Electrical Engineering

Li Bai, Ph.D, Chair
Engineering Building, Room 712
215-204-6616
lbai@temple.edu

Brian Thomson, Ph.D, Undergraduate Coordinator
Engineering Building, Room 727A
215-204-8737
brian.thomson@temple.edu

https://engineering.temple.edu/academics/departments/electrical-computer-engineering-department

The Electrical Engineering program is accredited by the Engineering Accreditation Commission (EAC) of ABET, https://www.abet.org.

Program Goals, Objectives & Design Integration

The objective of the Electrical Engineering program is to prepare students for careers as practicing engineers in areas such as digital systems, embedded processor applications, digital communications, control systems, sensor networks, biomedical signal processing, microelectronics, computer security, and power networks. These careers are in applications, development, research, and design of electric and electronic systems and devices. Electrical Engineers are involved in the design and development of telecommunications networks, cellular telephones, computer and other microprocessor-based devices, consumer electronics, control systems for space vehicles and robots, and in many aspects of the power and automotive industries.

The Department offers a concentration in Computer Engineering. The objective of the computer engineering concentration is to prepare students for a career in the area of Computer Engineering as it relates to the design of integrated software/hardware systems with both high- and low-level computer systems programming and applications to electrical systems. Computer engineers are responsible for the design, implementation, and application of computers and digital systems. The field covers hardware, software, and the interaction between them. The Computer Engineering concentration integrates courses on computer science fundamentals from the Department of Computer and Information Sciences of Temple University into the curriculum.

The Department also offers a concentration in Bioelectrical Engineering. The objective of the Bioelectrical Engineering concentration is to prepare students for careers in the emerging areas of biomedical signal and image processing, assistive devices for the impaired, and bioelectronics. The Bioelectrical Engineering concentration utilizes courses in Biology, and Mammalian Anatomy and Physiology from the Department of Kinesiology at Temple University as part of the curriculum.

The Electrical Engineering degree program is accredited by ABET. The curriculum features required courses in Mathematics, Chemistry, Physics, General Education, and the fundamentals of Electrical and Computer Engineering. The ABET minimum requirement for graduation is 128 semester hours, and students must satisfy the minimum requirement in each category. "Approved Elective" courses include elective electrical engineering courses, and a selection of math, science, engineering, and computer science courses as approved by the Department Chair. Students should consult the department chair or their academic advisor for any questions concerning the credit distribution.

Cooperative Education Program

A Cooperative Education (Co-op) is an optional program available at the College of Engineering where you have the opportunity to gain professional work experience before graduation. It is designed to give you the chance to apply the knowledge learned in the classroom to real life problems. You will be exposed to the latest technology and new ideas at a worksite helping you understand your field of work more extensively. During the Co-op, you will make valuable connections with professionals in your field. A cooperative education can enhance and strengthen you academically, professionally and personally.

Programs

- Bachelor of Science in Electrical Engineering
- Bachelor of Science in Electrical Engineering - Bioelectrical Engineering Concentration
- Bachelor of Science in Electrical Engineering - Bioelectrical Engineering Concentration with Co-op
- Bachelor of Science in Electrical Engineering - Computer Engineering Concentration
- Bachelor of Science in Electrical Engineering - Computer Engineering Concentration with Co-op
- Bachelor of Science in Electrical Engineering with Co-op

Courses

ECE 0822. Investing for the Future. 4 Credit Hours.
This class will teach you about seemingly complicated financial topics in a very comprehensible manner that will help you make informed financial decisions to ensure a secure financial future. We begin with identification of common financial problems among the "young, fabulous and broke" and how to avoid them. After thinking about life and financial priorities, we address why thinking about retirement now must be at the top of your list. We examine how to compute your retirement needs and how to get there, primarily with a focus on investing in common stock. You will learn how to think smart about big ticket purchases such as cars, housing, and graduate/professional education. Finally we will make sure you understand how to create a safety net to protect your future. NOTE: This course fulfills the Quantitative Literacy (GQ) requirement for students under GenEd and a Quantitative Reasoning (QA or QB) requirement for students under Core. Students cannot receive credit for this course if they have successfully completed FIN 0822, FIN 0922 or RMI 0822.

Course Attributes: GQ

Repeatability: This course may not be repeated for additional credits.

ECE 0832. Digital World 2020. 3 Credit Hours.
Digital technology is everywhere in our daily lives and in many industries. Innovations happen at a breakneck speed with dazzling new products and baffling buzz words. Do you know what digital currency, augmented reality, and Internet-of-Things are? How is digital technology going to affect you, your field of study, and your future profession now and for years to come? Would you like to take control of the technology instead of allowing it to control you? This course demystifies digital technology for non-engineers in a logical way that actually makes sense to non-engineers, following its evolution from the very basics to today's advanced applications, and will enable you to follow future technology trends and their pros and cons with confidence. This course covers digital information representation, storage, wired and wireless transmission, transmission protocols, internet, WWW, security, and management. Students choose from an array of possible reports or hands-on projects, such as a business plan to sell innovative ideas to investors, Java programming, cell phone App coding, or using Raspberry Pi, a credit card sized computer to build a gadget.

Department Restrictions: May not be enrolled in one of the following Departments: CST:Computer & Info Sci, Engineering:Elec Engineering.
Field of Study Restrictions: May not be enrolled in one of the following Majors: Computer & Information Science, Electrical Engineering.

Course Attributes: GS

Repeatability: This course may not be repeated for additional credits.

ECE 1012. Introduction to Electrical Engineering. 2 to 3 Credit Hours.
This course introduces basic concepts in Electrical and Computer Engineering, and demonstrates them in the context of real applications. Course topics include basics of DC and AC circuits, transistor, diode and operational amplifier circuits, digital logic gates and power supply operation. Students assemble and test a robot car or mouse as part of the class project.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
MATH 1022 to 4999| Required Courses:1|Minimum Grade of C-|May not be taken concurrently
OR MC6 Y|May not be taken concurrently
OR MC6A Y|May not be taken concurrently
OR MATW Y|May not be taken concurrently.

ECE 1014. Evolution of Modern Electronic Systems. 3 Credit Hours.
Introduction to modern electronic systems such as telephone networks, television, radio, radar, and computers. Key discoveries such as the vacuum tube, transistor, and laser are covered. The fundamental operating principles are presented in a non-mathematical and historic context. The evolution of these technologies is presented in terms of the need for communication systems and their impact on society. NOTE: This course can be used to satisfy the university Core Science & Technology Second Level (SB) requirement.

Course Attributes: SB

Repeatability: This course may not be repeated for additional credits.

ECE 1022. Technology and You. 3 Credit Hours.
The practitioners of science are scientists. However, we never refer to the practitioners of technology as technologists; rather, they are always referred to as engineers. Therefore understanding the process of engineering is to understand the process of technological development. The engineer of today is either making an old technology better or developing a new technology. As will be illustrated in the readings, engineering is a human endeavor that has existed since the dawn of human kind. To understand engineering and its roots is to understand and appreciate one of humanity's greatest assets. NOTE: This course can be used to satisfy the university Core Science & Technology Second Level (SB) requirement.

Course Attributes: SB

Repeatability: This course may not be repeated for additional credits.

ECE 1111. Engineering Computation I. 4 Credit Hours.
This course will cover the essentials of computer program design, development, testing, and debugging for engineers. In addition to fundamentals such as loops, branching, and subroutines, the course will discuss memory management, pointers, file and data I/O, compilers and linkers, objects, data structures, algorithms, and variable scope. Students will become familiar with scientific and technical computing in the context of solving engineering design challenges. The course will be programming intensive, and students will be expected to code both in and out of class.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(MATH 1022|Minimum Grade of C-|May be taken concurrently
OR MC6 Y|May not be taken concurrently
OR MC6A Y|May not be taken concurrently)
AND (ENGR 1102|Minimum Grade of C-|May be taken concurrently)

ECE 1112. Electrical Applications. 2 Credit Hours.
This course introduces basic concepts in Electrical and Computer Engineering, and demonstrates them in the context of real applications. Course topics include basics of DC and AC circuits, transistor, diode and operational amplifier circuits, digital logic gates and power supply operation.

Co-requisites: ECE 1113.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
MATH 1022 to 4999| Required Courses:1|Minimum Grade of C-|May not be taken concurrently
OR MC6 Y|May not be taken concurrently
OR MC6A Y|May not be taken concurrently
OR MATW Y|May not be taken concurrently.

ECE 1113. Electrical Applications Laboratory. 1 Credit Hour.
Laboratory for ECE 1112 (0007): Electrical Applications. This is a hands-on lab based on the material covered in ECE 1112.

Co-requisites: ECE 1112.

Repeatability: This course may not be repeated for additional credits.

ECE 2105. Introduction to Cyber Physical Security. 3 Credit Hours.
This is an introductory course to build foundational knowledge in Cyber Physical Security. While Cyber Security (CS) is to ensure security when we use globally interconnected digital network, Cyber Physical Security (CPS) is to ensure the security of critical, real-time, automated and distributed cyber physical infrastructures and facilities that we depend our livelihood on such as water, power (electrical), energy (oil, nuclear), communication, transportation, manufacturing, the emerging world of Internet-of-Things (IoT). This course starts with high level knowledge areas in CS foundations and principles. The course then expands to knowledge areas in Industrial Control System (ICS), embedded systems, mobile technology, wireless sensor networks, and hardware and firmware security, highlighting various architectures, devices, network, operations, processes, and their vulnerability and potential resilient solutions. Case studies such as an actual attack on power grids are used to analyze the incident and its responses. In some cases, tools are used to demonstrate the CPS applications.

Degree Restrictions: Must be enrolled in one of the following Degrees: Bachelor Sci in Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ENGR 1101|Minimum Grade of C-|May not be taken concurrently.

ECE 2112. Electrical Devices & Systems I. 3 Credit Hours.
The purpose of this course is to teach non-Electrical Engineering major students the basics of Electrical circuits and systems, such as: voltage and current, electrical elements (resistors, inductors, capacitors), Kirchoff current and voltage Laws, parallel and series connections, time domain vs. frequency domain analysis, AC power, three phase systems, electrical machines, operational amplifiers, semiconductor diodes and transistors.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(PHYS 1062|Minimum Grade of C-|May not be taken concurrently
OR PHYS 1022|Minimum Grade of C-|May not be taken concurrently)
AND (MATH 1042|Minimum Grade of C-|May be taken concurrently
OR MATH 1942|Minimum Grade of C-|May be taken concurrently
OR MATH 1031|Minimum Grade of C-|May be taken concurrently
OR MATW Y|May not be taken concurrently)

ECE 2113. Electrical Devices & Systems I Lab. 1 Credit Hour.
The purpose of this course is to teach non-Electrical Engineering major students the basics of Electrical circuits and systems in a laboratory environment and to reinforce the theoretical concepts of ECE 2112 by using experimentation.

Repeatability: This course may not be repeated for additional credits.

ECE 2122. Electrical Devices and Systems II. 4 Credit Hours.
Students will study circuit analysis using frequency domain techniques, Laplace Transforms, Operational amplifiers, elements of semiconductor devices, electronic circuits, and logic circuits. Students will work on practical applications relating primarily to the mechanical engineering discipline. The laboratory portion of this course allows students to undertake practical applications of the principles discussed in the lecture. NOTE: This course is for Mechanical Engineering majors only.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2112|Minimum Grade of D-|May not be taken concurrently)
AND (MATH 1042|Minimum Grade of C-|May not be taken concurrently
OR MATH 1942|Minimum Grade of C-|May not be taken concurrently
OR MATW Y|May not be taken concurrently)

ECE 2142. Engineering Principles for Building Science. 4 Credit Hours.
The engineering design approach centers around principles that apply across disciplines, especially those focused on those studying structures. Every architectural student should have an instinctive understanding of fundamental and traditional concepts in the engineering approach to solving problems in making creative design decisions within physical constraints and requirements. Students will learn properties of structures and materials in context of building science and apply their knowledge to solve open ended problems with focus on intelligently choosing methods rather than arriving at exact solutions. Students will become familiar with emerging technologies while relating them to fundamental concepts. The course is design project based with topics including: Vectors, Physical Modeling of Forces, Free Body Diagrams, Structure Analysis, Perspective, Camera/Projector Optics, Introduction to Sensors, Networks and Smart Buildings.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
MATH 1031|Minimum Grade of C-|May not be taken concurrently
OR MATH 1032 to 4999| Required Courses:1|Minimum Grade of C-|May not be taken concurrently
OR MATW Y|May not be taken concurrently.

ECE 2312. Electrical Engineering Science I. 3 Credit Hours.
Electric circuit fundamentals including DC and transient circuit analysis are covered in the course. Topics include independent and dependent sources, circuit elements such as resistors, inductors, capacitors and operational amplifiers, linearity, source transformation, Thevenin and Norton equivalent circuits, as well as the analysis and design of first and second order circuits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(MATH 1042|Minimum Grade of C-|May be taken concurrently
OR MATH 1942|Minimum Grade of C-|May be taken concurrently
OR MATH 1951|Minimum Grade of C|May be taken concurrently
OR MATH 2043 to 3080| Required Courses:1|Minimum Grade of C-|May be taken concurrently
OR MA07 Y|May not be taken concurrently
OR MATW Y|May not be taken concurrently)
AND (PHYS 1062|Minimum Grade of C-|May be taken concurrently)
AND (ECE 2313|Minimum Grade of C-|May be taken concurrently)

ECE 2313. Electrical Engineering Science I Lab. 1 Credit Hour.
This laboratory is concerned with the analysis and design of first and second order circuits with direct current (DC) power sources. This laboratory complements ECE 2312: Electrical Engineering Science I. Topics include independent and dependent sources, circuit elements such as resistors, inductors, capacitors, and operational amplifiers. We also investigate the concept of linearity and source transformation, Thevenin equivalent circuits, and Norton Equivalent circuits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 2312|Minimum Grade of C-|May be taken concurrently.

ECE 2322. Electrical Engineering Science II. 3 Credit Hours.
This course is concerned with the analysis of alternate current (AC) circuits. Sinusoidal steady-state analysis, AC power analysis, magnetically coupled circuits, and frequency responses are covered. Laplace transforms are introduced and are used to solve first, second and higher order differential equations. The use of Laplace transforms for circuit analysis is studied and applied.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2312|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 2323|Minimum Grade of C-|May be taken concurrently)
AND (MATH 1042|Minimum Grade of C|May be taken concurrently
OR MATW Y|May not be taken concurrently
OR CRMA09 Y|May not be taken concurrently)

ECE 2323. Electrical Engineering Science II Lab. 1 Credit Hour.
This course provides hands-on experience of the principles discussed in ECE 2322. Specifically students will gain practical experience on the use of various electrical equipment and their applications for measuring alternating current quantities.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 2322|Minimum Grade of C-|May be taken concurrently.

ECE 2332. Principles of Electric Circuits. 4 Credit Hours.
Electric circuit fundamentals including DC and AC circuit analysis are covered in the course. Topics include circuit elements such as resistors, inductors, capacitors, voltage and current sources, and operational amplifiers; methods of circuit analysis, such as superposition theorem, Thevenin and Norton equivalent circuits, as well as the analysis of first and second order circuits. Sinusoidal steady-state analysis, AC power analysis, magnetically coupled circuits, and frequency responses are covered. Laplace transforms are introduced and are used to solve first, second and higher order differential equations.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(MATH 1041|Minimum Grade of C-|May not be taken concurrently
OR MATH 1941|Minimum Grade of C-|May not be taken concurrently
OR MATH 1038|Minimum Grade of C-|May not be taken concurrently
OR MATW Y|May not be taken concurrently)
AND (MATH 1042|Minimum Grade of C-|May be taken concurrently
OR MATH 1942|Minimum Grade of C-|May be taken concurrently
OR MATW Y|May not be taken concurrently)

ECE 2333. Principles of Electric Circuits Lab. 1 Credit Hour.
This is a hands-on laboratory course for electric circuit fundamentals including DC and AC circuits. Experiments for this laboratory course will be based on the course material covered in ECE 2332. Topics include series and parallel circuits in DC and AC, frequency response, transient response, and AC sinusoidal response.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 2332|Minimum Grade of C-|May not be taken concurrently.

ECE 2612. Digital Circuit Design. 3 Credit Hours.
This course considers binary number systems, codes, truth tables and the fundamental operation of digital logic circuits. The implementation of combination and sequential digital logic is by a hardware description language in Verilog behavioral synthesis. Complex digital logic and state machine analysis and design are implemented in simulation and programmable gate array hardware.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2312|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May be taken concurrently
OR PHYS 1062|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 2613|Minimum Grade of C-|May be taken concurrently)
AND (CIS 1057|Minimum Grade of C-|May not be taken concurrently
OR CIS 1068|Minimum Grade of C-|May not be taken concurrently
OR ECE 1111|Minimum Grade of C-|May not be taken concurrently)

ECE 2613. Digital Circuit Design Laboratory. 1 Credit Hour.
Laboratory for ECE 2612: Digital Circuit Design. This course provides hands-on experience in digital circuits, gates, flip-flops etc.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 2612|Minimum Grade of C-|May be taken concurrently.

ECE 2922. Honors Electrical Engineering Science II. 3 Credit Hours.
Topics in this course include: sinusoidal analysis, power measurements, three-phase circuits, complex frequency and network functions, resonance, scaling, frequency response, two-port networks, Fourier series and transforms. This Honors course will be challenging and held to a high standard.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2312|Minimum Grade of C|May not be taken concurrently)
AND (ECE 2923|Minimum Grade of C-|May be taken concurrently)
AND (MATH 1942|Minimum Grade of C-|May not be taken concurrently)

ECE 2923. Honors Electrical Engineering Science II Lab. 1 Credit Hour.
Topics in this course include: sinusoidal analysis, power measurements, three-phase circuits, complex frequency and network functions, resonance, scaling, frequency response, two-port networks, Fourier series and transforms. This Honors course will be challenging and held to a high standard.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 2922|Minimum Grade of C-|May be taken concurrently.

ECE 3082. Independent Study in Electrical Engineering. 1 to 3 Credit Hour.
With the department chair's approval, students may complete a regular course during semesters the course is not offered in order to meet prerequisite or graduation requirements. An instructor supervises the student.

Repeatability: This course may be repeated for additional credit.

ECE 3091. Independent Research in Electrical Engineering. 1 to 3 Credit Hour.
Project assigned with the approval of the department chair and conducted under the supervision of a faculty sponsor.

Repeatability: This course may be repeated for additional credit.

ECE 3312. Microelectronics I. 3 Credit Hours.
Students study ideal and non ideal operational amplifier circuits, diodes in nonlinear circuit applications, bipolar junction transistors, field-effect transistors (JFETs), metal oxide semiconductor field effect transistors (MOSFETs), biasing techniques, gain and bandwidth, the design of amplifiers, and transistors as loads.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2322|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 3313|Minimum Grade of D-|May be taken concurrently)

ECE 3313. Microelectronics I Laboratory. 1 Credit Hour.
Electrical devices and circuits laboratory to be taken concurrently with Electrical Engineering 3312.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3312|Minimum Grade of D-|May be taken concurrently)
AND (ECE 2323|Minimum Grade of C-|May not be taken concurrently
OR ECE 2333|Minimum Grade of C-|May not be taken concurrently
OR ECE 2113|Minimum Grade of C-|May not be taken concurrently)

ECE 3412. Classical Control Systems. 3 Credit Hours.
Students will learn the basic theory of analog (classical) control systems. The concept of what constitutes a system is learned as well as how to analyze a system by using input-output pairs. The importance of a transfer function and how it characterizes the behavior of a linear time invariant system will be studied. What a feedback system is and how it may change the behavior of a system is learned. Finally, students will learn how to analyze and design linear time invariant control systems using both time domain and frequency domain techniques.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3512|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 3413|Minimum Grade of D-|May be taken concurrently)
AND (MATH 3041|Minimum Grade of D-|May not be taken concurrently
OR MATH 3941|Minimum Grade of D-|May not be taken concurrently)

ECE 3413. Classical Control Laboratory. 1 Credit Hour.
Experimentation on selected topics in ECE 3412: Classical Control Systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3412|Minimum Grade of D-|May be taken concurrently.

ECE 3432. Robotic Control using Raspberry Pi Microcontroller. 3 Credit Hours.
This course covers the steps of building a robot capable of autonomous movement and remote control from start to finish. It is to educate the beginning robot builder and hopefully inspire creativity so that you can design, build, and modify your own robots. The skills and concepts taught in this course are presented from an interdisciplinary approach which merges practices in arts and technology. Essential elements of this course are 1) building a 3D-printed hardware platform, 2) motor drive and sensor integration, 3) Raspberry Pi microcontroller interface, 4) basics of Python programming language, and 5) controlling the robot using control algorithms, signal and image processing, and cloud computing.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 1111|Minimum Grade of C-|May not be taken concurrently
OR CIS 1057|Minimum Grade of C-|May not be taken concurrently.

ECE 3512. Signals: Continuous and Discrete. 4 Credit Hours.
This course covers continuous time signal models, convolution, and superposition integral and impulse response. Students also study Fourier series and periodic signals, Parseval's theorem, energy spectral density, Fourier transform and filters, discrete time signals, difference equations, discrete Fourier transform, and discrete convolution.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2322|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May not be taken concurrently)
AND (ENGR 2011|Minimum Grade of C-|May not be taken concurrently)

ECE 3522. Stochastic Processes in Signals and Systems. 3 Credit Hours.
To provide the student with an understanding about probability, random variables and random processes and their applications to linear systems. Therefore, the student will learn about the various aspects of probability such as distribution and density functions, conditional probability and various types of random processes such as stationary and nonstationary, ergodic and random processes, the autocorrelation and crosscorrelation, power spectral density, white noise and frequency domain analysis of random signals and their evaluation in linear systems analysis.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3512|Minimum Grade of C-|May not be taken concurrently.

ECE 3612. Processor Systems. 3 Credit Hours.
The course considers the Atmel 8-bit processor hardware/software architecture through both assembly language programming and C and its hardware system implementation focused on using the Atmel 169P microcontroller. Emphasis will be on both C and assembly languages and how they interact with I/O ports and memory. Additional topics include memory addressing modes, stack operations, arithmetic computations, logic operations, subroutine calls, input/output (I/O) interfacing, interrupts, timers, pulse width modulation and A/D conversion. The lecture material is supplemented by coordinated homework and in class assignments in microcontroller simulations using Atmel Studio 6.1 and the AVR 169P Butterfly board.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2612|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 2613|Minimum Grade of D-|May not be taken concurrently)
AND (ECE 3613|Minimum Grade of D-|May be taken concurrently)

ECE 3613. Processor Systems Laboratory. 1 Credit Hour.
This Junior ECE course is the corresponding laboratory for ECE 3612 Processor Systems. The laboratory assignments utilize Atmel AVR microcontroller simulations using Atmel Studio 6.1 and hardware experiments with the Atmel 169P Butterfly microcontroller. Labs will cover reading and writing to memory, stack operations, LED's on I/O ports, PWM for servo motor control, timers and counters.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3612|Minimum Grade of D-|May be taken concurrently.

ECE 3622. Embedded System Design. 3 Credit Hours.
This course and co-requisite laboratory considers embedded systems in digital process control and digital signal processing using the Verilog hardware description language and behavioral synthesis using the programmable gate array. Topics include: the controller-datapath construct, nested modules, soft core processing elements, fixed and floating point arithmetic calculations in programmable hardware, interfacing to hard core peripherals and soft core microprocessors.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3612|Minimum Grade of D-|May not be taken concurrently)
AND (ECE 3613|Minimum Grade of D-|May not be taken concurrently)
AND (ECE 3623|Minimum Grade of D-|May be taken concurrently)

ECE 3623. Embedded System Design Laboratory. 1 Credit Hour.
Laboratory for ECE 3622 (0245): Embedded System Design.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3622|Minimum Grade of D-|May be taken concurrently.

ECE 3712. Introduction to Electromagnetic Fields and Waves. 3 Credit Hours.
Engineering applications of electromagnetic field theory including Coulomb's Law, Gauss' Law and Faraday's Law and applications of Poisson's equations with boundary values, Magnetic flux and the use of Gauss' and Ampere's Laws. The course will also consider transmission lines, the development of Maxwell's equations and the transmission of plane waves in free space and uniform, homogenous, isotropic media.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(PHYS 1062|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 2322|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May not be taken concurrently)
AND (ENGR 2011|Minimum Grade of C-|May not be taken concurrently
OR MATH 2101|Minimum Grade of C-|May not be taken concurrently)

ECE 3722. Electromagnetic Wave Propagation. 3 Credit Hours.
This course considers the application of the time-harmonic Maxwell's equations to electromagnetic wave propagation, transmission lines, wave guides, antenna, and methods for numerical analysis. Matlab and computer aided design software is used for simulation of electromagnetic wave propagation in engineering applications.

Co-requisites: ECE 3723.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3712|Minimum Grade of D-|May not be taken concurrently.

ECE 3723. Electromagnetic Wave Propagation Laboratory. 1 Credit Hour.
Laboratory for ECE 3722 (0222): Electromagnetic Wave Propagation.

Co-requisites: ECE 3722.

Repeatability: This course may not be repeated for additional credits.

ECE 3732. Electromechanical Energy Systems. 3 Credit Hours.
Fundamentals of electromechanical energy conversion, electromechanical devices, and systems. Energy state functions, force-energy relationships, basic transducers, and introduction to AC and DC machines. DC motors and generators, synchronous motors and generators, induction motors, and transformers.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3733|Minimum Grade of D-|May be taken concurrently)
AND (ECE 2322|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May not be taken concurrently
OR ECE 2112|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 2323|Minimum Grade of C-|May not be taken concurrently
OR ECE 2333|Minimum Grade of C-|May not be taken concurrently
OR ECE 2113|Minimum Grade of C-|May not be taken concurrently)

ECE 3733. Electromechanical Energy Systems Laboratory. 1 Credit Hour.
This course provides hands-on experience on various types of electrical machines, such as DC and AC motors and generators, and transformers. Experiments include operation of transformers, motors and generators, control of motor speed, and loading of generators. Computer data acquisition system is utilized for interface.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3732|Minimum Grade of D-|May be taken concurrently)
AND (ECE 2333|Minimum Grade of C-|May not be taken concurrently
OR ECE 2323|Minimum Grade of C-|May not be taken concurrently
OR ECE 2113|Minimum Grade of C-|May not be taken concurrently)

ECE 3822. Engineering Computation II. 3 Credit Hours.
The primary goal for this course is to teach engineers how to solve problems of scale using a variety of computer tools. The three main goals of this course are: (1) introduce students to the hierarchy of software tools (e.g., scripting languages, interpreted languages, compiled languages) used to solve engineering problems; (2) introduce the basics of Python, a scripting language that is a dominant tool in engineering; and (3) introduce Java, object-oriented design, and a number of Java-related software tools that automate testing, documentation and cross-compilation into web applications. A common thread throughout these topics is the decomposition of large-scale problems into smaller problems that can be solved using reusable modules. Good software engineering practices will be stressed throughout the course. The latter part of the course will involve developing a significant computer simulation of a real-world engineering system that involves real data and utilizes both Python and Java.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(CIS 1057|Minimum Grade of C-|May not be taken concurrently
OR ECE 1111|Minimum Grade of C-|May not be taken concurrently)
AND (ENGR 2011|Minimum Grade of C-|May not be taken concurrently)

ECE 3912. Honors Signals: Continuous and Discrete. 4 Credit Hours.
This course covers continuous time signal models, convolution, and superposition integral and impulse response. Students also study Fourier series and periodic signals, Parseval's theorem, energy spectral density, Fourier transform and filters, discrete time signals, difference equations, Z transforms, and discrete convolution. This honors course will be very challenging.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 2322|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May not be taken concurrently.

ECE 3914. Honors Microprocessor Systems. 3 Credit Hours.
Students study finite-state machines in process control, assembly language programming of the Intel i186EX 16-bit microprocessor and its hardware system implementation. Additional topics include: dynamic RAM read/write and DMA access, hardware interrupts, I/O port addressing, peripheral interface design, microprocessor addressing modes, op codes, and arithmetic computation. A stimulating and challenging Honors course.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2612|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 2613|Minimum Grade of D-|May not be taken concurrently)
AND (ECE 2922|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May not be taken concurrently)
AND (ECE 3915|Minimum Grade of D-|May be taken concurrently)

ECE 3915. Honors Microprocessor Systems Lab. 1 Credit Hour.
This course is the hardware and software laboratory in microprocessor systems.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3914|Minimum Grade of D-|May be taken concurrently.

ECE 4110. Special Topics. 1 to 4 Credit Hour.
Topics vary by semester. See the course schedule for the specific topic each semester.

Field of Study Restrictions: Must be enrolled in one of the following Majors: Civil Engineering, Electrical Engineering, Engineering, Mechanical Engineering.

Repeatability: This course may be repeated for additional credit.

ECE 4312. Microelectronics II. 3 Credit Hours.
This course emphasizes solving software design problems as well as advanced study of electronic devices and their application to linear, non-linear, and digital circuits. Further topics include: transistors, FET's filters, oscillators, amplifiers, A/D, D/A, some integrated circuits, and VLSI systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3312|Minimum Grade of D-|May not be taken concurrently.

ECE 4322. VLSI Systems Design. 3 Credit Hours.
This course introduces the hierarchical design methodology of VLSI and the study of basic logic elements and design methods in MOS and CMOS, as well as the physics of MOS devices and the fabrication process. Design rules and computation of circuit parameters from layout, and system level design are further topics.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3312|Minimum Grade of C-|May not be taken concurrently.

ECE 4412. Modern Control Theory. 3 Credit Hours.
Analysis and design of control systems using state variable techniques, including discrete and continuous state variable analysis, linear vector spaces, eigenvalues, eigenevectors, controllability, observability, stability, state feedback design, and observer design.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3412|Minimum Grade of D-|May not be taken concurrently.

ECE 4422. Digital Control Systems. 3 Credit Hours.
Subjects for this course include: discrete data and digital control systems, signal conversions and processing, the Z transform and state variable techniques applied to digital control system, time and frequency domain analysis techniques, stability of digital control systems, etc. The students are required to design and implement a digital control system in groups and are assigned with different tasks.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3412|Minimum Grade of D-|May not be taken concurrently.

ECE 4512. Digital Communication Systems. 3 Credit Hours.
This course and co-requisite laboratory considers techniques of digital signaling and data communication with amplitude, frequency and phase modulation and demodulation in the presence of noise using MATLAB/Simulink simulation. Topics include: the optimum correlation receiver in baseband and bandpass systems, binary and multiple level signaling, time and frequency division multiplexing, error detection and correction, analog-to-digital conversion and traditional analog amplitude and frequency modulation.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3522|Minimum Grade of D-|May not be taken concurrently)
AND (ECE 4513|Minimum Grade of D-|May be taken concurrently)

ECE 4513. Digital Communication Systems Laboratory. 1 Credit Hour.
Laboratory for Electrical Engineering 4512: Digital Communication Systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 4512|Minimum Grade of D-|May be taken concurrently.

ECE 4522. Digital Signal Processing. 3 Credit Hours.
Course topics include: Discrete-time signals and systems, Random signals, Sampling process, Digital processing of analog signals, Discrete-time Fourier Transforms (DTFT), Filter types and characteristics, Filter design, Finite Impulse Response (FIR) systems, linear phase FIR filters, Infinite Impulse Response (IIR) systems, Discrete Fourier Transforms (DFT), Fast Fourier Transform (FFT), Circular convolution, Transfer functions, and Applications of digital signal processing.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 3522|Minimum Grade of D-|May not be taken concurrently.

ECE 4526. Introduction to Computer Intrusion and Detection of Cyber Physical Security. 3 Credit Hours.
This is an introductory course to computer and system intrusion and detection techniques for cyber physical security (CPS). Students will learn hardware/firmware security and hardware reverse engineering, gaining theoretical and practical knowledge to analyze critical security vulnerabilities of Industrial Control Systems (ICS), in wired and wireless environment - the backbones of any cyber physical systems. Students will learn case studies from actual ICS attacks and run hands-on exercises and tools of being all the 'hats' - red, blue, and white.

Degree Restrictions: Must be enrolled in one of the following Degrees: Bachelor Sci in Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 4532|Minimum Grade of D-|May not be taken concurrently.

ECE 4528. Introduction to Cryptography for Cyber Physical Security. 3 Credit Hours.
This is an introductory course to the theory and practice of cryptography used in security for cyber physical systems or Cyber Physical Security (CPS). Cyber physical systems are built upon Industrial Control Systems (ICS) and have a unique set of challenges with the need to support security in three key operations: real-time protection, SCADA (supervisory control and data acquisition), and engineering access (event log). The course starts with cryptography foundations and principles. The course then covers various cryptographic primitives, algorithms, intrusion attacks, security protocols, crypto devices and hardware, government standards, and case studies, specific for CPS needs.

Degree Restrictions: Must be enrolled in one of the following Degrees: Bachelor Sci in Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 4532|Minimum Grade of D-|May not be taken concurrently.

ECE 4532. Data and Computer Communication. 3 Credit Hours.
This course considers wired and wireless data transmission, communication networks and protocols, error detection and correction coding, spread spectrum modulation and demodulation. Topics include protocol architectures, flow and error control, multiplexing, code division multiple access 4G LTE cellular systems and embedded Ethernet.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3522|Minimum Grade of D-|May not be taken concurrently)
AND (CIS 1057|Minimum Grade of C-|May not be taken concurrently
OR ECE 1111|Minimum Grade of C-|May not be taken concurrently)

ECE 4542. Telecommunications Engineering. 3 Credit Hours.
This course considers digital data communication with complex modulation and error detection and correction in the presence of noise using MATLAB/Simulink simulation. Topics include: quadrature amplitude and continuous phase modulation, frequency hopping and spread spectrum modulation, linear, block, cyclic, convolutional and CRC codes, fading and multipath interference, Doppler shift in mobile environments and the performance of cellular and wireless communication systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 4512|Minimum Grade of D-|May not be taken concurrently.

ECE 4574. Introduction to Cisco Certificate Preparation. 3 Credit Hours.
This course introduces/prepares students to become certified as a Cisco Certified Entry Network Technician (CCENT). CCENT-certified professionals have the knowledge and skill to install, operate, and troubleshoot a small enterprise branch network, including basic network security. The course includes a hands-on lab equipped with Cisco networking equipment, access to the powerful Cisco Packet Tracer networking simulation software, as well as access to the online courses at Cisco Networking Academy. Students who complete the online curricula will receive a discount voucher to reduce the cost of the CCENT exam. Students who wish to prepare to become certified in the Cisco Certified Networking Associate program may take other follow-up courses.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 4532|Minimum Grade of C-|May be taken concurrently.

ECE 4612. Advanced Processor Systems. 3 Credit Hours.
This course focuses on Verilog hardware description language and its applications to digital hardware system design including CPU and memory, as well as synchronous and asynchronous events and multitasking in the design of computational and data communication processors. The course will also consider computer-aided-design software and simulators, and hardware description language compilers.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 3612|Minimum Grade of D-|May not be taken concurrently)
AND (ECE 3613|Minimum Grade of D-|May not be taken concurrently)

ECE 4712. Power System Analysis. 3 Credit Hours.
This course introduces the modern power systems and its changing landscape. Topics include the basics of power generation, transmission and distribution, power flow, economic dispatch, transient and stability analysis, short circuit analysis, and HVDC systems.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
ECE 2322|Minimum Grade of C-|May not be taken concurrently
OR ECE 2332|Minimum Grade of C-|May not be taken concurrently.

ECE 4722. Power Electronics. 3 Credit Hours.
This course introduces the basics of power electronic circuits and their applications in modern power systems. Topics include converters and inverters, and their applications in power systems. Course material covers DC-DC converters in buck and boost topologies, and their analysis; AC-DC rectification and control; DC-AC inverters and their applications in voltage and frequency control; three-phase inverters and HVDC transmission. This course will use Matlab/Simulink simulation for student projects and homework.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ECE 2332|Minimum Grade of C-|May not be taken concurrently
AND ECE 2333|Minimum Grade of C-|May not be taken concurrently)
OR (ECE 2112|Minimum Grade of C-|May not be taken concurrently
AND ECE 2113|Minimum Grade of C-|May not be taken concurrently)
OR (ECE 2322|Minimum Grade of C-|May not be taken concurrently
AND ECE 2323|Minimum Grade of C-|May not be taken concurrently)