Electrical Engineering (ELEG)

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Electrical Engineering Website (http://electrical-engineering.uark.edu/)

Degrees Conferred:
M.S.E.E. (ELEG)
Ph.D. in Engineering (ELEG)

Primary Areas of Faculty Research: Communications, digital signal processing and sensor networks; electronics and electronic packaging, analog and mixed signal, and integrated circuits; power systems, power electronics, renewable energy and control; RF and microwave, electromagnetics, antennas, and terahertz; semiconductors, nanotechnology, optoelectronics, photovoltaic and photonics

M.S.E.E. in Electrical Engineering

Requirements for Admission: A student must have a grade point average of at least 3.0 (based on a 4.0 system) on all undergraduate work, or a 3.0 average or above on the last 60 hours of undergraduate coursework.

Requirements for Graduate Degrees: In addition to the requirements of the Graduate School and the College of Engineering, the following departmental requirements must be satisfied by candidates for advanced degrees in electrical engineering.

1. Candidates for the Master of Science degree who present a thesis are required to complete a minimum of 24 semester hours of course work and six semester hours of thesis.
2. Candidates for the Master of Science degree who do not present a thesis are required to complete a minimum of 30 semester hours of course work.
3. Course work presented for the degree of Master of Science must include a minimum of 12 semester hours at the 5000- or 6000-level in electrical engineering. At least 15 (21 for non-thesis option) hours of the student's graduate course work must be ELEG courses. No more than six hours of ELEG 588V may be presented for degree credit.
4. Students who complete a B.S. degree in Electrical Engineering at the University of Arkansas, Fayetteville, with a GPA of 3.5 or greater may count towards the M.S. degree up to six hours of ELEG graduate-level coursework completed as an undergraduate student.
5. Students who are applying for the coursework-only M.S.E.E. degree through distance education may have the GRE requirement waived providing the student meets the following conditions. The student must meet the following three criteria:
   a. The student has passed an equivalent exam (like the Fundamentals of Engineering);
   b. The student has a B.S. degree in electrical engineering from an ABET-Accredited program, or already completed a graduate degree (M.Sc. or higher) in an engineering related field; and
   c. The student has at least one year of professional working experience after completing a baccalaureate degree.
6. Candidates for the M.S.E.E. degree must take an M.S. Readiness Assessment exam during their first semester of graduate work. This exam is administered by the student's major professor and advisory committee, and is designed to assess the student's undergraduate preparation for his or her graduate work. The student may be required to take whatever undergraduate courses are deemed necessary in addition to the graduate courses specified in items 1-3.
7. The M.S.E.E. degree includes a distance education option for which students complete most or all of their coursework using distance education courses. The use of this option is subject to approval by the student's major professor, and to the availability of sufficient distance education courses in the student's specialty areas to enable completion of the M.S.E.E.
8. The M.S.E.E. degree will allow transfer of up to nine credit hours of graduate level coursework from universities with which the University of Arkansas has a "1+1" M.S.E.E. exchange program. This is an exception to the Graduate School rule that only six hours may be transferred. Each course transferred must be graduate level, and must be approved for transfer by the Electrical Engineering Graduate Committee. The transferred courses will not count toward the M.S.E.E. requirement for 5000 or 6000 level ELEG courses.
9. Any other conditions as stipulated in the departmental guidelines for master's degrees.

Ph.D. in Electrical Engineering

In addition to the requirements of the graduate school, the program of study for the Ph.D. degree must satisfy the following:

1. The Ph.D. degree requires 36 hours of coursework, as follows:
   a. A student entering the Ph.D. program with a B.S.E.E. will be required to complete a minimum of 36 hours of graded coursework.
   b. A student entering the Ph.D. program with an M.S. degree will be required to complete a minimum of an additional 12 hours of graded coursework on the University of Arkansas, Fayetteville, campus.
   c. All Ph.D. students must complete a minimum of 12 hours of graded coursework on the University of Arkansas, Fayetteville, campus.
2. The course work specified in item 1a. must include a minimum of 30 hours of course work at the 5000 and 6000 level, and at least 24 of these 5000- and 6000-level hours must be in electrical engineering.
3. The course work specified in item 1a. must include EMGT 50303 , GRSD 50003 or MSEN 53803.
4. The doctoral program must include at least 72 hours of course work and thesis or dissertation hours. A maximum of six of these hours may be thesis hours. The remaining hours that are not course work must be dissertation. The Graduate School requires a minimum of 18 hours of dissertation for graduation.
5. Candidates for the Ph.D. degree must take a Ph.D. Readiness Assessment exam during their first semester of graduate work. This exam is administered by the student's major professor and advisory committee, and is designed to assess the student's readiness to conduct research during his or her graduate work. The student may

be required to take whatever undergraduate courses are deemed necessary in addition to the graduate courses specified above.

6. Students who are applying for the Ph.D. E.E. degree may have the GRE requirement waived providing the student obtained a B.S. degree from an ABET-Accredited program in the United States.
7. It is emphasized that the course work specified above represents minimums, and many students' programs will include more than this minimum, particularly if the student has an M.S.E.E. degree from a school that is not a recognized graduate school in the United States.

Graduate Faculty Courses

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 medullization. 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 Si3N4 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.