Department of Civil and Environmental Engineering

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CIVIL ENGINEERING

Civil Engineering is primarily concerned with the public domain. The profession includes analysis, planning, design, construction, and maintenance of many types of facilities for government, commerce, and industry. These include high-rise office towers, factories, schools, airports, tunnels and subway systems, dams, canals, and water purification and environmental protection facilities such as solid waste and wastewater treatment systems. Civil engineers are concerned with the impact of their projects on the public and the environment, and they attempt to coordinate the needs of society with technical and economic feasibility.

Career opportunities in the field. University graduates with the B.S.E. degree in Civil Engineering readily find employment. Civil engineers work in many different types of companies, from large corporations to small, private consulting firms, or in governmental agencies. A civil engineering background is an excellent foundation for jobs in management and public service. Civil engineering is one of the best engineering professions from the viewpoint of international travel opportunities or for eventually establishing one's own consulting business.

Uniqueness of the program at ASU. The faculty in the Department of Civil and Environmental Engineering at ASU offer a challenging program of study designed to provide the student with the resources and background to pursue a career in a wide range of specialty areas. Some of these areas are structural, geotechnical, environmental and water resources, transportation and materials engineering. The Civil Engineering program is fully accredited by ABET. With the program, students will be prepared for the Fundamentals of Engineering (FE) examination and professional registration.

The Department of Civil and Environmental Engineering offers challenging programs of study designed to provide students with the scientific and technical resources to pursue a broad and multifaceted range of careers. Areas of study in the civil engineering curriculum are described below.

Geotechnical engineering. This area of study includes the analysis and design of foundation systems, seepage control, earthdams and water resource structures, earthwork operations, fluid flow-through porous media, and response of foundations and embankments to earthquakes.

Structural engineering. This area of study considers the planning, analysis and design of steel and concrete bridges, buildings, dams; special offshore and space structures; composite materials.

Transportation and materials engineering. This area of study is pursued in two major areas and several interrelated areas: (1) transportation planning, design, and operation, and (2) pavements and materials. Transportation planning, design, and operation emphasizes the highway mode but also encompasses public transit and airport planning and design. Urban transport planning, geometric design of facilities, traffic operations, and evaluation of highway capacity and safety are also a part of transportation planning. The application of advanced technology to the vehicle and the roadway is included in the study of intelligent vehicle/highway systems. Pavements and materials focus on pavement analysis and design; pavement maintenance and rehabilitation; pavement evaluation and management; and characterization of highway materials such as asphalt, concrete, portland cement, and portland cement concrete; durability of highway structures; and structural retrofit of existing bridges.

Water resources engineering. This area of study is concerned with surface and groundwater flow, planning and management of water supply, and water distribution system modeling.

The undergraduate program provides an excellent background for entry to graduate study in engineering.

Environmental Engineering Option

The environmental engineering option has been developed and recently implemented at ASU. Environmental engineering is a multidisciplinary field based on the traditional engineering principles, and chemistry, biology, and geology. Environmental engineers are involved with the design and operation of water and wastewater treatment systems, remediation of contaminated soils and waters, construction of hazardous waste containment systems, analysis of the fate and transport of pollutants in natural environments, water conservation and reuse, and surface water quality management.

Career opportunities in the field. University graduates with the B.S.E. in Civil Engineering (environmental engineering option) find employment in consulting firms, municipalities, regulatory agencies, and industry. The growth of environmental engineering positions has been balanced by the growing number of students entering the field, resulting in a stable job market. International opportunities are great and are likely to expand. After earning the undergraduate B.S.E. degree in Civil Engineering (environmental engineering option), many students continue their education by enrolling in an environmental engineering graduate degree program.

Uniqueness of the program at ASU. The environmental engineering option at ASU is presently one of a few such programs in the country. The curriculum includes a solid core of engineering fundamentals, in accordance with an ABET-accredited Civil and Environmental Engineering degree program, so

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that students will be prepared for the Fundamentals of Engineering (FE) examination and professional registration. The curriculum also includes a strong emphasis on chemistry, microbiology, and water and wastewater treatment processes.

ENTRANCE REQUIREMENTS

See "Admission," and "Degrees," pages 194–195 for information regarding entrance requirements.

DEGREE REQUIREMENTS

The B.S.E. degree in Civil Engineering and the B.S.E. degree in Civil Engineering with an option in environmental engineering require a minimum of 128 semester hours of course work. A minimum of 50 upper-division semester hours is required. The minimum requirements are for a student who has successfully completed at least a year (each) of high school chemistry, physics, computer programming; and precalculus, algebra, and trigonometry.

The B.S.E. degree program consists of the following categories:

Civil Engineering

First-Year Composition	6
General Studies/School Requirements	54
Engineering Core	19–20
Major	49–48
Total	128

Environmental Engineering Option

First-Year Composition	6
General Studies/School Requirements	54
Engineering Core	19
Major	49
Total	128

Graduation Requirements

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 79–83.

Course Requirements. See pages 196–197 for General Studies, school, and engineering core requirements.

DEGREE REQUIREMENTS FOR MAJOR IN CIVIL ENGINEERING

Civil Engineering Core

Twenty-seven hours are required. CEE courses, except CEE 296, may not be taken until all mathematics (MAT) and all engineering core courses (ECE), except ECE 380 and 384 have been completed with an average grade of "C" or higher. No CEE 400-level courses may be taken until ECE 380 and 384 have been completed.

CEE	296	Civil Engineering Systems	3
CEE	321	Structural Analysis and Design	4
CEE	341	Fluid Mechanics for Civil Engineers	4
CEE	351	Geotechnical Engineering	4
CEE	361	Introduction to Environmental Engineering	4
CEE	372	Transportation Engineering	4
CEE	496	Topics in Civil Engineering Practice	1
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
Total			27

Civil Engineering Design Electives

Six semester hours from the following list are required.

CEE	423	Structural Design	3
CEE	441	Water Resources Engineering	3
CEE	452	Foundations	3
CEE	466	Sanitary Systems Design	3
CEE	475	Highway Geometric Design	3

Civil Engineering Technical Electives

Fifteen to 16 semester hours are required. The design elective courses that have not been selected to satisfy the design electives requirement (see above) may be used as technical electives.

A maximum of seven hours may be selected from outside of civil engineering with advisor's approval. Students must select technical electives from at least three different CEE areas of study.

Construction. A maximum of three hours may be selected from any of the following Construction (CON) courses.

CON	341	Surveying	3
CON	383	Construction Estimating	3
CON	495	Construction Planning and Scheduling *N3*	3
CON	496	Construction Contract Administration	3

Environmental Engineering. This area includes water treatment, industrial and domestic waste treatment and disposal, public health engineering, and industrial hygiene.

CEE	362	Environmental Engineering	3
CEE	466	Sanitary Systems Design	3
CHM	231	Elementary Organic Chemistry	3
MIC	220	Biology of Microorganisms or MIC 205 Microbiology *S2* (3) and MIC 206 Microbiology Laboratory *S2* (1)	3

Geotechnical Engineering. This area includes assessment of engineering properties and design utilizing soils and rocks as engineering materials.

CEE	452	Foundations	3

Structural Engineering. This area includes analysis and design of structures for buildings, bridges, space frames, structural mechanics.

CEE	322	Steel Structures	3
CEE	323	Concrete Structures	3
CEE	423	Structural Design	3
CEE	432	Matrix and Computer Applications in Structural Engineering	3

Transportation/Materials Engineering. This area includes analysis and design of transportation facilities, transportation planning and economics, and transportation in the urban environment.

CEE	412	Pavement Analysis and Design	3
CEE	471	Intelligent Transportation Systems	3
CEE	475	Highway Geometric Design	3

Water Resources Engineering. This area includes planning and design of facilities for collection, storage and distribution of water, water systems management, and estimating availability of water resources.

CEE	440	Engineering Hydrology	3
CEE	441	Water Resources Engineering	3

Civil Engineering Program of Study A Four-Year Sequence

First Year

First Semester

CHM	114	General Chemistry for Engineers *S1/S2*	4
ECE	100	Introduction to Engineering Design *N3*	4
ENG	101	First-Year Composition	3

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MAT	270	Calculus with Analytic Geometry I *N1*	4
Total			15

Second Semester

CEE	296	Civil Engineering Systems	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

Second 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*[2]	3
PHY	132	University Physics Laboratory II *S1/S2*[2]	1
HU, SB, and awareness area course[3]			3
Total			17

Second Semester

ECE	312	Engineering Mechanics II: Dynamics	3
ECE	313	Introduction to Deformable Solids	3
ECE	340	Thermodynamics	3
		or ECE 301 Electrical Networks I (4)	
ECE	384	Numerical Analysis for Engineers I	2
ECN	111	Macroeconomic Principles *SB*	3
		or ECN 112 Microeconomic Principles *SB* (3)	
Basic science elective			3
Total			17

Third Year

First Semester

CEE	321	Structural Analysis and Design	4
CEE	341	Fluid Mechanics for Civil Engineers	4
ECE	300	Intermediate Engineering Design *L1*	3
ECE	351	Engineering Materials	3
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
Total			17

Second Semester

CEE	351	Geotechnical Engineering	4
CEE	361	Introduction to Environmental Engineering	4
CEE	372	Transportation Engineering	4
HU, SB, and awareness area course[3]			3
Total			15

Fourth Year

First Semester

CEE	496	Topics in Civil Engineering Practice	1
Design elective			3
HU, SB, and awareness area course(s)[3]			4
Technical electives			9
Total			17

Second Semester

CEE	486	Integrated Civil Engineering Design *L2*	3
Design elective			3
HU, SB, and awareness area course[3]			3
Technical electives			6–7
Total			15–16
Graduation requirement 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.

[3] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. See page 196.

A maximum of two graduate courses may be taken for undergraduate credit by students whose cumulative GPA is 3.00 or higher and with the approval of the instructor, advisor, department chair, and the dean of the college.

Concurrent Studies in Architecture and Civil Engineering

Undergraduate. Qualified lower-division students interested in combining studies in architecture and civil engineering may prepare for upper-division and graduate courses in both programs by taking courses listed in option B of the School of Architecture.

DEGREE REQUIREMENTS FOR ENVIRONMENTAL ENGINEERING OPTION

Environmental Engineering Core

See pages 196–197 for General Studies, school, and engineering core requirements.

Thirty semester hours are required. CEE courses, except CEE 296, may not be taken until mathematics (MAT), and engineering core (ECE) courses, except ECE 380 and 384, have been completed with an average grade of "C" or higher. No CEE 400-level courses may be taken until ECE 380 and 384 have been completed.

CEE	296	Civil Engineering Systems	3
CEE	321	Structural Analysis and Design	4
CEE	341	Fluid Mechanics for Civil Engineers	4
CEE	351	Geotechnical Engineering	4
CEE	361	Introduction to Environmental Engineering	4
CEE	372	Transportation Engineering	4
CEE	496	Topics in Civil Engineering Practice	1
CHM	341	Elementary Physical Chemistry	3
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
Total			30

Environmental Design Courses

CEE	441	Water Resources Engineering	3
CEE	466	Sanitary Systems Design	3
Total			6

Environmental Technical Courses

BIO	320	Fundamentals of Ecology	3
		or PUP 442 Environmental Planning (3)	
		or PUP 475 Environmental Impact Assessment (3)	
		or CHM 302 Environmental Chemistry (3)	
		or CHM 361 Principles of Biochemistry (3)	
CEE	362	Environmental Engineering	3
CEE	440	Engineering Hydrology	3
MIC	205	Microbiology *S2*	3
MIC	206	Microbiology Laboratory *S2*	1
Total			13

Environmental Engineering Program of Study A Four-Year Sequence

First Year

First Semester

CHM	114	General Chemistry for Engineers *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

CEE	296	Civil Engineering Systems	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

Second 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*[2]	3
PHY	132	University Physics Laboratory II *S1/S2*[2]	1
HU, SB , and awareness area course[3]			3
Total			17

Second Semester

CHM	231	Elementary Organic Chemistry	3
ECE	312	Engineering Mechanics II: Dynamics	3
ECE	313	Introduction to Deformable Solids	3
ECE	340	Thermodynamics	3
ECE	384	Numerical Analysis for Engineers I	2
ECN	111	Macroeconomic Principles *SB*	3
		or ECN 112 Microeconomic Principles *SB* (3)	
Total			17

Third Year

First Semester

CEE	321	Structural Analysis and Design	4
CEE	341	Fluid Mechanics for Civil Engineers	4
ECE	300	Intermediate Engineering Design *L1*	3
ECE	351	Engineering Materials	3
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
Total			17

Second Semester

CEE	351	Geotechnical Engineering	4
CEE	361	Introduction to Environmental Engineering	4
CEE	372	Transportation Engineering	4
CHM	341	Physical Chemistry	3
HU, SB, and awareness area course[3]			3
Total			18

Fourth Year

First Semester

CEE	362	Environmental Engineering	3
CEE	440	Engineering Hydrology	3
CEE	466	Sanitary Systems Design	3
CEE	496	Topics in Civil Engineering Practice	1
MIC	205	Microbiology S2	3
MIC	206	Microbiology Laboratory *S2*	1
HU, SB, and awareness area courses[3]			4
Total			18

Second Semester

BIO	320	Fundamentals of Ecology	3
		or CHM 302 Environmental Chemistry (3)	
		or CHM 361 Principles of Biochemistry (3)	
		or PUP 442 Environmental Planning (3)	
		or PUP 475 Environmental Impact Assessment (3)	
CEE	441	Water Resources Engineering	3
CEE	486	Integrated Civil Engineering Design *L2*	3
HU, SB, and awareness area course[3]			3
Total			12
Graduation requirement 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.

[3] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU or SB requirements. See page 196.

A maximum of two graduate courses may be taken for undergraduate credit by students whose cumulative GPA is 3.00 or higher and with the approval of the instructor, advisor, department chair, and the dean of the college.

CIVIL ENGINEERING (CEE)

CEE 296 Civil Engineering Systems. (3) F, S
Introduction to civil engineering. Problem solving, economics, description of civil engineering systems, design concepts, ethics, and professional responsibilities. Lecture, field trips. Pre- or corequisite: ECE 100.

CEE 310 Testing of Materials for Construction. (3) F, S
Structural and behavioral characteristics, engineering properties, measurements, and application of construction materials. Lecture, lab. Not open to engineering students. Prerequisite: CON 323.

CEE 321 Structural Analysis and Design. (4) F, S
Statically determinate and indeterminate structures (trusses, beams, and frames) by classical and matrix methods. Introduction to structural design. Lecture, recitation. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 322 Steel Structures. (3) F
Behavior of structural components and systems. Design of steel members and connections. Load and resistance factor design methods. Lecture, recitation. Prerequisite: CEE 321.

CEE 323 Concrete Structures. (3) S
Behavior of concrete structures and the design of reinforced and prestressed concrete members, including footings. Partial design of concrete building system. Lecture, recitation. Prerequisite: CEE 321.

CEE 340 Hydraulics and Hydrology. (3) F, S
Application of hydraulic engineering principles to flow of liquids in pipe systems and open channels; hydrostatics; characteristics of pumps and turbines. Introduction to hydrology. Not open to engineering students. Lecture, lab. Prerequisite: CON 221.

CEE 341 Fluid Mechanics for Civil Engineers. (4) F, S
Fundamental principles and methods of fluid mechanics forming the analytical basis for water resources engineering. Conduit and open channel flow. 3 hours lecture, 1 hour lab. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 351 Geotechnical Engineering. (4) F, S
Index properties and engineering characteristics of soils. Compaction, permeability and seepage, compressibility and settlement, and shear strength. Lecture, lab. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 361 Introduction to Environmental Engineering. (4) F, S
Concepts of air and water pollution; environmental regulation, risk assessment, chemistry, water quality modeling, water and wastewater treatment systems designs. Lecture, lab. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 362 Environmental Engineering. (3) S
Natural environment, the carbon cycle and biochemistry of wastes, principles of waste treatment, and drainage systems. Prerequisite: CEE 361.

CEE 371 Introduction to Urban Planning. (3) N
Theoretical and practical aspects of city planning. Interrelationships among physical planning, environment, government, and society. Not acceptable as a technical elective for CEE students.

CEE 372 Transportation Engineering. (4) F, S
Highway, rail, water, and air transportation. Operational characteristics and traffic control devices of each transport mode. Impact on urban form. Prerequisites: ECE 312, 313. Pre- or corequisites: ECE 380, 384.

CEE 412 Pavement Analysis and Design. (3) F
Design of flexible and rigid pavements for highways and airports. Surface, base, and subgrade courses. Cost analysis and pavement selection. Prerequisites: CEE 351; ECE 351.

CEE 423 Structural Design. (3) F
Analysis and design of reinforced concrete steel, masonry, and timber structures. Lecture, lab. Prerequisite: CEE 323. Corequisite: CEE 322.

CEE 432 Matrix and Computer Applications in Structural Engineering. (3) S
Matrix and computer applications to structural engineering and structural mechanics. Stiffness and flexibility methods, finite elements, and differences. Prerequisite: CEE 321.

CEE 440 Engineering Hydrology. (3) F
Descriptive hydrology; hydrologic cycle, models, and systems. Rain-runoff models. Hydrologic design. Concepts, properties, and basic equations of groundwater flow. Prerequisite: CEE 341.

CEE 441 Water Resources Engineering. (3) S
Application of the principles of hydraulics and hydrology to the engineering of water resources projects; design and operation of water resources systems; water quality. Prerequisite: CEE 341.

CEE 450 Soil Mechanics in Construction. (3) F, S
Soil mechanics as applied to the construction field, including foundations, highways, retaining walls, and slope stability. Relationship between soil characteristics and geologic formations. Not open to engineering students. Lecture, lab. Prerequisite: CON 323.

CEE 452 Foundations. (3) F, S
Applications of soil mechanics to foundation systems, bearing capacity, lateral earth pressure, and slope stability. Prerequisite: CEE 351.

CEE 466 Sanitary Systems Design. (3) F
Capacity, planning and design of water supply, domestic and storm drainage, and solid waste systems. Prerequisite: CEE 361.

CEE 471 Intelligent Transportation Systems. (3) F
Application of advanced technology to the vehicle and the roadway to solve traffic congestion, safety, and air quality problems. Prerequisite: CEE 372 or instructor approval.

CEE 475 Highway Geometric Design. (3) S
Design of the visible elements of the roadway. Fundamental design controls with application to rural roads, at-grade intersections, freeways, and interchanges. Lecture, recitation. Prerequisite: CEE 372.

CEE 486 Integrated Civil Engineering Design. (3) F, S
Students are required to complete a civil engineering design in a simulated practicing engineering environment. Lecture, team learning. Limited to undergraduates in their final semester. Prerequisites: CEE 321, 341, 351, 361, 372. *General Studies: L2.*

CEE 496 Topics in Civil Engineering Practice. (1) F, S
Professional engineering practice. Interviewing and résumé writing, professional registration requirements, continuing education, graduate study, financial planning, and employment. Prerequisite: senior standing.

CEE 512 Pavement Performance and Management. (3) S
Pavement management systems, including data collection, evaluation, optimization, economic analysis, and computer applications for highway and airport design. Prerequisite: CEE 412.

CEE 514 Bituminous Materials and Mixture. (3) F
Types of bituminous materials used in pavement mixtures. Chemical composition and physical properties, desirable aggregate characteristics, and optimum asphalt contents. Lecture, lab. Prerequisite: ECE 351.

CEE 515 Properties of Concrete. (3) S
Materials science of concrete. Cement chemistry, mechanisms of hydration, interrelationships among micro and macro properties of cement-based materials. Mechanical properties, failure theories, fracture mechanics of concrete materials. Cement-based composite materials and the durability aspects. Lecture, lab. Prerequisite: ECE 350 or 351.

CEE 521 Stress Analysis. (3) F
Advanced topics in the analytical determination of stress and strain. Prerequisite: CEE 321.

CEE 524 Advanced Steel Structures. (3) S
Strength properties of steel and their effects on structural behavior. Elastic design of steel structures. Plastic analysis and design of beams, frames, and bents. Plastic deflections. Plastic design requirements. Multistory buildings. Prerequisite: CEE 322.

CEE 526 Finite Element Methods in Civil Engineering. (3) F
Finite element formulation for solutions of structural, geotechnical, and hydraulic problems. Prerequisite: CEE 432.

CEE 527 Advanced Concrete Structures. (3) N
Ultimate strength design. Combined shear and torsion. Serviceability. Plastic analysis. Special systems. Prerequisite: CEE 323.

CEE 530 Prestressed Concrete. (3) S
Materials and methods of prestressing. Analysis and design for flexure, shear, and torsion. Prestress losses due to friction, creep, shrinkage, and anchorage set. Statically indeterminate structures. Design of flat slabs, bridges, and composite beams. Prerequisite: CEE 323.

CEE 533 Structural Optimization. (3) S
Linear and nonlinear programming. Problem formulation. Constrained and unconstrained optimization. Sensitivity analysis. Approximate techniques. FEM-based optimal design of mechanical and aerospace structures. Cross-listed as MAE 521. Prerequisite: instructor approval.

CEE 536 Structural Dynamics. (3) F
Structures and structural members subjected to dynamic loadings, response spectra theory applications to bridges and power plants, investigations of the responses of multidegree of freedom structures, and matrix and numerical methods of analysis. Lecture, recitation. Prerequisites: CEE 321; instructor approval.

CEE 537 Topics in Structural Engineering. (1–3) F, S
Advanced topics, including, wind engineering, earthquake engineering, probabilistic concepts, and bridge and building engineering. Prerequisite: instructor approval.

CEE 540 Groundwater Hydrology. (3) F
Physical properties of aquifers, well pumping, subsurface flow modeling, unsaturated flow, numerical methods, land subsidence, and groundwater pollution. Prerequisite: CEE 440 or instructor approval.

CEE 541 Surface Water Hydrology. (3) S
Hydrologic cycle and mechanisms, including precipitation, evaporation, and transpiration; hydrograph analysis; flood routing; statistical methods in hydrology and hydrologic design. Prerequisite: CEE 440 or instructor approval.

CEE 542 Water Resources Systems Planning. (3) N
Philosophy of water resources planning; economic, social, and engineering interaction; introduction to the theory and application of quantitative planning methodologies in water resources planning. Guest lecturers, case studies. Prerequisite: instructor approval.

CEE 543 Water Resources Systems I. (3) F
Theory and application of quantitative planning methodologies for the design and operation of water resources systems; class projects using a computer; case studies. Pre- or corequisite: CEE 542 or instructor approval.

CEE 545 Foundations of Hydraulic Engineering. (3) S
Review of incompressible fluid dynamics. Flow in pipes and channels; unsteady and varied flows; wave motion. Prerequisite: CEE 341.

CEE 546 Free Surface Hydraulics. (3) N
Derivation of 1-dimensional equations used in open channel flow analysis; computations for uniform and nonuniform flows, unsteady flow, and flood routing. Mathematical and physical models. Prerequisite: CEE 341.

CEE 547 Principles of River Engineering. (3) N
Uses of rivers, study of watershed, and channel processes. Sediment sources, yield, and control; hydrologic analysis. Case studies. Prerequisite: CEE 341 or instructor approval.

CEE 548 Sedimentation Engineering. (3) N
Introduction to the transportation of granular sedimentary materials by moving fluids. Degradation, aggregation, and local scour in alluvial channels. Mathematical and physical models. Prerequisite: CEE 547 or instructor approval.

CEE 550 Soil Behavior. (3) S
Physicochemical aspects of soil behavior, stabilization of soils, and engineering properties of soils. Prerequisite: CEE 351.

CEE 551 Advanced Geotechnical Testing. (3) N
Odometer, triaxial (static and cyclic) back pressure saturated and unsaturated samples, pore pressure measurements, closed-loop computer-controlled testing, in-situ testing, and sampling. Lecture, lab. Prerequisite: CEE 351.

CEE 552 Geological Engineering. (3) S
Geological investigations for engineering purposes, case histories, geologic structure, weathering, remote sensing, geophysics, and air photo interpretation for engineering site locations. Lecture, field trips. Prerequisite: CEE 351.

CEE 553 Advanced Soil Mechanics. (3) N
Application of theories of elasticity and plasticity to soils, theories of consolidation, failure theories, and response to static and dynamic loading. Prerequisite: CEE 351.

CEE 554 Shear Strength and Slope Stability. (3) S
Shear strength of saturated and unsaturated soils strength-deformation relationships, time-dependent strength parameters, effects of sampling, and advanced slope stability. Prerequisite: CEE 351.

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

CEE 555 Advanced Foundations. (3) F
Deep foundations, braced excavations, anchored bulkheads, reinforced earth, and underpinning. Prerequisite: CEE 351.

CEE 556 Seepage and Earth Dams. (3) N
Transient and steady state fluid flow through soil, confined and unconfined flow, pore water pressures, and application to earth dams. Prerequisite: CEE 351.

CEE 557 Hazardous Waste: Site Assessment and Mitigation Measures. (3) F
Techniques for hazardous waste site assessment and mitigation. Case histories presented by instructor and guest speakers. Prerequisites: graduate standing; instructor approval.

CEE 559 Earthquake Engineering. (3) N
Characteristics of earthquake motions, selection of design earthquakes, site response analyses, seismic slope stability, and liquefaction. Prerequisite: CEE 351.

CEE 560 Soil and Groundwater Remediation. (3) S
Techniques for remediation of contaminated soils and groundwaters are presented with basic engineering principles. Prerequisite: instructor approval.

CEE 561 Physical-Chemical Treatment of Water and Waste. (3) F
Theory and design of physical and chemical processes for the treatment of water and waste waters. Prerequisite: CEE 361.

CEE 562 Environmental Biochemistry and Waste Treatment. (3) S
Theory and design of biological waste treatment systems. Pollution and environmental assimilation of wastes. Prerequisite: CEE 362.

CEE 563 Environmental Chemistry Laboratory. (3) F
Analysis of water, domestic and industrial wastes, laboratory procedures for pollution evaluation, and the control of water and waste treatment processes. Lecture, lab. Prerequisite: CEE 361.

CEE 566 Industrial/Hazardous Waste Treatment. (3) F
Emphasis on treatment of local industrial/hazardous waste problems, including solvent recovery and metals. Lecture, project. Prerequisites: CEE 561, 563.

CEE 573 Traffic Engineering. (3) F
Driver, vehicle, and roadway characteristics, laws and ordinances, traffic control devices, traffic engineering studies, and Transportation System Management measures. Prerequisite: CEE 372.

CEE 574 Highway Capacity. (3) S
Highway capacity for all functional classes of highways. Traffic signalization, including traffic studies, warrants, cycle length, timing, phasing, and coordination. Prerequisite: CEE 372.

CEE 575 Traffic Flow Theory and Safety Analysis. (3) N
Traffic flow theory; distributions, queuing, delay models, and car-following. Highway safety; accident records systems, accident analysis, identifying problem locations, and accident countermeasures. Prerequisite: CEE 573 or 574.

CEE 576 Airport Engineering. (3) F
Planning and design of airport facilities. Effect of aircraft characteristics, air traffic control procedures and aircraft demand for runway and passenger handling facilities, on-site selection, runway configuration, and terminal design. Prerequisite: CEE 372.

CEE 577 Urban Transportation Planning. (3) S
Application of land use parameters traffic generation theory, traffic distribution and assignment models, transit analysis, and economic factors to the solution of the urban transportation problem. Prerequisite: CEE 372.

Students enrolled in CEE 580, 590, 592, 599, 792, and 799 are required to attend graduate student seminars at the times shown in the Schedule of Classes*. Each semester, every graduate student enrolled for more than eight semester hours is to enroll for at least one semester hour of CEE 592, 599, 792, or 799.*

Students fast at work in a computer lab located in Wilson Hall. Tim Trumble photo

Department of Computer Science and Engineering

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PROFESSORS
ASHCROFT, BLACKLEDGE, COLLOFELLO, FARIN, GOLSHANI, LEWIS, NIELSON, J. URBAN, WOODFILL, YAU

ASSOCIATE PROFESSORS
BHATTCHARYA, DASGUPTA, DIETRICH, FALTZ, GHOSH, HUEY, KAMBHAMPATI, LINDQUIST, MILLER, O'GRADY, PANCHANATHAN, PHEANIS, ROCKWOOD, SEN, S. URBAN

ASSISTANT PROFESSORS
BAZZI, CANDAN, HSU, WAGNER

LECTURERS
DELIBERO, HOUSTON, NAVABI, WHITEHOUSE

Computers have a significant impact on our daily lives, and this impact is likely to be even greater in the future as computer professionals continue to develop more powerful, smaller, faster, and less expensive computing systems. Computer science and computer engineering deal with the study, design, development, construction, and application of modern computing machinery. Other important topics include computing techniques and appropriate languages for general information processing, for scientific computation, for the recognition, storage, retrieval, and processing of data of all kinds, and for the automatic control and simulation of processes.

The curricula offered by the Department of Computer Science and Engineering prepare the student to be a participant in this rapidly changing area of technology by presenting in-depth treatments of the fundamentals of computer science and computer engineering. The department offers two undergraduate degrees: a B.S. degree in Computer Science and a B.S.E. degree in Computer Systems Engineering.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is required for the B.S. degree in Computer Science and the B.S.E. degree in Computer Systems Engineering. A minimum of 50 upper-division semester hours is required. In addition to the requirement for a cumulative GPA of 2.00 or higher, all computer science and computer systems engineering students must obtain a minimum grade of "C" in all CSE courses used for degree credit.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 79–83.

DEGREES

Computer Science—B.S.

The faculty in the Department of Computer Science and Engineering offer a B.S. degree that prepares the student for a career in computer science. A student pursuing a B.S. degree must complete the First-Year Composition requirement, the General Studies requirement, department degree requirements, the computer science core courses, a senior-level breadth requirement in the major, technical electives, and unrestricted electives. More detail on these requirements is available at the department office, on the department Web site, or e-mail questions to cse.ugrad.desk@asu.edu.

The following list specifies departmental requirements for the B.S. degree in Computer Science.

First-Year Composition

ENG	101, 102	First-Year Composition	6
		or ENG 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	
Total			6

General Studies/Department Requirements

Humanities and Fine Arts/ Social and Behavioral Sciences

HU/SB electives	18

Literacy and Critical Inquiry

L1/L2 electives	6

Natural Sciences/Basic Sciences

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
Science elective[3]			4
Total			12

Numeracy/Mathematics

ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
MAT	243	Discrete Mathematical Structures	3
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	342	Linear Algebra	3
Total			21
General Studies/department requirement total			57

In addition, the following courses constitute the Computer Science core:

Computer Science Core

CSE	120	Digital Design Fundamentals	3
CSE	200	Concepts of Computer Science *N3*	3
CSE	210	Data Structures and Algorithms I *N3*	3
CSE	225	Assembly Language Programming and Microprocessors (Motorola) *N3*	4
		or CSE 226 Assembly Language Programming and Microprocessors (Intel) *N3* (4)	
CSE	240	Introduction to Programming Languages	3
CSE	310	Data Structures and Algorithms II	3
CSE	330	Computer Organization and Architecture	3
CSE	340	Principles of Programming Languages	3
CSE	355	Introduction to Theoretical Computer Science	3
CSE	360	Introduction to Software Engineering	3
CSE	430	Operating Systems	3
Total computer science core			34

Computer science breadth requirement	18
Each student must complete 18 hours of CSE 400-level courses.	
Technical electives	6
Each student must complete six hours of courses chosen from the computer science technical elective list and approved by the student's advisor.	
Unrestricted electives	7
Total	31
Degree requirements 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.

[3] This elective may be satisfied by any physics courses requiring PHY 131 as a prerequisite or any laboratory science for majors in the discipline and satisfying the S1 or S2 General Studies requirements (except PHS 110, PHY 101, 105, 111, or 112).

Computer Science Program of Study Typical Four-Year Sequence

First Year

First Semester

CSE	200	Concepts of Computer Science *N3*	3
ENG	101	First-Year Composition	3
MAT	270	Calculus with Analytic Geometry I *N1*	4
HU, SB, awareness area course[1]			3
Total			13

Second Semester

CSE	120	Digital Design Fundamentals	3
CSE	210	Data Structures and Algorithms I *N3*	3
ENG	102	First-Year Composition	3
MAT	271	Calculus with Analytic Geometry II	4
Laboratory science *S2*[2]			4
Total			17

Second Year

First Semester

CSE	240	Introduction to Programming Languages	3
MAT	243	Discrete Mathematical Structures	3
MAT	272	Calculus with Analytic Geometry III	4
PHY	121	University Physics I: Mechanics *S1/S2*	3
PHY	122	University Physics Laboratory I *S1/S2*	1
HU, SB, awareness area course[1]			3
Total			17

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

Second Semester

CSE	225	Assembly Language Programming and Microprocessors (Motorola)	4
CSE	310	Data Structures and Algorithms II	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, awareness area course[1]			3
L1 elective			3
Total			17

Third Year

First Semester

CSE	330	Computer Organization and Architecture	3
CSE	340	Principles of Programming Languages	3
MAT	342	Linear Algebra	3
HU, SB, awareness area course[1]			3
Unrestricted elective			4
Total			16

Second Semester

CSE	355	Introduction to Theoretical Computer Science	3
CSE	360	Introduction to Software Engineering	3
CSE	430	Operating Systems	3
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
HU, SB, awareness area course[1]			3
Unrestricted elective			3
Total			18

Fourth Year

First Semester

400-level CSE computer science breadth electives			9
L2 elective			3
Technical elective			3
Total			15

Second Semester

HU, SB, awareness area course[1]			3
400-level CSE computer science breadth electives			9
Technical elective			3
Total			15

[1] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 196.

[2] This elective may be satisfied by any physics courses requiring PHY 131 as a prerequisite or any laboratory science for majors in the discipline and satisfying the S1 or S2 General Studies requirements (except PHS 110, PHY 101, 105, 111, or 112).

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

Computer Systems Engineering—B.S.E.

The Department of Computer Science and Engineering offers a B.S.E. degree that prepares the student for a career in computer systems engineering. This degree program provides training in both engineering and computer science. The following list specifies departmental requirements for the B.S.E. degree in Computer Systems Engineering.

First-Year Composition

ENG	101, 102	First-Year Composition	6
		or ENG 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	
Total			6

General Studies/Department Requirements

Humanities and Fine Arts/ Social and Behavioral Sciences

ECN	111	Macroeconomic Principles *SB*	3
		or ECN 112 Microeconomic Principles *SB* (3)	
HU/SB electives			13
Total			16

Literacy and Critical Inquiry

CSE	423	Microcomputer System Hardware *L2*	3
ECE	300	Intermediate Engineering Design *L1*	3
Total			6

Natural Sciences/Basic Sciences

CHM	114	General Chemistry for Engineers *S1/S2*	4
		or CHM 116 General Chemistry *S1/S2* (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	361	Introductory Modern Physics	3
Total			15

Numeracy/Mathematics

ECE	100	Introduction to Engineering Design *N3*	4
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
MAT	243	Discrete Mathematical Structures	3
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
Total			28
General Studies/department requirement total			65

Engineering Core

CSE	200	Concepts of Computer Science *N3*	3
CSE	225	Assembly Language Programming and Microprocessors (Motorola)	4
ECE	210	Engineering Mechanics I: Statics	3
ECE	301	Electrical Networks	4
ECE	334	Electronic Devices and Instrumentation	4
Total			18

Computer Science Core

CSE	120	Digital Design Fundamentals	3
CSE	210	Data Structures and Algorithms I *N3*	3
CSE	240	Introduction to Programming Languages	3
CSE	310	Data Structures and Algorithms II	3
CSE	330	Computer Organization and Architecture	3
CSE	340	Principles of Programming Languages	3
CSE	355	Introduction to Theoretical Computer Science	3
CSE	360	Introduction to Software Engineering	3
CSE	421	Microprocessor System Design I	4
CSE	422	Microprocessor System Design II	4
CSE	430	Operating Systems	3
Technical electives			4
Each student must complete four hours of courses chosen from the computer science technical elective list and approved by the student's advisor.			
Total			39
Degree requirement 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.

Computer Systems Engineering Program of Study Typical Four-Year Sequence

First Year

First Semester

CSE	200	Concepts of Computer Science *N3*	3
ECE	100	Introduction to Engineering Design *N3*	4
ECN	111	Macroeconomic Principles *SB*	3
ENG	101	First-Year Composition	3
MAT	270	Calculus with Analytic Geometry I *N1*	4
Total			17

Second Semester

CHM	114	General Chemistry for Engineers *S1/S2*	4
CSE	120	Digital Design Fundamentals	3
CSE	210	Data Structures and Algorithms I *N3*	3
ENG	102	First-Year Composition	3
MAT	271	Calculus with Analytic Geometry II	4
Total			17

Second Year

First Semester

CSE	225	Assembly Language Programming and Microprocessors (Motorola)	4
MAT	243	Discrete Mathematical Structures	3
MAT	272	Calculus with Analytic Geometry III	4
PHY	121	University Physics I: Mechanics *S1/S2*[1]	3
PHY	122	University Physics Laboratory I *S1/S2*[1]	1
Total			15

Second Semester

CSE	240	Introduction to Programming Languages	3
CSE	330	Computer Organization and Architecture	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			16

Third Year

First Semester

CSE	310	Data Structures and Algorithms II	3
ECE	300	Intermediate Engineering Design *L1*	3
MAT	342	Linear Algebra	3
HU, SB, awareness area courses[3]			7
Total			16

Second Semester

CSE	340	Principles of Programming Languages	3
CSE	360	Introduction to Software Engineering	3
CSE	421	Microprocessor System Design I	4
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
HU, SB, awareness area course[3]			3
Total			16

Fourth Year

First Semester

CSE	355	Introduction to Theoretical Computer Science	3
CSE	422	Microprocessor System Design II	4
CSE	430	Operating Systems	3
ECE	301	Electrical Networks I	4
PHY	361	Introductory Modern Physics	3
Total			17

Second Semester

CSE	423	Microcomputer System Hardware *L2*	3
ECE	334	Electronic Devices and Instrumentation	4
HU, SB, awareness area course[3]			3
Technical electives			4
Total			14

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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 fulfill HU and SB requirements. See page 196.

COMPUTER SCIENCE AND ENGINEERING (CSE)

CSE 100 Principles of Programming. (3) F, S, SS
Concepts of problem solving, algorithm design, structured programming, fundamental algorithms and techniques, and computer systems concepts. Social and ethical responsibility. Prerequisite: MAT 170. *General Studies: N3.*

CSE 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 EEE 120. Prerequisite: computer literacy.

CSE 180 Computer Literacy. (3) F, S, SS
Introduction to personal computer operations and their place in society. Problem-solving approaches using databases, spreadsheets, and word processing. May be taken for credit on either Windows or Macintosh, but not both. Lecture, demonstration. Prerequisite: nonmajor. *General Studies: N3.*

CSE 181 Applied Problem Solving with BASIC. (3) F, S, SS
Introduction to systematic definition of problems, solution formulation, and method validation. Computer solution using BASIC required for projects. Lecture, lab. Prerequisites: MAT 117; nonmajor. *General Studies: N3.*

CSE 183 Applied Problem Solving with FORTRAN. (3) F
A human-oriented, systems approach to problem definition, formulation, and solution using FORTRAN. Computer solution required for projects. Prerequisites: MAT 170; nonmajor. *General Studies: N3.*

CSE 185 Internet and the World Wide Web. (3) F, S
Fundamental Internet concepts, World Wide Web browsing, publishing, searching, advanced Internet productivity tools.

CSE 200 Concepts of Computer Science. (3) F, S, SS
Overview of algorithms, architecture, languages, operating systems, theory. Problem solving with a high level language (C++). Lecture, lab. Prerequisite: one year of high school programming with a structured language (C++ preferred) or CSE 100. *General Studies: N3.*

CSE 210 Data Structures and Algorithms I. (3) F, S, SS
Object oriented design, static and dynamic data structures (strings, stacks, queues, binary trees), recursion, and searching and sorting. Professional responsibility. Prerequisite: CSE 200. *General Studies: N3.*

CSE 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 EEE 225. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

CSE 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 EEE 226. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

CSE 240 Introduction to Programming Languages. (3) F, S, SS
Introduction to the procedural (Ada), applicative (LISP), and declarative (Prolog) languages. Lecture, lab. Prerequisite: CSE 210.

CSE 310 Data Structures and Algorithms II. (3) F, S, SS
Advanced data structures and algorithms, including stacks, queues, trees (B, B+, AVL), and graphs. Searching for graphs, hashing, external sorting. Lecture, lab. Prerequisites: CSE 210; MAT 243.

CSE 330 Computer Organization and Architecture. (3) F, S, SS
Instruction set architecture, processor performance and design; datapath, control (hardwired, microprogrammed), pipelining, input/output. Memory organization with cache, virtual memory. Prerequisite: CSE/EEE 225 or 226.

CSE 340 Principles of Programming Languages. (3) F, S, SS
Introduction to language design and implementation. Parallel, machine-dependent and declarative features; type theory; specification, recognition, translation, run-time management. Prerequisites: CSE 240, 310; CSE/EEE 225 (or 226).

CSE 355 Introduction to Theoretical Computer Science. (3) F, S
Introduction to formal language theory and automata, Turing machines, decidability/undecidability, recursive function theory, and introduction to complexity theory. Prerequisite: CSE 310.

CSE 360 Introduction to Software Engineering. (3) F, S, SS
Software life cycle models; project management, team development environments and methodologies; software architectures; quality assurance and standards; legal, ethical issues. Prerequisites: CSE 210, 240.

CSE 408 Multimedia Information Systems. (3) F
Design, use, and applications of multimedia systems. An introduction to acquisition, compression, storage, retrieval, and presentation of data from different media such as images, text, voice, and alphanumeric. Prerequisite: CSE 310.

CSE 412 Database Management. (3) F, S
Introduction to DBMS concepts. Data models and languages. Relational database theory. Database security/integrity and concurrency. Prerequisite: CSE 310.

CSE 420 Computer Architecture I. (3) S
Computer architecture. Performance versus cost trade-offs. Instruction set design. Basic processor implementation and pipelining. Prerequisite: CSE 330.

CSE 421 Microprocessor System Design I. (4) F, S
Assembly-language programming and logical hardware design of systems using 8-bit microprocessors and microcontrollers. Fundamental concepts of digital system design. Reliability and social, legal implications. Lecture, lab. Prerequisite: CSE/EEE 225 or 226.

CSE 422 Microprocessor System Design II. (4) F, S
Design of microcomputer systems using contemporary logic and microcomputer system components. Requires assembly language programming. Prerequisite: CSE 421.

CSE 423 Microcomputer System Hardware. (3) S
Information and techniques presented in CSE 422 are used to develop the hardware design of a multiprocessor, multiprogramming, microprocessor-based system. Prerequisite: CSE 422. *General Studies: L2.*

CSE 428 Computer-Aided Processes. (3) A
Hardware and software considerations for computerized manufacturing systems. Specific concentration on automatic inspection, numerical control, robotics, and integrated manufacturing systems. Prerequisite: CSE 330.

CSE 430 Operating Systems. (3) F, S
Operating system structure and services, processor scheduling, concurrent processes, synchronization techniques, memory management, virtual memory, input/output, storage management, and file systems. Prerequisites: CSE 330, 340.

CSE 434 Computer Networks. (3) F, S
Cryptography fundamentals; data compression; error handling; flow control; multihop routing; network protocol algorithms; network reliability, timing, security; physical layer basics. Prerequisite: CSE 330.

CSE 438 Systems Programming. (3) A
Design and implementation of systems programs, including text editors, file utilities, monitors, assemblers, relocating linking loaders, I/O handlers, and schedulers. Prerequisite: CSE 421 or instructor approval.

CSE 440 Compiler Construction I. (3) F
Introduction to programming language implementation. Implementation strategies such as compilation, interpretation, and translation. Major compilation phases such as lexical analysis, semantic analysis, optimization, and code generation. Prerequisites: CSE 340, 355.

CSE 450 Design and Analysis of Algorithms. (3) F
Design and analysis of computer algorithms using analytical and empirical methods; complexity measures, design methodologies, and survey of important algorithms. Prerequisite: CSE 310.

CSE 457 Theory of Formal Languages. (3) A
Theory of grammar, methods of syntactic analysis and specification, types of artificial languages, relationship between formal languages, and automata. Prerequisite: CSE 355.

CSE 459 Logic for Computing Scientists I. (3) F
Propositional logic, syntax and semantics, proof theory versus model theory, soundness, consistency and completeness, first order logic, logical theories, automated theorem proving, ground resolution, pattern matching unification and resolution, Dijkstras logic, proof obligations, and program proving. Prerequisite: CSE 355.

CSE 461 Software Engineering Project I. (3) F
First of two-course software design sequence. Development planning, management; process modeling; incremental and team development using CASE tools. Lecture, lab. Prerequisite: CSE 360.

CSE 462 Software Engineering Project II. (3) S
Second of two-course software design sequence. Process, product assessment and improvement; incremental and team development using CASE tools. Lecture, lab. Prerequisite: CSE 461.

CSE 470 Computer Graphics. (3) F, S
Display devices, data structures, transformations, interactive graphics, 3-dimensional graphics, and hidden line problem. Prerequisites: CSE 310; MAT 342.

CSE 471 Introduction to Artificial Intelligence. (3) F, S
State space search, heuristic search, games, knowledge representation techniques, expert systems, and automated reasoning. Prerequisites: CSE 240, 310.

CSE 473 Nonprocedural Programming Languages. (3) S
Functional and logic programming using languages like Lucid and Prolog. Typical applications would be a Screen Editor and an Expert System. Prerequisite: CSE 355.

CSE 476 Introduction to Natural Language Processing. (3) F
Principles of computational linguistics, formal syntax, and semantics, as applied to the design of software with natural (human) language I/O. Prerequisite: CSE 310 or instructor approval.

CSE 477 Introduction to Computer-Aided Geometric Design. (3) F, S
Introduction to parametric curves and surfaces, Bezier and B-spline interpolation, and approximation techniques. Prerequisites: CSE 210, 470; MAT 342.

CSE 507 Virtual Reality Systems. (3) S
Computer generated 3D environments, simulation of reality, spatial presence of virtual objects, technologies of immersion, tracking systems. Lecture, lab. Prerequisite: CSE 408 or 470 or 508 or instructor approval.

CSE 508 Digital Image Processing. (3) S
Digital Image fundamentals, image transforms, image enhancement and restoration techniques, image encoding, and segmentation methods. Prerequisite: EEE 303 or instructor approval.

CSE 510 Advanced Database Management. (3) F, S
Advanced data modeling, deductive databases, object-oriented databases, distributed and multidatabase systems; emerging database technologies. Prerequisite: CSE 412.

CSE 512 Distributed Databases. (3) A
Fragmentation design. Query optimization. Distributed joins. Concurrency control. Distributed deadlock detection. Prerequisite: CSE 510.

CSE 513 Deductive Databases. (3) F
Logic as a data model. Query optimization emphasizing the top-down and bottom-up evaluation of declarative rules. Prerequisite: CSE 510.

CSE 514 Object-Oriented Database Systems. (3) A
Object-oriented data modeling, database and language integration, object algebras, extensibility, transactions, object managers, versioning/configuration, active data, nonstandard applications. Research seminar. Prerequisite: CSE 510.

CSE 517 Hardware Design Languages. (3) N
Introduction to hardware design languages using VHDL. Modeling concepts for specification, simulation, and synthesis. Prerequisite: CSE 423 or EEE 425 or instructor approval.

CSE 518 Synthesis with Hardware Design Languages. (3) N
Modeling VLSI design in hardware design languages for synthesis. Transformation of language-based designs to physical layout. Application of synthesis tools. Prerequisite: CSE 517.

CSE 520 Computer Architecture II. (3) F
Computer architecture description languages, computer arithmetic, memory-hierarchy design, parallel, vector, and multiprocessors, and input/output. Prerequisites: CSE 420, 430.

CSE 521 Microprocessor Applications. (4) S
Microprocessor technology and its application to the design of practical digital systems. Hardware, assembly language programming, and interfacing of microprocessor-based systems. Lecture, lab. Prerequisite: CSE 421.

CSE 523 Microcomputer Systems Software. (3) F
Developing system software for a multiprocessor, multiprogramming, microprocessor-based system using information and techniques presented in CSE 421, 422. Prerequisite: CSE 422.

CSE 526 Parallel Processing. (3) N
Real and apparent concurrency. Hardware organization of multiprocessors, multiple computer systems, scientific attached processors, and other parallel systems. Prerequisite: CSE 330 or 423.

CSE 530 Operating System Internals. (3) F
Implementation of process management and synchronization, system call and interrupt handling, memory management, device drivers and file systems in UNIX. Prerequisites: CSE 430; knowledge of C language.

CSE 531 Distributed and Multiprocessor Operating Systems. (3) N
Distributed systems architecture, remote file access, message-based systems, object-based systems, client/server paradigms, distributed algorithms, replication and consistency, and multiprocessor operating systems. Prerequisite: CSE 530 or instructor approval.

CSE 532 Advanced Operating System Internals. (3) F
Memory, processor, process and communication management, and concurrency control in the Windows NT multiprocessor and distributed operating system kernels and servers. Prerequisite: CSE 530 or instructor approval.

CSE 534 Advanced Computer Networks. (3) F
Advanced network protocols and infrastructure, applications of high-performance networks to distributed systems, high-performance computing and multimedia domains, special features of networks. Prerequisite: CSE 434.

CSE 536 Theory of Operating Systems. (3) S
Protection. Communication and synchronization in distributed systems, distributed file systems, deadlock theory, virtual memory theory, and uniprocessor and multiprocessor thread management. Prerequisite: CSE 430.

CSE 540 Compiler Construction II. (3) S
Formal parsing strategies, optimization techniques, code generation, extensibility and transportability considerations, and recent developments. Prerequisite: CSE 440.

CSE 545 Programming Language Design. (3) N
Language constructs, extensibility and abstractions, and runtime support. Language design process. Prerequisite: CSE 440.

CSE 550 Combinatorial Algorithms and Intractability. (3) N
Combinatorial algorithms, nondeterministic algorithms, classes P and NP, NP-hard and NP-complete problems, and intractability. Design techniques for fast combinatorial algorithms. Prerequisite: CSE 450.

CSE 555 Automata Theory. (3) N
Finite state machines, pushdown automata, linear bounded automata, Turing machines, register machines, rams, and rasps; relationships to computability and formal languages. Prerequisite: CSE 355.

CSE 556 Expert Systems. (3) S
Knowledge acquisition and representation, rule-based systems, frame-based systems, validation of knowledge bases, inexact reasoning, and expert database systems. Prerequisite: CSE 471.

CSE 560 Software Engineering. (3) F, S
Software engineering foundations, formal representations in the software process; use of formalisms in creating a measured and structured working environment. Lecture, lab. Prerequisite: CSE 360.

CSE 562 Parallel and Distributed Software Engineering. (3) A
Software engineering characteristics particular to parallel and distributed systems. Tools and techniques to support software engineering involving parallel processing and distributed systems. Prerequisite: CSE 560.

CSE 563 Software Requirements and Specification. (3) A
Examination of the definitional stage of software development; analysis of specification representations, formal methods, and techniques emphasizing important application issues. Prerequisite: CSE 560.

CSE 564 Software Design. (3) A
Examination of software design issues and techniques. Includes a survey of design representations and a comparison of design methods. Prerequisite: CSE 560.

CSE 565 Software Verification, Validation, and Testing. (3) A
Test planning, requirements-based and code-based testing techniques, tools, reliability models, and statistical testing. Prerequisite: CSE 560.

CSE 566 Software Project, Process, and Quality Management. (3) A
Project management, risk management, configuration management, quality management, and simulated project management experiences. Prerequisite: CSE 560.

CSE 570 Advanced Computer Graphics I. (3) F
Hidden surface algorithms, lighting models, and shading techniques. User interface design. Animation techniques. Fractals and stochastic models. Raster algorithms. Prerequisite: CSE 470.

CSE 571 Artificial Intelligence. (3) S
Definitions of intelligence, computer problem solving, game playing, pattern recognition, theorem proving, and semantic information processing; evolutionary systems; heuristic programming. Prerequisite: CSE 471.

CSE 573 Advanced Computer Graphics II. (3) S
Modeling of natural phenomena: terrain, clouds, fire, water, and trees. Particle systems, deformation of solids, antialiasing, and volume visualization. Lecture, lab. Prerequisite: CSE 470.

CSE 574 Planning and Learning Methods in AI. (3) F
Reasoning about time and action, plan synthesis and execution, improving planning performance, applications to manufacturing intelligent agents. Prerequisite: CSE 471 or equivalent.

CSE 575 Decision-Making Strategies in AI. (3) S
Automatic knowledge acquisition, automatic analysis/synthesis of strategies, distributed planning/problem solving, causal modeling, predictive human-machine environments. Prerequisite: CSE 471 or 571 or equivalent.

CSE 576 Topics in Natural Language Processing. (3) S
Comparative parsing strategies, scoping and reference problems, nonfirst-order logical semantic representations, and discourse structure. Prerequisite: CSE 476 or instructor approval.

CSE 577 Advanced Computer-Aided Geometric Design I. (3) F
General interpolation; review of curve interpolation and approximation; spline curves; visual smoothness of curves; parameterization of curves; introduction to surface interpolation and approximation. Prerequisites: CSE 470 and 477 *or* instructor approval.

CSE 578 Advanced Computer-Aided Geometric Design II. (3) S
Coons patches and Bezier patches; triangular patches; arbitrarily located data methods; geometry processing of surfaces; higher dimensional surfaces. Prerequisites: CSE 470 and 477 *or* instructor approval.

CSE 579 NURBs: Nonuniform Rational B-Splines. (3) S
Projective geometry, NURBs-based modeling, basic theory of conics and rational Bezier curves, rational B-splines, surfaces, rational surfaces, stereographic maps, quadrics, IGES data specification Prerequisites: CSE 470, 477.

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

Department of Electrical Engineering

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REGENTS' PROFESSORS
BALANIS, FERRY

PROFESSORS
ALLSTOT, BACKUS, CROUCH, DeMASSA, GOODNICK, GORUR, HEYDT, HIGGINS, KARADY, KOZICKI, PALAIS, PAN, ROEDEL, SADOWSKY, SCHRODER, SPANIAS, THORNTON

ASSOCIATE PROFESSORS
ABERLE, ALLEE, BIRD, CHAKRABARTI, COCHRAN, EL-GHAZALY, EL-SHARAWY, GREENEICH, GRONDIN, HOLBERT, MORRELL, RODRIGUEZ, C. SHEN, J. SHEN, SI, SKROMME, TSAKALIS, TYLAVSKY, ZHANG

ASSISTANT PROFESSORS
CAPONE, KARAM, VASILESKA-KAFEDZISKA

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 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 goal of the Electrical Engineering undergraduate program is to prepare the graduates for entry-level positions as electrical engineers for the broad range of opportunities available in industrial, commercial, and governmental organizations, and to prepare the graduates for continued learning experiences either in a formal graduate program or in continuing education applications.

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.

The engineering design experience is structured around three backbone courses employing engineering teams: ECE 100 Introduction to Engineering Design (freshman year), ECE 300 Intermediate Engineering Design (junior year), and EEE 490 Senior Design Laboratory. The integrated experience is strengthened with required courses, EEE 120 Digital Design Fundamentals, EEE 225/226 Assembly Language Programming and Microprocessors, EEE 303 Signals and Systems, and EEE 360 Energy Conversion and Transport. Students focus on design pertaining to specific electrical engineering areas in their senior technical electives before the culminating, capstone design experience in EEE 490.

DEGREE REQUIREMENTS

A minimum of 128 semester hours is necessary for the B.S.E. degree in Electrical Engineering. A minimum of 50 upper-division semester hours is required.

GRADUATION REQUIREMENTS

A student must earn a grade of "C" or higher 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 100; ECE 300, 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, students must satisfy all university graduation requirements. See pages 79–83.

COURSE REQUIREMENTS

The specific course requirements for the B.S.E. degree in Electrical Engineering follow.

First-Year Composition*

ENG	101, 102	First Year Composition	6
		or ENG 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	
Total			6

* A minimum grade of "C" is required.

General Studies/School Requirements

Humanities and Fine Arts/ Social and Behavioral Sciences

ECN	111	Macroeconomic Principles *SB*	3
		or ECN 112 Microeconomic Principles *SB* (3)	
HU courses			6–10
SB courses			3–7
Minimum total			16

Literacy and Critical Inquiry

ECE	300	Intermediate Engineering Design *L1*	3
EEE	490	Senior Design Laboratory *L2*	3
Total			6

Natural Sciences/Basic Sciences

CHM	114	General Chemistry for Engineers *S1/S2*	4
		or CHM 116 General Chemistry *S1/S2* (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	241	University Physics III	3
Total			15

[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.

Numeracy and Mathematics

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
Total			25
General Studies/school requirements total			68

Engineering Core

ECE	301	Electrical Networks I	4
ECE	314	Engineering Mechanics	4
ECE	334	Electronic Devices and Instrumentation	4
ECE	352	Properties of Electronic Materials	4
EEE	225	Assembly Language Programming and Microprocessors (Motorola)	4
		or EEE 226 Assembly Language Programming and Microprocessors (Intel) (4)	
Total			20

Electrical Engineering Major

The following courses are required to fulfill the Electrical Engineering major:

CSE	100	Principles of Programming *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 17 hours of technical electives. To ensure breadth of knowledge, students *must* select courses from at least 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	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 department 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

First 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

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

Second Year

First Semester

CSE	100	Principles of Programming *N3*	3
ECN	111	Macroeconomic Principles *SB*	3
		or ECN 112 Microeconomic Principles *SB* (3)	
MAT	272	Calculus with Analytic Geometry III	4
MAT	274	Elementary Differential Equations	3

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

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) or EEE 226 Assembly Language Programming and Microprocessors (Intel) (4)	4
MAT	362	Advanced Mathematics for Engineers and Scientists I	3
PHY	241	University Physics III	3
HU, SB, and awareness area course[3]			3
Total			17

Third Year

First Semester

ECE	300	Intermediate Engineering Design *L1*	3
EEE	302	Electrical Networks II	3
EEE	340	Electromagnetic Engineering I	4
MAT	342	Linear Algebra	3
HU, SB, and awareness area course(s)[3]			4
Total			17

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

Fourth Year

First Semester

ECE	314	Engineering Mechanics	4
EEE	350	Random Signal Analysis	3
HU, SB, and awareness area course[3]			3
Technical electives			7
Total			17

Second Semester

EEE	490	Senior Design Laboratory *L2*	3
HU, SB, and awareness area course[3]			3
Technical electives			10
Total			16

[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 196.

ELECTRICAL ENGINEERING (EEE)

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.

EEE 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. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

EEE 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. Prerequisites: CSE 100 (or 200); CSE/EEE 120.

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

EEE 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.

EEE 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.

EEE 350 Random Signal Analysis. (3) F, S
Probabilistic and statistical analysis as applied to electrical signals and systems. Pre- or corequisite: EEE 303 or MAE 317.

EEE 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.

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

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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. Prerequisite: EEE 436.

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

EEE 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.

EEE 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.

EEE 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.

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

EEE 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. Prerequisites: EEE 303, 350.

EEE 459 Data Communication Systems. (3) S
System characteristics. Communications media. Communication codes. Data validity checking. Line protocols, terminals, and system configurations. Examples. Prerequisites: EEE 303, 350.

EEE 460 Nuclear Concepts for the 21st Century. (3) N
Radiation interactions, damage, dose, and instrumentation. Cosmic rays, satellite effects; soft errors; transmutation doping. Fission reactors, nuclear power. TMI, Chernobyl. Radioactive waste. Prerequisite: PHY 241 or 361.

EEE 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, 340 (or PHY 241).

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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 300, 334; EEE 303; senior status. *General Studies: L2.*

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

EEE 507 Multidimensional Signal Processing. (3) F
Processing and representation of multidimensional signals. Design of systems for processing multidimensional data. Introduction to image and array processing issues. Prerequisite: EEE 407 or instructor approval.

EEE 508 Digital Image Processing and Compression. (3) S
Fundamentals of digital image perception, representation, processing, and compression. Emphasis on image coding techniques. Signals include still pictures and motion video. Prerequisites: EEE 350 and 407 *or* equivalents.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 533 Semiconductor Process/Device Simulation. (3) F
Process simulation concepts, oxidation, ion implantation, diffusion, device simulation concepts, pn junctions, MOS devices, bipolar transistors. Prerequisite: EEE 436 or equivalent.

EEE 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).

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

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

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

EEE 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.

EEE 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.

EEE 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.

EEE 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 and 340 *or* equivalents.

EEE 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.

EEE 546 Advanced Fiber-Optics. (3) N
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.

EEE 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.

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

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

EEE 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.

EEE 551 Information and Coding Theory. (3) N
Fundamental theorems of information theory for sources and channels; convolutional and burst codes. Prerequisites: EEE 553, 554.

EEE 552 Digital Communications I. (3) S
Fundamentals of digital communications: complex signal theory; modulation; optimal coherent and incoherent receivers; coded modulation and the Viterbi algorithm. Prerequisites: EEE 455, 554.

EEE 553 Error-Correcting Codes. (3) S
Application of modern algebra to the design of random error-detecting and error-correcting block codes. Prerequisite: EEE 455.

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

EEE 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.

EEE 556 Detection and Estimation Theory. (3) S
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.

EEE 558 Digital Communications II. (3) F
Continuation of EEE 552. Advanced topics in digital communications: synchronization; multipath and fading; equalization; miscellaneous topics. Prerequisite: EEE 552.

EEE 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.

EEE 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.

EEE 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.

EEE 577 Power Engineering Operations and Planning. (3) F
Economic dispatch, unit commitment, dynamic programming, power system planning and operation, control, generation modeling, AGC, and power production. Prerequisite: EEE 471 or graduate standing.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 587 Optimal Control. (3) F
Optimal control of systems. Calculus of variations, dynamic programming, linear quadratic regulator, numerical methods, and Pontryagin's principle. Cross-listed as MAE 507. Prerequisite: EEE 482 or MAE 506.

EEE 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.

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

EEE 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.

EEE 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.

EEE 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.

EEE 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.

EEE 686 Adaptive Control. (3) N
Main topics covered: adaptive identification, convergence, parametric models, performance and robustness properties of adaptive controllers, persistence of excitation, and stability. Prerequisites: EEE 582 and 586 *or* instructor approval.

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

EEE 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.

EEE 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 and 579 *or* equivalents; instructor approval.

Department of Industrial and Management Systems Engineering

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PROFESSORS
BAILEY, DOOLEY, HENDERSON, HOGG, KEATS, MONTGOMERY, SMITH, UTTAL, WOLFE

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CARLYLE, FOWLER, MOU

The industrial engineer (IE) provides leadership for American organizations in reestablishing competitiveness in the global marketplace through system integration and productivity improvement. No challenge 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; including 50 upper-division semester hours.

Graduation Requirements

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 79–83.

Course Requirements

See pages 196–197 for General Studies, school, and engineering core course requirements.

Industrial Engineering Major

The following courses are required:

ASE	485	Engineering Statistics *N2*	3
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	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	ST: 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 *N3*	3
IEE	476	Operations Research Techniques/Applications *N2*	4
IEE	490	Project in Design and Development	3
Technical elective			3
Total			48

Industrial Engineering
Program of Study
Typical Four-Year Sequence

First Year

First Semester

CHM	114	General Chemistry for Engineers *S1/S2*[1]	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*	3
		or ECN 112 Microeconomic Principles *SB* (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 course[3]			3
Total			17

Second Year

First Semester

IEE	205	Microcomputer Applications in Industrial Engineering *N3*	3
IEE	300	Economic Analysis for Engineers	3
MAT	242	Elementary Linear Algebra	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 *N2*	3
MAT	274	Elementary Differential Equations	3
Core elective			3
Basic science elective[5]			3
HU, SB, and awareness area course[3]			3
Total			18

Third Year

First Semester

ASE	485	Engineering Statistics *N2*	3
IEE	305	Information Systems Engineering *N3*	3
IEE	367	Methods Engineering and Facilities Design	4
IEE	374	Quality Control *N2*	3
HU, SB, and awareness area course(s)[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	ST: Introduction to Manufacturing Processes	4
IEE	476	Operations Research Techniques/Applications *N2*	4
Total			17

Fourth 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 *N3*	3
HU, SB, and awareness area course[3]			3
Total			16

Second Semester

ECE	400	Engineering Communications *L2*	3
IEE	463	Computer-Aided Manufacturing and Control *N3*	3
IEE	490	Project in Design and Development	3
Technical elective			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 196.

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 *N2*	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

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

IEE	394	ST: 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	498	PS: Manufacturing Design Project	3
MAE	406	CAD/CAM Applications in MAE	4
Technical electives*			12
Total			47

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

INDUSTRIAL AND MANAGEMENT SYSTEMS ENGINEERING (IEE)

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.*

IEE 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.

IEE 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.*

IEE 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.

IEE 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.*

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

IEE 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.

IEE 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.

IEE 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.*

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

IEE 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.*

IEE 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.*

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

IEE 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.

IEE 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.

IEE 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.

IEE 530 Enterprise Modeling. (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.

IEE 531 Topics in Engineering Administration. (3) S 2000
Consideration given to philosophical, psychological, political, and social implications of administrative decisions. Prerequisite: IEE 532 or instructor approval.

IEE 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.

IEE 533 Scheduling and Network Analysis Models. (3) S 2000
Application of scheduling and sequencing algorithms, deterministic and stochastic network analysis, and flow algorithms. Prerequisites: ECE 380; IEE 476 (or 546).

IEE 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.

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

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

IEE 545 Discrete Event Simulation. (3) F, S
Modeling and analysis of stochastic systems using queuing theory and simulation. Statistical aspects of systems and analysis of output measures. Prerequisites: IEE 475 (or equivalent); instructor approval.

IEE 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 (or equivalent); IEE 205; instructor approval.

IEE 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.

IEE 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.

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

IEE 561 Production Systems. (3) F, S
Enabling theory for production control systems including: class item discounting, costing, factory physics, factory variability, inventory control, JIT, lot sizing, and sequencing. Prerequisites: ASE 485 (or 500 or ECE 380) and IEE 461 and 475 and 546 (or equivalents) and MAT 242.

IEE 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.

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

IEE 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.

IEE 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.

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

IEE 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 545.

IEE 569 Advanced Statistical Methods. (3) F 1998
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.

IEE 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.

IEE 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.

IEE 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.

IEE 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.

IEE 574 Applied Deterministic Operations Research Models. (3) F, S
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.

IEE 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.

IEE 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.

IEE 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.

IEE 579 Time Series Analysis and Forecasting. (3) F 1999
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.

IEE 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.

IEE 672 Advanced Topics in Experimental Design. (3) S 2000
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.

IEE 677 Regression and Linear Models. (3) S 1999
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.

IEE 679 Time Series Analysis and Control. (3) F 1998
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.

IEE 681 Reliability, Availability, and Serviceability. (3) F 1998
Organizing hardware and software, integrity and fault-tolerant design, maintenance design and strategy, Markov models, fault-free analysis, and military standards. Prerequisite: ECE 380.

Department of Mechanical and Aerospace Engineering

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ASSOCIATE PROFESSORS
CHEN, KOURIS, KUO, MIGNOLET, RANKIN, SQUIRES, WELLS

ASSISTANT PROFESSORS
LEE, McNEILL, PHELAN, PUIG-SUARI

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 and take a minimum of 50 upper-division semester hours in order to be eligible for graduation. Also, the department may require additional or remedial course work for those students who have demonstrated a trend toward academic difficulties.

GRADUATION REQUIREMENTS

In addition to fulfilling school and major requirements, majors must satisfy all university graduation requirements. See pages 79–83.

COURSE REQUIREMENTS

General Studies

See pages 196–197 for General Studies, school, and engineering core course requirements.

Engineering Core Options

Among the options listed on pages 195–196 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 *LI*	3
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	350	Structure and Properties of Materials	3
Total			26

AEROSPACE ENGINEERING—B.S.E.

The goal of the Aerospace Engineering program is to provide students with an education in technological areas critical to the design and development of aerospace vehicles and systems. The program emphasizes aeronautical engineering with topics in required courses covering aerodynamics, aerospace materials, aerospace structures, propulsion, flight mechanics, aircraft performance, and stability and control. Astronautic topics such as orbital mechanics, attitude dynamics, spacecraft control, and rocket propulsion are also covered in required courses.

Design is integrated throughout the curriculum beginning with ECE 100 Introduction to Engineering Design and followed later by ECE 300 Intermediate Engineering Design, both of which focus on basic design theory as well as professional practice. These required courses are followed by topic-specific design content in aerospace engineering courses in the junior and senior years. The senior capstone design course integrates design and analysis topics from the earlier courses and completes the required design sequence. This sequence includes a minimum of 20 semester hours of required design. In addition, many of the aerospace technical electives have design content.

Laboratory experience is provided in the areas of aerodynamics, aerospace structures, and vibrations. Laboratory facilities include four major wind tunnels, an integrated mechanical-testing laboratory, a controls laboratory, and a vibrations laboratory.

Aerospace Engineering Major

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

MAT	242	Linear Algebra	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	Aircraft Performance, Stability, and Control	3
MAE	415	Vibration Analysis	4
MAE	425	Aerospace Structures	4
MAE	460	Gas Dynamics	3
MAE	462	Space Vehicle Dynamics and Control	3
MAE	463	Propulsion	3
MAE	464	Aerospace Laboratory	3
MAE	468	Aerospace Systems Design *L2*	3
MAE	498	PS: Principles of Aerospace Design	3
Area of emphasis (technical electives)			6
Total			48

Aerospace Engineering Areas of Emphasis

To further the design experience, all Aerospace Engineering students must choose at least one technical elective from the following list of courses:

MAE	426	Design of Aerospace Structures	3
MAE	461	Aerodynamics II	3
MAE	465	Rocket Propulsion	3
MAE	466	Rotary Wing Aerodynamics and Performance	3
MAE	467	Aircraft Performance	3
MAE	469	Projects in Astronautics and Aeronautics	3

The remaining technical elective(s) may be selected from among any of the courses listed in the following course tables 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 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 *L2*	3
MAT	421	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

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

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 *L2*	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	4
MAE	471	Computational Fluid Dynamics	3
MAE	541	CAD Tools for Engineers	3
MAT	421	Applied Computational Methods *N3*	3
MAT	423	Numerical Analysis I *N3*	3
MAT	425	Numerical Analysis II *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	4
MAE	426	Design of Aerospace Structures	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 *L2*	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 *L2*	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 System Design	3
MAE	447	Robotics and Its Influence on Design	3
MAE	469	Projects in Astronautics or Aeronautics	3
MAE	490	Projects in Design and Development *L2*	3

Typical Four-Year Sequence

The first two years are usually devoted to the General Studies and engineering core requirements. Thus, the degree programs in the department share essentially the same course schedule for that period of time. A typical schedule is given below:

Aerospace Engineering Program of Study Typical Four-Year Sequence

First 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

ENG	102	First-Year Composition	3
MAT	242	Linear Algebra	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

Second 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
ECE	350	Structure and Properties of Materials	3
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	384	Numerical Analysis for Engineers I	2
ECE	386	Partial Differential Equations for Engineers	2
Total			17

Third Year

First Semester

ECE	300	Intermediate Engineering Design *L1*	3
MAE	317	Dynamic Systems and Control	3
MAE	361	Aerodynamics I	3
MAE	425	Aerospace Structures	4
HU, SB, and awareness area course[2]			3
Total			16

Second Semester

EEE	350	Random Signal Analysis	3
MAE	413	Aircraft Performance, Stability, and Control	3
MAE	460	Gas Dynamics	3
MAE	498	PS: Principles of Aerospace Design	3
HU, SB, and awareness area course[2]			3
Total			15

Fourth Year

First Semester

PHY	361	Introductory Modern Physics	3
MAE	415	Vibration Analysis	4
MAE	462	Space Vehicle Dynamics and Control	3

MAE	463	Propulsion	3
Required design technical elective			3
Total			16

Second Semester

MAE	464	Aerospace Laboratory	3
MAE	468	Aerospace Systems Design *L2*	3
Technical electives			3
HU, SB, and awareness area courses[2]			7
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 196.

[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.

Design is integrated throughout the curriculum, beginning with ECE 100 Introduction to Engineering Design and followed later by ECE 300 Intermediate Engineering Design, both of which focus on basic design theory as well as professional practice. These required courses are followed by topic specific design content in mechanical engineering courses in the junior and senior years. The senior capstone design course combines the design topics from the earlier courses and completes the required design sequence. In addition, many of the mechanical technical electives have design content.

Laboratory experience is provided in the areas of thermofluid systems, mechanics of materials, and controls. Laboratory facilities include thermal systems, and integrated mechanical-testing laboratory, a controls laboratory, and a manufacturing laboratory.

Mechanical Engineering Major

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

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	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			53

Areas of Emphasis

Technical electives may be selected from among any of the following courses 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 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	411	Biomedical Engineering I	3
BME	412	Biomedical Engineering II	3
BME	416	Biomechanics	3
BME	419	Biocontrol Systems	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	4
MAE	471	Computational Fluid Dynamics	3
MAE	541	CAD Tools for Engineers	3

MAT	421	Applied Computational Methods *N3*	3
MAT	423	Numerical Analysis I *N3*	3
MAT	425	Numerical Analysis II *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	Aircraft Performance, Stability, and Control	3
MAE	417	Control System Design	3
MAE	462	Space Vehicle Dynamics and Control	3
MAE	467	Aircraft Performance	3

Design. Select from these courses:

MAE	341	Mechanism Analysis and Design	3
MAE	351	Manufacturing Processes	3
MAE	404	Finite Elements in Engineering	3
MAE	406	CAD/CAM Applications in MAE	4
MAE	413	Aircraft Performance, Stability, and Control	3
MAE	417	Control System Design	3
MAE	434	Internal Combustion Engines	3
MAE	435	Turbomachinery	3
MAE	442	Mechanical Systems Design	3
MAE	446	Thermal Systems Design	3
MAE	447	Robotics and Its Influence on Design	3
MAE	462	Space Vehicle Dynamics and Control	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	434	Internal Combustion Engines	3
MAE	435	Turbomachinery	3
MAE	436	Combustion	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	Aircraft Performance, Stability, and Control	3
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	421	Applied Computational Methods *N3*	3
MAT	423	Numerical Analysis I *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	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	372	Fluid Mechanics	3
MAE	382	Thermodynamics	3
MAE	433	Air Conditioning and Refrigeration	3
MAE	434	Internal Combustion Engines	3
MAE	435	Turbomachinery	3
MAE	436	Combustion	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

First 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	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

Second Year

First Semester

ECE	210	Engineering Mechanics I: Statics	3
ECE	350	Structure and Properties of Materials	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
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

Third Year

First Semester

ECE	300	Intermediate Engineering Design *L1*	3
MAE	317	Dynamic Systems and Control	3
MAE	318	Dynamic Systems and Control 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 I	2
EEE	350	Random Signal Analysis	3
MAE	388	Heat Transfer	3
MAE	441	Principles of Design	3
HU, SB, and awareness area course[2]			3
Technical elective			3
Total			17

Fourth Year

First Semester

MAE	491	Experimental Mechanical Engineering	3
PHY	361	Introductory Modern Physics	3
HU, SB, and awareness area course(s)[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 196.

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

MECHANICAL AND AEROSPACE ENGINEERING (MAE)

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.

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

MAE 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.

MAE 351 Manufacturing Processes. (3) S
Automation and assembly systems; forming and machining processes; machining and forming labs; materials and manufacturing properties; tool and equipment designs. Lecture, lab. Prerequisites: ECE 313, 350.

MAE 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.

MAE 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.

MAE 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).

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

MAE 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.

MAE 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).

MAE 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).

MAE 406 CAD/CAM Applications in MAE. (4) 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. 3 hours lecture, 3 hours lab. Prerequisites: MAE 441; instructor approval.

MAE 413 Aircraft Performance, Stability, and Control. (3) S
Aircraft performance, cruise, climbing and turning flights, energy maneuverability, 6 DOF equations for aircraft, aerodynamic stability derivatives, flight stability/control. Prerequisites: MAE 317, 361.

MAE 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).

MAE 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.

MAE 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.

MAE 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).

MAE 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.

MAE 433 Air Conditioning and Refrigeration. (3) A
Air conditioning processes; environmental control; heating and cooling loads; psychrometry; refrigeration cycles. Prerequisite: MAE 388 or MET 432 or instructor approval.

MAE 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.

MAE 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.

MAE 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.

MAE 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. Lecture, lab (project). Prerequisites: ECE 300, 350. Pre- or corequisite: MAE 422 or 425.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 460 Gas Dynamics. (3) A
Compressible flow at subsonic and supersonic speeds; duct flow; normal and oblique shocks, perturbation theory, and wind tunnel design. Prerequisites: ECE 386; MAE 361 (or 371).

MAE 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.

MAE 462 Space Vehicle Dynamics and Control. (3) F
Attitude dynamics and control, launch vehicles, orbital mechanics, orbital transfer/rendezvous, space mission design, space structures, spacecraft control systems design. Prerequisite: MAE 317.

MAE 463 Propulsion. (3) A
Fundamentals of gas-turbine engines and design of components. Principles and design of rocket propulsion and alternative devices. Lecture, design projects. Prerequisite: ECE 386. Pre- or corequisite: MAE 361 (or 371).

MAE 464 Aerospace Laboratory. (3) F, S
Aerodynamic 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: ECE 386; MAE 361, 460.

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

MAE 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 and MAE 361 *or* instructor approval.

MAE 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.

MAE 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.*

MAE 469 Projects in Astronautics or Aeronautics. (3) F, S
Various multidisciplinary team projects available each semester. Projects include design of high-speed rotocraft autonomous vehicles, liquid-fueled rockets, micro-aerial vehicles, satellites. Prerequisite: instructor approval.

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

MAE 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.*

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 507 Optimal Control. (3) F
Optimal control of systems. Calculus of variations, dynamic programming, linear quadratic regulator, numerical methods, and Pontryagin's principle. Cross-listed as EEE 587. Prerequisite: EEE 482 or MAE 506.

MAE 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.

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

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

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

MAE 521 Structural Optimization. (3) S
Linear and nonlinear programming. Problem formulation. Constrained and unconstrained optimization. Sensitivity analysis. Approximate techniques. FEM-based optimal design of mechanical and aerospace structures. Cross-listed as CEE 533. Prerequisite: instructor approval.

MAE 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.

MAE 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.

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

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 546 CAD/CAM Applications in MAE. (4) 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. 3 hours lecture, 3 hours lab. Prerequisite: instructor approval.

MAE 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.

MAE 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.

MAE 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.

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

MAE 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.

MAE 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. Prerequisites: MAE 460 (or 461), 562.

MAE 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.

MAE 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.

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

MAE 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.

MAE 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.

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

MAE 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.

MAE 581 Thermodynamics. (3) F
Basic concepts and laws of classical equilibrium thermodynamics; applications to engineering systems. Introduction to statistical thermodynamics.

MAE 582 Statistical Thermodynamics. (3) A
Kinetic and quantum theory. Statistical mechanics; ensemble theory. Structure and thermodynamics of noninteracting and interacting particles. Boltzmann integro-differential equation. Prerequisite: graduate standing.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 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.

MAE 598 Special Topics. (1–3) F, S
Special topics courses, including the following, which are regularly offered, are open to qualified students:
(a) Advanced Spacecraft Control
(b) Aeroelasticity
(c) Aerospace Vehicle Guidance and Control
(d) Boundary Layer Stability
(e) Hydrodynamic Stability
(f) Plasticity
(g) Polymers and Composites

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

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

ENGINEERING SPECIAL STUDIES—B.S.E.

Manufacturing Engineering. This program option is offered by the Department of Industrial and Management Systems Engineering. See pages 228–229 for program requirements.

Premedical 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 premedical engineering option and have been selected to meet all university and school requirements. *Note:* In order to fulfill medical school admission requirements, BIO 182 General Biology is also required in addition to the degree requirements and is best taken in summer session before the Medical College Admission Test (MCAT).

First-Year Composition

ENG	101, 102	First Year Composition	6
		or 105 Advanced First-Year Composition (3) or ENG 107, 108 English for Foreign Students (6)	
Total			6

General Studies/School Requirements

Humanities and Fine Arts/ Social and Behavioral Sciences

ECN	111	Macroeconomic Principles *SB*[1]	3
		or ECN 112 Microeconomic Principles (3) *SB*[1]	
HU, SB, and awareness area courses[2]			13
Total			16

Literacy and Critical Inquiry 7

Natural Sciences

PHY	121	University Physics I: Mechanics *S1/S2*[3]	3
PHY	122	University Physics Laboratory I *S1/S2*[3]	1
PHY	131	University Physics II: Electricity and Magnetism *S1/S2*[4]	3
PHY	132	University Physics Laboratory II *S1/S2*[4]	1
Total			8

Numeracy/Mathematics

ECE	100	Introduction to Engineering Design *N3*	4
MAT	242	Elementary Linear Algebra	2
		or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers (2)	
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
Total			21
General Studies/school requirements total			58

Engineering Core

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
Total			20

Engineering Special Studies Program Major—Premedical Engineering Option

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

NOTE: For the General Studies requirement, codes (such as L1, N3, C, and H), and courses, see pages 84–108. For graduation requirements, see pages 79–83. For omnibus courses offered but not listed in this catalog, see pages 56–57.

BME	435	Physiology for Engineers	4
BME	470	Microcomputer Applications in Bioengineering	4
BME	490	Biomedical Engineering Capstone Design II	4
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 *N2*	3
Technical elective			1
Total			58

[1] ECN 111 or ECN 112 must be included to fulfill the HU and SB requirements.

[2] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to fulfill HU and SB requirements. See page 196.

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

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

Premedical 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 Analytic 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 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			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	272	Calculus with Analytic Geometry III	4
PHY	131	University Physics II: Electricity and Magnetism *S1/S2*[2]	3
PHY	132	University Physics Laboratory II *S1/S2*[2]	1
Total			18

Second Semester

CHM	331	General Organic Chemistry	3
CHM	335	General Organic Chemistry Laboratory	1
ECE	301	Electrical Networks I	4
ECE	350	Structure and Properties of Materials	3
ECN	111	Macroeconomic Principles *SB* or ECN 112 Microeconomic Principles *SB* (3)	3
MAT	274	Elementary Differential Equations	3
Total			17

Third Year

First Semester

BME	331	Biomedical Engineering Transport I: Fluids	3
BME	435	Physiology for Engineers	4
CHM	332	General Organic Chemistry	3
ECE	300	Intermediate Engineering Design *L1*	3
ECE	340	Thermodynamics	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* or ECE 384 Numerical Analysis for Engineers I (2) or ECE 386 Partial Differential Equations for Engineers (2)	2
HU, SB, and awareness area course(s)[3]			4
Total			17

Fourth Year

First Semester

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
HU, SB, and awareness area courses[3]			6
Total			16

Second Semester

BME	470	Microcomputer Applications in Bioengineering	4
BME	490	Biomedical Engineering Capstone Design II	3
ECE	380	Probability and Statistics for Engineering Problem Solving *N2*	3
HU, SB, and awareness area course[3]			3
Technical elective			1
Total			14
Degree requirements 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.

[3] Engineering students may not use aerospace studies (AES) or military science (MIS) courses to satisfy HU or SB requirements. See page 196.

Sara Gerke, a student in Environmental Civil Engineering, works with a gas chromatograph in the Environmental Engineering Laboratory. Ken Sweat photo