

# Electrical Engineering (ELEG)

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## Courses

### **ELEG 21001. Electric Circuits I Laboratory. 1 Hour.**

Experimental investigation of the steady-state behavior of resistive circuits excited by DC sources and transient behavior of simple R, L, and C circuits. Topics include fundamental laws of circuit theory applied to resistive networks and time response functions of R-L and R-C circuits. Corequisite: ELEG 21003. (Typically offered: Fall and Summer)

### **ELEG 21003. Electric Circuits I. 3 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: ELEG 21001. Pre- or Corequisite: MATH 25004 and PHYS 20404. Prerequisite: PHYS 20304. (Typically offered: Fall and Summer)

### **ELEG 21101. Electric Circuits II Laboratory. 1 Hour.**

Experimental investigation of the steady-state behavior of circuits excited by sinusoidal sources. Topics include complex power, three-phase circuits, transformers, and resonance. Corequisite: ELEG 21103. (Typically offered: Spring and Summer)

### **ELEG 21103. Electric Circuits II. 3 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: ELEG 21101. Pre- or Corequisite: MATH 25804. Prerequisite: ELEG 21003, ELEG 21001 and PHYS 20404. (Typically offered: Spring and Summer)

### **ELEG 2870V. 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 29004. 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 21104.

### **ELEG 31204. 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 25804. Corequisite: Lab component. Prerequisite: ELEG 21003 or ELEG 39003 or BMEG 29004. (Typically offered: Fall)

### **ELEG 312H4. 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 25804. Corequisite: Lab component. Prerequisite: ELEG 21003 or ELEG 39003 or BMEG 29004. (Typically offered: Fall) This course is equivalent to ELEG 31204.

### **ELEG 31403. 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. Prerequisite: ELEG 31204. Pre- or Corequisite: MATH 26004. (Typically offered: Spring)

### **ELEG 314H3. 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 31204. (Typically offered: Spring) This course is equivalent to ELEG 31403.

### **ELEG 32101. Electronics I Laboratory. 1 Hour.**

Experimental investigation into electronic circuit analysis concepts. Topics include: diode behavior and applications, zener diode regulator design, bipolar junction transistor biasing, BJT common-emitter amplifier design, and operational amplifier fundamentals. Corequisite: ELEG 32103. (Typically offered: Fall and Spring)

### **ELEG 32103. Electronics I. 3 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 26004 and ELEG 21103. Corequisite: ELEG 32101. Prerequisite: MATH 25804. (Typically offered: Fall and Spring)

### **ELEG 321H1. Honors Electronics I Laboratory. 1 Hour.**

Experimental investigation into electronic circuit analysis concepts. Topics include: diode behavior and applications, zener diode regulator design, bipolar junction transistor biasing, BJT common-emitter amplifier design, and operational amplifier fundamentals. Corequisite: ELEG 321H3. Prerequisite: Honors standing. (Typically offered: Fall and Spring) This course is equivalent to ELEG 32101.

### **ELEG 321H3. Honors Electronics I. 3 Hours.**

Introduction to electronic systems and signal processing, operational amplifiers, diodes, non-linear circuit applications, MOSFETS, and BJTs. Pre- or Corequisite: MATH 26004 and ELEG 21103. Corequisite: ELEG 321H1. Prerequisite: Honors standing and PHYS 20404. (Typically offered: Fall and Spring) This course is equivalent to ELEG 32103.

### **ELEG 32201. Electronics II Laboratory. 1 Hour.**

Selected experiments to illustrate and complement topics covered in companion course ELEG 32203 - Electronics II Laboratory. Corequisite: ELEG 32203. (Typically offered: Spring)

### **ELEG 32203. Electronics II. 3 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: ELEG 32201. Prerequisite: ELEG 32103 and ELEG 21103. (Typically offered: Spring)

### **ELEG 322H1. Honors Electronics II Laboratory. 1 Hour.**

Selected experiments to illustrate and complement topics covered in companion course ELEG 32203 - Electronics II Laboratory. Corequisite: ELEG 322H3. Prerequisite: Honors standing. (Typically offered: Spring) This course is equivalent to ELEG 32201.

### **ELEG 322H3. Honors Electronics II. 3 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: ELEG 322H1. Prerequisite: Honors standing, ELEG 32103 and MATH 25804. (Typically offered: Spring) This course is equivalent to ELEG 32203.

### **ELEG 33004. 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 21103. (Typically offered: Spring)

**ELEG 330H4. 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 21103.

(Typically offered: Spring)

This course is equivalent to ELEG 33004.

**ELEG 37004. 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 20404. Prerequisite: ELEG 21103 and MATH 26004. (Typically offered: Fall)

**ELEG 370H4. 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 20404 and MATH 26004. Prerequisite: ELEG 21103. (Typically offered: Fall)

This course is equivalent to ELEG 37004.

**ELEG 3870V. 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 39003. 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 25004 and PHYS 20404. (Typically offered: Fall and Spring)

**ELEG 39204. 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 29004. (Typically offered: Fall)

**ELEG 392H4. 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 29004. (Typically offered: Fall)

This course is equivalent to ELEG 39204.

**ELEG 39903. 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 25804 and PHYS 20404. (Typically offered: Spring)

**ELEG 400HV. Honors Senior Thesis. 1-3 Hour.**

Honors senior thesis. Prerequisite: Senior standing. (Typically offered: Fall, Spring and Summer)

**ELEG 40603. Electrical Engineering Design I. 3 Hours.**

Capstone design and application in electrical engineering. Prerequisite: ELEG 32203 and ELEG 39204. (Typically offered: Fall and Spring)

**ELEG 406H3. Honors Electrical Engineering Design I. 3 Hours.**

Design and application in electrical engineering. Prerequisite: ELEG 32203 and ELEG 39204. (Typically offered: Fall and Spring)

This course is equivalent to ELEG 40603.

**ELEG 40701. Electrical Engineering Design II. 1 Hour.**

Design and application in electrical engineering. Prerequisite: ELEG 40603. (Typically offered: Fall and Spring)

**ELEG 407H1. Honors Electrical Engineering Design II. 1 Hour.**

Design and application in electrical engineering. Prerequisite: ELEG 40603.

(Typically offered: Fall and Spring)

This course is equivalent to ELEG 40701.

**ELEG 42003. 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 42003 and ELEG 52003. Prerequisite: MATH 25804 and ELEG 32103, or graduate standing. (Typically offered: Irregular)

**ELEG 420H3. 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 42003 and ELEG 52003. Prerequisite: MATH 25804 and ELEG 32103, or graduate standing. (Typically offered: Irregular)

This course is equivalent to ELEG 42003.

**ELEG 42303. 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 42303 and ELEG 59203. Prerequisite: ELEG 32103 or ELEG 39903 and ELEG 29004 or equivalent. (Typically offered: Fall)

**ELEG 42403. 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 32203. (Typically offered: Irregular)

**ELEG 42503. Integrated Circuit Design Lab I. 3 Hours.**

This course will cover digital VLSI design and integrated circuit design tools. The course is structured with lectures. This course is offered to both senior undergraduate and graduate students. Students cannot get credit for both the undergraduate and graduate version of the course. Students cannot receive credit for both ELEG 42503 and ELEG 52503. Prerequisite: ELEG 42303 or ELEG 59203. (Typically offered: Spring)

**ELEG 42803. 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 43003. 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 42003. Prerequisite: ELEG 32103 and PHYS 20404. (Typically offered: Irregular) May be repeated for up to 6 hours of degree credit.

**ELEG 44003. 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 44003 and ELEG 54003. Prerequisite: ELEG 31204. (Typically offered: Irregular)

**ELEG 440H3. 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 44003 and ELEG 54003. Prerequisite: ELEG 31204. (Typically offered: Irregular)

**ELEG 44103. 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 44103 and ELEG 54103. Prerequisite: ELEG 44003 or equivalent course. (Typically offered: Irregular)

**ELEG 44203. 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 44003. (Typically offered: Irregular)

**ELEG 44603. 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 39204 and ELEG 31204. (Typically offered: Irregular)

**ELEG 45003. 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 45003 and ELEG 55003. Prerequisite: ELEG 33004. (Typically offered: Irregular)

**ELEG 45103. 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 45103 and ELEG 55103. Prerequisite: ELEG 21103. (Typically offered: Irregular)

**ELEG 45303. 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 45303 and ELEG 55303. Prerequisite: ELEG 33004 and ELEG 32203. (Typically offered: Irregular)

**ELEG 45403. 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 55403 and ELEG 45403. Prerequisite: ELEG 21103 and ELEG 32103. (Typically offered: Irregular)

**ELEG 45503. 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 32203 and ELEG 31204. (Typically offered: Irregular)

**ELEG 45603. 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 45603 and ELEG 55603. Prerequisite: ELEG 21003 or equivalent and MATH 26004. (Typically offered: Irregular)

**ELEG 45803. Programming for Power Electronics: DSPs. 3 Hours.**

This course will focus on the development of both theoretical and practical skills needed to design and implement controls for power electronic systems using a Digital Signal Processors (DSPs). The course is structured with lectures and utilizes a project-based approach. Students cannot receive credit for both ELEG 55803 and ELEG 45803. Prerequisite: Senior standing, ELEG 29004, ELEG 39204, and CSCE 20004. (Typically offered: Spring)

**ELEG 45903. Programming for Power Electronics: FPGA. 3 Hours.**

This course will focus on the development of both theoretical and practical skills needed to design and implement controls for power electronic system using Field Programmable Gate Arrays (FPGAs). The course is structured with lectures and utilizes a project-based approach. Students cannot receive credit for both ELEG 55903 and ELEG 45903. Prerequisite: Senior standing, ELEG 29004, ELEG 39204 and CSCE 20004. (Typically offered: Spring)

**ELEG 46003. 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 31204. (Typically offered: Irregular)

**ELEG 46203. 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, FKS, and DPSK. The effects of quantization and thermal noise in digital systems. Information theory and coding. Students may not receive credit for both ELEG 46203 and ELEG 56603. Pre- or Corequisite: ELEG 31403. (Typically offered: Irregular)

**ELEG 47003. 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 37004. (Typically offered: Irregular)

**ELEG 47803. 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 37004. (Typically offered: Irregular)

**ELEG 478H3. 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 37004. (Typically offered: Irregular)  
This course is equivalent to ELEG 47803.

**ELEG 4870V. 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 4880V. Special Problems. 1-3 Hour.**

Individual study and research on a topic mutually agreeable to the student and a faculty member. Prerequisite: Senior standing. (Typically offered: Fall, Spring and Summer) May be repeated for up to 6 hours of degree credit.

**ELEG 49603. 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: CSCE 21104 with "C" grade or higher. (Typically offered: Irregular)  
This course is cross-listed with CSCE 43503.

**ELEG 49803. 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 39204. (Typically offered: Irregular)  
This course is cross-listed with CSCE 42103.

**ELEG 51703. 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 31204. (Typically offered: Irregular)

**ELEG 52003. 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 42003 and ELEG 52003. Prerequisite: Graduate standing. (Typically offered: Irregular)

**ELEG 52103. 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 metallization. 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 42003 or ELEG 52003. (Typically offered: Irregular)

**ELEG 52203. 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. Prerequisite: ELEG 42003 or ELEG 52003. (Typically offered: Irregular)

**ELEG 52503. 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 42303, and design of very large scale chips. Prerequisite: ELEG 42303 or ELEG 59203. (Typically offered: Irregular)  
This course is cross-listed with CSCE 52503.

**ELEG 52703. 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. Prerequisite: Graduate standing in Electrical Engineering, Materials Science & Engineering, or Computer Engineering. (Typically offered: Irregular)

**ELEG 52903. 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 52103. (Typically offered: Irregular)

**ELEG 53003. 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 42003. Prerequisite: ELEG 32103 and PHYS 20404. (Typically offered: Irregular) May be repeated for up to 6 hours of degree credit.

**ELEG 53103. 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 42003 or graduate standing. (Typically offered: Irregular)

**ELEG 53203. 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 42003 or instructor permission. (Typically offered: Irregular)

**ELEG 53503. 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 42003 or ELEG 52003. (Typically offered: Spring Odd Years)

**ELEG 53603. 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 42003 or ELEG 52003 and instructor consent. (Typically offered: Irregular)



**ELEG 53703. Materials for Quantum Computing. 3 Hours.**

This course provides a survey of materials used in different implementations of quantum computing. The goal is to develop an operational understanding of the physical operation of a qubit using each of several methods, while gaining an understanding of the possible benefits as well as the complications of each. In addition to examining current material systems, the course will develop an understanding of very simple quantum computing algorithms, such that the materials studied have a context within the field. Prerequisite: Graduate standing. (Typically offered: Spring)

**ELEG 53803. 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 on Si, SiGeSn, or Si<sub>3</sub>N<sub>4</sub> on sapphire platform. Prerequisite: ELEG 42003 and ELEG 53503. (Typically offered: Irregular)

**ELEG 53903. 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 materials 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 54003. 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 44003 and ELEG 54003. Prerequisite: Graduate standing or ELEG 31204. (Typically offered: Irregular)

**ELEG 54103. 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 44103 and ELEG 54103. Prerequisite: ELEG 54003 or equivalent. (Typically offered: Irregular)

**ELEG 54203. Optimal Control Systems. 3 Hours.**

Conditions for optimality; calculus of variations; linear quadratic regulators; Kalman filter theory; H-infinity design. Prerequisite: ELEG 54103. (Typically offered: Irregular)

**ELEG 54403. Nonlinear Systems Analysis and Control. 3 Hours.**

Second-order nonlinear systems analysis; Describing function analysis; Lyapunov stability; Feedback linearization; Backstepping control; Sliding mode control; Model reference adaptive control. Prerequisite: ELEG 54103. (Typically offered: Irregular)

**ELEG 54703. 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 44003 or graduate standing. (Typically offered: Irregular)

**ELEG 55003. Design of Advanced 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 45003 and ELEG 55003. Prerequisite: ELEG 33004 or graduate standing. (Typically offered: Irregular)

**ELEG 55103. 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 45103 and ELEG 55103. Prerequisite: Graduate standing. (Typically offered: Irregular)

**ELEG 55203. 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 33004 or graduate standing. (Typically offered: Irregular)

**ELEG 55303. 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 45303 and ELEG 55303. Prerequisite: Graduate standing or ELEG 32203 and ELEG 33004. (Typically offered: Irregular)

**ELEG 55403. 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 55403 and ELEG 45403. Prerequisite: ELEG 21103 and ELEG 32103, or graduate standing. (Typically offered: Irregular)

**ELEG 55503. 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 45503 and ELEG 55503. Prerequisite: Graduate standing. (Typically offered: Irregular)

**ELEG 55603. 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 45603 and ELEG 55603. Prerequisite: Graduate standing. (Typically offered: Irregular)

**ELEG 55803. Programming for Power Electronics: DSPs. 3 Hours.**

This course will focus on the development of both theoretical and practical skills needed to design and implement controls for power electronic systems using a Digital Signal Processors (DSPs). The course is structured with lectures and utilizes a project-based approach. Students cannot receive credit for both the undergraduate (ELEG 45803) and graduate version (ELEG 55803) of the course. Prerequisite: Graduate Standing. (Typically offered: Spring)

**ELEG 55903. Programming for Power Electronics: FPGA. 3 Hours.**

This course will focus on the development of both theoretical and practical skills needed to design and implement controls for power electronic systems using a Field Programmable Gate Arrays (FPGAs) to implement these control algorithms. The course is structured with lectures and utilizes a project-based approach. Students cannot receive credit for both the undergraduate (ELEG 45903) and graduate (ELEG 55903) version of the course. Prerequisite: Graduate Standing. (Typically offered: Spring)

**ELEG 56603. 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. Students may not receive credit for both ELEG 46203 and ELEG 56603. Prerequisite: Graduate standing. (Typically offered: Irregular) May be repeated for degree credit.

**ELEG 56903. 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 57003. 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 47003. Prerequisite: ELEG 37004. (Typically offered: Irregular)

**ELEG 57203. 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 37004 and ELEG 47003 or ELEG 57003. (Typically offered: Irregular)

**ELEG 57603. 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 37004. (Typically offered: Irregular)

**ELEG 57803. 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 57803 if they have taken ELEG 47803. Prerequisite: ELEG 37004. (Typically offered: Irregular)

**ELEG 5870V. 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 5880V. 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 59003. 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 59203. 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 42303 and ELEG 59203. Prerequisite: ELEG 32103 or ELEG 39903 and MATH 25804. (Typically offered: Fall)

**ELEG 59503. Semiconductor Device and IC ESD Reliability. 3 Hours.**

This course will cover semiconductor device and IC ESD design. The course is structured with lecture sessions and is offered to graduate students. The objective of this course is for students to understand semiconductor device and IC ESD design. Students will be able to demonstrate understanding of the basic concepts of ESD on-chip and off-chip protection for ICs and the future trends in ESD protections for advanced and emerging ICs. Prerequisite: ELEG 59203. (Typically offered: Irregular)

**ELEG 59803. 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 39204. (Typically offered: Irregular)

**ELEG 6000V. 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 7000V. Doctoral Dissertation. 1-18 Hour.**

Doctoral Dissertation. (Typically offered: Fall, Spring and Summer) May be repeated for degree credit.