

# DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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The Department of Electrical and Computer Engineering prepares students for highly competitive, national placement in electrical and computer engineering employment and graduate education by providing a thorough grounding in electrical science and design, together with a sound foundation in mathematics, basic sciences and life skills.

The department offers baccalaureate degrees in computer engineering and electrical engineering, in addition to minors in both areas, as well as the option to choose course work appropriate for a pre-medicine or pre-dentistry curriculum. An electrical and computer engineering track is available in the Master of Science in Engineering as well as the Ph.D. in Engineering. The track is designed to prepare students for practice, research and/or teaching of electrical and computer engineering at the advanced level by providing intensive preparation for professional practice in the microelectronics, nanoelectronics, computer engineering, and controls and communications aspects of electrical and computer engineering. At the advanced level, this track prepares individuals to perform original, leading-edge research in the broad areas of microelectronics, nanoelectronics, controls and communications, and computer engineering.

The curricula of the department provide a strong foundation in the fundamentals of the profession, including engineering problem-solving, breadth in the major facets of the profession and the opportunity to specialize in today's critical areas of computer engineering, communication systems and microelectronics. Graduates will be well prepared for constant technological change and growth through lifelong learning.

- Computer Engineering, Bachelor of Science (B.S.) (<http://bulletin.vcu.edu/undergraduate/engineering/electrical-computer-engineering/computer-engineering-bs/>)
- Electrical Engineering, Bachelor of Science (B.S.) (<http://bulletin.vcu.edu/undergraduate/engineering/electrical-computer-engineering/electrical-engineering-bs/>)
- Computer engineering, minor in (<http://bulletin.vcu.edu/undergraduate/engineering/electrical-computer-engineering/computer-engineering-minor/>)
- Electrical engineering, minor in (<http://bulletin.vcu.edu/undergraduate/engineering/electrical-computer-engineering/electrical-engineering-minor/>)
- Electrical and computer engineering (EGRE) (p. 1)
- Engineering (ENGR) (p. 5)

## Electrical and computer engineering

### EGRE 101. Introduction to Engineering. 4 Hours.

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Course open to first-year students majoring in electrical or computer engineering.

Introduction to engineering through instruction on basic concepts of engineering. Topics will include an introduction to basic circuit components and circuit analysis, digital logic design and programming. General topics important to all engineers will also be covered, such as mathematics, improving written and oral communication skills, teamwork, ethics and life-long learning. The laboratory introduces fundamental testing, measurement, troubleshooting methodology and proper laboratory notebook maintenance. Engineering design and analysis is also emphasized through a team-based design that involves designing, building and programming a robot.

### EGRE 206. Electric Circuits. 4 Hours.

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: MATH 200; and one of EGRE 101 or EGRB 102 or both EGMN 103 and EGMN 190, as applicable per department, all with minimum grades of C. Corequisite: MATH 201. An introduction to electrical circuit theory and its application to practical direct and alternating current circuits. Topics include Kirchhoff's Laws (review from departmental prerequisites, as applicable), fundamental principles of network theorems, transient and steady-state response of RC, RL and RLC circuits by classical methods, time-domain and frequency-domain relationships, phasor analysis and power. Laboratory work, practical applications and integral laboratory demonstrations emphasize and illustrate the fundamentals presented in this course.

### EGRE 207. Electric Circuits II. 4 Hours.

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: EGRE 206, with a minimum grade of C. An introduction to higher level electric circuit theory, including the study of basic active components, such as diodes and operational amplifiers. Emphasis will be placed on design rather than analysis. The laboratory exercises will serve to train students in the art of designing a circuit to perform specific tasks and to conform to specific design parameters.

### EGRE 245. Engineering Programming. 4 Hours.

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: MATH 151 with a minimum grade of C. Enrollment restricted to electrical and computer engineering majors. Students are expected to have fundamental computer skills. Introduction to the concepts and practice of structured programming using C. Problem-solving, top-down design of algorithms, basic C syntax, control structures, functions, arrays, files and strings.

### EGRE 246. Advanced Engineering Programming. 3 Hours.

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 245 with a minimum grade of C. Enrollment is restricted to electrical and computer engineering majors. Advanced programming for engineering applications in C. Topics include recursion, searching and sorting techniques, data structures, program design and problem solving, and software testing.

**EGRE 254. Digital Logic Design. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits.  
Prerequisites: EGRE 101 and EGRE 245 or equivalents, both with a minimum grade of C. An introduction to digital logic design with an emphasis on practical design techniques and circuit implementations. Topics include number representation in digital computers, Boolean algebra, theory of logic functions, mapping techniques and function minimization, design of combinational, clocked sequential and interactive digital circuits such as comparators, counters, pattern detectors, adders and subtractors. An introduction on designing digital circuits using schematic capture, logic simulation and hardware description languages is included. Students will use the above basic skills in the laboratory to design and fabricate digital logic circuits using discrete logic and field programmable gate arrays.

**EGRE 303. Electronic Devices. 3 Hours.**

Semester course; 2 lecture and 3 laboratory hours. 3 credits.  
Prerequisites: EGRE 306 and MATH 301, both with a minimum grade of C. An introduction to solid state electronic devices covering the fundamentals of atomic structure, band theory, free carrier statistics and charge transport in solids as well as terminal electrical characteristics of semiconductor devices. The course covers basic device physics of p-n junctions, metal-semiconductor junctions, metal-oxide semiconductor capacitors and transistors, light-emitting and -detecting devices, and materials and device characterization methods, including four-probe, Hall effect, I-V, C-V, and carrier lifetime, and optical spectroscopy.

**EGRE 306. Introduction to Microelectronics. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits.  
Prerequisites: EGRE 207 and MATH 301, both with a minimum grade of C. This course covers the analysis, modeling and design of electrical circuits which contain electronic devices. Students will learn to design analog circuits to specifications through laboratory problems, a design project and circuit simulation.

**EGRE 307. Integrated Circuits. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits.  
Prerequisites: EGRE 306 and EGRE 337, both with a minimum grade of C. Corequisite: EGRE 336. Analysis, modeling, design and measurement of advanced MOSFET and bipolar analog integrated circuits. Topics include active filters, differential amplifiers, frequency response and feedback topologies. Operational amplifier circuit topologies are used as a means of studying input, gain, level shift and output stages. Circuit design techniques are explored for mixed signal analog-digital circuits. This course provides the opportunity for a group design project of an integrated circuit chip, using advanced software tools for simulation and physical layout.

**EGRE 309. Introduction to Electromagnetic Fields. 3 Hours.**

Semester course; 2 lecture and 3 laboratory hours. 3 credits.  
Prerequisites: EGRE 207, MATH 301, MATH 307 and PHYS 208, all with a minimum grade of C. This course provides an introduction to the concept of electromagnetic fields. Topics include electrostatics, magnetostatics, scalar and vector potentials, and work and energy in fields, as well as the analysis and understanding of the phenomena associated with static electric and magnetic fields. Laboratory exercises will serve to reinforce students' understanding of fields and train them in methods to measure, quantify and analyze electromagnetic phenomena.

**EGRE 310. Electromagnetic Fields and Waves. 3 Hours.**

Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: EGRE 309 with a minimum grade of C. This course covers the fundamentals of time-varying electromagnetic fields. Topics include electromagnetic induction, Maxwell's equations, wave propagation, guided waves, transmission lines and antennas. Laboratory exercises will serve to reinforce students' understanding of time-varying fields and waves and train them in methods to measure, quantify and analyze dynamic electromagnetic phenomena.

**EGRE 334. Introduction to Microfabrication. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits.  
Prerequisites: CHEM 101, MATH 201 and PHYS 208, all with a minimum grade of C. This course gives an overview of microscale device fabrication and testing for a general audience. A wide variety of new terms, equipment and processes are presented. Fundamentals of photolithography, mask making, diffusion, oxidation, ion implantation, film deposition and etching are covered. Laboratory work consists of safety training, hands-on fabrication experience and testing. A laboratory chip test is fabricated from start to finish and then tested. The test chip includes basic integrated circuit elements as well as solar cells.

**EGRE 335. Signals and Systems. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits.  
Prerequisites: EGRE 206, EGRE 245 and MATH 301, all with a minimum grade of C. Presents the concept of linear continuous-time and discrete-time signals and systems, their classification, and analysis and design using mathematical models. Topics to be covered: linear systems and their classification, differential and difference equations, convolution, Fourier series, Fourier transforms, the Laplace and Z transforms and their application, continuous-time to discrete-time conversion.

**EGRE 336. Introduction to Communication Systems. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 337 with a minimum grade of C. Introduction to the theory and application of analog and digital communications including signal analysis, baseband transmission, amplitude and angle modulation, digital modulation, baseband digital communication, and design considerations.

**EGRE 337. Statistical Information Processing. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 335 with a minimum grade of C. This class presents an introduction to probability, random variables, random processes and statistics with applications in electrical and computer engineering.

**EGRE 347. Applied Object-oriented Programming. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 246 with a minimum grade of C. Enrollment is restricted to electrical and computer engineering majors. Object-oriented programming for engineering applications in C++ and other advanced object-oriented languages. Topics include classes and methods, inheritance, templates, and object-oriented program development. The use of standard libraries for applications such as image processing and cryptography will be explored.

**EGRE 364. Microcomputer Systems. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits.  
Prerequisites: EGRE 246 and 254, both with a minimum grade of C. Basic computer organization, microprocessor instruction sets and architectures, assembly language programming and the function of computer memory and I/O subsystems will be discussed. The laboratory is designed to reinforce the lectures by providing the opportunity to study the workings of a simple computer system in detail using simulation models and real hardware. Students will write and execute assembly language programs and make use of commercial design automation tools.

**EGRE 365. Digital Systems. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits.  
Prerequisites: EGRE 246 and 254, both with a minimum grade of C. Corequisite: EGRE 364. Focuses on the design of modern digital systems. Topics covered include: introduction to modeling, simulation, synthesis and FPGA design techniques using VHDL; microprocessor peripherals and interfacing; embedded system hardware and software design issues.

**EGRE 404. Senior Design Studio I (Laboratory/Project Time). 2 Hours.**

Semester course; 6 laboratory hours. 2 credits. Prerequisites: for electrical engineering majors: EGRE 207, EGRE 246, EGRE 254 and EGRE 335; and completion of three from: EGRE 306, EGRE 309, EGRE 310, EGRE 337 and EGRE 364, or completion of EGRE 347, EGRE 364 and EGRE 365; for computer engineering majors: EGRE 207, EGRE 335, EGRE 347, EGRE 364 and EGRE 365. Corequisite: any electrical or computer engineering technical elective. All prerequisite courses must be completed with a minimum grade of C. Enrollment is restricted to students with senior standing in electrical engineering or computer engineering and participation in a senior design (capstone) project. A minimum of six laboratory hours per week dedicated to the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects.

**EGRE 405. Senior Design Studio II (Laboratory/Project Time). 2 Hours.**

Semester course; 6 laboratory hours. 2 credits. Prerequisite: EGRE 404 with a minimum grade of C. Enrollment is restricted to students with senior standing in electrical engineering or computer engineering and participation in a senior design (capstone) project. A minimum of six laboratory hours per week dedicated to the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects.

**EGRE 406. Senior Design Studio I - VIP (Laboratory/Project Time). 2 Hours.**

Semester course; 6 laboratory hours. 2 credits. Prerequisites: for electrical engineering majors: EGRE 207, EGRE 246, EGRE 254, EGRE 335, and three credits of ENGR 497 during the two semesters prior to enrollment; and completion of three from: EGRE 306, EGRE 309, EGRE 310, EGRE 337 and EGRE 364, or completion of EGRE 347, EGRE 364 and EGRE 365; for computer engineering majors: EGRE 207, EGRE 335, EGRE 347, EGRE 364, EGRE 365 and three credits of ENGR 497 during the two semesters prior to enrollment. Corequisite: any electrical or computer engineering technical elective. All prerequisite courses must be completed with a minimum grade of C. Enrollment is restricted to students with senior standing in electrical engineering or computer engineering, and participation in a senior design (capstone) project associated with their vertically integrated project team. A minimum of six laboratory hours per week dedicated to the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects.

**EGRE 407. Senior Design Studio II - VIP (Laboratory/Project Time). 2 Hours.**

Semester course; 6 laboratory hours. 2 credits. Prerequisite: EGRE 406 with a minimum grade of C. Enrollment is restricted to students with senior standing in electrical engineering or computer engineering and participation in a senior design (capstone) project associated with their vertically integrated project team. A minimum of six laboratory hours per week dedicated to the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects.

**EGRE 426. Computer Organization and Design. 3 Hours.**

Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: EGRE 364 or CMSC 311 with a minimum grade of C. This course presents the foundation for computer design at the register transfer level. Starting from an instruction set architecture, students will learn the process used to design a data path and control unit to implement that instruction set. In addition, the topics of computer components and structures, data paths and control unit organizations, I/O and memory systems, interrupt systems, pipelining, and multiprocessing will be discussed. In addition to reinforcing the lecture material, the laboratory exercises will teach students the art of modeling and designing computer system components using a hardware description language.

**EGRE 428. Introduction to Integrated Systems Design. 2 Hours.**

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisites: EGRE 364 and EGRE 365, both with a minimum grade of C. This course provides an introduction to senior capstone design for computer engineers. Topics include hardware/software project design methodologies, integrated hardware and software design tools, life cycle costs analysis and requirements and specification analysis. Students are also introduced to concepts and design tools for FPGA and system-on-a-chip devices. Lectures are intended to support tasks required to execute a successful senior capstone experience. These tasks include, but are not limited to, project configuration management, customer interaction skills, requirements elicitation, simulation, procurement, design, testing and validation.

**EGRE 429. Advanced Digital Systems Design. 2 Hours.**

Semester course; 1 lecture and 3 laboratory hours. 2 credits. Prerequisite: EGRE 428 with a minimum grade of C. This course provides students with theoretical and practical foundations for advanced embedded systems design and cyber physical system applications. It extends the concepts introduced in EGRE 428. Special emphasis is placed on the design of advanced embedded computing platforms for cyber physical system applications. Topics covered include: introduction to cyber physical systems; cyber physical systems theory; FPGA and system-on-a-chip design environments; designing, developing and implementing cyber physical systems using FPGA and system-on-a-chip technology; real-time computing and operating systems; real-time sensor networks; engineering design standards; and verification and validation of complex designs. In the laboratory the students will use state-of-the-art system development tools to design, construct, test and verify a system-on-a-chip-based system to meet appropriate engineering standards and multiple realistic system constraints.

**EGRE 435. Microscale and Nanoscale Fabrication. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: EGRE 306 and EGRE 334, both with a minimum grade of C. This course presents the design tools and techniques for designing a fabrication process as well as a device design and layout for advanced microscale and nanoscale devices. A number of different types of device technologies are covered, incorporating electronic, micromechanical and microfluidic devices and sensors. In the laboratory section of the course, students work in design teams to develop a complete fabrication process and design layout for a microscale device to meet appropriate engineering standards and multiple realistic constraints. Computer simulations and computer-aided design tools are used in the final design. The laboratory section of this course accomplishes the design phase of the senior design capstone project, which is presented at the end of semester and fabricated in the subsequent course, EGRE 436.

**EGRE 436. Advanced Microscale and Nanoscale Fabrication. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 435 with a minimum grade of C. This course presents a detailed analysis of the physics and modeling of the fundamental processes used in semiconductor processing. Emphasis is placed on the non-ideal effects that cause realistic processes to deviate from first order models, including second order effects such as interactions on the atomic level and the influence of crystal defects. Processes covered in detail include oxidation, diffusion, ion implantation, thin film deposition and plasma etching techniques.

**EGRE 444. Communication Systems. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 336 with a minimum grade of C. Design and analysis of analog and digital communication systems, pulse modulation, information and digital transmission, digital modulation, information theory and coding will be treated. Emphasis is placed on the student gaining an appreciation for and an understanding of the role of optimization and trade-offs by considering bandwidth requirements, signal-to-noise ratio limitations, complexity and cost of analog and digital communication systems.

**EGRE 454. Automatic Controls. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisite: EGRE 335, EGMN 305 or EGMN 315 with a minimum grade of C. For computer engineering or electrical engineering majors, the prerequisite is EGRE 335 with a minimum grade of C. This course covers the design and analysis of linear feedback systems. Emphasis is placed upon the student gaining mathematical modeling experience and performing sensitivity and stability analysis. The use of compensators to meet systems design specifications will be treated. Topics include: an overview and brief history of feedback control, dynamic models, dynamic response, basic properties of feedback, root-locus, frequency response and state space design methods. The laboratory will consist of modeling and control demonstrations and experiments of single-input/single-output and multivariable systems, analysis and simulation using MATLAB/Simulink and other control system analysis/design/implementation software.

**EGRE 455. Control Systems Design. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 454 with a minimum grade of C. This course covers the use of state space methods to model analog and digital linear and nonlinear systems. Emphasis is placed on the student gaining mathematical modeling experience, performing sensitivity and stability analysis and designing compensators to meet systems specifications. Topics treated will include a review of root locus and frequency design methods, linear algebraic equations, state variable equations, state space design and digital control systems (principles and case studies). The students will use complex dynamic systems for analysis and design.

**EGRE 471. Power System Analysis. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: EGRE 309 with a minimum grade of C. Provides a comprehensive overview of electrical power system operation and design. Students develop models and tools for investigating system behavior and have opportunities for using those tools in design processes. At the completion of the course students will be able to develop appropriate models for an interconnected power system, perform power flow analysis, economic dispatch, power system protection and controls. Students will also be able to write a basic power flow computer program.

**EGRE 491. Special Topics. 1-5 Hours.**

Semester course; variable hours. 1-5 credits. May be repeated with different topics for a total of 21 credits. Advanced study of a selected topic in electrical or computer engineering. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

**EGRE 492. Independent Study in Electrical and Computer Engineering. 1-5 Hours.**

Semester course; variable hours. 1-5 credits. May be repeated with different content for a total of 9 credits. Prerequisite: permission of the instructor. Students must submit a written proposal to be approved by the supervising instructor prior to registration. Investigation of specialized electrical or computer engineering problems through literature search, mathematical analysis, computer simulation and/or laboratory experimentation. Written and oral progress reports as well as a final report and presentation are required.

## Engineering

### **ENGR 100. Engineering Student Success. 0 Hours.**

Semester course; seminar hours. 0 credits. Enrollment is restricted to new first-year students in the School of Engineering; required for students admitted conditionally. Students will meet for a 90-minute class once per week for five weeks. The course is dedicated to helping students understand the expectations and responsibilities of being a college student. Presentations will center on planning the semester, academic professionalism, study skills and test-taking strategies, financial literacy, health and wellness, time management, and the Honor Code. Seminars will be supplemented throughout the semester with online assignments to reinforce the discussions. Graded as pass/fail.

### **ENGR 101. Introduction to Engineering. 4 Hours.**

Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: admission to the School of Engineering or permission of instructor. Introduces basic circuits including resistors, diodes, transistors, digital gates and motors. Simple electromechanical systems are considered including motors, gears and wheels. The laboratory introduces fundamental circuit testing and measurement, and proper laboratory notebook writing; students are required to analyze, build and test a digitally controlled robot.

### **ENGR 111. Innovation Shop Training I. 0.5 Hours.**

Semester course; 1 laboratory hour. 0.5 credits. Enrollment restricted to students in the School of Engineering. The course provides training on innovation shop safety, includes a tour of the shop, measuring and layout tools and techniques, use of general manual and powered hand tools. Students will be instructed on the use of a bench-top drill press, deburring and finishing tools, 3D printing, laser engraving and thermoforming equipment. Students need to achieve a minimum score of 76% in the class to attain Level I (Blue) certification. Only certified students have permission to use tools and equipment covered in this training. Graded as Pass/Fail.

### **ENGR 121. Engineering Fundamentals. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: permission of instructor. Open only to non-engineering majors in Certificate in Product Innovation program. Introduces engineering fundamentals to students from non-engineering disciplines. Particular focus is the engineering problem-solving process as applied to open-ended problems. Students will be introduced to the different types of engineering, examine engineering issues and apply the engineering problem-solving process.

### **ENGR 211. Innovation Shop Training II. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Prerequisite: ENGR 111. Enrollment restricted to students in the School of Engineering. The course provides training on machine/innovation shop safety, blueprint reading, measuring and layout tools and techniques, and use of general and powered hand tools. Students will be instructed on sawing, sanding, drilling and tapping operations, 3D printing and laser engraving/cutting equipment. Hands-on graded assignment is the part of the course.

### **ENGR 291. Special Topics in Engineering. 1-5 Hours.**

Semester course; variable hours. 1-5 credits. Prerequisite: to be determined by the instructor. Specialized topics in engineering designed to provide a topic not covered by an existing course or program. General engineering or multidisciplinary. May be repeated with different content. Graded as pass/fail or normal letter grading at the option of the instructor. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

### **ENGR 296. Part-time Internship Experience. 0 Hours.**

Semester course; 0 credit. Students may attempt this course a total of six times. Enrollment restricted to School of Engineering majors. The student works part time in an approved internship and must work a minimum of 90 hours, but less than 300 hours during the semester. The student works to meet learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor and student both complete evaluations of the learning experience. Graded pass/fail.

### **ENGR 303. Junior Seminar. 3 Hours.**

Semester course; 3 lecture hours. 3 credits. Prerequisite: permission of instructor. This course provides students an opportunity to explore business and leadership topics. Topics include the fundamentals of product design and new product development, manufacturing and quality systems, finances and financial reports, ethics in the workplace, intellectual property, teamwork, leadership and communications. Students will be assigned selected readings, written compositions and oral presentations. This course prepares the student to participate in the Engineering Laboratory/Manufacturing Internship.

### **ENGR 311. Innovation Shop Training III. 1 Hour.**

Semester course; 2 laboratory hours. 1 credit. Prerequisite: ENGR 211. Enrollment is restricted to students with Level II (Red) certification. The Level III (Green) course provides basic training on set-up and operation of manual milling machines and the lathe. The course covers cutting tool, speed and feed calculation. Students must develop a technological process and machine metal parts per assigned drawings on vertical mill and lathe. They will also use other techniques and equipment that were covered in previous levels. Students need to achieve a minimum score of 76 % in the class to attain Level III (Green) certification. Only certified students have permission to use tools and equipment covered in this training.

### **ENGR 395. Professional Development. 1 Hour.**

Semester course; 1 lecture and 1 workshop hour. 1 credit. Enrollment is restricted to majors in the School of Engineering. Professional development course to help prepare students to find a job and succeed in a professional environment, and specifically to work as an intern or in a cooperative education position. Topics covered include career paths; job searches; resume and cover letter writing; preparing for the interview; personal assessment of interests, values and strengths; networking; professional and ethical behavior on the job; overview of legal issues related to hiring, such as nondisclosure agreements and noncompete clauses; overview of personal finance management at the first job; workplace safety; and expectations and requirements for internships and cooperative education positions.

### **ENGR 396. Internship Experience. 0 Hours.**

Semester course; 0 credit. Students may attempt this course a total of three times. Enrollment restricted to School of Engineering majors. The student works in an approved internship and must work a minimum of 300 hours during the semester. The student works to meet learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor and student both complete evaluations of the learning experience. Graded pass/fail.

**ENGR 398. Cooperative Education Experience. 0 Hours.**

Semester course; 0 credits. Students may attempt this course a total of four times. Prerequisite: ENGR 395. Restricted to School of Engineering majors in good academic standing. The student works full-time in an approved cooperative education position. The student works to meet specific learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor/mentor and student both complete midterm and final evaluations of the learning experience. Graded pass/fail.

**ENGR 399. Cooperative Education Experience II. 3 Hours.**

Semester course; 3 credits. Prerequisite: ENGR 398. Restricted to School of Engineering majors in good academic standing. A student that has completed at least one work term in a full-time approved cooperative education position completes an additional full-time work term. The student works to meet specific learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor/mentor and student both complete midterm and final evaluations of the learning experience.

**ENGR 402. Senior Design Studio (Seminar). 1 Hour.**

Continuous courses; 1 lecture hour. 1-1 credit. Prerequisites: senior standing and participation in a senior design (capstone) project; completion of ENGR 402 to enroll in ENGR 403. This weekly seminar presents and discusses topics relevant to senior-level engineering students in support of the capstone project and upcoming graduation. A single course coordinator manages and administers the course and schedules the various faculty lectures and guest speakers. Topics include, but are not limited to, the following: proposal writing, project planning and management, scheduling resources and budgeting for technical projects, patents and intellectual property, quality systems (six sigma, ISO standards, statistical process control), entrepreneurship, creativity and innovation and professional registration.

**ENGR 403. Senior Design Studio (Seminar). 1 Hour.**

Continuous courses; 1 lecture hour. 1-1 credit. Prerequisites: senior standing and participation in a senior design (capstone) project; completion of ENGR 402 to enroll in ENGR 403. This weekly seminar presents and discusses topics relevant to senior-level engineering students in support of the capstone project and upcoming graduation. A single course coordinator manages and administers the course and schedules the various faculty lectures and guest speakers. Topics include, but are not limited to, the following: proposal writing, project planning and management, scheduling resources and budgeting for technical projects, patents and intellectual property, quality systems (six sigma, ISO standards, statistical process control), entrepreneurship, creativity and innovation and professional registration.

**ENGR 410. Review of Internship. 1 Hour.**

Semester course; 1 credit. Prerequisites: chemical, electrical and computer, or mechanical engineering major and experience to satisfy the engineering internship requirements. Students complete oral presentations and written reports summarizing the internship experience.

**ENGR 411. Fundamentals of Engineering Exam Preparation. 1 Hour.**

Semester course; 1 lecture hour. 1 credit. Prerequisite: senior or graduate standing, or permission of instructor. This course prepares students for taking the fundamentals of Engineering Exam. Passing the FE Exam is the first step to getting a Professional Engineering license. This course is not intended to teach the various subject matters, but to review the subject areas and help students prepare as well as possible for the examination.

**ENGR 490. Engineering Seminar. 1-3 Hours.**

Semester course; variable hours. 1-3 credits. May be repeated with different content. Prerequisite: permission of the instructor. A series of specialized topics in engineering that are of general interest but not covered by an existing course or program. Lectures will be presented in seminar format by speakers from business, industry, government and academia. Subjects will be multidisciplinary in nature. Graded as pass/fail or normal letter grading at the option of the instructor.

**ENGR 491. Special Topics in Engineering. 1-5 Hours.**

Semester course; variable hours. 1-5 credits. Prerequisite: determined by the instructor. Specialized topics in engineering designed to provide a topic not covered by an existing course or program. General engineering or multidisciplinary. May be repeated with different content. Graded as pass/fail or normal letter grading at the option of the instructor. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

**ENGR 492. Independent Study in Engineering. 1-5 Hours.**

Semester course; variable hours. 1-5 credits. May be repeated with different content. Prerequisite: permission of the instructor. Students must submit a written proposal to be approved by the supervising instructor prior to registration. Investigation of specialized engineering problems that are multidisciplinary or of general interest through literature search, mathematical analysis, computer simulation and/or laboratory experimentation. Written and oral progress reports as well as a final report and presentation are required. Graded as pass/fail or normal letter grading at the option of the instructor.

**ENGR 496. Internship Review. 0 Hours.**

Semester course; 0 credits. Prerequisite: ENGR 296 or ENGR 396. Restricted to School of Engineering majors. This course is to be taken following the completion of a minimum of 300 hours of approved internship experience relevant to the student's major and documents that a student has fulfilled all internship requirements, including a final evaluation by the employer, a final self-evaluation, a final report describing the experience and a final oral presentation about the experience. Graded pass/fail.

**ENGR 497. Vertically Integrated Projects. 1,2 Hour.**

Semester course; 3 or 6 laboratory hours. 1 or 2 credits. May be repeated for a maximum total of 8 credits Prerequisites: permission of the project faculty adviser. This course provides undergraduate students the opportunity to participate in multiyear, multidisciplinary projects under the guidance of faculty and graduate students in their areas of expertise. As they address research and development issues, students learn and practice many different professional skills, make substantial technical contributions to the project, and experience many different roles on a large, multidisciplinary design/discovery team. Students must earn a minimum of 4 credits in ENGR 497 with a minimum grade of C in order for these credits to be eligible to count toward a technical or departmental elective. More restrictive requirements may be imposed by individual departments.

**ENGR 498. Review of Cooperative Education Experience. 0 Hours.**

Semester course; 0 credits. Prerequisite: ENGR 398. Restricted to School of Engineering majors. This course is completed following the final work term of a cooperative education experience and is required to obtain transcript notation to document that a student has fulfilled all the requirements of the school's cooperative education program. The requirements include a final evaluation by the employer, a final self-evaluation, a final report describing the experience and a final oral presentation about the experience.