Department of Electrical & Computer Engineering

Electrical engineers develop and apply the theories of electricity, electronics and electromagnetics to analyze and design systems which generate or use electricity. Examples of such systems are those for power generation and transmission, computation, communication, automatic control and instrumentation. The devices that practicing engineers work with and design include integrated circuits (VLSI), waveguides, antennas, computers and other digital systems, rotating machines and motor drives, lasers and optical fibers.

The curriculum is designed to prepare the undergraduate for work in the highly diverse electrical engineering profession. A solid foundation in physics, chemistry and mathematics is used to support courses in the fundamentals of electrical engineering. The use of computers is integrated throughout the curriculum, and basic studies in circuits, electronics, electromagnetic fields and digital logic lead to a flexible program of electives in the junior and senior year. Electives may be chosen from the broad categories of controls/communications/signal processing, computer engineering, electronics, electro-physics/electro-optics/microwaves, power systems/power electronics, and biomedical imaging/sensing and systems. Laboratory work is structured to first familiarize the student with the basic concepts and then to apply these concepts to engineering problems.

Students who expect to enroll in electrical engineering after attending another college or university should note that there is a five-semester sequence of electrical engineering courses in the curriculum. If the prerequisites are satisfied, transfer students may complete this sequence in two years and one summer session.

Educational Program Objectives

Activities of the Electrical and Computer Engineering Department including research, teaching, and professional and community service revolve around the threefold mission of the department:

- To create new knowledge and challenge young minds by participation in the process of discovery and invention;
- To educate electrical and computer engineers with a solid background of fundamentals, stretching their imagination and preparing them for an exciting future;
- To serve the society through research, education and outreach activities.

Undergraduate education plays a major part in helping the department to achieve its mission. As such, the department has established a set of undergraduate educational program objectives which will help to insure that the mission of the department is upheld. These program objectives represent a concise, measurable set of descriptions of what the department is trying to accomplish through its undergraduate program. Furthermore, these objectives are designed to be observable in our graduates in a time window of two to five years after graduation from the program.

The Department of Electrical and Computer Engineering’s three Undergraduate Educational Program Objectives are as follows:

1. Objective 1—Graduates who choose to pursue a career in industry or government will become productive and valuable engineers.
2. Objective 2—Graduates who choose to pursue advanced degrees will be able to gain admission to graduate programs and will become successful graduate students.
3. Objective 3—In keeping with the legacy of an Aggie Engineer, graduates will be successful in attaining positions of leadership in their professional careers.

The extent to which the department is meeting these objectives is periodically assessed through such instruments as alumni surveys, employer/recruiter surveys, graduating senior surveys and Fundamentals of Engineering exam results. Our goal is to continually improve the program’s ability to meet these educational objectives. The electrical engineering curriculum and individual course contents are periodically evaluated and adjusted in order to further support our ability to achieve the program objectives. The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org. More information on these efforts can be found at the Department of Electrical and Computer Engineering (http://engineering.tamu.edu/electrical) website by clicking on the link for ABET Accreditation. The department welcomes comments and suggestions from any interested individuals regarding the above program objectives and/or how the department can better meet these objectives.

Before commencing course work in the major, students must be admitted to the major or have the approval of the department.

Faculty

Ali, Dallia, Lecturer
Electrical & Computer Eng
PHD, Alexandria University, 1997

Annapareddy, Narasimha, Professor
Electrical & Computer Eng
PHD, University of Illinois, 1990

Balog, Robert, Associate Professor
Electrical & Computer Eng
PHD, University of Illinois at Urbana-Champaign, 2006

Begovic, Miroslav, Professor
Electrical & Computer Eng
DEN, Virginia Polytechnic Institute, 2014

Bhattacharyya, S, Professor
Electrical & Computer Eng
PHD, Rice University, 1971

Booshard, John, Lecturer
Electrical & Computer Eng
PHD, Texas A&M University, 2012

Braga Neto, Associate Professor
Electrical & Computer Eng
PHD, John Hopkins University, 2002

Butler-Purry, Karen, Professor
Electrical & Computer Eng
PHD, Howard University, 1994

Cantrell, Pierce, Associate Professor
Electrical & Computer Eng
PHD, Georgia Institute of Technology, 1981
Chamberland-Tremblay, Jean-Francois, Associate Professor
Electrical & Computer Eng
PhD, University of Illinois, 2004

Chang, Kai, Professor
Electrical & Computer Eng
PhD, University of Michigan, 1976

Cheng, Xing, Associate Professor
Electrical & Computer Eng
PhD, University of Michigan, 2005

Choi, Seong, Associate Professor
Electrical & Computer Eng
PhD, University of Illinois at Urbana-Champaign, 1994

Cui, Shuguang, Professor
Electrical & Computer Eng
PhD, Stanford University, 2005

Datta, Aniruddha, Professor
Electrical & Computer Eng
PhD, University of Southern California, 1991

Deshpande, Yateendra, Lecturer
Electrical & Computer Eng
PHD, Texas A&M University, 2014

Dougherty, Edward, Distinguished Professor
Electrical & Computer Eng
PhD, Rutgers State University of New Jersey, 1974

Duffield, Nicholas, Professor
Electrical & Computer Eng
PhD, Queen Mary College, Univ. of London, 1987

Ehsani, Mehrdad, Professor
Electrical & Computer Eng
PhD, University of Wisconsin-Madison, 1981

Eknoyan, Ohannes, Professor
Electrical & Computer Eng
PhD, Columbia University, 1975

Enjeti, Prasad, Professor
Electrical & Computer Eng
PhD, Concordia University, Montreal, Canada, 1984

Entesari, Kamran, Associate Professor
Electrical & Computer Eng
PhD, University of Michigan, 2006

Georghiades, Costas, Professor
Electrical & Computer Eng
DSc, Washington University in St. Louis, 1985

Gratz, Paul, Associate Professor
Electrical & Computer Eng
PhD, University of Texas, 2008

Han, Arum, Associate Professor
Electrical & Computer Eng
PhD, Georgia Institute of Technology, 2005

Harris, Harlan, Associate Professor
Electrical & Computer Eng
PhD, Texas Tech University, 2003

Hemmer, Philip, Professor
Electrical & Computer Eng
PhD, Massachusetts Institute of Technology, 1984

Hou, I-Hong, Assistant Professor
Electrical & Computer Eng
PhD, University of Illinois, 2011

Hoyos, Sebastian, Associate Professor
Electrical & Computer Eng
PhD, University of Delaware, 2004

Hu, Jiang, Professor
Electrical & Computer Eng
PhD, University of Minnesota, 2001

Huang, Garng, Professor
Electrical & Computer Eng
DSc, Washington University in St. Louis, 1980

Huff, Gregory, Associate Professor
Electrical & Computer Eng
PhD, University of Illinois, 2006

Ji, Jim, Associate Professor
Electrical & Computer Eng
PhD, University of Illinois, 2003

Kameoka, Jun, Associate Professor
Electrical & Computer Eng
PhD, Cornell University, 2002

Karsilayan, Aydin, Associate Professor
Electrical & Computer Eng
PhD, Portland State University, 2000

Kezunovic, Mladen, Professor
Electrical & Computer Eng
PhD, University of Kansas, 1980

Khatri, Sunil, Professor
Electrical & Computer Eng
PhD, University of California, Berkeley, 1999

Kish, Laszlo, Professor
Electrical & Computer Eng
PhD, Uppsala University, Sweden, 1994

Kumar, Panganamala, Distinguished Professor
Electrical & Computer Eng
DSc, Washington University in St. Louis, 1977

Kundur, Deepa, Associate Professor
Electrical & Computer Eng
PhD, University of Toronto, 1999

Li, Peng, Professor
Electrical & Computer Eng
PhD, Carnegie Mellon University, 2003
Liu, Tie, Associate Professor
Electrical & Computer Eng
PhD, University of Illinois, 2006

Lu, Mi, Professor
Electrical & Computer Eng
PhD, Rice University, 1987

Madsen, Christi, Professor
Electrical & Computer Eng
PhD, Rutgers State University of New Jersey, 1996

Michalski, Krzysztof, Associate Professor
Electrical & Computer Eng
PhD, University of Kentucky, 1981

Miller, Scott, Professor
Electrical & Computer Eng
PhD, University of California, San Diego, 1988

Narayanan, Krishna, Professor
Electrical & Computer Eng
PhD, Georgia Institute of Technology, 1998

Nevels, Robert, Professor
Electrical & Computer Eng
PhD, University of Central Florida, 1990

Nguyen, Cam, Professor
Electrical & Computer Eng
PhD, University of Central Florida, 1990

Palermo, Samuel, Associate Professor
Electrical & Computer Eng
PhD, Stanford University, 2007

Pfister, Henry, Associate Professor
Electrical & Computer Eng
PhD, University of California, San Diego, 2003

Qaraqe, Khalid, Professor
Electrical & Computer Eng
PhD, Texas A&M University, 1997

Qian, Xiaoning, Assistant Professor
Electrical & Computer Eng
PhD, Yale University, 2005

Rahimian, Mina, Senior Lecturer
Electrical & Computer Eng
PhD, Texas A&M University, 2011

Rentzepts, Peter, Professor
Electrical & Computer Eng
PhD, University of Cambridge, 1963

Righetti, Raffaella, Associate Professor
Electrical & Computer Eng
PhD, University of Houston, 2005

Russell, Billy, Distinguished Professor
Electrical & Computer Eng
PhD, University of Oklahoma, 1975

Sanchez-Sinencio, E, Professor
Electrical & Computer Eng
PhD, University of Illinois, 1973

Savari, Serap, Associate Professor
Electrical & Computer Eng
PhD, Massachusetts Institute of Technology, 1996

Serpedin, Erchin, Professor
Electrical & Computer Eng
PhD, University of Virginia, 1999

Shakkottai, Srinivas, Associate Professor
Electrical & Computer Eng
PhD, University of Illinois, 2007

Shi, Weiping, Professor
Electrical & Computer Eng
PhD, University of Illinois, 1992

Silva-Martinez, Jose, Professor
Electrical & Computer Eng
PhD, Katholieke Universiteit Leuven, 1992

Singh, Chanan, Professor
Electrical & Computer Eng
PhD, University of Saskatchewan, 1972

Sprintson, Alexander, Associate Professor
Electrical & Computer Eng
PhD, Israel Institute of Technology, 2003

Su, Chin, Professor
Electrical & Computer Eng
PhD, Brandeis University, 1979

Sundqvist, Kyle, Visiting Assistant Professor
Electrical & Computer Eng
PhD, University of California - Berkeley, 2012

Thatte, Anupam, Lecturer
Electrical & Computer Eng
PhD, Texas A&M University, 2014

Toliyat, Hamid, Professor
Electrical & Computer Eng
PhD, University of Wisconsin-Madison, 1991

Tyler, John, Senior Lecturer
Electrical & Computer Eng
PhD, University of Central Texas, 1979

Villareal, Samuel, Senior Lecturer
Electrical & Computer Eng
PhD, Texas A&M University, 1999

Wang, Haiyan, Professor
Electrical & Computer Eng
PhD, North Carolina State University, 2002

Wright, Steven, Professor
Electrical & Computer Eng
PhD, University of Illinois, 1984
Xie, Le, Associate Professor  
Electrical & Computer Eng  
PhD, Carnegie Mellon University, 2009

Xiong, Zixiang, Professor  
Electrical & Computer Eng  
PhD, University of Illinois, 1996

Yoon, Byung-Jun, Assistant Professor  
Electrical & Computer Eng  
PHD, California Institute of Technology, 2007

Yu, Peng, Assistant Professor  
Electrical & Computer Eng  
PhD, University of Texas, 2009

Zhang, Xi, Professor  
Electrical & Computer Eng  
PhD, University of Michigan, 2002

Zou, Jun, Associate Professor  
Electrical & Computer Eng  
PhD, University of Illinois, 2002

**Majors**

- Bachelor of Science in Computer Engineering, Electrical Engineering Track
- Bachelor of Science in Electrical Engineering

**Minors**

- Electrical Engineering Minor

**Courses**

**ECEN 214 Electrical Circuit Theory**  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Resistive circuits: circuit laws, network reduction, nodal analysis, mesh analysis; energy storage elements; sinusoidal steady state; AC energy systems; magnetically coupled circuits; the ideal transformer; resonance; introduction to computer applications in circuit analysis.  
**Prerequisites:** ENGR 111, ENGR 112, PHYS 208, CHEM 107, CHEM 117 with a grade of C or better; MATH 308 with a grade of C or better or registration therein; admission to electrical and computer engineering.

**ECEN 215 Principles of Electrical Engineering**  
Credits 3. 2 Lecture Hours. 2 Lab Hours.  
Fundamentals of electric circuit analysis and introduction to electronics for engineering majors other than electrical and computer engineering.  
**Prerequisites:** ENGR 111, ENGR 112, PHYS 208, CHEM 107, CHEM 117 with a grade of C or better; MATH 308 with a grade of C or better or registration therein; admission to an engineering major.

**ECEN 222/CSCE 222 Discrete Structures for Computing**  
Credits 3. 3 Lecture Hours.  
Provide mathematical foundations from discrete mathematics for analyzing computer algorithms, for both correctness and performance; introduction to models of computation, including finite state machines and Turing machines.  
**Prerequisite:** MATH 151.  
**Cross Listing:** CSCE 222/ECEN 222.

**ECEN 248 Introduction to Digital Systems Design**  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Combinational and sequential digital system design techniques; design of practical digital systems.  
**Prerequisite:** ENGR 111, ENGR 112, PHYS 208, CHEM 107, CHEM 117, MATH 152 with a grade of C or better; admission to electrical and computer engineering.

**ECEN 285 Directed Studies**  
Credits 1 to 4. 1 to 4 Other Hours.  
Problems of limited scope approved on an individual basis intended to promote independent study.  
**Prerequisite:** Approval of department head.

**ECEN 289 Special Topics in...**  
Credits 1 to 4. 1 to 4 Other Hours.  
Selected topics in an identified area of electrical engineering. May be repeated for credit.  
**Prerequisite:** Approval of instructor.

**ECEN 291 Research**  
Credits 1 to 4. 1 to 4 Other Hours.  
Research conducted under the direction of faculty member in electrical engineering. May be repeated 3 times for credit.  
**Prerequisites:** Freshman or sophomore classification and approval of instructor.

**ECEN 303 Random Signals and Systems**  
Credits 3. 3 Lecture Hours. 1 Lab Hour.  
Concepts of probability and random variables necessary for study of signals and systems involving uncertainty; applications to elementary problems in detection, signal processing and communication.  
**Prerequisites:** Grade of C or better in MATH 308; junior or senior classification.

**ECEN 314 Signals and Systems**  
Credits 3. 3 Lecture Hours.  
Introduction to the continuous-time and discrete-time signals and systems; time domain characterization of linear time-invariant systems; Fourier analysis; filtering; sampling; modulation techniques for communication systems.  
**Prerequisites:** Grade of C or better in ECEN 214; MATH 308; junior or senior classification.

**ECEN 322 Electric and Magnetic Fields**  
Credits 3. 3 Lecture Hours. 1 Lab Hour.  
Vector analysis, Maxwell's equations, wave propagation in unbounded regions, reflection and refraction of waves, transmission line theory; introduction to waveguides and antennas.  
**Prerequisites:** ECEN 214, PHYS 208, and MATH 311 with a grade of C or better; junior or senior classification.

**ECEN 325 Electronics**  
Credits 4. 3 Lecture Hours. 4 Lab Hours.  
Introduction to electronic systems; linear circuits; operational amplifiers and applications; diodes, field effect transistors, bipolar transistors; amplifiers and nonlinear circuits.  
**Prerequisite:** MATH 311 with a grade of C or better; ECEN 314 with a grade of C or better, or registration therein.
ECEN 326 Electronic Circuits
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Basic circuits used in electronic systems; differential and multistage amplifiers; output stages and power amplifiers; frequency response, feedback circuits, stability and oscillators, analog integrated circuits, active filters.
Prerequisites: Grade of C or better in ECEN 314 and ECEN 325; junior or senior classification.

ECEN 338 Electromechanical Energy Conversion
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Introduction to magnetic circuits, transformers, electromechanical energy conversion devices such as dc, induction and synchronous motors; equivalent circuits, performance characteristics and power electronic control.
Prerequisite: ECEN 214.

ECEN 403 Electrical Design Laboratory I
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Application of design process and project engineering as practiced in industry; team approach to the design process; development of a project proposal; proposed project implemented in ECEN 404.
Prerequisites: COMM 205 or COMM 243 or ENGL 210; grade of C or better in ECEN 314, ECEN 325, ECEN 350/CSCE 350; grade of C or better in ECEN 303, ECEN 322, ECEN 370 or grade of C or better in CSCE 315, ECEN 449, STAT 211 or ECEN 303; senior classification.

ECEN 404 Electrical Design Laboratory II
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Continuation of ECEN 403; application of the design process and project engineering as practiced in industry; team approach to the design process; completion of project based on proposal from ECEN 403; includes testing, evaluation and report writing.
Prerequisites: Grade of C or better in ECEN 403; senior classification.

ECEN 405 Electrical Design Laboratory
Credits 3. 1 Lecture Hour. 6 Lab Hours.
Introduction to the design process and project engineering as practiced in industry; student teams apply the design process by developing a project from proposal through test and evaluation.
Prerequisites: ENGL 210 or 301, completion of selected major field courses, senior classification and project approval.

ECEN 410 Medical Imaging
Credits 4. 3 Lecture Hours. 2 Lab Hours.
Fundamentals of physics and the engineering principles of medical imaging systems; focus on magnetic resonance imaging, x-ray computer tomography, ultrasonography, optical imaging and nuclear medicine; includes systems, sources, energy tissue interaction, image formation and clinical examples; virtual labs, on- and off-campus lab tours.
Prerequisites: Grade of C or better in MATH 222 or MATH 251 or MATH 253; ECEN 444 or grade of C or better in ECEN 314; junior or senior classification.

ECEN 411 Introduction to Magnetic Resonance Imaging and Magnetic Resonance Spectroscopy
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Introduction to the basic physics of magnetic resonance, the principles of MR imaging and spectroscopy, the major contrast mechanisms in MRI and MR imaging system hardware; development of pulse sequences for different imaging methods, including flow and spectroscopic imaging; will build RF coils.
Prerequisites: Grade of C or better in MATH 251 and PHYS 208; junior or senior classification.

ECEN 412 Ultrasound Imaging
Credits 3. 2 Lecture Hours.
Mathematical analysis of wave propagation, scattering of ultrasound in biological tissues, electronic transducer arrays for the beam forming, models of the received signals and signal processing methods for medical ultrasound imaging of tissues; includes discussions of research related to fundamental ultrasound imaging concepts.
Prerequisites: Grade of C or better in ECEN 314; junior or senior classification.

ECEN 414 Biosensors
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Hands-on lab experience in the development of miniaturized biosensors; includes microfluidic devices for biosensing.
Prerequisite: Senior classification or approval of instructor.

ECEN 415 Physical and Economical Operations of Sustainable Energy Systems
Credits 3. 3 Lecture Hours.
Operational issues for sustainable electric energy systems; basic relevant topics in engineering, optimization and economic concepts; modular view of individual electric energy processing components; physical and market operations in electricity industry in support of sustainable energy integration; computer simulations and demonstrations to create and evaluate examples of power systems.
Prerequisites: Grade of C or better in ECEN 214; ECEN 420; ECEN 460; junior or senior classification.

ECEN 419 Genomic Signal Processing
Credits 3. 3 Lecture Hours.
Fundamentals of molecular biology; application of engineering principles to systems biology; topics include unearthing intergene relationships, carrying out gene-based classification of disease, modeling genetic regulatory networks, and altering their dynamic behavior.
Prerequisites: Grade of C or better in ECEN 314; junior or senior classification.
ECEN 420 Linear Control Systems  
Credits 3. 3 Lecture Hours.  
Application of state variable and frequency domain techniques to modeling, analysis and synthesis of single input, single output linear control systems.  
**Prerequisites:** Grade of C or better in ECEN 314 and MATH 308; junior or senior classification.

ECEN 421 Digital Control Systems  
Credits 3. 3 Lecture Hours.  
Feedback systems in which a digital computer is used to implement the control law; Z-transform and time domain methods serve as a basis for control systems design. Effects of computer word length and sampling rate.  
**Prerequisite:** ECEN 420 or equivalent.

ECEN 422 Control Engineering and Design Methodology  
Credits 3. 2 Lecture Hours. 3 Lab Hours.  
Modeling, specifications, rating and operating principles of sensors, actuators and other control system components; experiments on conceptual design, simulation and physical implementation of control systems.  
**Prerequisite:** ECEN 420 or equivalent.

ECEN 424 Fundamentals of Networking  
Credits 3. 3 Lecture Hours.  
Foundations of computer networking; layered architecture of the Internet, analysis of protocols, new-age networks such as the Web and social networks; computer network programming and offline analysis of real network data.  
**Prerequisites:** Grade of C or better in ECEN 303 or STAT 211; junior or senior classification.

ECEN 425 Radio Frequency and Microwave Engineering  
Credits 3. 3 Lecture Hours.  
Fundamental Radio Frequency (RF) and microwave circuit analysis: scattering and ABCD matrices, return loss, insertion loss; transmission lines, lumped elements, impedance matching; theory, analysis and design of basic RF and microwave passive circuits; use of commercial CAD programs for RF and microwave circuit design and simulation.  
**Prerequisites:** Grade of C or better in ECEN 322; junior or senior classification.

ECEN 430 Optimization for Electrical and Computer Engineering Applications  
Credits 3. 3 Lecture Hours.  
Principles of optimization including linear and nonlinear optimization as well as electrical and computer engineering applications in signal estimation, routing in communication networks, flows in wireless networks, wafer fabrication plants, and economic dispatch in power systems.  
**Prerequisites:** Grade of C or better in MATH 304 or MATH 309 or MATH 311; grade of C or better in MATH 251; junior or senior classification.

ECEN 438 Power Electronics  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Electric power conditioning and control; characteristics of solid state power switches; analysis and experiments with AC power controllers, controlled rectifiers, DC choppers and DC-AC converters; applications to power supplies, airborne and spaceborne power systems.  
**Prerequisite:** Junior or senior classification in electrical engineering or approval of instructor.

ECEN 440 Introduction to Thin Film Science and Technology  
Credits 3. 3 Lecture Hours. 1 Lab Hour.  
The course focuses on the thin film technology in semiconductor industry; topics include the basic growth mechanisms for thin films (growth models, lattice matching epitaxy and domain matching epitaxy), the instrumental aspects of different growth techniques and advanced topics related to various applications.  
**Prerequisites:** Junior or senior classification.

ECEN 441 Electronic Motor Drives  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Application of semiconductor switching power converters to adjustable speed DC and AC motor drives; steady state theory and analysis of electric motion control in industrial, robotic and traction systems; laboratory experiments in power electronic motor drives and their control.  
**Prerequisite:** Junior or senior classification in electrical engineering.

ECEN 442 DSP Based Electromechanical Motion Control  
Credits 3. 2 Lecture Hours. 3 Lab Hours.  
Overview of energy conversion and basic concepts on electromechanical motion devices; different control strategies including the solid-state drive topologies; for every electromechanical motion device, its DSP control implementation discussed and implemented in the lab.  
**Prerequisites:** Grade of C or better in ECEN 314; junior or senior classification.

ECEN 444 Digital Signal Processing  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Digital signal processing; discrete-time signals and systems, linear shift-invariant systems, the discrete Fourier transform and fast Fourier transform algorithm, and design of finite impulse response and infinite impulse response digital filters.  
**Prerequisites:** Grade of C or better in ECEN 314; junior or senior classification.

ECEN 445 Applied Electromagnetic Theory  
Credits 3. 3 Lecture Hours.  
Guided wave and wireless methods; applications of Maxwell’s equations and electromagnetic wave phenomena to radiation, antennas and microwave circuit design; digital transmission line analysis and design.  
**Prerequisites:** Grade of C or better in ECEN 322; junior or senior classification.

ECEN 447 Digital Image Processing  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Improvement of pictorial information using spatial and frequency domain techniques; two-dimensional discrete Fourier transform; image filtering, enhancement, restoration, compression; image processing project.  
**Prerequisites:** Grade of C or better in ECEN 314; junior or senior classification.

ECEN 448 Real-Time Digital Signal Processing  
Credits 3. 2 Lecture Hours. 3 Lab Hours.  
Features and architectures of digital signal processing (DSP) chips; fundamental compromises amongst computational accuracy, speed and cost; real-time implementation of filtering, audio, image and video processing algorithms; rapid prototyping via MATLAB/Simulink.  
**Prerequisites:** ECEN 444; junior or senior classification.
ECEN 449 Microprocessor Systems Design
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Introduction to microprocessors; 16/32 bit single board computer hardware and software designs; chip select equations for memory board design, serial and parallel I/O interfacing; ROM, static and dynamic RAM circuits for no wait-state design; assembly language programming, stack models, subroutines and I/O processing.
Prerequisites: Grade of C or better in ECEN 248; junior or senior classification.

ECEN 451 Antenna Engineering
Credits 3. 3 Lecture Hours.
Introduction to antenna theory and design; includes antenna performance parameters, analysis of radiation from sources using Maxwell's equations, theory and design of wire antennas, arrays and frequency independent antennas; computer methods for antenna design.
Prerequisite: Grade of C or better in ECEN 322; junior or senior classification.

ECEN 452 Ultra High Frequency Techniques
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Introduction to theory and practice of ultra high frequency radio wave generation, transmission and radiation; application of Maxwell's equations to transmission of electrical energy in wave guides.
Prerequisites: ECEN 322; ECEN 351 or registration therein.

ECEN 453 Microwave Solid-State Circuits and Systems
Credits 3. 3 Lecture Hours.
Microwave solid-state devices and circuits; theory and design of various types of active circuits; applications of these devices and circuits in radar, communication and surveillance systems.
Prerequisites: Grade of C or better in ECEN 322; junior or senior classification.

ECEN 454 Digital Integrated Circuit Design
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Analysis and design of digital devices and integrated circuits using MOS and bipolar technologies and computer aided simulation.
Prerequisites: Grade of C or better in ECEN 214 and ECEN 248; junior or senior classification.

ECEN 455 Digital Communications
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Digital transmission of information through stochastic channels; analog-to-dialog conversion, entropy and information, Huffman coding; signal detection, the matched-filter receiver, probability of error; baseband and passband modulation, signal space representation of signals, PAM, QAM, PSK, FSK; block coding, convolutional coding; synchronization; communication through fading channels; spread-spectrum signaling; simulation of digital communication systems.
Prerequisites: Grade of C or better in ECEN 314; junior or senior classification.

ECEN 457 Operational Amplifiers
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Analysis of basic operational amplifier and operational transconductance amplifier (OTA) circuits; noise analysis in Op amp and OTA circuits; nonlinear OTA and Op amp circuits; instrumentation amplifiers; transducer circuits; function generators; oscillators and D/A converters and basics of switched-capacitor circuits.
Prerequisite: Grade of C or better in ECEN 325; junior or senior classification.

ECEN 458 Active Filter Analysis and Design
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Systematic analysis and design for active RC filters; continuous-time; switched-capacitor circuits; filter approximations; synthesis techniques; sensitivity; practical considerations for monolithic integrated filters; experimental and computer-simulation verification.
Prerequisite: Grade of C or better in ECEN 325; junior or senior classification.

ECEN 459 Power System Fault Analysis and Protection
Credits 4. 3 Lecture Hours. 2 Lab Hours.
General considerations in transmission and distribution of electrical energy as related to power systems; calculation of electric transmission line constants; general theory of symmetrical components and application to analysis of power systems during fault conditions.
Prerequisite: Grade of C or better in ECEN 215 or ECEN 314; junior or senior classification.

ECEN 460 Power System Operation and Control
Credits 4. 3 Lecture Hours. 2 Lab Hours.
Load flow studies; power system transient stability studies; economic system loading and automatic load flow control.
Prerequisite: Grade of C or better in ECEN 215 or ECEN 314; junior or senior classification.

ECEN 462 Optical Communication Systems
Credits 3. 3 Lecture Hours.
Principles of optical communication systems; characteristics of optical fibers, lasers and photodetectors for use in communication systems; design of fiber-optic digital systems and other optical communication systems.
Prerequisites: Grade of C or better in ECEN 322 and ECEN 370; junior or senior classification.

ECEN 464 Optical Engineering
Credits 3. 3 Lecture Hours.
Ray optics; wave optics; propagation, reflection, refraction and diffraction of light; passive optical components, polarization, optical modulators, interferometers and lasers.
Prerequisites: Grade of C or better in ECEN 322 and ECEN 370; junior or senior classification.

ECEN 465 Operational Optics
Credits 4. 2 Lecture Hours. 7 Lab Hours.
Systematic study of experimental optical techniques; opto-mechanical assemblies; passive optics; interferometers; opto-electronics; basic op-amp circuits; feedback and control of optics with electronics.
Prerequisite: Junior or senior classification or approval of instructor.

ECEN 468 Advanced Digital System Design
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Design, modeling and verification of complex digital systems using hardware description language and electronic system level language.
Prerequisite: Grade of C or better in ECEN 248; junior or senior classification.
ECEN 472 Microelectronic Circuit Fabrication  
**Credits 4. 3 Lecture Hours. 3 Lab Hours.**
Fundamentals of MOS and bipolar microelectronic circuit fabrication; theory and practice of diffusion, oxidation, ion implantation, photolithography, etch; yield and reliability considerations; statistical process control; integrated process design, simulation and characterization.  
**Prerequisites:** Grade of C or better in ECEN 325 and ECEN 370; junior or senior classification.

ECEN 473 Microelectronic Device Design  
**Credits 3. 3 Lecture Hours.**
General processes for the fabrication of microelectronic devices and integrated circuits; a review of the electronic properties of semiconductors and carrier transport and recombination; analysis and characterization of p-n junctions, bipolar transistors, and MOS capacitors and transistors; design considerations for achieving optimum performance and practical structures are discussed.  
**Prerequisites:** Grade of C or better in ECEN 325 and ECEN 370; junior or senior classification.

ECEN 474 VLSI Circuit Design  
**Credits 4. 3 Lecture Hours. 3 Lab Hours.**
Analysis and design of monolithic analog and digital integrated circuits using NMOS, CMOS and bipolar technologies; device modeling; CAD tools and computer-aided design; design methodologies for LSI and VLSI scale circuits; yield and economics; test and evaluation of integrated circuits.  
**Prerequisite:** ECEN 326.

ECEN 475 Introduction to VLSI Systems Design  
**Credits 4. 3 Lecture Hours. 3 Lab Hours.**
Introduction to design and fabrication of microelectronic circuits; emphasis on very large scale integration (VLSI) digital systems; use of state-of-the art design methodologies and tools; design of small to medium scale integrated circuits for fabrication.  
**Prerequisites:** Grade of C or better in ECEN 248 and ECEN 325; junior or senior classification.

ECEN 477 Photonics: Fiber and Integrated Optics  
**Credits 4. 3 Lecture Hours. 3 Lab Hours.**
Photonics lab including optical power and spectral measurements of singlemode and multimode optical fibers, hands-on arc fusion splicing, lasers, amplifiers, interferometers, photodetectors, integrated optics, fiber-optic devices, optical modulators.  
**Prerequisite:** Grade of C or better in ECEN 322 and ECEN 370; junior or senior classification.

ECEN 478 Wireless Communications  
**Credits 3. 3 Lecture Hours.**
Overview of wireless applications, models for wireless communication channels, modulation formats for wireless communications, multiple access techniques, wireless standards.  
**Prerequisites:** ECEN 455; junior or senior classification.

ECEN 480 RF and Microwave Wireless Systems  
**Credits 3. 3 Lecture Hours.**
Introduction to various RF and microwave system parameters, architectures and applications; theory, implementation, and design of RF and microwave systems for communications, radar, sensor, surveillance, navigation, medical and optical applications.  
**Prerequisite:** Grade of C or better in ECEN 322; junior or senior classification.

ECEN 485 Directed Studies  
**Credits 1 to 6. 1 to 6 Other Hours.**
Problems of limited scope approved on an individual basis intended to promote independent study.  
**Prerequisites:** Senior classification; approval of department head.

ECEN 489 Special Topics in...  
**Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 7 Lab Hours.**
Selected topics in an identified area of electrical engineering. May be repeated for credit.  
**Prerequisite:** Approval of instructor.

ECEN 491 Research  
**Credits 1 to 4. 1 to 4 Other Hours.**
Research conducted under the direction of faculty member in electrical engineering. May be repeated 3 times for credit. Registration in multiple sections of this course is possible within a given semester provided that the per semester credit hour limit is not exceeded.  
**Prerequisites:** Junior or senior classification and approval of instructor.