequisite: E MCH 215, E SC 414, OR MATSE 259

E SC 481: Elements of Microelectromechanical Systems Processing and Design (3). Fundamentals and elements of microfabrication and micromachining. Design, process flow, and modeling for microelectromechanical devices. Prerequisite: E MCH 013; E MCH 215, E SC 314M, or E SC 414M; PHYS 203

E SC 197: Special Topics (1 - 9):

E SC 296: Independent Studies (1 -18):

E SC 297: Special Topics (1 - 9):

E SC 397: Special Topics (1 - 9):

E SC 496: Independent Studies (1 -18) :

E SC 497: Special Topics (1 - 9):

E MCH 400: Advanced Strength of Materials and Design (3). Combined stresses; energy methods; special problems in bending and torsion; plates; thin-walled structures; buckling and stability; design projects. Prerequisite: E MCH 013, E MCH 110H, or E MCH 210

E MCH 402: Applied and Experimental Stress Analysis (3). Experimental design of structural and machine components; photoelasticity, electrical resistance strain gauge techniques, Moire techniques, interferometry, holography. Prerequisite: E MCH 013, E MCH 110H, or E MCH 210

E MCH 403: Strength Design in Materials and Structures (4).

Determination, interpretation, significance, and application of mechanical properties such as plastic flow, fatigue strength, creep resistance, and dynamic properties. Prerequisite: E MCH 215, E MCH 216 [may not be taken for credit by students who received credit for E MCH 416H]

E MCH 407: Computer Methods in Engineering Design (3).

Numerical methods and computer programming, with applications to design problems in structural mechanics, dynamics, vibrations, and stability. Students who have passed E SC 407H may not schedule this course. Prerequisite: CMPSC 201C, CMPSC 201F, or E SC 261M; E MCH 013, E MCH 110H, or E MCH 210

E MCH 409: Advanced Mechanics (3).

Continuation of E MCH 012; Euler's equations for the rotation of a rigid body, gyroscopic motion, impulsive motion, Lagrangian mechanics. Prerequisite: E MCH 012 or E MCH 112H; MATH 230

E MCH 412: Experimental Methods in Vibrations (3).

Systems of one or more degrees of freedom, mechanical vibrations, vibration properties of materials, vibration techniques in nondestructive testing. Prerequisite: E MCH 454

E MCH 440 (MATSE): Nondestructive Evaluation of Flaws (3).

Methods and limitations of nondestructive evaluation of mechanical flaws; optical, acoustical, electromagnetic, x-ray, radiography, thermography, and dye techniques. Prerequisite: E MCH 013, E MCH 110H, OR E MCH 210

E MCH 454 (M E): Analysis and Design in Vibration Engineering (3).

Application of Lagrange's equations to mechanical system modeling, multiple-degree-of-freedom systems, experimental and computer methods; some emphasis on design applications. Prerequisite: E MCH 012 or E MCH 112H; M E 054 or E SC 407H

E MCH 461 (M E): Applied Finite Element Analysis (3).

Computer modeling and fundamental analysis of solid, fluid, and heat flow problems using existing computer codes. Prerequisite: CMPSC 201C, CMPSC 201F, or E SC 261M; E MCH 013, E MCH 110H, or E MCH 210

E MCH 471: Engineering Composite Materials (3). Properties, manufacture, forms of composites; micromechanics; orthotropic

lamina properties; laminate analysis; theories; failure analysis; thermal, environmental effects. Prerequisite: E MCH 013, E MCH 110H, or E MCH 210; E MCH 215, E SC 414M, or MATSE 201

E MCH 473 (AERSP): Composites Processing (3). An introduction to the principles of mechanics governing manufacturing, computer-aided design, and testing of composite materials and structures. Prerequisite: E MCH 471

E MCH 197: Special Topics (1 - 9):

E MCH 296: Independent Studies (1 -18 per semester) :

E MCH 297: Special Topics (1 - 9):

E MCH 397: Special Topics (1 - 9) :

E MCH 496: Independent Studies (1 -18) :

E MCH 497: Special Topics (1 - 9):

I. 11 —Technical Selections

The purpose of the *technical selections* courses is to enable students to pursue broader studies in selected subjects related to their chosen field. These courses are selected by each student from the 400-level courses in the Department (see Section 2.10) and in the College of Engineering. Other 400-level courses may be permitted with approval of the student's adviser.

Consistent with the objectives of the Engineering Science curriculum, *at least two credits of technical electives must be taken in engineering design and at least three in engineering science.* The following definitions have been adopted to distinguish between the two.

The *engineering sciences* have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other.

Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

A listing of some of the engineering courses and their engineering science/design category content appears on the following page. For any other engineering course, it is the student's responsibility to obtain documentation from the instructor that specifies the engineering science/design category content of that course.

Co-op students may substitute three credits, one for each work experience (ENGR 295, 395, 495), as a technical selection provided the student satisfactorily completes all three work assignments for a letter grade. These three credits will be considered to be in the engineering design category.

Table 1: Science (ES)/Design (ED)Category Content

Course No.	ES	ED	Course No.	ES	ED
ACS 402	3.0		ABE 461		3.0
ACS 403	1.0	2.0	ABE 462		3.0
AERSP 308	3.0		ABE 465	1.0	3.0
AERSP 401A		2.0	ABE 467	1.0	3.0
AERSP 401B		2.0	ABE 469		3.0
AERSP 402A		2.0	ABE 472		1.0
AERSP 402B		2.0	AE 401	1.0	2.0
AERSP 403	2.0	1.0	AE 402	1.5	1.5
AERSP 405		1.0	AE 403		3.0
AERSP 406W	1.0	1.0	AE 430	3.0	
AERSP 407	2.0	1.0	AE 431		3.0
AERSP 410	2.0	1.0	AE 439	3.0	
AERSP 411	2.0	1.0	AE 441		3.0
AERSP 412	3.0		AE 444		3.0
AERSP 413	2.0	1.0	AE 454		3.0
AERSP 420	2.0	1.0	AE 455	1.0	2.0
AERSP 423	3.0		AE 456	2.5	0.5
AERSP 425	2.0	1.0	AE 458	1.0	2.0
AERSP 430	2.0	1.0	AE 461		3.0
AERSP 450	2.0	1.0	AE 464		3.0
AERSP 473	1.0	2.0	AE 467		3.0
AERSP 490	3.0		AE 470		3.0
AERSP 492	2.0	1.0	AE 470		3.0
ABE 400	3.0		AE 474		3.0
ABE 401	3.0		AE 475		3.0
ABE 402	2.0	1.0	AE 476		3.0
ABE 403	2.0	1.0	AE 477		3.0
ABE 404	3.0		BIOE 401	1.0	
ABE 405	2.0	1.0	BIOE 402	2.0	1.0
			BIOE 403		1.0
			BIOE 505	2.0	1.0

Course	No.	ES	ED	Course	No.	ES	ED
CH E	401	3.0		CSE	485	2.0	1.0
CH E	407W	1.0	2.0	CSE	486	2.0	1.0
CH E	413	2.0	1.0	EE	210	2.0	2.0
CH E	414	2.0	1.0	EE	251	2.0	1.0
CH E	415	1.5	1.5	EE	317	2.0	1.0
CH E	420	1.5	1.5	EE	340	2.5	0.5
CH E	441	1.5	1.5	EE	352	2.7	0.3
CH E	446	3.0		EE	367	2.0	1.0
CH E	448	1.5	1.5	EE	368	2.0	1.0
CH E	450	1.5	1.5	EE	369	2.0	1.0
CH E	453	1.5	1.5	EE	402W		3.0
CH E	455	1.5	1.5	EE	403W		3.0
CH E	460	3.0	1.0	EE	409	3.0	
CH E	464		3.0	EE	411	2.0	1.0
CH E	465		3.0	EE	412	2.0	1.0
CE	421W	1.0	2.0	EE	413	2.0	1.0
CE	422	1.0	2.0	EE	414	2.0	1.0
CE	423	2.0	1.0	EE	417	2.0	1.0
CE	431		3.0	EE	418	1.5	1.5
CE	432		3.0	EE	419	2.5	0.5
CE	433		3.0	EE	420	2.0	1.0
CE	446		3.0	EE	422	1.0	2.0
CE	447	3.0		EE	423	2.0	1.0
CE	448W	1.0	2.0	EE	425	2.0	1.0
CE	449W		3.0	EE	428	2.0	1.0
CE	451	2.0	1.0	EE	429	1.0	2.0
CE	462	2.0	1.0	EE	432	2.0	1.0
CE	456W		3.0	EE	428	1.0	2.0
CE	472W		3.0	EE	439	2.0	1.0
CE	474		3.0	EE	447	2.0	1.0
CE	475	3.0		EE	448	1.0	2.0
CE	476	2.0	1.0	EE	453	2.0	1.0
CE	477	1.0	2.0	EE	458	2.0	1.0
CE	479	1.0		EE	459	3.0	
CE	482W	1.2	1.8	EE	461	2.0	1.0
CSE	411	2.0	1.0	EE	485	2.0	1.0
CSE	412	1.0	2.0	EE	486	2.0	1.0
CSE	418	1.0	2.0	EE	490	3.0	
CSE	421	2.0	1.0	EE	492	2.0	1.0
CSE	428	2.0	1.0	E MCH	400	2.0	1.0
CSE	430W	1.0	1.0	E MCH	401	2.0	1.0
CSE	431	2.0	1.0	E MCH	402	2.0	1.0
CSE	441W	1.0	1.0	E MCH	403	1.0	2.0
CSE	447	2.0	1.0	E MCH	407	2.0	1.0
CSE	458	2.0	1.0	E MCH	408	2.0	1.0
CSE	465	3.0		E MCH	409	3.0	
CSE	471	2.0	1.0	E MCH	412	1.0	2.0
CSE	477	1.0	2.0	E MCH	416H	1.0	2.0
CSE	481	2.0	1.0	E MCH	440	2.0	1.0

Course	No.	ES	ED
E MCH	446	3.0	
E MCH	461	2.0	1.0
E MCH	471	2.0	1.0
E MCH	473	1.0	2.0
E MCH	500	2.0	1.0
E MCH	506	2.0	1.0
E MCH	507	2.0	1.0
E MCH	509	2.0	1.0
E MCH	516	3.0	
E MCH	520	3.0	
E MCH	521	2.5	0.5
E MCH	523	1.0	2.0
E MCH	524A	3.0	
E MCH	524B	3.0	
E MCH	524C	3.0	
E MCH	525	3.0	
E MCH	527	3.0	
E MCH	528	1.0	1.0
E MCH	530	1.0	1.0
E MCH	531	3.0	
E MCH	532	1.5	1.5
E MCH	534	1.5	1.5
E MCH	535	3.0	
E MCH	540	3.0	
E MCH	546	3.0	
E MCH	550	2.0	1.0
E MCH	552	3.0	
E MCH	553	3.0	
E MCH	560	1.5	1.5
E MCH	562	2.0	1.0
E MCH	563	2.0	1.0
E MCH	570	3.0	
E MCH	581	2.0	1.0
E MCH	582	3.0	
E MCH	261M	1.5	1.5
E SC	314	3.0	
E SC	400H	2.5	0.5
E SC	404H	3.0	
E SC	405H	3.0	
E SC	406H	3.0	
E SC	407H	3.0	
E SC	414M	1.0	2.0
E SC	433H	1.0	
E SC	445	2.0	
E SC	450	2.0	1.0
E SC	455	1.0	2.0
E SC	456	1.0	2.0
E SC	475	2.0	1.0
E SC	481	1.5	1.5

Course	No.	ES	ED
E SC	501	1.5	1.5
E SC	502	2.5	0.5
E SC	511	3.0	
E SC	536	2.0	1.0
E SC	537	3.0	1.0
E SC	577	2.0	1.0
E SC	578	3.0	
E SC	581	2.0	1.0
E SC	400	1.5	1.5
I E	402		3.0
I E	425	3.0	
I E	408W	3.0	
I E	418	1.0	2.0
I E	419		3.0
I E	423	1.0	2.0
I E	424	3.0	
I E	425	3.0	
I E	426	1.0	2.0
I E	430	1.0	2.0
I E	438		3.0
I E	450	1.0	2.0
I E	451	1.0	2.0
I E	453	1.0	2.0
I E	454	3.0	
I E	455	3.0	
I E	456		3.0
I E	460		3.0
I E	462	1.2	1.8
I E	463	1.5	1.5
I E	465	1.0	2.0
ME	403	1.0	2.0
ME	405	1.0	2.0
ME	409	1.0	2.0
ME	411		3.0
ME	412	2.5	0.5
ME	413	1.0	2.0
ME	414W		4.0
ME	415W		4.0
ME	416	2.0	1.0
ME	417		3.0
ME	418		3.0
ME	420		3.0
ME	421	3.0	
ME	434	2.0	1.0
ME	440	2.0	1.0
ME	450	1.0	2.0
ME	451	1.0	2.0
ME	452	1.0	2.0
ME	454	2.0	1.0

Course	No.	ES	ED
M E	455	1.0	2.0
M E	456	1.0	2.0
M E	458	1.0	2.0
M E	460	1.0	2.0
M E	461	2.0	1.0
M E	462	1.0	2.0
M E	466H		3.0
M E	470	1.0	2.0
NUC E	307	3.0	
NUC E	401	1.0	2.0
NUC E	403	2.0	1.0
NUC E	405	3.0	
NUC E	408		3.0
NUC E	409	3.0	
NUC E	420	3.0	
NUC E	428	3.0	
NUC E	430		3.0
NUC E	431W		4.0
NUC E	444	1.0	
NUC E	445		3.0
NUC E	450	3.0	
NUC E	451	3.0	
NUC E	460	2.0	1.0
NUC E	470	2.0	1.0
NUC E	490	3.0	

Chapter 2: ESM Department Information

2. 1 —Statistics

E SC Majors: 75

E MCH Minors: 42

Graduate Students (M.S., M.Eng., Ph.D.): 110

ESM Faculty: 38

Research Laboratories and Centers: 30

2. 2 —ESM Faculty

S. Ashok Professor	407C EES Bldg.	863-4588
O. O. Awadelkarim Professor	407D EES Bldg.	863-1773
C. E. Bakis Professor	1 Research West Bldg.	865-3178
F. Costanzo Associate Professor	409D EES Bldg.	863-2030
J. P. Cusumano Professor	305D EES Bldg.	865-3179
M. Demirel Assistant Professor	205A EES Bldg.	863-2270
C. Dong Bioengineering Professor	228 Hallowell Bldg.	865-1407
R. S. Engel Associate Vice Provost, Professor	304 Rider II Bldg.	865-8681

2. 2 —ESM Faculty

S. J. Fonash Bayard D. Kunkle Chair in Engineering	114 Lubert Bldg.	865-4931
L. H Friedman Assistant Professor	309D EES Bldg.	865-7684
R. M. German Brush Chair Professor	147B Research West Bldg.	863-8025
G. L. Gray Associate Professor	409C EES Bldg.	863-1778
R. E. Harbaugh Professor and Chair, HMC Neurosurgery Dept.	H110 Derry Township	717 531-7487
S. I. Hayek Distinguished Emeritus Professor	307C EES Bldg.	865-6143
M. W. Horn Associate Professor	305C EES Bldg.	865-0332
T. Huang James Henderson Assistant Professor	302B EES Bldg.	863-4209
A. Lakhtakia University Distinguished Professor and Graduate Advisor	206 EES Bldg.	863-4319
M. Lanagan Assoc. Director MRI Associate Professor	407B EES Bldg. and 278 MRI	865-6992
P. M. Lenahan Professor	101 EES Bldg.	863-4630
C. J. Lissenden Associate Professor and Undergraduate Officer	211 EES Bldg.	863-5754

2. 2 —ESM Faculty

C. B. Masters Assistant Prof. and Undergrad Coordinator	210 EES Bldg.	865-6674
R. P. McNitt Professor and Dept. Head Emeritus	3 Research West Bldg.	865-6661
R. Messier Professor Emeritus	307B EES Bldg.	865-6161
R. N. Pangborn Associate Dean for Undergraduate Studies	101 Hammond Bldg.	863-3750
J. L. Pytel Associate Dean for Student Services	208 Hammond Bldg.	865-7539
J. L. Rose Paul Morrow Professor	411E EES Bldg.	863-8026
N. J. Salamon Professor	411D EES Bldg.	863-4628
A. E. Segall Associate Professor	403B EES Bldg.	865-7829
V. Semak Professor and Sr. Research Associate	165 ARL Bldg.	863-7669
B. A. Shaw Professor	403C EES Bldg.	865-7828
I. Smid Associate Professor	147 Research West Bldg.	863-8025
S. Suliman Assistant Professor	407B EES Bldg.	863-3574
W. Thompson, Jr. Professor Emeritus	307B EES Bldg.	865-6951

2. 2 —ESM Faculty

B. R. Tittmann Schell Professor	309E EES Bldg.	865-7827
J. A. Todd P. B. Breneman Dept. Head Chair Prof.	214 EES Bldg.	863-0771
M. Urquidi-Macdonald Professor	203C EES Bldg.	863-4217
E. Ventsel Professor	203B EES Bldg.	863-0754
J. Xu Assistant Professor	205B EES Bldg.	863-0721
S. Y. Zamrik Professor Emeritus	307A EES Bldg.	865-5241

2. 3 —Facilities

The Engineering Science and Mechanics (ESM) Departmental Office, most faculty, and teaching and research laboratories are housed in the *Earth-Engineering Sciences Building* on the West Campus. The ESM faculty also have laboratories in Hammond Building, the Materials Institute, the Materials Research Lab (MRL), and Research West Building. These state-of-the-art facilities are primarily created and maintained by instructional and research funding. Themes for the labs include nanofabrication, MEMS (micro electro-mechanical systems), powdered materials, ultrasonic characterization, underwater acoustics, environmental degradation, neural networking, composite materials and structures, as well as thermomechanical fatigue and failure analysis. In as much as the Engineering Science curriculum features undergraduate research through seminars, special lab course E SC 433H, research internships, and the senior research and design project, E SC students will have opportunities to work in many of these laboratories during their undergraduate years.

The ESM laboratories include:

AI/Neural Networking: AI/Chaos/ Neural Networking/Fuzzy Logic/ Data Mining computer with software facilities to develop applications.

Primary and Secondary Battery Laboratory: including glove boxes, Solartron frequency analyzers, potentiostats, cell testing facilities.

Bio-molecular Materials Laboratory: Genetic analyzer and sequencer, thermo-cycle (PCR), incubator, airflow system (class level-II), microfluidic laser system (CO₂), optical microscope for visualization of cell studies, chromatography (HPLC), spectrophotometer, electrophoresis, and other small devices required for bio-molecular materials and cell level studies.

BioNEMS Laboratory - Under development:

Center for Innovative Sintering Products: die compaction, injection molding, hot and cold isostatic presses, wide variety of sintering and prototyping facilities, optical and electron microscopy, materials and powder characterization tools, process models and computer simulations.

Composites Manufacturing Technology Center: filament winder, pultruder, hot presses, furnaces, impact systems, flywheel testing chamber, thermal analyzer, resin transfer molder, autoclave, and loading frames for impact, high-rate, cyclic, quasi-static, and creep tests.

Computational Mechanics: rack-mount cluster for high-performance parallel computing, gigabit Ethernet, MPI software libraries, symbolic algebra and visualization software, a variety of compilers.

Corrosion/Environmental Degradation: salt fog cabinet, computer controlled and stand-alone potentiostats, humidity cabinet, alternate immersion tester, corrosion cells, class 1000 clean-room, dual gun EB-PVD system.

Corrosion Detection and Prediction: on underground pipelines.

Dynamics/Shock/Vibration: shaker tables, non-linear simulators, high speed camera system, high strain rate hydraulic system.

XL30 ESEM Scanning Electron Microscope: wide range of magnification, EDAX X-ray system, imaging of non-conductive or even wet

samples, light element analysis (such as oxygen and carbon), excellent resolution over wide depth of field

Experimental Stress Analysis: strain gage instrumentation, photo-elastic test benches, Moire interferometer, quasi-static load frames.

Fourier Optics Laboratory: Optical information extraction.

Fatigue, Fracture, and Creep: tension/torsion, tension/compression, and internal pressure hydraulic systems, 3-point and 4-point bending, anticlastic bending, induction heating system, strain gage instrumentation, extensometry, creep frames.

Laser Technology: design and fabrication of semiconductor lasers, solid state lasers technology, laser ablation, pulse laser deposition of novel materials, and pump-probe detection of ultrafast phenomenon with femtosecond laser pulses.

MEMS (micro-electronic-mechanical-systems): newest lab-stereo lithography, characterization, processing.

Microscopy/Failure Analysis: scanning electron microscope, scanning laser conformal optical microscope, metallograph.

Microwaves: vector network analyzer, shielded chamber, wave guides, anechoic chamber, tabletop freespace material characterization facility, in-situ high temperature facility.

Nanofabrication: class 10 and class 100 cleanroom, plasma and chemical film deposition tools, wet and plasma etching systems, ebeam and photo lithography, surface modification and characterization tools, light, scanning electron and atomic force microscope systems.

Non-Destructive Evaluation: ultrasonic systems, radiography, SEM, thermographic system, photoelasticity.

Optoelectronics Laboratory: focus is on development of novel optoelectronic materials and their device applications in bio/chemical sensing, optical communication and displays. Particular emphasis is placed on synthesizing low dimensional semiconductor structures such as colloidal nanocrystal quantum dots, nanowires and nanosheets and exploring their potentials by integrating them in a variety of electronic and photonic device structures.

Semiconductor Spectroscopy: electron spin resonance, spin dependent recombination, ultraviolet illuminator.

Smart Structures & Systems: pulse tube facility for underwater measurements, active vibration and noise control, wireless SAW microsensors, DSP and controllers.

Thermal Shock and Laser Machining: 500W (1.5KW peak) power CO₂ laser with custom and simultaneous, dual-beam capability developed for reduced-fracture-risk methods.

Thermomechanical Processing of Materials: fabrication, heat treatment, room and high temperature deformation processing.

Thin Film Preparation: Sculptured thin films, RF and DC sputtering systems, ion assisted evaporation, plasma assisted chemical vapor deposition, FTIR spectroscopy, profilometry, deflection method of thin film stress analysis.

Tribology: Plint system, pin-on-disk, high pressure/temp system for ceramics.

Ultrasonics: scanning acoustic microscope, atomic force microscope, C-Scan, tomography, guided waves, structural health monitoring.

Wave/Materials Interactions: active coatings, transducers, chiral materials.

2. 4 —The Undergraduate Program

The College of Engineering and the Engineering Science Honors program, the undergraduate major in the Department of Engineering Science and Mechanics, are both highly ranked nationally. (For example, the College is ranked high nationally in the *U.S. News and World Report College Report* and the Engineering Science program has been included in the top ten programs in the *Gourman Report*). The Engineering Science curriculum is characterized by greater breadth of training in the engineering sciences than is found in traditional engineering majors. It is a broad, science-based program, with relatively uniform emphasis over all the engineering sciences for the first three years. In their senior year, students can use their technical electives in conjunction with their design project to pursue any particular engineering area in depth.

The engineering sciences are built on a foundation of required courses in basic science and mathematics, most of which are taught exclusively for Engineering Science students. These courses stress the basic principles underlying engineering analysis and the transferability of engineering concepts from one discipline to another. The student builds on these sequences by choosing elective courses and a senior research and design project appropriate to his or her specific field of interest.

It should be noted that in the Engineering Science curriculum, depth in an area is not sacrificed to obtain overall breadth. This is accomplished by (1) an array of accelerated courses (appropriate for the E SC Honors students), (2) a junior year devoted to the engineering sciences, and (3) a senior year wherein the student may choose four technical electives in an area in which to carry out the research and design project and write a senior thesis.

Engineering Science students may select the engineering mechanics minor as a focus area of study. Among courses in mechanics and materials is a sequence with an emphasis on engineering design: E MCH 013D, 407, 400 and 461, which is unique within the College of Engineering.

The Engineering Science major offers a unique opportunity for excellent students who are interested in serving society as creative engineers. Its emphasis on a science background and interdisciplinary nature prepares students to cope with the complex, multi-faceted problems of technology in contemporary society. The many options available permit students to enrich and strengthen their background in an area of individual choice.

A distribution of topic areas, a listing of courses satisfying these topic areas, and a listing of credit assignments to the various areas is in the following table:

	Formal Course	Credits
Engineering Science		
Chemistry	CHEM 012, 013, 014	7
Physics	PHYS 211, 212, 213, 214	12
Math	MATH 140, 141, 220, 230, 251, E SC 404H	21
Mechanics		
Equilibrium	E MCH 110H or 210, or 011 and 013/013D	5 or 6
Dynamics	E MCH 112H or 012	3
Electricity & Magnetism	E E 210H, E SC 400H, E E 340	10
Thermodynamics, Heat and Mass Transfer,	M E 120, AERSP 308	7
Materials Structure, Characterization,	E SC 414M, E MCH 416H, PHYS 237	9
Computer Science and Utilization	E SC 261M or CMPSC 201, E SC 407H/E MCH 407	6
Area of Student's Choice		
Capstone Project and Senior Thesis	E SC 410H, 411H	7
Technical Selections	Various	12

2.5 —Scholastic Requirements, Honors Program

The Engineering Science major is the Honors program of the College of Engineering. The following features characterize this Honors program at Penn State:

1. For admission to the Engineering Science program, a student must show unusual academic promise.

2. For admission, a cumulative grade-point average of at least 3.00 is required. Faculty approval is required if the cumulative average is below 3.00.
3. Students who are in the first or second year and who are considering Engineering Science as a major are encouraged to take Honors courses whenever possible. During the combined third and fourth years, without exception, no fewer than 14 Honors credits will be accepted in satisfaction of Honors degree requirements.
4. Each student in the Honors program must complete a senior thesis. In Engineering Science, the report of the senior research and design project (E SC 410H and 411H) serves as the senior thesis. The thesis must be typed and submitted no later than one week before the last day of classes of the semester in which the student is registered for E SC 411H. The report is submitted in triplicate and each copy must be prepared according to Departmental regulations. One copy is for the Department, one is for the student's project adviser. The Schreyer Honors College receives an unbound copy for students in that program. Appendix D contains guidelines for the preparation of the thesis.
5. Each student must pass a comprehensive examination administered by the Department Honors committee. This examination is usually taken in the semester in which the student is registered for E SC 411H of the senior year. The examination may be either oral or written, and may concentrate on the senior project, or it may be broader in scope, dealing with the basic topics in the engineering sciences.
6. Each student will maintain a portfolio as described in section 4.7.
7. To remain in the Engineering Science major, a student must maintain a cumulative average of at least 2.50. If the average falls below 2.50, the student is expected to change to another major.
8. Engineering Science students must earn a minimum grade of C in the following required courses: E MCH 110H or 210 (or the combination of E MCH 011 and 013 or E MCH 011 and 013D), E MCH 112H or 12, E SC 404H, E SC 407H, and E SC 414M.
9. Engineering Science seniors who have completed the requirements for graduation will be recommended for an honors diploma if

they: (1) complete a satisfactory senior thesis, (2) pass the senior comprehensive examination, and (3) have a cumulative average of 3.20 or higher at the time of graduation.

10. At the end of every semester, the chair of the curriculum committee and the Department head, in consultation with appropriate members of the faculty, review the academic record of each student enrolled in Engineering Science to determine if the level of his/her performance is in keeping with the goals and requirements of the major. Should this review identify any students whose performances are below the standards expected of Engineering Science students, the Department Head, on behalf of the Department faculty, counsels these students on the advisability of continuing in the major.

2. 6 —Student Organizations and Programs of Interest

The Department of Engineering Science and Mechanics maintains a student chapter of a professional society, the Society of Engineering Science (SES). The student chapter of SES was established at Penn State in 1972. This professional society was founded by engineers in widely divergent and interdisciplinary fields whose interests did not fall within the boundaries of traditional disciplines such as electrical or mechanical engineering. The SES student chapter should be of interest to every student in the Department. Students are encouraged to take advantage of the opportunity to benefit from both the career and social aspects of membership.

Announcements of organization officers and activities are listed on the Department website.

Through a program called Summer Research Experience for Undergraduates, a limited number of sophomores and juniors may obtain up to the number of hours per week determined by the supervising faculty member (40 hour per week) summer employment at the University. The students will work on current research and development projects with faculty and graduate students.

A very limited number of upper level students may be chosen each semester to participate in the Teaching Interns Program. These students will be provided some financial remuneration to assist in the teaching of a lower level engineering course under the supervision and mentoring of the faculty member teaching the course. This program

is designed to encourage students to consider a career involving teaching by providing some practical experience in the profession.

The students in the Department elect two representative to the Engineering Undergraduate Council, which speaks for the entire undergraduate student body of the College.

The College of Engineering is committed to providing opportunities and access to women and minorities. The Minority Engineering Program is responsible for recruiting and retaining under-represented minorities, and for encouraging these qualified students to pursue engineering careers. The minority Engineering Program offers advising, counseling, and tutoring services through the minority engineering student assistance center.

The Women in Engineering Program is responsible for recruiting and retaining women students. The program offers advising for women, organizes activities, and conducts research about women in engineering.

Interested students are encouraged to take advantage of the Cooperative Education program, explore the opportunity to study abroad during the junior year, or consider participation in the Integrated Undergraduate/Graduate program.

2. 7 —Scholarships and Financial Aid

Current information is available in the Office of Student Aid, 314 Shields Building, 865-6301. Financial need is an important factor in the selection criteria for most of the department's scholarships.

<http://www.psu.edu/studentaid/>

2. 8 —Employment Opportunities

The B.S. Honors degree in Engineering Science provides a balanced education in both the theoretical and experimental aspects of pure and applied science. Graduates are sought by many branches of industry, as well as by research and administrative agencies of the federal government. Starting salaries in past years have been among the highest for all graduates in the College of Engineering.

Among the graduates in Engineering Science over the past few years, approximately 50 percent have entered graduate schools immediately after graduation, earning advanced degrees in a range of fields from

engineering to medicine and law. The others have accepted full-time industrial positions.

Most Engineering Science graduates who go on to graduate school have financial assistance in the form of a graduate assistantship. Students interested in graduate studies should see their adviser for more information.

Announcements of employment opportunities are provided to the Department on a continuing basis by the University Placement Office. These announcements are posted on the bulletin board near the Department office. Students may obtain more detailed information concerning employment opportunities at the Career Services Office in the 235 MBNA Career Services Building.

Department majors may also elect to participate in the Cooperative Engineering Education Program, which offers the opportunity to experience engineering as it is actually practiced. Interested students should contact the Departmental Co-op coordinator (see Appendix A for more information).

The following are two websites that contain extensive listings of employment opportunities that all students should find useful:

<http://www.engr.psu.edu/coop/>

<http://www.sa.psu.edu/career/joblink.shtml>

Chapter 3: Advising and Student Portfolio

3. 1 —Advising and How it Functions

Each student is assigned an academic adviser and must meet with the adviser during the first week of each semester to evaluate his/her program of courses, to plan an overall program of study, and to update and discuss the student portfolio. The adviser must approve the student's program plans and any modifications to the requirements of the major. In the event that the adviser is not available for initial contact, the student should see the Assistant for Undergraduate Student Affairs, Kathleen Zimmerman, in Room 212 Earth-Engineering Sciences Building (865-4523), for help in making contact with an adviser.

The adviser also serves as a counselor, and may be consulted about any problem, whether it is academic or personal. As the student approaches graduation, the adviser can provide helpful information about employment opportunities and graduate schools.

3. 2 —Conferences With Your Adviser

At the appropriate times each semester, you must meet with your adviser to discuss your current status and portfolio (during the first week of the semester) and to arrange your preregistration for the following semester (during the latter part of the semester). Other meetings with your advisor are encouraged, as appropriate for your situation. The preregistration period is announced in each semester's *Schedule of Classes* or is available on line at <https://elion.oas.psu.edu/>.

3. 3 —Petitions

All exceptions to the Engineering Science curriculum, as described herein, must be approved by filing a petition. It is the responsibility of the student, in consultation with the academic adviser, to properly prepare a College petition (for exceptions to College requirements) or a Department petition (for exceptions to Department requirements)

which accurately but succinctly describes what the request is about and provides the justification for such an exception. These petition forms are available in the Department office (212 Earth-Engineering Science). Note—The College no longer requires a petition in order to pursue a 9/6/3 credit sequence of courses in the Arts, Humanities, or Social and Behavioral Sciences; however, it is still necessary that the student file a Department petition for completeness of academic records. Petitions for exceptions to the AHS requirements will not be considered during a student's final semester.

3. 4 —Academic Integrity

The Department of Engineering Science and Mechanics at the Pennsylvania State University considers academic training to be apprenticeship for practice in the professions. Students are expected to demonstrate a code of moral integrity and ethical standards commensurate with the high expectations that society places upon professional practice. Accordingly, it is the policy of the department to maintain the highest standard of academic honesty and integrity. The Council of Academic Deans statement describing academic integrity can be found at <http://www.engr.psu.edu/Forms/AcademicIntegrity/form.pdf>

Academic dishonesty includes, but is not limited to, cheating, copying on tests, plagiarizing, acts of aiding or abetting, unauthorized possession of materials, tampering with work, ghosting, altering examinations and theft of any property (hardware, software, lab equipment and supplies, intellectual property, etc.). Students are encouraged to report incidents of academic dishonesty to their instructors in order to promote a fair academic climate and equal opportunity learning environment.

A student charged with academic dishonesty will be given oral or written notice of the charge by the instructor. A student contesting such a charge may seek redress through informal discussions with the instructor(s), department head or college dean. If the instructor believes that the infraction is sufficiently serious to warrant referral to the Office of Conduct Standards, or if the instructor awards a final grade of F in the course because of the infraction, the student and instructor will be afforded formal due process procedures governed by Penn State Senate Policy 49-20. Policy 49-20 and procedures can be found in the document "Policy and Rules for Students" issued annu-

ally by the Senate Office and available through each student's home department or college dean's office. Academic Integrity policy information can also be found on the web at <http://www.engr.psu.edu/CurrentStudents/acadinteg.asp>

3. 5 —Student's Academic File

A file is established for each student who enters the Engineering Science curriculum. This file contains the following:

1. a curriculum checksheet for recording the courses completed
2. copies of the undergraduate transcript
3. copies of the various registrations, preregistrations, and degree audits
4. records of changes, such as drop-adds, petitions, etc.
5. other, such as co-op reports

This file is an official Department record and is retained by the Department.

3. 6 —Advisor's Checksheet

To graduate, each student must satisfactorily complete all Department, College and University requirements. To keep track of progress, a checksheet of course work completed is maintained by each adviser, and it is suggested that students maintain a similar sheet for their own records.

The curriculum and/or College requirements are sometimes changed and the checksheets are revised accordingly. The proper checksheet will be furnished by each adviser. (See *Appendix E* for a sample checksheet). When regulations are changed, a student has the option of following the new regulations, if they are to his/her advantage, or of continuing to follow those that were in effect at the time he/she matriculated.

3. 7 —Student Portfolio

There is a national trend in education to create, maintain, and utilize portfolios for engineering students. Although this has been an established practice of Art, Architecture, Advertising and other professionally oriented disciplines, it is somewhat new to engineering. The

primary purpose is the collection at one place of one's academic and professional accomplishments, and thereby, provide hard evidence of the student's progression towards achieving professional level quality in their activities. This evidence will be used in two ways; 1) to supplement the department's records to assess the effectiveness of the program and 2) to evaluate the development of each student in achieving outcomes deemed essential to good engineering practice by ABET (Accreditation Board of Engineering and Technology) who recognizes the creation and evaluation of such portfolios as a legitimate factor in student evaluation. The portfolio will clearly be an asset to faculty when writing letters of reference, providing information to potential employers, and granting of scholarships.

The portfolio of hard copies of representative work is kept on file in the Department office by the Assistant for Undergraduate Student Affairs. Additionally, electronic archiving of portfolio materials is being developed through the ANGEL system.

The materials that a student should consider for his/her portfolio can be any material that demonstrate achievement in four specific areas:

- design (see definition of design in the next section)
- communication (both oral and written)
- group work/leadership
- academic excellence

The student must meet with his/her academic advisor at least once per semester to discuss new entries so that the portfolio can be assessed on a continuing basis.

Design in the Engineering Science curriculum has a broad interpretation. For Engineering Science faculty and students, design is a creative and iterative process that encompasses systems, components and processes related to, for example, material, biological, chemical, mechanical and electrical systems. Within these systems, design is performed at length scales ranging from nanometers (the atomic level) to tens of meters (the length scales associated with our everyday experiences). The tools used for design include mathematical models (their development and iterative refinement), algorithms (of all sorts), computer simulations, experimentation and prototyping. These tools are integrated to achieve the objective of our Senior Research and

Design Project.

Our Senior Capstone Research and Design Project, which culminates in an oral presentation and a written thesis, incorporates design in a variety of ways befitting our inter-disciplinary department. Engineering Science students participate in projects in all engineering disciplines and employ design principles before, during, and after analysis, experimentation and/or simulation. The resulting designs of systems, components or processes are then tested and refined by changing material, geometric, stochastic or other parameters, as required. The design is often not a machine component or a bridge, but may be a new experimental process, nanoscale device, or computer code for the modeling and/or analysis of an engineering system or process. Computer programs, written initially to analyze, are frequently rewritten to function as design tools. As appropriate, knowledge of physics, chemistry, mathematics, mechanics, materials science, etc., is harnessed along with the iterative nature of design to complete an independent research project, within a team-based environment, in a timely manner.

Chapter 4: Department and University Procedures

4. 1 —Schedule Change, Drop or Add a Course

1. A student may not add a course to his or her schedule after the first ten calendar days of a semester. (See Senate Policy 34-87 for exceptions).
2. A student may drop a course during the first ten calendar days of a semester. The student should consult with his/her adviser to discuss any ramifications of this action.
3. If a student is taking a course concurrently with a prerequisite course, the prerequisite course may not be dropped without also dropping the course for which it is a prerequisite.
4. A student may late drop a course beginning with the 11th day and ending on the last day of the 12th week. A WP (passing) or WF (failing) or WN (no grade) symbol will be entered on the student's academic record and transcript.
5. No student may drop a course after the last day of the 12th week for any reason.
6. Use of the late course drop form from the beginning of the 11th day to the end of the 12th week of classes is limited to a maximum 16 credits for baccalaureate degree candidates.
7. A fee will be charged for each change of schedule filed after the seventh working day of the semester.

4. 2 —Satisfactory/Unsatisfactory Grading System

With the exceptions of ENGR 295, 395, 495, Engineering Science students are not permitted to use the satisfactory/unsatisfactory system to satisfy graduation requirements.

4.3 —Schedules

Standard Schedule

A student enrolled in the College is expected to take the prescribed courses of his/her major in accordance with the outline published in the *Baccalaureate Bulletin*. A standard or normal schedule, as indicated by these outlines, includes 12 to 19 credits per semester.

Irregular Schedule

An adviser is authorized to approve irregular schedules that are necessary because of a student's transfer from another institution with advanced standing, change or major, failure in one or more courses, or extenuating circumstances beyond the student's control.

Heavy Schedule (Maximum Credit Load)

No student shall be permitted to be enrolled for more than a typical credit load (19 credits, Senate Policy 34-52; the credit value of an audited course is included in the credit load) in any one semester by all delivery systems without permission of the student's academic adviser. All credit courses scheduled regardless of delivery system must be approved by the student's adviser (Senate Policy 34-55).

At Commonwealth Campuses the student must get the signature of the dean's representative from the College of Engineering.

Minimum Schedule

A student carrying a schedule with fewer than 12 credits is classified as a part-time student (Senate Policy 34-53).

Light Schedule

In cases of illness or other extenuating circumstances that justify the action, a student may be permitted to drop one or more courses (but not after the 12th week) and continue in the College with a light

schedule. If the schedule then has fewer than 12 credits, he/she will be reclassified as a part-time student.

Chapter 5: General Education Requirements

All baccalaureate degree students must complete 49 credits of General Education. The General Education program reflects the belief of educators and leaders in all professions that successful, satisfying lives require a wide range of skills and knowledge. Skills courses teach the ability to reason logically and quantitatively and to communicate effectively. Other courses provide broad overviews of the world we live in. Courses that satisfy General Education requirements are designated with appropriate suffixes in the *Baccalaureate Bulletin*. Consult your *Bulletin* or the *General Education* brochure for specific details.

Arts courses emphasize the traditions, literature, and history of the arts and architecture that have served as an expression of the cultural values of society. They are designed to help students understand the approaches to human experience that distinguish the arts. The student may select courses from the following Arts divisions: interdisciplinary; architecture/landscape architecture; music, performance arts; and visual arts.

Humanities courses emphasize coherent overviews of cultural and intellectual currents, shaping or interpreting individual and social values. They relate major figures, ideas, achievements, and/or world-shaping events to the most enduring continuities in human experience. Humanities divisions include: interdisciplinary, history, language and literature, philosophy, and religion.

Social and Behavioral Sciences courses emphasize major concepts, findings, and analytic methods most useful to an informed citizenry that needs to understand politics, economic systems, social institutions, individual and group behavior, and human communication. Courses in this division include: interdisciplinary; anthropology and linguistics; economics, geography, mass communications; politics, government, and history; psychology and developmental studies; sociology.

The student may select from a wide range of courses to fulfill these requirements. The student's own judgment, interests, and curiosity will determine the courses to select. *There is no best course for an engineering student. There is only a best course for the student, and the student is the determinant of that. It is the student's responsibility to check the Bulletin to see if there are prerequisites for a course.*

In the College of Engineering, and specifically for the Engineering Science major, the General Education requirements are met as follows:

Skills (18 credits required)

1. Writing/Speaking (12 credits)
ENGL 015 or 030
ENGL 202C
CAS 100A/B
Writing Intensive course (E SC 261Mor E SC 414M)

2. Quantification (6 credits required)

MATH 140 and MATH 141

Health and Physical Activity (3 credits required)

Choose a course or courses totaling three credits with the suffixes GHS or GPE to satisfy this requirement.

Distribution Component (28 credits required)

1. Natural Sciences (9 credits)
CHEM 012, PHYS 211, PHYS 212
2. Arts (6 credits of courses designated GA)
3. Humanities (6 credits designated GH)
4. Social and Behavioral Sciences (6 credits of courses designated GS)
5. First-Year Seminar (1 credit-any University course designated FYS)

5. I —Arts, Humanities, and the Social and Behavioral Sciences

A 3-credit economics course is required by every engineering major. The Engineering Science and Mechanics Department will accept ECON 002, 004, or 014. A student having passed an engineering economics course need not take an ECON course, but must still

complete 18 credits in the Arts, Humanities, and the Social and Behavioral Sciences.

In consultation with the adviser, a student may develop a sequence of 9 credits in either the Arts, Humanities, or Social and Behavioral Sciences by substituting 3 credits from one of the other two areas not in the student's major field of study. A petition to this effect must be filed with the ESM Department.

A petition must be approved by the Dean before the student is permitted to take any course which is not listed in the booklet, "General Education in the Curriculum," to meet the General Education requirements.

A language course at the 12th credit level or higher can be substituted for 3 credits of Arts, Humanities, or Social Science requirements. Note: if this substitution is made, it cannot be the ONLY course in a category (i.e. it cannot be substituted for the 3 credit category in a 3-6-9 credit sequence of courses). Beginning language courses at Penn State are 4 credits each, so the 12th credit level would be a level III course (Span 003, Italian 003, French 003, etc.). If a student intends to take a language course elsewhere, he/she should consult with an adviser first, as the 12th credit level may be defined differently at other institutions.

5. 2 —Writing Across the Curriculum

As part of the baccalaureate degree program general education requirements, students are required to complete at least 3 credits of a writing-intensive course (Writing Across the Curriculum requirement) prior to graduation. Engineering Science students fulfill this requirement by completing ESC 261M or E SC 414M. Note: the M suffix signifies both a Writing Across the Curriculum requirement and an Honors course.

5. 3 —U.S. and International Cultures Requirement

All baccalaureate degree students must take at least one 3-credit United States Cultures course and one 3-credit International Cultures course. The approved courses have the designations US and IL respectively (formerly GI). Students should make sure that these US and IL courses also fulfill one of the GA, GH, or GS requirements to avoid having to take an extra course. Students with life experiences

which meet the spirit of the International requirement, such as study abroad, some internships, and working in the Peace Corps, may petition to have this count as their IL requirement.

5.4 —Other

Substitution of ENGL 202B for ENGL 202C. Students who entered the University with Advanced Standing, including credit for ENGL 202B (Writing in the Humanities) or students who changed their major to the College of Engineering having already taken ENGL 202B, may petition to substitute ENGL 202B for ENGL 202C (Technical Writing).

Students may count up to 3 ROTC credits toward AHS requirements (section 6.1) and up to 3 ROTC credits as departmental technical electives.

Chapter 6: Schedule of Course Offerings

Course	F	S	S	Course	F	S	S
		p	u			p	u
E MCH 011	x	x	x	E MCH 471	x		
E MCH 012	x	x	x	E MCH 473		x	
E MCH 013	x	x	x	E MCH 496	x	x	x
E MCH 110H	x			E MCH 497	x	x	x
E MCH 112H		x		E SC 261M		x	
E MCH 210	x	x		E SC 314	x	x	x
E MCH 215	x	x	x	E SC 400H		x	
E MCH 216	x	x	x	E SC 404H	x		
E MCH 313		x		E SC 405H			x
E MCH 400	x		x	E SC 406H		x	
E MCH 401	x			E SC 407H	x		
E MCH 402		x		E SC 410H	x	x	x
E MCH 403		x		E SC 411H	x	x	x
E MCH 407		x		E SC 414H	x		
E MCH 408	x			E SC 433H	x		
E MCH 409	x			E SC 445		x	
E MCH 412		x		E SC 450	x		
E MCH 416H		x		E SC 455		x	
E MCH 440		x		E SC 475	x		
E MCH 446		x		E SC 481		x	
E MCH 461	x	x		E SC 496	x	x	x
				E SC 497	x	x	x

Chapter 7: Special Academic Programs

The University offers many special academic programs including the Cooperative Education program, the Integrated Undergraduate/Graduate program, the Study Abroad program, the Schreyer Honors College, the Concurrent Majors Program, and a variety of minor specialization programs (the Engineering Science and Mechanics Department offers a minor in Engineering Mechanics). Appendices A, B, and C of this guide offer additional information of the Co-op program, the Integrated Undergraduate/Graduate program, and the E MCH minor, respectively. Before entering any special program, students should first refer to the current Penn State *Baccalaureate Degree Programs Bulletin* and consult with their academic advisers.

APPENDIX A: The Engineering Science Co-op Program

Description of the Program

The Cooperative Education Program of the College of Engineering was developed to provide an opportunity for students to obtain one full year of work experience while they earn their undergraduate degrees. The program has many benefits for students, including exposure to real work situations, on-the-job training, and earned salary that can be used toward tuition and living expenses. In general, the work experience will be divided into three segments: a fall semester, a spring semester and a summer session. Students participating in the program will typically graduate in December of the fifth academic year, thus completing the degree program in four and one-half years.

Sources of Information on the Program:

- Booklet – *Penn State Engineering Co-op Student Handbook*
- Website <http://www.engr.psu.edu/coop/>

Application and Admission to the Program

1. Eligibility: Students must seek to enter the program by the end of the *sophomore* year. A declaration of major should have been made prior to entry into the program.
2. Admission requirements: A student intending to enter the program must be in good standing. However, some of the participating employers may have their own standards with regard to the minimum GPA students must have to be considered for placements with their company. U.S. citizenship may be required for some positions.

3. Application procedure: Follow the detailed set of instructions in the above referenced *Co-op Student Handbook*.
4. Staff support (people to help you):
 - College Co-op Program Director
205 Hammond Bldg. (863-1032).
 - Engineering Science Co-op Coordinator:
Dr. Christine Masters
210 Earth-Engineering Sciences Building. (865-6674).

The Eight Steps

The *Co-op Student Handbook* lists the following eight steps (Understanding Cooperative Education, Participation in the Engineering Cooperative Education Program, Creating a Resume, Job Searching with the Co-op Office, the Interview Process, Selecting and Accepting a Position, Preparing to Go on Co-op, and Returning from Your Co-op Assignment) that must be understood and followed in order for the co-op experience to be successful. It is the responsibility of every co-op student to know and abide by these regulations. These steps also discuss some very basic concerns of students such as canceling dorm contracts, financial aid, and registering for the next semester while on co-op assignment.

After Each Segment of the Work Experience

Evaluation and Reporting: Near the end of each work experience, a Students Evaluation of Employer and Co-op Program form must be completed and submitted to the Co-op office. Furthermore, a term report on the work experience must be prepared. Grades for ENGR 295, 395, and 495 are based on these reports and the grades will be automatically deferred until the semester following that in which these courses are taken. In order to convert the deferred grade to a Pass/Fail grade, a student must submit a written report on his or her work assignment. *The report is due on the Thursday of the last week of classes of any semester that you are on co-op assignment.* However, if you do two consecutive work assignments without a semester of classes in between, you must submit a report covering the time period corre-

sponding to the first semester, at the end of that semester, and then a second report at the end of the second semester.

Curricula and Summer Courses

Curricula: Sample curricula for earning the 70 credits associated with the junior and senior years are shown on the next page. Students can follow either Curriculum A, for which the first work experience will occur in the summer preceding the junior year, Curriculum B, for which the first work experience will occur in the fall semester of the junior year, or Curriculum C, for which the first work experience will occur in the spring of the junior year. If none of these sample curricula are applicable for your situation, meet with the Undergraduate Coordinator to develop an individualized curriculum.

Summer session: Students are encouraged to schedule as many summer credits as possible in courses offered by the College of Engineering. A preliminary list of courses that will be offered the next summer, which will serve to satisfy course work required for the major or technical electives, will be made available late in the fall semester. Final listings, for both the College of Engineering and for the other colleges, are published in the *Summer Schedule of Courses* and on the website at: <http://elion.oas.psu.edu>.

Academic Credit

If a student completes all three co-op work experiences (ENGR 295, 395, and 495), and only if all three are completed, three academic credits will be granted which may be used to replace one of the four technical selections in the senior year. These three credits will be considered to be in the engineering design category.

CO-OP
ENGINEERING SCIENCE

	Freshman and Sophomore Years	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall (Last Semester)
<i>Curriculum A</i>	IDENTICAL	WORK	E SC 407H 3 ME 120 4 EE 210H 4 E SC 414M 4 PHYS 237 3 <u>17</u>	WORK	AHS 3 ENGL 202C 3 HL/PH ACT 3 <u>9</u>	ENGR 495	AERSP 308 3 E SC 400H 3 EE 340 3 BUN E 307 3 or I E 424 3 E MCH 416H 3 or E SC 314 3 AHS 3 <u>18</u>	E SC 410H 3 TE 3 TE (ENGR 295,395,495) 3 E SC 411H 4 TECH LAB 1 <u>17</u>	AHS 3 E SC 404H 3 TE 3 TE 3 TE (ENGR 295,395,495) 3 E SC 411H 4 TECH LAB 1 <u>17</u>
		ENGR 295	ENGR 295	ENGR 395	ENGR 395	ENGR 495	ENGR 495	ENGR 495	ENGR 495
<i>Curriculum B</i>	CURRENT	EE 210H 3 ENGL 202C 3 AHS 3 <u>9</u>	WORK	AERSP 308 3 E SC 400H 3 EE 340 3 BUN E 307 3 or I E 424 3 E MCH 416H 3 or E SC 314 3 AHS 3 <u>18</u>	WORK	E SC 407H 3 ME 120 4 E SC 414M 3 PHYS 237 3 HL/PH ACT 3 <u>17</u>	WORK	TE 3 TE 3 E SC 410H 3 9 295,395,495) 3 E SC 411H 4 TECH LAB 1 <u>17</u>	AHS 3 E SC 404H 3 TE 3 TE 3 TE (ENGR 295,395,495) 3 E SC 411H 4 TECH LAB 1 <u>17</u>
		ENGR 295	ENGR 295	ENGR 295	ENGR 395	ENGR 395	ENGR 395	ENGR 495	ENGR 495
<i>Curriculum C</i>	PROGRAMS	ENGL 202C 3 AHS 3 AHS 3 <u>9</u>	WORK	ENGR 295	AHS 3 TE 3 HL/PH ACT 3 <u>9</u>	ENGR 395	AERSP 308 3 E SC 400H 3 EE 340 3 BUN E 307 3 or I E 424 3 E MCH 416H 3 or E SC 314 3 E SC 410h 3 <u>18</u>	WORK	E SC 404H 3 TE 3 TE 3 TE (ENGR 295,395,495) 3 E SC 411H 4 TECH LAB 1 <u>17</u>
		ENGR 295	ENGR 295	ENGR 295	ENGR 395	ENGR 395	ENGR 395	ENGR 495	ENGR 495

APPENDIX B: Engineering Science and Mechanics Integrated Undergraduate/ Graduate Study

Introduction

Engineering Science students, because of the flexibility of the curriculum, have a unique opportunity to take advantage of one of two Integrated Undergraduate Graduate (IUG) programs; one administered by the Engineering Science and Mechanics Department and the other administered by the Schreyer Honors College. Application for IUG status may be made in the fourth, fifth, or sixth semester.

IUG status permits students to take on the rigors and research challenges of graduate study at Penn State, coordinating and combining them with their baccalaureate studies. Because some credits earned as an undergraduate may be applied to both degree programs, the time required for completion of integrated undergraduate/graduate studies is normally less than that required to complete separate degree programs. The actual time required is determined by the individual student's objectives and needs. In no case, however, should the acceleration of work in the major be at the expense of the richest possible undergraduate experience; there must be a balance between the accelerated specialization and a sound general education.

The advantages of Integrated Undergraduate/Graduate Status are several: (1) It permits coherent planning of studies through the graduate degree, with advising informed by not only the requirements of the baccalaureate program, but also the longer-range goals of the graduate degree. (2) For most students, the total time required to reach completion of the higher degree will be shortened. (3) The student will have earlier contact with the rigors of graduate study (in some cases substituting graduate courses for undergraduate requirements) and with graduate faculty; the resources of the Graduate School are accessible to IUG students. (4) While still undergraduates,

students with IUG status benefit from their association with graduate students whose level of work and whose intensity of interest and commitment parallel their own.

IUG arrangements have been designed for the truly extraordinary among Schreyer Scholars: those who have exceptional academic records; whose progress in the major is so advanced that they would be taking graduate courses in later semesters even without IUG status; whose general education progress and plans indicate a readiness to forge ahead with specialization; and who are ready, indeed eager, for that particular challenge of graduate work, advancing knowledge. Schreyer Scholars who believe they are among such students are encouraged to apply for Integrated Undergraduate/Graduate status.

ESM IUG Application Procedures and Guidelines

1. IUG proposals may be filed by Engineering Science students holding at least fifth semester standing with a GPA of 3.4 or better.
2. The application for IUG status consists of the following materials, all of which should be submitted to the ESM IUG Selection Committee through the ESM Undergraduate Officer in 212 EES Building.
 - a) A nomination from the head or graduate officer of the ESM department.
 - b) A personal statement that summarizes the student's academic progress, outlines long-term goals, states the proposed use of IUG status, and addresses in moderate detail the research area that will constitute the focus of the graduate degree.
 - c) An explicit plan of study leading to the graduate degree (form available in the ESM departmental office) signed by the Honors adviser. NOTE: As many as 12 of the credits required for the master's degree may be applied to both undergraduate and graduate degree programs. A minimum of 50 percent of the courses proposed to count for both degrees must be at the 500 level. Thesis credits may not be double counted.
 - d) Three faculty recommendations including one from the Honors adviser and one from the prospective research mentor for the master's program or a faculty member expert in the proposed area of graduate

research concentration. The latter must address the details of the proposed area of research focus and assess the student's ability to conclude the program.

e) A transcript.

f) A completed Graduate School application form. GRE scores need not be submitted.

When all materials have been submitted, the applicant should schedule an interview with the ESM Undergraduate and Graduate Officers to discuss her or his IUG proposal.

After this interview, an evaluation of the application is made by the ESM IUG Advisory committee. The committee will look for (a) an undergraduate record which is superior, even among Engineering Science students; (b) evidence of accelerated progress in the major toward graduate study; (c) an indication of how the student compares with other applicants for graduate study and with other Engineering Science students; (d) a plan of study consistent with the requirements and spirit of the program; and (e) strong recommendations that comment incisively on the aforementioned criteria.

3. Applicants are notified of the action of the committee. If the application has been approved by the ESM IUG Committee, it is sent to the Graduate School for approval. The Graduate School application fee must be sent along with the application.

4. When a candidate has been approved for IUG status by both the Engineering Science Department and the Graduate School, he or she will receive a letter of notification from the director of graduate admissions.

5. At the end of each semester, a student with IUG status must report to the ESM Undergraduate Officer which courses taken that semester are to be counted both toward the graduate and undergraduate degrees or toward the graduate degree alone. A form for such reporting is available in 212 EES Building.

6. Undergraduate tuition rates will apply as long as the student is an undergraduate, unless the student receives financial support, such as an assistantship, requiring the payment of graduate tuition.

7. A student may retain IUG status for as long as he or she maintains a GPA of 3.2 or better. If the GPA falls below 3.2, the ESM Under-

graduate Officer and the ESM Graduate Officer shall jointly review the student's performance to ascertain if the student could be allowed the probationary period of a semester to meet or exceed the 3.20 GPA requirement, in light of extenuating circumstances. If IUG status is terminated, the provisions of item 2(c), above, relative to 12 credits being applicable to both an undergraduate and graduate degree program, cease to apply. Termination of the IUG status would require the student to fulfill all regular requirements of the M.S. degree program in order to obtain that degree

8. An appropriate notation of participation in the Integrated Undergraduate Graduate program will be made on the student's transcript.

9. Undergraduate tuition rates will apply as long as the student is an undergraduate, unless the student receives financial support, for example, an assistantship requiring the payment of graduate tuition.

SHC IUG Application Procedures and Guidelines

1. IUG proposals may be filed by Engineering Science students holding fourth, fifth, or sixth semester standing. Students in their senior year are ineligible to apply.
2. The application for IUG status consists of the following materials, all of which should be sent to the Schreyer Honors College, 10 Schreyer Honors College (Atherton Hall).
 - A nomination from the head or graduate officer of the major department (one from the head of the undergraduate department and one from the head or graduate officer of the graduate program if the undergraduate and graduate programs are different).
 - personal statement that summarizes the student's academic progress, outlines long-term goals, states the proposed use of IUG status, and addresses in moderate detail the research area that will constitute the focus of the graduate degree.
 - An explicit plan of study leading to the graduate degree (form available in the Schreyer Honors College) signed by the Honors adviser. NOTE: As many as 12 of the credits required for the master's degree may be applied to both undergraduate and graduate degree programs. A minimum of 50 percent of the courses

proposed to count for both degrees must be at the 500 level. Thesis credits may not be double counted.

- Three faculty recommendations including one from the Honors adviser and one from the prospective research mentor for the master's program or a faculty member expert in the proposed area of graduate research concentration. The latter must address the details of the proposed area of research focus and assess the student's ability to conclude the program.
- A transcript.
- A completed Graduate School application form. GRE scores need not be submitted, unless required by a particular graduate program.

When all materials have been submitted, the applicant should schedule an interview with the program director to discuss her or his IUG proposal.

After this interview, an evaluation of the application is made by the faculty advisory committee of the Schreyer Honors College. The committee will look for (a) an undergraduate record which is superior, even among Schreyer Scholars; (b) evidence of accelerated progress in the major toward graduate study; (c) an indication of how the student compares with other applicants for graduate study and with other Schreyer Scholars in the Department; (d) a plan of study consistent with the requirements and spirit of the program; and (e) strong recommendations that comment incisively on the aforementioned criteria.

3. Applicants are notified of the action of the committee. If the application has been approved by the Schreyer Honors College, it is sent to the Graduate School for approval. The Graduate School application fee must be sent along with the application.
4. When a candidate has been approved for IUG status by both the Schreyer Honors College and the Graduate School, he or she will receive a letter of notification from the director of graduate admissions.

5. At the end of each semester, a student with IUG status must report to the Schreyer Honors College office which courses taken that semester are to be counted both toward the graduate and undergraduate degrees or toward the graduate degree alone. A form for such reporting is available in the Schreyer Honors College office.
6. Undergraduate tuition rates will apply as long as the student is an undergraduate, unless the student receives financial support, such as an assistantship, requiring the payment of graduate tuition.
7. A student may retain IUG status for as long as he or she remains in the Schreyer Honors College. If IUG status is terminated, the provisions of item 2 above, relative to 12 credits being applicable to both an undergraduate and graduate degree program, cease to apply.
8. An appropriate notation of participation in the Integrated Undergraduate Graduate program will be made on the student's transcript.

APPENDIX C: Minor in Engineering Mechanics

Engineering Mechanics is the engineering science that deals with the effects of loads and environments on particles, or deformable media. It is typically subdivided into **statics**, or **dynamics of rigid bodies** and **mechanics of deformable bodies**.

Statics considers the algebra of vectors, equilibrium, equivalency of force-torque systems, and the concept of the freebody diagram. Special topics include friction, machines, and trusses.

Dynamics treats the motion resulting from unequilibrated force/torque systems through the study of acceleration, velocity, and displacement. An important special topic is simple harmonic motion, caused by a restoring force linearly dependent on displacement—this topic is the foundation of vibrations. Newton's laws and energy principles form the basis of dynamics.

Mechanics of deformable materials covers the internal distribution of force per unit area (stress), local normalized deformation (strain), and material response (strain, strain rate) to stress and temperature. Failure criteria are introduced, as in design. Because the determination of the stress distribution in most engineering components is complex, specialized topics include:

- Strength of Materials: Stretching, bending, twisting of long elastic bodies, Hooke's law, yielding, failure, and design.
- Engineering Materials: Characterization of material properties, deformation mechanisms, and failure criteria.
- Computer Methods/Finite Element Methods
- Experimental Stress Analysis
- Nondestructive Evaluation (NDE)
- Failure Analysis and Prevention

- Composite Materials: Multiple component materials.
- Elasticity: Stress/strain in three-dimensional elastic bodies.
- Viscoelasticity: Stress proportional to strain and strain rate.

The Engineering Science and Mechanics Department offers more than twenty engineering mechanics courses at a level appropriate to an undergraduate minor.

Career Opportunities

Contemporary engineering design of mechanical components requires precise information and modern analysis techniques regarding material response to anticipated loads. Designers must have the analytical and experimental tools to precisely define deformation under load and to characterize dynamic responses as well as prevent mechanical failure. In the event of failure the cause(s) must be ascertained with a view toward redesign and/or material substitution. Thus, high-tech industry has a significant need for those with a sound background in Engineering Mechanics. The aerospace, automotive, power, structures, and appliance industries, for example, hire students competent in Engineering Mechanics.

Program Requirements

Students must:

- Complete at least 18 credits in Penn State Engineering Mechanics courses;
- Take a minimum of 6 credits at the 400-level, and
- Achieve grade of C or better in each E MCH course counted toward 18-credit minimum.
- Students majoring in Engineering Science may apply the three credits of E SC 407H toward the E MCH minor as this course is deemed to cover the E MCH type material of E MCH 407.

Admission Requirements

Applicants wishing to enroll in the Engineering Mechanics Minor should have completed a background course in mathematics (MATH 250 or 251) and physics (PHYS 211), present an acceptable schedule for completion of requirements, and have a 2.50 grade-point average at the time of application. Application forms may be obtained from the Engineering Science Assistant for Undergraduate Student Affairs (Kathleen Zimmerman, 212 Earth-Engineering Sciences Building, 865-4523) on the web at: http://www.psu.edu/registrar/forms_for_students/entrancetominor.pdf.

For more information about the undergraduate Engineering Mechanics Minor, contact:

undergradofficer@mail.psu.edu
Room 212 Earth-Engineering Sciences Building
University Park, PA 16802

APPENDIX D: Guidelines for Thesis Preparation and Submittal

1. Prepare an outline of the thesis and clear it with your supervisor prior to attempting a first draft. Please refer, for example, to J. Schall's book *Style for Students' Effective Writing in Science and Engineering*, Burgess Pub. (1995), pp. 23-28.
2. The regulations will be the same as the Schreyer's Honors College. They can be seen on the web at:
<http://www.shc.psu.edu/thesis/writing.htm>.

APPENDIX E: Undergraduate Checksheet

See next page for E SC graduation checksheet.

DEPARTMENT OF ENGINEERING SCIENCE AND MECHANICS (August 2004)

STUDENT NAME: _____

ADVISER: _____

First Semester

	Cr	Sem
MATH 140	4	_____
CHEM 12	3	_____
ED&G 100	3	_____
ECON 2/4/14	3	_____
ENGL 30/15	3	_____
_____	_____	_____
_____	_____	_____
	16	

Second Semester

	Cr	Sem
MATH 141	4	_____
CHEM13	3	_____
CHEM 14	1	_____
E SC 261 M or	_____	_____
CMPSC 201	3	_____
PHYS 211	4	_____
FIRST-YEAR SEMINAR	1	_____
_____	_____	_____
	16	

AHS REQUIREMENTS

Arts (6 cr) † _____

Human (6 cr) † _____

Soc. & Behav. Sci (6 cr) † _____

† Student may develop 9-6-3

Third Semester

	Cr	Sem
MATH 230	4	_____
sequence	_____	_____
MATH 220	2	_____
PHYS 212	4	_____
E MCH 110H/210 ^c	5	_____
AHS	3	_____
_____	_____	_____
	18	

Fourth Semester

	Cr	Sem
MATH 251	4	_____
PHYS 213	2	_____
PHYS 214	2	_____
E MCH 112H/12 ^c	3	_____
AHS	3	_____
SPCOM 100A/B	3	_____
_____	_____	_____
	17	

INTERCUL/INTL REQMT.

Fifth Semester

	Cr	Sem
OTHER	_____	_____
E SC 407H ^c	3	_____
M E 120	4	_____
E E 210H	4	_____
_____	_____	_____
E SC 414M ^c	3	_____
PHYS 237	3	_____
_____	_____	_____
	17	

Sixth Semester

	Cr	Sem
AERSP 308	3	_____
E SC 400H	3	_____
E E 340	3	_____
_____	_____	_____
NUC E 307 or	_____	_____
I E 424	3	_____
AHS	3	_____
E MCH 416H or	_____	_____
_____	_____	_____
E SC 314	3	_____
_____	_____	_____
	18	

TECHNICAL SELECTIONS*

ENGR	ENGR
DESIGN	SCIENCE
(2 credits min.**)	(3 credits min.)
_____	_____
_____	_____
_____	_____

*A minimum of six credits of the technical
be courses in the College of Engineering

two of those must be designated as

**Three for students who have not taken ED&G

selections must

and a minimum of
Seventh Semester
engineering design.

Eighth Semester

	Cr	Sem
E SC 410H	3	_____
E SC 404H ^c	3	_____
ENGL 202C	3	_____
TECH SEL	3	_____
TECH SEL	3	_____
HL/PH ACT	3	_____
_____	_____	_____
	18	

	Cr	Sem
E SC 411H	4	_____
AHS	3	_____
AHS	3	_____
TECH SEL	3	_____
TECH SEL	3	_____
TECH LAB	1	_____
_____	_____	_____
	17	

Co-op CREDITS

ROTC CREDITS (If applicable)

Total Number of Credits - 137

EXTRA CREDITS

^cCourses in which a minimum grade of C is required
for graduation.

NOTE: E SC 414M (or E SC 261M) fulfills the
Writing Across the Curriculum requirement.

Thesis Title _____

The baccalaureate program in Engineering Science and Mechanics is accredited by the
Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology
111 Market Place
Baltimore, MD 21202-4012
410.347.7000

