

## Mechanical and Materials Engineering

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### Mechanical and Materials Engineering Department Mission Statement

The Mechanical and Materials Engineering Department at Florida International University (FIU) offers a curriculum designed to give the student a thorough understanding of the basic laws of science and simultaneously to stimulate and develop creative thinking, a professional attitude, economic judgement and environmental consciousness. The aim is to develop the student's potential to the fullest, to prepare the student for superior performance as a mechanical engineer, and to provide the student with the fundamental principles necessary for pursuing advanced study in the diverse fields of engineering, science and business.

A graduate of the Mechanical Engineering program should possess

the following, which are also established as the Mechanical Engineering Program Educational Objectives:

1. Broad and in-depth knowledge of engineering science and principles in the following four major branches of Mechanical Engineering: Fluids/Thermal Sciences and Energy Systems, Mechanics and Materials, Design and Manufacturing, and Biomechanics and Biomedical Engineering for effective engineering practice, professional growth and as a base for lifelong learning
2. Hands-on experience with state-of-the-art instruments and laboratory techniques to bridge classroom learning with practical "real-life" problems.
3. The ability to utilize analytical and experimental methods and modern computer technology for decision making, engineering design, and to solve realistic engineering problems.
4. The ability to work effectively with others in a team while simultaneously maintaining independent and creative thought.
5. The ability to articulate technical matters using verbal, written and graphic techniques.
6. An adequate background to pursue graduate studies in engineering and other fields.
7. A sense of professional and social responsibility, including a commitment to protect both occupational and public health and safety, developed through consideration of moral, social, and ethical paradigms related to the engineering profession and practice.

The Program Outcomes listed below have been established based on the Mechanical Engineering Program Educational Objectives and are expected to be met for all graduates receiving the BSME degree. These objectives were established following the requirement set forth in the EC 2000 Engineering Criterion 3. These outcomes are defined as follows:

- a. Ability to apply knowledge of mathematics, science, and engineering,
- b. Ability to design and conduct experiments, as well as to analyze and interpret data,

- c. Ability to design a system, component, or process to meet desired needs,
- d. Ability to function on multidisciplinary teams;
- e. Ability to identify, formulate, and solve engineering problems,
- f. Understanding of professional and ethical responsibility;
- g. Ability to communicate effectively;
- h. Broad education necessary to understand the impact of engineering solutions in a global and societal context;
- i. Recognition of the need for, and an ability to engage in, life long learning;
- j. Knowledge of contemporary issues;
- k. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice;
- l. Knowledge of probability and statistics, including applications to mechanical engineering;
- m. Knowledge of mathematics and basic and engineering science necessary to carry out analysis and design appropriate to mechanical engineering; and the
- n. Ability to apply advanced mathematics through multivariable calculus and differential equations.

Based on the goals set above the academic program provides a well-balanced curriculum in the following three major areas of Mechanical Engineering:

Fluid/Thermal Science  
Mechanics and Materials  
Design and Manufacturing

Further specializations in any of the following areas may be obtained by the proper choice of electives:

Environmental and Waste  
Management  
Energy Systems  
Heating, Ventilation, and Air  
Conditioning  
Mechanics and Material Sciences  
Biomechanics and Bioengineering  
Manufacturing  
Robotics  
Design  
Computer-Aided Engineering

The courses in the Manufacturing Methods area and Robotics are offered by both the Mechanical and the Industrial Engineering Departments. Biomechanics and Biomedical

Engineering are interdisciplinary studies with courses offered by both the Mechanical and Electrical and Computer Engineering Departments. The courses in the Environmental and Waste Management area are offered by the Mechanical and Civil Engineering Departments.

A Bachelor's degree in Mechanical Engineering provides students with the background suitable for immediate employment in engineering industries, as well as excellent preparation for graduate studies in Engineering, Medicine, Law, or Business Administration.

### Bachelor of Science in Mechanical Engineering

#### Common Prerequisites

CHM 1045	General Chemistry I
CHM 1045L	General Chemistry Lab I
MAC 2311	Calculus I
MAC 2312	Calculus II
MAC 2313	Multivariable Calculus
MAP 2302	Differential Equations
EGM 3311	Analysis of Engineering Systems
PHY 2048	Physics with Calculus I
PHY 2048L	General Physics Lab I
PHY 2049	Physics with Calculus II
PHY 2049L	General Physics Lab II

#### Degree Program Hours: 128

The qualifications for admissions to the Department of Mechanical and Materials Engineering are the same as for admission to the School of Engineering.

The academic program is designed to satisfy the criteria outlined by the Accreditation Board for Engineering and Technology (ABET), as well as to meet the State of Florida's articulation policy. Entering freshmen at FIU should seek advisement from the Undergraduate Studies Office as well as from the Mechanical and Materials Engineering Department's office of advisement.

#### Lower Division Preparation

Lower division requirements include at least 60 hours of pre-engineering credits (see the Undergraduate Studies portion of this catalog for specific requirements). These courses include Software for Mechanical Design, Calculus I, II, III, Differential Equations, Analysis of Engineering Systems, Chemistry I and Lab, Calculus based Physics I & II and labs, 2 semesters of English and 2 other Gordon rule writing courses. (Engineering Graphics or CAD is a required prerequisite

unless previously taken in high school). A minimum grade of a "C" is required in all writing courses, all calculus courses, Differential Equations, Analysis of Engineering Systems both Physics classes and Chemistry. In addition, both transfer students and FIU Freshman must take a combination of social sciences and humanities that fulfill the state general education requirements, the FIU University Core Curriculum Requirements, and whose topics also complement the goals and objectives of the College of Engineering (including economic, environmental, political, and/or social issues. See semester-by-semester sample program for courses that fulfill this requirement). Students must make up any missing prerequisites before they will be allowed to begin taking certain engineering courses (see course listing for required pre/co-requisites).

#### Other Requirements

Students must meet the University Foreign Language Requirement. Students must pass the CLAST or have it waived. Students who enter the university with fewer than 36 semester hours must satisfy a summer residency requirement by taking a minimum of 9 credit hours during the summer semester while at FIU. Students must meet all of the state and university requirements in order to graduate.

The minimum requirements for graduation in Mechanical Engineering consist of two parts: 1) Mathematics, Basic Sciences, Humanities and Social Science requirements, and 2) Engineering Sciences, Engineering Design, Laboratory and Elective requirements.

### Mechanical Engineering Curriculum

Engineering Science, Engineering Design, Laboratory and Elective semester credit hour requirements:

EGN 1100	Introduction to Engineering	2
EML 2030	Software for Mechanical Design	3
EGN 3311	Statics <sup>1</sup>	3
EGN 3321	Dynamics <sup>1</sup>	3
EGN 3365	Materials in Engineering <sup>1</sup>	3
EMA 3702	Mechanics and Material Science <sup>1</sup>	3
EMA 3702L	Mechanics and Materials Science Lab	1
EML 3126	Transport Phenomena <sup>1</sup>	3

EML 3126L	Transport Phenomena Lab	1
EGN 3343	Thermodynamics I <sup>1</sup>	3
EML 3101	Thermodynamics II	3
EML 3262	Kinematics & Mechanism Design	3
EML 4220	Mechanical Vibrations	3
EIN 3354	Engineering Economy	3
EML 4312	Automatic Control Theory	3
EML 4140	Heat Transfer	3
EIN 3390	Manufacturing Processes	2
EIN 3390L	Manufacturing Processes Lab	1
EEL 3003	Electrical Engineering I <sup>1</sup>	3
EEL 3111L	Circuits Lab	1
EML 3301L	Instrumentation & Measurement Lab	1
EML 4906L	Mechanical Lab I	1
EML 3500	Mechanical Design I	3
EML 4501	Mechanical Design II	3
EML 4706	Design of Thermal and Fluid Systems	3
EML 4551	Design Project Organization <sup>2</sup>	1
EML 4905	Senior Design Project <sup>2</sup>	3
	Design Elective <sup>3</sup>	3
	Engineering Electives	8
	Math/Statistics Elective <sup>4</sup>	3

<sup>1</sup>These courses are four contact hours to include a one-hour non-credit tutorial.

<sup>2</sup>The Senior Design Project is taken in two consecutive semesters during the senior year. During the first semester of his/her senior year, the student must register for EML 4551 Design Project Organization. The senior project begins during this course. The next semester the student must register for EML 4905 to complete the project.

<sup>3</sup>Approved Design Electives:

EGM 4350	Finite Element Analysis in Mechanical Design	3
EML 4503	Production Machine Modeling and Design	3
EML 4525	Mechanical Design Synthesis and Analysis	3
EML 4535	Mechanical Computer Aided Design	3
EML 4561	Introduction to Electronic Packaging	3
EML 4585	Design of Biomedical Systems and Devices	3
EML 4603	Air Conditioning Design	3
EML 5509	Mechanical Design Optimization	3
EML 5519	Fault-Tolerant System Design	3
EIN 4395	Computer Integrated Manufacturing	3

<sup>4</sup>Approved Math/Statistics Electives:

EIN 3235	Evaluation of Engineering Data	3
STA 3033	Introduction to Probability and Statistics for CS	3
EEL 3135	Signals and Systems	3
MAS 3135	Linear Algebra	3
MAP 4401	Advanced Differential Equations	3

Students must maintain and achieve a grade point average of 2.0 or better in those engineering courses to be used to satisfy BSME degree requirements. This "major GPA" is computed in the manner of the overall GPA. Courses that are excluded from the calculation of the overall GPA will also be excluded from the calculation of the major GPA. Students failing to maintain a major GPA of 2.0 will be placed on major GPA probation, suspension, or dismissed from the program according to the same criteria that are utilized with the overall GPA.

Students who are dismissed for the first time from the University due to low grades may appeal to the Dean for reinstatement. A second dismissal results in no possibility of reinstatement.

**Laboratories**

Over and above the laboratory requirements in Physics and Chemistry, the program consists of six semester hours of required Engineering laboratory work. The students are assigned two hours of laboratory work (one hour in Instrumentation and Measurement Lab and one hour in Mechanical Lab) which are specifically devoted to solving design problems using experimental methods. The laboratory experience includes the following areas: Machining, Circuits, Fluid Mechanics, Mechanics of Materials and Materials Testing, Applications in Fluid and Thermal Science, and Instrumentation and Measurement.

The elective areas offer the following additional laboratories: Air Conditioning and Refrigeration, Biomedical Engineering, Material Sciences, Computer/Aided Design, and Computer/Integrated Manufacturing.

**Electives**

Four concentrations available within the Mechanical Engineering program with some of their elective offerings are listed below.

**Fluids/Thermal Sciences and Energy Systems**

EGM 4350	Finite Element Analysis in Mechanical Design	3
EML 3450	Energy Systems	3
EML 4419	Propulsion Systems	3
EML 4421	Internal Combustion Engines	3
EML 4525	Mechanical Design Synthesis and Analysis	3
EML 4601	Principles of Refrigerating and Air Conditioning	3
EML 4601L	Refrigeration and A/C Lab	1
EML 4603	Air Conditioning Design	3
EML 4608C	Mechanical Systems in Environmental Control	3
EML 4702	Fluid Dynamics	3
EML 4711	Gas Dynamics	3
EML 5103	Intermediate Thermodynamics	3
EML 5104	Classical Thermodynamics	3
EML 5152	Intermediate Heat Transfer	3
EML 5606C	Advanced Refrigeration and A/C Systems	3
EML 5615C	CAD in Air Conditioning	3
EML 5708	Advanced Design of Thermal and Fluid Systems	3
EML 5709	Intermediate Fluid Mechanics	3

**Mechanics, Materials and Design**

EGM 3311	Analysis of Mechanical Systems	3
EGM 4610	Introduction to Continuum Mechanics	3
EGM 4350	Finite Element Analysis in Mechanical Design	3
EGM 5315	Intermediate Analysis of Mechanical Systems	3
EGM 5615	Synthesis of Engineering Mechanics	3
EGN 5367	Industrial Materials and Engineering Design	3
EMA 3066	Polymer Science and Engineering	3
EMA 4121	Physical Metallurgy	3
EMA 4121L	Materials Laboratory	1
EMA 4223	Mechanical Metallurgy	3
EMA 5295	Principles of Composite Materials	3
EMA 5507C	Analytical Techniques of Material Sciences	3
EMA 5935	Advanced Topics in Materials Engineering	3
EML 3222	System Dynamics	3
EML 3301C	Instrumentation	3
EML 4260	Dynamics of Machinery	3

EML 4525	Mechanical Design Synthesis and Analysis	3
EML 4535	Mechanical Computer-Aided Design	3
EML 4561	Introduction to Electronic Packaging	3
EML 5125	Classical Dynamics	3
EML 5385	Identification Techniques of Mechanical Systems	3
EML 5530	Intermediate CAD/CAE	3
EML 5562	Advanced Electronic Packaging	3

**Biomechanics and Biomedical Engineering**

EEL 5071	Bioelectrical Models	3
EEL 5085	Bioradiation Engineering	3
EGM 4580	Principles of Bioengineering	3
EGM 4580L	Biomedical Engineering Lab	1
EGM 4581	Biomechanics of Cardiovascular Systems	3
EGM 4582	Engineering Hemodynamics	3
EGM 4583	Orthopaedic Biomechanics	3
ELR 4202C	Medical Instrumentation Design	4
EML 4585	Design of Biomedical Systems & Devices	3

**Manufacturing and Robotics**

EIN 3600	Introduction to Robotics	2
EIN 4391	Product Design for Manufacturing and Automation	3
EIN 4395	Computer-Integrated Manufacturing	3
EML 4535	Mechanical Computer-Aided Design	3
EML 4561	Introduction to Electronic Packaging	3
EML 4806	Modeling and Control of Robots	3
EML 5562	Advanced Electronic Packaging	3

Students are required to complete eleven credit hours of technical electives, three of which are approved design credits.

Students with special needs may take other elective courses (not listed above) with permission of the Mechanical Engineering Advisor. Students are not restricted to these four concentration areas but may choose courses, with the advisor's consent, that will form a coherent concentration area. Special topics may be counted as an elective.

**Areas of Specialization**

Air Conditioning and Refrigeration

Applied Mechanics  
 Bioengineering/Biomechanics  
 Computer-Aided Engineering  
 Computer-Integrated Manufacturing  
 and Design  
 Energy Systems  
 Environmental and Waste  
 Management  
 Finite Element Analysis  
 Fluid Mechanics  
 Heat Transfer  
 Material Sciences  
 Robotics  
 Thermal Science

In order to specialize in manufacturing, students need to collaborate with the faculty of the Industrial Engineering Department.

### Options in Mechanical Engineering

The following options are available:

#### Biomechanical/Biochemical Option

EIN 3235	Evaluation of Engineering Data	3
STA 3033	Probability and Statistics for Computer Science	3
EML 4585	Design of Biomedical Systems and Devices	3
EGM 4581	Biomechanics of Cardiovascular Systems	3
EGM 4582	Engineering Hemodynamics	3

#### Mechanical Engineering Program Requirements—Freshman to Senior

##### First Semester: (17)

MAC 2311	Calculus I	4
CHM 1045	General Chemistry I	3
CHM 1045L	General Chemistry I Lab	1
ENC 1101	Freshman Composition	3
MUH 2116	Evolution of Jazz	3
	<b>or</b>	
TPP 2100	Introduction to Acting	3
	<b>or</b>	
THE 2000	Theatre Appreciation	3
	<b>or</b>	
CRW 2001	Creative Writing	3
	<b>or</b>	
MUH 1011	Music Appreciation <sup>1</sup>	3
EGN 1100	Introduction to Engineering	2
SLS 1501	Freshman Experience Seminar	1

##### Second Semester: (18)

MAC 2312	Calculus II	4
PHY 2048	Physics I with Calculus	4
PHY 2048L	General Physics I Lab	1
ENC 1102	Literary Analysis	3
EGN 3365	Materials in Eng	3
EGN 1xxx	Technology, Humans and Society	3

##### Third Semester: (18)

MAC 2313	Multivariable Calculus	4
PHY 2049	Physics with Calculus II	4
PHY 2049L	General Physics II Lab	1
EGN 3311	Statics	3
EGM 3311	Analysis of Engineering Systems	3
	Humanities with Writing*	3

##### Fourth Semester: (15)

EML 2030	Software for Mechanical Design	3
MAP 2302	Differential Equations	3
EGN 3321	Dynamics	3
EGN 3343	Thermodynamics I	3
	Humanities and Writing*	3

##### Fifth Semester: (18)

EMA 3702	Mechanics and Materials Science	3
EMA 3702L	Mechanics and Materials Science Lab	1
EML 3101	Thermodynamics II	3
EML 3126	Transport Phenomena	3
EML 3126L	Transport Phenomena Lab	1
EIN 3390	Manufacturing Processes	2
EIN 3390L	Manufacturing Processes Lab	1
EEL 3003	Electrical Engineering I	3
EEL 3111L	Circuits Lab	1

##### Sixth Semester: (16)

EML 4140	Heat Transfer	3
EML 3500	Mechanical Design I	3
EML 3262	Kinematics and Mechanisms Design	3
EML 3301L	Instrumentation and Measurement Lab	1
EIN 3354	Engineering Economy	3
INP 2002	Introductory Industrial/Organization	3
	<b>or</b>	
ECO 2023	Principles of Microeconomics	3
	<b>or</b>	
ECO 2013	Principles of Macroeconomics	3
	<b>or</b>	
SYG 2010	Social Problems	3
	<b>or</b>	
GEO 2000	Introduction to Geography	3
	<b>or</b>	
INR 2002	Dynamics of World Politics	3

##### Seventh Semester: (13)

EML 4501	Mechanical Design II	3
EML 4706	Design of Thermal and Fluid Systems	3
EML 4220	Mechanical Vibrations	3
EML 4551	Design Project	

Organization	1
Engineering Elective	3

##### Eighth Semester: (13)

EML 4312	Automatic Control Theory	3
EML 4906L	Mechanical Lab	1
EML 4905	Senior Design Project	3
	Design Elective	3
	Engineering Elective	3
	*Humanities with Writing: Choose from the following list:	
PHI 2600	Introduction to Ethics	3
ARC 2701	History of Architecture	3
HUM 3306	History of Ideas	3
WOH 2001	World Civilization	3
EUH 2030	Western Civilization-Europe in the Modern Era	3
AMH 2002	Modern American Civilization	3

### Combined BSME/MSME Program

Students who have completed a minimum of 90 credit hours toward their BSME degree and have earned at least a 3.25 GPA may apply to the department to enroll in the combined BSME/MSME program. Acceptance to the program requires the approval of the undergraduate advisor and two mechanical engineering faculty members.

The BSME/MSME (3 +2) Program has been designed to be a continuous program. Students in 3 + 2 programs will apply for graduation with the BS and MS at the same time. Students will receive a BS degree and a MS degree on the same date, after requirements for both are completed. The student's advisor will ensure that appropriate forms are completed, and that students do not apply for BS degree graduation until both BS and MS requirements are finished. Upon the completion of BS degree requirements, students can elect to permanently leave the combined program at any time and earn only the BS degree. Once the BS is granted, students will have the same access requirements to regular graduate programs as any other student. However, the combined MS degree would not be available to those who elect to leave the combined program.

Students enrolled in the program may count up to 6 credit hours of ME graduate courses toward the elective engineering BSME requirements as well as toward the MSME degree. Only graduate lecture courses can be counted for both degrees.

Admission to the combined BSME/MSME program by the department does not automatically qualify students for admission to the MSME degree program. To enroll in the MSME degree program, students must meet the graduate admission requirements.

### Professional Certificate Program

#### Heating, Ventilating and Air Conditioning Design

**Yong X. Tao, Associate Professor and Coordinator**

This Professional Certificate Program provides both traditional students and practicing professionals with a learning experience that enhances their design capabilities in the HVAC field. The program focuses on both basic engineering science and practical applications of system design. Interested applicants must contact the department chairperson or the coordinator prior to registering for the program.

The Certificate will be awarded to a student who successfully demonstrates competency in:

EGN 3343	Thermodynamics I	3
EIN 3354	Engineering Economy	3
EML 4601	Principles of Refrigerating and Air Conditioning	3
EML 4603	Air Conditioning Design	3
EML 4608C	Mechanical Systems in Environmental Control	3

Some of these courses may require additional prerequisites or permission of the program coordinator.

### Course Descriptions

#### Definition of Prefixes

EAS – Engineering; Aerospace  
 ECH – Engineering; Chemical  
 EGM - Engineering Mechanics;  
 EGN - Engineering; General;  
 EMA - Engineering; Materials;  
 EML - Engineering; Mechanical

**EAS 4105 Introduction to Flight Mechanics (3).** An introductory level course on the fundamentals of aerospace engineering with emphasis on aerodynamics and airplane performance. Prerequisite: EML 3126.

**ECH 3704 Principles of Industrial Electrochemistry (3).** This course provides a discussion of the basic principles underlying various electrochemical processes. The

emphasis is on theoretical principles involved in plating, refining, winning; aqueous and fused salts, primary, secondary and fuel cells. Prerequisite: CHM 3411.

**ECH 4706 Engineering Application of Electrochemistry (3).** The application of the electrochemical engineering principles to the analysis of industrial processes. Emphasis is placed on electrolysis in aqueous solutions and in fused salts; electrodeposition, electrowinning, and refining; electrochemical power systems. Prerequisite: ECH 3704.

**ECH 4826 Corrosion Control (3).** Various forms of corrosion, including pitting, stress, crevice, galvanic and microbial induced corrosion, are presented. The problems of material selection, failure analyses and corrosion control are discussed. Prerequisites: EGN 3365 and CHM 3411

**EGM 3311 Analysis of Engineering Systems (3).** Statistics and probability analysis of materials and fluids experiments, structural and fluid system modeling and analysis using lumped parameters; numerical methods to find solutions. Prerequisite: MAC 2312.

**EGM 3503 Applied Mechanics (3).** Statics and dynamics of solids and fluids. Science of engineering materials. Open to non-mechanical engineering students only. Prerequisite: Permission of the instructor.

**EGM 4350 Finite Element Analysis in Mechanical Engineering (3).** Finite Element Analysis is developed as a means to determine stress and deformation levels as well as temperature and heat flux levels in solids. Application by means of commercial software. Prerequisites: CGS 2420 or CGS 2423, EML 4140 and EMA 3702.

**EGM 4521C Material Science I (3).** Course provides a more in-depth understanding of principles that determine material properties. Topics include structure, effects of thermodynamics, phase and kinetics on microstructural development. Prerequisite: EGN 3365.

**EGM 4522C Materials Science II (3).** Mechanical properties of materials, including strengthening plasticity and fracture. Introduction into ceramic and polymer materials systems. Prerequisite: EGN 3365.

**EGM 4580 Principles of Bioengineering (3).** Medical instrumentation and design, regulations for medical devices, application of computers in medicine, biomaterials, biocommunications, artificial implants; clinical engineering. Prerequisite: Permission of the instructor.

**EGM 4580L Biomedical Engineering Lab (1).** Introduction to the principles of biological signal measurements, biological data acquisition and image processing. Prerequisite: Permission of the instructor.

**EGM 4581 Biomechanics of Cardiovascular Systems (3).** Functional cardiovascular physiology and anatomy; analysis and computation of cardiovascular flow; constitutive properties of tissue; coronary and systemic circulation; flow and stress considerations in cardiovascular assist devices. Prerequisites: EMA 3702 and EML 3126.

**EGM 4582 Engineering Hemodynamics (3).** Fluid Mechanics of the circulatory system, rheology of blood, lubrication mechanics. Prerequisites: EML 3126 and EML 3126L.

**EGM 4583 Orthopaedic Biomechanics (3).** Introduction to the fundamentals of human musculo-skeletal physiology and anatomy and computation of mechanical forces as it applies to orthopaedic biomechanics. Prerequisites: EGN 3321 and EMA 3702.

**EGM 4610 Introduction to Continuum Mechanics (3).** Introduction to modern continuum mechanics, mathematical preliminaries, stress and equilibrium, deformations and compatibility, constitutive equations, balance laws, problem solution strategies. Prerequisite: EMA 3702

**EGM 5315 Intermediate Analysis of Mechanical Systems (3).** First course at the graduate level in the analysis of mechanical systems. Modeling of the system and analytical and numerical methods of solution of the governing equations will be studied. Fluid and thermodynamic systems will be emphasized in this course. Prerequisites: EGM 3311, MAP 2302, or permission of the instructor.

**EGM 5346 Computational Engineering Analysis (3).** Application of computational methods to mechanical engineering problems of translational, rotational, control, thermal and fluid systems employing linear/nonlinear

system elements. Prerequisites: EML 2030 or CGS 2420 or CGS 2423, MAP 2302 or EGM 3311, and EML 3222, or permission of the instructor.

**EGM 5354 Finite Element Method Applications in Mechanical Engineering (3).** Utilize the finite element method to solve problems in heat transfer, fluid dynamics, diffusion, acoustics, vibrations, and electromagnetism, as well as the coupled interaction of these phenomena. Prerequisites: CGS 2420 or EML 2030, EMA 3702, and EML 4140.

**EGM 5585 Biotransport Processes (3).** Transport of fluid, heat, and mass in the human body. Application to dialyzers and heart-lung devices. Prerequisites: EML 3126L and EML 4140.

**EGM 5615 Synthesis of Engineering Mechanics (3).** Unified approach to the analysis of continuous media using constitutive equations, mechanical behavior of materials and their usefulness in handling failure theories and composite materials. Prerequisites: MAP 2302 or EGM 3311, and EMA 3702.

**EGM 5935 Review of Topics in Mechanical Engineering (4).** To prepare qualified candidates to take the Mechanical Engineering PE written examination. Reviewed courses include: Thermodynamics, Fluid Mechanics, Mechanics of Materials, Mechanical Design and Heat Transfer.

**EGM 1100 Introduction to Engineering (2).** This course will provide a broad exposure, "birdseye" view, of the engineering profession to entering freshmen.

**EGM 1110C Engineering Drawing (3).** Laboratory experiences in the principles and practice of idea development and expression through free hand sketching and conventional instrument drafting. A beginning course for students with no prior drafting experience.

**EGM 1XXX Technology, Humans, and Society (3).** The course examines the interaction between the technology humans develop and their culture, politics and the quality of life. The foundation for envisioning the appropriate use of technology for a sustainable future is developed.

**EGM 3311 Statics (3).** Forces on particles, and two and three dimensional rigid bodies, equilibrium

of forces, moments, couples, centroids, section properties, and load analysis of structures; vector approach is utilized. Prerequisites: MAC 2312 and PHY 2048.

**EGN 3321 Dynamics (3).** Study of the motion of particles and rigid bodies, conservation of energy and momentum. A vector approach is utilized. Prerequisite: EGN 3311.

**EGN 3343 Thermodynamics I (3).** Fundamental concepts of basic thermodynamics including first and second law topics, equations of state and general thermodynamic relationships. Prerequisites: MAC 2312, PHY 2048, and CHM 1045.

**EGN 3365 Materials in Engineering (3).** A study of materials used in engineering. Includes atomic structure phase diagrams and reactions within solid materials. Prerequisite: CHM 1045, MAC 2311 and PHY 2048.

**EGN 5367 Industrial Materials and Engineering Design (3).** Industrial materials, material selection, and engineering design process, including synthesis, analysis, optimization, and evaluation.

**EGN 5990 Fundamentals of Engineering (FE) Exam Review (4).** Prepares upper level engineering students to take the Fundamentals of Engineering (FE) State Board Examinations. Reviews Chemistry, Engineering Economics, Statics, Dynamics, Electrical Circuits, Fluid Mechanics, Mechanics of Materials, Material Science and Thermodynamics.

**EMA 3066 Polymer Science and Engineering (3).** Introduction to molecular structure; property relationships; preparation, processing and applications of macromolecular materials. Prerequisite: EGN 3365.

**EMA 3702 Mechanics and Materials Science (3).** A mid-level course addressing the selection of engineering materials based on static and dynamic loadings, environmental analysis and the experimental analysis of mechanical systems. Emphasis on metals and composite materials. Prerequisite: EGN 3311.

**EMA 3702L Mechanics and Materials Science Lab (1).** Introduction to measurements of basic mechanical properties of materials. Experiments including tension, bending, torsion, fatigue, buckling, strain, and stress

visualization. Prerequisite: EGN 3311. Corequisite: EMA 3702.

**EMA 4121 Physical Metallurgy (3).** Correlation of properties; structural, mechanical, and thermal history and service behavior of various metals and their alloys. Prerequisite: EGN 3365.

**EMA 4121L Materials Laboratory (1).** Laboratory techniques in materials, including metallography, mechanical testing, heat treatment and non-destructive testing techniques. Prerequisite: EGN 3365.

**EMA 4223 Mechanical Metallurgy (3).** Fundamentals of plastic deformation of crystalline solids: elementary theory of statics and dynamics of dislocations; applications to deformation of single crystals and polycrystals; fracture of metals. Prerequisites: EGN 3365 and EMA 3702.

**EMA 5001 Physical Properties of Materials (3).** The physical properties of materials, including the influence of structure on properties, thermodynamics of solids and phase transformations and kinetics on microstructural development. Prerequisite: EGM 4521C.

**EMA 5015 Introduction to Nanomaterials Engineering (3).** The science and engineering of nanomaterials, the fabrication, behavior, and characterization of the nano-size particles and materials. Prerequisites: EGN 3365 Materials in Engineering, EGM 3311 Analysis of Mechanical Systems.

**EMA 5104 Advanced Mechanical Properties of Materials (3).** Advanced treatment of the mechanical behavior of solids; examines crystal plasticity, dislocations, point defects and grain boundaries, creep and fatigue behavior, fracture. Prerequisites: EGM 3311 Analysis of Mechanical Systems (3).

**EMA 5106 Thermodynamics and Kinetics of Materials (3).** Laws of thermodynamics. Entropy and free energy. Diffusion mechanisms. Transition state theory and field effects. Phase diagrams. Nucleation in condensed phases. Crystal growth. Prerequisite: EGN 3343.

**EMA 5140 Introduction to Ceramic Materials (3).** Synthesis of ceramics, inorganic glasses and their microstructure as related to physical properties. Prerequisites: EGN 3365 or instructor's permission.

**EMA 5295 Principles of Composite Materials (3).** The mechanical behavior of composite materials used in the automotive, aircraft and sporting goods industries. Material and laminar properties; design of composites; failure analysis; and environmental effects. Prerequisite: EGM 5615 or permission of the instructor.

**EMA 5507C Analytical Techniques of Materials Sciences (3).** Fundamental theories and techniques of the analytical methods for materials including: X-ray diffraction, scanning and transmission electron microscopy, thermal and surface analysis, and vacuum systems. Prerequisite: EGN 3365.

**EMA 5584 Biomaterials Science (3).** Materials used in prostheses for skin and soft tissue, vascular implant devices, bone repair, and artificial joints. Structure-property relationships for biological tissue. Prerequisites: EGN 3365, and EMA 3702.

**EMA 5935 Advanced Topics in Materials Engineering (3).** Topics include thermodynamics of solids, principles of physical metallurgy, including phase transformation and diffusion and analytical methods in materials engineering. Prerequisites: EGN 3343 and EGN 3365.

**EMC 5415 Digital Control of Mechanical Systems (3).** Discrete modeling of mechanical systems. Digital feedback with emphasis on hydraulic, pneumatic and electro-mechanical devices. Prerequisite: EML 4312.

**EML 2030 Software for Mechanical Design (3).** Students will use software to develop solid models and a mathematical software package to solve mechanical engineering problems. A programming language will be used to define input parameters. Prerequisite: EGN 1100 or EML 3006, Corequisite: MAC 2313.

**EML 3006 Concepts of Engineering (2).** Provide a broad exposure, "birdseye" view, of the engineering profession to junior and senior transfer students. To be completed within two terms after admission to the ME program.

**EML 3101 Thermodynamics II (3).** Continuation of Thermodynamics I covering reactive and nonreactive mixtures and various thermodynamic cycles. Prerequisite: EGN 3343.

**EML 3126 Transport Phenomena (3).** Fundamental principles of transport phenomena; Governing Equations; Compressible Flow. Prerequisite: EGN 3321 or EGN 3343, and MAP 2302 or EGM 3311.

**EML 3126L Transport Phenomena Laboratory (1).** Experiments illustrating the principles of transport phenomena: wind tunnel, shock tubes, airfoils. Prerequisite: EGN 3321, Corequisite: EML 3126.

**EML 3222 System Dynamics (3).** Introduction to modeling of mechanical systems; derivation of system equations and response of fluid, thermal, and vibrational systems. Available solution methods will be discussed. Prerequisites: EGN 3321, EMA 3702, EML 2030 or CGS 2420 or CGS 2423.

**EML 3262 Kinematics and Mechanism Design (3).** Fundamentals of kinematics and mechanism design; study of the mechanisms used in machinery and analysis of their motion. Two and three dimensional analytical and numerical methods of computer application. Design is emphasized. Prerequisites: EGN 3321, EML 2030 or CGS 2420 or CGS 2423.

**EML 3301C Instrumentation (3).** A practical study of common instrumentation techniques. The use of instrumentation and measurement methods to solve problems is emphasized. Prerequisite: EEL 3003 or EEL 3111.

**EML 3301L Instrumentation and Measurement Laboratory (1).** A practical study of common instrumentation elements and measurement systems used in mechanical and electro-mechanical applications. Prerequisite: EEL 3111L.

**EML 3450 Energy Systems (3).** Review of theory and engineering aspects of conventional energy conversion systems, fuels and combustion, fossil fuels, and nuclear power plants. Aspects of direct energy conversion. Prerequisite: EML 3101.

**EML 3500 Mechanical Design I (3).** Design of basic machine members including shafts, springs, belts, clutches, chains, etc. Prerequisites: EGN 3321, EMA 3702, and EGN 3365.

**EML 4140 Heat Transfer (3).** Study of the fundamentals of heat transfer including conduction, convection, and

radiation. Computer applications and design problems emphasized. Prerequisites: EML 2030 or CGS 2420 or CGS 2423, EGN 3343, EML 3126, and MAP 2302 or EGM 3311.

**EML 4220 Mechanical Vibrations (3).** Theory and application of mechanical vibrations. Includes damped and undamped vibrations with one or more degrees of freedom computer methods emphasized. Prerequisites: EGN 3321, EMA 3702, and EML 2030 or CGS 2420 or CGS 2423.

**EML 4246 Tribological Design for Machines and Elements (3).** Introduction to friction and wear, analysis of tribological systems, and applications of Tribological Principles to machine and machine element design. Prerequisite: EML 4501 or permission of the instructor.

**EML 4260 Dynamics of Machinery (3).** Acceleration and force analysis of reciprocating and rotating mechanisms and machines. Dynamic balancing of idealized systems. Torsional and lateral critical speeds of a rotor and self-excited instability. Prerequisite: EML 3262.

**EML 4264 Introduction to Vehicle Dynamics (3).** Fundamentals of dynamics applied to the study of automotive vehicle performance. Emphasis will be placed on the use of models to evaluate or improve vehicle design. Prerequisite: EGN 3321.

**EML 4312 Automatic Control Theory (3).** Feedback control systems; stability analysis; graphical methods. Applications with emphasis on hydraulic, pneumatic and electro-mechanical devices. Prerequisites: EGN 3321, MAP 2302 or EGM 3311, EML 2030 or CGS 2420 or CGS 2423.

**EML 4410 Combustion Processes (3).** Introduction to combustion processes, thermochemistry, chemical kinetics, laminar flame propagation, detonations and explosions, flame-mability and ignition, applications in IC engines and gas turbines. Prerequisites: EML 3101 and EML 4140.

**EML 4419 Propulsion Systems (3).** Basics of air breathing and rocket engines used in flight systems, gas turbine and ramjet fundamentals. Introduction to compressor and turbine design. Propulsion performance. Unconventional means of propulsion in space. Prerequisites: EML 3101 and EML 3126.

**EML 4421 Internal Combustion Engines (3).** Engine types, characteristics and operation. Performance factors, fuel combustion, power cycles. Knock and engine variables. Exhaust emissions. Fuel Metering. Compressors and turbines. Prerequisite: EML 3101.

**EML 4501 Mechanical Design II (3).** Continuation of design analysis of elementary machine elements, including lubrication bearings, and gearings. Introduction to advanced analysis techniques. Prerequisite: EML 3500.

**EML 4503 Production Machine Modeling and Design (3).** The modeling of metal removing, forming, and polymer processing operations will be introduced. The design of production machines will be discussed based on the models. Prerequisites: EGN 3365, EMA 3702, and EIN 3390.

**EML 4535 Mechanical Computer Aided Design (3).** Introduction to the use of computers in the design process. Course emphasizes the use of interactive computing and computer graphics in developing CAD applications. Programming project is required. Prerequisite: EML 2030.

**EML 4551 Design Project Organization (1).** Organization to include problem definition, goals, survey, conceptual and preliminary design, ethics and cost components, social and environmental impact, presentation to enhance communication skills. Corequisites: EML 3101, EGM 3311, EML 3500, and EML 4140.

**EML 4561 Introduction to Electronic Packaging (3).** Introduction to mechanical packaging of electronic systems. Integrates concepts in mechanical engineering to the packaging of electronic systems, such as hybrid microelectronics. Prerequisites: EEL 3003 or EEL 3111, and EEL 3111L.

**EML 4585 Design of Biomedical Systems and Devices (3).** Mechanical design and material choices of various biomedical systems and devices such as cardiovascular assist devices, total artificial heart, pulmonary assist devices, total hip prosthesis and other orthopaedic devices. Prerequisites: EGN 3365, EMA 3702, EML 3126 or permission of the instructor.

**EML 4601 Principles of Refrigerating and Air Conditioning (3).** Refrigeration cycles. Psychometrics. Thermal comfort. Load and

energy calculations. Pump and piping design. Fan and air distribution. Heat exchangers design. Refrigeration systems and applications. Prerequisite: EML 3101 or permission of the instructor.

**EML 4601L Refrigeration and Air Conditioning Lab (1).** Experiments in Air Conditioning and Refrigeration applications. Corequisite: EML 4601.

**EML 4603 Air Conditioning Design (3).** Mechanical design and optimization of an air conditioning system for a selected application including comfort, industrial applications, building operation and management. Design project required. Prerequisites: EML 3101 and EML 4140 or permission of the instructor.

**EML 4608C Mechanical Systems in Environmental Control (3).** Analysis of refrigeration, heating and air handling systems. Design of environmental control systems. Prerequisite: EML 3101.

**EML 4702 Fluid Dynamics (3).** A mid-level course on ideal fluid flow, compressible flow and viscous flow. Analysis and numerical techniques of continuity and Navier-Stokes equation for incompressible and compressible flow. Prerequisite: EML 3126.

**EML 4706 Design of Thermal and Fluid Systems (3).** Design of thermal and fluid systems and components. Piping networks, duct works. Selection of pumps and fittings. Basic design of heat exchangers, turbomachinery, pumps, and fans. Prerequisites: EML 3101 and EML 4140.

**EML 4711 Gas Dynamics (3).** Basic equations of motion for the flow of a compressible fluid, isentropic flow, normal and oblique shock waves, linearized flows method of characteristics and supersonic thin-air foil theory. Prerequisites: EML 3126 and EGN 3343.

**EML 4804 Introduction to Mechatronics (3).** This course will introduce computer controlled precise motion generation in smart machines. Prerequisite: EML 3301L.

**EML 4806 Modeling and Control of Robots (3).** Robot models in terms of geometric parameters. Kinematic and dynamic modeling of robots. Static and dynamic force equilibrium. Robot programming, control algorithms, simulations. Prerequisite: EML 3262.

**EML 4823 Introduction to Sensors and Signal Processing (3).** This course will introduce the basic sensors and signal processing techniques for design and development of smart products. Prerequisite: EML 3301L.

**EML 4905 Senior Design Project (3).** Project statement, in-depth survey, conceptual and structural design, analysis, statistical and cost analyses, ethical, societal and environmental impact, prototype construction, final presentation. Prerequisites: EML 4551 and permission of the advisor. Corequisites: EML 4501, EML 4706.

**EML 4906L Mechanical Lab (1).** Experiments with various types of mechanical equipment including engines, fans, boilers, pumps, motions and mechanics. Prerequisites: EGN 3343 and EML 3126.

**EML 4930 Special Topics/Projects (1-3).** Individual conferences, assigned readings, and reports on independent investigations selected by the students and professor with approval of advisor.

**EML 4949 Co-op Work Experience (3).** Supervised full-time work experience in engineering field. Limited to students admitted to the co-op program with consent of advisor. Evaluation and reports required.

**EML 5103 Intermediate Thermo Dynamics (3).** Thermodynamic approach to processes and engines; alternative formulations and legendre transformations; maxwell relations, first and second order phase transitions. Prerequisite: EML 3101.

**EML 5104 Classical Thermodynamics (3).** Mathematical analysis of the laws of classical reversible and irreversible thermodynamics. Applications to mechanical, electro-magnetic, and chemical systems. Prerequisite: EML 3101.

**EML 5125 Classical Dynamics (3).** Kinematics of rigid body motion, Eulerian angles, lagrangian equations of motion, inertia tensor, momental ellipsoid. Rigid-body equations of motion, Euler's equations, force-free motion, polhode and herpolhode, theory of tops and gyroscopes. Variational principles. Hamiltonian equations of motion. Poincote representation. Prerequisites: MAP 2302 or EGM 3311, and EGN 3321.

**EML 5152 Intermediate Heat Transfer (3).** Multidimensional heat con-

duction under steady and transient conditions. Heat, mass and momentum transfer. Radiation heat transfer. Gas radiation. Free and forced convection. Prerequisite: EML 4140.

**EML 5385 Identification Techniques of Mechanical Systems (3).** FFT, time series analysis and neural networks are introduced. Applications of these techniques are discussed for identification of mechanical structures and machine diagnostics. Prerequisite: EML 4312.

**EML 5412 Combustion Processes (3).** Introduction to combustion processes, thermochemistry, chemical kinetics, laminar flame propagation, detonations and explosions, flammability and ignition, applications in IC engines and gas turbines. Prerequisites: EML 3101 and EML 4140.

**EML 5509 Mechanical Design Optimization (3).** Finite element analysis and sensitivity analysis combined with numerical optimization techniques to optimize design. Prerequisite: EGM 5354 or permission of the instructor.

**EML 5505 Smart Machine Design and Development (3).** Design of independently operating smart electromechanical systems (most consumer products) which monitor their environment, give decisions, and create motion. Prerequisite: EML 4312 or consent of the instructor.

**EML 5514 Aerodynamics and Flight Mechanics (3).** Fundamentals of aerodynamics, definition of aerodynamic shapes, analysis of aerodynamic forces, airplane performance, and flight stability and control. Prerequisites: EGN 3321, EML 3126, EGN 3343.

**EML 5519 Fault-Tolerant System Design (3).** Fault tolerance in mechanical, manufacturing, computer, and aerospace systems. Basic stages of fault isolation. Fault tolerance measures, architectures, and mechanical system design methodologies. Prerequisite: EML 3500.

**EML 5528 Digital Control of Mechanical Systems (3).** Discrete modeling of mechanical systems. Digital feedback systems. Computer interface with mechanical systems. Controller design with emphasis on hydraulic, pneumatic and electromechanical devices. Prerequisite: Permission of the instructor.

**EML 5530 Intermediate Computer-Aided Design/Computer-Aided Engineering (3).** Computer-aided geometrical modeling of spatial mechanical systems. Design criteria and analytical approaches for planer kinematic systems will be emphasized. Prerequisite: EML 4535 or permission of the instructor.

**EML 5562 Advanced Electronic Packaging (3).** Advanced topics in electronic packaging. Evaluation of first through fourth level assembly. Applications of computer layout design, thermal management and mechanical stability analysis. Prerequisite: EML 4561 or permission of the instructor.

**EML 5599 Heat Pipe Theory and Applications (3).** Heat pipe theory, heat pipe design and its applications, especially in the areas of energy conversion and conservation. Prerequisites: EML 3101 and EML 4140.

**EML 5606C Advanced Refrigeration and Air Conditioning Systems (3).** The various methods used in the thermal design and analysis of both refrigeration and heat pump systems are investigated. Various methods of producing heating and cooling are examined including vapor compression, absorption, air cycle, steam jet, thermoelectric, solar heating and cooling systems. Prerequisite: EML 4601.

**EML 5615C Computer-Aided Design in Air Conditioning (3).** Software will be used to demonstrate heating, ventilating and air conditioning design concepts and sizing equipment & determining performance parameters. Project design is required. Prerequisites: EML 2030 or CGS 2420 or CGS 2423, and EML 4601.

**EML 5708 Advanced Design of Thermal and Fluid Systems (3).** Advanced designs of pumps, compressors, heat exchangers, HVAC systems and thermal and fluid control devices. Prerequisite: EML 4706.

**EML 5709 Intermediate Fluid Mechanics (3).** Basic concepts and scope of fluid dynamics; non-inertial reference frames. Two-dimensional potential theory. Applications to airfoils. The Navier-Stokes equations; selected exact and approximate equations. Prerequisite: EML 3126.

**EML 5748 Boundary Layer Theory (3).** Advanced fluid dynamic analysis

of the Navier - Stokes equations, using boundary layer assumptions. Focus will be on solutions of thermal and fluid boundary layers. Prerequisite: EML 3126.

**EML 5808 Control Technology for Robotic Systems (3).** State-space equations of robots. Controller design based on linearization, nonlinearity cancellation, optimal control, adaptive control, and other methods. Stability analysis, performance comparison. Prerequisites: EGN 3321, EML 4312, or equivalent.

**EML 5825 Sensors and Applied Machine Intelligence (3).** Sensors, signal analysis techniques, and error compensation methods will be introduced for machine intelligence. Prerequisites: EML 4312, EML 4503, or equivalent, or permission of the instructor.