# Department of Electrical Engineering

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**REGENTS' PROFESSORS**
BALANIS, FERRY

**PROFESSORS**
AKERS, BACKUS, CROUCH, DeMASSA, HEYDT, HIGGINS, KARADY, KELLY, PALAIS, PAN, ROEDEL, SCHRODER, WANG

**ASSOCIATE PROFESSORS**
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**ASSISTANT PROFESSORS**
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The professional activities of electrical engineers directly affect the lives of most of the world's population every day. They are responsible for the design and development of radio and television transmitters and receivers, telephone networks and switching systems, computer systems, and electric power generation and distribution. Within the broad scope of these systems, the electrical engineer is concerned with a challenging and diverse array of design and development problems.

Electrical engineers design minuscule semiconductor integrated circuits that contain many thousands of elementary devices. They design systems for automatically controlling mechanical devices and a variety of processes. They are responsible for the design of satellite communication links as well as patient monitoring systems for hospitals. The development of the microprocessor has expanded the opportunities for electrical engineers to improve the design of familiar products since these devices are now incorporated in automobiles, consumer and office products, entertainment systems, and a vast variety of test and measurement instruments and machine tools.

Students who earn a B.S.E. degree majoring in Electrical Engineering will be involved in a variety of electrical and electronic problems in the course of their careers. To ensure the necessary breadth of knowledge, the Electrical Engineering curriculum includes basic (core) engineering courses and courses in networks and electronic circuits, electromagnetic fields and waves, microprocessors, communication and control systems, solid state electronics, electrical power systems, and other specialty courses.

## ELECTRICAL ENGINEERING—B.S.E.

The curriculum in Electrical Engineering builds upon the base provided by the engineering core. Beyond the engineering core, the curriculum includes a number of required electrical engineering and technical elective courses. Approved technical elective courses serve to provide students with an opportunity either to broaden their background in electrical engineering or to study, in greater depth, technical subjects in which they have special interests. Successful completion of the curriculum leaves the student prepared to embark on a career in electrical engineering or to pursue advanced education in graduate school.

## DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. Degree in Electrical Engineering.

## GRADUATION REQUIREMENTS

A student must earn a grade of "C" or better in the mathematics and physics courses listed in the program of study. The student must also have an overall GPA of at least 2.00 for the following group of courses: CSE 200, ECE 301, 334, 352; all courses with an EEE prefix; and all other courses used as technical electives.

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 66–70.

## COURSE REQUIREMENTS

The specific courses requirements for the B.S.E. degree in Electrical Engineering are listed below.

**First-Year Composition.** A minimum grade of "C" is required:

| | | | |
|---|---|---|---|
| ENG | 101, 102 | First Year Composition or ENG 105 Advanced First-Year Composition (3) | 6 |

**General Studies/School Requirements.** (62 semester hours) The humanities and fine arts and social behavioral science requirements (16 hours minimum) are met by taking the following courses:

| | | | |
|---|---|---|---|
| ECN | 111 | Macroeconomic Principles *SB* or ECN 112 Microeconomic Principles *SB* (3) | 3 |
| HU courses | | | 6–10 |
| SB courses | | | 3–7 |

The literacy and critical inquiry requirements are met by taking the following courses:

| | | | |
|---|---|---|---|
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| EEE | 490 | Senior Design Laboratory *L2* | 3 |

The natural science and basic science requirements are met by taking the following courses:

| | | | |
|---|---|---|---|
| CHM | 114 | General Chemistry for Engineers *S1/S2* or CHM 116 General Chemistry *S1/S2* (4) | 4 |
| PHY | 121 | University Physics I: Mechanics *S1/S2*[1] | 3 |
| PHY | 122 | University Physics Laboratory I *S1/S2*[1] | 1 |
| PHY | 131 | University Physics II: Electricity and Magnetism *S1/S2*[2] | 3 |
| PHY | 132 | University Physics Laboratory II *S1/S2*[2] | 1 |
| PHY | 252 | Physics III *S1/S2* | 4 |

[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

**NOTE**: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

The numeracy and mathematics requirements are met by taking the following courses:

| | | | |
|---|---|---|---|
| ECE | 100 | Introduction to Engineering Design *N3* | 4 |
| MAT | 270 | Calculus with Analytic Geometry I *N1* | 4 |
| MAT | 271 | Calculus with Analytic Geometry II | 4 |
| MAT | 272 | Calculus with Analytic Geometry III | 4 |
| MAT | 274 | Elementary Differential Equations | 3 |
| MAT | 342 | Linear Algebra | 3 |
| MAT | 362 | Advanced Mathematics for Engineers and Scientists I | 3 |

Students in Electrical Engineering fulfill the requirements of the engineering core by taking the following courses:

| | | | |
|---|---|---|---|
| ECE | 301 | Electrical Networks I | 4 |
| ECE | 312 | Engineering Mechanics II: Dynamics | 3 |
| ECE | 334 | Electronic Devices and Instrumentation | 4 |
| ECE | 352 | Properties of Electronic Materials | 4 |
| EEE | 225 | Assembly Language Programming and Microprocessors (Motorola) *N3* or EEE 226 Assembly Language Programming and Microprocessors (Intel) *N3* (4) | 4 |

## Electrical Engineering

The following courses are required to fulfill the electrical engineering major:

| | | | |
|---|---|---|---|
| CSE | 200 | Principles of Computing *N3* | 3 |
| EEE | 120 | Digital Design Fundamentals | 3 |
| EEE | 302 | Electrical Networks II | 3 |
| EEE | 303 | Signals and Systems | 3 |
| EEE | 340 | Electromagnetic Engineering I | 4 |
| EEE | 350 | Random Signal Analysis | 3 |
| EEE | 360 | Energy Conversion and Transport | 4 |
| Total | | | 23 |

## Technical Electives in Electrical Engineering

The program in Electrical Engineering requires a total of 18 hours of technical electives. To ensure breadth of knowledge, students *must* select courses from not less than three of the following six areas. In addition, to ensure depth, two courses must be taken in one area.

**Communications**

| | | | |
|---|---|---|---|
| EEE | 407 | Digital Signal Processing | 4 |
| EEE | 451 | Error-Correcting Codes | 3 |
| EEE | 455 | Communication Systems | 4 |
| EEE | 459 | Data Communication Systems | 3 |

**Control**

| | | | |
|---|---|---|---|
| EEE | 480 | Feedback Systems | 4 |
| EEE | 482 | Introduction to State Space Methods | 3 |

**Electromagnetics**

| | | | |
|---|---|---|---|
| EEE | 440 | Electromagnetic Engineering II | 4 |
| EEE | 443 | Antennas | 3 |
| EEE | 445 | Microwaves | 4 |
| EEE | 448 | Fiber Optics | 4 |

**Electronic Circuits**

| | | | |
|---|---|---|---|
| EEE | 405 | Filter Design | 3 |
| EEE | 425 | Digital Systems and Circuits | 4 |
| EEE | 433 | Analog Integrated Circuits | 3 |

**Power Systems**

| | | | |
|---|---|---|---|
| EEE | 460 | Nuclear Concepts for the 21st Century | 3 |
| EEE | 463 | Electrical Power Plant | 3 |
| EEE | 470 | Electric Power Devices | 3 |
| EEE | 471 | Power System Analysis | 3 |
| EEE | 473 | Electrical Machinery | 3 |

**Solid State Electronics**

| | | | |
|---|---|---|---|
| EEE | 434 | Quantum Mechanics for Engineers | 3 |
| EEE | 435 | Microelectronics | 3 |
| EEE | 436 | Fundamentals of Solid State Devices | 3 |
| EEE | 437 | Optoelectronics | 3 |
| EEE | 439 | Semiconductor Facilities and Cleanroom Practices | 3 |

With department approval Computer Science and Engineering courses at or above the 300 level may be substituted for one of the above areas. Of the remaining technical electives, two courses may be taken outside electrical engineering. With faculty-advisor approval, qualified students may choose two technical electives from other courses in engineering, mathematics, and the sciences at or above the 300 level, including graduate courses. Students must have a GPA of not less than 3.00 and approval of the dean to enroll in EEE graduate-level courses. In addition, these technical electives may be chosen from the approved list of courses from the College of Business.

**Electrical Engineering**
**Program of Study**
**Typical Four-Year Sequence**

**Freshman Year**

**First Semester**

| | | | |
|---|---|---|---|
| CHM | 114 | General Chemistry for Engineers S1/S2 or CHM 116 General Chemistry *S1/S2* (4) | 4 |
| ECE | 100 | Introduction to Engineering Design *N3* | 4 |
| ENG | 101 | First-Year Composition | 3 |
| MAT | 270 | Calculus with Analytic Geometry I *N1* | 4 |
| Total | | | 15 |

**Second Semester**

| | | | |
|---|---|---|---|
| EEE | 120 | Digital Design Fundamentals | 3 |
| ENG | 102 | First-Year Composition | 3 |
| MAT | 271 | Calculus with Analytic Geometry II | 4 |
| PHY | 121 | University Physics I: Mechanics *S1/S2*[1] | 3 |
| PHY | 122 | University Physics Laboratory I *S1/S2*[1] | 1 |
| Total | | | 14 |

**Sophomore Year**

**First Semester**

| | | | |
|---|---|---|---|
| CSE | 200 | Principles of Computing *N3* | 3 |
| ECN | 111 | Macroeconomic Principles *SB* or ECN 112 Microeconomic Principles *SB* (3) | 3 |
| MAT | 272 | Calculus with Analytic Geometry III | 4 |
| MAT | 274 | Elementary Differential Equations | 3 |
| PHY | 131 | University Physics II: Electricity and Magnetism *S1/S2*[2] | 3 |
| PHY | 132 | University Physics Laboratory II *S1/S2*[2] | 1 |
| Total | | | 17 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 301 | Electrical Networks I | 4 |
| EEE | 225 | Assembly Language Programming and Microprocessors (Motorola) *N3* or EEE 226 Assembly Language Programming and Microprocessors (Intel) *N3* (4) | 4 |
| MAT | 362 | Advanced Mathematics for Engineers and Scientists I | 3 |
| PHY | 252 | Physics III *S1/S2* | 4 |
| HU, SB, and awareness area courses[3] | | | 3 |
| Total | | | 17 |

### Junior Year

**First Semester**

| | | | |
|---|---|---|---|
| ECE | 312 | Engineering Mechanics II: Dynamics | 3 |
| EEE | 302 | Electrical Networks II | 3 |
| EEE | 340 | Electromagnetic Engineering I | 4 |
| MAT | 342 | Linear Algebra | 3 |
| HU, SB, and awareness area courses[3] | | | 3 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 334 | Electronic Devices and Instrumentation | 4 |
| ECE | 352 | Properties of Electronic Materials | 4 |
| EEE | 303 | Signals and Systems | 3 |
| EEE | 360 | Energy Conversion and Transport | 4 |
| Total | | | 15 |

### Senior Year

**First Semester**

| | | | |
|---|---|---|---|
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| EEE | 350 | Random Signal Analysis | 3 |
| HU, SB, and awareness area courses[3] | | | 3 |
| Technical electives | | | 7 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| EEE | 490 | Senior Design Laboratory *L2* | 3 |
| HU, SB, and awareness area courses[3] | | | 3 |
| Technical electives | | | 11 |
| Total | | | 17 |

[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

[3] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 277.

## ELECTRICAL ENGINEERING

**EEE 120 Digital Design Fundamentals.** (3) F, S, SS
Number systems, conversion methods, binary and complement arithmetic, Boolean algebra, circuit minimization, ROMs, PLAs, flipflops, synchronous sequential circuits. Lecture, lab. Cross-listed as CSE 120. Prerequisite: computer literacy.

**225 Assembly Language Programming and Microprocessors (Motorola).** (4) F, S, SS
Assembly language programming, including input/output programming and exception/interrupt handling. Register-level computer organization, I/O interfaces, assemblers, and linkers. Motorola-based assignments. Lecture, lab. Cross-listed as CSE 225. Prerequisite: CSE/EEE 120. *General Studies: N3.*

**226 Assembly Language Programming and Microprocessors (Intel).** (4) F, S
CPU/memory/peripheral device interfaces and programming. System buses, interrupts, serial and parallel I/O, DMA, coprocessors. Intel-based assignments. Lecture, lab. Cross-listed as CSE 226. Prerequisite: CSE/EEE 120. *General Studies: N3.*

**302 Electrical Networks II.** (3) F, S, SS
Analysis of linear and nonlinear networks. Analytical and numerical methods. Prerequisite: ECE 301.

**303 Signals and Systems.** (3) F, S, SS
Introduction to continuous and discrete time signal and system analysis, linear systems, Fourier, and z-transforms. Prerequisite: EEE 302. Pre- or corequisite: MAT 342.

**340 Electromagnetic Engineering I.** (4) F, S, SS
Static and time varying vector fields; boundary value problems; dielectric and magnetic materials; Maxwell's equations; boundary conditions. Prerequisites: MAT 362; PHY 131.

**350 Random Signal Analysis.** (3) F, S
Probablistic and statistical analysis as applied to electrical signals and systems. Prerequisite: EEE 303.

**353 Introduction to Materials Processing and Synthesis.** (3) F
Principles of materials structure and properties with emphasis on applications in bulk and thin film materials processing and synthesis. Cross-listed as MSE 353. Prerequisites: CHM 116; PHY 131 *or* equivalents.

**354 Experiments in Materials Synthesis and Processing I.** (2) S
Small groups of students complete three experiments selected from a list. Each is supervised by a selected faculty member. Lab. Cross-listed as MSE 354. Prerequisite: EEE/MSE 353 or equivalent.

**360 Energy Conversion and Transport.** (4) F, S
Three phase circuits. Energy supply systems. Magnetic circuit analysis, synchronous generators, transformers, induction and DC machines. Transmission Line Modeling and Design. Lecture, lab. Prerequisite: EEE 302.

**405 Filter Design.** (3) F
Principles of active and passive analog filter design, frequency domain approximations, sensitivity and synthesis of filters. Prerequisite: EEE 303.

**407 Digital Signal Processing.** (4) F
Time and frequency domain analysis, difference equations, z-transform, FIR and IIR Digital Filter Design, Discrete Fourier Transform, FFT, and random sequences. Lecture, lab. Prerequisites: EEE 303; MAT 342.

**425 Digital Systems and Circuits.** (4) F, S
Digital logic gate analysis and design. Propagation delay times, fan out, power dissipation, noise margins. Design of MOS and bipolar logic families, including NMOS, CMOS, standard and advanced TTL, ECL, and BiCMOS. Inverter, combinational and sequential logic circuit design, MOS memories, VLSI circuits. Computer simulations using PSPICE. Lecture, lab. Prerequisite: ECE 334.

**433 Analog Integrated Circuits.** (3) S
Analysis, design, and applications of modern analog circuits using integrated bipolar and field effect transistor technologies. Prerequisite: ECE 334.

**434 Quantum Mechanics for Engineers.** (3) F
Angular momentum, wave packets, Schroedinger wave equation, probability, problems in one dimension, principles of wave mechanics, scattering, tunneling, central forces, angular momentum, hydrogen atom, perturbation theory, variational techniques. Prerequisites: ECE 352; EEE 340.

**435 Microelectronics.** (3) S
Practice of solid state device fabrication techniques, including thin film and integrated circuit fabrication principles. Lecture, lab. Pre- or corequisite: EEE 436.

**436 Fundamentals of Solid State Devices.** (3) F, S
Semiconductor fundamentals, pn junctions, metal-semiconductor contacts, metal-oxide-semiconductor capacitors and field-effect transistors, bipolar junction transistors. Prerequisite: ECE 352.

**437 Optoelectronics.** (3) N
Basic operating principles of various types of optoelectronic devices which play important roles in commercial and communication electronics; light emitting diodes, injection lasers and photodetectors. Prerequisites: ECE 352; EEE 436.

**439 Semiconductor Facilities and Cleanroom Practices.** (3) F
Microcontamination, controlled environments, cleanroom layout and systems, modelling, codes and legislation, ultrapure water, production materials, personnel and operations, hazard management, advanced concepts. Prerequisite: EEE 435 or instructor approval.

**440 Electromagnetic Engineering II.** (4) F, S
Second half of an introductory course in electromagnetic theory and its application in electrical engineering. Analytical and numerical solution of boundary value problems. Advanced transmission lines; waveguides; antennas; radiation and scattering. Lecture, lab. Prerequisite: EEE 340 or equivalent.

**443 Antennas.** (3) S
Fundamental parameters; engineering principles and radiation integrals; linear wire antennas; loops and arrays; numerical computations; measurements. Prerequisite: EEE 340 or equivalent.

**445 Microwaves.** (4) F
Waveguides; circuit theory for waveguiding systems; microwave devices, systems, and energy sources; striplines and microstrips; impedance matching transformers; measurements. Lecture, lab. Prerequisite: EEE 340 or equivalent.

**448 Fiber Optics.** (4) F
Principles of fiber-optic communications. Lectures, lab. Prerequisites: EEE 303, 340.

**451 Error-Correcting Codes.** (3) S
Application of modern algebra to the design of random error-detecting and error-correcting block codes. Prerequisite: CSE/EEE 120.

**453 Experiments in Materials Synthesis and Processing II.** (2) F
A continuation of EEE 354, with emphasis on characterization. Small groups complete 3 experiments supervised by selected faculty members. Lab. Cross-listed as MSE 453. Prerequisites: EEE/MSE 353 and 354 *or* equivalents.

**454 Advanced Materials Processing and Synthesis.** (3) S
Case studies from published literature of current techniques in materials processing and synthesis. Student participation in classroom presentations. Lecture, recitation. Cross-listed as MSE 454. Prerequisites: EEE/MSE 353 and 354 *or* equivalents.

**455 Communication Systems.** (4) F, S
Signal analysis techniques applied to the operation of electrical communication systems. An introduction to and overview of modern digital and analog communications. Lecture, lab. Prerequisite: EEE 303.

**459 Data Communication Systems.** (3) F
System characteristics. Communications media. Communication codes. Data validity checking. Line protocols, terminals, and system configurations. Examples. Prerequisite: EEE 303.

**460 Nuclear Concepts for the 21st Century.** (3) N
Neutron interactions with matter. Principles of neutron chain reacting systems. Neutron diffusion and moderation. Heat removal from nuclear reactors. Point reactor kinetics. Prerequisite: PHY 361.

**463 Electrical Power Plant.** (3) F
Nuclear, fossil, and solar energy sources. Analysis and design of steam supply systems, electrical generating systems, and auxiliary systems. Power plant efficiency and operation. Prerequisites: ECE 301 and 340 (or PHY 252).

**470 Electric Power Devices.** (3) F
Analysis of devices used for short circuit protection, including circuit breakers, relays, and current and voltage transducers. Protection against switching and lightning over voltages. Insulation coordination. Prerequisite: EEE 360.

**471 Power System Analysis.** (3) S
Review of transmission line parameter calculation. Zero sequence impedance, symmetrical components for fault analysis, short circuit calculation, review of power flow analysis, power system stability, and power system control concepts. Prerequisite: EEE 360.

**473 Electrical Machinery.** (3) F
Operating principles, constructional details, and design aspects of conventional DC and AC machines, transformers and machines used in computer disc drives, printers, wrist watches, and automobiles. Prerequisite: EEE 360.

**480 Feedback Systems.** (4) F, S
Analysis and design of linear feedback systems. Frequency response and root locus techniques, series compensation, and state variable feedback. Lecture, lab. Prerequisite: EEE 303.

**482 Introduction to State Space Methods.** (3) F
Discrete and continuous systems in state space form controllability, stability, and pole placement. Observability and observers. Pre- or corequisites: EEE 303, 480; MAT 342.

**490 Senior Design Laboratory.** (3) F, S
Project-oriented laboratory. Each student must complete one or more design projects during the semester. Lecture, lab. Prerequisites: ECE 334; EEE 303; senior status; *or* instructor approval. *General Studies: L2.*

**506 Digital Spectral Analysis.** (3) S
Principles and applications of digital spectral analysis, least squares, random sequences, parametric, and non-parametric methods for spectral estimation. Prerequisites: EEE 407, 554.

**511 Artificial Neural Computation Systems.** (3) F
Networks for computation, learning function representations from data, learning algorithms and analysis, function approximation and information representation by networks, applications in control systems and signal analysis. Prerequisite: instructor approval.

**523 Advanced Analog Integrated Circuits.** (3) F
Analysis and design of analog integrated circuits: analog circuit blocks, reference circuits, operational-amplifier circuits, feedback, and nonlinear circuits. Prerequisite: EEE 433 or equivalent.

**525 VLSI Design.** (3) F, S
Analysis and design of Very Large Scale Integrated (VLSI) Circuits. Physics of small devices, fabrication, regular structures, and system timing. Open only to graduate students.

**526 VLSI Architectures.** (3) F
Special-purpose architectures for signal processing. Design of array processor systems at the system level and processor level. High-level synthesis. Prerequisite: CSE 330 or EEE 407 or instructor approval.

**530 Advanced Silicon Processing.** (3) S
Thin films, CVD, oxidation, diffusion, ion-implantation for VLSI, metallization, silicides, advanced lithography, dry etching, rapid thermal processing. Pre- or corequisite: EEE 435.

**531 Semiconductor Device Theory I.** (3) F
Transport and recombination theory, pn and Schottky barrier diodes, bipolar and junction field-effect transistors, and MOS capacitors and transistors. Prerequisite: EEE 436 or equivalent.

**532 Semiconductor Device Theory II.** (3) S
Advanced MOSFETs, charge-coupled devices, solar cells, photodetectors, light-emitting diodes, microwave devices, and modulation-doped structures. Prerequisite: EEE 531.

**533 Semiconductor Modeling.** (3) S
Process and device modeling, device parameter extraction, process integration, and exposure to current modeling software. Prerequisite: EEE 436 or equivalent.

**534 Semiconductor Transport.** (3) S
Carrier transport in semiconductors. Hall effect, high electric field, Boltzmann equation, correlation functions, and carrier-carrier interactions. Prerequisites: EEE 434, 436 (or 531).

**535 Solar Cells.** (3) N
Photovoltaic devices, including homojunctions and heterojunctions. Photogeneration of carriers, spectral response, electrical characteristics, and efficiency. Prerequisite: EEE 436 or equivalent.

**536 Semiconductor Characterization.** (3) S
Measurement techniques for semiconductor materials and devices. Electrical, optical, physical, and chemical characterization methods. Prerequisite: EEE 436 or equivalent.

**537 Semiconductor Optoelectronics I.** (3) N
Electronic states in semiconductors, quantum theory of radiation, absorption processes, radiative processes, nonradiative processes, photoluminescence, and photonic devices. Prerequisites: EEE 434, 436 (or 531).

**538 Semiconductor Optoelectronics II.** (3) N
Material and device physics of semiconductor lasers, light-emitting diodes, and photodetectors. Emerging material and device technology in III-V semiconductors. Prerequisite: EEE 537.

**539 Introduction to Solid State Electronics.** (3) F
Crystal lattices, reciprocal lattices, quantum statistics, lattice dynamics, equilibrium, and nonequilibrium processes in semiconductors. Prerequisite: EEE 434.

**541 Electromagnetic Fields and Guided Waves.** (3) F
Polarization and magnetization; dielectric, conducting, anisotropic, and semiconducting media; duality, uniqueness, and image theory; plane wave functions, waveguides, resonators, and surface guided waves. Prerequisite: EEE 440 or equivalent.

**542 Selected Microwave Devices.** (3) N
Use of ferrite, semiconductor, and piezoelectric materials in microwave systems. Prerequisites: ECE 352; EEE 445 *or* equivalents.

**543 Antenna Analysis and Design.** (3) F
Impedances, broadband antennas, frequency independent antennas, miniaturization, aperture antennas, horns, reflectors, lens antennas, and continuous sources design techniques. Prerequisite: EEE 443 or equivalent.

**544 High Resolution Radar.** (3) N
Fundamentals; wideband coherent design, waveforms, and processing; stepped frequency; synthetic aperture radar (SAR); inverse synthetic aperture radar (ISAR); imaging. Prerequisites: EEE 303, 340 *or* equivalents.

**545 Microwave Circuit Design.** (3) S
Analysis and design of microwave attenuators, in-phase and quadrature-phase power dividers, magic tee's, directional couplers, phase shifters, DC blocks, and equalizers. Prerequisite: EEE 445 or instructor approval.

**546 Advanced Fiber-Optics.** (3) S
Theory of propagation in fibers, couplers and connectors, distribution networks, modulation, noise and detection, system design, and fiber sensors. Prerequisite: EEE 448 or instructor approval.

**547 Microwave Solid State Circuit Design I.** (3) N
Application of semiconductor characteristics to practical design of microwave mixers, detectors, limiters, switches, attenuators, multipliers, phase shifters, and amplifiers. Prerequisite: EEE 545 or instructor approval.

**548 Coherent Optics.** (3) N
Diffraction, lenses, optical processing, holography, electro-optics, and lasers. Prerequisite: EEE 440 or equivalent.

**549 Lasers.** (3) N
Theory and design of gas, solid, and semiconductor lasers. Prerequisite: EEE 448 or instructor approval.

**550 Transform Theory and Applications.** (3) N
Introduction to abstract integration, function spaces, and complex analysis in the context of integral transform theory. Applications to

signal analysis, communication theory, and system theory. Prerequisite: EEE 303.

**551 Information and Coding Theory.** (3) N
Fundamental theorems of information theory for sources and channels; convolutional and burst codes. Prerequisites: EEE 451, 554.

**552 Coherent Communications.** (3) N
Systems analysis and design of telecommunication systems using phase-locked loops. Prerequisite: EEE 554.

**554 Random Signal Theory I.** (3) F
Application of statistical techniques to the representation and analysis of electrical signals and to communications systems analysis. Prerequisite: EEE 303, 350 *or* instructor approval.

**555 Random Signal Theory II.** (3) S
Processing of signals in the presence of noise. Random signals, correlation, frequency spectra, estimation, filtering, noise, prediction, and transients. Prerequisite: EEE 554.

**556 Detection and Estimation Theory.** (3) N
Combination of the classical techniques of statistical inference and the random process characterization of communication, radar, and other modern data processing systems. Prerequisites: EEE 455, 554.

**558 Modulation Theory.** (3) N
Noise performance of analog and digital modulation systems. Emphasis on modern digital techniques in terrestrial and satellite communications systems. Prerequisites: EEE 455, 554.

**571 Power System Transients.** (3) N
Simple switching transients. Transient analysis by deduction. Damping of transients. Capacitor and reactor switching. Transient recovery voltage. Travelling waves on transmission lines. Lightning. Protection of equipment against transient overvoltages. Introduction to computer analysis of transients. Prerequisite: EEE 471.

**572 Advanced Power Electronics.** (3) N
Analysis of device operation, including thyristors, gate-turn-off thyristors, and transistors. Design of rectifier and inverter circuits. Applications such as variable speed drives, HVDC, motor control, and uninterruptable power supplies. Prerequisite: EEE 470.

**573 Power System Control.** (3) N
Concepts of economic and secure operation of power systems; load frequency control, economic dispatch, unit commitment; state estimation, contingency analysis, optimal power flow; power system control centers. Prerequisites: EEE 471.

**574 Computer Solution of Power Systems.** (3) S
Algorithms for digital computation for power flow, fault, and stability analysis. Sparse matrix and vector programming methods, numerical integration techniques, stochastic methods, solution of the least squares problem. Prerequisite: EEE 471.

**577 Power System Planning.** (3) F
Load forecasting, reliability assessment, unit commitment, economic dispatching, hydrothermal coordination. Generation and bulk transmission planning, synchronous machine dynamic simulation, and system stability assessment and simulation. Prerequisite: EEE 471.

**579 Power Transmission and Distribution.** (3) S
High voltage transmission line electric design; conductors, corona, RI and TV noise, insulators, clearances. DC characteristic, feeders voltage drop, and capacitors. Prerequisite: EEE 470.

**581 Filtering of Stochastic Processes.** (3) N
Modeling, estimation, and filtering of stochastic processes, with emphasis on the Kalman filter and its applications in signal processing and control. Prerequisites: EEE 482, 550, 554.

**582 Linear System Theory.** (3) S
Controllability, observability, and realization theory for multivariable continuous time systems. Stabilization and asymptotic state estimation. Disturbance decoupling, noninteracting control. Prerequisite: EEE 482.

**585 Digital Control Systems.** (3) F
Analysis and design of digital and sampled data control systems, including sampling theory, z-transforms, the state transition method, stability, design, and synthesis. Prerequisites: EEE 482, 550.

**586 Nonlinear Control Systems.** (3) N
Stability theory, including phase-plane, describing function, Liapunov's method, and frequency domain criteria for continuous and discrete, nonlinear, and time-varying systems. Prerequisite: EEE 482.

**587 Optimal Control Systems.** (3) N
Application of calculus of variations, Pontryagin's principle, and dynamic programming to control problems. Computational techniques for solving optimal control problems. Prerequisite: EEE 482.

**606 Adaptive Signal Processing.** (3) F
Principles/applications of adaptive signal processing, adaptive linear combiner, Wiener least-squares solution, gradient search, performance surfaces, LMS/RLS algorithms, block time/frequency domain LMS. Prerequisites: EEE 506, 554.

**631 Heterojunctions and Superlattices.** (3) F
Principles of heterojunctions and quantum well structures, band line-ups, optical, and electrical properties. Introduction to heterojunction devices. Prerequisites: EEE 436, 531.

**632 Heterojunction Devices.** (3) N
Principles of semiconductor heterojunctions and quantum wells are applied to the analysis of advanced electronic and optical devices. Devices studied are modulation doped field effect transistors (MODFETs), pseudomorphic MODFETs, heterojunction bipolar transistors, quantum well and superlattice optical detectors, modulators, and lasers. Prerequisites: EEE 434, 436, 531, 631.

**641 Advanced Electromagnetic Field Theory.** (3) N
Cylindrical wave functions, waveguides, and resonators; spherical wave functions and resonators; scattering from planar, cylindrical, and spherical surfaces; Green's functions. Prerequisite: EEE 541 or equivalent.

**643 Advanced Topics in Electromagnetic Radiation.** (3) N
High-frequency asymptotic techniques, geometrical and physical theories of diffraction (GTD and PTD), moment method (MM), radar cross section (RCS) prediction, Fourier transforms in radiation, and synthesis methods. Prerequisite: EEE 543.

**645 Microwave Filter Design.** (3) N
Analysis and design of microwave low-pass, high-pass, band-pass, and band-stop filters and microwave diplexers/multiplexers. Prerequisite: EEE 545 or instructor approval.

**647 Microwave Solid State Circuit Design II.** (3) F
Practical design of microwave free-running and voltage-controlled oscillators using Gunn and Impatt diodes and transistors; analysis of noise characteristics of the oscillator. Prerequisites: EEE 545, 547.

**731 Advanced MOS Devices.** (3) S
Threshold voltage, subthreshold current, scaling, small geometry effects, hot electrons, and alternative structures. Prerequisite: EEE 531.

**732 Advanced Bipolar Devices and Circuits.** (3) N
Critical examination of new bipolar device and circuit technologies. Performance trade-offs, scaling effects, and modeling techniques. Prerequisite: EEE 531.

**770 Advanced Topics in Power Systems.** (3) N
Power system problems of current interest, approached at an advanced technical level, for mature students. Prerequisites: EEE 577, 579 *or* equivalents; instructor approval.

# Department of Industrial and Management Systems Engineering

**Gary L. Hogg**
***Chair***
**(GWC 502) 602/965–3185**

**PROFESSORS**
BAILEY, HOGG, MONTGOMERY, SMITH, UTTAL, WOLFE

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**PROFESSORS EMERITI**
BEDWORTH, HOYT, KNIGHT, YOUNG

The industrial engineer (IE) provides leadership for American organizations in reestablishing competitiveness in the global marketplace through system integration and productivity improvement. No challenge to a man or woman

**NOTE**: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

can be greater than improving productivity, which is the application of knowledge and skills to provide improved goods and services to enhance the quality of life, both on and off the job. This improvement must be achieved without waste of physical and human resources while maintaining the environmental balance. Industrial engineers are the “productivity people” who provide the necessary leadership and skills to integrate technology. This gives IEs a wide range of interests and responsibilities.

As in other engineering fields, industrial engineering is concerned with solving problems through the application of scientific and practical knowledge. What sets industrial engineering apart from other engineering disciplines is its broader scope. An IE relates to the total picture of productivity. An IE looks at the “big picture” of what makes society perform best—the right combination of human resources, natural resources, synthetic structures, and equipment. An IE bridges the gap between management and operations, dealing with and motivating people as well as determining what tools should be used and how they should be used.

An IE deals with people as well as things. In fact, industrial engineering is often called the “people-oriented profession.” It is a primary function of the IE to integrate people and technology-oriented systems. Therefore, IEs are active in the fields of ergonomics and human factors.

To be competitive in this global economy, it is essential to emphasize and continually improve the quality of goods and services. Industrial engineering is the only engineering discipline offering course work in designing and implementing quality assurance systems.

The IE’s skills are applicable to every kind of organization. IEs learn how to approach, think about, and solve productivity and integration problems regardless of their settings. IEs work in manufacturing facilities, banks, hospitals, government, transportation, construction, and social services. Within this wide variety of organizations, IEs get involved in projects such as designing and implementing quality control systems, independent work groups, the work flow in a medical laboratory, real-time production control systems, computer-based management information systems, and manufacturing operating systems, to name a few. A unique feature of most industrial engineering assignments is that they involve interdisciplinary teams. For example, the IE might be the leader of a team consisting of electrical and mechanical engineers, accountants, computer scientists, and planners. This IE program gives the student the skills necessary to direct these teams. These skills include team building, brainstorming, group dynamics, and interpersonal relationships.

IEs have a sound background in technology integration, management theory and application, engineering economics and cost analysis. They are well equipped to deal with problems never seen before, making them prime candidates for promotion through the management career path, especially in high-tech organizations. In fact, more than half of all practicing IEs are in management positions. This area of expertise has placed the IE in the leadership role in the establishment of a new field of activity called “management of technology.”

Industrial engineers are well trained in the development and use of analytical tools, and their most distinctive skill is in the area of model building. IEs must quickly learn and understand the problems of their clients. In this context, good people skills and good analytic skills are essential. This industrial engineering program offers both.

## INDUSTRIAL ENGINEERING—B.S.E.

### Degree Requirements

A minimum of 128 semester hours is necessary for the B.S.E. degree in Industrial Engineering.

### Graduation Requirements

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 66–70.

### Course Requirements

See pages 277–278 for General Studies, school, and engineering core course requirements.

**Major Requirements.** The following courses are required for the Industrial Engineering major:

| | | | |
|---|---|---|---|
| ASE | 485 | Engineering Statistics *N2* | 3 |
| ECE | 380 | Probability and Statistics for Engineering Problem Solving | 3 |
| IEE | 205 | Microcomputer Applications in Industrial Engineering *N3* | 3 |
| IEE | 300 | Economic Analysis for Engineers | 3 |
| IEE | 305 | Information Systems Engineering *N3* | 3 |
| IEE | 367 | Methods Engineering and Facilities Design | 4 |
| IEE | 374 | Quality Control *N2* | 3 |
| IEE | 394 | Introduction to Manufacturing Processes | 4 |
| IEE | 431 | Engineering Administration | 3 |
| IEE | 461 | Integrated Production Control | 3 |
| IEE | 463 | Computer-Aided Manufacturing and Control *N3* | 3 |
| IEE | 475 | Introduction to Simulation | 3 |
| IEE | 476 | Operations Research Techniques/Applications *N2* | 4 |
| IEE | 488 | Industrial Engineering Analysis | 3 |
| IEE | 490 | Project in Design and Development | 3 |
| Total | | | 48 |

### Industrial Engineering Program of Study Typical Four-Year Sequence

#### Freshman Year

**First Semester**

| | | | |
|---|---|---|---|
| CHM | 114 | General Chemistry for Engineers[1] *S1/S2* | 4 |
| ECE | 100 | Introduction to Engineering Design *N3* | 4 |
| ENG | 101 | First-Year Composition | 3 |
| MAT | 270 | Calculus with Analytic Geometry I *N1* | 4 |
| Total | | | 15 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECN | 111 | Macroeconomic Principles *SB* or ECN 112 Microeconomic Principles *SB* (3) | 3 |
| ENG | 102 | First-Year Composition | 3 |
| MAT | 271 | Calculus with Analytic Geometry II | 4 |
| PHY | 121 | University Physics I: Mechanics *S1/S2*[2] | 3 |
| PHY | 122 | University Physics Laboratory I *S1/S2*[2] | 1 |
| HU, SB, and awareness area courses[3] | | | 3 |
| Total | | | 17 |

#### Sophomore Year

**First Semester**

| | | | |
|---|---|---|---|
| IEE | 205 | Microcomputer Applications in Industrial Engineering *N3* | 3 |
| IEE | 300 | Economic Analysis for Engineers | 3 |
| MAT | 242 | Elementary Linear Algebra *N1* | 2 |
| MAT | 272 | Calculus with Analytic Geometry III | 4 |

| | | | |
|---|---|---|---|
| PHY | 131 | University Physics II: Electricity and Magnetism *S1/S2*[4] | 3 |
| PHY | 132 | University Physics Laboratory II *S1/S2*[4] | 1 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 210 | Engineering Mechanics I: Statics | 3 |
| ECE | 380 | Probability and Statistics for Engineering Problem Solving | 3 |
| MAT | 274 | Elementary Differential Equations | 3 |
| Core elective | | | 3 |
| Basic science elective[5] | | | 3 |
| HU, SB, and awareness area courses[3] | | | 3 |
| Total | | | 18 |

**Junior Year**

**First Semester**

| | | | |
|---|---|---|---|
| ASE | 485 | Engineering Statistics *N2* | 3 |
| IEE | 305 | Information Systems Engineering *N3* | 3 |
| IEE | 367 | Methods Engineering and Facility Design | 4 |
| IEE | 374 | Quality Control *N2* | 3 |
| HU, SB, and awareness area courses[3] | | | 4 |
| Total | | | 17 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| ECE | 312 | Engineering Mechanics II: Dynamics | 3 |
| ECE | 350 | Structure and Properties of Materials | 3 |
| IEE | 394 | Introduction to Manufacturing Processes | 4 |
| IEE | 476 | Operations Research Techniques/Applications *N2* | 4 |
| Total | | | 17 |

**Senior Year**

**First Semester**

| | | | |
|---|---|---|---|
| ECE | 301 | Electrical Networks I | 4 |
| IEE | 431 | Engineering Administration | 3 |
| IEE | 461 | Integrated Production Control | 3 |
| IEE | 475 | Introduction to Simulation | 3 |
| HU, SB, and awareness area courses[3] | | | 3 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 400 | Engineering Communications *L2* | 3 |
| IEE | 463 | Computer-Aided Manufacturing and Control *N3* | 3 |
| IEE | 488 | Industrial Engineering Analysis | 3 |
| IEE | 490 | Project in Design and Development | 3 |
| Total | | | 12 |

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[1] Students who have taken no high school chemistry should take CHM 113 and 116.

[2] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[3] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 277.

[4] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

[5] Must be an earth science or life science course; if physics or chemistry, the course must be of a more advanced level than CHM 114 or 116 or PHY 131.

## Manufacturing Engineering

Manufacturing engineering is the field of engineering that focuses on the design, implementation, and optimization of manufacturing functions and operations. Competing in a worldwide environment leads to the need for a world-class manufacturing operation. Integration of all manufacturing entities, whether physical or informational, is a task for the manufacturing engineer. Automation decisions, their economic consequences, and the role of total quality control and management are some of the functions of the manufacturing engineer.

Manufacturing engineers are key role players in all manufacturing organizations; for example, electronic, aerospace, and automotive are just three categories of manufacturing. The ability for any manufacturing operation to compete just in the United States, let alone worldwide, requires that the manufacturing segment of the operation be efficient, cost effective, and produce products that are defect free. The manufacturing engineer is instrumental in how well the organization will compete through determination of the correct manufacturing processes and equipment, the best work flow possible, and efficient total quality control and statistical process control innovations. Recent reports have shown that the U.S. semiconductor and automotive manufacturing operations have regained their preeminent positions in the world. The role for the manufacturing engineer can only grow in these two industries as well as in all the other industries that make up this important segment of the economy. Salary potential is very competitive with all other engineering fields.

The following courses are required for the manufacturing engineering option:

| | | | |
|---|---|---|---|
| ECE | 380 | Probability and Statistics for Engineering Problem Solving | 3 |
| ECE | 394 | ST: Introduction to Manufacturing Engineering | 3 |
| IEE | 205 | Microcomputer Applications in Industrial Engineering *N3* | 3 |
| IEE | 300 | Economic Analysis for Engineers | 3 |
| IEE | 374 | Quality Control *N2* | 3 |
| IEE | 394 | Introduction to Manufacturing Processes | 4 |
| IEE | 431 | Engineering Administration | 3 |
| IEE | 461 | Integrated Production Control | 3 |
| IEE | 463 | Computer-Aided Manufacturing and Control *N3* | 3 |
| IEE | 464 | Concurrent Engineering | 3 |
| IEE | 498 | Manufacturing Design Project | 3 |
| MAE | 406 | CAD/CAM Applications in MAE | 3 |
| Technical electives* | | | 10 |
| Total | | | 46 |

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*Technical electives must meet ABET requirements of engineering science and engineering design.

## INDUSTRIAL AND MANAGEMENT SYSTEMS ENGINEERING

**IEE 205 Microcomputer Applications in Industrial Engineering.** (3) F, S
Concepts related to development of operational capability in the use of microcomputer hardware, software, and networking as related to industrial engineering applications. Prerequisite: ECE 100. *General Studies: N3.*

**300 Economic Analysis for Engineers.** (3) F, S
Economic evaluation of alternatives for engineering decisions, emphasizing the time value of money. Prerequisites: ECE 100; MAT 270.

**305 Information Systems Engineering.** (3) F
Emphasis on systems analysis, design and implementation of information systems using fourth generation languages and alternative data base structures. Prerequisite: IEE 205. *General Studies: N3.*

**NOTE**: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

**367 Methods Engineering and Facilities Design.** (4) F
Analyzing and designing work systems for productivity, including time and motion studies, human factors, material handling, facility layout and location. Lecture, lab. Prerequisites: IEE 205, 300.

**374 Quality Control.** (3) F
Control charting and other statistical process control techniques. Organization and managerial aspects of quality assurance, plus acceptance sampling plans. Prerequisite: ECE 380. *General Studies: N2.*

**422 Information Systems Design.** (3) N
Emphasis on the application of system analysis and design to information systems. Microprocessor MIS project required. Prerequisite: IEE 205 or equivalent.

**431 Engineering Administration.** (3) F
Introducing quantitative and qualitative approaches to management functions, engineering administration, organizational analysis, decision making, and communication. Prerequisite: senior standing.

**437 Human Factors Engineering.** (3) F
Study of the human psychological and physiological factors that underlie the design of equipment and the interaction between people and machines.

**461 Integrated Production Control.** (3) F
Production control techniques for the planning, analysis, control, and evaluation of operating systems. Time series forecasting, network planning, scheduling, and control. Prerequisites: ECE 380; IEE 205.

**463 Computer-Aided Manufacturing and Control.** (3) F, S
Computer control in manufacturing, CIM, NC, logic controllers, group technology, process planning and robotics. Prerequisite: "C" programming capability. *General Studies: N3.*

**464 Concurrent Engineering.** (3) S
Understanding and analysis of complex design issues, including product attributes, manufacturing processes and service issues. Prerequisites: ECE 100; IEE 205.

**475 Introduction to Simulation.** (3) F, S
Using simulation and modeling in analysis and design of network and discrete systems with statistical aspects. Prerequisites: ECE 380; IEE 205. *General Studies: N3.*

**476 Operations Research Techniques/Applications.** (4) F, S
Linear programming, network optimization, Markov processes, queuing models, emphasizing model building for solving industrial system problems. Prerequisites: ECE 380; MAT 242. *General Studies: N2.*

**488 Industrial Engineering Analysis.** (3) S
*Effective through fall 1996.*
Labor material and overhead cost analysis, parametric cost estimating, risk analysis involving budget limitations, assurance of estimates, quality cost systems, and life cycles cost analysis, including effects on engineering design, reliability, maintainability, serviceability, testability, and availability. Prerequisites: IEE 300.

**488 Industrial Engineering Analysis.** (3) S
*Effective starting spring 1997.*
Cost estimation and risk analysis including labor, material, overhead, budget limitations, quality, and life cycle costs. Prerequisites: ECE 380; IEE 300.

**490 Project in Design and Development.** (3) F, S
Individual or team capstone project in creative design and synthesis. Prerequisite: senior standing.

**505 Applications Engineering.** (3) F
Develop working knowledge of application systems development tools needed for computer integrated enterprise. Includes techniques for application generation in fourth and fifth generation software environments. Topics include client server network systems, decision support systems, and transaction systems in distributed environment.

**506 Statistics and Probability for Engineers.** (3) N
Intensive calculus-based statistics. No graduate degree credit for College of Engineering and Applied Sciences students.

**510 Measurement of Productivity.** (3) S '97
The engineering economic audit and its use with applications to break-even analysis, variable budget control cost analysis, and product pricing. Prerequisites: ECE 380; IEE 205 or equivalent.

**511 Analysis of Decision Processes.** (3) S
Methods of making decisions in complex environments and statistical decision theory; effects of risk, uncertainty, and strategy on engineering and managerial decisions. Prerequisite: ECE 380.

**520 Ergonomics Design.** (3) S
Human physiological and psychological factors in the design of work environments and in the employment of people in man-machine systems. Open-shop lab assignments in addition to class work. Prerequisite: IEE 437 or 547.

**530 Enterprise Modelling.** (3) S
Focus on social, economic, and technical models of the enterprise with emphasis on the management of technological resources. Included are organization, econometric, financial, and large-scale mathematical models.

**531 Topics in Engineering Administration.** (3) S '98
Consideration given to philosophical, psychological, political, and social implications of administrative decisions. Prerequisite: IEE 532 or instructor approval.

**532 Management of Technology.** (3) F
Topics include designing a technical strategy; technological forecasting; interfacing marketing engineering and manufacturing; designing and managing innovation systems; creativity; application of basic management principles to technology management. Prerequisite: IEE 431 or 541 or instructor approval.

**533 Scheduling and Network Analysis Models.** (3) S '98
Application of scheduling and sequencing algorithms, deterministic and stochastic network analysis, and flow algorithms. Prerequisites: ECE 380; IEE 476 or 546.

**541 Engineering Administration.** (3) F
Introducing quantitative and qualitative approaches to management functions, engineering administration, organizational analysis, decision making, and communication. IEE 431 students ineligible.

**542 Information System Design.** (3) N
Emphasis on the application of system analysis and design to information systems. Microprocessor MIS project required. Open only to students without previous credit for IEE 422. Prerequisite: IEE 205 or equivalent.

**543 Computer-Aided Manufacturing and Control.** (3) F, S
Computer control in manufacturing, CIM, NC, logic controllers, group technology, process planning and robotics. IEE 463 students ineligible. Prerequisite: "C" programming capability.

**544 Concurrent Engineering.** (3) S
Understanding and analysis of complex design issues, including product attributes, manufacturing processes and service issues. IEE 464 students ineligible. Prerequisites: ECE 100; IEE 205.

**545 Introduction to Simulation.** (3) F, S
Using simulation and modeling in analysis and design of network and discrete systems with statistical aspects. IEE 475 students ineligible. Prerequisites: ECE 380; IEE 205.

**546 Operations Research Techniques/Applications.** (4) F, S
Linear programming, network optimization, Markov processes, queuing models, emphasizing model building for solving industrial system problems. IEE 476 students ineligible. Prerequisites: ECE 380; MAT 242.

**547 Human Factors Engineering.** (3) F
Study of people at work; designing for human performance effectiveness and productivity. Considerations of human physiological and psychological factors. Open only to students without previous credit for IEE 437.

**548 Industrial Engineering Analysis.** (3) S
Cost estimation and risk analysis including labor, material, overhead, budget limitations, quality, life cycle costs. IEE 488 students ineligible. Prerequisites: ECE 380; IEE 300.

**552 Strategic Technological Planning.** (3) S
Study of concept of strategy, strategy formulation process, and strategic planning methodologies with emphasis on engineering design and manufacturing strategy, complemented with case studies. An analytical executive planning decision support system is presented and used throughout course. Pre- or corequisite: IEE 545 or 566 or 567 or 574 or 575.

**560 Database Concepts for Industrial Management Systems.** (3) S
Application of object oriented database technology concepts to manufacturing and enterprise systems.

**561 Production Control Information Systems.** (3) F
Development of information system designs for production control. Topics include MRP I, MRP II, scheduling, sequencing, and inventory control. On-line design concepts are covered. Prerequisites: ASE 485 or 500; IEE 461; MAT 242.

**562 Computer-Aided Manufacturing (CAM) Tools.** (3) F
Current topics in automation, distributed control, control code generation, control logic validation, CAM integration, CAD/CAM data structures, planning for control systems. Topics vary by semester. Prerequisite: IEE 463 or 543 or equivalent.

**563 Systems Analysis for Distributed Systems.** (3) S
Analysis and design of distributed groupware applications for manufacturing and enterprise systems. Prerequisite: ECE 380.

**564 Planning for Computer-Integrated Manufacturing.** (3) F
Theory and use of IDEF methodology in planning for flexible manufacturing, robotics, and real-time control. Simulation concepts applied to computer-integrated manufacturing planning. Prerequisite: IEE 463 or 543.

**565 Computer-Integrated Manufacturing Research.** (3) S
Determination and evaluation of research areas in computer-integrated manufacturing, including real-time software, manufacturing information systems, flexible and integrated manufacturing systems, robotics, and computer graphics. Prerequisite: IEE 564.

**566 Simulation in Computer-Integrated Manufacturing Planning.** (3) F
Use of simulation in the planning of computer-integrated manufacturing planning related to robotics, flexible, and integrated manufacturing systems. Use of computer graphics combined with simulation analysis for CIM decision support. Prerequisite: IEE 475 or 545.

**567 System Simulation.** (3) S
Use of simulation in the analysis and design of systems involving continuous and discrete processes; simulation languages; statistical aspects of simulation. Prerequisite: IEE 475 or 545.

**569 Advanced Statistical Methods.** (3) F '96
Application of statistical inference procedures, based on ranks, to engineering problems. Efficient alternatives to classical statistical inference constrained by normality assumptions. Prerequisite: ASE 485 or 500.

**570 Advanced Quality Control.** (3) S
Economic-based acceptance sampling, multiattribute acceptance sampling, narrow limit gauging in inspector error and attributes acceptance sampling, principles of quality management, and selected topics from current literature. Prerequisite: ASE 485 or 500 or equivalent.

**571 Quality Management.** (3) F
Total quality concepts, quality strategies, quality and competitive position, quality costs, vendor relations, the quality manual, and quality in the services. Prerequisite: IEE 431 or 541.

**572 Design of Engineering Experiments.** (3) F, S
Analysis of variance and experimental design. Topics include general design methodology, incomplete blocks, confounding, fractional replication, and response surface methodology. Prerequisite: ASE 485 or 500.

**573 Reliability Engineering.** (3) S
Nature of reliability, time to failure densities, series/parallel/standby systems, complex system reliability, Bayesian reliability, and sequential reliability tests. Prerequisite: ECE 380.

**574 Applied Deterministic Operations Research Models.** (3) F
Formulation, solution, analysis, and application of deterministic models in operations research, including those of linear programming, integer programming, and nonlinear programming. Prerequisite: IEE 476 or 546.

**575 Applied Stochastic Operations Research Models.** (3) S
Application of stochastic models, including inventory theory, queuing theory, Markov processes, stochastic programming, and renewal theory. Prerequisite: ASE 485 or 500.

**577 Decision and Expert Systems Methodology.** (3) F
Systems approach to the analysis, design, and implementation of decision support systems. Emphasis on development of databases, model bases dialogs, and systems architecture as well as systems effectiveness. Introduction to expert systems as decision aid included. Term project required. Prerequisite: IEE 205 or equivalent.

**578 Regression Analysis.** (3) F
A course in regression model building oriented toward engineers/physical scientists. Topics include linear regression, diagnostics biased and robust fitting, nonlinear regression. Prerequisite: ASE 485 or 500.

**579 Time Series Analysis and Forecasting.** (3) F '97
Forecasting time series by the Box-Jenkins and exponential smoothing techniques; existing digital computer programs are utilized to augment the theory. Prerequisites: ASE 485 or 500; IEE 461.

**582 Response Surfaces and Process Optimization.** (3) S
An introduction to response surface method and its applications. Topics include steepest ascent, canonical analysis, designs, and optimality criteria. Prerequisite: IEE 572.

**672 Advanced Topics in Experimental Design.** (3) S '98
Engineering applications of factorial and fractional factorial designs with randomization restrictions, analysis techniques in parameter comparison, missing data, unbalanced designs. Prerequisite: IEE 572 or instructor approval.

**677 Regression and Linear Models.** (3) S '97
General linear models, applications, theory, including least squares, maximum likelihood estimation, properties of estimators, likelihood ratio tests and computational procedures. Prerequisite: IEE 578 or instructor approval.

**679 Time Series Analysis and Control.** (3) F '96
Identification, estimation, diagnostic checking techniques for ARIMA models, transfer functions, multiple time series models for feedback and feedforward control schemes.
Prerequisite: IEE 579 or instructor approval.

**681 Reliability, Availability, and Serviceability.** (3) F '96
Organizing hardware and software, integrity and fault-tolerant design, maintenance design and strategy, Markov models, fault-free analysis, and military standards. Prerequisite: ECE 380.

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**NOTE**: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

# Department of Mechanical and Aerospace Engineering

**Don L. Boyer**
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**PROFESSORS**
BICKFORD, BOYER, DAVIDSON, EVANS, FERNANDO, HENDERSON, HIRLEMAN, JACOBSON, JANKOWSKI, KRAJCINOVIC, LIU, PECK, REED, ROY, SARIC, SHAH, SO, TONG, TSENG, WALLACE, WIE, WOOD, YAO

**ASSOCIATE PROFESSORS**
CHATTOPADHYAY, K. CHEN, KOURIS, KUO, LAANANEN, MIGNOLET, RANKIN, SIERADZKI, WELLS

**ASSISTANT PROFESSORS**
LEE, McNEILL, PHELAN, PUIG-SUARI,

**PROFESSORS EMERITI**
BEAKLEY, S. CHEN, DITSWORTH, FLORSCHUETZ, FRY, KAUFMAN, LOGAN, RICE, SHAW, THOMPSON, TURNBOW, WILCOX, WOOLDRIDGE

The Department of Mechanical and Aerospace Engineering is the administrative home for two undergraduate majors: Aerospace Engineering and Mechanical Engineering.

Both majors build on the broad exposure to the engineering, chemical, and physical sciences and the mathematics embodied in the General Studies and engineering core courses required of all engineering students.

The *Aerospace Engineering* major provides students an education in technological areas critical to the design and development of aerospace vehicles and systems. Aerospace Engineering graduates are typically employed at government laboratories (e.g., NASA) and in a wide range of aerospace and mechanical industries. The *Mechanical Engineering* major is perhaps one of the most broadly applicable programs in engineering, providing education for a wide variety of employment opportunities.

The two majors, discussed in more detail below, can serve as entry points to immediate professional employment or to graduate study. The emphasis in all fields is on the development of fundamental knowledge that will have long-lasting utility in our rapidly changing technical society.

## DEGREE REQUIREMENTS

All degree programs in the department require that students attain a minimum GPA of 2.00 in the engineering core and in the major in order to be eligible for graduation. Also, the department may require additional or remedial work for those students who have demonstrated a trend of academic difficulty.

## GRADUATION REQUIREMENTS

In addition to fulfillling school and major requirements, majors must satisfy all university graduation requirements. See pages 66–70.

## COURSE REQUIREMENTS

### General Studies

See pages 277–278 for General Studies, school, and engineering core course requirements.

### Engineering Core Options

Among the options listed on page 278 as part of the engineering core requirements, students in the Department of Mechanical and Aerospace Engineering are required to take the following:

| | | | |
|---|---|---|---|
| ECE | 100 | Introduction to Engineering Design *N3* | 4 |
| ECE | 210 | Engineering Mechanics I: Statics | 3 |
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| ECE | 312 | Engineering Mechanics II: Dynamics | 3 |
| ECE | 313 | Introduction to Deformable Solids | 3 |
| ECE | 340 | Thermodynamics | 3 |
| ECE | 350 | Structure and Properties of Materials | 3 |

## AEROSPACE ENGINEERING—B.S.E.

The primary concern of aerospace engineers is the design and development of a wide variety of aircraft and space vehicles and systems. The current challenges to the aerospace engineer include the design of a new generation of high efficiency transport aircraft, the development of the next generation of space transports, and the design of large space systems. In addition to the design of vehicles, the aerospace engineer is involved in the further development of the many spin-offs of the aerospace industry. These include contributions to power generation, communications, air and water pollution monitoring, management of the earth's resources, and the understanding of weather. Future contributions are anticipated in the area of zero-gravity manufacturing of high-purity materials and medicines, and the design of solar power satellites.

The undergraduate curriculum includes the study of flight mechanics, aerospace structures and materials, aerodynamics and propulsion. These subjects provide the foundation necessary for design of aircraft and space vehicles.

### Aerospace Engineering Major

Aerospace Engineering students are required to select the following two courses in addition to those required for the major outlined below:

| | | | |
|---|---|---|---|
| MAT | 242 | Linear Algebra *N1* | 2 |
| PHY | 361 | Introductory Modern Physics | 3 |

The Aerospace Engineering major consists of the following courses:

| | | | |
|---|---|---|---|
| ECE | 384 | Numerical Analysis for Engineers I | 2 |
| ECE | 386 | Partial Differential Equations for Engineers | 2 |
| EEE | 350 | Random Signal Analysis | 3 |
| MAE | 317 | Dynamic Systems and Control | 3 |
| MAE | 361 | Aerodynamics I | 3 |
| MAE | 413 | Dynamics of Aerospace Vehicles | 4 |
| MAE | 415 | Vibration Analysis | 4 |
| MAE | 425 | Aerospace Structures | 4 |
| MAE | 441 | Principles of Design | 3 |
| MAE | 460 | Gas Dynamics | 3 |
| MAE | 463 | Propulsion | 3 |
| MAE | 464 | Aerospace Laboratory | 3 |
| MAE | 468 | Aerospace Systems Design *L2* | 3 |
| Area of emphasis (technical electives) | | | 12 |
| Total | | | 52 |

### Aerospace Engineering Areas of Emphasis

Technical electives may be selected from among any of the courses listed below or from courses listed under the Mechanical Engineering areas of emphasis. The courses are grouped so that the student may select an elective package of closely related courses. A student may, with prior approval of the advisor and department, select a general area and a corresponding set of courses not listed below that would support a career objective not covered by the following categories:

*Aerodynamics.* Select from these courses:

MAE 372 Fluid Mechanics .................... 3
MAE 434 Internal Combustion Engines .................................. 3
MAE 435 Turbomachinery .................... 3
MAE 461 Aerodynamics II .................... 3
MAE 463 Propulsion............................. 3
MAE 466 Rotary Wing Aerodynamics and Performance.................... 3
MAE 471 Computational Fluid Dynamics.............................. 3
MAE 490 Projects in Design and Development.................. 3
MAT 466 Applied Computational Methods *N3* .......................... 3

*Aerospace Materials*. Select from these courses:

MAE 455 Polymers and Composites ..... 3
MSE 355 Introduction to Materials Science and Engineering ....... 3
MSE 420 Physical Metallurgy............... 3
MSE 440 Mechanical Properties of Solids................................ 3
MSE 441 Analysis of Material Failures.................... 3
MSE 450 X-Ray and Electron Diffraction ............................ 3
MSE 471 Introduction to Ceramics....... 3

*Aerospace Structures.* Select from these courses:

MAE 404 Finite Elements in Engineering ....................... 3
MAE 426 Design of Aerospace Structures.............................. 3
MAE 455 Polymers and Composites ..... 3
MAE 490 Projects in Design and Development.................. 3

*Computer Methods*. Select from these courses:

ASE 485 Engineering Statistics *N2* ...... 3
CSE 310 Data Structures and Algorithms II ......................... 3
CSE 422 Microprocessor System Design II ............................... 4
CSE 428 Computer-Aided Processes ... 3
IEE 463 Computer-Aided Manufacturing and Control *N3* ............................ 3
IEE 464 Concurrent Engineering ........ 3
IEE 475 Introduction to Simulation .... 3
MAE 404 Finite Elements in Engineering ....................... 3
MAE 406 CAD/CAM Applications in MAE ................................. 3
MAE 471 Computational Fluid Dynamics.............................. 3
MAE 541 CAD Tools for Engineers...... 3
MAT 464 Numerical Analysis I *N3* ....... 3
MAT 465 Numerical Analysis II *N3*...... 3
MAT 466 Applied Computational Methods *N3* .......................... 3

*Design.* Select from these courses:

MAE 341 Mechanism Analysis and Design............................ 3
MAE 404 Finite Elements in Engineering ....................... 3
MAE 406 CAD/CAM Applications in MAE ................................. 3
MAE 435 Turbomachinery .................... 3
MAE 442 Mechanical Systems Design................................... 3
MAE 446 Thermal Systems Design....... 3
MAE 455 Polymers and Composites ..... 3
MAE 466 Rotary Wing Aerodynamics and Performance.................... 3
MAE 467 Aircraft Performance............. 3
MAE 490 Projects in Design and Development.................. 3
MSE 440 Mechanical Properties of Solids................................ 3
MSE 441 Analysis of Material Failures.................... 3

*Mechanical.* Any courses listed under Mechanical Engineering Areas of Emphasis may be selected.

*Propulsion.* Select from these courses:

MAE 382 Thermodynamics.................. 3
MAE 388 Heat Transfer......................... 3
MAE 434 Internal Combustion Engines ................................. 3
MAE 435 Turbomachinery .................... 3
MAE 436 Combustion ........................... 3
MAE 461 Aerodynamics II .................... 3
MAE 465 Rocket Propulsion ................. 3
MAE 466 Rotary Wing Aerodynamics and Performance.................... 3
MAE 471 Computational Fluid Dynamics.............................. 3
MAE 490 Projects in Design and Development.................. 3

*System Dynamics and Control.* Select from these courses:

CSE 428 Computer-Aided Processes ... 3
EEE 480 Feedback Systems ................. 4
EEE 482 Introduction to State Space Methods ...................... 3
MAE 417 Control Systems Design ........ 3
MAE 447 Robotics and Its Influence on Design.............................. 3
MAE 462 Advanced Dynamics and Control of Aerospace Vehicles ................................ 3
MAE 490 Projects in Design and Development.................. 3

### Aerospace Engineering Program of Study Typical Four-Year Sequence

The first two years are usually devoted to General Studies and engineering core requirements. Thus, departmental degree programs share a similar course schedule for that period.

### Program of Study Typical Four-Year Sequence

#### Freshman Year

**First Semester**

CHM 114 General Chemistry for Engineers *S1/S2*..................... 4 or CHM 116 General Chemistry *S1/S2* (4)
ECE 100 Introduction to Engineering Design *N3*............................. 4
ENG 101 First-Year Composition......... 3
MAT 270 Calculus with Analytic Geometry I *N1*....................... 4

Total ........................................................ 15

**Second Semester**

ENG 102 First-Year Composition......... 3
MAT 242 Linear Algebra *N1*................. 2
MAT 271 Calculus with Analytic Geometry II ........................... 4
PHY 121 University Physics I: Mechanics *S1/S2*[1] .................... 3
PHY 122 University Physics Laboratory I *S1/S2*[1] ................ 1
HU, SB, and awareness area course[2] ........... 3

Total ........................................................ 16

#### Sophomore Year

**First Semester**

ECE 210 Engineering Mechanics I: Statics .................................... 3
MAT 272 Calculus with Analytic Geometry III.......................... 4
MAT 274 Elementary Differential Equations............................... 3
PHY 131 University Physics II: Electricity and Magnetism *S1/S2*[3] .................... 3
PHY 132 University Physics Laboratory II *S1/S2*[3] ................ 1
HU, SB, and awareness area course[2] ........... 3

Total ........................................................ 17

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[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 277.

[3] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| ECE | 312 | Engineering Mechanics II: Dynamics | 3 |
| ECE | 313 | Introduction to Deformable Solids | 3 |
| ECE | 340 | Thermodynamics | 3 |
| ECE | 384 | Numerical Analysis | 2 |
| ECE | 386 | Partial Differential Equations for Engineers | 2 |
| Total | | | 16 |

**Junior Year**

**First Semester**

| | | | |
|---|---|---|---|
| ECE | 350 | Structure and Properties of Materials | 3 |
| MAE | 317 | Dynamic Systems and Control | 3 |
| MAE | 361 | Aerodynamics I | 3 |
| MAE | 425 | Aerospace Structures | 4 |
| PHY | 361 | Introductory Modern Physics | 3 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| EEE | 350 | Random Signal Analysis | 3 |
| MAE | 413 | Dynamics of Aerospace Vehicles | 4 |
| MAE | 441 | Principles of Design | 3 |
| MAE | 460 | Gas Dynamics | 3 |
| HU, SB, and awareness area course[2] | | | 3 |
| Total | | | 16 |

**Senior Year**

**First Semester**

| | | | |
|---|---|---|---|
| MAE | 415 | Vibration Analysis | 4 |
| MAE | 463 | Propulsion | 3 |
| HU, SB, and awareness area course[2] | | | 3 |
| Technical electives | | | 6 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| MAE | 464 | Aerospace Laboratory | 3 |
| MAE | 468 | Aerospace Systems Design *L2* | 3 |
| HU, SB, and awareness area course(s)[2] | | | 4 |
| Technical electives | | | 6 |
| Total | | | 16 |

[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 277.

[3] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

## MECHANICAL ENGINEERING—B.S.E.

Mechanical engineering is a creative discipline that draws upon a number of basic sciences to design the devices, machines, processes, and systems that involve mechanical work and its conversion from and into other forms. It includes: the conversion of thermal, chemical, and nuclear energy into mechanical energy through various engines and power plants; the transport of energy via devices like heat exchangers, pipelines, gears, and linkages; the use of energy to perform a variety of tasks for the benefit of society, such as in transportation vehicles of all types, manufacturing tools and equipment, and household appliances. Furthermore, since all manufactured products must be constructed of solid materials and because most products contain parts that transmit forces, Mechanical Engineering is involved in the structural integrity and materials selection for almost every product on the market.

Mechanical engineers are employed in virtually every kind of industry. They are involved with seeking new knowledge through research, with doing creative design and development, and with the construction, control, management, and sales of the devices and systems needed by society. Therefore, a major strength of a mechanical engineering education is the flexibility it provides in future employment opportunities for its graduates.

The undergraduate curriculum includes the study of: the principles governing the use of energy; the principles of design, instruments and control devices; and the application of these studies to the creative solution of practical, modern problems.

### Mechanical Engineering Major

Mechanical Engineering students are required to select the following supplemental courses:

| | | | |
|---|---|---|---|
| ECE | 301 | Electrical Networks | 4 |
| ECE | 384 | Numerical Analysis for Engineers I | 2 |
| ECE | 386 | Partial Differential Equations for Engineers | 2 |
| EEE | 350 | Random Signal Analysis | 3 |
| MAT | 242 | Elementary Linear Algebra *N1* | 2 |
| PHY | 361 | Introductory Modern Physics | 3 |

The Mechanical Engineering major requires the following departmental courses:

| | | | |
|---|---|---|---|
| MAE | 317 | Dynamic Systems and Control | 3 |
| MAE | 318 | Dynamic Systems and Control Laboratory | 1 |
| MAE | 371 | Fluid Mechanics | 3 |
| MAE | 388 | Heat Transfer | 3 |
| MAE | 422 | Mechanics of Materials | 4 |
| MAE | 441 | Principles of Design | 3 |
| MAE | 443 | Engineering Design | 3 |
| MAE | 490 | Projects in Design and Development *L2* | 3 |
| MAE | 491 | Experimental Mechanical Engineering | 3 |
| Area of emphasis (technical electives) | | | 15 |
| Total | | | 57 |

### Areas of Emphasis

Technical electives may be selected from among any of the courses listed below or from courses listed under the Aerospace Engineering areas of emphasis. The courses are grouped to assist a student in assembling an elective package of closely related courses. Students preferring a broader technical background may choose courses from different areas. With prior approval of the advisor and department, a student may select a general area and a corresponding set of courses not listed below that would support a career objective not covered by the following categories:

*Aerospace.* Any courses listed under Aerospace Engineering areas of emphasis may be selected.

*Biomechanical.* Select from these courses (BME 517 is recommended):

| | | | |
|---|---|---|---|
| BME | 411 | Biomedical Engineering I | 3 |
| BME | 412 | Biomedical Engineering II | 3 |
| BME | 416 | Biomechanics | 3 |
| BME | 419 | Biocontrol Systems | 3 |
| BME | 517 | Medical Transport Devices I | 3 |
| EEE | 302 | Electrical Networks II | 3 |
| EEE | 434 | Quantum Mechanics for Engineers | 3 |

*Computer Methods.* Select from these courses:

| | | | |
|---|---|---|---|
| ASE | 485 | Engineering Statistics *N2* | 3 |
| CSE | 310 | Data Structures and Algorithms II | 3 |
| CSE | 422 | Microprocessor System Design II | 4 |
| CSE | 428 | Computer-Aided Processes | 3 |
| IEE | 463 | Computer-Aided Manufacturing and Control *N3* | 3 |
| IEE | 464 | Concurrent Engineering | 3 |
| IEE | 475 | Introduction to Simulation *N3* | 3 |
| MAE | 404 | Finite Elements in Engineering | 3 |
| MAE | 406 | CAD/CAM Applications in MAE | 3 |
| MAE | 471 | Computational Fluid Dynamics | 3 |
| MAE | 541 | CAD Tools for Engineers | 3 |
| MAT | 464 | Numerical Analysis I *N3* | 3 |
| MAT | 465 | Numerical Analysis II *N3* | 3 |

MAT 466 Applied Computational Methods *N3* .......... 3

*Control and Dynamic Systems.* Select from these courses:

CSE 428 Computer-Aided Processes ...3
EEE 360 Energy Conversion and Transport..........4
IEE 463 Computer-Aided Manufacturing and Control *N3* .......... 3
MAE 413 Dynamics of Aerospace Vehicles ..........4
MAE 417 Control System Design..........3
MAE 462 Advanced Dynamics and Contol of Aerospace Vehicles ..........3
MAE 467 Aircraft Performance..........3

*Design.* Select from these courses:

MAE 341 Mechanism Analysis and Design..........3
MAE 351 Manufacturing Processes Survey..........3
MAE 404 Finite Elements in Engineering ..........3
MAE 406 CAD/CAM Applications in MAE ..........3
MAE 413 Dynamics of Aerospace Vehicles ..........4
MAE 417 Control System Design..........3
MAE 434 Internal Combustion Engines ..........3
MAE 435 Turbomachinery ..........3
MAE 438 Solar Energy..........3
MAE 442 Mechanical Systems Design..3
MAE 446 Thermal Systems Design.......3
MAE 447 Robotics and Its Influence on Design..........3
MAE 462 Advanced Dynamics and Control of Aerospace Vehicles ..........3
MAE 467 Aircraft Performance..........3

*Energy Systems.* Select from these courses:

EEE 360 Energy Conversion and Transport..........4
MAE 372 Fluid Mechanics ..........3
MAE 382 Thermodynamics..........3
MAE 430 Introduction to Nuclear Engineering..........3
MAE 434 Internal Combustion Engines ..........3
MAE 435 Turbomachinery ..........3
MAE 436 Combustion ..........3
MAE 437 Direct Energy Conversion.....3
MAE 438 Solar Energy..........3
MAE 446 Thermal Systems Design.......3

*Engineering Mechanics.* Select from these courses:

MAE 341 Mechanism Analysis and Design..........3
MAE 402 Introduction to Continuum Mechanics..........3
MAE 404 Finite Elements in Engineering ..........3
MAE 413 Dynamics of Aerospace Vehicles ..........4
MAE 415 Vibration Analysis..........4
MAE 426 Design of Aerospace Structures..........3
MAE 442 Mechanical Systems Design..3
MAE 460 Gas Dynamics ..........3
MAE 461 Aerodynamics II ..........3
MAE 471 Computational Fluid Dynamics..........3
MAT 464 Numerical Analysis I *N3* ....... 3
MAT 466 Applied Computational Methods *N3* .......... 3
MSE 440 Mechanical Properties of Solids..........3

*Manufacturing.* Select from these courses:

CSE 428 Computer-Aided Processes ...3
IEE 300 Economic Analysis for Engineers ..........3
IEE 374 Quality Control *N2* .......... 3
IEE 461 Integrated Production Control..........3
IEE 463 Computer-Aided Manufacturing and Control *N3* .......... 3
MAE 341 Mechanism Analysis and Design..........3
MAE 351 Manufacturing Processes Survey..........3
MAE 404 Finite Elements in Engineering ..........3
MAE 442 Mechanical Systems Design..3
MAE 447 Robotics and Its Influence on Design..........3
MAE 455 Polymers and Composites .....3
MSE 355 Introduction to Materials Science and Engineering .......3
MSE 420 Physical Metallurgy..........3
MSE 431 Corrosion and Corrosion Control..........3
MSE 440 Mechanical Properties of Solids..........3

*Stress Analysis, Failure Prevention, and Materials.* Select from these courses:

MAE 341 Mechanism Analysis and Design..........3
MAE 404 Finite Elements in Engineering ..........3
MAE 426 Design of Aerospace Structures..........3
MAE 447 Robotics and Its Influence on Design..........3
MAE 455 Polymers and Composites .....3
MSE 355 Introduction to Materials Science and Engineering .......3
MSE 420 Physical Metallurgy..........3
MSE 431 Corrosion and Corrosion Control..........3
MSE 440 Mechanical Properties of Solids..........3
MSE 450 X-Ray and Electron Diffraction ..........3

*Thermosciences.* Select from these courses:

MAE 336 Air Conditioning and Refrigeration..........3
MAE 372 Fluid Mechanics ..........3
MAE 382 Thermodynamics..........3
MAE 430 Introduction to Nuclear Engineering..........3
MAE 434 Internal Combustion Engines ..........3
MAE 435 Turbomachinery ..........3
MAE 436 Combustion ..........3
MAE 437 Direct Energy Conversion.....3
MAE 438 Solar Energy..........3
MAE 446 Thermal Systems Design.......3
MAE 460 Gas Dynamics ..........3
MAE 463 Propulsion..........3
MAE 471 Computational Fluid Dynamics..........3

## Mechanical Engineering Program of Study Typical Four-Year Sequence

### Freshman Year

**First Semester**

CHM 114 General Chemistry for Engineers *S1/S2*.......... 4 or CHM 116 General Chemistry *S1/S2* (4)
ECE 100 Introduction to Engineering Design *N3*.......... 4
ENG 101 First-Year Composition..........3
MAT 270 Calculus with Analytical Geometry I *N1*.......... 4

Total ..........15

**Second Semester**

ENG 102 First-Year Composition..........3
MAT 242 Linear Algebra *N1*.......... 2
MAT 271 Calculus with Analytical Geometry II ..........4
PHY 121 University Physics I: Mechanics *S1/S2*[1] .......... 3
PHY 122 University Physics Laboratory I *S1/S2*[1] .......... 1
HU, SB, and awareness area courses[2] .......... 3

Total ..........16

[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 277.

**NOTE**: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

### Sophomore Year

**First Semester**

| | | | |
|---|---|---|---|
| ECE | 210 | Engineering Mechanics I: Statics | 3 |
| ECE | 350 | Structure and Properties of Materials | 3 |
| MAT | 272 | Calculus with Analytical Geometry III | 4 |
| MAT | 274 | Elementary Differential Equations | 3 |
| PHY | 131 | University Physics II: Electricity and Magnetism *S1/S2*[3] | 3 |
| PHY | 132 | University Physics Laboratory II *S1/S2*[3] | 1 |
| Total | | | 17 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 301 | Electrical Networks I | 4 |
| ECE | 312 | Engineering Mechanics II: Dynamics | 3 |
| ECE | 313 | Introduction to Deformable Solids | 3 |
| ECE | 340 | Thermodynamics | 3 |
| ECE | 386 | Partial Differential Equations for Engineers | 2 |
| Total | | | 15 |

### Junior Year

**First Semester**

| | | | |
|---|---|---|---|
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| MAE | 317 | Dynamic Systems and Controls | 3 |
| MAE | 318 | Dynamic Systems and Controls Laboratory | 1 |
| MAE | 371 | Fluid Mechanics | 3 |
| MAE | 422 | Mechanics of Materials | 4 |
| HU, SB, and awareness area course[2] | | | 3 |
| Total | | | 17 |

**Second Semester**

| | | | |
|---|---|---|---|
| ECE | 384 | Numerical Analysis for Engineers | 2 |
| EEE | 350 | Random Signal Analysis | 3 |
| MAE | 388 | Heat Transfer | 3 |
| MAE | 441 | Design Theory and Techniques | 3 |
| HU, SB, and awareness area course[2] | | | 3 |
| Technical elective | | | 3 |
| Total | | | 17 |

### Senior Year

**First Semester**

| | | | |
|---|---|---|---|
| MAE | 491 | Experimental Mechanical Engineering | 3 |
| PHY | 361 | Introductory Modern Physics | 3 |
| HU, SB, and awareness area course[2] | | | 4 |
| Technical electives | | | 6 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| MAE | 443 | Engineering Design | 3 |
| MAE | 490 | Projects in Design and Development *L2* | 3 |
| HU, SB, and awareness area course[2] | | | 3 |
| Technical electives | | | 6 |
| Total | | | 15 |

[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 277.

[3] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

## MECHANICAL AND AEROSPACE ENGINEERING

**MAE 317 Dynamic Systems and Control.** (3) F, S
Modeling and representations of dynamic physical systems, including transfer functions, block diagrams, and state equations. Transient response. Principles of feedback control and linear system analysis, including root locus and frequency response. Prerequisite: ECE 312. Corequisite for Mechanical Engineering majors only: MAE 318. Pre- or corequisite: ECE 386.

**318 Dynamic Systems and Control Lab.** (1) F, S
Series of labs designed to illustrate concepts presented in MAE 317. Lab. Corequisite: MAE 317 for Mechanical Engineering majors only.

**336 Air Conditioning and Refrigeration.** (3) A
Refrigeration cycles, refrigerant properties, heating, and cooling loads; psychrometry and purification; temperature and humidity control. Prerequisite: MAE 388 or MET 432 or instructor approval.

**341 Mechanism Analysis and Design.** (3) A
Positions, velocities, and accelerations of machine parts; cams, gears, flexible connectors, and rolling contact; introduction to synthesis. Prerequisite: ECE 312.

**351 Manufacturing Processes Survey.** (3) A
Production techniques and equipment. Casting and molding, pressure forming, material removal, joining and assembly processes, automation, and material handling. Lecture, recitation. Prerequisite: ECE 350.

**361 Aerodynamics I.** (3) A
Fluid statics, conservation principles, stream function, velocity potential, vorticity, inviscid flow, Kutta-Joukowski, thin-airfoil theory, and panel methods. Prerequisites: ECE 312, 340.

**371 Fluid Mechanics.** (3) F, S
Introductory concepts of fluid motions; fluid statics; control volume forms of basic principles; viscous internal flows. Prerequisites: ECE 312, 340.

**372 Fluid Mechanics.** (3) A
Application of basic principles of fluid mechanics to problems in viscous and compressible flow. Prerequisites: ECE 384, 386; MAE 361 or 371.

**382 Thermodynamics.** (3) A
Applied thermodynamics; gas mixtures, psychrometrics, property relationships, power and refrigeration cycles, and reactive systems. Prerequisite: ECE 340.

**388 Heat Transfer.** (3) F, S
Steady and unsteady heat conduction, including numerical solutions; thermal boundary layer concepts and applications to free and forced convection. Thermal radiation concepts. Prerequisite: MAE 361 or 371.

**402 Introduction to Continuum Mechanics.** (3) A
Application of the principles of continuum mechanics to such fields as flow in porous media, biomechanics, electromagnetic continua, and magneto-fluid mechanics. Prerequisites: ECE 313; MAE 361 or 371; MAT 242 or 342.

**404 Finite Elements in Engineering.** (3) A
Introduction to ideas and methodology of finite element analysis. Applications to solid mechanics, heat transfer, fluid mechanics, and vibrations. Prerequisites: ECE 313; MAT 242 or 342.

**406 CAD/CAM Applications in MAE.** (3) A
Solution of engineering problems with the aid of state-of-the-art software tools in solid modeling, engineering analysis, and manufacturing; selection of modeling parameters; reliability tests on software. Prerequisite: instructor approval.

**413 Dynamics of Aerospace Vehicles.** (4) A
Rigid body kinematics and dynamics, satellite orbits and maneuvers. Aircraft performance, static and dynamic stability, longitudinal motion and stability derivatives. Prerequisites: ECE 312; MAT 242 or 342.

**415 Vibration Analysis.** (4) F, S
Free and forced response of single and multiple degree of freedom systems, continuous systems; applications in mechanical and aerospace systems numerical methods. Lecture, lab. Prerequisites: ECE 312; MAE 422 or 425; MAT 242 or 342.

**417 Control System Design.** (3) A
Tools and methods of control system design and compensation, including simulation, response optimization, frequency domain techniques, state variable feedback, and sensitivity analysis. Introduction to nonlinear and discrete time systems. Prerequisite: MAE 317.

**422 Mechanics of Materials.** (4) F, S
Failure theories, energy methods, finite element methods, plates, torsion of noncircular members, unsymmetrical bending, shear center, and beam column. Lecture, lab. Prerequisites: ECE 313; MAT 242 or 342. Pre- or corequisite: ECE 386.

**425 Aerospace Structures.** (4) A
Stability, energy methods, finite element methods, torsion, unsymmetrical bending and torsion of multicelled structures, design of aerospace structures. Lecture, lab. Prerequisites: ECE 313; MAT 242 or 342.

**426 Design of Aerospace Structures.** (3) A
Flight vehicle loads, design of semi-monocoque structures, local buckling and crippling, fatigue, aerospace materials, composites, joints, and finite element applications. Prerequisites: MAE 361, 425.

**430 Introduction to Nuclear Engineering.** (3) A
Neutron interactions with matter. Principles of neutron chain reacting systems. Neutron diffusion and moderation. Heat removal from nuclear reactors. Point reactor kinetics. Prerequisite: PHY 361.

**434 Internal Combustion Engines.** (3) A
Performance characteristics, combustion, carburetion and fuel-injection, and the cooling and control of internal combustion engines. Computer modeling. Lab. Prerequisite: MAE 388.

**435 Turbomachinery.** (3) A
Design and performance of turbomachines, including steam, gas and hydraulic turbines, centrifugal pumps, compressors, fans, and blowers. Pre- or corequisite: MAE 361 or 371.

**436 Combustion.** (3) A
Thermochemical and reaction rate processes; combustion of gaseous and condensed-phase fuels. Applications to propulsion and heating systems. Pollutant formation. Prerequisite: MAE 388.

**437 Direct Energy Conversion.** (3) N
Unconventional methods of energy conversion; fuel cells, thermoelectrics, thermionics, photovoltaics, and magnetohydrodynamics. Prerequisites: ECE 340, 350.

**438 Solar Energy.** (3) A
Solar radiation and instrumentation, design and testing of collectors, performance analyses of systems, thermal storage, photovoltaics, materials, and economic analysis. Prerequisite: MAE 388.

**441 Principles of Design.** (3) F, S
Conceptual and embodiment design of mechanical elements; form synthesis; material selection, failure modes, manufacturability tolerances, common mechanisms and machine elements. Prerequisites: ECE 300, 313, 350.

**442 Mechanical Systems Design.** (3) A
Application of design principles and techniques to the synthesis, modeling, and optimization of mechanical, electromechanical, and hydraulic systems. Prerequisites: MAE 422 (or 425), 441.

**443 Engineering Design.** (3) F, S
Group projects to design engineering components and systems. Problem definition ideation, modeling, and analysis; decision making and documentation activities emphasized. 6 hours lab. Prerequisite: MAE 441.

**446 Thermal Systems Design.** (3) A
Application of engineering principles and techniques to the modeling and analysis of thermal systems and components. Optimization techniques are presented and their use demonstrated. Prerequisite: ECE 300; MAE 388.

**447 Robotics and Its Influence on Design.** (3) A
Robot applications, configurations, singular positions, and work space; modes of control; vision; programming exercises; design of parts for assembly. Prerequisite: MAE 317.

**455 Polymers and Composites.** (3) F
Relationship between chemistry, structure, and properties of engineering polymers. Design, properties, and behavior of fiber composite systems. Cross-listed as MSE 470. Prerequisite: ECE 350.

**460 Gas Dynamics.** (3) A
Compressible flow at subsonic and supersonic speeds; duct flow; normal and oblique shocks, perturbation theory, and wind tunnel design. Prerequisite: MAE 361 or 371.

**461 Aerodynamics II.** (3) A
Transonic/hypersonic flows, wing theory, Navier-Stokes, laminar/turbulent shear flows, pressure drop in tubes, separation, drag, viscous/inviscid interaction, and wing design. Prerequisite: MAE 460.

**462 Advanced Dynamics and Control of Aerospace Vehicles.** (3) A
Spacecraft attitude dynamics and control. Aircraft lateral-directional motion and stability derivatives, aircraft control systems. Lecture, design projects. Prerequisites: MAE 317, 413.

**463 Propulsion.** (3) F, S
Fundamentals of gas-turbine engines and design of components. Principles and design of rocket propulsion and alternative devices. Lecture, design projects. Pre- or corequisite: MAE 361 or 371.

**464 Aerospace Laboratory.** (3) F, S
Aeordynamic flow parameters; flow over airfoils and bodies of revolution; flow visualization; computer-aided data acquisition and processing; boundary layer theory. 1 hour lecture, 4 hours lab. Prerequisites: MAE 361, 460.

**465 Rocket Propulsion.** (3) A
*Effective through fall 1996.*
Rocket flight performance; nozzle design; combustion of liquid and solid propellants; component design; advanced propulsion systems; interplanetary missions; testing. Prerequisite: MAE 460.

**465 Rocket Propulsion.** (3) A
*Effective starting spring 1997.*
Rocket flight performance; nozzle design; combustion of liquid and solid propellants; component design; advanced propulsion systems; interplanetary missions; testing. Prerequisite: MAE 361 or 371.

**466 Rotary Wing Aerodynamics and Performance.** (3) A
Introduction to helicopter and propeller analysis techniques. Momentum, blade-element, and vortex methods. Hover and forward flight. Ground effect, autorotation, and compressibility effects. Prerequisites: ECE 386; MAE 361 or instructor approval.

**467 Aircraft Performance.** (3) A
Integration of aerodynamic and propulsive forces into aircraft performance design. Estimation of drag parameters for design. Engine, airfoil selection. Conceptual design methodology. Lecture, design projects. Prerequisite: MAE 361 or 371. Pre- or corequisite: MAE 441.

**468 Aerospace Systems Design.** (3) F, S
Group projects related to aerospace vehicle design, working from mission definition and continuing through preliminary design. Prerequisites: MAE 361, 413, 463. *General Studies: L2.*

**471 Computational Fluid Dynamics.** (3) A
Numerical solutions for selected problems in fluid mechanics. Prerequisites: ECE 384; MAE 361 or 371.

**490 Projects in Design and Development.** (3) F, S
Capstone projects in fundamental or applied aspects of engineering. Prerequisites: MAE 441, 491. *General Studies: L2.*

**491 Experimental Mechanical Engineering.** (3) F, S
Experimental and analytical studies of phenomena and performance of fluid flow, heat transfer, thermodynamics, refrigeration, and mechanical power systems. 6 hours lab. Prerequisites: EEE 350; MAE 388.

**498 Pro-Seminar.** (1–3) N
Special topics for advanced students. Application of the engineering disciplines to design and analysis of modern technical devices and systems. Prerequisite: instructor approval.

**504 Laser Diagnostics.** (3) S
Fundamentals of optics and the interaction of light with matter. Laser sources, laser spectroscopy, velocimetry, particle sizing, and surface characterization.

**505 Perturbation Methods in Mechanics.** (3) N
Nonlinear oscillations, strained coordinates, renormalization, multiple scales, boundary layers, matched asymptotic expansions, turning point problems, and WKBJ method.

**506 Advanced System Modeling, Dynamics, and Control.** (3) S
Lumped-parameter modeling of physical systems with examples. State variable representations and dynamic response. Introduction to modern control. Prerequisite: ASE 582 or MAT 442.

**507 Optimal Control Theory and Application.** (3) F
Optimal control of physical systems. Calculus of variations, Pontryagin's principle, minimum time/fuel problems, linear quadratic regulator, and numerical methods. Prerequisite: MAE 506.

**509 Robust Multivariable Control.** (3) S
Characterization of uncertainty in feedback systems, robustness analysis, synthesis techniques, multivariable Nyquist criteria, computer-aided analysis and design. Prerequisites: MAE 417, 506.

**510 Dynamics and Vibrations.** (3) F
Lagrange's and Hamilton's equations, rigid body dynamics, gyroscopic motion, and small oscillation theory.

**511 Acoustics.** (3) F
Principles underlying the generation, transmission, and reception of acoustic waves. Applications to noise control, architectural acoustics, random vibrations, and acoustic fatigue.

**512 Random Vibrations.** (3) S
Review of probability theory, random processes, stationarity, power spectrum, white noise process, random response of single and multiple DOF systems, and Markov processes simulation. Prerequisite: MAE 510 or instructor approval.

**515 Structural Dynamics.** (3) S
Free vibration and forced response of discrete and continuous systems, exact and approximate methods of solution, finite element modeling, and computational techniques. Prerequisite: MAE 510 or instructor approval.

**517 Nonlinear Oscillations.** (3) F
Existence, stability, and bifurcation of solutions of nonlinear dynamical systems. Methods of analysis of regular and chaotic responses. Prerequisite: MAE 510 or instructor approval.

**518 Dynamics of Rotor-Bearing Systems.** (3) S
Natural whirl frequency, critical speed, and response analysis of rigid and flexible rotor systems. Bearing influence and representation. Stability analysis. Methods of balancing.

**520 Solid Mechanics.** (3) F
Introduction to tensors: kinematics, kinetics, and constitutive assumptions leading to elastic, plastic, and viscoelastic behavior. Applications.

**522 Variational Principles of Mechanics.** (3) S
Virtual work, stationary, and complementary potential energies. Hamilton's principle. Application of these and direct methods to vibrations, elasticity, and stability. Prerequisite: MAE 520 or equivalent.

**523 Theory of Plates and Shells.** (3) F
Linear and nonlinear theories of plates. Membrane and bending theories of shells. Shells of revolution. Prerequisite: MAE 520.

**524 Theory of Elasticity.** (3) S
Formulation and solution of 2- and 3-dimensional boundary value problems. Prerequisite: MAE 520.

**527 Finite Element Methods in Engineering Science.** (3) F
Discretization, interpolation, elemental matrices, assembly, and computer implementation. Application to solid and fluid mechanics, heat transfer, and time dependent problems. Prerequisite: ASE 582.

**536 Combustion.** (3) N
Thermodynamics; chemical kinetics of combustion. Explosion and ignition theories. Reactive gas dynamics. Structure, propagation, and stability of flames. Experimental methods. Prerequisite: MAE 436 or instructor approval.

**540 Advances in Engineering Design Theory.** (3) F
Survey of research in engineering design process, artifact and design, knowledge, formal and informal logic, heuristic and numerical searches, theory of structure and complexity. Prerequisite: graduate standing.

**541 CAD Tools for Engineers.** (3) F
Elements of computer techniques required to develop CAD software. Data structures, including lists, trees, and graphs. Computer graphics, including 2- and 3-dimensional algorithms and user interface techniques.

**542 Geometric Modeling in CAD/CAM.** (3) S
Geometric and solid modeling, curve and surface design, CAD database architectures, and integration of solid modeling into engineering processes. Prerequisite: MAE 541 or instructor approval.

**544 Mechanical Design and Failure Prevention.** (3) F
Modes of mechanical failure; application of principles of elasticity and plasticity in multiaxial state of stress to design synthesis; failure theories; fatigue; creep; impact. Prerequisite: MAE 443.

**546 CAD/CAM Applications in MAE.** (3) F
Solution of engineering problems with the aid of state-of-the-art software tools in solid modeling, engineering analysis, and manufacturing; selection of modeling parameters; reliability tests on software. Open only to students without previous credit for MAE 406 or with instructor approval.

**547 Mechanical Design and Control of Robots.** (3) N
Homogeneous transformations, 3-dimensional kinematics, geometry of motion, forward and inverse kinematics, workspace and motion trajectories, dynamics, control, and static forces.

**548 Mechanism Synthesis and Analysis.** (3) S
Algebraic and graphical methods for exact and approximate synthesis of cam, gear, and linkage mechanisms; design optimization; methods of planar motion analysis; characteristics of plane motion; spatial kinematics.

**557 Mechanics of Composite Materials.** (3) S
Analysis of composite materials and applications. Micromechanical and macromechanical behavior. Classical lamination theory developed with investigation of bending-extension coupling.

**560 Propulsion Systems.** (3) N
Design of air-breathing gas turbine engines for aircraft propulsion; mission analysis; cycle analysis; engine sizing; component design.

**561 Computational Fluid Dynamics.** (3) S
Finite-difference and finite-volume techniques for solving the subsonic, transonic, and supersonic flow equations. The method of characteristics. Numerical grid-generation techniques. Prerequisite: MAE 571 or instructor approval.

**563 Unsteady Aerodynamics.** (3) S
Unsteady incompressible and compressible flow. Wings and bodies in oscillatory and transient motions. Kernel function approach and panel methods. Aeroelastic applications. Prerequisite: MAE 460 or 461.

**564 Advanced Aerodynamics.** (3) F
Perturbation method. Linearized subsonic and supersonic flows. Thin wing/slender body theories. Lifting surface theory. Panel method computation. Prerequisite: MAE 460 or 461.

**565 Turbomachinery.** (3) N
Design and performance of turbomachines, including turbines, compressors, pumps, fans, and blowers.

**566 Rotary-Wing Aerodynamics.** (3) F
Introduction to helicopter and propeller analysis techniques. Momentum, blade-element, and vortex methods. Hover and forward flight. Ground effect, autorotation, and compressiblilty effects. Prerequisite: MAE 361.

**571 Fluid Mechanics.** (3) F
Basic kinematic, dynamic, and thermodynamic equations of the fluid continuum and their application to basic fluid models.

**572 Inviscid Fluid Flow.** (3) S
Mechanics of fluids for flows in which the effects of viscosity may be ignored. Potential flow theory, waves, and inviscid compressible flows. Prerequisite: MAE 571.

**573 Viscous Fluid Flow.** (3) F
Mechanics of fluids for flows in which the effects of viscosity are significant. Exact and approximate solutions of the Navier-Stokes system, laminar flow at low and high Reynolds number. Prerequisite: MAE 571.

**575 Turbulent Shear Flows.** (3) F
Homogeneous, isotropic, and wall turbulence. Experimental results. Introduction to turbulent-flow calculations. Prerequisite: MAE 571.

**577 Turbulent Flow Modeling.** (3) S
Reynolds equations and their closure. Modeling of simple and complex turbulent flows, calculations of internal and external flows, and application to engineering problems. Prerequisite: MAE 571.

**581 Thermodynamics.** (3) F
Basic concepts and laws of classical equilibrium thermodynamics. Applications to engineering systems.

**582 Statistical Thermodynamics.** (3) N
Kinetic and quantum theory. Statistical mechanics; ensemble theory. Structure and thermodynamics of non-interacting and interacting particles. Boltzmann integro-differential equation. Cross-listed as MSE 531. Prerequisite: MAE 581.

**585 Conduction Heat Transfer.** (3) F
Basic equations and concepts of conduction heat transfer. Mathematical formulation and solution (analytical and numerical) of steady and unsteady, one- and multidimensional heat conduction and phase change problems. Prerequisites: ECE 386; MAE 388.

**586 Convection Heat Transfer.** (3) S
Basic concepts and governing equations. Analysis of laminar and turbulent heat transfer for internal and external flows. Natural and mixed convection. Prerequisite: MAE 388.

**587 Radiation Heat Transfer.** (3) F
Advanced concepts and solution methodologies for radiation heat transfer, including exchange of thermal radiation between surfaces, radiation in absorbing, emitting, and scattering media and radiation combined with conduction and convection. Prerequisite: MAE 388.

**588 Two-Phase Flows and Boiling Heat Transfer.** (3) S
Pool and flow boiling heat transfer, condensation heat transfer, various models of vapor-liquid mixture flows, gas-solid mixture flows, and experimental measurement techniques.

**589 Heat Transfer.** (3) F
Basic concepts; physical and mathematical models for heat transfer. Applications to conductive, convective, radiative, and combined mode heat transfer. Prerequisite: MAE 388.

**594 Graduate Research Conference.** (1) F, S
Topics in contemporary research. Required every semester of all departmental graduate students registered for 9 or more semester hours. Not for degree credit.

**598 Special Topics.** (1–3) F, S
Special topics courses, including the following, which are regularly offered, are open to qualified students:

(a) Boundary Layer Stability
(b) Polymers and Composites
(c) Hydrodynamic Stability
(d) Advanced Spacecraft Control
(e) Plasticity
(f) Aeroelasticity
(g) Aerospace Vehicle Guidance and Control

# Programs in Engineering Special Studies

**Daniel F. Jankowski**
***Director***

The programs leading to the B.S.E. degree in Engineering Special Studies are administered by the Dean of the College of Engineering and Applied Sciences.

## PURPOSE

The major of Engineering Special Studies accommodates students whose educational objectives require more intensity of concentration on a particular subject or more curricular flexibility within an engineering discipline than the traditional departmental majors generally permit. The major is a School of Engineering program. Unlike the departmental major areas, however, there is not a separate faculty. The faculty teaching and advising in these programs are from the various departments within the School of Engineering.

For many students, engineering studies form the basis of preparation for professional engineering work where proficiency in the application of science and the physical and social technologies is brought to bear on problems of a large scope. The necessary breadth that these students seek often is not obtainable in traditional engineering fields. Rather, specially designed programs of course work that merge the required principles and approaches drawn from all fields of engineering and other pertinent disciplines are desired.

The B.S.E. in Engineering Special Studies is designed primarily for students intending to pursue engineering careers at a professional level in industry or graduate studies.

The curriculum leading to the B.S.E. degree is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET) under the non-traditional program criteria.

## ENGINEERING SPECIAL STUDIES—B.S.E.

**Manufacturing Engineering.** This program option is offered by the Department of Industrial and Management Systems Engineering. See page 309 for program requirements.

**Pre-medical Engineering.** In the past decade, the interrelation between engineering and medicine has become vigorous and exciting. Our rapidly expanding technology dictates that engineering will continue to become increasingly involved in all branches of medicine. As this develops, so will the need for physicians trained in the engineering sciences—medical men and women with a knowledge of computer technology, transport phenomena, biomechanics, bioelectric phenomena, operations research, and cybernetics. This option is of special interest to students desiring entry into a medical college and whose medical interests lie in research, aerospace and undersea medicine, artificial organs, prostheses, biomedical engineering, or biophysics. Since both engineering and medicine have as their goal the well-being of humans, this program is compatible with any field of medical endeavor.

*Academic Requirements.* The following courses are required in the pre-medical engineering option and have been selected to meet all university and ABET accreditation requirements.

*Note:* To fulfill medical school admission requirements, BIO 182 General Biology is also required in addition to the degree requirements.

**First-Year Composition** (6)

ENG 101, 102 First-Year Composition ..6

**General Studies/Department Requirements** (45)

Humanities and Fine Arts and Social and Behavioral Sciences................16
- ECN 111 Macroeconomic Principles *SB* (3) or ECN 112 Microeconomic Principles *SB* (3)
- HU/SB electives (13)

Natural and Basic Sciences ........................8
- PHY 121 University Physics I: Mechanics *S1/S2*[1] (3)
- PHY 122 University Physics Laboratory I *S1/S2*[1] (1)
- PHY 131 University Physics II: Electricity and Magnitism *S1/S2*[2] (3)
- PHY 132 University Physics Laboratory II *S1/S2*[2] (1)

Numeracy/Mathematics...........................21
- ECE 100 Introduction to Engineering Design *N3* (4)
- MAT 270 Calculus with Analytical Geometry I *N1* (4)
- MAT 271 Calculus with Analytical Geometry II (4)
- MAT 272 Calculus with Analytical Geometry III (4)
- MAT 274 Elementary Differential Equations (3)
- Math Elective (2)

**Engineering Core** (20)

| | | | |
|---|---|---|---|
| ECE | 210 | Engineering Mechanics I: Statics | 3 |
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| ECE | 301 | Electrical Networks I | 4 |
| ECE | 334 | Electronic Devices and Instrumentation | 4 |
| ECE | 340 | Thermodynamics | 3 |
| ECE | 350 | Structure and Properties of Materials | 3 |

**Major** (57)

| | | | |
|---|---|---|---|
| BIO | 181 | General Biology *S1/S2* | 4 |
| BME | 201 | Introduction to Bioengineering *L1* | 3 |
| BME | 318 | Biomaterials | 3 |
| BME | 331 | Biomedical Engineering Transport I: Fluids | 3 |
| BME | 334 | Bioengineering Heat and Mass Transfer | 3 |
| BME | 413 | Biomedical Instrumentation *L2* | 3 |
| BME | 416 | Biomechanics | 3 |
| BME | 417 | Biomedical Engineering Capstone Design I | 3 |
| BME | 423 | Biomedical Instrumentation Laboratory *L2* | 1 |
| BME | 435 | Physiology for Engineers | 4 |
| BME | 470 | Microcomputer Applications in Bioengineering | 4 |
| BME | 490 | Biomedical Engineering Capstone Design II | 1–5 |
| CHM | 113 | General Chemistry *S1/S2* | 4 |
| CHM | 116 | General Chemistry *S1/S2* | 4 |
| CHM | 331 | General Organic Chemistry | 3 |
| CHM | 332 | General Organic Chemistry | 3 |
| CHM | 335 | General Organic Chemistry Laboratory | 1 |
| CHM | 336 | General Organic Chemistry Laboratory | 1 |
| ECE | 380 | Probability and Statistics for Engineering Problem Solving | 3 |

Total ......................................................128

[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

**NOTE**: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 71–94. For graduation requirements, see pages 66–70. Omnibus courses are offered that are not listed in the catalog; see pages 44–45.

## Pre-medical Engineering
## Program of Study
## Typical Four-Year Sequence

### First Year

**First Semester**

| | | | |
|---|---|---|---|
| CHM | 113 | General Chemistry *S1/S2* | 4 |
| ECE | 100 | Introduction to Engineering Design *N3* | 4 |
| ENG | 101 | First-Year Composition | 3 |
| MAT | 270 | Calculus with Analytical Geometry I *N1* | 4 |
| Total | | | 15 |

**Second Semester**

| | | | |
|---|---|---|---|
| CHM | 116 | General Chemistry *S1/S2* | 4 |
| ENG | 102 | First-Year Composition | 3 |
| MAT | 271 | Calculus with Analytical Geometry II | 4 |
| PHY | 121 | University Physics I: Mechanics *S1/S2*[1] | 3 |
| PHY | 122 | University Physics Laboratory I *S1/S2*[1] | 1 |
| Total | | | 15 |

### Second Year

**First Semester**

| | | | |
|---|---|---|---|
| BIO | 181 | General Biology *S1/S2* | 4 |
| BME | 201 | Introduction to Bioengineering *L1* | 3 |
| ECE | 210 | Engineering Mechanics I: Statics | 3 |
| MAT | 274 | Elementary Differential Equations | 3 |
| PHY | 131 | University Physics II: Electricity and Magnetism *S1/S2*[2] | 3 |
| PHY | 132 | University Physics Laboratory II *S1/S2*[2] | 1 |
| Total | | | 17 |

**Second Semester**

| | | | |
|---|---|---|---|
| BME | 331 | Biomedical Engineering Transport I: Fluids | 3 |
| CHM | 331 | General Organic Chemistry | 3 |
| CHM | 335 | General Organic Chemistry Laboratory | 1 |
| ECE | 301 | Electrical Networks I | 4 |
| ECN | 111 | Macroeconomic Principles *SB* | 3 |
| | | or ECN 112 Microeconomic Principles *SB* (3) | |
| MAT | 272 | Calculus with Analytical Geometry III | 4 |
| Total | | | 18 |

### Third Year

**First Semester**

| | | | |
|---|---|---|---|
| BME | 435 | Physiology for Engineers | 4 |
| CHM | 332 | General Organic Chemistry | 3 |
| ECE | 300 | Intermediate Engineering Design *L1* | 3 |
| ECE | 340 | Thermodynamics | 3 |
| ECE | 350 | Structure and Properties of Materials | 3 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| BME | 318 | Biomaterials | 3 |
| BME | 334 | Bioengineering Heat and Mass Transfer | 3 |
| CHM | 336 | General Organic Chemistry Laboratory | 1 |
| ECE | 334 | Electronic Devices and Instrumentation | 4 |
| MAT | 242 | Elementary Linear Algebra *N1* | 2 |
| | | or ECE 384 Numerical Analysis for Engineers I (2) | |
| | | or ECE 386 Partial Differential Equations for Engineers (2) | |
| HU, SB, and awareness area course[3] | | | 4 |
| Total | | | 17 |

### Fourth Year

**First Semester**

| | | | |
|---|---|---|---|
| BME | 413 | Biomedical Instrumentation I *L2* | 3 |
| BME | 416 | Biomechanics | 3 |
| BME | 417 | Biomedical Engineering Capstone Design I | 3 |
| BME | 423 | Biomedical Instrumentation Laboratory *L2* | 1 |
| HU, SB, and awareness area course[3] | | | 6 |
| Total | | | 16 |

**Second Semester**

| | | | |
|---|---|---|---|
| BME | 470 | Microcomputer Applications in Bioengineering | 4 |
| BME | 490 | Biomedical Engineering Capstone Design II | 1–4 |
| ECE | 380 | Probability and Statistics for Engineering Problem Solving | 3 |
| HU, SB, and awareness area course[3] | | | 3 |
| Total | | | 11–14 |

*Degree requirements: 128 semester hours.*

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[1] Both PHY 121 and 122 must be taken to secure S1 or S2 credit.

[2] Both PHY 131 and 132 must be taken to secure S1 or S2 credit.

[3] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 277.