ELECTRICAL & COMPUTER ENGRG (ECE)

ECE 100 - Introduction to Electrical and Computer Engineering (2.0 hours)
Introduction to fundamental concepts in electrical and computer engineering.

ECE 101 - Introduction to EE: DC Circuits (2.0 hours)
Introduction to electrical engineering. Topics includes: voltage, current, and power, circuit elements, fundamentals of DC circuit analysis using Ohm's and Kirchoff's laws, Thevenin and Norton equivalent circuits, superposition, and DC analysis of operational amplifiers.

ECE 102 - Intro to EE: Digital Systems (3.0 hours)
Introduction to logic design with focus on the following topics: fundamentals of Boolean algebra and minimization techniques, logic realizations of SOP and POS functions, multiple function synthesis using PLDs, combinational circuit design as it applies to computers, sequential circuit elements, flip flops, counters and shift-registers, clock generation circuits, algorithmic state machine method of designing sequential circuits, and VHDL design and synthesis. Course culminates with a design project that uses VHDL to implement a finite state machine.

ECE 103 - Intro to EE: Computers and Programming (3.0 hours)
Introduction to computers and operating systems; introduction to programming in a high level language appropriate to electrical engineering.

ECE 200 - Engineering Co-Op (0.0 hours)
Core Curriculum: EL
Full-time cooperative education assignment for electrical engineering students who alternate periods of full-time school with periods of full-time academic or career-related work in industry. Satisfactory/Unsatisfactory.
Prerequisite: Sophomore standing in the College of Engineering and Technology, 2.0 overall grade point average at Bradley, approval of engineering and technology Co-op coordinator and Co-op faculty advisor.

ECE 204 - AC Circuits and Introduction to Systems (3.0 hours)
The study of AC circuits with a dynamical systems approach. Topic covered: capacitance, inductance, phasors, impedance, admittance, Thevenin and Norton equivalents, operational amplifiers, differential equation models of linear circuits and systems, impulse and step responses, convolution integral, Laplace transform, frequency response, and transformers. Simulation and analysis of AC circuits using SPICE and MATLAB.
Prerequisite: ECE 101 with a minimum grade of C

ECE 205 - Microcontroller Architecture and Programming (3.0 hours)
Introduction to an 8-bit microcontroller. Topics include: architecture, instruction set, assembly language programming, assembler directives, input/output operations, C language programming for an 8-bit embedded device, timers, analog-to-digital conversion, interrupts, timing analysis, embedded design project, and discussion of an integrated design environment that includes a assembler, compiler, and debugger.
Prerequisite: A minimum grade of C in: ECE 102, ECE103

ECE 206 - Continuous-time Signals and Systems (3.0 hours)
The study of signals and systems using the continuous-time approach. Topics covered: Modeling of continuous time physical systems, sampling, transformation of continuous-time signals, Fourier series, Fourier transform, energy and power density spectra, filter design, stability, state variables for continuous-time systems, feedback, bandwidth, modulation. Simulation and analysis of systems using MATLAB and Simulink.
Prerequisite: ECE 204 with a minimum grade of C.

ECE 207 - Simulation and Analysis for Electrical Engineers (2.0 hours)
Numerical analysis and modeling techniques of real-world problems as pertinent to electrical engineers using MATLAB and Simulink.
Prerequisite: ECE103 with a minimum grade of C.
Corequisite: Concurrent enrollment in MTH 207.

ECE 208 - Transmission Lines and Electromagnetic Fields (3.0 hours)
Time-harmonic steady-state and transient analysis of radio frequency (RF) transmission lines (T Lines); impedance matching; the Smith chart and its applications; vector analysis; static electric fields and capacitance; steady currents and resistance; static magnetic fields and inductance; electrical and magnetic properties of materials; electric and magnetic boundary conditions; electric and magnetic energies.
Prerequisite: ECE 204 with a minimum grade of C,Concurrent enrollment in MTH 223

ECE 214 - Linear Circuits Analysis and Design (4.0 hours)
The study of linear circuits analysis and design. DC and AC circuits. Basic circuit laws and circuit theorems. Characteristics of circuit elements (Resistor, Capacitor, Inductor, Signal Sources, Op-Amps). Signal waveforms, Phasors, Impedance. Thevenin and Norton equivalents. Time domain circuit analysis and design. Phasor domain circuit analysis and design. Laplace transform. S-domain circuit analysis and design. Frequency response. AC power systems. Transformers, average power, reactive power, and complex power. Simulation and analysis of linear circuits using SPICE and MATLAB. Circuit analysis and design hands-on labs and projects.
Prerequisite: Sophomore Standing. Instructor approval may be required.

ECE 221 - Circuits and Systems Laboratory (2.0 hours)
Introduction to experimental design and implementation of analog and digital electronic circuits and systems. Students develop hardware and software troubleshooting and testing skills. The design experience culminates in a multi-week, specification-driven project.
Prerequisite: A minimum grade of C in ECE 214 and 103.
Corequisite: ECE 102.

ECE 227 - Electrical Engineering Fundamentals (4.0 hours)
Introduce fundamentals of electrical engineering principles. Basic circuit theory, Operational Amplifiers, First and second order passive circuits, AC sinusoidal analysis, Frequency Responses, Digital logic circuits, DC motors and generators, and accompanying laboratory experiments and projects. Open to non-electrical engineering majors only.
Prerequisite: PHY 201
Corequisite: MTH 224

ECE 301 - Discrete-time Signals and Systems (3.0 hours)
The study of signals and systems using the discrete-time approach. Topic covered: modeling of discrete-time physical systems, sampling and reconstruction of signals, analog-to-digital converters, quantization, arithmetic formats (fixed- and floating-point), analysis of discrete-time LTI systems, Implementation of discrete-time systems, Z-transforms, frequency analysis of discrete-time signals, frequency domain analysis of LTI systems, discrete Fourier transform, design of FIR and IIR filters. Simulation and analysis of systems using MATLAB and Simulink.
Prerequisite: A minimum grade of C in: ECE 206

ECE 302 - Probability, Statistics, and Random Processes for EE (3.0 hours)
Exploration of probability, statistics and random processes with emphasis on engineering applications. Topics covered: probability models, probability axioms, statistical independence, conditional probability, random variables, probability distributions, joint probability density functions, correlation, covariance, statistical estimate of random parameters, sampling distributions, reliability, random processes, power spectral density, and response of LTI systems to random inputs. Simulation and analysis using MATLAB.
Prerequisite: A minimum grade of C in: ECE 206

ECE 303 - Electronics (3.0 hours)
Function and applications of diodes, transistors and operational amplifiers. Simulations of electronic devices and circuits using SPICE.
Prerequisite: ECE 204 with a minimum grade of C.

ECE 304 - Advanced Electronics and Integrated Circuits (3.0 hours)
Fundamentals on analog IC and digital IC. Building blocks of integrated-circuit amplifiers. Differential and Multistage amplifiers. Power amplifiers. Feedback and filters. Oscillators. CMOS digital logic circuits. Memory and Clocking circuits. Electronic control devices and circuits. Simulations and experiments of electronic devices and circuits.
Prerequisite: A minimum grade of C in ECE 303

ECE 305 - Microcontroller Architecture, Programming and Applications (4.0 hours)
Introduction to microcontroller architecture and programming. Topics include microcontroller architecture, fundamentals of assembly language, common microcontroller peripherals, and developing microcontroller-based applications in a relevant high-level procedural programming language. Students develop hardware and software troubleshooting and testing skills. The design experience culminates in a specification-driven project.
Prerequisite: For ECE majors, a minimum grade of C in ECE 102 and ECE 103. For non-ECE majors, proficiency in computer programming using a strongly typed programming language, such as C, C++, or Java. Consent of the instructor may be required.

ECE 322 - Electronics and Interfacing Lab (3.0 hours)
Laboratory sequence with lectures focused on embedded system design using devices such as microcontroller and FPGA. Interfacing from both a hardware and software perspective. Including electronic interfaces, data acquisition, communication protocols and applications; The design experience culminates in a multi-week, specification-driven project.
Prerequisite: A minimum grade of C in: ECE 221, ECE 303, and ECE 305.

ECE 398 - Vertical Integrated Project (0.0-4.0 hours)
It provides the time and context necessary for students to learn and practice many different professional skills, make substantial contributions to a project, and experience many different roles in a team. Under the approval of department and advisors, up to 1 credit hour per semester for first and second year students; up to 2 credit hours per semester for third year students; not open to graduating senior students in ECE department.
Prerequisite: Approval from department and advisors

ECE 401 - Undergraduate Design Seminar I (1.0 hour)
Multidisciplinary team effort to identify a market need based on realistic constraints; propose an electrical or electronic product to meet the need; prepare a feasibility study assessing economic and technical viability of the product.
Corequisite: ECE 497.

ECE 402 - Undergraduate Design Seminar II (1.0 hour)
Core Curriculum: EL,WI
Continuation of multidisciplinary team effort to prepare a business plan for the launch of a venture based on the electronic product proposed and analyzed in ECE 401. Each student will also gain insight into the critical importance of professional ethics by identifying and analyzing a case in which flawed ethical decisions lead to negative outcomes for individuals and their company. Both deliverables require significant writing, the quality of which will have a major impact on the student's grade.
Prerequisite: ECE401 with a minimum grade of C.

ECE 409 - Special Topics (1.0-6.0 hours)
Topics of special interest which may vary each time course is offered. Topic stated in current Schedule of Classes.
Prerequisite: Consent of instructor.

ECE 410 - Special Topics (1.0-6.0 hours)
Topics of special interest which may vary each time course is offered. Topic stated in current Schedule of Classes.
Prerequisite: Consent of instructor.

ECE 431 - Communication Theory I (3.0 hours)
Orthogonal signal representation; review of Fourier series and Fourier transform; basic probability theory; random processes; power spectral density; Shannon's channel capacity; sampling theorem; baseband signaling; bandpass signaling; complex envelop representation of signals and systems; analog modulations; binary and M-ary digital modulations; phase locked loops, demodulation circuits; matched filter; error performance in digital communications. Cross-listed as ECE 531.
Prerequisite: Minimum grade of C in ECE 206
Corequisite: Concurrent enrollment in ECE 302

ECE 432 - Communication Theory II (3.0 hours)
Digital communication systems; modulation; demodulation; maximum likelihood detection; trade-offs between bandwidth and power; bit error rate; channel coding techniques: block coding, convolutional coding, and iterative decoding; mutual information; channel capacity; trellis-coded modulation; synchronization. Cross-listed as ECE 532.
Prerequisite: ECE 431 with a minimum grade of C.

ECE 440 - Electromechanical Systems (3.0 hours)
Introduction to dynamic systems analysis with emphasis on mathematical modeling of sensors and electromechanical devices for control system applications. Fundamentals of power and industrial electronics.
Prerequisite: ECE 206 with a minimum grade of C
Corequisite: Concurrent enrollment in ECE303

ECE 441 - Feedback Control of Dynamic Systems (3.0 hours)
Analysis and design of linear automatic control systems for continuous-time systems using classical control theory. Root locus and Bode methods. Modeling of physical systems. Introduction to digital control. Computer-aided design and simulation. Cross listed as ECE 541.
Prerequisite: ECE 206 or equivalent, or approval of the instructor. Not open to students with credits in ECE 541.

ECE 442 - Advanced Data-Driven Control and Applications (3.0 hours)
Frequency domain design of linear automatic control systems. Analysis and design of linear automatic control systems for sampled-data and discrete-time systems. Classical and modern control theory methods. Modeling and data driven system identification and control of sampled-data and discrete-time systems. Micro-controller-based control applications. Cross listed as ECE 542.
Prerequisite: ECE 441 or equivalent, or approval of the instructor. Not open to students with credits in ECE 542.

ECE 443 - Distributed Learning Control of Dynamic Systems (3.0 hours)
The analysis and control of distributed dynamic systems, distributed learning and control issues in dynamic systems, distributed control and estimation of multiple dynamic systems, use of fundamental tools in modeling and control of linear and nonlinear dynamic systems, applications of distributed learning and control for multiple dynamic systems through case studies in multiple robot coordination and distributed power grids. Cross-listed as ECE 543.
Prerequisite: ECE 302 and MTH 207

ECE 444 - Autonomous Robotics (3.0 hours)
The project-based course deals with the fundamentals on autonomous robotic systems. It covers kinematics, sensors, and actuators of robots. Motion planning, control, and navigation techniques of autonomous mobile robots are introduced through a series of hands-on experiments. Cross-listed as ECE 544.
Prerequisite: ECE 103 or proficiency in programming in a structural computer programming language, ECE 214 or ECE 227, or approval of the instructor. Not open to students with credit in ECE 544.

ECE 445 - Power Electronics Fundamentals (3.0 hours)
Fundamentals of power electronics. Covered topics: DC/DC converters, DC/AC converters (inverters), and AC/DC rectifiers, analysis, design, simulation and application of power electronic based systems. Cross-listed as ECE 545.
Prerequisite: ECE 303

ECE 446 - Power Laboratory (3.0 hours)
Experiments in transformers and rotating machines. Covered topics: electric machinery principles; brushed DC motor connections, operational characteristics, and applications; linear brushed DC motor model development, simulation, and verification; wound rotor and squirrel cage AC induction motor connections, operational characteristics, and applications; linear single-phase transformer model development and verification; power electronic H-bridge.
Prerequisite: ECE 303

ECE 450 - Electromagnetic Theory (3.0 hours)
Time-varying electric and magnetic fields; Maxwell's equations; electromagnetic potentials; electromagnetic boundary conditions; plane-wave propagation in unbounded conducting and non-conducting media; wave polarization; Poynting vector; reflection and transmission of waves at boundaries;and radiation and antennas. Cross-listed as ECE 550.
Prerequisite: ECE 208 with a minimum of C.

ECE 451 - Radio Frequency Circuits and Systems (3.0 hours)
Review of transmission lines, impedance matching and transformations, S-parameters, passive RF junctions, RF amplifier design, RF systems, and front-end design. Cross-listed as ECE 551.
Prerequisite: ECE208, or approval of the instructor. Not open to students with credit in ECE 551.

ECE 452 - Wireless Communication Systems (3.0 hours)
Introduction to wireless communication systems; modulation and detection; noise, attenuation; multipath and fading; sensitivity, distortion, inter-modulation, and dynamic range; wireless link RF design; transmitter and receiver architectures; RF components and subsystems; selected wireless systems including multiple-access cellular systems. Cross-listed as ECE 552.
Prerequisite: A minimum grade of C in: ECE 206, ECE 208
Corequisite: Concurrent enrollment in ECE303

ECE 453 - Radio Frequency Communications Laboratory (3.0 hours)
Radio frequency measurements of wireless system components and subsystems, time and frequency domain measurements of analog and digital signals in communication systems, computer-aided design, fabrication, and testing of microwave integrated circuit. Cross-listed as ECE 553.
Prerequisite: ECE 451 with a minimum of C

ECE 460 - Digital Signal Processing (3.0 hours)
Design of digital filters and multirate systems. Topics include: review of discrete-time signals and systems, generalized linear phase, all-pass filters, minimum phase systems, inverse systems, FIR filter design, IIR filter design, resampling in time and frequency domain, half-band filters, polyphase filters, quadrature mirror filters and wavelets. Cross-listed as ECE 560.
Prerequisite: ECE 301 with a minimum grade of C.

ECE 462 - Digital Image Processing (3.0 hours)
Introduction to image processing. Topics covered: digital image fundamentals, image enhancements in spatial domain, image restoration, color image processing, wavelets and multiresolution, image compression, morphological image processing, image segmentation, pattern recognition. Cross-listed as ECE 562.
Prerequisite: ECE 103 or M E 273 or proficiency in computer programming in a structural language, or approval of the instructor. Not open to students with credit in ECE 562.

ECE 463 - Medical Imaging (3.0 hours)
Introduction to the common methods and devices employed for medical imaging, including conventional x-ray imaging, x-ray computed tomography (CT), nuclear medicine (single photon planar imaging), single photon emission computed tomography (SPECT), and positron emission tomography (PET), magnetic resonance imaging (MRI), and ultra-sound imaging. The physics and design of systems, typical clinical applications, medical image processing, and tomographic reconstruction. Cross-listed as ECE 563 and M E 582.
Prerequisite: ECE 206 with a minimum grade of C.

ECE 465 - Engineering Applications of Machine Learning (3.0 hours)
This course covers the theory, design, and engineering applications of machine learning with the emphasis on computational intelligence. Embedded hardware platforms, high-performance libraries, and high-performance architectures are used for implementation. Variants such as Deep Neural Networks and Convolutional Neural Networks are examined. Cross-listed as ECE 565.
Prerequisite: ECE 302 with a minimum grade of C.

ECE 467 - Mobile Robotics Laboratory (3.0 hours)
An explorative laboratory-based study of autonomous mobile robotics. Mobile robots utilizing sensors and microcontrollers to navigate using localization, motion control, and mapping algorithms.
Prerequisite: ECE 207 and ECE 322 with a minimum grade of C.

ECE 468 - Mechatronics (3.0 hours)
Introduction to mechatronics: mechatronics overview, sensors and actuators modeling, interfacing sensors and actuators with digital systems. Cross-listed as ECE568.
Prerequisite: ECE 214 or ECE 227, or approval of the instructor. Not open to students with credit in ECE 568.

ECE 470 - Embedded Data Structures and Object Oriented Programming (3.0 hours)
Introduction to data structures, object-oriented programming, memory management, problems of efficiency and complexity of algorithms applicable to embedded systems. Cross-listed as ECE 570.
Prerequisite: ECE 205 or ECE 305 with a minimum grade of C, or proficiency in microcontroller programming in a structural computer language.

ECE 471 - Real-time Operating Systems (3.0 hours)
Advanced programming of small microprocessor-based systems using high-level programming languages applied to real situations: data acquisition, control, communication, small real-time operating systems. Software development for devices from a family of microcontrollers that are relevant to industrial applications. Cross-listed as ECE 571.
Prerequisite: ECE 205 or ECE 305 with a minimum grade of C, or proficiency in microcontroller programming in a structural computer language.

ECE 472 - Embedded Microcontroller Linux (3.0 hours)
Understanding of Linux and its adoption as an embedded OS platform, including process and thread management; communication, synchronization, and deadlocks; virtual memory and file systems; overview of methods and techniques to design and create embedded systems based on the Linux kernel. The essentials of the Linux operating system are discussed from the embedded system point of view, including selecting, configuring, cross-compiling, and installing a target-specific kernel, drivers, and subsystems; the GNU development tool chain; and tools used to build embedded Linux systems. Cross-listed as ECE 572.
Prerequisite: ECE 205 or ECE 305 with a minimum grade of C, or proficiency in microcontroller programming in a structural computer language.

ECE 473 - Embedded TCP/IP (3.0 hours)
Fundamental concepts of computer networks and network programming; computer network topologies; TCP/IP stack; IP routing and routing algorithms; client-server paradigm; lower-layers protocols: IP, UDP, and TCP; basic application-layer protocols: HTTP, SMTP, POP3, TIME, TFTP, and DHCP; Berkeley Socket API; examples of socket API for small 8-bit or 16-bit embedded microcontroller system; principles of network security. Cross-listed as ECE 573.
Prerequisite: ECE 205 or ECE 305 with a minimum grade of C, or proficiency in microcontroller programming in a structural computer language.

ECE 474 - Mobile Robot Navigation and Mapping (3.0 hours)
Software aspects of simultaneous localization and mapping of mobile robots and cooperative multi-robot motion coordination. Cross-listed as ECE 574.
Prerequisite: ECE 470 or high proficiency in computer programming and data structures, or approval of the instructor. Not open to students with credit in ECE 574.

ECE 475 - Security for Industrial Automation (3.0 hours)
Introductory topics in industrial automation cyber-physical systems security, fundamental security primitives specific to cyber-physical systems, and their application to a broad range of current and future security challenges. Purdue Model for ICS Security. Industrial control systems as an example instance of cyber-physical systems. Cross-listed as ECE575.
Prerequisite: ECE 205 or ECE305 with a minimum grade of C, or proficiency in programming in a structural language and familiarity with microcontrollers.

ECE 480 - Digital Systems: Communication and Interface (3.0 hours)
A survey of the most common peripheral devices used in embedded and programmable devices. Cross-listed as ECE 580.
Prerequisite: ECE 205 or ECE 305 with a minimum grade of C.

ECE 481 - Digital Systems: Design and Synthesis (3.0 hours)
A structured guide to the modeling of the design of digital systems. Hardware description language (VHDL or Verilog) is used to simulate and synthesize designs. Reconfigurable devices such as FPGAs are used for design implementations. Assignments and projects of various engineering applications are included. Cross-listed as ECE 581.
Prerequisite: ECE 305 or equivalent, or approval of the instructor. Not open to students with credit in ECE 581.

ECE 482 - Digital Systems: High Level Synthesis and Codesign (3.0 hours)
Introduce high level synthesis and codesign for System-on-a-Chip (SoC) using FPGA devices, which supports the concurrent design to effectively reduce multiple iteration and major redesigns in embedded systems. Topics covered: FPGA architecture and development tool flow, Introduction to SoC, customized IP design, system partition, hardware acceleration, and performance analysis, and FPGA design applications. Cross-listed as ECE 582.
Prerequisite: ECE 305 or equivalent, or approval of the instructor. Not open to students with credit in ECE 582.

ECE 483 - Digital systems: Microprocessor Architecture and Design (3.0 hours)
Architectures of CISC & RISC microprocessors: CPU, Control Unit, ALU, MMU, pipelines, etc. Design trade-offs investigated. Cross-listed as ECE 583.
Prerequisite: ECE 205 or ECE 305 with a minimum grade of C.

ECE 484 - Digital Systems: Peripheral Architecture and Design (3.0 hours)
Architecture of microprocessor systems: Evolution, external memory, Input & Output, Operating Systems, etc. Design trade-offs investigated. Cross-listed as ECE 584.
Prerequisite: ECE 205 or ECE 305 with a minimum grade of C.

ECE 497 - Capstone Project System Level Design (1.0 hour)
Under the guidance of project advisor(s), and feedback from project clients (if any), students work on system-level design for their capstone project using a top-down design approach. In addition, student groups are trained through invited talks and/or workshops related to project design.
Prerequisite: A minimum grade of C in ECE 322, and Senior standing in ECE. Instructor consent may be required.

ECE 498 - Senior Capstone Project I (2.0 hours)
Core Curriculum: EL,WI
Design and implementation of senior design capstone project. Requires an oral progress presentation.
Prerequisite: Concurrent enrollment in ECE 497.

ECE 499 - Senior Capstone Project II (3.0 hours)
Core Curriculum: EL,WI
Continuation of the design and implementation of the senior design capstone project. Culminates in an oral presentation and a written report.
Prerequisite: ECE 498 with a minimum grade of C.

ECE 509 - Special Topics in Electrical and Computer Engineering (0.0-9.0 hours)
Topics of special interest which may vary each time course is offered. Topic stated in the current Schedule of Classes. Students may repeat the course under different topic names up to a maximum of 9 credits.
Prerequisite: Approval of instructor.

ECE 510 - Special Topics in Electrical and Computer Engineering (0.0-9.0 hours)
Topics of special interest which may vary each time course is offered. Topic stated in the current Schedule of Classes. Students may repeat the course under different topic names up to a maximum of 9 credits.
Prerequisite: Approval of instructor.

ECE 531 - Communication Theory I (3.0 hours)
Orthogonal signal representation; review of Fourier series and Fourier transform; basic probability theory; random processes; power spectral density; Shannon's channel capacity; sampling theorem; baseband signaling; bandpass signaling; complex envelop representation of signals and systems; analog modulations; binary and M-ary digital modulations; phase locked loops, demodulation circuits; matched filter; error performance in digital communications. Cross-listed as ECE 431.
Prerequisite: Graduate standing or a minimum grade of C in: ECE 206, ECE 302 or equivalents. Not open to students with credit in ECE 431.

ECE 541 - Feedback Control of Dynamic Systems (3.0 hours)
Analysis and design of linear automatic control systems for continuous-time dynamic systems using classical control theory. Fundamentals on feedback control theory. Root locus and Bode methods. Modeling and control of physical systems. Introduction to digital control. Computer-aided design and simulation. Cross listed as ECE 441.
Prerequisite: ECE206 or equivalent, or approval of instructor, or Graduate standing. Instructor's consent may be required. Not open to students with credits in ECE 441.

ECE 542 - Advanced Data-Driven Control and Applications (3.0 hours)
Frequency domain and time domain design of linear/nonlinear control systems. Analysis and design of linear/nonlinear control systems for sampled-data and discrete-time systems. Classical and modern control theory methods. Modeling and data driven system identification and control of sampled-data and discrete-time systems. Micro-controller-based control applications. Cross listed as ECE 442.
Prerequisite: ECE 541 or equivalent, or Graduate standing. Instructor's consent may be required. Not open to students with credits in ECE 442.

ECE 543 - Distributed Learning Control of Dynamic Systems (3.0 hours)
The analysis and control of distributed dynamic systems, distributed learning and control issues in dynamic systems, distributed control and estimation of multiple dynamic systems, use of fundamental tools in modeling and control of linear and nonlinear dynamic systems, applications of distributed learning and control for multiple dynamic systems through case studies in multiple robot coordination and distributed power grids. Cross-listed as ECE 443.
Prerequisite: Not open to students with credit in ECE 443.

ECE 544 - Autonomous Robotics (3.0 hours)
The project-based course deals with the fundamentals on autonomous robotic systems. It covers kinematics, sensors, and actuators of robots. Motion planning, control, and navigation techniques of autonomous mobile robots are introduced through a series of hands-on experiments. Cross-listed as ECE444.
Prerequisite: ECE103 or proficiency in programming in a structural computer programming language, ECE 214 or ECE 227, or graduate standing. Instructor's consent may be required. Not open to students with credit in ECE 444.

ECE 545 - Power Electronics Fundamentals (3.0 hours)
Fundamentals of power electronics. Covered topics: DC/DC converters, DC/AC converters (inverters), and AC/DC rectifiers, analysis, design, simulation and application of power electronic based systems. Cross-listed as ECE 445. Not open to students with credit in ECE 445.

ECE 546 - Power Laboratory (3.0 hours)
Experiments in transformers and rotating machines. Covered topics: electric machinery principles; brushed DC motor connections, operational characteristics, and applications; linear brushed DC motor model development, simulation, and verification; wound rotor and squirrel cage AC induction motor connections, operational characteristics, and applications; linear single-phase transformer model development and verification; power electronic H-bridge. Cross-listed as ECE 446. Not open to students with credit in ECE 446.
Prerequisite: ECE 303

ECE 550 - Electromagnetic Theory (3.0 hours)
Time-varying electric and magnetic fields; Maxwell's equations, electromagnetic potentials, electromagnetic boundary conditions, plane-wave propagation in unbounded conducting and non-conducting media, wave polarization, Poynting vector, reflection and transmission of waves at boundaries; radiation and antennas.Cross-listed as ECE 450.
Prerequisite: Graduate standing or a minimum grade of C in ECE 208. Not open to students with credits in ECE 450.

ECE 551 - Radio Frequency Circuits and Systems (3.0 hours)
Review of transmission lines, impedance matching and transformations, S-parameters, passive RF junctions, RF amplifier design, RF systems, and front-end design. Cross-listed as ECE 451.
Prerequisite: ECE 208 or equivalent, or graduate standing. Instructor's consent may be required. Not open to students with credit in ECE 451.

ECE 552 - Wireless Communication Systems (3.0 hours)
Introduction to wireless communication systems; modulation and detection; noise, attenuation; multipath and fading; sensitivity distortion, inter-modulation, and dynamic range; wireless link RF design; transmitter and receiver architectures; RF components and subsystems; selected wireless systems including multiple-access cellular systems. Cross-listed as ECE 452.
Prerequisite: Graduate standing or a minimum grade of C in: ECE 206, ECE 208, ECE 303 or equivalents. Not open to students with credit in ECE 452.

ECE 553 - Radio Frequency Communications Laboratory (3.0 hours)
Radio frequency measurements of wireless system components and subsystems, time and frequency domain measurements of analog and digital signals in communication systems, computer-aided design, fabrication, and testing of microwave integrated circuit. Cross-listed as ECE 453.
Prerequisite: ECE 551 with a minimum of B or equivalent. Not open to students with credit in ECE 453.

ECE 560 - Digital Signal Processing (3.0 hours)
Design of digital filters and multirate systems. Topics include: review of discrete-time signals and systems, generalized linear phase, all-pass filters, minimum phase systems, inverse systems, FIR filter design, IIR filter design, resampling in time and frequency domain, half-band filters, polyphase filters, quadrature mirror filters and wavelets. Cross-listed as ECE 460.
Prerequisite: Graduate standing or a minimum grade of C in ECE 301 or equivalent. Not open to students with credit in ECE 460.

ECE 562 - Digital Image Processing (3.0 hours)
Introduction to image processing. Topics covered: digital image fundamentals, image enhancements in spatial domain, image restoration, color image processing, wavelets and multiresolution, image compression, morphological image processing, image segmentation, pattern recognition. Cross-listed as ECE 462.
Prerequisite: ECE 103 or M E 273 or proficiency in computer programming in a structural language, or Graduate standing. Instructor's consent may be required. Not open to students with credit in ECE 462.

ECE 563 - Medical Imaging (3.0 hours)
Introduction to the common methods and devices employed for medical imaging, including conventional x-ray imaging, x-ray computed tomography (CT), nuclear medicine (single photon planar imaging), single photon emission computed tomography (SPECT), and positron emission tomography (PET), magnetic resonance imaging (MRI), and ultra-sound imaging. The physics and design of systems, typical clinical applications, medical image processing, and tomographic reconstruction. Cross-listed as ECE 463.
Prerequisite: Graduate standing or a minimum grade of C in ECE 206 or equivalent. Not open to students with credit in ECE 463.

ECE 565 - Engineering Applications of Machine Learning (3.0 hours)
This course covers the theory, design, and engineering applications of machine learning with the emphasis on computational intelligence. Embedded hardware platforms, high-performance libraries, and high-performance architectures are used for implementation. Variants such as Deep Neural Networks and Convolutional Neural Networks are examined. Cross-listed as ECE 465.
Prerequisite: Graduate standing or a minimum grade of C in ECE 302 or equivalent. Not open to students with credit in ECE 465.

ECE 568 - Mechatronics (3.0 hours)
Introduction to mechatronics: mechatronics overview, sensors and actuators modeling, interfacing sensors and actuators with digital systems. Cross-listed as ECE 468.
Prerequisite: ECE 214 or ECE 227, or Graduate standing. Instructor's consent may be required. Not open to students with credit in ECE 468.

ECE 570 - Embedded Data Structures and Object Oriented Programming (3.0 hours)
Introduction to data structures, object-oriented programming, memory management, problems of efficiency and complexity of algorithms applicable to embedded systems. Cross-listed as ECE 470.
Prerequisite: Graduate standing or a minimum grade of C in ECE 305 or proficiency in microcontroller programming in a structural computer language. Not open to students with credit in ECE 470. Instructor's consent may be required.

ECE 571 - Real-time Operating Systems (3.0 hours)
Advanced programming of small microprocessor-based systems using high-level programming languages applied to real situations: data acquisition, control, communication, small real-time operating systems. Software development for devices from a family of microcontrollers that is relevant to industrial applications. Cross-listed as ECE 471.
Prerequisite: Graduate standing or a minimum grade of C in ECE 305 or high proficiency in microcontroller programming in a structural computer language. Not open to students with credit in ECE 471. Instructor's consent may be required.

ECE 572 - Embedded Microcontroller Linux (3.0 hours)
Understanding of Linux and its adoption as an embedded OS platform, including process and thread management; communication, synchronization, and deadlocks; virtual memory and file systems; overview of methods and techniques to design and create embedded systems based on the Linux kernel. The essentials of the Linux operating system are discussed from the embedded system point of view, including selecting, configuring, cross-compiling, and installing a target-specific kernel, drivers, and subsystems; the GNU development tool chain; and tools used to build embedded Linux systems. Cross-listed as ECE 472.
Prerequisite: Graduate standing or a minimum grade of C in ECE 305 or proficiency in microcontroller programming in a structural computer language. Not open to students with credit in ECE 472. Instructor's consent may be required.

ECE 573 - Embedded TCP/IP (3.0 hours)
Fundamental concepts of computer networks and network programming; computer network topologies; TCP/IP stack; IP routing and routing algorithms; client-server paradigm; lower-layers protocols: IP, UDP, and TCP; basic application-layer protocols: HTTP, SMTP, POP3, TIME, TFTP, and DHCP; Berkeley Socket API; examples of socket API for small 8-bit or 16-bit embedded microcontroller system; principles of network security. Cross-listed as ECE 473.
Prerequisite: Graduate standing or a minimum grade of C in ECE305 or proficiency in microcontroller programming in a structural computer language. Not open to students with credit in ECE 473. Instructor's consent may be required.

ECE 574 - Mobile Robot Navigation and Mapping (3.0 hours)
Software aspects of simultaneous localization and mapping of mobile robots and cooperative multi-robot motion coordination. Cross-listed as ECE 474.
Prerequisite: ECE 570 or high proficiency in computer programming and data structures. Instructor's consent may be required. Not open to students with credit in ECE 474.

ECE 575 - Security for Industrial Automation (3.0 hours)
Introductory topics in industrial automation cyber-physical systems security, fundamental security primitives specific to cyber-physical systems, and their application to a broad range of current and future security challenges. Purdue Model for ICS Security. Industrial control systems as an example instance of cyber-physical systems. Not open to students with credit in ECE 475.
Prerequisite: Graduate standing or a minimum grade of C in ECE 305 or proficiency in microcontroller programming in a structural computer language. Not open to students with credit in ECE 475. Instructor's consent may be required.

ECE 581 - Digital Systems: Design and Synthesis (3.0 hours)
A structured guide to the modeling of the design of digital systems. Hardware description language (VHDL or Verilog) is used to simulate and synthesize designs. Reconfigurable devices such as FPGAs are used for design implementations. Assignments and projects of various engineering applications are included. Cross-listed as ECE 481.
Prerequisite: ECE 305 or equivalent, or graduate standing. Instructor's consent may be required. Not open to students with credit in ECE 481.

ECE 582 - Digital Systems: High Level Synthesis and Codesign (3.0 hours)
Introduce high level synthesis and codesign for System-on-a-Chip (SoC) using FPGA devices, which supports the concurrent design to effectively reduce multiple iteration and major redesigns in embedded systems. Topics covered: FPGA architecture and development tool flow, Introduction to SoC, customized IP design, system partition, hardware acceleration, and performance analysis, and FPGA design applications. Cross-listed as ECE 482.
Prerequisite: ECE 305 or equivalent, or Graduate standing. Instructor's consent may be required. Not open to students with credit in ECE 482.

ECE 583 - Digital Systems: Microprocessor Architecture and Design (3.0 hours)
Architectures of CISC & RISC microprocessors: CPU, Control Unit, ALU, MMU, pipelines, etc. Design trade-offs investigated. Cross-listed as ECE 483.
Prerequisite: A minimum grade of C in ECE 205 or equivalent, or graduate standing, or consent of the instructor. Not open to students with credit in ECE 483.

ECE 681 - Topics in Electrical Engineering (0.0-6.0 hours)
Topics of special interest which may vary each time course is offered. Topic stated in current Schedule of Classes. Repeatable to a maximum of 6 semester hours.

ECE 691 - Research I (0.0-6.0 hours)
Graduate research on a project selected by student and advisor. Repeatable to a maximum of 6 semester hours.

ECE 699 - Thesis (0.0-6.0 hours)
Advanced electrical and computer engineering research or design under the guidance of a faculty advisor. Required of students choosing thesis option. Repeatable to a maximum of 6 semester hours.
Prerequisite: Consent of department chair; unconditional status.