Electrical Engineering (ELEG)

Courses

ELEG 2104. Electric Circuits I. 4 Hours.
Introduction to circuit variables, elements, and simple resistive circuits. Analysis techniques applied to resistive circuits. The concept of inductance, capacitance and mutual inductance. The natural and step responses of RL, RC, and RLC circuits. Corequisite: Lab component. Pre- or Corequisite: MATH 2564 or MATH 2564C. (Typically offered: Fall and Summer)

ELEG 2114. Electric Circuits II. 4 Hours.
Introduction to complex numbers. Sinusoidal steady-state analysis of electric circuits, active, reactive, apparent and complex power; balanced and unbalanced three-phase circuits; mutual inductance; the use of the Laplace transform for electric circuit analysis and two-port networks. Corequisite: Lab component. Pre- or Corequisite: MATH 2584. Prerequisite: ELEG 2104. (Typically offered: Spring and Summer)

ELEG 287V. Special Topics in Electrical Engineering. 1-4 Hour.
Consideration of current electrical engineering topics not covered in other courses. (Typically offered: Irregular) May be repeated for up to 4 hours of degree credit.

ELEG 2904. Digital Design. 4 Hours.
To introduce students to modern logic concepts, problem solving and design principles, and vocabulary and philosophy of the digital world. Corequisite: Lab component. Prerequisite: Engineering major. (Typically offered: Fall) This course is cross-listed with CSCE 2114.

ELEG 3124. System & Signal Analysis. 4 Hours.
Definition and description of signals and systems; analog, digital, continuous- and discrete-time and frequency analysis of systems, Z- and Fourier Transforms, sampling and signal reconstruction, filter design and engineering applications. Pre- or Corequisite: MATH 2584. Corequisite: Lab component. Prerequisite: ELEG 2104 or ELEG 3903 or BMEG 2904. (Typically offered: Fall)

ELEG 3124H. Honors System & Signal Analysis. 4 Hours.
Definition and description of signals and systems; analog, digital, continuous- and discrete-time and frequency analysis of systems, Z- and Fourier Transforms, sampling and signal reconstruction, filter design and engineering applications. Pre- or Corequisite: MATH 2584. Corequisite: Lab component. Prerequisite: ELEG 2104 or ELEG 3903 or BMEG 2904. (Typically offered: Fall)
This course is equivalent to ELEG 3124.

ELEG 3143. Probability & Stochastic Processes. 3 Hours.
Review of system analysis, probability, random variables, stochastic processes, auto correlation, power spectral density, systems with random inputs in the time and frequency domain, and applications. Pre- or Corequisite: ELEG 3124. (Typically offered: Spring)

ELEG 3143H. Honors Probability & Stochastic Processes. 3 Hours.
Review of system analysis, probability, random variables, stochastic processes, auto correlation, power spectral density, systems with random inputs in the time and frequency domain, and applications. Pre- or Corequisite: ELEG 3124. (Typically offered: Spring)
This course is equivalent to ELEG 3143.

ELEG 3214. Electromagnetics I. 4 Hours.
Introduction to electronic systems and signal processing, operational amplifiers, diodes, non-linear circuit applications, MOSFETS, and BJTs. Course has a lab component. Pre- or Corequisite: MATH 2574 and ELEG 2114. Corequisite: Lab component. Prerequisite: PHYS 2074. (Typically offered: Fall and Spring)

ELEG 3214H. Honors Electronics I. 4 Hours.
Introduction to electronic systems and signal processing, operational amplifiers, diodes, non-linear circuit applications, MOSFETS, and BJTs. Pre- or Corequisite: MATH 2574 and ELEG 2114. Corequisite: Lab component. Prerequisite: PHYS 2074. (Typically offered: Fall and Spring) This course is equivalent to ELEG 3214.

ELEG 3224. Electronics II. 4 Hours.
Differential pair amplifier, current mirrors, active loads, multistage amplifiers, amplifier frequency response, bode plots, Millers theorem, short circuit and open circuit time constant methods, feedback amplifiers, and stability of feedback amplifiers. Corequisite: Lab component. Prerequisite: ELEG 3214 and MATH 2584. (Typically offered: Spring)

ELEG 3224H. Honors Electronics II. 4 Hours.
Differential pair amplifier, current mirrors, active loads, multistage amplifiers, amplifier frequency response, bode plots, Millers theorem, short circuit and open circuit time constant methods, feedback amplifiers, and stability of feedback amplifiers. Corequisite: Lab component. Prerequisite: ELEG 3214 and MATH 2584. (Typically offered: Spring) This course is equivalent to ELEG 3224.

ELEG 3304. Energy Systems. 4 Hours.
Steady state analysis of DC machines, transformers, induction machines and synchronous machines. Introduction to speed control of electric machines using power electronics. Corequisite: Lab component. Prerequisite: ELEG 2114. (Typically offered: Spring)

ELEG 3304H. Honors Energy Systems. 4 Hours.
Steady state analysis of DC machines, transformers, induction machines and synchronous machines. Introduction to speed control of electric machines using power electronics. Corequisite: Lab component. Prerequisite: ELEG 2114. (Typically offered: Spring) This course is equivalent to ELEG 3304.

ELEG 3704. Applied Electromagnetics. 4 Hours.
Analysis of transmission lines with sinusoidal and transient excitation. Development and use of the Smith Chart and methods of impedance matching. Vector analysis, static form of Maxwell's equations, electrostatics, and magnetostatics. Corequisite: Lab component. Pre- or Corequisite: PHYS 2074 and MATH 2574. Prerequisite: ELEG 2114. (Typically offered: Fall)

ELEG 3704H. Honors Applied Electromagnetics. 4 Hours.
Analysis of transmission lines with sinusoidal and transient excitation. Development and use of the Smith Chart and methods of impedance matching. Vector analysis, static form of Maxwell’s equations, electrostatics, and magnetostatics. Corequisite: Lab component. Pre- or Corequisite: PHYS 2074 and MATH 2574. Prerequisite: ELEG 2114. (Typically offered: Fall)

ELEG 387V. Special Topics in Electrical Engineering. 1-4 Hour.
Consideration of current electrical engineering topics not covered in other courses. (Typically offered: Irregular) May be repeated for up to 9 hours of degree credit.

ELEG 3903. Electric Circuits and Machines. 3 Hours.
Basic electrical principles and circuits; Introduction to sinusoidal steady-state analysis of electric circuits, active, reactive, and complex power; balanced three-phase circuits; Steady-state analysis of electric machines and transformers. Introduction to power electronics for machine speed control and alternative energy sources. For engineering students other than those in electrical engineering. Prerequisite: MATH 2564 and PHYS 2074. (Typically offered: Fall and Spring)

ELEG 3924. Microprocessor Systems Design. 4 Hours.
Introduction to 8-bit microprocessors and their application. Microprocessor architecture and assembly language; interface devices; system design using microprocessors. Corequisite: Lab component. Pre- or Corequisite: ELEG 2904. (Typically offered: Fall)
ELEG 3924H. Honors Microprocessor Systems Design. 4 Hours. 
Introduction to 8-bit microprocessors and their application. Microprocessor architecture and assembly language; interface devices; system design using microprocessors. Corequisite: Lab component. Prerequisite: ELEG 2904. (Typically offered: Fall)
This course is equivalent to ELEG 3924.

ELEG 3933. Circuits & Electronics. 3 Hours. 
Basic principles of electric and electronic circuits and devices. For engineering students who are not pursuing a degree in electrical engineering. Prerequisite: MATH 2584 and PHYS 2074. (Typically offered: Spring)

ELEG 400VH. Honors Senior Thesis. 1-3 Hour. 
Honors senior thesis. Prerequisite: Senior standing. (Typically offered: Fall, Spring and Summer)

ELEG 4063. Electrical Engineering Design I. 3 Hours. 
Capstone design and application in electrical engineering. Prerequisite: ELEG 3224 and ELEG 3924. (Typically offered: Fall and Spring)

ELEG 4063H. Honors Electrical Engineering Design I. 3 Hours. 
Design and application in electrical engineering. Prerequisite: ELEG 3224 and ELEG 3924. (Typically offered: Fall and Spring)
This course is equivalent to ELEG 4063.

ELEG 4071. Electrical Engineering Design II. 1 Hour. 
Design and application in electrical engineering. Prerequisite: ELEG 4063. (Typically offered: Fall and Spring)

ELEG 4071H. Honors Electrical Engineering Design II. 1 Hour. 
Design and application in electrical engineering. Prerequisite: ELEG 4063. (Typically offered: Fall and Spring)
This course is equivalent to ELEG 4071.

ELEG 4203. Semiconductor Devices. 3 Hours. 
Crystal properties and growth of semiconductors, energy bands and charge carriers in semiconductors, excess carriers in semiconductors, analysis and design of p/n junctions, analysis and design of bipolar junction transistors, and analysis and design of field-effect transistors. Students may not receive credit for both ELEG 4203 and ELEG 5203. Prerequisite: MATH 2584 and ELEG 3214, or graduate standing. (Typically offered: Irregular)

ELEG 4203H. Honors Semiconductor Devices. 3 Hours. 
Crystal properties and growth of semiconductors, energy bands and charge carriers in semiconductors, excess carriers in semiconductors, analysis and design of p/n junctions, analysis and design of bipolar junction transistors, and analysis and design of field-effect transistors. Students may not receive credit for both ELEG 4203 and ELEG 5203. Prerequisite: MATH 2584 and ELEG 3214, or graduate standing. (Typically offered: Irregular)
This course is equivalent to ELEG 4203.

ELEG 4223. Design and Fabrication of Solar Cells. 3 Hours. 
Solar insolation and its spectral distribution; p-n junction solar cells in dark and under illumination; solar cell parameters efficiency limits and losses; standard cell technology; energy accounting; design of silicon solar cells using simulation; fabrication of designed devices in the lab and their measurements. Students may not receive credit for both ELEG 4223 and ELEG 5223. Prerequisite: ELEG 4203. (Typically offered: Irregular)

ELEG 4233. Introduction to Integrated Circuit Design. 3 Hours. 
Design and layout of large scale digital integrated circuits using CMOS technology. Topics include MOS devices and basic circuits, integrated circuit layout and fabrication, dynamic logic, circuit design, and layout strategies for large scale CMOS circuits. Students may not receive credit for both ELEG 4233 and ELEG 5923. Prerequisite: ELEG 3214 or ELEG 3933 and ELEG 2904 or equivalent. (Typically offered: Fall)
This course is equivalent to ELEG 4233H.

ELEG 4233H. Honors Introduction to Integrated Circuit Design. 3 Hours. 
Design and layout of large scale digital integrated circuits using NMOS and CMOS technology. Topics include MOS devices and basic circuits, integrated circuit layout and fabrication, dynamic logic, circuit design, and layout strategies for large scale NMOS and CMOS circuits. Prerequisite: ELEG 3214 or ELEG 3933 and ELEG 2904 or equivalent. (Typically offered: Irregular)

ELEG 4243. Analog Integrated Circuits. 3 Hours. 
Theory and design techniques for linear and analog integrated circuits. Current mirrors, voltage to base emitter matching, active loads, compensation, level shifting, amplifier design techniques, circuit simulation using computer-assisted design programs. Prerequisite: ELEG 3224. (Typically offered: Irregular)

ELEG 4253. Nanotechnology in Engineering & Medicine. 3 Hours. 
The objective of this course is to present a concise and concurrent introduction to Nanotechnology and its applications in engineering and medicine, particularly for nanoelectronics, nanosensors and nanocomputing. This course presents basic aspects of the nanotechnology, its fabrication and imaging technologies and integration of biomolecules with electronic systems for the design of devices in nanoelectronics, nanobioelectronics and Nanomedicine. Prerequisite: Senior standing or instructor consent. (Typically offered: Irregular) May be repeated for up to 6 hours of degree credit.

ELEG 4283. Mixed Signal Test Engineering I. 3 Hours. 
Overview of mixed signal testing, the test specification process, DC and parametric measurements, measurement accuracy, tester hardware, sampling theory, DSP-based testing, analog channel testing, digital channel testing. Prerequisite: Senior or graduate standing. (Typically offered: Irregular)

ELEG 4293. Mixed-Signal Modeling & Simulation. 3 Hours. 
Study of basic analog, digital & mixed signal simulation solution methods. Modeling with hardware description languages. Use of state-of-the-art simulators and HDLs. Students may not receive credit for both ELEG 4293 and ELEG 5993. Prerequisite: ELEG 3224. (Typically offered: Irregular)

ELEG 4303. Introduction to Nanomaterials and Devices. 3 Hours. 
This course provides the students with an introduction to nanomaterials and devices. The students will be introduced to the quantization of energy levels in nanomaterials, growth of nanomaterials, electrical and optical properties, and devices based on these nanomaterials, such as tunneling resonant diodes, transistors, detector, and emitters. Graduate students will be given additional or different assignments. Graduate students will be expected to explore and demonstrate an understanding of the material with a greater level of depth and breadth than the undergraduates. Each group of students will have different expectations and grading systems. The instructor will prepare and distribute two distinct syllabi. Corequisite: ELEG 4203. Prerequisite: ELEG 3214 and PHYS 2074. (Typically offered: Irregular) May be repeated for up to 6 hours of degree credit.

ELEG 4343. Organic Electronics Technology. 3 Hours. 
Students become familiar with recent developments in and process technology for organic material based devices and sensors in the classroom, but also gain hands on experience with fabrication processes using micro-fabrication tools in the lab. Students may not receive credit for both ELEG 4343 and ELEG 5343. (Typically offered: Irregular)

ELEG 4403. Control Systems. 3 Hours. 
Mathematical modeling of dynamic systems, stability analysis, control system architectures and sensor technologies. Time-domain and frequency-domain design of feedback control systems: lead, lag, PID compensators. Special topics in microprocessor implementation. Students may not receive credit for both ELEG 4403 and ELEG 5403. Prerequisite: ELEG 3124. (Typically offered: Irregular)
ELEG 4403H. Honors Control Systems. 3 Hours.
Mathematical modeling of dynamic systems, stability analysis, control system architectures and sensor technologies. Time-domain and frequency-domain design of feedback control systems; lead, lag, PID compensators. Special topics in microprocessor implementation. Students may not receive credit for both ELEG 4403 and ELEG 5403. Prerequisite: ELEG 3124. (Typically offered: Irregular)

ELEG 4413. Advanced Control Systems. 3 Hours.
A second course in linear control systems. Emphasis on multiple-input and multiple-output systems: State-space analysis, similarity transformations, eigenvalue and eigenvector decomposition, stability in the sense of Lyapunov, controllability and observability, pole placement, quadratic optimization. Students may not receive credit for both ELEG 4413 and ELEG 5413. Prerequisite: ELEG 4403 or equivalent course. (Typically offered: Irregular)

ELEG 4423. Optimal Control. 3 Hours.
Introductory theory of optimizing dynamic systems: Formulation of performance objectives; calculus of variations; linear quadratic optimal control; discrete-time optimization; robustness and frequency domain techniques; reinforcement learning and optimal adaptive control. Prerequisite: ELEG 4403. (Typically offered: Irregular)

ELEG 4463L. Control Systems Laboratory. 3 Hours.
Experimental study of various control systems and components. The use of programmable logic controllers in the measurement of systems parameters, ladder-logic applications, process-control applications, and electromechanical systems. Prerequisite: ELEG 3924 and ELEG 3124. (Typically offered: Irregular)

ELEG 4473. Power System Operation and Control. 3 Hours.
Study of the control and operation of electric power systems: Modeling, dynamics, and stability of three-phase power systems. Design and implementation of control systems related to generation and transmission. Overview of the related industry and government regulations for power system protection and reliability. Students may not receive credit for both ELEG 4473 and ELEG 5473. Prerequisite: ELEG 3124 and ELEG 3304. (Typically offered: Irregular)

ELEG 4503. Design of Advanced Electric Power Distribution Systems. 3 Hours.
Design considerations of electric power distribution systems, including distribution transformer usage, distribution system protection implementation, primary and secondary networks design, applications of advanced equipment based on power electronics, and use of capacitors and voltage regulation. Prerequisite: ELEG 3304. (Typically offered: Irregular)

ELEG 4503H. Honors Design of Advanced Electric Power Distribution Systems. 3 Hours.
Design considerations of electric power distribution systems, including distribution transformer usage, distribution system protection implementation, primary and secondary networks design, applications of advanced equipment based on power electronics, and use of capacitors and voltage regulation. Students may not receive credit for both ELEG 4503H and ELEG 5503. Prerequisite: ELEG 3304. (Typically offered: Irregular)

This course is equivalent to ELEG 4503.

ELEG 4513. Power and Energy Systems Analysis. 3 Hours.
Modeling and analysis of electric power systems: Energy sources and conversion; load flow analysis; reference frame transformations; symmetrical and unsymmetrical fault conditions; load forecasting and economic dispatch. Students may not receive credit for both ELEG 4513 and ELEG 5513. Prerequisite: ELEG 2114. (Typically offered: Irregular)

ELEG 4523. Quality of Electric Power. 3 Hours.
This course addresses concepts related to the quality of electric power (in particular wiring and grounding, voltage sags and interruptions, harmonics, and transients), distributed generation and power electronic systems, power quality benchmarking, as well as instrumentation and PQ analyzers. Students may not receive credit for both ELEG 4523 and ELEG 5523. Prerequisite: ELEG 3304. (Typically offered: Irregular)

ELEG 4533. Power Electronics and Motor Drives. 3 Hours.
Characteristics of Insulated Gate Bipolar Transistors (IGBTs), Silicon Carbide (SiC) MOSFETs, Gallium Nitride (GaN) devices, Design of driver and snubber circuits for IGBTs and SiC MOSFETs, and an introduction to electric motor drives. Students may not receive credit for both ELEG 4533 and ELEG 5533. Prerequisite: ELEG 3304 and ELEG 3224. (Typically offered: Irregular)

ELEG 4543. Introduction to Power Electronics. 3 Hours.
Presents basics of emerging areas in power electronics and a broad range of topics such as power switching devices, electric power conversion techniques and analysis, as well as their applications. Students may not receive credit for both ELEG 5543 and ELEG 4543. Prerequisite: ELEG 2114 and ELEG 3214. (Typically offered: Irregular)

ELEG 4553. Switch Mode Power Conversion. 3 Hours.
Basic switching converter topologies: buck, boost, buck-boost, Cuk, flyback, resonant; pulse-width modulation; integrated circuit controllers; switching converter design case studies; SPICE analyses of switching converters; state-space averaging and linearization; and switching converter transfer functions. Prerequisite: ELEG 3224 and ELEG 3124. (Typically offered: Irregular)

ELEG 4563. EMI in Power Electronics Converters: Generation, Propagation and Mitigation. 3 Hours.
Concepts of electro-magnetic-interference issues in power electronics converters. Basic concepts of EMI measurement, modeling and mitigation, with a focus on conducted EMI in power electronics converters. The course is structured with lectures and a lab session. Students can not receive credit for both ELEG 4563 and ELEG 5563. Prerequisite: ELEG 2104 or equivalent and MATH 2574. (Typically offered: Irregular)

ELEG 4603. Deterministic Digital Signal Processing System Design. 3 Hours.
Design of Digital Signal Processing systems with deterministic inputs. Sampling, quantizing, oversampling, ADC trade-offs, distortion, equalizers, anti-aliasing, coherency, frequency domain design, audio and video compression. Prerequisite: ELEG 3124. (Typically offered: Irregular)

ELEG 4623. Communication Systems. 3 Hours.
Various modulation systems used in communications. AM and FM fundamentals, pulse modulation, signal to noise ratio, threshold in FM, the phase locked loop, matched filter detection, probability of error in PSK, FSK, and DPSK. The effects of quantization and thermal noise in digital systems. Information theory and coding. Pre- or Corequisite: ELEG 3143. (Typically offered: Irregular)

ELEG 4703. Introduction to RF and Microwave Design. 3 Hours.
An introduction to microwave design principles. Transmission lines, passive devices, networks, impedance matching, filters, dividers, and hybrids will be discussed in detail. Active microwave devices will also be introduced. In addition, the applications of this technology as it relates to radar and communications systems will be reviewed. Prerequisite: ELEG 3704. (Typically offered: Irregular)

ELEG 4703H. Honors Introduction to RF and Microwave Design. 3 Hours.
An introduction to microwave design principles. Transmission lines, passive devices, networks, impedance matching, filters, dividers, and hybrids will be discussed in detail. Active microwave devices will also be introduced. In addition, the applications of this technology as it relates to radar and communications systems will be reviewed. Prerequisite: ELEG 3704. (Typically offered: Irregular)

This course is equivalent to ELEG 4703.
ELEG 4773. Electronic Response of Biological Tissues. 3 Hours.
Understand the electric and magnetic response of biological tissues with particular reference to neural and cardiovascular systems. Passive and active forms of electric signals in cell communication. We will develop the central electrical mechanisms from the membrane channel to the organ, building on those excitation, dielectric models for tissue behavior, Debye, Cole-Cole models. Role of bound and free water on tissue properties. Magnetic response of tissues. Experimental methods to measure tissue response. Applications to Electrocardiography & Electroencephalography, Microwave Medical Imaging, RF Ablation will be discussed that are common to many electrically active cells in the body. Analysis of Nernst equation, Goldman equation, linear cable theory, and Hodgkin-Huxley Model of action potential generation and propagation. High frequency response of tissues to microwave. Prerequisite: ELEG 3704 or equivalent; MATH 2584 or equivalent; basic Biology. (Typically offered: Irregular)

ELEG 4783. Introduction to Antennas. 3 Hours.
Basic antenna types: small dipoles, half wave dipoles, image theory, monopoles, small loop antennas. Antenna arrays: array factor, uniformly excited equally spaced arrays, pattern multiplication principles, nonuniformly excited arrays, phased arrays. Use of MATLAB programming and mathematical techniques for antenna analysis and design. Emphasis will be on using simulation to visualize variety of antenna radiation patterns. Corequisite: Drill component. Prerequisite: ELEG 3704. (Typically offered: Irregular)

ELEG 4783H. Honors Introduction to Antennas. 3 Hours.
Basic antenna types: small dipoles, half wave dipoles, image theory, monopoles, small loop antennas. Antenna arrays: array factor, uniformly excited equally spaced arrays, pattern multiplication principles, nonuniformly excited arrays, phased arrays. Use of MATLAB programming and mathematical techniques for antenna analysis and design. Emphasis will be on using simulation to visualize variety of antenna radiation patterns. Corequisite: Drill component. Prerequisite: ELEG 3704. (Typically offered: Irregular)

ELEG 487V. Special Topics in Electrical Engineering. 1-3 Hour.
Consideration of current electrical engineering topics not covered in other courses. Prerequisite: Senior standing. (Typically offered: Irregular) May be repeated for up to 6 hours of degree credit.

ELEG 487VH. Honors Special Topics in Electrical Engineering. 1-3 Hour.
Consideration of current electrical engineering topics not covered in other courses. Prerequisite: Senior standing. (Typically offered: Irregular) May be repeated for up to 6 hours of degree credit.

ELEG 488V. Special Problems. 1-3 Hour.
Individual study and research on a topic mutually agreed to the student and a faculty member. Prerequisite: Senior standing. (Typically offered: Fall, Spring and Summer) May be repeated for up to 3 hours of degree credit.

ELEG 488VH. Honors Special Problems. 1-3 Hour.
Individual study and research on a topic mutually agreed to the student and a faculty member. Prerequisite: Senior standing. (Typically offered: Irregular)

ELEG 4914. Advanced Digital Design. 4 Hours.
To master advanced logic design concepts, including the design and testing of synchronous and asynchronous combinational and sequential circuits using state of the art CAD tools. Students may not receive credit for both ELEG 4914 and ELEG 5914. Corequisite: Lab component. Prerequisite: ELEG 2904 or CSCE 2114. (Typically offered: Irregular)

ELEG 4914H. Honors Advanced Digital Design. 4 Hours.
To master advanced logic design concepts, including the design and testing of synchronous and asynchronous combinational and sequential circuits using state of the art CAD tools. Students may not receive credit for both ELEG 4914H and ELEG 5914. Corequisite: Lab component. Prerequisite: ELEG 2904 or CSCE 2114. (Typically offered: Irregular)

This course is cross-listed with ELEG 4914, CSCE 4914.

ELEG 4963. CPLD/FPGA Based System Design. 3 Hours.
Field Programmable logic devices (FPGAs/CPLDs) have become extremely popular as basic building blocks for digital systems. They offer a general architecture that users can customize by inducing permanent or reversible physical changes. This course will deal with the implementation of logic options using these devices. Corequisite: Lab component. Prerequisite: ELEG 4914. (Typically offered: Irregular)

This course is cross-listed with CSCE 4353.

ELEG 4963H. Honors CPLD/FPGA Based System Design. 3 Hours.
Field Programmable logic devices (FPGAs/CPLDs) have become extremely popular as basic building blocks for digital systems. They offer a general architecture that users can customize by inducing permanent or reversible physical changes. This course will deal with the implementation of logic options using these devices. Corequisite: Lab component. Prerequisite: ELEG 4914. (Typically offered: Irregular)

This course is cross-listed with ELEG 4963, CSCE 4353.

ELEG 4983. Computer Architecture. 3 Hours.
Design of a single board computer including basic computer organization, memory subsystem design, peripheral interfacing, DMA control, interrupt control, and bus organization. Prerequisite: ELEG 3924. (Typically offered: Irregular)

This course is cross-listed with CSCE 4213.

ELEG 5173L. Digital Signal Processing Laboratory. 3 Hours.
Use of DSP integrated circuits. Lectures, demonstrations, and projects. DSP IC architectures and instruction sets. Assembly language programming. Development tools. Implementation of elementary DSP operations, difference equations, transforms and filters. Prerequisite: ELEG 3124. (Typically offered: Irregular)

ELEG 5193L. Advanced DSP Processors Laboratory. 3 Hours.
Familiarization with, and use of, advanced DSP processors. Parallel processor configurations, timing consideration, specialized programming techniques, and complex pipelines. Prerequisite: ELEG 5173L. (Typically offered: Irregular)

ELEG 5203. Semiconductor Devices. 3 Hours.
Crystal properties and growth of semiconductors, energy bands and charge carriers in semiconductors, excess carriers in semiconductors, analysis and design of p/n junctions, analysis and design of bipolar junction transistors, and analysis and design of field-effect transistors. Students may not receive credit for both ELEG 4203 and ELEG 5203. Prerequisite: Graduate standing. (Typically offered: Irregular)

ELEG 5213. Integrated Circuit Fabrication Technology. 3 Hours.
Theory and techniques of integrated circuit fabrication technology; crystal growth, chemical vapor deposition, impurity diffusion, oxidation, ion implantation, photolithography and medulization. Design and analysis of device fabrication using SUPREM and SEDAN. In-process analysis techniques. Student review papers and presentations on state of the art fabrication and device technology. Prerequisite: ELEG 4203 or ELEG 5203. (Typically offered: Irregular)

ELEG 5223. Design and Fabrication of Solar Cells. 3 Hours.
Solar insolation and its spectral distribution/ p-n junction solar cells in dark and under illumination; solar cell parameters efficiency limits and losses; standard cell technology; energy accounting; design of silicon solar cells using simulation; fabrication of designed devices in the lab and their measurements. Students cannot receive credit for both ELEG 4223 and ELEG 5223. Prerequisite: ELEG 4203 or ELEG 5203. (Typically offered: Irregular)
ELEG 5243L. Microelectronic Fabrication Techniques and Procedures. 3 Hours.
The Thin-Film Fabrication course is designed to prepare students to use the thin-film equipment and processes available at the Engineering Research Center's thin-film cleanroom. The process modules to be trained on include lithography, metal deposition and etching, oxide deposition, growth and etching, reactive dry etching, tantalum anodization, photodefined spin-on dielectric and electroplating. The related metrology modules include microscope inspection, spectrophotometric measurement of oxide, profilometry and four-point probe measurements. Prerequisite: ELEG 5273. (Typically offered: Irregular)

ELEG 5253L. Integrated Circuit Design Laboratory I. 3 Hours.
Design and layout of large scale digital integrated circuits. Students design, check, and simulate digital integrated circuits which will be fabricated and tested in I.C. Design Laboratory II. Topics include computer-aided design, more in-depth coverage of topics from ELEG 4233, and design of very large scale chips. Prerequisite: ELEG 4233 or ELEG 5923. (Typically offered: Irregular)
This course is cross-listed with CSCE 5253L.

ELEG 5273. Electronic Packaging. 3 Hours.
An introductory treatment of electronic packaging, from single chip to multichip, including materials, substrates, electrical design, thermal design, mechanical design, package modeling and simulation, and processing considerations. Credit cannot be earned for both MEEG 5273 and ELEG 5273. Prerequisite: Graduate standing. (Typically offered: Irregular)
This course is cross-listed with MEEG 5273.

ELEG 5283. Mixed Signal Test Engineering II. 3 Hours.
Focus calibrations, DAC testing, ADC testing, DIB design, Design for Test, Data Analysis, and Test Economics. Prerequisite: ELEG 4283. (Typically offered: Irregular)

ELEG 5293L. Integrated Circuits Fabrication Laboratory. 3 Hours.
Experimental studies of silicon oxidation, solid-state diffusion, photolithographical materials and techniques, bonding and encapsulation. Fabrication and testing of PN diodes, NPN transistors and MOS transistors. Prerequisite: ELEG 5213. (Typically offered: Irregular)

ELEG 5313. Power Semiconductor Devices. 3 Hours.
Carrier transport physics; breakdown phenomenon in semiconductor devices; power bipolar transistors, thyristors, power junction field-effect transistors, power field-controlled diodes, power metal-oxide-semiconductor field-effect transistors, and power MOS-bipolar devices. Prerequisite: ELEG 4203 or graduate standing. (Typically offered: Irregular)

ELEG 5323. Semiconductor Nanostructures I. 3 Hours.
This course is focused on the basic theoretical and experimental analyses of low dimensional systems encountered in semiconductor heterojunctions and nanostructures with the emphasis on device applications and innovations. Prerequisite: ELEG 4203 or instructor permission. (Typically offered: Irregular)

ELEG 5333. Semiconductor Nanostructures II. 3 Hours.
This course is a continuation of ELEG 5323. It is focused on the transport properties, growth, electrical and optical properties of semiconductor nanostructures, and optoelectronic devices. Prerequisite: ELEG 5323 or instructor permission. (Typically offered: Irregular)

ELEG 5343. Organic Electronics Technology. 3 Hours.
Students become familiar with recent developments in and process technology for organic material based devices and sensors in the classroom, but also gain hands-on experience with fabrication processes using micro-fabrication tools in the lab. (Typically offered: Irregular)

ELEG 5353. Semiconductor Optoelectronic Devices. 3 Hours.
This course will provide graduate students a detailed background in semiconductor optoelectronic devices such as light emitting diodes and lasers, photodetectors, solar cells, modulators. The applications of these devices will also be discussed. Prerequisite: ELEG 4203 or ELEG 5203. (Typically offered: Spring Odd Years)

ELEG 5363. Semiconductor Material and Device Characterization. 3 Hours.
This course provides an overview of semiconductor characterization techniques in industry: Electrical measurements, Optical measurements, Electron and ion beam measurements, X-ray and probe measurements. Prerequisite: ELEG 4203 or ELEG 5203 and instructor consent. (Typically offered: Irregular)

ELEG 5383. Introduction of Integrated Photonics. 3 Hours.
This course is designed to provide junior and senior graduate students detailed knowledge of integrated photonics by using silicon photonics as an example. The course covers a cycle of design, fabrication, and testing of photonic devices by using analytic and numerical methods. The course will focus on designing an interferometer, which is widely used in communication and sensing applications. Students will be exposed to use the state-of-art design simulation tool, Lumerical, to design the photonic circuits and to evaluate the performances. In the course project, students will extend the design rules to design a set of components to be used for integrated microwave photonics based on Ge or Si on sapphire or Si3N4 on sapphire platform. Prerequisite: ELEG 4203 and ELEG 5353. (Typically offered: Irregular)

ELEG 5393. Electronic Materials. 3 Hours.
This is a lecture course designed to provide a fundamental introduction to materials science. Upon this fundamental basis, we will survey many of the properties and materials relevant to modern electronics. This course will cover semiconductors, but only briefly. The focus will be on properties and materials not generally well covered in other electrical engineering courses from a material's perspective. This will include, but not be limited to metals, dielectrics, and magnetic and optical materials. Prerequisite: Graduate standing. A knowledge of quantum mechanics is helpful but not required. (Typically offered: Spring)

ELEG 5403. Control Systems. 3 Hours.
Mathematical modeling of dynamic systems, stability analysis, control systems architectures and sensor technologies. Time-domain and frequency-domain design of feedback control systems: lead, lag, PID compensators. Special topics on microprocessor implementation. Credit not given for both ELEG 4403 and ELEG 5403. Prerequisite: Graduate standing or ELEG 3124. (Typically offered: Irregular)

ELEG 5413. Modern Control Systems. 3 Hours.
A second course in linear control systems. Emphasis on multiple-input and multiple-output systems: State-space analysis, similarity transformations, eigenvalue and eigenvector decomposition, stability in the sense of Lyapunov, controllability and observability, pole placement, quadratic optimization. Credit not given for both ELEG 4413 and ELEG 5413. Prerequisite: ELEG 5403 or equivalent. (Typically offered: Irregular)

ELEG 5423. Optimal Control Systems. 3 Hours.
Basic concepts, conditions for optimality, the minimum principle, the Hamilton Jacobi equation, structure and properties of optimal systems. Prerequisite: ELEG 4403 or graduate standing. (Typically offered: Irregular)

ELEG 5433. Digital Control Systems. 3 Hours.
Signal processing in continuous-discrete systems. System modeling using the z-transform and state-variable techniques. Analysis and design of digital control systems. Digital redesign for continuous control. Prerequisite: ELEG 4403 or graduate standing. (Typically offered: Irregular)

ELEG 5443. Nonlinear Systems Analysis and Control. 3 Hours.
Second-order nonlinear systems. Nonlinear differential equations. Approximate analysis methods. Lyapunov and input-output stability. Design of controllers, observers, and estimators for nonlinear systems. Prerequisite: ELEG 4403 or graduate standing. (Typically offered: Irregular)
ELEG 5453. Adaptive Filtering and Control. 3 Hours.

ELEG 5463. Biomedical Control Systems. 3 Hours.
Study of control systems analysis and design as applied to human physiological systems: Modeling and dynamics of biological processes, biomedical sensors, time and frequency domain analysis, identification of physiological systems. Overview of medical device regulations. Prerequisite: ELEG 4403 or graduate standing. (Typically offered: Irregular)

ELEG 5473. Power System Operation and Control. 3 Hours.
Study of the control and operation of electric power systems: Modeling, dynamics, and stability of three-phase power systems. Design and implementation of control systems related to generation and transmission. Overview of the related industry and government regulations for power system protection and reliability. Prerequisite: ELEG 4403 or graduate standing. (Typically offered: Irregular)

ELEG 5503. Design of Advanced Power Distribution Systems. 3 Hours.
ELEG 5503 Design of Advanced Power Distribution Systems. 3 credit hours. Design considerations of electric power distribution systems, including distribution transformer usage, distribution system protection implementation, primary and secondary networks design, applications of advanced equipment based on power electronics, and use of capacitors and voltage regulation. Students may not receive graduate credit for both ELEG 4503 and ELEG 5503. Prerequisite: ELEG 3304 or graduate standing. (Typically offered: Irregular)

ELEG 5513. Power Systems Analysis. 3 Hours.
Modeling and analysis of electric power systems: Energy sources and conversion; load flow analysis; reference frame transformations; symmetrical and unsymmetrical fault conditions; load forecasting and economic dispatch. Credit not given for both ELEG 4513 and ELEG 5513. Prerequisite: Graduate standing. (Typically offered: Irregular)

ELEG 5523. Electric Power Quality. 3 Hours.
The theory and analysis of electric power quality for commercial, industrial and residential power systems. Specific topics include harmonics, voltage sags, wiring and grounding, instrumentation, distributed generation and power electronic systems, and site surveys. Case studies complement the theoretical concepts. Prerequisite: ELEG 3304 or graduate standing. (Typically offered: Irregular)

ELEG 5533. Power Electronics and Motor Drives. 3 Hours.
Fundamentals of power electronics, diode bridge rectifiers, inverters, general concepts on motor drives, induction motor drives, synchronous motor drives, and dc motor drives. Students may not receive credit for both ELEG 4533 and ELEG 5533. Prerequisite: Graduate standing or ELEG 3224 and ELEG 3304. (Typically offered: Irregular)

ELEG 5543. Introduction to Power Electronics. 3 Hours.
Presents basics of emerging areas in power electronics and a broad range of topics such as power switching devices, electric power conversion techniques and analysis, as well as their applications. Students may not receive credit for both ELEG 5543 and ELEG 4543. Prerequisite: ELEG 2114 and ELEG 3214, or graduate standing. (Typically offered: Irregular)

ELEG 5553. Switch Mode Power Conversion. 3 Hours.
Basic switching converter topologies, control scheme of switching converters, simulation of switching converters, resonant converters, isolated converters, dynamic analysis of switching converters. Students will not receive graduate credit for both ELEG 4553 and ELEG 5553. Prerequisite: Graduate standing. (Typically offered: Irregular)

ELEG 5563. EMI in Power Electronics Converters: Generation, Propagation and Mitigation. 3 Hours.
Concepts of electro-magnetic-interference issues in power electronics converters. Basic concepts of EMI measurement, modeling and mitigation, with a focus on conducted EMI in power electronics converters. The course is structured with lectures and a lab session. Students can not receive credit for both ELEG 4563 and ELEG 5563. Prerequisite: Graduate standing. (Typically offered: Irregular)

ELEG 5613. Introduction to Telecommunications. 3 Hours.
Overview of public and private telecommunication systems; traffic engineering; communications systems basics, information technology, electromagnetics, and data transmission. Prerequisite: ELEG Graduate Standing or ELEG 3124. (Typically offered: Irregular)

ELEG 5623. Information Theory. 3 Hours.
Continuous and discrete source and channel models, measure of information, channel capacity, noisy-channel coding theorem, coding and decoding techniques. Prerequisite: ELEG 3143 or ELEG 4623 or graduate standing. (Typically offered: Irregular)

ELEG 5633. Detection and Estimation. 3 Hours.
Binary and multiple decisions for single and multiple observations; sequential, composite, and non-parametric decision theory; estimation theory; sequential, non-linear, and state estimation; optimum receiver principles. Prerequisite: Graduate standing. (Typically offered: Irregular)

ELEG 5653. Artificial Neural Networks. 3 Hours.
Fundamentals of artificial neural networks, both theory and practice. Teaches basic concepts of both supervised and unsupervised learning, and how they are implemented using artificial neural networks. Topics include the perceptron, back propagation, the competitive Hamming net, self-organizing feature maps, topological considerations, requirements for effective generalization, subpattern analysis, etc. Prerequisite: MATH 2584. (Typically offered: Irregular)

ELEG 5663. Communication Theory. 3 Hours.
Principles of communications. Channels and digital modulation. Optimum receivers and algorithms in the AWGN and fading channels. Coherent, non-coherent detectors and matched filters. Bounds on the performance of communications, and comparison of communications systems. Background in stochastic processes and probabilities, communication systems is desirable. Prerequisite: Graduate standing. (Typically offered: Irregular) May be repeated for degree credit.

ELEG 5693. Wireless Communications. 3 Hours.
Comprehensive course in fast developing field of wireless mobile/cellular personal telecommunications. Topics include cellular system structures, mobile radio propagation channels, etc. Prerequisite: Graduate standing. (Typically offered: Irregular)

ELEG 5703. RF & Microwave Design. 3 Hours.
An introduction to microwave design principles. Transmission lines, passive devices, networks, impedance matching, filters, dividers, and hybrids will be discussed in detail. Active microwave devices will also be introduced. In addition, the applications of this technology as it relates to radar and communications systems will be reviewed. Selected topics for device fabrication and measurements will be covered. Cannot get credit if student has taken ELEG 4703. Prerequisite: ELEG 3704. (Typically offered: Irregular)

ELEG 5723. Advanced Microwave Design. 3 Hours.
This course is an advanced course in microwave design building on the introduction to microwave design course. A detailed discussion of active devices, biasing networks, mixers, detectors, Microwave Monolithic Integrated Circuits (MMIC), and wideband matching networks will be provided. In addition, a number of advanced circuits will be analyzed. Prerequisite: ELEG 3704 and ELEG 4703 or ELEG 5703. (Typically offered: Irregular)
ELEG 5763. Advanced Electromagnetic Scattering & Transmission. 3 Hours.
Reflection and transmission of electromagnetic waves from a flat interface, the Poynting theorem, the complex and average power, the rectangular wave guides, TE and TM modes, radiation from antennas in free space and introduction to computational electromagnetics. Prerequisite: ELEG 3704. (Typically offered: Irregular)

ELEG 5773. Electronic Response of Biological Tissues. 3 Hours.
Understand the electric and magnetic response of biological tissues with particular reference to neural and cardiovascular systems. Passive and active forms of electric signals in cell communication. We will develop the central electrical mechanisms from the membrane channel to the organ, building on those that are common to many electrically active cells in the body. Analysis of Nernst equation, Goldman equation, linear cable theory, and Hodgkin-Huxley Model of action potential generation and propagation. High frequency response of tissues to microwave excitation, dielectric models for tissue behavior, Debye, Cole-Cole models. Role of bound and free water on tissue properties. Magnetic response of tissues. Experimental methods to measure tissue response. Applications to Electrocardiography & Electroencephalography, Microwave Medical Imaging, RF Ablation will be discussed. Students may not receive credit for both ELEG 4773 and ELEG 5773. Prerequisite: MATH 2584, ELEG 3704 or BIOL 2533 or equivalent. (Typically offered: Irregular)

ELEG 5783. Introduction to Antennas. 3 Hours.
Basic antenna types: small dipoles, half wave dipoles, image theory, monopoles, small loop antennas. Antenna arrays: array factor, uniformly excited equally spaced arrays, pattern multiplication principles, nonuniformly excited arrays, phased arrays. Use of MATLAB programming and mathematical techniques for antenna analysis and design. Emphasis will be on using simulation to visualize variety of antenna radiation patterns. Students cannot get credit for ELEG 5783 if they have taken ELEG 4783. Prerequisite: ELEG 3704. (Typically offered: Irregular)

ELEG 578V. Special Topics in Electrical Engineering. 1-3 Hour.
Consideration of current electrical engineering topics not covered in other courses. Prerequisite: Graduate standing. (Typically offered: Irregular) May be repeated for up to 3 hours of degree credit.

ELEG 588V. Special Problems. 1-6 Hour.
Opportunity for individual study of advanced subjects related to a graduate electrical engineering program to suit individual requirements. (Typically offered: Fall, Spring and Summer) May be repeated for up to 6 hours of degree credit.

ELEG 5903. Engineering Technical Writing. 3 Hours.
In this course, advanced graduate students (PhD candidates and selected MS students) will be trained in rephrasing and preparing technical papers, including scientific reports. Illustrations step by step will be explained. Each student is required to prepare technical papers based on their own research results and will be guided from selecting a title to a finished product. The emphasis will be placed on the structures of the articles including figures and table preparation, abstract writing, citations and references, and acknowledgments. The students will also be trained to prepare letters to the journals' editors and how to respond to reviewers' comments. Prerequisite: Graduate standing. (Typically offered: Fall)

ELEG 5914. Advanced Digital Design. 4 Hours.
To master advanced logic design concepts, including the design and testing of synchronous and asynchronous combinational and sequential circuits using state of the art CAD tools. Students may not receive credit for both ELEG 5914 and ELEG 4914 or CSCE 4914. Corequisite: Lab component. Prerequisite: ELEC 2904 or CSCE 2114. (Typically offered: Irregular)

ELEG 5923. Introduction to Integrated Circuit Design. 3 Hours.
Design and layout of large scale digital integrated circuits using CMOS technology. Topics include MOS devices and basic circuits, integrated circuit layout and fabrication, dynamic logic, circuit design, and layout strategies for large scale CMOS circuits. Students may not receive credit for both ELEG 4233 and ELEG 5923. Prerequisite: ELEG 3214 or ELEG 3933 and MATH 2584. (Typically offered: Fall)

ELEG 5993. Mixed-signal Modeling and Simulation. 3 Hours.
Study of basic analog, digital & mixed signal simulation solution methods. Modeling with hardware description languages. Use of state-of-the-art simulators and HDLs. Students may not receive credit for both ELEG 4293 and ELEG 5993. Prerequisite: ELEG 3224 or graduate standing. (Typically offered: Irregular)

ELEG 600V. Master's Thesis. 1-6 Hour.
Master's Thesis. Prerequisite: Graduate standing. (Typically offered: Fall, Spring and Summer) May be repeated for up to 6 hours of degree credit.

ELEG 6801. Graduate Seminar. 1 Hour.
Papers presented by candidates for the Doctor of Philosophy degree in electrical engineering on current research or design problems in the field of electrical engineering. (Typically offered: Fall, Spring and Summer)

ELEG 700V. Doctoral Dissertation. 1-18 Hour.
Doctoral Dissertation. (Typically offered: Fall, Spring and Summer) May be repeated for degree credit.