ELEG 4213. MEMS and Microsensors. 3 Hours.
The aim of this course is to teach the theory and developments in MEMS, microsensors, NEMS and smart devices and to train the students for the fabrication using microfabrication tools in the clean room. The students will design, fabricate and characterize a MEMS/Microsensor device during the lab hours at the HIDEC clean room. Prerequisite: Engineering student.

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.

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, nanoelectroelectronics and Nanomedicine. Prerequisite: Senior standing or instructor consent. 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.

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. May be repeated for up to 6 hours of degree credit.

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.

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.

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.

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

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. This course is cross-listed with 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. This course is cross-listed with CSCE 4213.

ELEG 5173L. Digital Signal Processing Laboratory. 3 Hours.

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.

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.

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.

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.

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.
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.
This course is cross-listed with CSCE 5253L.

ELEG 5263L. Integrated Circuit Design Laboratory II. 3 Hours.
Students test the I.C. chips they designed in I.C. Design Laboratory I and propose design corrections where needed. Topics include gate arrays, bipolar design, I2L, memory design, and microprocessor design. Prerequisite: ELEG 5253L.
This course is cross-listed with CSCE 5363L.

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. 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.

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.

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.

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.

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

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.

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.

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.

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 on Si, SiGeSn, or Si3N4 on sapphire platform. Prerequisite: ELEG 4203 and ELEG 5353.

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.

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.

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.

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.

ELEG 5443. Nonlinear Systems Analysis and Control. 3 Hours.

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.

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.
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.

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.

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.

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.

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.

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 5553 and ELEG 4553. Prerequisite: Graduate standing or ELEG 3224 and ELEG 3304.

ELEG 5563. 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. 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.

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.

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.

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.

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.

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.

ELEG 5801. Written and Oral Communication. 1 Hour.
This course is designed to improve the oral presentations and technical writing of graduate students. Emphasis is placed on writing journal articles, theses and dissertations, and on giving oral presentations at conferences and job interviews. Each student delivers a 20 minute PowerPoint presentation to other students in the class. Prerequisite: Readiness to begin writing thesis.
ELEG 587V. Special Topics in Electrical Engineering. 1-3 Hour.
Consideration of current electrical engineering topics not covered in other courses.
Prerequisite: Graduate standing. 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. 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.

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: ELEG 2904 or CSCE 2114.

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.

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.

ELEG 600V. Master's Thesis. 1-6 Hour.
Master's Thesis. Prerequisite: Graduate standing. 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.

ELEG 700V. Doctoral Dissertation. 1-18 Hour.
Doctoral Dissertation. May be repeated for degree credit.