Newark College of Engineering

One of the oldest and largest professional engineering schools in the United States, Newark College of Engineering offers 13 undergraduate degree programs, 16 master’s and 10 doctoral degree programs. Undergraduate enrollment is more than 2,500, and more than 1,100 are enrolled in graduate study. The 150-member faculty includes engineers and scholars who are widely recognized in their fields.

Programs

- Biomedical Engineering - B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/biomedical/bs)
- Civil Engineering - B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/civil-environmental/civil-engineering-bs)
- Engineering Technology Concrete Industry Management (CIM) - B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/technology/concrete-industry-management-technology)
- Engineering Technology, Mechanical Engineering Technology (MET) - B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/technology/mechanical-engineering-technology)
- Engineering Technology, Medical Informatics Technology (MIT) - B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/technology/medical-informatics-technology)

Accelerated Programs (http://catalog.njit.edu/undergraduate/academic-policies-procedures/special-degree-options)

- Biomedical Engineering, Pre-Health - Accelerated B.S. (http://catalog.njit.edu/undergraduate/newark-college-engineering/biomedical/accelerated-bs-prehealth)
- Biomedical Engineering Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/biomedical/minor) (for Engineering Science students)
- Geosystems Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/civil-environmental/geosystems-minor)
- Geriatric Engineering Technology Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/civil-environmental/geriatric-minor)
- Nanotechnology Minor (http://catalog.njit.edu/undergraduate/newark-college-engineering/biomedical/nanotechnology-minor)

**Programs**

- Biomedical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/biomedical/ms)
- Biopharmaceutical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/biopharmaceutical-ms)
- Chemical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/chemical-ms)
- Civil Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/civil-ms)
- Civil Engineering - M.S. online (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/civil-ms-online)
- Computer Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/electrical-computer/computer-ms)
- Critical Infrastructure Systems - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/critical-infrastructure-systems-ms)
- Electrical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/electrical-computer/electrical-ms)
- Engineering Science - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/interdisciplinary-engineering-science/ms)
- Environmental Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-ms)
- Industrial Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/mechanical-industrial/industrial-ms)
- Internet Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/electrical-computer/internet-ms)
- Mechanical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/mechanical-industrial/mechanical-ms)
- Pharmaceutical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/pharmaceutical-ms)
- Power and Energy Systems - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/electrical-computer/power-energy-systems-ms)
- Telecommunications - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/electrical-computer/telecommunications-ms)
- Transportation - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/transportation-ms)

**Double Majors** (http://catalog.njit.edu/graduate/academic-policies-procedures/special-programs)

- Architecture - M.Arch. and Civil Engineering - M.S. (http://catalog.njit.edu/graduate/architecture-design/architecture/march-civil-engineering-ms)

**Programs**

- Biomedical Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/biomedical/phd)
- Chemical Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/chemical-materials-engineering/chemical-phd)
- Civil Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/civil-phd)
- Computer Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/electrical-computer/computer-phd)
Newark College of Engineering Courses

BME 101. Introduction to Biomedical Engineering. 3 credits, 3 contact hours (3;0;0).
This course is open only to freshmen and new transfer students. Faculty members describe their research in biomedical engineering.

BME 102. Biomedical Engr Research. 1 credit, 1 contact hour (1;0;0).
Corequisite: FED 101 OR BME 111. Students at our prehealth program aim to be in medical practice. This course offers them to critically read medical engineering articles, understand it, research it and present engineering design principles to our faculty. This will enhance their ability to both succeed professionally and to contextualize their chosen vocations.

BME 105. Introduction to Human Physiology I. 2 credits, 2 contact hours (2;0;0).
BME 106. Introduction to Human Physiology II. 1 credit, 1 contact hour (1;0;0).

BME 111. Introduction to Physiology. 3 credits, 3 contact hours (3;0;0).
This course is open only to freshmen and transfer students. An overview of human physiology is presented as an introduction to subsequent core courses in the Biomedical Engineering curriculum. Not intended to be an exhaustive review of physiology, the course will instead emphasize key examples that highlight understanding of the interaction between the biomedical and engineering worlds.

BME 210. Processing Fund for Biol Signa. 3 credits, 4 contact hours (3;1;0).
Prerequisite: Sophomore Standing. This course will introduce the fundamentals of filtering and processing specifically designed for applications using biologically inspired signals. This course will provide an introduction to computation and data analysis using MATLAB - an industry standard programming and graphical environment that is employed in several core and elective courses in engineering. A major component of this course is the application of digital signal processing to biologically inspired signals using MATLAB.

BME 301. Electrical Fundamentals of Biomedical Engineering. 3 credits, 4 contact hours (1;3;0).
Prerequisites: Grade of C or higher in PHYS 121 and MATH 112. Course lectures and laboratories will address important issues for biomedical engineers at the introductory level; covering the origins of bio-electric signals and the instrumentation involved in collection of biopotentials from the electrodes to processing of the signals on the computer. Some other topics included are the transducers/sensors and modern engineering software used in bio-instrumentation. Laboratory work will provide hands-on experience in all of these areas. The course will also address practical issues in design of medical devices such as noise, resolution, linearity, and saturation. This course is offered in Studio format that involves the integration of lectures and labs into one highly participatory structure.

BME 302. Mechanical Fundamentals of Biomedical Engineering. 3 credits, 4 contact hours (1;3;0).
Prerequisites: Grade of C or higher in PHYS 121 and MATH 112. BME 301 is not a prerequisite. The format is identical to that of BME 301. Course lectures and laboratories will address important issues covering the mechanical fundamentals that are important bases for later learning experiences. This course introduces the students to engineering mechanics and how those principles are relevant to biomechanical issues. This course is offered in Studio format that involves the integration of lectures and labs into one highly participatory structure.

BME 303. Biological and Chemical Foundations of Biomedical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: Grade of C or higher in CHEM 126 or CHEM 122. This course covers organic chemistry, biochemistry and cellular mechanics in sufficient depth to give biomedical engineering students a strong enough background for them to understand the introductory aspects of the discipline, which focus on the application of engineering principles to medicine and surgery.

BME 304. Material fundamentals of Biomedical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: A Grade of C or higher in (CHEM 126 or CHEM 122) and PHYS 111. This course is an introduction to the field of biomaterials with an emphasis on the wound healing process and interactions between the human body and implanted devices fabricated from various types of biomaterials. The thrust of this course will be to illuminate the processes occurring at the tissue-biomaterial interface. Attention will be given to the biological events occurring at the molecular level on the surface of an implanted device. The nature of these surfaces and the physiological consequences of these processes will be examined in terms of how the body and functioning of the device are impacted.

BME 310. Biomedical Computing. 3 credits, 4 contact hours (3;1;0).
Prerequisites: BME 301 and (CS 101 or BNFO 135 or CS 115). This course covers the application of digital signal processing to biomedical problems. Application of programming language common in engineering, for signal acquisition and processing. Applications include analysis of the electrocardiogram and other electrical signals generated by the body.

BME 311. Co-op Work Experience. 3 credits, 3 contact hours (0;0;3).
Restriction: sophomore standing or above, approval of department, and permission of Career Development Services. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated by the co-op office and approved by the department. Mandatory participation in seminars and completion of a report. Note: Normal grading applies to this COOP Experience.

Newark College of Engineering

• Electrical Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/electrical-computer/electrical-phd)
• Environmental Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/environmental-phd)
• Industrial Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/mechanical-industrial/industrial-phd)
• Mechanical Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/mechanical-industrial/mechanical-phd)
• Transportation - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/civil-environmental/transportation-phd)
BME 321. Adv Mechanics for Biomed Engr. 3 credits, 3 contact hours (3;0;0).
Prerequisite: BME 302 with a grade of C or better. This course provides an understanding of engineering mechanics, especially as applied to biomechanical systems. Students should be familiar with static equilibrium analysis and concepts of stress and strain. Course topics include method of sections, area moment of inertia, mechanical properties of materials, torsion, bending, stress transformation, Mohr’s circle, and deflection of beams.

BME 333. Biomedical Signals and Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisites: BME 301, MATH 222, (BME 210 or BME 310). BME Tools such as the Laplace and Fourier Transforms, time-frequency analysis are introduced. Applications include signals and noise, processing of the ECG, mathematics of imaging and derivation of useful physiological parameters from input signals.

BME 351. Introduction to Biofluid Mechanics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: BME 302, MECH 236 and (MECH 320 or BME 321). Introduction to the principles of fluid flow. Basic fluid principles, such as fluid properties, fluid statics, conservation of mass, momentum, and energy will be discussed and presented in BME context. Special attention will be given to the non-Newtonian nature of blood, viscous flow in arteries, unsteady flows, and to the fluidic output of the heart. The textbook material will be supplemented throughout the course to emphasize examples relative to BME.

BME 372. Biomedical Electronics. 3 credits, 3 contact hours (3;0;0).
Prerequisite: BME 111 and BME 301 with a C or better. The first of a two-semester sequence that covers the design of electronic circuits for Biomedical applications. This course covers basic operational amplifier circuits as well as the operation of semiconductor diodes and transistors. An introduction to digital logic circuits is also provided. Computer simulation as well as hands-on breadboarding of electronic circuits are used throughout the course to supplement the lectures.

BME 373. Biomedical Electronics II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: BME 372. This is a continuation of BME 372 emphasizing biomedical applications of oscillators, active filters, and wave-shaping circuits.

BME 382. Engineering Models of Physiological Systems. 3 credits, 5 contact hours (5;0;0).
Prerequisites: BME 111, BME 301, BME 302 and Math 222 all with a C or better. Students learn to develop quantitative models of organs and organ systems from an engineering viewpoint. Students translate their understanding of physiological systems into models that evolve dynamically based on engineering block diagrams. Additional topics include: hierarchical structure, sensitivity analysis, parameter estimation, negative feedback control, and characteristic traits of models. Students will use models to gain insight into how a physiological system functions and to design a biomedical engineering device or procedure that interacts with the physiological system. Systems studied include the cardiovascular system, gas exchange in the lungs, nerve and muscle action potentials, and musculo-skeletal spinal reflex.

BME 383. Measurement Lab for Physiological Systems and Tissue. 3 credits, 4 contact hours (1;3;0).
Prerequisites: BME 302, (BME 210 or BME 310), (MATH 279 or MATH 333). Through laboratory experiences, students will apply engineering methods for measuring and interpreting the properties of physiological systems and biological tissues. Topics include measurements relevant to cardio-pulmonary, nerve and muscular systems.

BME 384. Biomechanics Laboratory. 3 credits, 4 contact hours (1;3;0).
Prerequisites: BME 302, MECH 236, BME 321, (MATH 279 or MATH 333), (CS 101 or BNSO 135 or CS 115 or BME 210). This course is an introduction to the experimental analysis of biomechanics of human motion. Laboratory experiments include the application and integration of anatomical and mechanical concepts to a wide variety of activities. Students will develop basic competence in a systematic approach to the observation, analysis and evaluation of human movement in clinical, educational, and industrial environments.

BME 385. Cell and Biomaterial Engineering Laboratory. 3 credits, 4 contact hours (1;3;0).
Prerequisite: MATH 112, PHYS 121 BME 304 and (MATH 279 or MATH 333) all with a C or better. This laboratory course is designed to provide students with valuable hands-on experience in the field of cellular and biomaterial engineering. Experiments include biomatieral fabrication and characterization, mechanical testing of biomaterials, colorometric protein assay, cell-based assay, the basics of cell culture techniques, the basics of light and electron microscopy, and image capture and analysis. A lecture on the principles of a given technique will be followed by laboratory activity.

BME 386. Bioinstrumentation Laboratory. 3 credits, 4 contact hours (1;3;0).
Prerequisites: ECE 251, BME 372 and (MATH 279 or MATH 333). Laboratory exercises involve projects at all levels of a bioinstrumentation system from sensors to data acquisition and data processing. Analog and digital circuits are constructed to condition the signals from sensors and convert them into a format that can be displayed or acquired into a computer. The final projects help to develop the skills to integrate various parts of a bioinstrumentation system, collect and analyze data and troubleshoot a circuit.

BME 411. Co-op Work Experience. 0 credits, 0 contact hours (0;0;0).
Prerequisites: BME 311 and completion of sophomore year, approval of department, and permission of Career Development Services. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated by the co-op office and approved by the department. Mandatory participation in seminars and completion of a report. May count as BME or approved elective. Grade will now be issued as a letter grade.
BME 420. Advanced Biomaterials Science. 3 credits, 3 contact hours (3;0;0).
Prerequisites: BME 302, BME 304, and MTSE 301. The goal of this course is to understand material selection, important properties of materials for use in the body and failure modes of applied biomaterials. The course will cover the structure and properties of materials used as biomaterials including metals, ceramics, synthetic polymers, and biopolymers. The structure and composition of these materials will be explored to understand how they define the behavior of a material. The bulk behavior of materials will be reviewed, including the generalized Hooke's Law, and new concepts will be introduced (including thermal strain, surface properties, and viscoelasticity). Students will be presented with problems of property characterization, failure analysis and performance testing. Students will work in teams to analyze a marketed implant or device using biomaterial(s) using the tool and concepts learned in the course.

BME 422. Biomaterials Characterization. 3 credits, 3 contact hours (3;0;0).
Prerequisites: Math 112, Phys 121, BME 304 and MTSE 301 all with a C or better. The quantum mechanical origins of spectroscopy, the relationship of spectroscopic behavior to thermal characteristics of a material, and the differences in approach to the chemical and physical characterization of synthetic and biological polymers are discussed.

BME 427. Biotransport. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 222, (BME 303 or R120 102), and CHE 230. This course provided an introduction to basic concepts in thermodynamics and transport phenomena as applied to biological systems. The structure and composition of the body will be covered followed by an exploration of the properties of the blood and its flow in the cardiovascular system, and the body as a heat source and as a series of compartments involved in the mass transfer of materials (such as those in the kidneys and lungs). Design of artificial kidneys and heart-lung machines is also explored.

BME 430. Fundamentals of Tissue Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: BME 302, (BME 303 or R120 102), BME 304, MATH 222 and MTSE 301. This course is an introduction to the field of tissue engineering as a therapeutic approach to treating damaged or diseased tissues in the biotechnology industry. In essence, new and functional living tissue can be fabricated by delivering cells, scaffolds, DNA, proteins, and/or protein fragments at surgery. This course will cover the advances in the fields of cell biology, molecular biology, material science and their relationship towards developing novel "tissue engineered" therapies.

BME 451. Biomechanics I. 3 credits, 3 contact hours (3;0;0).

BME 452. Mechanical Behavior and Performance of Biomaterials. 3 credits, 3 contact hours (3;0;0).
Prerequisites: BME 302, BME 304, MATH 222, MATH 279, and BME 321. Biomaterial selection and performance is essential to the design and implementation of most any biomedical application. Students will learn about important properties of materials for use in the body and failure modes of applied biomaterials. Material behavior will be reviewed, including the generalized Hooke's Law, and new concepts will be introduced including thermal strain, surface properties, and viscoelasticity. Material biocompatibility will be introduced in regards to body responses including cell and tissue interaction, toxicity and safety.

BME 471. Principles of Medical Imaging. 3 credits, 3 contact hours (3;0;0).
Prerequisites: BME 301, (BME 210 or BME 310). This is an introductory undergraduate course in biomedical imaging. This course will cover medical physics, instrumentation, data acquisition and processing to generate structural and functional images. A number of modalities including X-ray, Computer Tomography, Ultrasound, and magnetic resonance imaging systems are included. This course is an elective in the Bioinstrumentation track.

BME 478. Introduction to CAD for Biomechanics. 4 credits, 6 contact hours (4;2;0).
Prerequisites: BME 302 and (MECH 320 or BME 321). Introduction to Computer Aided Designing and analysis as applied to biomedical engineering design programs. Topics include theoretical insight into the process of design and geometrical modeling and design using industry standard CAD (Computer Aided Design) software packages. The course will also include several projects involving the application of design principles to standard problems in biomedical design.

BME 489. Medical Instrumentation. 3 credits, 3 contact hours (3;0;0).
Prerequisites: BME301 and (BME210 or BME310). This course covers the hardware and instrumentation needed to measure variables from different physiological systems. The following topics will be taught: electrodes, sensors and transducers. Bioelectric amplifiers, electrical safety and computing. Applications include the study and design of instrumentation for measurement of the ECG, EEG, EMG, respiratory system, nervous system in general.

BME 491. Research and Independent Study I. 3 credits, 3 contact hours (0;0;3).
In depth research experience taught under the guidance of a professor typically within a laboratory. Approved requirements are needed for engineering credit. Research thesis required. Needs permission of professor.

BME 492. Research and Independent Study II. 3 credits, 3 contact hours (0;0;3).
Prerequisite: BME 491. Approved requirements are needed for engineering credit. Research thesis required. Needs permission of professor.

BME 493. Honors Research Thesis I. 3 credits, 3 contact hours (0;0;3).
Prerequisites: GPA 3.5, an appropriate research methods course and ENG 352 Part of a two semester undergraduate research thesis. Students will learn how to formulate a hypothesis, design a scientific based experiment, analyze data using statistics, interprete data, and describe work within oral defense and written thesis.

BME 494. Honors Research Thesis II. 3 credits, 3 contact hours (0;0;3).
Prerequisite: BME 393 Part of a two semester undergraduate research thesis. Students will learn how to formulate a hypothesis, design a scientific based experiment, analyze data using statistics, interprete data, and describe work within oral defense and written thesis.
BME 495. Capstone Design I. 2 credits, 4 contact hours (1;0;3).
Prerequisites: Senior Standing and BME 372 OR MTSE 301 OR (MECH 236 & MECH 320) OR (MECH 236 & BME 321) The goal of this course is to provide students with the guidance to choose a capstone design topic and advisor conduct library/search engine background research and to prepare the design proposal for their chosen project. The course introduces the student to the definition of design as well as introducing issues of intellectual property, bioethics and safety, and professional societies.

BME 496. Capstone Design 2. 3 credits, 4 contact hours (1;3;0).
Prerequisite: BME 495. Implementation of the project approved in BME 495. This portion of the project includes library research, time and cost planning, oral and written reports, as well as construction, troubleshooting and demonstration of a working prototype.

BME 498. ST: 3 credits, 3 contact hours (3;0;0).

CE 101. CE Computer Aided Design. 1 credit, 2 contact hours (0;2;0).
Co-requisite or Pre-requisite: FED 101 Introduce students to the basics of Civil Engineering computer aided design and the application of practical engineering ideas with the linking of technology. CE CAD teaches students the use of basic tools, such as Autocad software, used in the preparation of Civil Engineering contract documents. Autocad is a widely used computer program for generating engineering drawings.

CE 200. Surveying. 2 credits, 3 contact hours (2;1;0).
Prerequisite: MATH 111 or ENGR 101. Angle and distance measurement; leveling; topographic mapping; traverse and area computations; horizontal and vertical curves; cross sections; triangulation; state plane coordinates; global positioning system. Emphasis on the use of the computer for solving typical field and office problems. Lab should be taken concurrently.

CE 200A. Surveying Laboratory. 1 credit, 3 contact hours (0;3;0).
Corequisite: CE 200. Field exercises in conjunction with the classroom exercises in CE 200 utilizing classical and electronic instruments and COGO/CAD software.

CE 210. Construction Materials and Procedures. 3 credits, 3 contact hours (3;0;0).
Prerequisite: HUM 101. Introduction to construction management organization, contracts, construction safety, engineering economics, and engineering ethics. Studies current practices of heavy construction including soil and rock excavation productivity, and building construction materials and procedures. Field trips to construction sites provide opportunities to directly view many of the practices.

CE 260. Civil Engineering Methods. 2 credits, 3 contact hours (2;1;0).
Prerequisite: HUM 101, CE 101, CE 200, CE 200A. Provides students with in-depth experience in computer applications in civil engineering and with written and oral communication.

CE 307. Geometric Design for Highways. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CE 200, CE 200A. Highway design based on a study of traffic distribution, volume, and speed with consideration for the predictable future. Analysis of elements of at-grade intersections and interchanges and the geometrics of highway design and intersection layout with advanced curve work including compound and transition curves.

CE 311. Co-op Work Experience I. 0 credits, 0 contact hours (0;0;0).
Restriction: completion of the sophomore year, approval of the department, and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated and approved by the co-op office. Mandatory participation in seminars and completion of a report.

CE 320. Fluid Mechanics. 3 credits, 4 contact hours (3;1;0).
Prerequisite or Co-requisite: MECH 236 with a grade of C or better. Prerequisite: Mech 235 with a grade of C or better, Math 112 and Phys 111/111A This course is designed to present the fundamental laws relating to the static and dynamic behavior of fluids. The emphasis is placed on applications dealing with the flow of water and other incompressible fluids. These include flow in pipe systems and natural channels.

CE 320A. Hydraulics Laboratory. 1 credit, 3 contact hours (0;3;0).
Prerequisite or corequisite: CE 320. Explores the principles of fluid mechanics through laboratory experiments. Investigates various hydraulic phenomena with both physical and computer models. Demonstrates basic civil engineering design principles for pipe networks, open channel systems, and ground water regimes.

CE 321. Water Resources Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 279. Training in methods of developing water supplies and the means to treat supplies for consumptive use. Covers hydrologic techniques such as surface and ground water yield, hydrograph and routing analyses, and probabilistic methods related to hydrologic studies.

CE 322. Hydraulic Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CE 320, CE 321. The objective is to provide the tools required to design water distribution systems, storm drains, and sanitary sewers. Examines related hydrologic and hydraulic techniques.

CE 332. Structural Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MECH 237 with a grade of C or better. A working knowledge of free body diagrams, equilibrium conditions for force systems and moments. The primary objective is an understanding of the various methods of analyzing determinate and indeterminate beams, frames, and trusses encountered in practice.
CE 333. Reinforced Concrete Design. 2 credits, 3 contact hours (2:1:0).
Prerequisite: CE 332. The student must have a working knowledge of structural analysis including determinate and indeterminate beams and frames. Primary objectives include the following: to acquaint the student with the properties of concrete and steel and with the behavior of reinforced concrete as a structural material; also, to develop methods for the design of reinforced concrete structural members such as beams, slabs, footings, and columns. Both ultimate strength design and working stress method will be studied.

CE 341. Soil Mechanics. 3 credits, 3 contact hours (3:0:0).
Prerequisite: MECH 237 with a grade of C or better or equivalent. Corequisite: CE 341A. A study of soil types and properties is made with the objective of developing a basic understanding of soil behavior. The methods of subsurface investigation and compaction are presented. Fundamentals pertaining to permeability, seepage, consolidation, and shear strength are introduced. Settlement analysis is also presented. Lab must be taken concurrently.

CE 341A. Soil Mechanics Laboratory. 1 credit, 3 contact hours (0:3:0).
Corequisite: CE 341. Students perform basic experiments in soil mechanics.

CE 342. Geology. 3 credits, 3 contact hours (3:0:0).
Restriction: Sophomore status. Studies science of geology with emphasis on physical geological processes. Stresses the principle of uniformity of process in the context of rock and soil formation, transformation, deformation, and mass movement. Includes aspects of historical geology and geomorphology.

CE 350. Transportation Engineering. 3 credits, 3 contact hours (3:0:0).
Prerequisites: CE 200, CE 200A. A study of the principal modes of transportation, with emphasis on the planning, design and construction of facilities for modern transportation systems.

CE 351. Intro To Transportation System. 3 credits, 3 contact hours (3:0:0).
Prerequisites: CE 200, CE 200A, CE 350 A study of the principal modes of transportation, with emphasis on the planning, design and construction of facilities for modern transportation systems.

CE 360. Sustainable Civil Engr Mat. 3 credits, 3 contact hours (3:0:0).
Prerequisites: CHEM 121 or 125 and MECH 237 (with a grade of C or better) This course will provide instruction on engineering materials used in the construction of civil engineering projects. Additionally, the fundamentals of sustainability and sustainable design within the context of civil engineering will be discussed. The engineering properties of aggregates, wood, metal, portland cement concrete and asphaltic concrete and design of these materials will be covered. These materials will be used to discuss sustainability concepts and design within civil engineering.

CE 381. Geomorphology. 3 credits, 3 contact hours (3:0:0).
This is a course in geomorphology, the study of landforms and the contemporary processes that create and modify them. The course will emphasize earth surface processes and quantitative analysis of landform change. Lectures will stress geomorphic principles and two field-based problems will enable students to apply these principles to contemporary geomorphic problems in engineering and management with a focus on the natural environment.

CE 406. Remote Sensing. 3 credits, 3 contact hours (3:0:0).
Prerequisite: PHYS 234. Principles of remote sensing are covered including general concepts, data acquisition procedures, data analysis and role of remote sensing in terrain investigations for civil engineering practices.

CE 410. Construction Scheduling and Estimating. 3 credits, 3 contact hours (3:0:0).
Prerequisite: CE 210. Quantity take off, cost estimate and CPM computer analysis of typical building or highway projects. A study is made of construction project organization, contract requirements and management control techniques with an introduction to computer applications.

CE 412. Construction Codes and Specifications. 3 credits, 3 contact hours (3:0:0).
Prerequisite: CE 210. Code and specification aspects of engineered construction. Topics include professional ethics, contracts, specifications, bidding procedures, building codes such as B.O.C.A. and New Jersey Uniform Construction Code, Energy Code Provisions, construction safety, and the impact of the EPA on construction.

CE 413. Co-op Work Experience II. 3 credits, 3 contact hours (0:0:3).
Prerequisites: CE 311 or equivalent, approval of the department, and permission of the Office of Cooperative Education and Internships. Provides major-related work experience. Mandatory participation in seminars and completion of requirements including a report and/or project. Note: Normal grading applies to this COOP Experience.

CE 414. Engineered Construction. 3 credits, 3 contact hours (3:0:0).
Prerequisites: CE 210, CE 332, CE 341. Design, erection, and maintenance of temporary structures and procedures used to construct an engineering project. Business practices, codes, design philosophies, construction methods, hardware, inspection, safety, and cost as they pertain to engineered construction projects.

CE 431. Construction Materials Lab. 1 credit, 3 contact hours (0:3:0).
Prerequisites: CE 210, MECH 237 with a grade of C or better, CE 210. This course provides an understanding of the basic properties of construction materials, and presents current field and laboratory standards and testing requirements for these materials. Students select a material or component assembly for testing, design a testing procedure, and present their results.

CE 432. Steel Design. 2 credits, 3 contact hours (2:1:0).
Prerequisite: CE 332. A working knowledge of structural analysis including determinate and indeterminate beams and frames is essential. The development of current design procedures for structural steel elements and their use in multistory buildings, bridges, and industrial buildings.
CE 443. Foundation Design. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CE 341, CE 341A. Site investigation, selection of foundation types and basis for design, allowable loads, and permissible settlements of shallow and deep foundations. Computations of earth pressure and design of retaining walls.

CE 450. Urban Planning. 3 credits, 3 contact hours (3;0;0).
Prerequisite: junior engineering standing. Introduction to urban planning, its principles, techniques, and use. Topics include development of cities, planning of new towns, redevelopment of central cities, and land use and transportation planning.

CE 461. Professional Practice in CEE. 3 credits, 3 contact hours (3;0;0).
Develop an understanding of the process to become a licensed professional engineer and familiarize the students with the professional practice of engineering including codes of ethics and professional business practices and to provide an adequate background for the Fundamentals of Engineering.

CE 465. Green and Sustainable Civil Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CE 210 and Junior standing. Designed to teach students currently available approaches that incorporate renewable energy and sustainable development concepts in civil engineering projects. This will include various methods of planning, design, and evaluation which promote increased energy efficiency and sustainable use of materials. Cost estimating and life cycle planning will also be included. The course will encourage students to look beyond the information in the course, to come up with additional methodologies which may not currently be in use.

CE 485. Special Topics in Civil Engineering. 3 credits, 3 contact hours (3;0;0).
The study of new and/or advanced topics in an area of civil engineering not regularly covered in any other CE course. The precise topics to be covered in the course, along with prerequisites, will be announced in the semester prior to the offering of the course.

CE 490. Civil Engineering Projects. 3 credits, 3 contact hours (0;0;3).
Restriction: senior standing in civil engineering and approval of the department. Work on an individually selected project, guided by the department faculty advisor. The project may include planning, research (library or laboratory), engineering reports, statistical or analytical investigations, and designs. Any of these may follow class-inspired direction or the student may select his or her own topic. The project must be completed and professionally presented by assigned due dates for appropriate review and recording of accomplishment.

CE 491. Research Exper-Civil Engr. 3 credits, 3 contact hours (0;0;3).
Prerequisites: Junior standing, agreement of a department faculty advisor, and approval of the associate chairperson for undergraduate studies. This course provides the student with an opportunity to work on a research project under the individual guidance of a member of the department. A written report is required for course completion. Open to students with a GPA of 3.0 or higher.

CE 494. Civil Engineering Design I. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CE 210, CE 260, CE 320, CE 321, CE 350, CE 341, CE 341A and senior standing in civil engineering. Simulates the submission and acceptance process normally associated with the initial design phases for a civil engineering project. Familiarizes students with the preparation of sketch plats, preliminary engineering design, and a related environmental assessment. Requirements include written submittals and oral presentations in defense of the project.

CE 495. Civil Engineering Design II. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CE 333, CE 432, CE 443 and CE 494. Provides students with the type of design experience they would receive if engaged in civil and environmental engineering design practice. Course will focus on one or more of these design areas: structural, geotechnical, transportation and planning, and sanitary and environmental engineering.

CET 233. Structural Analysis in Construction. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MET 237. This course will cover the aspects of the design and construction of structural steel and reinforced concrete for construction engineering technology students. This will include the design of beams, slabs and columns as well review of the connection of these structural members as encountered in practice.

CET 313. Construction Procedures I. 3 credits, 3 contact hours (3;0;0).
Corequisite: CET 317. An introduction to heavy construction practices. Emphasis is on construction equipment, site preparation, earthmoving, compaction, dewatering, piles, drilling and blasting, and tunnelling. Case studies in heavy construction are used.

CET 314. Construction Procedures II. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CET 313, CET 317. An introduction to building construction practices and building materials. Emphasis is on structural systems, construction materials and detailed finishing operations required to make a serviceable structure. Case studies in building construction are used.

CET 317. Construction Computing. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CS 106 Application of available software to construction-related computing problems, including: strength of materials, structural analysis, fluids/ hydraulics, surveying, scheduling, cost estimating, and computerized drafting (CAD).

CET 322. Construction Codes and Regulations. 3 credits, 3 contact hours (3;0;0).
An introduction to the New Jersey Uniform Construction Code, the BOCA National Building Code, NJ DOT Standard Specifications and the CSI specification format. A code analysis of a typical construction project is undertaken.

CET 323. Construction Safety. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CET 313 and CET 314 This course will address the safety issues encountered in construction as mandated by the Occupational Safety and Health Act (OSHA)and other similar regulations.
CET 331. Structural Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CET 233. Study of types and behavior of modern structures using both analytical and intuitive techniques. Examples include beam and column, one- and two-way slab systems, wood and masonry systems, and wind and seismic analysis.

CET 341. Soils and Earthwork. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MET 237 A study of the significant soil types and tests. Problems are investigated relating to soil mechanics, soil supported foundations for engineering structures. Appropriate field trips are made.

CET 411. Cost Estimating. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CET 313, CET 314, CET 317. Take off of quantities of materials from typical building and highway projects. Pricing for labor, materials, and equipment. Crew sizes, productivity and manpower leveling. Computerized cost estimating and take off methods. Prepare a complete bid estimate for a construction project.

CET 413. Environmental Science. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CET 313, CET 314, CET 431. An introduction to construction-related environmental science topics, including basic environmental chemistry, geology, ground water hydrology, basic air quality, surface water run-off, erosion and sedimentation control, indoor air quality, and vibration analysis. Case studies cover various construction activities with respect to their effect on the environment and the manner in which they can be controlled.

CET 415. Construction Project Management. 3 credits, 3 contact hours (3;0;0).
Restriction: Senior standing in construction engineering technology or construction management technology. An introduction to construction management and administration methods and procedures including the design and construction process, project organizational structure, construction planning, contract administration, records and reports, financial management, risk analysis, manual and computerized GANTT and CPM scheduling, change orders and extra work, claims and disputes, cost accounting and document tracking.

CET 416. Senior Construction Project. 2 credits, 3 contact hours (1;2;0).
Prerequisites: CET 415; second semester senior standing in construction engineering technology or construction management technology. Simulates the methods and procedures used to successfully manage a construction project. Provides familiarization with constructability analysis, value engineering, productivity improvement, quality control, advanced field and office administration techniques, problem solving, and construction automation. Extensive use of construction-related computer software. Written submittals and oral presentations required.

CET 421. Construction Contracts. 3 credits, 3 contact hours (3;0;0).
Legal aspects of the various types of construction contracts and specifications. Scope, format, and use of various types of contracts such as owner-contractor and contractor-sub-contractor.

CET 431. Construction Testing. 3 credits, 4 contact hours (2;2;0).
Prerequisite: MET237 Exposure to a variety of construction-related field tests and field testing equipment. Includes concrete mix design, concrete testing, soil density and compaction, asphalt tests, load testing of wood, mortar analysis and testing, brick and CMU testing, and quality control methods and procedures for finishes.

CET 435. Design of Temporary Structures. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CET 331. Analysis of loadings on, and design of, temporary structures required in construction. Formwork, shoring and scaffolding systems, temporary bridges, trenching, and temporary retaining walls are among the subjects covered. Construction safety associated with temporary structures is stressed.

CET 460. Forensics in Construction. 3 credits, 3 contact hours (3;0;0).
Restriction: Senior standing in construction engineering technology. Construction failure, in its many forms, are both interesting and instructive and in the context of this course students will study construction failures in their many forms.

CET 490. Special Project. 3 credits, 3 contact hours (0;0;3).
Prerequisite: Senior standing in construction engineering technology. The student works on one or more individually selected projects guided by the department staff. The project must be construction related and may include planning, research (library or lab), engineering report, and statistical, analytical, or field investigation. Any of these may follow class-inspired direction, or the students may branch out on their own. The project(s) of each student must be completed and professionally presented by assigned due date for appropriate review and recording of accomplishments.

CET 491. Special Projects. 1 credit, 1 contact hour (1;0;0).
Restriction: Senior standing in construction engineering technology. The student works on an individually selected project guided by the department staff. The project may be design- or construction-related and may include research, engineering design, technical report, or field investigation. Requirements will include a written submittal.

CET 492. Special Projects. 2 credits, 2 contact hours (0;0;2).
Restriction: Senior standing in construction engineering technology. The student works on a selected project guided by the department staff. The project may be design or construction related and may include research, engineering design, technical report or field investigation. Requirements will include a written submittal.
CET 493. Special Projects. 3 credits, 3 contact hours (3;0;0).

CET 497. Co-op Work Experience. 3 credits, 3 contact hours (0;0;3).
Restriction: Approval of the department, and permission of the Office of Cooperative Education and Internships. Provides major-related work experience as co-op/intern. Mandatory participation in seminars and completion of requirements that include a report and/or project. Note: Normal grading applies to this COOP Experience.

CHE 101. Introduction to Chemical Engineering, 0 credits, 1 contact hour (1;0;0).
Prerequisites: None. An introduction to the field of chemical engineering and to the Otto H. York Department of Chemical Engineering. Topics include the curriculum, tours of department teaching laboratories and computing facilities, undergraduate research opportunities, cooperative employment, and student professional societies. Also included are visits by alumni who discuss their careers after graduation from the department.

CHE 210. Chemical Process Calculations I. 2 credits, 3 contact hours (2;0;1).
Prerequisites: CHEM 126, MATH 112. Analysis of chemical processes is introduced, emphasizing steady and unsteady-state mass and species balances. This course uses primarily chemistry and algebra to determine, for a wide variety of processes and applications, the flow and concentrations of different chemical species.

CHE 230. Chemical Engineering Thermodynamics I. 3 credits, 4 contact hours (3;0;1).
Prerequisites: CHEM 126, MATH 112, PHYS 111. Corequisite MATH 211 (or MATH 213). The Fundamentals of thermodynamics are applied to chemical engineering processes. Thermophysical properties and their engineering correlations are covered. Applications include chemical engineering and related fields such as environmental and biomedical engineering.

CHE 240. Chemical Process Calculations II. 2 credits, 3 contact hours (2;0;1).
Prerequisites: CHE 210 and CHE 230. This course covers the basic principles of energy balances for a variety of engineering systems. Combined with material from other sophomore courses, simple designs of chemical processes are considered. The course also introduces chemical process simulation software.

CHE 260. Fluid Flow. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CHE 230. Corequisite: CHE 240, MATH 222. This course considers the principles of molecular and turbulent transport of momentum, particularly as they apply to pressure drop calculations in piping systems, packed columns, and other flow devices. Flow around submerged objects is also considered.

CHE 312. Chemical Process Safety, 3 credits, 3 contact hours (3;0;0).
Restriction: Junior standing. A study of the technical fundamentals of chemical process safety: includes impact of chemical plant accidents and concepts of societal and individual risk; hazards associated with chemicals and other agents used in chemical plants, including toxic, flammable and reactive hazards: concepts of inherently safer design; control and mitigation of hazards to prevent accidents, including plant procedures and designs; major regulations that impact safety of chemical plants; consequences of chemical plant incidents due to acute and chronic chemical release and exposures; hazard identification procedures; introduction to risk assessment.

CHE 342. Chemical Engineering Thermodynamics II. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHE 230, MATH 211 (or MATH 213), CHEM 236. The principles and methods developed in Chemical Engineering Thermodynamics I are extended to multicomponent systems, and used to treat phase and chemical equilibrium as well as such applications as chemical reactors and refrigeration systems.

CHE 349. Kinetics and Reactor Design, 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHE 342, CHE 370, MATH 222, CHEM 236. Derive and solve species and energy balances for single chemical reactors; introduces heterogeneous catalysis, non-ideal reactors as ideal reactor combinations, and special topics such as polymeric or biochemical reactions.

CHE 360. Separation Processes I. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHE 342, CHE 370. This is the first course in separations, examines traditional methods and technologies by which chemical engineers separate and purify mixtures. Emphasis here is on strippers, absorbers, distillations, and extractions.

CHE 365. Chemical Engineering Computing. 3 credits, 4 contact hours (0;0;4).
Prerequisites: CHE 370, CS 115 co-requisite: CHE 360. Introduction to basic concepts of computational methods for solving chemical engineering problems and performing process simulations. Topics include common numerical techniques encountered in chemical engineering, for the solution of linear and nonlinear algebraic equations and ordinary differential equations, differentiation/integration, optimization and interpolation/regression of data. Students will be exposed to modern computational software and commercial chemical processes simulators.

CHE 370. Heat and Mass Transfer. 4 credits, 4 contact hours (4;0;0).
Prerequisites: CHE 240, CHE 260, MATH 222. The principles of heat and mass transfer in chemical engineering systems are covered. Steady and unsteady heat transfer is examined, with emphasis on the heat exchanger design. Mass transfer by steady and unsteady molecular diffusion, and turbulent convective mass transfer is studied.
CHE 375. Structure, Properties and Processing of Materials. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHEM 236 or CHEM 235 Tailoring materials properties by engineering their microscopic/macroscopic structures via processing is central to product design and development in the chemical industry. This course introduces the principles of materials engineering from the perspective of structure-property-processing relationships. Instead of covering different types of materials separately, this course will use the principles common to engineering of all important materials as an underlying theme. These are atomic/molecular structure, nanoscale, morphology, principles of phase transformation, structure development during processing, and property dependence on structure. All these topics will be introduced through the paradigm of comparing metals, ceramics and polymers. Besides single component systems, advanced materials such as multiphase and/or multicomponent systems (e.g. composites and gels) and nanomaterials will be discussed based on these principles. An integral part of this course will be the criteria for selection of materials for the chemical process industry.

CHE 380. Introduction to Biotechnology. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHEM 122 or CHEM 126. Basic principles of molecular biotechnology with selected examples of applications.

CHE 396. Chemical Engineering Laboratory I. 3 credits, 5 contact hours (0;5;0).
Prerequisites: CHE 370, ENG 352. Corequisite: MATH 225A. In this first course in chemical engineering capstone laboratory, experiments are conducted in the areas of fluid mechanics and heat transfer. Bench and pilot-scale equipment is used. Oral and written reports are prepared by the students.

CHE 402. Applied Optics in Chemical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: Junior or senior standing in chemical engineering. Combined laboratory and lecture course emphasizing photonics and laser applications in chemical engineering.

CHE 415. Introduction to 3D Printing. 3 credits, 4 contact hours (2;2;0).
Prerequisites: Junior standing or higher. This course introduces 3D printing technologies including history and basics of 3D printing, currently available 3D printing methods and printable materials as well as current and emerging applications of 3D printing. Students will get a general idea on the major players in 3D printing industry and global effects of 3D printing. The course will be composed of a lecture and a hands-on laboratory session, during which students will create a 3D design and print a functional prototype.

CHE 427. Biotransport. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHE 230 and MATH 222. Introduction to basic concepts of transport phenomena as applied to biological systems. Topics include the structure and composition of the human body, the properties of the blood and its flow in the cardiovascular system, and the body as a heat source and as a series of compartments involved in the mass transfer of materials (such as those in the kidneys and lungs). Students learn to analyze solute transport in biological systems and apply it to the design of biomedical devices.

CHE 444. Introduction to Polymer Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CHE 370. Introduction to the basic concepts of polymer engineering. Topics covered include rheology, heat transfer, and kinetics of polymerization reactors.

CHE 460. Separation Processes II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CHE 360. This second course in separations examines non-traditional methods and technologies such as fixed-bed processes, membranes, crystallization, and mechanical separations.

CHE 472. Process and Plant Design. 4 credits, 4 contact hours (4;0;0).
Prerequisites: CHE 349, CHE 365, CHE 375, IE 492. A capstone course in the chemical engineering program. This class is divided into three- or four-person groups. Each group must complete an open-ended process design problem, including equipment specification and economics.

CHE 473. Mathematical Methods in Chemical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 222, CHE 349, CHE 360, and CHE 370. An introduction to the use of differential equations to solve chemical engineering problems.

CHE 476. Introduction to Biochemical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHEM 245, CHE 349. Corequisite: CHE 349. The application of chemical engineering to biochemical processes. Topics include enzyme reactions, dynamics of microbial populations, fermentation equipment, bioreactor design, and sterilization.

CHE 489. Process Dynamics and Control. 3 credits, 4 contact hours (4;0;0).
Prerequisites: CHE 349, CHE 365. This course is an introduction to chemical process dynamics and control. Topics include analysis of the dynamics of open-loop systems, the design of control systems, and the dynamics of closed-loop systems. Control techniques and methodologies, used by practicing chemical engineers, are emphasized.

CHE 490. Special Topics in Chemical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHE 349, CHE 360. Topics of current interest in chemical engineering, such as supercritical fluid extraction, combustion research, environmental problems, biotechnology, technologies in hazardous and toxic substance management, etc. As interests develop, other topics will be considered.

CHE 491. Research and Independent Study I. 3 credits, 3 contact hours (0;0;3).
Restriction: senior standing in chemical engineering, agreement of a department faculty advisor, and approval of the associate chairperson for undergraduate studies. Normally a GPA greater than 3.0 is required to participate in the course. Provides the student with an opportunity to work on a research project under the individual guidance of a member of the department. A written report is required for course completion.
CHE 492. Research and Independent Study II. 3 credits, 3 contact hours (0;0;3).
Prerequisite: CHE 491. A continuation of CHE 491.

CHE 495. Chemical Engineering Lab I. 2 credits, 5 contact hours (0;5;0).
Prerequisites: CHE 349, CHE 360, CHE 495, CHEM 339, MATH 225; co-requisites: CHE 489. In this first course in chemical engineering capstone laboratory, experiments are conducted in the areas of fluid mechanics and heat transfer. Bench and pilot-scale equipment is used. Oral and written reports are prepared by the students.

CHE 496. Chemical Engineering Laboratory II. 3 credits, 6 contact hours (0;6;0).
Prerequisites: CHE 349, CHE 360, CHE 495, CHEM 339, MATH 225; co-requisites: CHE 489. In this second course in chemical engineering capstone laboratory, experiments are conducted in the areas of mass transfer, separations, reaction engineering, and process dynamics and control. Bench and pilot-scale equipment is used. Oral and written reports are prepared by the students.

CIIMT 101. Introduction to Concrete. 3 credits, 3 contact hours (3;0;0).
This course is an overview of the concrete industry including historical aspects, the chemistry, properties and uses of concrete, production and delivery, and management of production facilities. Students will also be introduced to concrete construction and contracting, environmental concerns, professionalism, and career opportunities in the concrete industry.

CIIMT 205. Concrete Properties and Testing. 3 credits, 4 contact hours (2;2;0).
The effects of concrete-making materials (aggregates, cements, admixtures, etc.) on the properties of fresh and hardened concrete will be studied and analyzed from an applications point of view. Concrete mixture proportioning calculations, statistical analysis of strength tests, and the economics of various concrete mixes will also be discussed.

CIIMT 210. Concrete Applications I. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CIIMT 101 and CIIMT 205. This course is the first of two courses designed to provide a detailed study of the many applications of concrete in the construction of buildings, pavements, and other facilities as they relate directly to the concrete industry. Emphasis will be placed on the advantages, disadvantages and unique problems facing the concrete industry and suppliers of materials used in the manufacture of concrete products.

CIIMT 305. Concrete Applications II. 3 credits, 3 contact hours (3;0;0).
This course is a continuation of CIIMT 210 and focuses on codes, specifications and industry standards as well as the production and delivery issues related to traditional and unique concrete applications.

CIIMT 310. Concrete Products and Delivery. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CIIMT 210 Concrete Applications I. This course will provide the student with a basic understanding of managing the order and delivery process common to all concrete products. An emphasis will be given to planning, organizing and controlling at both the management level as well as the supervisory level.

CIIMT 315. Concrete Construction Methods. 3 credits, 3 contact hours (3;0;0).

CIIMT 405. Advanced Concrete Testing and Quality Assurance. 3 credits, 4 contact hours (2;2;0).
Prerequisite: CIIMT 205. This course will focus on advanced concrete testing techniques and quality assurance procedures currently used in the industry for traditional and specialty applications.

CIIMT 410. Senior Project in CIM. 3 credits, 3 contact hours (3;0;0).
Prerequisite: Senior standing in Concrete Industry Management. The student works on one or more individually selected projects guided by the department staff. The project must be concrete industry related and may include planning, research, library or lab, engineering report and statistical, analytical, or field investigation. Any of these may follow class-inspired direction, or the students may branch out on their own. The project(s) of each student must be completed and professionally presented by assigned due date for appropriate review and recording of accomplishments.

CIIMT 491. Special Project in CIM. 1 credit, 1 contact hour (1;0;0).

CIIMT 492. Special Project in CIM. 2 credits, 2 contact hours (2;0;0).

CIIMT 493. Independent Study. 3 credits, 3 contact hours (0;0;3).

CIIMT 497. Co-op Work Experience I. 3 credits, 3 contact hours (0;0;3).
Prerequisites: Approval of the department, and permission of the Office of Cooperative Education and Internships. Provides major-related work experience as co-op/intern. Mandatory participation in seminars and completion of requirements that include a report and/or project. Note: Normal grading applies to this COOP Experience.

CIIMT 498. Coop Work Experience II. 3 credits, 3 contact hours (0;0;3).

CIIMT 332. Structural Systems for Construction Management. 3 credits, 3 contact hours (3;0;0).
Study of the types and behavior of building structural systems using qualitative analysis techniques. Systems to be covered will include those involving structural steel, reinforced concrete, wood and timber, and plain and reinforced masonry. The effect of wind and seismic events on these systems is reviewed.

CIIMT 414. Environmental Science for Construction Management. 3 credits, 3 contact hours (3;0;0).
An introduction to construction-related environmental topics, including environmental chemistry, geology, ground water hydrology, outdoor air quality, surface water run-off, erosion and sedimentation control, indoor air quality, asbestos abatement, radon remediation, and noise and vibration.
CMT 436. Temporary Structures for Construction Management. 3 credits, 3 contact hours (3;0;0).
Prerequisite: CMT 332. Study of the types of the various temporary systems and structures used in field construction activities, including concrete forming and falsework, sheeting and shoring for excavations, scaffolding, barricades, ladders, and temporary bridges and ramps. Construction safety with respect to the systems is covered.

CMT 452. Mechanical and Electrical Systems for Construction. 3 credits, 3 contact hours (3;0;0).
Study of the different types of water supply, plumbing, fire protection, heating, ventilation, air conditioning and electrical systems commonly employed in residential and commercial buildings. Case studies include an overview of the design of these systems and their installation in the field.

CPT 310. Computer Design Fundamentals for Computer Technology. 3 credits, 4 contact hours (2;2;0).
Restriction: enrolled in the computer technology option. Boolean algebra, gates, combinational and sequential logic. Memory, microprocessor, and I/O control IC's. Sequential bus architecture.

CPT 315. Computer Architecture for Computer Technology. 3 credits, 4 contact hours (2;2;0).
Prerequisite: CPT 310. Computer design fundamentals for computer technology, Von Neumann computer architecture: processor, memory and I/O. Processor organization: registers, ALU, and control. Memory organization and memory bus, I/O organization: I/O bus, memory mapped I/O. Number representations and ALU designs. Fundamentals of assembly language, lab exercises in assembly language are used throughout to illustrate concepts.

CPT 325. Medical Informatics Technology. 3 credits, 3 contact hours (3;0;0).
Restriction: Junior standing. Medical Informatics (MI) professionals use information technology to benefit the health and human services industry. One of the main challenges is to develop an integrated medical record/information system that links doctors, pharmacists, medical imaging facilities and hospitals. In addition, MI professionals will also develop skills to design and develop support technology for seniors to maintain independent life styles. This includes remote monitoring systems linked to medical professionals, software for support services, and home automation technology.

CPT 330. Software Web Applications for Engineering Technology I. 3 credits, 4 contact hours (2;2;0).
Common software applications using software objects. The use of software objects in the management of programming projects. Projects illustrate concepts.

CPT 335. Networks Applications for Computer Technology I. 3 credits, 4 contact hours (2;2;0).
Prerequisites: C++, Visual Basic, UNIX utilities. Covers common gateway interface (CGI), servers, network protocols, network administration, server and network performance.

CPT 341. Visual Basic.NET for Engineering Technology. 3 credits, 4 contact hours (2;2;0).
Prerequisite: Previous programming experience. Creation of windows with text, controls, menus and graphics, events detection, files and objects management, object oriented techniques.

CPT 373. Web App Development for Mobile. 3 credits, 4 contact hours (2;2;0).
Prerequisites: A basic programming course, in addition is recommended an introductory web programming course. Mobile platforms are becoming ubiquitous and software development for these devices is becoming an essential skill for technical professionals. This software/App development course integrates software and web skills with cross platform open source tools that allow developers to write apps for multiple platforms. Course topics will include PhoneGap and open course development software, App layout, CSS (styling) and navigation (transition animations), JavaScript and native functions, geolocation listeners and Asynchronous JavaScript and XML (AJAX) skills. A class project will incorporate skills introduced in this course. Medical informatics majors will design and build an Electronic Medical records Apps. Other projects will be tailored to the interest of other majors.

CPT 395. Co-op Work Experience I. 3 credits, 3 contact hours (0;0;3).
Restriction: Approval of the department and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated and approved by the co-op office. Mandatory participation in seminars and completion of a report. Note: Normal grading applies to this COOP Experience.

CPT 401. Senior Project. 2 credits, 2 contact hours (2;0;0).
Prerequisite: MIS 345. Restriction: senior standing in computer technology. Project management and development, scheduling, proposal writing, documentation of software projects, technical presentations. The successful completion of the project consists of research on a recent computer software and/or hardware product, and the application of the findings to the development of a project, which must include a software component. The senior project may be replaced by a cooperative education experience course, subject to advisor's approval.

CPT 425. Medical Informatics Technology II. 3 credits, 4 contact hours (2;2;0).

CPT 430. Software Web Applications for Engineering Technology II. 3 credits, 4 contact hours (2;2;0).
Prerequisite: CPT 330. Common applications using software objects. The use of software objects in the management of programming projects. Projects are used to illustrate concepts.

CPT 435. Networks Applications for Computer Technology II. 3 credits, 4 contact hours (2;2;0).

CPT 440. Visual Basic Applications for Engineering Technology. 3 credits, 4 contact hours (2;2;0).
CPT 450. Computer Graphics for Computer Technology. 3 credits, 4 contact hours (2;2;0).
Prerequisites: Calculus II, knowledge of the programming language used in the course, check with the instructor. Drawing shapes, curves and text. Colors and areas, point of light, shading. Masking, 2-D drawings and transformations, 3-D drawings and transformations. Animation. Introduction of a popular graphics package. Lab exercises are used throughout to illustrate concepts.

CPT 491. Special Projects in Computer Technology. 1 credit, 1 contact hour (1;0;0).
Restriction: Senior standing in computer technology. The student works on selected projects guided by the department staff.

CPT 492. Special Projects in Computer Technology. 2 credits, 2 contact hours (2;0;0).
See CPT 491.

CPT 493. Special Projects in Computer Technology. 3 credits, 3 contact hours (3;0;0).
See CPT 492.

ECE 101. Introduction to Electrical and Computer Engineering. 0 credits, 1 contact hour (0;0;1).
Familiarize students with various disciplines, career opportunities and curricula in electrical and computer engineering. Invited speakers include faculty and industrial representatives.

ECE 231. Circuits and Systems I. 3 credits, 4 contact hours (4;0;0).
Prerequisites: PHYS 122 and MATH 112. The basic concepts of electric circuit theory and system analysis. Topics include basic circuit elements, loop and node analysis, network theorems, sinusoidal steady-state analysis, power, resonance, mutual inductance, and ideal transformers.

ECE 232. Circuits and Systems II. 3 credits, 4 contact hours (4;0;0).
Prerequisite: ECE 231. Corequisite: MATH 222. A continuation of circuits and systems with special emphasis on transient response. Topics include Laplace transform analysis, transfer functions, convolution, Bode diagrams, and Fourier series.

ECE 251. Digital Design. 3 credits, 4 contact hours (4;0;0).
Prerequisite: PHYS 122. The design of combinational and sequential logic circuits used in digital processing systems and computers. Basic register transfer operations are covered. Topics include Boolean algebra, minimization techniques and the design of logic circuits such as adders, comparators, decoders, multiplexers, counters, arithmetic logic units, and memory systems.

ECE 252. Microprocessors. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 251. An introduction to microprocessor system organization and assembly language programming. The course covers the architecture, instruction set and assembly language of a specific microprocessor. Other topics included are memory organization, input/output interfacing, interrupt processing as well as exception processing. The problems associated with the design of a single board computer are also covered. Students receiving degree credit for CIS 453 cannot receive degree credit for ECE 352. Co-listed as COE 252.

ECE 271. Electronic Circuits I. 3 credits, 4 contact hours (4;0;0).
Prerequisite: ECE 231. The electronic devices, junction diodes, bipolar transistors and field-effect transistors, are introduced and studied based on semiconductor physics models. The study then continues with analysis and design of main digital electronic circuits (NMOS and CMOS inverters and logic gates, MOS memory and storage circuits) and with introduction to analog electronic circuits such as simple one transistor amplifiers.

ECE 291. Electrical Engineering Laboratory I. 1 credit, 3 contact hours (0;3;0).
Prerequisites: ECE 231, HUM 101. Corequisites: ECE 232. Laboratory work in the areas covered in ECE 231, ECE 232. Assembling, testing and analysis of basic analog circuits. Emphasis electronic measurement techniques, instrumentation and data analysis. Simulations of dc, ac, and transient circuit response on the personal computer.

ECE 3**. ECE Technical Elective. 3 credits, 3 contact hours (3;0;0).

ECE 310. Co-op Work Experience I. 0 credits, 0 contact hours (0;0;0).
Restriction: completion of the sophomore year, approval of the department, and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated and approved by the co-op office. Mandatory participation in seminars and completion of a report.

ECE 321. Random Signals and Noise. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 232. Corequisite: ECE 333. Random processes occurring in electrical engineering. An introduction to probability and random variables is followed by stochastic processes and noise. Topics include auto- and cross-correlation functions, power spectral density, response of linear systems to random signals, and noise figure calculations.

ECE 333. Signals and Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 232, MATH 222. A continuation of circuits and systems. Topics include signal models, system representations and properties, convolution, Fourier transform, sampling, z-transform, and an introduction to IIR and FIR filter design.

ECE 341. Energy Conversion. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 231. Magnetic materials and their applications including the design of singly- and multiply-excited magnetic circuits and transformers, and the steady-state performance of dc and ac electromechanical energy converters.

ECE 353. Computer Organization and Architecture. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 252. Emphasizes the hardware design of computer systems. Topics include register transfer logic, central processing unit design, microprogramming, ALU design, pipelining, vector processing, micro-coded arithmetic algorithms, I/O organization, memory organization and multiprocessor.
ECE 354. Digital Test. 2 credits, 2 contact hours (2;0;0).
Prerequisites: ECE 251 or equivalent, MATH 333 or equivalent. Covers theory and practice related to test technology. Topics include fault modeling, test generation, fault simulation, design for testability, fault diagnosis, built-in self-test, scan design, and many others. Surveys several industrial design for testability structures.

ECE 361. Electromagnetic Fields I. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 231, MATH 213 and MATH 222. Overview of vectors analysis. The study of static electric and magnetic fields, basic laws of electrostatics (Coulomb’s and Gauss’s laws), scalar electric potential, electrostatic force and energy; basic laws of magnetostatics (Biot–Savart and Ampère’s laws), magnetostatic force and energy, vector magnetic potential; fundamental meaning of capacitance, resistance and inductance in terms of electric and magnetic fields: Poisson’s and Laplace’s equation; characterization of materials (conductors, dielectrics, magnetic materials).

ECE 362. Electromagnetic Fields II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 361. Maxwell's equations solutions, reflection and refraction of plane waves in dielectric and conducting media, transmission lines; transients and frequency domain solutions in lossy and lossless lines, Smith chart and its applications, parallel plate and rectangular waveguides.

ECE 366. Signal Transmission. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 361. Maxwell's equations solutions, reflection and refraction of plane waves in dielectric and conducting media, transmission lines; transients and frequency domain solutions in lossy and lossless lines, Smith chart and its applications, parallel plate and rectangular waveguides.

ECE 372. Electronic Circuits II. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 232, ECE 271. Principles of MOSFET and BJT small signal amplifiers: Q point design, input and output impedance, gain, and signal range limitations for different single stage configurations. Design of analog integrated circuits including differential amplifiers, current sources, active loads. Transistor high frequency models, Miller effect, and frequency response of multistage amplifiers. Feedback in multistage amplifiers. Design and analysis of nonlinear circuits based on comparators. Design and analysis of signal generators.

ECE 374. Electronic Device I. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 271. This course addresses electronic devices on a fundamental level. Topics include semiconductors, structure and properties of p/n junction, Schottky barrier, BJT, MOS, MOS FET, semiconductor optoelectronics.

ECE 392. Electrical Engineering Laboratory II. 2 credits, 3 contact hours (0;3;0).

ECE 394. Digital Systems Lab. 1 credit, 3 contact hours (0;3;0).
Prerequisites: ECE 251, ECE 271 and ECE 291. Experiments emphasize digital design from basic electronic circuits to complex logic. Topics include switching speed, basic sequential circuits, the arithmetic/logic unit, and computer memories.

ECE 395. Microprocessor Laboratory. 2 credits, 4 contact hours (0;4;0).
Prerequisites: ECE 291, ECE 252. In this laboratory the students are expected to learn to apply their theoretical knowledge of both the hardware and software aspects of microprocessors. To attain this objective the students are required to construct a microprocessor based single board computer (SBC), with adequate interfacing capabilities to be able to perform some useful control tasks. Programming of the device is done in assembly language. Some of the experiments that follow the construction project deal with software while others deal with the problems of interfacing of microprocessors.

ECE 405. Electrical Engineering Principles. 3 credits, 3 contact hours (3;0;0).
Prerequisites: PHYS 121 or PHYS 122 and Junior standing. (No credit for ECE students.) For non-electrical engineering majors. Topics include basic dc and ac circuits, basic electronics, an introduction to electromechanical energy conversion and control theory.

ECE 410. Co-op Work Experience II. 3 credits, 3 contact hours (0;0;3).
Prerequisites: ECE 310, approval of the department, and permission of the Office of Cooperative Education and Internships. Provides major-related work experience. Mandatory participation in seminars and completion of requirements that include a report and/or project. May count as EE or approved elective. Note: Normal grading applies to this COOP Experience.

ECE 414. Electrical and Computer Engineering Project I. 1 credit, 1 contact hour (1;0;0).
Prerequisites: In EE program: ECE 321, ECE 341, ECE 372, ECE 392, and ECE 395. In COE: ECE 353, ECE 368, ECE 395 and ECE 394. With the instructor's approval some of these courses can be taken as co-requisites. Student teams prepare and submit technical proposals for the senior design ("capstone") project to be completed the following semester in ECE 416 or ECE 417. Discussion of issues related to the engineering profession, including such topics as: intellectual property, sources of technical information, engineering codes and standards, professional organizations, professional registration. Required of all ECE students.

ECE 416. Electrical and Computer Engineering Project II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 414. Continuation and completion of the project based on the proposal approved in ECE 414. Progress of the project is monitored by the instructor with demonstrations and presentations at given due dates of the regularly scheduled course. An oral presentation and demonstration of the project by the student team must be given and a written report submitted at the end of the course. Successful projects are approved for the presentation at the Senior Design Project Workshop in the presence of students, faculty and industry representatives.
ECE 417. Electrical & Computer Engineering Project II. 3 credits, 3 contact hours (0;0;3).
Prerequisite: ECE 414. Faculty adviser approval required. Continuation and completion of the project based on the proposal approved in ECE 414 guided by a faculty or a faculty and industrial mentors with meetings scheduled as needed. A formal written report is presented to the faculty advisor at the end of the course. An oral presentation of a successful project is made at the Senior Design Project Showcase attended by students, faculty, and industry representatives.

ECE 418. Independent Study. 3 credits, 3 contact hours (0;0;3).
Requirements: senior standing or approval of the associate chairperson for undergraduate studies, a GPA greater than 3.0, and agreement of a faculty advisor. Provides the student with an opportunity to work on a research project under individual guidance of a faculty. The required work and intellectual challenge correspond to at least those of other senior ECE courses. A written report is required for the course completion.

ECE 421. Digital Data Communication. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 232, MATH 333, or ECE 321. Topics include signal classification, correlation, spectral analysis, noise, signal transmission through linear systems, principles of digital data transmission, AM, FM and pulse modulations, sampling and digitalization of signals, inter-symbol interference and equalization, channel capacity, data compression techniques, error detection and correction methods.

ECE 422. Computer Communications Networks. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 321 or MATH 333. Introduction to the fundamental concepts of computer communication networks. Topics include the OSI reference model, the physical, data link, network, and transport layers, TCP/IP, LANs (including token ring, token bus, and ethernet), ALOHA, routing and flow control.

ECE 423. Data Communications Networking Devices. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 421 or ECE 481. Provides a working knowledge of data communication networking devices, including modems, routers, multiplexers, switches, and concentrators and are used as building blocks in the implementation, modification, or optimization of data communications networks. Emphasizes device design, functionality and physical layer protocols.

ECE 424. Optical Communication Network. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 232 and either ECE 321 or MATH 333. Focuses on digital optical networks, architecture, modulation techniques, and detection noise. Related topics are wireless communication, infrared link, and CATV. Computer simulations of network systems are done with commercial software packages.

ECE 425. Wireless Communication Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 481 or ECE 421. Introduction to wireless system design and engineering. Develops an understanding and appreciation of the wireless engineering problems such as cellular layout design, resource allocation, mobility management, capacity and performance and signaling load calculations. Introduces physical layer building blocks such as modulation, synchronization, coding, diversity, equalization, and spreading.

ECE 429. Computer Communications Lab. 2 credits, 4 contact hours (0;4;0).
Prerequisite: ECE 422. Experiments with different protocols and standards used in the TCP/IP computer communications, including Ethernet/802.3 standard, Address Resolution Protocol (ARP), Internet Protocol (IP), Transport Control Protocol (TCP), User Datagram Protocol (UDP), and others. Exercises with network measurements and virtualization tools, and configurations of some commercial routers are included.

ECE 431. Introduction to Feedback Control Systems. 3 credits, 3 contact hours (3;0;0).

ECE 432. Control Systems Elective. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 431. A continuation of the study of automatic control systems with emphasis on computer-aided design and problem solving. Topics covered include state feedback control, observers, industrial regulators, linear quadratic regulators, and the analysis of various common system nonlinearities. Implementation techniques on both analog and digital platforms will be addressed.

ECE 435. Medical Imaging Instrumentation and Data Acquisition Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 231, ECE 252 and ECE 333. Three-Dimensional medical imaging modalities including X-ray Computer Tomography, Magnetic Resonance Imaging, Single Photon Emission Computer Tomography, Positron Emission Tomography, and Ultrasound utilizes advanced highly integrated electronic sensors, fast processor-based computers, and advanced signal processing and reconstruction methods.

ECE 436. Bio Control Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 431. This course provides an introduction to dynamic and control in biological systems, with particular emphasis on engineering aspects of biological oscillators/waves. A combination of theoretical and simulation tools will be applied to analyze the qualitative and quantitative properties of selected biological systems. Feedback and control mechanisms in selected biological systems will be introduced. Real time signal acquisition and processing are also addressed.

ECE 439. Control Systems Laboratory. 2 credits, 4 contact hours (0;4;0).
Prerequisite: ECE 431. Laboratory work in the design and synthesis of control systems, closely coordinated with the control systems elective.

ECE 441. Power Electronics. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 373. Electronic devices and circuits used to energize various apparatus and systems. Topics include circuits, freewheeling diodes, thyristors, firing and commutation of silicon-controlled rectifiers, converters, dc choppers, and power supplies.
ECE 442. Power Systems Elective. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 341. Introduction to power plants and power networks. Topics include transmission line parameters, system modeling, economic operations of power systems, load flow studies, short circuit analysis, and power system stability.

ECE 443. Renewable Energy Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 231 and ECE 271. This course presents the various sources of renewable energy including wind, solar, and biomass as potential sources of energy and investigates the contribution they can make to the energy profile of the nation. The technology used to harness these resources will be presented. Discussions of economic, environment, and social policies are integral components of the course.

ECE 449. Power Systems Laboratory. 2 credits, 4 contact hours (0;4;0).
Prerequisite: ECE 448. Corequisite: ECE 442. Laboratory work in the design and synthesis of power systems, closely coordinated with the power systems elective.

ECE 451. Advanced Computer Architecture. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 353. Focuses on advanced concepts in computer systems design, and the interaction between hardware and software components at various levels (i.e., hardware/software design). Introduces basic performance measures used by hardware and software designers to facilitate comparative analysis. Main topics are: advanced pipelining, good instruction sets, CISC and RISC microprocessors, introduction to parallel computing, and a brief historical survey of computer designs.

ECE 452. Advanced Computer Architecture II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 451 Overview of recent advances and topics of current active research in the field of Computer Architecture. Includes: new computing paradigms such as brain inspired non-von Neumann architectures, stochastic computing, hybrid memory systems and other architectures leveraging emerging memory technologies. Stochastic array systems; new interconnect architectures including NoCs; GPU-accelerated computing etc. are also discussed.

ECE 453. Introduction to Discrete Event Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECE 251 or CS 251 or equivalent, and MATH 333 or ECE 321 or equivalent. Introduces logical models, timed models, and stochastic timed models of discrete event systems. Applies petri net methodology to the modeling of computer systems, flexible manufacturing systems, communication networks, and robotics. Contrasts the approaches of simulation, elementary queueing theory, and Markov processes.

ECE 457. Digital Image Processing. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 333. An introduction to the fundamental techniques for digital image processing. Covers human visual systems, image sensing and acquisition, image sampling and quantization, 1-D and 2-D systems, image enhancement, image restoration, image degradation, features extraction, and image segmentation.

ECE 459. Advanced Computer Systems Design Lab. 2 credits, 4 contact hours (0;4;0).
Prerequisite: ECE 451, ECE 495. Corequisite: ECE 442. Laboratory work in the design and synthesis of power systems, closely coordinated with the power systems elective.

ECE 461. Microwave and Integrated Optics. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 362. The analysis and design of microwave transistor amplifiers and oscillators using scattering parameter techniques. Topics include transmission line theory, scattering parameters, matching networks, signal flow graphs, amplifier design considerations (power gain stability, noise and bandwidth), and negative resistance oscillator design.

ECE 462. RF/Fiber Optics Systems Elective. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 362. Topics include dielectric waveguides and optical fibers, semiconductor optical sources and detectors; rf/microwave modulation and demodulation of an optical carrier; design concepts in optical transmitters and receivers; and usage of CAD software tools for rf/microwave simulations.

ECE 463. Optoelectronics. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 374. The course addresses electronic and optoelectronics device concepts. Topics include optical materials, semiconductor materials, light propagation in waveguide, solar cell, LED and modulation of light.

ECE 469. RF/Microwave and Fiber Optics Systems Laboratory. 2 credits, 4 contact hours (0;4;0).
Corequisite: ECE 462. Laboratory work in characterization of RF/microwave transmission structures and optical fibers, sources and detectors, spectral and time domain (OTDR) measurements in micro-waves and optics. Experiments in microwave and fiber optic links. Usage of CAD software tools for RF/microwave simulations.

ECE 472. Pulse Techniques. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 373. Topics in electronics including linear and non-linear operational-amplifier circuits, the frequency compensation of operational-amplifiers, higher-order active filters including switched-capacitor designs, waveform generators, multi-vibrators, timers, waveshapers, converters, and other selected topics.

ECE 475. VLSI Circuits. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 372. Topics include MOSFETs, their characteristics and use in analog and digital circuit design, static and dynamic circuits; memory cells; differential stages; symbolic layout of NMOS and CMOS circuits; fundamentals of silicon processing technology and associated design rules and methodology; calculation of chip performance including power, speed and area; logic arrays.
ECE 481. Digital Communications Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 321. An introduction to digital communications systems and modulation and techniques, along with simulation experiments of communications systems and techniques in Matlab/Simulink. Description of AM and FM modulations, sampling and digitalization of signals, baseband and carrier-modulated digital transmission, signal detection in noise, inter-symbol interference and equalization, channel capacity, data compression techniques, error detection and correction methods.

ECE 482. Communications Systems Elective. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECE 481. A continuation of the study of communications systems with selected topics from different areas of communications theory such as sampled-data communications, information theory and noise.

ECE 489. Communications Systems Laboratory. 2 credits, 4 contact hours (0;4;0).
Prerequisite: ECE 421. The laboratory experiments are designed using Matlab/Simulink and Software Defined Radio (SDR). The major lab tasks include time and frequency domain analysis of AM and FM signals, generation and detection of digitally modulated waveforms such as BPSK, QPSK, 16QAM and 64QAM which are widely used in wireless communication networks. Through the experiments, students learn how to use Matlab/Simulink to control the SDR, to assess and combat the impairments due to noise and interference, and become familiar with instruments such as spectrum analyzers, audio analyzers and noise generators.

ECE 494. Electrical Engineering Laboratory III. 2 credits, 3 contact hours (1;2;0).
Prerequisites: ECE 341, ECE 374, ECE 392. A senior laboratory with experiments in two distinct areas: A) power and energy conversion, and B) semiconductor devices. Part A involves experiments with full size ac and dc electric motors, generators, and transformers. In part B characteristics of diodes, transistors and solar cells are measured using computer controlled instrumentation.

ECE 495. Computer Engineering Design Lab. 3 credits, 5 contact hours (1;4;0).
Prerequisites: ECE 353, ECE 394. Preparation for putting into practice the concepts learned in ECE 353. Emphasizes hardware design and debugging. Topics include combinational and sequential logic design using CAD tools, design based upon PLA/PLD devices, computer interface design using hardware and software, and an open-ended design project such as a central processing unit design.

ECE 498. Special Topics in Electrical and Computer Engineering. 3 credits, 3 contact hours (3;0;0).
The study of new and/or advanced topics in an area of electrical and computer engineering not regularly covered in any other ECE course. The precise topics to be covered in the course, along with prerequisites, will be announced in the semester prior to the offering of the course.

ECET 201. Circuits I. 3 credits, 4 contact hours (2;2;0).
This first course in Electrical Circuits introduces the student to both DC and AC Circuit Theory. It includes Ohm's and Kirchhoff's Laws for analysis of series and parallel circuits. Series-parallel, ladder and bridge networks are analyzed. Resonance and frequency response are included along with an introduction to AC circuits. Circuit simulations and laboratory experiments are designed to support the theory and obtain measurement skills.

ECET 202. Circuits II. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECET 201 or ECE 231 and Math 138 or Math 111 This second course in Electrical Circuits expands on Circuit Theory introduced in ECET 201. It includes Ohm's and Kirchhoff's Laws for analysis of series and parallel AC circuits. Series-parallel, ladder and bridge networks are analyzed using AC signals. Resonance and frequency response are included. The basic theory and operation of diodes and transistors, including dc biasing are studied. Circuit simulation and laboratory experiments are designed to support the theory and obtain measurement skills.

ECET 205. Fundamentals of Analog Electronics. 3 credits, 4 contact hours (2;2;0).
Prerequisite: ECET 202 or ECE 232 This course introduces students to the active components used in electronics circuits. It covers the physics, the characteristics, and some applications of semiconductor diodes and transistors. The applications will include amplifiers, rectifiers, op amps, oscillators, and timers. Circuit simulation and laboratory experiments are designed to support the theory and provide measurement skills.

ECET 210. Intro. to Microprocessors and Computer Architecture. 3 credits, 4 contact hours (2;2;0).
Prerequisite: None This is an introductory course in computer architecture and microprocessor applications for students who already have basic knowledge of digital circuit principles. Computer hardware architecture is analyzed, and assembly-language programs are written and run. Computer architecture concepts are applied through the use of assembly software programs for a popular microprocessor family. Theoretical ideas are reinforced by building and testing realistic experimental systems in the laboratory.

ECET 211. Computer Architecture. 2 credits, 4 contact hours (3;1;0).
Prerequisites: ECET 215 and (CS 106 or CS 113 or CS 114 or CS 115 or CS 116). This course covers the fundamentals of computer architecture and organization including processor organization, registers, ALU, memory, and IO. The architecture and design of each element is studied and reinforced during lab. Lab projects may include the design a simple RISC microcomputer using HDL or the use of RISC microcontroller systems to perform basic IO and control functions. HDL and assembly languages are studied.

ECET 214. Introduction to Communications. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECET 202 or ECE 232. Corequisite: ECET 205 A study of amplitude modulation, frequency modulation, and pulse modulation systems of transmission and reception, including applications of these systems in radio, television and telemetry. Introduces the latest digital communications theory and applications. Computer simulation and laboratory experiments are designed to support the theory and obtain measurement skills.

ECET 215. Introduction to Digital Electronics. 3 credits, 4 contact hours (2;2;0).
The first course in digital electronics develops the fundamentals of the binary system, circuit implementation from Boolean functions and map minimization. Course includes study of combinational logic, sequential logic circuits, flip-flops, counters, and shift register. Computer simulation and laboratory experiments are designed to support the theory and obtain measurement skills.
ECET 300. Circuit Analysis: Transform Methods. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ECET 303 or ECE 232 and MATH 238 or Math 112. Corequisite: MATH 322 or MATH222. The principles, theorems and techniques of circuit analysis are reviewed. The technique of waveform and circuit transforms is introduced. Laplace transforms are studied and applied in the solution of circuit problems with a variety of input functions. Fourier analysis also is introduced. Extensive use of computer simulation software.

ECET 303. Circuit Measurements. 2 credits, 4 contact hours (1;3;0).
Prerequisites: ECET 205 or ECE 271 and MATH 238 or MATH 112. Lecture and laboratory sessions are designed to develop techniques for the measurement of various circuit parameters as well as the theoretical prediction of these parameters. Extensive use of computer simulation software.

ECET 305. Integrated Circuit Applications. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECET 303 and MATH 238 or MATH 112. Corequisite: ECET 300. Provides a working knowledge of the characteristics and applications of integrated circuits. Topics include how linear ICs work, the most common circuit configurations in which ICs are used, and how to design the most commonly needed circuits with ICs, using manufacturers specification sheets.

ECET 310. Microprocessors I. 3 credits, 4 contact hours (2;2;0).
Prerequisites: Courses in digital logic and introduction to microprocessors (AAS level). Develops a working knowledge of the characteristics and applications of microprocessors. Emphasis is put on the architecture and instruction set of an advanced microprocessor. Representative data handling problems are studied and tested in the laboratory.

ECET 311. Embedded Systems I. 3 credits, 4 contact hours (2;2;0).
Prerequisites: CPT 315 or ECE 251 and ECET 215. Develops a working knowledge of the characteristics and applications of devices used in embedded systems such as microcontrollers. Emphasis is put on the architecture, instruction sets, and assemblers. Representative data handling problems and interfacing are studied and tested in the laboratory using state-of-the-art hardware.

ECET 314. Communication Systems. 3 credits, 4 contact hours (2;2;0).
Corequisite: ECET 300. A study of amplitude modulation, frequency modulation, and pulse modulation systems of transmission and reception, including applications of these systems in radio, television, and telemetry. Introduces the latest digital communications theory and applications. Perform appropriate laboratory exercises and projects.

ECET 319. Electrical Systems and Power. 3 credits, 4 contact hours (2;2;0).
Prerequisites: Physics I and Calculus (AAS level). Restriction: For non-ECET majors only. The fundamentals of ac and dc circuit theory are studied. Transistor and diode theory and their applications in amplifiers and filters are investigated. Electrical machines are also included in this course. Computer simulation as well as appropriate laboratories are required.

ECET 329. Analog and Digital Electronics. 3 credits, 4 contact hours (2;2;0).
Prerequisite: ECET 201 or ECE 231. For MET majors only. Building on ECET 201, a study of more advanced topics in electronics including AC circuit analysis, op-amps, transistors, digital logic and microcontrollers. Computer simulation as well as laboratories are required.

ECET 344. Numerical Computing for Engineering Technology. 3 credits, 4 contact hours (2;2;0).
Prerequisites: Courses in digital logic and introduction to microprocessors (AAS level). Develops a working knowledge of the characteristics and applications of devices used in embedded systems such as microcontrollers. Emphasis is put on the architecture, instruction sets, and assemblers. Representative data handling problems and interfacing are studied and tested in the laboratory.

ECET 345. Digital Logic and Circuit Design. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ECET 215 or ECE 251 Develops the mathematics and minimization techniques together with the circuit implementation for design of combinational and sequential digital solid-state logic circuits. Studies decoders, multiplexers, counters, registers, and PLDs. Computer and communications circuits are used as examples. Projects employ computer simulation of digital circuits.

ECET 395. Co-op Work Experience I. 3 credits, 3 contact hours (0;0;3).
Restriction: Completion of Freshman year and Approval of the department and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated and approved by the co-op office. Mandatory participation in seminars and completion of a report. Note: Normal grading applies to this COOP Experience.

ECET 400. Senior Project. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECET 305, ECET 344, ECET 411 and ENG 352. Capstone project course for the ECET program. Students work as a group to design and develop a product. Students must study project management, concurrent engineering, proposal development, research, societal impact, market research, prototyping and testing. Students develop a formal project proposal, Gantt chart and design specifications for their project. Students apply technical knowledge to build and test their project. Documentation and demonstration of formal testing procedures, computer analysis, simulation, time and cost estimates and compliance with specifications is required. Students present a functioning prototype of the project to a design review board and other students enrolled in the course.
ECET 401. ECET Senior Project I. 2 credits, 2 contact hours (2;0;0).
Prerequisites: ECET 344, ECET 305, ECET 411 and ENG 352. The first course in a two-course sequence comprised of Senior Project 1 (ECET 401) and Senior Project 2 (ECET 402). Project management, concurrent engineering, proposal development, library research, and computer usage are stressed. Students develop a formal proposal, technical specifications, Gantt chart, and design specifications for the senior project to be implemented in ECET 402.

ECET 402. ECET Senior Project II. 1 credit, 2 contact hours (0;2;0).
Prerequisite: ECET 401 (The previous semester) Apply technical knowledge to implement, build, and test the project approved in ECET 401. Complete library research, design specifications, computer analysis, simulation, and time and cost estimates. Purchase and build a working prototype of the design. Complete formal testing procedures to verify that the prototype meets design specifications. Submit formal written documentation and present the project during an oral presentation to a design review board and other students in the class.

ECET 406. Control Systems and Transducers. 4 credits, 6 contact hours (3;3;0).
Prerequisite: ECET 305. Class and laboratory study of analog and digital automatic control. Using Laplace transforms, principles of analysis and design of control systems are introduced. Transducer characteristics and their application in instrumentation and control are investigated. Several experiments are implemented using Programmable Logic Controllers (PLCs).

ECET 410. Microprocessors II. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECET 310 and ECET 365. Covers the operations, bread boarding, and interfacing of devices peripheral to microcomputers. Emphasizes embedded applications of microprocessors to systems requiring both hardware and software development. Advanced topics include programmable peripheral I/O controllers, interrupts and local ISA, PCI and USB buses.

ECET 411. Embedded Systems II. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECET 311 and ECET 365. This course is the second of two embedded systems courses. The primary objective is to prepare students in the ECET curriculum to design embedded systems as part of senior project and also in industry. The design of embedded systems is investigated at the hardware and software level with an emphasis on processor and system architecture. The C language is used for programming.

ECET 412. Power Generation and Distribution. 3 credits, 4 contact hours (2;2;0).
Prerequisite: ECET 205 or ECE 271 Electrical generation, transmission, and distribution systems with an emphasis on 3 phase analysis, design, short circuit currents due to symmetrical faults, and reliability considerations of the electric power system. The laboratory portion includes hands on activities and experiments that align electric power theory with application. Design considerations for inside / outside plant, worker safety, system interconnection and protection, while focusing on reliability and cost considerations are covered.

ECET 415. Fundamentals of Telecommunications. 3 credits, 4 contact hours (2;2;0).
Prerequisite: ECET 214. The focus of this course is on network data communication systems and related protocols. Main topics include transmission media including coax, twisted pair, fiber optics, wired, and wireless media. The Transmission Control Protocol/Internet Protocol (TCP/IP) model as well as the Open System Interface (OSI) model are discussed with emphasis on the details of the TCP/IP model. Additional topics such as wired and wireless LAN, backbone networks, wide area networks, The Internet, networking security, and networking design are covered.

ECET 416. Networking Applications. 3 credits, 4 contact hours (2;2;0).
Prerequisite: ECET 344. Introduces students to the technology of networking with a particular focus on local area networks and the protocols associated with network communication. Comprised of two components: concept/theory and hands-on/applications in the laboratory. Topics include: an overview of network communication systems, networking protocols, network standards, wide area networks, local area networks, enterprise networks, network topology, media access control, transport control protocol, internet protocol, and routing. Students learn to analyze traffic flow on network links and how to write network based software applications.

ECET 418. Transmission Systems. 3 credits, 4 contact hours (2;2;0).
Prerequisite: ECET 214. A study of wireless and terrestrial transmission systems with an emphasis on fiber optics and the latest wireless techniques. The lectures examine the technologies as well as the advantages and disadvantages of the various transmission techniques. The laboratories are a mixture of fiber optic, microwave, and wireless experiments providing hands-on experience in these important areas.

ECET 440. Clinical Internship. 3 credits, 3 contact hours (3;0;0).
By Advisement". Consists of 200 hours of experience in the clinical engineering department of a hospital. The student is under the supervision, and is evaluated by, the director of clinical engineering at the hospital. A final report is submitted to and graded by the NJIT faculty advisor.

ECET 444. Technology Applications of Object-Oriented Programming. 3 credits, 4 contact hours (2;2;0).
Prerequisite: ECET 344. Brings together prior software knowledge and applies it to develop modern software applications. Comprised of theory and hands-on applications in the lab. Concepts in modular/structured design and object-oriented design will be combined to develop modern internet and database connected applications. Examine several case studies during the last few weeks. Design, construct, and test a practical software project.

ECET 491. Special Projects in ECET. 1 credit, 3 contact hours (3;0;0).
By Advisement". Special projects course for ECET students with subject matter to be arranged by instructor and approved by program coordinator.

ECET 492. Special Projects in ECET. 2 credits, 3 contact hours (3;0;0).
By Advisement". See ECET 491.

ECET 493. Special Projects in ECET. 3 credits, 3 contact hours (0;0;3).
By Advisement". See ECET 491.
ECET 495. Co-op Work Experience II. 3 credits, 3 contact hours (0;0;3).
Prerequisite: ECET 395. Provides major-related work experience as a co-op/intern. Mandatory participation in seminars and completion of requirements that include a report and/or project.

ENE 262. Introduction to Environmental Engineering. 3 credits, 4 contact hours (3;1;0).
Prerequisites: CHEM 126, MATH 112, and PHYS 121. To introduce students to the integrated science, engineering, design and management concepts of engineered environmental systems. The course will cover environmental regulations and standards, environmental parameters, mass balance and natural systems, water quality management, water and wastewater treatment, air pollution control, noise pollution, and solid and hazardous waste management. Background material and laboratories in the environmental sciences and management areas will be covered. Group term papers and presentations will be required.

ENE 360. Water and Waste Water Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ENE 262 and junior standing. Training in the methods used for water pollution control. Topics include the chemical, physical, and biological processes that occur in waste treatment design and in receiving waters; modeling schemes to determine allowable loadings in various bodies of water; and waste treatment processes used for water pollution control.

ENE 361. Solid and Hazardous Waste Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ENE 262 and junior standing. Exposure to the area of air pollution control, solid waste disposal, and radioactive waste disposal. Topics include the chemistry of contaminated atmospheres; the influence on meteorological conditions of dispersion of pollutants; abatement processes used in the control of emissions; classification and nature of solid waste, and solid waste disposal techniques; sources and methods for the disposal of radioactive contaminants; and related health effects.

ENE 362. Pollution Prevention. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHEM 126, Math 111, and Junior Standing. This course presents pollution prevention concepts and principles, terminologies, life cycle impact approaches, and management strategies. It will also serve as a community based service learning course. The course introduces available improvement techniques for industrial pollution prevention and control and examines specific applications to industries biological, chemical, physical, and thermal techniques.

ENE 485. Special Topics in Environmental Engineering. 3 credits, 3 contact hours (3;0;0).
The study of new and/or advanced topics in an area of environmental engineering not regularly covered in any other ENE course. The precise topics to be covered in the course, along with prerequisites, will be announced in the semester prior to the offering of the course.

ENE 490. Senior Project. 3 credits, 3 contact hours (0;0;3).

ENE 491. Research Experience in ENE. 3 credits, 3 contact hours (3;0;0).

ENGR 101. Analytical Meth for Engr Appl. 4 credits, 6 contact hours (4.5;1.5;0).
Prerequisite: SAT Math score of 500 or above. This course provides foundation in analytical methods that are used by engineers through an application-oriented, hands-on introduction to engineering analytical methods.

ENGR 210. Career Planning Seminar for En. 1 credit, 1.5 contact hour (1.5;0;0).
Prerequisite: Sophomore Standing. This course aims at providing engineering students with multidisciplinary and career planning skills in a seminar environment with emphasis on career planning, resume writing, and interview skills.

ENGR 290. Pers of the Grand Challenges. 1 credit, 1 contact hour (1;0;0).
Prerequisite: Approval of the Instructor and the Grand Challenges Program Director; sophomore or higher standing. The first step for aspiring students in becoming a grand challenges scholar. Seven engaging colloquia will be offered every fall semester. Faculty conducting research in a Grand Challenge Theme will present the colloquia with one faculty member presenting at each colloquium. At the conclusion of each faculty presentation, and in the weeks in-between the presentations, students will engage in an activity organized to focus on exploring a potential engineering solution, addressing societal impacts, and holding debates on differing perspectives.

ENGR 310. Co-op Work Experience I. 12 credits, 12 contact hours (0;0;12).
Prerequisites: ENGR 210; Completion of 36 credits; Cumulative GPA 2.5; Approval of department; Approval of CDS. Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Mandatory participation in seminars and completion of a report.

ENGR 410. Co-op Work Experience II. 12 credits, 12 contact hours (0;0;12).
Prerequisites: ENGR 310; Completed at least 9 credits after ENGR 310; Cumulative GPA 2.5; Approval of department; Approval of CDS. Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Mandatory participation in seminars and completion of a report.

ENGR 423. Drone Science Fundamentals. 3 credits, 4 contact hours (0;0;4).
Prerequisite: NCE students with senior standing and with instructor permission. This course will cover the fundamentals of quadrotor drone kinematics and dynamics, quadrotor sensor data analysis, linear and non-linear flight control, and motion planning for a single quadrotor. Students will be guided through the process of building a quadrotor drone, setting up the required flight control parameters and associated Hardware-In-The-Loop simulators, and using Python/C programming for basic single quadrotor motion planning algorithms. Students will also be guided through the preparation for the Federal Aviation Authority (FAA) Part 107 Certified Drone Pilot knowledge test.
ESC 310. Work Experience I. 3 credits, 3 contact hours (0;0;3).

ESC 491H. Honors Research and Independent Study I. 3 credits, 3 contact hours (0;0;3).
Restriction: senior standing in engineering science and enrolled in the Honors College. Same as ESC 491, but projects are more comprehensive and are of greater depth.

ET 101. Introduction to Engineering Technology. 0 credits, 2 contact hours (2;0;0).
This course introduces the student to engineering technology. Also included is an introduction to the various engineering technology options: Construction, Electrical and Computer, and Mechanical Engineering Technologies as well as Concrete Industry Management.

FED 101. Fundamentals of Engineering Design. 2 credits, 3 contact hours (2;1;0).
Corequisites: HUM 101 and (ENGR 101 and MATH 110) or MATH 111. Teams of students work on open-ended engineering projects. Sections are offered to represent an introduction to real-world engineering design problems in a specific engineering discipline. Topics covered include introduction to basic engineering design elements, processes, measurements, product and project design and development, with hands-on experiments in a specific major area. Students also learn to use engineering tools for computer-aided design and simulation. Technical writing and oral presentation along with project management skills are emphasized. Students are required to take an FED section corresponding to their declared major. Undecided students will be placed in FED sections which best correspond to their interests according to space availability.

IE 101. Introduction to Industrial Engineering. 1 credit, 2 contact hours (1;1;0).
An Introduction to the field of Industrial Engineering, the functions performed by industrial engineers, career paths and opportunities in the field, introduction to the student and senior professional societies, and initiation of a mentoring program.

IE 203. Applications of Computer Graphics in Industrial Engineering. 2 credits, 3 contact hours (1;2;0).
Restriction: sophomore standing. Methods, tools and technologies of networked, graphical/visual communication systems with an industrial engineering focus. Lean and sustainable green enterprise, product, process, service and shop floor level visual factory management systems. Provides analytical and practical knowledge of computer graphics in IE, including graphical standards necessary to meet the requirements of today’s practice. Introduction of modern web-based software tools and systems.

IE 224. Production Process Design. 3 credits, 4 contact hours (2;2;0).
Restriction: sophomore standing. Introduction to the theory and practice of manufacturing processes. Study covers the fabrication of metallic, plastic, and electrical products, operation of NC and other automatic equipment, and economics of the design and production process.

IE 310. Co-op Work Experience I. 0 credits, 0 contact hours (0;0;0).
Restriction: junior standing, approval of co-op faculty advisor, and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated by the co-op office and approved by the co-op faculty advisor. Mandatory participation in seminars and completion of a report.

IE 331. Applied Statistical Methods. 3 credits, 3 contact hours (3;3;0).
Prerequisite: MATH 211. A presentation of statistical analysis techniques and their applications. Topics include the statistical measures describing data, frequency distributions, probability distributions, sampling parameter estimation, hypothesis testing, regression analyses, and analyses of variance. Special emphasis on their application to industrial fields.

IE 334. Engineering Economy and Capital Investment. 3 credits, 3 contact hours (3;0;0).
Restriction: junior standing. Introduction to the principles of engineering economics for utilization and evaluation of capital investments, including time value of money, depreciation, cost of capital, life cycle cost, net present value, and payback. Consideration of decisions involving multiple choice replacement, uncertainty, and risk.

IE 335. Engineering Cost Analysis and Control. 3 credits, 3 contact hours (3;3;0).
Restriction: junior standing. The tools and techniques applicable for cost analysis and control including standard costs, variance analysis, cost volume relationships, cost estimation, and utilization of accounting data for control of operations.

IE 339. Work Measurement and Standards. 3 credits, 4 contact hours (2;2;0).
Prerequisites: IE 203, IE 224. Emphasizes the measurement and evaluation of existing work methods and how improvement can be achieved. Topics include visual and micro-motion study techniques, motion economy, time study, and work sampling. The development and use of standard data and computerized techniques. Also, hands-on experience through a series of laboratory experiments.

IE 355. Human Factors. 3 credits, 3 contact hours (3;3;0).
Restriction: junior standing. Human-machine systems analysis including study of workplace layout, measurement of employee efficiency and productivity, criteria for tool and fixture design or selection, industrial fatigue, environmental influences on performance including the effects of illumination, noise, vibration, thermal, and other atmospheric factors. Basic ideas of industrial hygiene; the impact of OSHA; and special techniques for experimenting with human subjects, via demonstrations and supervised experiments.

IE 411. Co-op Work Experience II. 3 credits, 3 contact hours (0;0;3).
Prerequisite: IE 310. Restriction: approval of co-op faculty advisor and permission of the Office of Cooperative Education and Internships. Full-time work experience of approximately one semester's duration. Provides major-related work experience as a co-op/intern. Mandatory participation in seminars and completion of requirements that include a report and an oral presentation to IE faculty. Note: Normal grading applies to this COOP Experience.
IE 436. Cost Analysis and Engineering Economics. 3 credits, 3 contact hours (3;0;0).
Restriction: junior or senior standing. Not open to industrial engineering majors. Focuses on the economic factors of concern to manufacturing engineers. Major topics include justification of proposed capital expenditures, equipment retirement and replacement decisions, cost determination, profitability studies, and manufacturing budget construction and utilization for cost control.

IE 439. Deterministic Models in Operations Research. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MATH 222 or equivalent. The deterministic techniques of operations research. Topics include the applications of linear, nonlinear, integer, and dynamic programming methods and network flows analysis to solve industrial and systems engineering problems.

IE 440. Stochastic Models in Operations Research. 3 credits, 3 contact hours (3;0;0).
Prerequisites: IE 331, MATH 222 or their equivalent. Probabilistic techniques of operations research. Topics include the applications of Markov chains, queueing and inventory control models to analyze and evaluate systems performance.

IE 441. Information and Knowledge Engineering. 3 credits, 3 contact hours (3;0;0).
Restriction: junior or senior standing. Introduction to recent advances in the application of computers in industrial engineering and database structures, both sequential and random. Description of methods for organizing data, database modeling, information storage and retrieval. Also, applications of expert systems concepts and techniques.

IE 443. Senior Project I. 2 credits, 4 contact hours (1;3;0).
Restriction: senior standing. Introduction to senior design project. Selection of specific system design for the project, establishment of initial contacts, preliminary collection and analysis of system data. Concepts of system design analysis emphasizing simulation modeling and analysis, model verification, and model validation.

IE 444. Senior Project II. 2 credits, 3 contact hours (1;2;0).
Prerequisite: IE 443. Senior design project, in which the concepts of industrial engineering systems, principles, and procedures are integrated and applied in industrial projects or case studies.

IE 445. Industrial Simulation. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CS 101, IE 331 or equivalent. Introduction to the application of simulation modeling for the analysis of complex industrial and manufacturing service systems. Examples are chosen from real-life situations such as warehousing, material handling, robotics, transportation, and hospital emergency rooms. Verification/validation as well as statistical analysis of both input/output data are introduced.

IE 447. Legal Aspects of Engineering. 3 credits, 3 contact hours (3;0;0).
Restriction: junior or senior standing. Familiarization with the U.S. system of case law, statutes and regulations applicable to professional relationships involving the engineer. Includes contracts, property, product liability and other torts, governmental regulatory bodies such as OSHA, EPA, and NRC, professional liability, and role of codes and standards.

IE 449. Industrial Robotics. 3 credits, 4 contact hours (2;2;0).
Prerequisites: CS 101, PHYS 121, junior or senior standing. Robotics in manufacturing systems. The field of robotics is studied with emphasis given to the role of programmable robots in manufacturing. Hands-on experience with hardware and software necessary for various industrial robot systems through laboratory experience.

IE 450. Product Engineering Standards. 3 credits, 3 contact hours (3;0;0).
Restriction: senior standing. Developing and using standards in the design, manufacturing, and use of products. Topics include economics of parts standardization, drawing and assembly techniques, and use of national and international standards. Review of the role of standards-setting bodies and methods for the development of product testing standards used in industry and commerce.

IE 451. Industrial Measuring Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisite: IE 331. Reviews contemporary measuring systems and provides a basic under-standing of the various methods, their accuracy, reliability, and relative costs to perform. Includes measuring methods needed for compliance evaluation in accordance with occupational and safety legislation, industrial processes, and product design.

IE 453. Computer Integrated Manufacturing. 3 credits, 4 contact hours (2;2;0).
Restriction: junior or senior standing. Examines the components of computer integrated manufacturing (CIM) including the design of information frameworks and network protocols required to orchestrate full manufacturing automation. Study of CAD, CAPP, robotics, NC, CNC, computer interfacing, and database systems in the context of a CIM environment. Exposure to state-of-the-art CIM software and hardware.

IE 455. Robotics and Programmable Logic Controllers. 3 credits, 4 contact hours (2;2;0).
Restriction: junior or senior standing. Introduction to the design and implementation of programmable logic controllers for use in industry in the areas of automotive assembly, pharmaceutical manufacturers, the chemical industry, and others. Includes ladder logic, input/output ports, continuous process control, timing and counting functions, chaining sequences, and digital gate logic.

IE 456. Introduction to Industrial Hygiene. 3 credits, 3 contact hours (3;0;0).
Prerequisite: IE 355. Analysis of the effects of various environmental stressors on people at work, including their interference with performance and the development of acute and chronic health problems. Study of how numerous airborne contaminants, noise, thermal extremes, ionizing and nonionizing radiation, etc., affect workers alone and in combination. Topics include measurement and evaluation techniques, TLVs, control methodologies, legal requirements for employers.
IE 459. Production Planning and Control. 3 credits, 3 contact hours (3;0;0).
Prerequisites: IE 221, IE 439, junior or senior standing. A study of the components and functioning of integrated production, planning, and control systems. Forecasting, aggregate planning, scheduling, and recent models of production and inventory control for optimizing continuous and intermittent manufacturing operations. MRP basics. Introduction to using a computer to apply scheduling models.

IE 460. Measuring Techniques and Quality Control. 3 credits, 3 contact hours (3;0;0).
Prerequisite: understanding of basic probability. Not open to industrial engineering majors; intended for other engineers, inspection supervisors, and management. Various types of control charts and acceptance sampling systems and procedures. These techniques are used widely in industry to improve product quality and reduce costs.

IE 461. Product Quality Assurance. 3 credits, 3 contact hours (3;0;0).
Prerequisite: IE 331. Methods used to achieve higher product quality, to prevent defects, to locate chronic sources of trouble, to measure process capability, and to use inspection data to regulate manufacturing processes are emphasized. Preparation of statistical control charts and selection of suitable sampling plans.

IE 463. Invention and Entrepreneurship. 3 credits, 3 contact hours (3;0;0).
Restriction: Junior or Senior standing or permission of instructor. This course will teach students the process of developing new products. It takes students from the art of creativity through product design and concludes with the formulation of a business plan for marking and production. If the new product satisfies the requirements of novelty, usefulness, and nonobviousness, a patent application may be filed.

IE 466. Material Handling and Facilities Layout. 3 credits, 3 contact hours (3;0;0).
Prerequisite: IE 439. Analysis of organized human activities typified by industrial and office operations. Recent methods are applied to optimize location and layout of facilities. Introduction to modern material handling systems, expert systems in plant layout, logistics of motion of people and materials, flow analysis, plant layout, and material handling techniques.

IE 469. Reliability in Engineering Systems. 3 credits, 3 contact hours (3;0;0).
Prerequisites: IE 331 or equivalent, senior standing. Emphasizes the determination of systems reliability from a knowledge of characteristics and reliability of individual system components. Topics include reliability concepts, failure rates, systems analysis, optimization, maintenance, etc. Covers techniques for the formulation and evaluation of reliability models.

IE 472. Product Liability Engineering. 3 credits, 3 contact hours (3;0;0).
Restriction: junior or senior standing. The techniques available to the engineer to minimize the hazards of design and manufacturing that result in product liability cases. The effect of legal precedents on design, manufacturing, advertising, marketing, and using a product within developing technical disciplines such as: reliability prediction and analysis methods, assuring the quality of manufactured products, loss control systems, safety engineering precepts, human factors principles and design review. Review of government regulations for safety and protection.

IE 473. Safety Engineering. 3 credits, 3 contact hours (3;0;0).
Restriction: junior or senior standing. The principles and practices of safety engineering in product and facilities design. Safe practices and hazard control, safety standards and codes, inspection procedures, the role of insurance, governmental regulations, and safety statistics. Participation in current safety engineering research studies. The Occupational Safety and Health Act and related legislation.

IE 480. Special Studies in Industrial Engineering for Non-Majors. 3 credits, 3 contact hours (3;0;0).
Restriction: permission of the IE faculty advisor. Not open to industrial engineering majors. Individual investigations under faculty guidance through consultation, readings, and visits with recognized authorities and institutions, dealing with specialized industrial engineering problems. Explore in depth an area of interest and give a report in a seminar setting, and submit a written project report.

IE 481. Investigations in Industrial Engineering I. 3 credits, 3 contact hours (0;0;3).
Restriction: junior or senior standing, per-mission of the IE faculty advisor. Individual investigation under faculty guidance through consultation, readings, and visits with recognized authorities and institutions, dealing with specialized industrial engineering design problems. Explore in depth an area of interest and give a report in a seminar setting, and submit a written project report.

IE 482. Investigations in Industrial Engineering II. 3 credits, 3 contact hours (0;0;3).
Prerequisites: IE 481, permission of the IE faculty advisor. Further individual investigations, a continuation of IE 481.

IE 492. Engineering Management. 3 credits, 3 contact hours (3;0;0).
Restriction: junior or senior standing. An introduction for engineering majors to the fundamentals of engineering economics and the management process for engineering and development. Major topics include capital investment justification methods, project organization, scheduling and control techniques, legal, quality, and staffing issues.

ME 215. Engineering Materials and Processes. 3 credits, 4 contact hours (2;2;0).
Prerequisite: CHEM 126 or CHEM 122. Students also must register for the lab component. Combined lecture and laboratory relating to the study of engineering materials. Processes of formation from liquid and particle state, plastic forming, molding deformation, and metal removal. Effects of heat treatment on material properties. Laboratory exercises involve basic machine tools and computer-controlled equipment.

ME 231. Kinematics of Machinery. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CS 101, MECH 234. Design, selection, and evaluation of mechanisms for various applications. Topics include displacement, velocity, and acceleration analysis of planar linkages, synthesis of function generators and motion generators, design of cams, gear-tooth geometry and analysis of gear trains.
ME 304. Fluid Mechanics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MECH 236, ME 311. Introduction to the basic principles of conservation of mass, momentum, and energy as they apply to engineering systems which utilize fluids. Some of the topics are dimensional analysis, theoretical and empirical analysis of one-dimensional compressible and incompressible flow, empirical analysis of external and internal flows, and elementary boundary layer theory.

ME 305. Introduction to System Dynamics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 222, MECH 236, ME 231. Principles of dynamic system modeling and response with emphasis on mechanical, electrical, and fluid systems. Application of computer simulation techniques.

ME 310. Co-op Work Experience I. 3 credits, 3 contact hours (0;0;3).
Prerequisites: Completion of freshman year, approval of department, and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated by the co-op office and approved by the department. Mandatory participation in seminars and completion of a report.

ME 311. Thermodynamics I. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 211, PHYS 111. Thermodynamic fundamentals. Topics are the first and second laws of thermodynamics, physical properties of pure substances, entropy, ideal and real gases, and gaseous mixtures.

ME 312. Thermodynamics II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ME 311. A continuation of ME 311 including studies of irreversibility and combustion. Thermodynamic principles are applied to the analysis of power generation, refrigeration, and air-conditioning systems. Introduction to solar energy thermal processes, nuclear power plants, and direct energy conversion.

ME 315. Stress Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 222, MECH 237, ME 215. Problems related to mechanical design. Topics include two-dimensional elasticity, transformation of stress and strain, plane stress problems, axisymmetric members, buckling criteria, and failure theories.

ME 316. Machine Design. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ME 231, ME 315. Aspects of the design process and design of machine elements. Mini-projects are used to introduce engineering design procedures.

ME 339. Fundamentals of Mechanical Design. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MECH 234. For industrial engineering majors. Topics include kinematics of mechanisms, machine components, and a brief introduction to mechanical vibrations. Students gain the ability to deal with design problems from the viewpoint of a non-specialist.

ME 343. Mechanical Laboratory I. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECE 405, MATH 279 or MATH 333 and MECH 236. Laboratory and lecture in instrumentation and measurement for mechanical engineering students. Applications for the sensing of such variables as pressure, temperature, mass flow, and displacement. Particular attention to the applicability and sensitivity of instruments.

ME 403. Mechanical Systems Design I. 3 credits, 3 contact hours (2;1;0).
Prerequisites: ME 304, ME 305, ME 312, ME 316. Lectures and projects covering problem solving methodology in the design, analysis, and synthesis of mechanical and thermal systems. The student's academic background combines with engineering principles and topics to serve as a foundation for broad engineering projects. Emphasis on creative thinking and the engineering design process in projects involving the optimal conversion of resources.

ME 405. Mechanical Laboratory II. 2 credits, 3 contact hours (1;2;0).
Prerequisites: ME 343, ME 312. Laboratory emphasizing the use of fundamental principles and instrumentation systems for the analysis and evaluation of mechanical components within a system.

ME 406. Mechanical Laboratory III. 2 credits, 3 contact hours (1;2;0).
Prerequisites: ME 405, ME 407. Laboratory covering the testing and evaluation of complete mechanical systems.

ME 407. Heat Transfer. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 222, ME 304, ME 311. A study of the three fundamental modes of heat transfer: conduction, convection, and radiation. A physical interpretation of the many quantities and processes in heat transfer using numerical methods. Theory is applied to the analysis and design of heat exchangers and other applications. Where appropriate, computer simulation is used.

ME 408. Mechanical Systems Design II. 2 credits, 3 contact hours (1;2;0).
Prerequisites: ME 403, ME 407. A continuation of ME 403 from a more integrated viewpoint, with lectures on special topics. Concepts in optimization and computer simulation are considered in the design and synthesis of mechanical engineering systems. The projects are more comprehensive, emphasizing creative design, and requiring design decisions of a more sophisticated nature.

ME 410. Co-op Work Experience II. 3 credits, 3 contact hours (0;0;3).
Prerequisites: ME 310, approval of the department, and permission of the Office of Cooperative Education and Internships. Full-time work experience of approximately one semester's duration. Provides major related work experience as co-op/internship. Mandatory participation in seminars and completion of requirements that include a report and project. Note: Normal grading applies to this COOP Experience.
ME 425. Finite Element Method in Mechanical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CS 101, Math 222, and Mech 237. Introduction to central ideas underlying the finite element method in mechanical engineering and its computer implementation. Fundamental concepts such as interpolation functions for one- and two-dimensional elements, bar element method, Galerkin’s method, discretization of a model, methods of assembling global matrices, and the final solution techniques for obtaining nodal values. Specific applications to mechanical engineering problems in trusses, beams, torsion, heat transfer, fluid flow, plane stress, and plane strain.

ME 430. Introduction to Computer-Aided Design. 3 credits, 4 contact hours (2;2;0).
Prerequisites: CS 101, FED 101 and Math 222. Introduction to basic concepts of computer-aided design as applied to mechanical engineering design problems. Topics include numerical techniques, computer graphics, geometric modeling, design optimization, and databases for design. The laboratory uses current CAD software packages for mechanical design. Projects involve applications of the basic principles using student's own as well as available software.

ME 431. Introduction to Robotics and Automation. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CS 101, MECH 236. Introduction to mechanics and control of robotic manipulators. Topics include spatial transformations, kinematics, dynamics, trajectory generation, actuators and control, and relations to product design and flexible automation.

ME 432. Principles of Air Conditioning and Refrigeration. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ME 304, ME 312; Corequisite: ME 407. A course in the fundamentals of air conditioning and refrigeration. Topics covered are psychrometrics, cooling and heat load calculations, air distribution systems, duct design, vapor compression and absorption systems, and the principles of cooling towers.

ME 433. Vibration Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MECH 236, MATH 222. An introduction to the fundamental theory of mechanical vibrations. Undamped and damped systems with single and multiple degrees of freedom, transient vibration, vibrations of continuous media, and analog and numerical methods.

ME 435. Thermodynamics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 211, PHYS 111. Intended for non-mechanical engineering students of all disciplines. Topics include the basic laws of thermodynamics, properties of fluids and solids, analysis of open and closed systems, gas and vapor power cycles, refrigeration and air conditioning, and an introduction to heat transfer. Cannot be taken for credit by mechanical engineering students.

ME 437. Structural Analysis. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ME 315. Fundamentals of structural analysis. Consideration of stresses and deflections of beams as well as the design of beams, columns, trusses, and structural connections of steel, reinforced concrete, and timber structures.

ME 438. Introduction to Physical Metallurgy. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHEM 126 or CHEM 122, and ME 215. Introduction to metallic microstructures, solid solutions and the mechanical properties of metals and alloys. Physical understanding of diffusion processes is emphasized in covering the relationship between the nature of metals and different heat treating processes.

ME 439. Principles of Tribology. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CHEM 126, MECH 237. An introduction to the principles of wear resistance of machine parts and tribology. Physical understanding of different mechanisms of wear and friction and methods of increasing durability.

ME 441. Computer Simulation and Analysis in Mechanical Engineering. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ME 430. This course covers various topics in Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE). The course provides an in-depth understanding and skill of constructing 2-D drawings using well-known commercial CAD package, and integrating 3-D solid modeling techniques into simulation, and analysis animation of new designs using commercial CAD/CAE software. The students will have hands-on experience to analyze Structure, Heat Transfer, and Computational Fluid Dynamics problems by using several different software packages. The course also focuses on CAD Product Data Exchange using both Direct Database conversion and International Standards based conversion methods between major CAD/CAE systems. Typical industrial applications will be illustrated.

ME 451. Introduction to Aerodynamics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ME 304, ME 311. Introduction to the basic principles and properties of fluid flow around immersed bodies. Topics include the kinematics and dynamics of fluid fields, the thin airfoil, finite wing theory, and one-dimensional compressible flow.

ME 452. Dynamics of Space Flight. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MECH 236, MATH 222. An introduction to the mechanics of space flight. After a brief introduction to the physics of the solar system, the dynamics of space flight are developed from the Newtonian viewpoint. Covers the performance and propulsion methods of rocketry.

ME 455. Automatic Controls. 3 credits, 3 contact hours (3;0;0).
Prerequisite: ME 305. Introduction to the principles of automatic controls. Emphasis on systems, considering their mechanical, hydraulic, pneumatic, thermal, and displacement -aspects. First and second order linear systems. Introduction to system analysis techniques such as Nyquist and Bode diagrams and applications in system design.

ME 470. Engineering Properties of Plastics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ME 215, MECH 237. A study of the physical properties of the various commercial thermosetting and thermoplastic resins. An introduction to linear viscoelastic theory and its relationship to measurable mechanical properties of plastics. Also, engineering properties such as flammability, chemical resistance, and electrical properties.
ME 471. Introduction to Polymer Processing Techniques. 3 credits, 3 contact hours (3;0;0).
Prerequisites: ME 304, ME 407. A study of the various plastics processing techniques, including extrusion, injection molding, blow molding, compression molding, thermoforming, rotational molding, casting, etc. The relationship between product design and choice of process will be presented.

ME 490. Mechanical Engineering Project A. 3 credits, 3 contact hours (0;0;3).
Prerequisite: departmental approval required. One or more individually selected projects. Projects usually require library research, design, cost analysis, planning of testing. Also involves an engineering report and a technical presentation.

ME 491. Mechanical Engineering Project B. 3 credits, 3 contact hours (0;0;3).
Prerequisites: ME 490 and departmental approval required. One or more selected projects. Projects usually require library research, design, cost analysis, planning of testing. Also involves an engineering report and a technical presentation.

MECH 234. Engineering Mechanics. 2 credits, 2 contact hours (2;0;0).
Prerequisites: PHYS 111, MATH 112. A course for industrial and mechanical engineering students in which the equilibrium of particles and rigid bodies subject to concentrated and distributed forces is studied.

MECH 235. Statics. 3 credits, 4 contact hours (3;0;1).
Prerequisites: PHYS 111, MATH 112. Available for CE students only. Provides an understanding of equilibrium of particles and rigid bodies subject to concentrated and distributed forces.

MECH 236. Dynamics. 2 credits, 2 contact hours (2;0;0).
Prerequisites: MECH 234 or MECH 235 with a grade of C or better or MECH 320 and Math 112, Phys 111/111A. Provides an understanding of the mathematics of the motion of particles and rigid bodies, and of the relation of forces and motion of particles.

MECH 237. Strength Of Materials. 3 credits, 4 contact hours (3;1;0).
Prerequisites: MECH 234 or MECH 235 with a grade of C or better and MATH 112, PHYS111/111A. A working knowledge of statics with emphasis on force equilibrium and free body diagrams. Provides an understanding of the kinds of stress and deformation and how to determine them in a wide range of simple, practical structural problems, and an understanding of the mechanical behavior of materials under various load conditions. Lab should be taken concurrently.

MECH 320. Statics and Strength of Materials. 3 credits, 3 contact hours (3;0;0).
Prerequisites: PHYS 111, MATH 112. For chemical engineering and electrical engineering majors. Statics provides an understanding of the equilibrium of particles and rigid bodies, including simple machines, trusses, and frictional forces. Mechanics of materials covers pressure vessels, thermal stresses, torsion of shafts, stresses and deflection in beams, and column action.

MET 103. Engineering Graphics and Intro. to CAD. 2 credits, 3 contact hours (1;2;0).
A first course in Computer Aided Design (CAD), includes lab work using AutoCAD software. Topics include fundamentals of engineering graphics, AutoCAD command structure, setting units and limits, drafting primitives, layering, use of editing tools; grid, snap, and axis commands. Upon successful completion of this course, students should be able to effectively produce two-dimensional drawings using the AutoCAD software program.

MET 105. Applied Computer Aided Design. 2 credits, 3 contact hours (1;2;0).
Prerequisite: MET 103. A second course in Computer Aided Design (CAD), additional AutoCAD topics include blocks, move and copy, array, mirror, text, text styles, 3D and isometric modes. Upon successful completion of this course, students should be able to use advanced AutoCAD commands to quickly and efficiently produce 2D and 3D drawings, and also be able to modify the AutoCAD environment (e.g., menus, macros, etc.) to boost productivity.

MET 205. Advanced Computer Aided Design. 3 credits, 4 contact hours (2;2;0).
Prerequisite: MET 105. This course introduces advanced CAD applications, including attribute and attribute extraction, external reference files, solid modeling, surface rendering and animation. Upon successful completion of this course, students should be able to use a CAD software package to develop animations consisting of 3D models with rendered surfaces.

MET 235. Statics for Technology. 3 credits, 3 contact hours (3;0;0).
Prerequisites: PHYS 102 and MATH 238. Provides an understanding of equilibrium of particles and rigid bodies subject to concentrated and distributed forces. Upon successful completion of this course, the students should be able to analyze problems involving the equilibrium of particles and rigid bodies, including simple machines, trusses, and frictional forces.

MET 236. Dynamics for Technology. 2 credits, 2 contact hours (2;0;0).
Prerequisite: MET 235 or MECH 235. Provides an understanding of the mathematics of the motion of particles and rigid bodies, and of the relation of forces and motion of particles. Upon successful completion of this course, the students should be able to describe the motion of particles and rigid bodies as functions of time and position, develop their equations of motions due to applied forces, and determine post impact behavior.

MET 237. Strength of Materials for Technology. 3 credits, 4 contact hours (2;2;0).
Prerequisite: MET 235 or MECH 235. Provides an understanding of the kinds of stress and deformation and how to determine them in a wide range of simple, practical structured problems, and an understanding of the mechanical behavior of materials under various load conditions. The laboratory experience is integrated within the course. Upon successful completion of this course, the students should be able to determine stresses and deformations for a variety of simple structural problems.
MET 301. Analysis and Design of Machine Elements I. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MATH 238, MET 236, MET 237, CS106. The principles of strength of materials are applied to mechanical design. Topics include theory of failure, stress concentration factors and fatigue, the design and analysis of shafts subjected to static and dynamic loadings, and critical speed of a rotating shaft.

MET 302. Analysis and Design of Machine Elements II. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MET 301. A continuation of MET 301, including analysis and design of power screws, brakes, clutches, belts, chain drives, gears, gear trains, bearings, and other machine elements.

MET 303. Applied Thermodynamics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: MATH 238 or MATH 112, PHYS 103 or PHYS 121, CS 106. Basic principles of thermodynamics and their applications to internal combustion engines, turbines, compressors, power generating and refrigeration systems.

MET 304. Applied Fluid Mechanics. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MATH 238 or MATH 112, PHYS 103 or PHYS 121. An introduction to fluid statics and the basic laws of fluid flow; conservation of mass, momentum and energy. Applications of the basic laws to internal and external incompressible flow, including specific topics in pipe flow systems, centrifugal pumps and fans, streamlining, and fluid flow meters.

MET 307. Plastics Technology. 3 credits, 4 contact hours (2;2;0).
Prerequisites: CHEM 301, MET 215, MET 237, MET 105. An introduction to the basic concepts of plastics conversion, resin classification, processing techniques and significant engineering properties.

MET 308. Plastics Processing Techniques. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MET junior standing, MET 307. A study of the various processing techniques for both thermoset and thermoplastic materials. Topics include extrusion, injection molding, blow molding, compression moldings, and casting processes.

MET 314. Dynamics of Machinery. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MET 236, MET 237, MATH 238, MET 105, CS 106. Acquaints students with motion and forces in machines. Topics include velocity and accelerations in linkages, gears, cam and gear trains, static and dynamic forces, and torques in linkages.

MET 395. Co-op Work Experience I. 3 credits, 3 contact hours (0;0;3).
Prerequisite: MET JUNIOR STANDING. Students gain major-related work experience and reinforcement of their academic program. Work assignments facilitated and approved by the co-op office. Mandatory participation in seminars and completion of a report. Note: Normal grading applies to this COOP Experience.

MET 401. Mechanical Design Project I. 2 credits, 2 contact hours (2;0;0).
Prerequisites:MET 302, MET 303, MET 304, MET 314, ECET 329, ENG 352. Project and lecture applies the principles learned in all technical courses to more advanced design situations. Proposal of a typical mechanical engineering system is presented by an individual or by small groups. The proposal must meet the approval of course instructor. A formal proposal is required.

MET 403. Applied Thermodynamics II. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MATH 309, MET 303 or its equivalent, MET 304. Builds on a first course on thermodynamics and covers thermodynamic properties of steam, first and second law of thermodynamics. Topics include power and refrigeration cycles, psychrometric chart and combustion.

MET 404. Applied Heat Transfer. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MATH 309, MET 303, MET 304. An introduction to the fundamental theories and applications of heat transfer. Emphasizes understanding and practical problem solving in covering the three fundamental modes of heat transfer: conduction, convection, and radiation.

MET 407. Structural Design. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MET 237, CS 106, MATH 238, MET 105. Acquaints students with the fundamentals of structural design. Topics include analysis and design of structural members due to various loadings (tension, compression, bending, torsion, and shear), deflections of structural members, truss analysis, stress analysis of weldment.

MET 409. Air Conditioning and Refrigeration. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MET 303, MET 304. Calculation of building cooling and heating loads, psychrometric charts, air distribution and duct design. Topics also include compression and absorption refrigeration cycles, automatic control of refrigeration systems, and building energy management.

MET 415. Automatic Control Systems. 3 credits, 4 contact hours (2;2;0).
Prerequisites: ECET 201, MET 302, CS 106, MET 105. Introduction to programmable logic controllers (PLC) as a tool for industrial controls of machines and process. Includes selections of hardware and software, ladder logic programming, wiring methods, maintenance and trouble shooting of.

MET 448. Mechanical Design Project II. 1 credit, 2 contact hours (2;0;0).
Prerequisite: MET 401. Continuation of project MET 401. Oral presentation and formal written report are required.

MET 450. Mech Design Capstone Project. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MET 302, MET 303, MET 304, MET 314, ECET 329, ENG 352. Project and lecture applies the principles learned in all technical courses to more advanced design situations. Proposal of a typical mechanical engineering system is presented by an individual or by small groups. The proposal must meet the approval of course instructor. A formal proposal is required.

MET 491. Special Projects in MET. 1 credit, 3 contact hours (3;0;0).
One-credit special project course for MET students. Must have an instructor agreeing to sponsor the project. Approval by program coordinator is required.
MET 492. Special Projects in MET. 2 credits, 3 contact hours (3:0:0).
Two-credit special project course for MET students. Must have an instructor agreeing to sponsor the project. Approval by program coordinator is required.

MET 493. Special Projects in MET. 3 credits, 3 contact hours (3:0:0).
Three-credit special project course for MET students. Must have an instructor agreeing to sponsor the project. Approval by program coordinator is required.

MET 495. Co-op Work Experience II. 3 credits, 3 contact hours (0:0:3).
Prerequisite: MET 395. Approval of the department, and permission of the Office of Cooperative Education and Internships. Full-time work experience for approximately one semester. Provides major-related work experience. Mandatory participation in seminars and completion of requirements that include a report and/or project.

MIT 231. Intro to Comp Security:Med Dev. 3 credits, 4 contact hours (2:2:0).
Prerequisites: An introductory Computer Programming Course: CS 100 or CS 106 and IT 120. Medical devices and systems are uniquely vulnerable to hacking and intrusion due to the nature of architecture; i.e. usually a dedicated device designed to solve a limited medical application such as an infusion pump that delivers medications in measured dosages. These systems rarely have more than a minimal computer footprint with limited or no operating system, i.e. a dedicated controller, and are usually updated periodically wirelessly. Our increased reliance on life sustaining technology required that computer professionals and engineers are educated on the evolving issues and solutions to these potentially life threatening dangers.

MIT 326. Electronic Medical Record Design. 3 credits, 4 contact hours (2:2:0).
This course will prepare students to manage medical records and related information in different medical settings like individual/group medical practices, health care organizations, long-term care settings, insurance companies, health-care software consulting companies, and/or government agencies. This course will also enable Medical Informatics student interns to become well versed in technology used during their internships. This course has two main objectives; first planning for Electronic Medical Record (EMR) adoption and implementation, and second, practical techniques of implementing and customizing Electronic Medical Records.

MIT 360. Introduction to Gerontology. 3 credits, 4 contact hours (2:2:0).
Prerequisites: Junior level standing, R920 201 or R830 101. Introduction to Gerontology is an introduction to the field of human aging. The course of study will include a multidisciplinary examination of the way in which human aging is viewed and how we perceive the process of growing older and how society responds to the issues of aging. The class will look at aging from multiple perspectives that include the social, political and biological sciences, arts and humanities, care giving and social services. This proposed course will provide students with an understanding of the unique challenges individuals experience as they age. Second it provides some basic hands/labs covering assistive technologies and personal and mobile sensors.

MIT 362. Geriatric Engineering I. 3 credits, 4 contact hours (2:2:0).
Prerequisites: MIT 360 and (CS 106 or CS 113 or CS 115 or CPT 341) and (MATH 305 or MNET 315.) This course will first provide students with an understanding of the unique challenges individuals experience as they age. It introduces system design techniques to facilitate assistive technologies that foster independent living. The course provides a labs for the emerging field of designing assistive technologies and personal and mobile sensors. Labs will incorporate A hands low-power small footprint computing devices for sensor monitoring. Students will explore the feasibility of using, for example Raspberry Pi, and Arduino platforms, to monitor vital signs and export data to Electronic Health Record (EHR) platforms. Big Data challenges will be explored in preparation for meaningful use applications required by all EHR systems.

MIT 440. Clinical Internship. 3 credits, 3 contact hours (0:0:3).
Prerequisites: Junior Level Standing, CPT 325 and permission MIT program coordinator. During the course of a semester the student gains 100 hours of experience in the IT or Network and Security department of a hospital. The student is under the supervision, and is evaluated by, the director of the corresponding program at the hospital. A final report is submitted to and graded by the BS, MIT Program Advisor at NJIT.

MNET 300. Concepts In Machining. 3 credits, 4 contact hours (2:2:0).
Prerequisite: ME 215. Applications in the machining of various materials. Topics include speeds and feeds calculations, tooling concepts, gaging techniques and prototype construction.

MNET 303. Advanced Techniques in CAD/CAM. 3 credits, 4 contact hours (2:2:0).
Prerequisite: MET 105. Applications including hands-on experience with CAD/CAM systems. Emphasis is on understanding how displayed objects are represented and manipulated on the computer. Laboratory experiences contribute to an understanding of the advantages and limitations of CAD/CAM systems.

MNET 315. Industrial Statistics. 3 credits, 4 contact hours (2:2:0).
Introduction to statistics covering data collection, analysis and presentation. Specialized topics include probability, control charts, correlation, regression, hypothesis testing, and experimentation.

MNET 318. Mfg Process Design. 3 credits, 4 contact hours (2:2:0).
Prerequisite: MNET 303. A development of the principles of production, methodology and economics in view of production requirements with respect to materials, tolerances and finish. Production processes are matched to the product requirements. Laboratory work supports the lecture. Computer problem solving is incorporated in the course.

MNET 395. Co-op Experience I. 3 credits, 3 contact hours (0:0:3).
Prerequisites: Completion of the sophomore year, approval of the department, and permission of the Office of Cooperative Education and Internships. Students gain major-related work experience and reinforcement of their academic program. Work assignments are facilitated by the co-op office. Mandatory participation in seminars and completion of a report. Note: Normal grading applies to this COOP Experience.
MNET 405. Numc Control Machn Tools. 3 credits, 4 contact hours (2;2;0).
Prerequisite: MNET 300 or equivalent. Fundamental concepts of numerical control systems. Assignments include mill and lathe programming techniques, sheet metal processing, and CNC economics.

MNET 414. Industrial Cost Analysis. 3 credits, 3 contact hours (3;0;0).
An introduction to general costing techniques. Time value of money concepts are introduced to decision-making matters such as equipment justification, design selection and fabrication costs.

MNET 416. Production Scheduling. 3 credits, 3 contact hours (3;0;0).
Prerequisite: MNET 315. A study of manual and computerized methods for setting schedules. Gantt charts, CPM, PERT, PERT/COST, and Line of Balance are some of the topics treated. Problems of line balancing and machine loading are discussed.

MNET 420. Quality Systems. 3 credits, 4 contact hours (2;2;0).
Prerequisite: MNET 315. Introduction in quality control that emphasizes design quality, total quality management and statistical process control. Additional topics include quality economics, ISO, reliability, service quality, measurement and acceptance sampling.

MNET 421. Contracts & Specs. 3 credits, 3 contact hours (3;0;0).

MNET 422. Tool Design. 3 credits, 4 contact hours (2;2;0).
Prerequisites: MNET 300 and MNET 303. Introduction to the design of cutting tools with emphasis on speeds, feeds, and power requirements. Covers design of jigs, fixtures, punch and dies, gaging and inspection tooling with emphasis on current industrial practices.

MNET 423. Motion & Time Study Tech. 3 credits, 4 contact hours (2;2;0).
A study of the basic principles of motion study concerning workplace design and related techniques involving process analyses, man-machine charts and micromotion study. Covers stopwatch time study techniques as well as predetermined time standards, work sampling and wage incentive system.

MNET 425. Advanced Manufacturing Rotation. 2 credits, 4 contact hours (3;1;0).
Prerequisites: MET 237, MNET 300, MNET 315, MNET 318. The course applies the principles learned in all technical courses to an Advanced Manufacturing environment. The student will rotate under the various manufacturing/metrology areas within an Advanced Manufacturing facility. Progress reports, oral presentation and a formal written report are required.

MNET 426. Manufacturing Project. 2 credits, 4 contact hours (1;3;0).
Prerequisite: Senior standing. A capstone project requiring a formal written report and oral presentation.

MNET 495. Cooperative Experien II. 3 credits, 3 contact hours (0;0;3).
Prerequisites: MNET 395 or its equivalent, approval of the department, and permission of the Office of Cooperative Education and Internships. Provides major-related work experience as a co-op/intern. Mandatory participation in seminars and completion of requirements that include a report and/or project.

SET 200. Introduction To Geomatics. 3 credits, 3 contact hours (3;0;0).
Plane surveying with angle and distance measurements; leveling; topographic mapping; traverse and area computations; horizontal and vertical curves; cross sections; triangulation; state plane coordinates; 3-D surveying using Global Positioning System (GPS), Geographic Information Systems (GIS) and remote sensing technology for surveying and mapping applications. Emphasis is on the use of the computers for solving typical field and office problems.

SET 200A. Introduction to Geomatics Lab. 1 credit, 3 contact hours (0;3;0).
Co-requisite: SET 200 or department permission. Field exercises in conjunction with the classroom exercises utilizing classical and electronic surveying instruments and COGO/CAD software.

SET 203. Intro to Remote Sensing Sci &. 3 credits, 3 contact hours (3;0;0).
This course provides an introduction to remote sensing (RS), emphasizing the techniques that are used to monitor the Earth’s surface. It will introduce the fundamentals of electromagnetic radiation (EMR), principles and concepts of RS, and EMR measurement by air- and space-borne optical, thermal, radar and LiDAR instruments, as well as Unmanned Aerial Vehicles (UAVs). The main theme will be how qualitative and quantitative information from RS data are acquired, processed, analyzed and utilized.

SET 207. Evidence and Procedures for Property Surveys. 3 credits, 3 contact hours (3;0;0).
Co-requisites: CE 200, SET 200 or permission of instructor. Introduction to surveying law and to the concept of evidence related to boundary locations as discoverable on the ground and through deeds or other written records. Understanding of the principles of property law, titles, land ownership, transfer of land ownership, deed descriptions, evidence recovery and conflict resolutions.

SET 280. Marine Surveying. 4 credits, 6 contact hours (3;3;0).
Prerequisite: CE 200 or SET 200. Marine Surveying builds on the core competencies introduced in "Introduction to Geomatics". This course focuses on computer generated solutions for nautical charts and water boundary delineations using imaging, optical, LiDAR, and acoustic observations via marine, airborne, and space-based platforms; to understand marine surveying technology for solutions on environmental problems; develop skills and techniques to enhance, interpret, and analyze acoustic measurements using computer-based methods.

SET 301. Route Surveying. 4 credits, 6 contact hours (3;3;0).
Co-requisites: CE 200, SET 200 or equivalent, or permission of instructor. Horizontal and vertical curves computation and layout with regard to highway design. Special emphasis on complex curves. Topics include control, positioning, error analysis, highway design problems, and layout. Concepts of right-of-way surveys. Also included is an introduction on the concepts of machine control.
SET 401. Fundamentals Of Geodesy. 3 credits, 3 contact hours (3;0;0).
Prerequisites: SET 302 and SET 303. Geodesy and its relation to surveying and other disciplines. Topics include geometric, physical and satellite geodesy. Also includes the concept of map projection.

SET 403. Remote Sensing Principles for Geomatics. 3 credits, 3 contact hours (3;0;0).
Prerequisites: CE 200 or SET 200. Principles of remote sensing for Geomatics application build on the core competencies introduced in Introduction to Surveying. This course focuses on computer generated solutions from technologies used for the acquisition and production of geospatial data via terrestrial, airborne, and space-based platforms; to understand remote sensing technology for solutions on scientific environmental problems; develop skills and techniques to enhance, interpret, and analyze digital imagery using computer-based methods.

SET 404. Adjustment Computations II. 3 credits, 3 contact hours (3;0;0).
Prerequisites: SET 304. Concepts of survey observations for adjustment and estimation models. A continuation of the theory of least squares and the mathematical weighting of observations. Also includes the statistical evaluation of least squares results with hands-on training using state-of-the-art industry standard software.

SET 407. Boundary Line Analysis. 4 credits, 6 contact hours (3;3;0).
Prerequisite: SET 307. Develops the analytical synthesis of real property law, land surveying procedures, and scenario development compatible with current case law decisions for the development of most probable scenarios of boundary location for the court's consideration.

SET 420. Geographic/Land Information Systems. 4 credits, 6 contact hours (3;3;0).
Prerequisites: SET 307 or MET 205 or permission of instructor. Geographic/Land Information System builds on the core competencies that were introduced in the course "Introduction to Surveying". This course focuses on understanding the fundamentals of Geographic/Land Information Systems (GIS/LIS) and Multi-Purpose Cadastres. Topics on LIS emphasize issues relating to the design, implementation, and maintenance of land records. Topics on GIS emphasize GIS data models (vector versus raster) and database development for applications in diverse fields like criminal justice, economics, and infrastructure. Students will learn practical skills on web-based mapping and GIS.

SET 423. Remote Sensing Digital Image. 3 credits, 3 contact hours (3;0;0).
This course introduces conceptual and practical aspects of digital image analysis from airborne and spaceborne earth-observing instruments, and provides up-to-date information on analytical methods used to analyze digital remote sensing data. The project-based course will emphasize the advanced techniques for remote sensing data processing and analysis. In-class exercises will give students hands-on experience in the fundamentals of digital image processing and information extraction techniques.
SET 440. Land Development. 3 credits, 3 contact hours (3;0;0).
Prerequisite: SET 207 and CE 321 or equivalent. Understanding the process of development of land through the study of land use law, federal, state and municipal land use regulations, federal and state regulations regarding environmental issues and the administrative and statutory laws governing the preparation of land surveys; impart the ability to prepare a land survey from initial contact and the proposal phase to preliminary and final plan approval through a class project designed to cover all of these phases.

SET 490. Senior Project in Surveying. 2 credits, 2 contact hours (2;0;0).
Prerequisite: Senior standing. The student works on an individual surveying project guided by the department staff. The project should concentrate on a specific aspect of surveying, not necessarily on field measurements. Project includes library research, written report and oral presentation of findings.

SET 491. Special Projects in Surveying. 1 credit, 1 contact hour (0;0;1).
This course provides students with research experience in Geomatics/Surveying at the undergraduate level. Course content and scope of study will be approved by the coordinator of the SET program. Topics can include GPS data processing, marine surveying for bathymetric modeling and generalization, and geophysical surveying using gravity and topography data. Course outcomes include knowledge of advanced data processing, data analysis, and interpretation at the undergraduate level.

SET 492. Special Projects in Surveying. 2 credits, 2 contact hours (0;0;2).
This course provides students with research experience in Geomatics/Surveying at the undergraduate level. Course content and scope of study will be approved by the coordinator of the SET program. Topics can include GPS data processing, marine surveying for bathymetric modeling and generalization, and geophysical surveying using gravity and topography data. Course outcomes include knowledge of advanced data processing, data analysis, and interpretation at the undergraduate level.

SET 493. Special Projects in Surveying. 3 credits, 3 contact hours (0;0;3).
This course provides students with research experience in Geomatics/Surveying at the undergraduate level. Course content and scope of study will be approved by the coordinator of the SET program. Topics can include GPS data processing, marine surveying for bathymetric modeling and generalization, and geophysical surveying using gravity and topography data. Course outcomes include knowledge of advanced data processing, data analysis, and interpretation at the undergraduate level.

TMT 301. Digital Electronics for Telecommunications. 3 credits, 4 contact hours (2;2;0).
Studies the fundamentals of digital electronics including combinational and sequential logic. Emphasizes those signals and configurations commonly employed in telecommunication systems. Theory is reinforced in hardware and simulation laboratory exercises.