Electrical & Computer Engineering (ECE)

ECE 1200. Intro to Microcontrollers. 1 Hour.
An introduction to engineering applications in Python and Arduino for those with basic programming experience. This course teaches how to apply previously-learned programming principles within the Python environment through examples and programming assignments. Students also learn to program and interface various sensors and motors with Arduino microcontrollers. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Demonstrate competence in basic programming principles in the MATLAB programming environment. 2. Construct satisfactory solutions to defined tasks within Simulink. 3. Program a microcontroller to take data from various types of sensors. 4. Program a microcontroller to control various types of motors such as servo, stepper, and DC motors. Prerequisites: CS 1400 (Grade C- or higher). FA.

ECE 2100. Semiconductor Devices. 3 Hours.
Introduction to semiconductor materials, physics, and devices. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Model and analyze semiconductor p-n junctions. 2. Analyze charge transport in semiconductor materials. 3. Model and analyze MOSFETs. 4. Design semiconductor process flows using knowledge of basic microfabrication processes. Prerequisite: (MECH 2210 AND MATH 2250) (all Grade C- or higher, can be taken concurrently). SP.

ECE 2280. Microelectronics. 3 Hours.
Introduction to semiconductor theory and electronic device concepts to understand analog integrated circuits. Analysis of diodes, amplifiers, and transistors. Microelectronic analog circuit analysis and design using small-signal and large-signal techniques. Introduction to frequency analysis of microelectronic circuits using magnitude and phase response. Associated laboratory include design, building, troubleshooting, and simulation of semiconductor circuits and amplifiers. Inclusive Access Course Material (electronic book) fees may apply, see Fees tab under each course section for details. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Analyze complex analog circuit problems with transistors, diodes, or other electronic elements. 2. Differentiate between different types of transistors and other electrical components. 3. Devise electrical circuits with multistage amplifiers to meet specified requirements. 4. Estimate analog circuit outputs using proper analysis techniques. Prerequisites: (MECH 2210 AND PHYS 2220) (both Grade C- or higher) AND ECE 2285 (Grade C- or higher, can be taken concurrently). SP.

ECE 2285. Microelectronics Lab. 1 Hour.
Lab portion of 2280. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Diagram and manipulate analog circuits in circuit modeling software. 2. Outline experimental results from laboratory work concisely and accurately. 3. Employ proper technique in using laboratory equipment and circuit components. 4. Assess analog circuit functionality based on experimental results. Prerequisites: ECE 2280 (Grade C- or higher, can be taken concurrently). SP.

ECE 2700. Digital Circuits. 3 Hours.
Introduction to digital design through both high level and low level topics and problems. Boolean logic, state machines, register-transfer level (TRL design), and timing analysis are all taught. Design of digital systems, including combinational and sequential circuits with physical realization through laboratory work. Use of computer-aided tools to design, minimize and simulate circuits. Inclusive Access Course Material (electronic book) fees may apply, see Fees tab under each course section for details. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Solve combinational logic circuits to determine circuit response. 2. Design logic circuits that satisfy design requirements. 3. Differentiate between the different logic components in their function within a logic circuit. 4. Demonstrate competency with computer-aided tools for the design and analysis of logic circuits. Prerequisites: (MATH 1050 or placement score into MATH 1060) (Grade C- or higher) AND (MECH 1205 OR ECE 1200) (any Grade C- or higher, can be taken concurrently) AND ECE 2705 (Grade C- or higher, can be taken concurrently). FA.

ECE 2705. Digital Circuits Lab. 1 Hour.
Lab portion of ECE 2700. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Describe the basic equipment and components used for logic circuit. 2. Explain the results from basic laboratory experiments of logic circuits. 3. Demonstrate proper use of laboratory equipment with appropriate precautionary measures. 4. Compare the results obtained in physical systems to those obtained from theoretical work. Prerequisite: ECE 2700 (Grade C- or higher, can be taken concurrently). FA.

ECE 3300. Electromagnetics & Transmission Lines. 3 Hours.
An analysis of electromagnetics including wave propagation, transmission line analysis, impedance matching, electrostatics, magnetostatics, Maxwell's equations, plane waves, reflection, refraction, lossy media, and wireless communication systems. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Calculate voltages, currents, and impedances on transmission lines using time-domain and frequency-domain analysis. 2. Calculate electric and magnetic fields from charges, current distributions, and plane waves. 3. Design matching systems for transmission lines and plane waves. 4. Calculate a link budget for simple wireless communication systems. Prerequisites:(MECH 2210 AND MATH 2250) (all Grade C- or higher) AND ECE 3305 (Grade C- or higher, can be taken concurrently). FA.

ECE 3305. Electromagnetics & Transmission Lines Lab. 1 Hour.
Lab portion of ECE 3300. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Acquire and analyze data from electromagnetic systems including transmission lines. 2. Evaluate uncertainty and/or error between experimental measurements and analytical/simulated predictions. Prerequisites: ECE 3300 (Grade C- or higher, can be taken concurrently). FA.

ECE 3500. Signals and Systems. 3 Hours.
Sampling of continuous-time systems. Transform domain analysis of circuits. Linear and time invariant systems in both continuous-time and discrete-time domains. Representation of systems using transfer functions, impulse-response functions, and frequency responses. Fourier analysis of continuous-time systems. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Evaluate time-invariant systems in both the time and frequency domains. 2. Formulate solutions to complex systems using appropriate transforms to reduce problem complexity. 3. Discriminate appropriate domains to solve linear, time-invariant systems. 4. Articulate the physical significance of the various domains and transforms. Prerequisites: (MATH 2250 OR (MATH 2270 AND MATH 2280)) (any Grade C- or higher) AND MECH 3200 (Grade C- or higher). SP.

ECE 3600. Electric Machinery. 3 Hours.
Fundamentals of electrical machinery and power transmission systems. Topics include three-phase circuits, magnetic circuits, transformers, DC & AC motors, power factor, and power flow. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Model and analyze DC to DC converters. 2. Model and analyze AC to DC converters. 3. Estimate heat dissipation in power electronics. 4. Design and analyze power electronic schemes for defined specifications. Prerequisites: (MECH 2210 AND MECH 3200) (Grade C- or higher) AND ECE 3605 (Grade C- or higher, can be taken concurrently). SP.

ECE 3605. Electric Machinery Lab. 1 Hour.
Lab portion of ECE 3600. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Acquire and analyze data from power electronics such as DC to DC and AC to DC converters. 2. Acquire and analyze data regarding heating in power electronics. 3. Design and prototype, in teams, a power electronics system that meets defined specifications. Prerequisite: ECE 3600 (Grade C- or higher, can be taken concurrently). SP.

ECE 3730. Embedded Systems I. 3 Hours.
Introduction to embedded system design with microcontrollers. Topics include hardware and software aspects of embedded systems, microcontroller architecture, serial and parallel I/O interfacing, analogy sensing, actuation, and interrupt synchronization. In the associated lab, student will design and prototype an embedded system according to design requirements. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Articulate software and hardware design considerations for embedded systems. 2. Analyze microcontroller, sensor, and actuator datasheets in the selection of embedded system components. 3. Use appropriate communication protocols to interface various analog and digital hardware. 4. Design embedded systems that satisfy criteria with respect to functionality, size and cost. Prerequisites: (ECE 1200 OR MECH 1200) (any Grade C- or higher) AND ECE 2700 (Grade C- or higher) AND ECE 3735 (Grade C- or higher, can be taken concurrently). FA.

ECE 3735. Embedded Systems I Lab. 1 Hour.
Lab portion of 3730. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Plan effectively with team members to meet deadlines and fulfill tasks. 2. Evaluate different embedded system designs through experimentation. 3. Construct and test an embedded system according to design specifications. 4. Appraise an embedded system design using hardware and microcontroller specifications. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Plan effectively with team members to meet deadlines and fulfill tasks. 2. Evaluate different embedded system designs through experimentation. 3. Construct and test an embedded system according to design specifications. 4. Appraise an embedded system design using hardware and microcontroller specifications. Prerequisites: ECE 3730 (Grade C- or higher, can be taken concurrently). FA.

ECE 4000. EE Product Design I. 3 Hours.
First course in the product design series required for Electrical Engineering majors. Students work in teams to develop a product through customer needs identification, concept generation and selection, concept testing, benchmarking, design parameter specification, engineering analysis, and critical function prototyping. The course culminates in an alpha prototype and formal design review of the product with faculty and industry leaders. Dual listed with MECH 4000 and ECE 4005 (students may only take one course for credit). **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Define and propose, in teams, solutions to a team-perceived problem using engineering design principles and ethics. 2. Formulate background for a team-defined project using prior work such as journal articles, patent databases, and/or benchmark data. 3. Propose project milestones and a plan to achieve project milestones. 4. Design and perform a feasibility study. 5. Prototype, in teams, an alpha solution to a team-defined problem. Course fee required. Prerequisites: (ECE 2100 and ECE 2280 and ECE 3300 and ECE 3500 and ECE 3600) (all grade C- or higher) and ENGL 3010 (grade C- or higher, can be taken concurrently). FA.

ECE 4005. CE Product Design I. 3 Hours.
First course in the product design series required for Computer Engineering majors. Students work in teams to develop a product through customer needs identification, concept generation and selection, concept testing, benchmarking, design parameter specification, engineering analysis, and critical function prototyping. The course culminates in an alpha prototype and formal design review of the product with faculty and industry leaders. Dual listed with MECH 4000 and ECE 4000 (students may only take one course for credit). **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Define and propose, in teams, solutions to a team-perceived problem using engineering design principles and ethics. 2. Formulate background for a team-defined project using prior work such as journal articles, patent databases, and/or benchmark data. 3. Propose project milestones and a plan to achieve project milestones. 4. Design and perform a feasibility study. 5. Prototype, in teams, an alpha solution to a team-defined problem. Course fee required. Prerequisites:(ECE 2280 and ECE 3500 and ECE 4730) (all Grade C- or higher) and ENGL 3010 (grade C- or higher, can be taken concurrently). FA.

ECE 4010. EE Product Design II. 3 Hours.
Second course in the product design series required for Electrical Engineering majors. Student teams further develop their product through engineering analysis, beta testing, economic analysis, design for manufacturing, design reviews, and documentation. The course culminates in a final product that will be presented to the public at Engineering Design Day. Dual listed with MECH 4010 and ECE 4015 (students may only take one course for credit). **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Evaluate economic considerations of a team-defined problem. 2. Propose a design and/or improvement to a component and/or system using engineering analysis. 3. Prepare and present a technical oral and poster presentation. 4. Prototype, in teams, a beta solution to a team-defined problem. Course fee required. Prerequisites: ECE 4000 (Grade C- or higher). SP.

ECE 4015. CE Product Design II. 3 Hours.
Second course in the product design series required for Computer Engineering majors. Student teams further develop their product through engineering analysis, beta testing, economic analysis, design for manufacturing, design reviews, and documentation. The course culminates in a final product that will be presented to the public at Engineering Design Day. Dual listed with MECH 4010 and ECE 4010 (students may only take one course for credit). **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Evaluate economic considerations of a team-defined problem. 2. Propose a design and/or improvement to a component and/or system using engineering analysis. 3. Prepare and present a technical oral and poster presentation. 4. Prototype, in teams, a beta solution to a team-defined problem. Course fee required. Prerequisites: ECE 4005 (Grade C- or higher). SP.

ECE 4100. Circuits II. 4 Hours.
This course will cover advanced circuit analysis methods, sequential switching, instrumentation amplifiers and balanced three phase power systems. Passive and active filters will be designed and modeled. Software tools to create printed circuit boards and model electrical circuits will be studied and implemented. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1) Analyze and evaluate complex circuit problems by applying principles of engineering, science, and mathematics. 2) Study and analyze sinusoidal three-phase power systems. 3) Design frequency selective circuits that meet specific requirements and using both the time and frequency domains analysis. 4) Implement software tools to analyze electrical circuits and create printed circuit boards. 5) Acquire and apply new knowledge using appropriate learning strategies. Prerequisites: MECH 2250 (grade C- or higher) OR Instructor Permission. FA.

ECE 4200. Modern Controls. 3 Hours.
Introduces the foundational principles of several advanced control and estimation techniques. Topics are drawn from the sub-fields of control theory including linear systems, optimal control, estimation, nonlinear systems, adaptive control, and reinforcement learning. Students learn the theoretical background of these methods and practice implementing them in simulation. ***COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1) Design and implement advanced control techniques on nonlinear uncertain Multiple-Input Multiple-Output (MIMO) systems. 2) Identify which control and estimation technique (including advanced and traditional methods) is most appropriate for a given system and justify that choice. 3) Analyze the stability of nonlinear systems using Lyapunov theory. 4) Explain the impacts of and (if necessary) account for disturbances, optimality requirements, measurement uncertainties, nonlinearities, and model uncertainties. 5) Acquire and apply new knowledge using appropriate learning strategies. Prerequisites: MECH 3200 (grade C- or higher) OR Instructor Permission. FA.

ECE 4290. Autonomous Vehicles. 4 Hours.
Design of guidance, navigation, and control for autonomous vehicles. Students are taught to develop a full autonomy stack including system modeling, control laws, sensors, state estimation, guidance, and navigation. The concepts taught in this course can be applied to aircraft, submarines, boats, cars, multi-rotors, helicopters, rockets, or satellites. However, particular attention is given to uncrewed fixed-wing aircraft. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: At the successful conclusion of this course, students will be able to: 1) Explain the physical implications of the unconstrained 6 degrees of freedom equations of motion. 2) Interpret the notation, conventions, and terminology commonly used in autonomy engineering. 3) Identify common sensors for autonomous vehicles including capabilities and limitations. 4) Design and simulate each block in the autonomy stack for a given vehicle. 5) Acquire and apply new knowledge using appropriate learning strategies. Prerequisites: MECH 3200 (grade C- or higher) OR Instructor Permission. SP.

ECE 4300. Antenna & RF Engineering. 4 Hours.
Antenna theory, design, and operation; parameters and limitations including arrays; RF components and circuits in building transmitters and receivers (amplifiers, oscillators, attenuators, couplers, mixers, etc); scattering matrices, impedance matching, and non-linearities. ***Course Learning Outcomes (CLOs)*** At the successful conclusion of this course, students will be able to: 1) Design and validate impedance and radiation characteristics of antenna. 2) Identify limitations in array design and apply techniques to overcome these limitations. 3) Analyze RF circuits and sub-systems using microwave network analysis. 4) Run EM simulations using software and identify limitations. 5) Acquire and apply new knowledge using appropriate learning strategies. Prerequisites: ECE 3300 (grade C- or higher) OR Instructor Permission. SP.

ECE 4400. Wearable Tech. 4 Hours.
A comprehensive exploration of wearable technology through hands-on projects. Students will study the history and evolution of wearable devices, the design and evaluation of new technologies, as well as human-machine interaction. Students will engage in projects such as remotely controlling a robotic hand with a wearable glove, building heart rate and oximetry monitors for medical devices, creating a personalized mini-Fitbit that can count steps and monitor biometrics signals, and designing wearables that enhance athletic training through sensory feedback. Additionally, the course covers the fundamentals of initiating an innovative research project, offering students the chance to present their work at the Trailblazer Symposium. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of this course students will: 1) Design and prototype wearable technology using sensors and microcontrollers. 2) Apply human-centered design principles to create assistive devices. 3) Develop hands-free assistive technology. 4) Acquire and apply new knowledge using appropriate learning strategies. Prerequisites: MECH 2250 (grade C- or higher) OR Instructor Permission. SP.

ECE 4500. Digital Signal Processing. 3 Hours.
Covers discrete-time systems and signals, z-transforms, and discrete-time Fourier transforms. Other topics include finite-impulse response and infinite impulse response digital filter design, sampling, signal quantization, and spectral transformation. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Analyze complex systems using discrete-time filters. 2. Construct digital filters to meet specified requirements. 3. Test physical systems experimentally and compare to theoretical results. 4. Discriminate between appropriate uses of the discrete-time transforms and digital filters. Prerequisites: ECE 3500 (Grade C- or higher).

ECE 4510. Image Processing. 3 Hours.
Methodologies and algorithms for processing digital images with software. Topics include gray level transformations, histogram analysis, spatial domain filtering, 2D Fourier transforms, frequency domain filtering, image restoration, and reconstruction of computed tomography (CT) medical images. **COURSE LEARNING OUTCOMES (CLOs)** At the successful conclusion of the course students will: 1. Recognize terminology used in image processing algorithms, acquisition, and storage. 2. Manipulate digital images in the spatial domain and in the frequency domain. 3. Assess image processing results related to a particular image processing algorithm. 4. Implement image processing algorithms using software. Prerequisite: MECH 2250 (grade C- or higher) OR Instructor Permission.

ECE 4610. Power Electronics. 4 Hours.
The course covers topics related to power processing electronic circuits, including rectifiers, AC voltage controllers, frequency converters, DC-DC converters, and inverters. It also introduces the fundamentals of power semiconductor devices such as SCRs, IGBTs, and MOSFETs. Detailed analysis of these power circuits is provided, along with explanations of waveforms and control techniques. Furthermore, the course delves into the applications of power electronic technology in various sectors, including power generation and transmission, as well as everyday uses like battery chargers, motor drives, and power supplies. **COURSE ENROLLMENT CLASSIFICATION (CLOs)** At successful conclusion of this course students will: 1) Identify and analyze power converters such as ac-dc, dc-dc, dc-ac, and ac-ac. 2) Design power converters. 3) Analyze power electronics for motor drives, SMPS, and PV based power generation. 4) Acquire and apply new knowledge using appropriate learning strategies. Prerequisites: MECH 2250 (grade C- or higher) OR Instructor Permission. FA.

ECE 4730. Embedded Systems II. 3 Hours.
Presents advanced topics for embedded systems, including hardware and software for real-time systems. Topics include scheduling paradigms, synchronization, inter-process communication, feedback control, verification & validation, and issues in safety-critical embedded systems. The laboratory associated with the course includes labs in these topics and a design project for students. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Design a real-time embedded system with appropriate consideration for issues unique to real-time systems. 2. Describe communication protocols, verification & validation, and software architectures that are unique to real-time embedded systems. 3. Develop software for an embedded real-time system. 4. Analyze hardware for sensing and actuation based on needs for an embedded system. Prerequisites: (ECE 3730 AND MECH 2250) (all grade C- or higher) AND ECE 4735 (Grade C- or higher, can be taken concurrently). SP.

ECE 4735. Embedded Systems II Lab. 1 Hour.
Lab portion of 4730. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Integrate hardware and software in an embedded system that meets specified needs. 2. Consider trade-offs when selective actuators, sensors, and microcontrollers in embedded systems. 3. Identify errors in the software to run a real-time embedded system. 4. Defend in writing the choices in an embedded system design. Prerequisites: ECE 4730 (Grade C- or higher, can be taken concurrently). SP.

ECE 4800R. Independent Research. 1-3 Hours.
An independent research course that allows upper-level electrical and computer engineering students to work closely with a faculty member to explore engineering through research. Projects are chosen at the discretion of the faculty member. Students will have an opportunity to present their research at Engineering Design Day or similar venue. Repeatable up to 3 credits subject to graduation restrictions. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Identify and compile background pertaining to the research project. 2. Propose solutions pertaining to the research project using engineering design principles and/or the scientific method. 3. Model and analyze a system pertaining to the research project. 4. Design and conduct experiments and interpret associated results pertaining to the research project. 5. Draw conclusions and identify future work pertaining to the research project. Prerequisites: Instructor permission.

ECE 4990. Special Topics Lecture. 1-4 Hours.
Specialized topics in Electrical and Computer Engineering used to fulfill technical elective requirements. Repeatable up to 24 credits subject to graduation restrictions. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Formulate and evaluate complex engineering problems by applying principles of engineering, science, and mathematics. 2. Model, analyze, and design electrical/electronic/mechatronic systems that accomplish a specified task or objective. Prerequisites: MECH 2250 (Grade C- or higher).

ECE 4995. Special Topics Lab. 0.5-3 Hours.
Specialized topics in Electrical and Computer Engineering used to fulfill technical elective requirements. Repeatable up to 18 credits subject to graduation restrictions. **COURSE LEARNING OUTCOMES (CLOs) At the successful conclusion of this course, students will be able to: 1. Design experiments for electrical/electronic systems or processes, analyze experimental data, and make informed conclusions from the data. 2. Design, prototype, and troubleshoot electrical/electronic/mechatronic systems that accomplish a specified task or objective.