ELECTRICAL AND COMPUTER ENGINEERING (ECEN)

ECEN 8006 ELECTRONIC INSTRUMENTATION (3 credits)
Applications of analog and digital devices to electronic instrumentation. Includes transducers, instrumentation amplifiers, mechanical and solid state switches, data acquisition systems, phase-lock loops, and modulation techniques. Demonstrations with working circuits and systems. (Cross-listed with ECEN 4000)
Prerequisite(s)/Corequisite(s): Senior Standing in Engineering or Permission. Not open to non-degree graduate students.

ECEN 8066 POWER SYSTEMS ANALYSIS (3 credits)
Symmetrical components and fault calculations, power system stability, generator modeling (circuit view point), voltage control system, high voltage DC transmission, and system protection. (Cross-listed with ECEN 4060)
Prerequisite(s)/Corequisite(s): ECEN 3380. Not open to non-degree graduate students.

ECEN 8076 POWER SYSTEMS PLANNING (3 credits)
Economic evaluation, load forecasting, generation planning, transmission planning, production simulation, power plant reliability characteristics, and generation system reliability. (Cross-listed with ECEN 4070)
Prerequisite(s)/Corequisite(s): ECEN 3050. Not open to non-degree graduate students.

ECEN 8086 ENGINEERING ELECTROMAGNETICS (3 credits)
Applied electromagnets: Transmission lines in digital electronics and communication. The quasistatic electric and magnetic fields; electric and magnetic circuits and electromechanical energy conversion. Guided waves; rectangular and cylindrical metallic waveguides and optical filters. Radiation and antennas: line and aperture antennas and arrays. (Cross-listed with ECEN 4080)
Prerequisite(s)/Corequisite(s): ECEN 3060. Not open to non-degree graduate students.

ECEN 8106 MULTIVARIATE RANDOM PROCESSES (3 credits)
Probability space, random vectors, multivariate distributions, moment generating functions, conditional expectations, discrete and continuous-time random processes, random process characterization and representation, linear systems with random inputs. (Cross-listed with ECEN 4100)
Prerequisite(s)/Corequisite(s): ECEN 3050. Not open to non-degree graduate students.

ECEN 8150 DIGITAL IMAGE PROCESSING (3 credits)
Topics covering the spatial and spectral analysis of digital image processing systems, the design of multi-dimensional digital filters and systems, and advanced theories and technologies in digital image processing systems.
Prerequisite(s)/Corequisite(s): ECEN 4240 or ECEN 8246 or permission.

ECEN 8166 MATERIALS AND DEVICES FOR COMPUTER MEMORY, LOGIC, AND DISPLAY (3 credits)
Survey of fundamentals and application of devices used for memory, logic, and display. Magnetic, superconductive, semi-conductive, and dielectric materials. (Cross-listed with ECEN 4160)
Prerequisite(s)/Corequisite(s): PHYS 2120, not open to non-degree graduate students.

ECEN 8176 SEMICONDUCTOR FUNDAMENTALS II (3 credits)
Analysis of BJTs and MOSFET'S from a first principle materials viewpoint. Statics and dynamic analysis and characterization. (Cross-listed with ECEN 4170.)
Prerequisite(s)/Corequisite(s): ECEN 4210 or ECEN 8216. Not open to non-degree graduate students.

ECEN 8206 PLASMA PROCESSING OF SEMICONDUCTORS (3 credits)
Physics of plasmas and gas discharges developed. Includes basic collisional theory, the Boltzmann equation and the concept of electron energy distribution. Results are related to specific gas discharge systems used in semiconductor processing, such as sputtering, etching, and deposition systems. (Cross-listed with ECEN 4200)
Prerequisite(s)/Corequisite(s): Senior or graduate Standing. Not open to non-degree graduate students.

ECEN 8216 PRINCIPLES OF SEMICONDUCTOR MATERIALS AND DEVICES I (3 credits)
Introduction to semiconductor fundamentals, charge carrier concentration and carrier transport, energy bands, and recombination. PN junction, static and dynamic, and special PN junction diode devices. (Cross-listed with ECEN 4210)
Prerequisite(s)/Corequisite(s): PHYS 2130. Not open to non-degree graduate students.

ECEN 8246 DIGITAL SIGNAL PROCESSING (3 credits)
The temporal and spectral analysis of digital signals and systems, the design of digital filters and systems, and advanced systems including multi-rate digital signal processing techniques. (Cross-listed with ECEN 4240)
Prerequisite(s)/Corequisite(s): ECEN 3550

ECEN 8266 POWER ELECTRONICS (3 credits)
Basic analysis and design of solid-state power electronic devices and converter circuitry. (Cross-listed with ECEN 4280)
Prerequisite(s)/Corequisite(s): ECEN 3040, ECEN 3160.

ECEN 8306 WIND ENERGY (3 credits)
This broad multidisciplinary course will combine engineering principles of both the mechanical/aerodynamical and electrical components and systems, along with economic and environmental considerations for siting and public policy, to appropriately cover the relevant topics associated with all scales of wind energy implementations. (Cross-listed with ECEN 4300)
Prerequisite(s)/Corequisite(s): Senior standing or permission.

ECEN 8336 MICROPROCESSOR SYSTEM DESIGN (4 credits)
Microprocessor based systems. Architecture; design and interfacing. Memory design, input/output ports, serial communications, and interrupts. Generating assembly ROM code, assembly/C firmware generation, and designing device drivers. (Cross-listed with ECEN 4330)
Prerequisite(s)/Corequisite(s): ECEN 3100 with grade of C or better and ECEN 3320 with grade of C or better.

ECEN 8356 EMBEDDED MICROCONTROLLER DESIGN (4 credits)
Microcontroller architecture; design, programming, and interfacing for embedded systems. Timing issues, memory interfaces, serial and parallel interfacing, and functions for common microcontrollers. (Cross-listed with ECEN 4360)
Prerequisite(s)/Corequisite(s): ECEN 4330/8336, STAT 3800. Pre-or co-req: CSCI 4500.

ECEN 8366 ELECTRIC MACHINES (3 credits)
Provides a solid background in electric machine analysis, covering fundamental concepts, techniques, and methods for analysis and design. Discussion of transformers and presentation of some new systems and applications. (Cross-listed with ECEN 4160)
Prerequisite(s)/Corequisite(s): PHYS 2120 and ECEN 2160

ECEN 8376 PARALLEL AND DISTRIBUTED PROCESS (3 credits)
Parallel and Distributed Processing concepts, principles, techniques and machines. Cross-listed with ECEN 4370.
Prerequisite(s)/Corequisite(s): ECEN 4350 or ECEN 8366

ECEN 8426 BASIC ANALYTICAL TECHNIQUES IN ELECTRICAL ENGINEERING (3 credits)
Applications of partial differential equations, matrices, vector analysis, complex variables, and infinite series to problems in electrical engineering. (Cross-listed with ECEN 4420)
Prerequisite(s)/Corequisite(s): MATH 2350. Not open to non-degree graduate students.
**ECEN 8446 LINEAR CONTROL SYSTEMS (3 credits)**
Classical (transfer function) and modern (state variable) control techniques. Both time domain and frequency domain techniques are studied. Traditional, lead, lag, and PID compensators are examined, as well as state variable feedback. (Cross-listed with ECEN 4440)
Prerequisite(s)/Corequisite(s): ECEN 3040. Not open to non-degree graduate students.

**ECEN 8486 DECISION ANALYSIS (3 credits)**
Principles of engineering economy including time value of money, net present value, and internal rate of return. Use of influence diagram and decision tree to structure and analyze decision situations under uncertainty including use of stochastic dominance, value of information, and utility theory. Fundamentals of two-person matrix games including Nash equilibrium. (Cross-listed with ECEN 4480)
Prerequisite(s)/Corequisite(s): ECEN 3050 or STAT 3800

**ECEN 8506 BIOINFORMATICS (3 credits)**
This course examines how information is organized in biological sequences such as DNA and proteins and will look at computational techniques which make use of this structure. During this class various biochemical processes that involve these sequences are studied to understand how these processes effect the structure of these sequences. In the process bioinformatics algorithms, tools, and techniques which are used to explore genomic and amino acid sequences are also introduced. (Cross-listed with ECEN 4500)
Prerequisite(s)/Corequisite(s): Computer programming language and ECEN 3050 or STAT 3800 or equivalent.

**ECEN 8516 INTRODUCTION TO VLSI SYSTEM DESIGN (3 credits)**
The concepts, principles, and methodology at all levels of digital VLSI system design and focused on gate-level VLSI implementation. (Cross-listed with ECEN 4510).
Prerequisite(s)/Corequisite(s): ECEN 3100

**ECEN 8526 INTRODUCTION TO COMPUTER-AIDED DIGITAL DESIGN (3 credits)**
The concepts, simulation techniques and methodology in computer-aided digital design at system and logic levels. (Cross-listed with ECEN4520)
Prerequisite(s)/Corequisite(s): ECEN 3100

**ECEN 8536 COMPUTATIONAL AND SYSTEMS BIOLOGY (3 credits)**
Provides the required biology primer and covers fundamental genomics, transcriptomics, differential expression, clustering, classification, prediction, biomarker discovery, pathway analysis and network based approaches to high throughput biological data analysis. Includes the development of databases, algorithms, web-based and other tools regarding management and analysis of life science data. Areas of study include DNA, RNA, and protein sequence analysis, functional genomics and proteomics, 3D macromolecule structure prediction, and systems/network approach. (Cross-listed with ECEN 4530).
Prerequisite(s)/Corequisite(s): ECEN 3050 or STAT 3800

**ECEN 8546 POWER SYSTEMS OPERATION AND CONTROL (3 credits)**
Characteristics and generating units. Control of generation, economic dispatch, transmission losses, unit commitment, generation with limited supply, hydrothermal coordination, and interchange evaluation and power pool. (Cross-listed with ECEN 4540)
Prerequisite(s)/Corequisite(s): ECEN 8386. Not open to non-degree graduate students.

**ECEN 8566 TELECOMMUNICATION ENGINEERING I (4 credits)**
Prerequisite(s)/Corequisite(s): ECEN 3620; ECEN 4610/8616 prior to or concurrent.

**ECEN 8656 INTRODUCTION TO DATA COMPRESSION (3 credits)**
Introduction to the concepts of Information Theory and Redundancy removal. Simulation of various data compression schemes such as Delta Modulation, Differential Pulse Code Modulation, Transform Coding and Runlength Coding. (Cross-listed with ECEN 4650)
Prerequisite(s)/Corequisite(s): ECEN 3050. Not open to non-degree graduate students.

**ECEN 8666 TELECOMMUNICATION ENGINEERING II (3 credits)**
Prerequisite(s)/Corequisite(s): ECEN 3620; ECEN 4610/8616 prior to or concurrent.

**ECEN 8676 ELECTROMAGNETIC THEORY AND APPLICATIONS (3 credits)**
Engineering application of Maxwell’s equations. Fundamental Parameters of Antennas, Radiation analysis, and synthesis of antenna arrays. Aperture Antennas. (Cross-listed with ECEN 4670)
Prerequisite(s)/Corequisite(s): ECEN 3060. Not open to non-degree graduate students.

**ECEN 8686 MICROWAVE ENGINEERING (3 credits)**
Applications of active and passive devices to microwave systems. Includes impedance matching, resonators, and microwave antennas. (Cross-listed with ECEN 4680)
Prerequisite(s)/Corequisite(s): ECEN 3060. Not open to non-degree graduate students.

**ECEN 8696 ANALOG INTEGRATED CIRCUITS (3 credits)**
Analysis and design of analog integrated circuits both bipolar and MOS. Basic circuit elements such as differential pairs, current sources, active loads, output drivers used in the design of more complex analog integrated circuits. (Cross-listed with ECEN 4690)
Prerequisite(s)/Corequisite(s): ECEN 3610. Not open to non-degree graduate students.

**ECEN 8706 DIGITAL AND ANALOG VLSI DESIGN (3 credits)**
Introduction to VLSI design techniques for analog and digital circuits. Fabrication technology and device modeling. Design rules for integrated circuit layout. LSI design options with emphasis on the standard cell approach of digital and analog circuits. Lab experiments, computer simulation and layout exercises. (Cross-listed with ECEN 4700)
Prerequisite(s)/Corequisite(s): ECEN 3610. Not open to non-degree graduate students.
ECEN 8716 COMPUTER COMMUNICATION NETWORKS (4 credits)
This course investigates the standard protocols and hardware solutions defined by the International Standard Organization (ISO) and Institute of Electrical and Electronics Engineers (IEEE) for the computer communications networks. Included are ISO OSI model, IEEE 802.X (Ethernet, token bus, taken ring) and Asynchronous Transfer Modes (ATM) networks. (Cross-listed with ECEN 4710)  
Prerequisite(s)/Corequisite(s): ECEN 3250

ECEN 8736 MOBILE AND PERSONAL COMMUNICATIONS (4 credits)
Concepts on mobile and personal communications. Modulation techniques for mobile radio, equalization, diversity, channel coding, and speech coding. (Cross-listed with ECEN 4730)
Prerequisite(s)/Corequisite(s): ECEN 3250

ECEN 8746 DIGITAL SYSTEMS (3 credits)
Synthesis using state machines; design of digital systems; micro programming in small controller design; hardware description language for design and timing analysis. (Cross-listed with ECEN 4740)  
Prerequisite(s)/Corequisite(s): ECEN 3700. Not open to non-degree graduate students.

ECEN 8756 SATELLITE COMMUNICATIONS (4 credits)
The fundamental concepts of satellite communications. Orbits, launching satellites, modulation and multiplexing, multiple access, earth stations, coding, interference and special problems in satellite communications. (Cross-listed with ECEN 4750)  
Prerequisite(s)/Corequisite(s): ECEN 3520

ECEN 8766 WIRELESS COMMUNICATIONS (3 credits)
The fundamental concepts of wireless communications. Basic communications concepts such as multiple access, and spectrum. Propagation, radio, standards, and internetworking. Current issues in wireless communications. (Cross-listed with ECEN 4760)  
Prerequisite(s)/Corequisite(s): ECEN 3250 or ECEN 4620 prior to or concurrent

ECEN 8776 DIGITAL SYSTEMS ORGANIZATION AND DESIGN (3 credits)
Hardware development languages, hardware organization and realization, microprogramming, interrupt, intersystem communication, and peripheral interfacing. (Cross-listed with ECEN 4770)  
Prerequisite(s)/Corequisite(s): ECEN 4750 or ECEN 8746. Not open to non-degree graduate students.

ECEN 8796 OPTICAL FIBER COMMUNICATIONS (4 credits)
Fundamentals of lightwave communication in optical fiber waveguides, physical description of fiber optic systems. Properties of the optical fiber and fiber components. Electro-optic devices: light sources and modulators, detectors and amplifiers; optical transmitter and receiver systems. Fiber optic link design and specification; fiber optic networks. (Cross-listed with ECEN 4790)
Prerequisite(s)/Corequisite(s): ECEN 4630.

ECEN 8806 INTRODUCTION TO LASERS AND LASER APPLICATIONS (3 credits)
Physics of electronic transition production stimulated emission of radiation. Threshold conditions for laser oscillation. Types of lasers and their applications in engineering. (Cross-listed with ECEN 4800)
Prerequisite(s)/Corequisite(s): PHYS 2130.

ECEN 8826 ANTENNAS AND RADIO PROPAGATION FOR WIRELESS COMMUNICATIONS (4 credits)
Fundamental theory of antennas and radio propagation for wireless communications. Basic antenna characteristics and various antennas and antenna arrays. Basic propagation mechanisms and various channel models, such as Friis free space model, Hata model, lognormal distribution, and multipath model. Includes practical antenna design for high radio frequency (RF) with modeling software tools such as Numerical Electromagnetic Code (NEC) and A/Dvanced Design System (ADS). Design projects will be assigned as the main part of course. (Cross-listed with ECEN 4820)  
Prerequisite(s)/Corequisite(s): ECEN 3280

ECEN 8830 RANDOM PROCESSES IN ENGINEERING (3 credits)
Topics related to the concept of random variables, functions of random variables and random processes.
Prerequisite(s)/Corequisite(s): STAT 3800

ECEN 8846 NETWORK SECURITY (4 credits)
Network security and cryptographic protocols. Classical encryption techniques, block ciphers and stream ciphers, public-key cryptography, authentications digital signatures, key management and distributions, network vulnerabilities, transport-level security, IP security. (Cross-listed with ECEN 4840)

ECEN 8850 SPREAD SPECTRUM COMMUNICATIONS (3 credits)
Introduction to the theory of spread spectrum communications: direct sequence, frequency and time hopping techniques. Topics include properties of pseudo-random binary sequences, low-probability-of-intercept (LPI) and anti-jamming (AJ) methods, performance of spread spectrum systems, applications of spread spectrum techniques in radio frequency and optical code-division multiple access (CDMA) systems.
Prerequisite(s)/Corequisite(s): ECEN 4630 or ECEN 8610 or permission.

ECEN 8866 APPLIED PHOTONICS (3 credits)
Introduction to the use of electromagnetic radiation for performing optical measurements in engineering applications. Basic electromagnetic theory and light interaction with matter are covered with corresponding laboratory experiments conducted. (Cross-listed with ECEN 4860)
Prerequisite(s)/Corequisite(s): ECEN 3060 or permission. Not open to non-degree graduate students.

ECEN 8886 WIRELESS SECURITY (4 credits)
A comprehensive overview on the recent advances in wireless network and system security. Covers security issues and solutions in emerging wireless access networks and systems as well as multihop wireless networks. (Cross-listed with ECEN 4880)
Prerequisite(s)/Corequisite(s): ECEN 3250

ECEN 8916 SPECIAL TOPICS IN ELECTRIC AND COMPUTER ENGINEERING IV (1-4 credits)
Special topics in the emerging areas of electrical, computer and electronics engineering which may not be covered in the other courses in the electrical, and computer engineering curriculum. (Cross-listed with ECEN 4910)

ECEN 8926 INDIVIDUAL STUDY IN ELECTRICAL AND COMPUTER ENGINEERING IV (1-3 credits)
Individual study in a selected electrical, computer or electronics engineering area under the supervision and guidance of a Electrical and Computer Engineering faculty member. (Cross-listed with ECEN 4920)

ECEN 8930 INDEPENDENT STUDY IN COMPUTER AND ELECTRONICS ENGINEERING (1-3 credits)
Individual study at the graduate level in a selected computer or electronics engineering area under the supervision and guidance of a Computer and Electronics Engineering faculty member.
Prerequisite(s)/Corequisite(s): Departmentally approved proposal.

ECEN 8950 SPECIAL TOPICS (1-3 credits)
Special topics in the newly emerging areas of computer and electronics engineering not covered in the other courses in the computer and electronics engineering curriculum.
ECEN 8986  SPECIAL TOPICS IN ELECTRICAL ENGINEERING IV (1-6 credits)
Offered as the need arises to meet electrical engineering topics for fourth-year and graduate students not covered in other courses. (Cross-listed with ECEN 4980)

ECEN 8990  MASTERS THESIS (1-10 credits)
Masters thesis work.
Prerequisite(s)/Corequisite(s): Admission to masters degree program and permission of supervisory committee chair. Not open to non-degree graduate students.

ECEN 9110  COMMUNICATION THEORY (3 credits)
Applications of probability and statistics to signals and noise; correlation; sampling; shot noise; spectral analysis; Gaussian processes; filtering.
Prerequisite(s)/Corequisite(s): ECEN 8626, and ECEN 8646 or ECEN 8106.

ECEN 9120  ERROR CONTROL CODING (3 credits)
Fundamentals of error correction and detection in digital communication and storage systems. Linear and algebraic block codes; Hamming, BCH and Reed Solomon codes; algebraic decoding techniques; structure and performance of convolutional codes, turbo codes, and trellis coded modulation; MAP, Viterbi, and sequential decoding techniques.
Prerequisite(s)/Corequisite(s): ECEN 4100 or ECEN 8106, and ECEN 4640 or ECEN 8646, or Permission.

ECEN 9130  ADVANCED ANALOG AND MIXED-SIGNAL INTEGRATED CIRCUITS (3 credits)
Prerequisite(s)/Corequisite(s): ECEN 8696 and permission. Not open to non-degree graduate students.

ECEN 9150  ADAPTIVE SIGNAL PROCESSING (3 credits)
Adaptive filtering algorithms, frequency and transform domain adaptive filters, and simulation and critical evaluation of adaptive signal processing for real world applications.
Prerequisite(s)/Corequisite(s): ECEN 4100 or ECEN 8106, ECEN 4630 or ECEN 8636, and permission. Not open to non-degree graduate students.

ECEN 9260  STATISTICAL SIGNAL PROCESSING FOR WIRELESS COMMUNICATION (3 credits)
Statistical signal processing and applications for wireless communications covering the characteristics of random signals, optimum linear filters, statistical parameter estimation using maximum likelihood (ML) and minimum mean-square error (MMSE) methods, adaptive signal processing using least-mean-square (LMS) and recursive least-square (RLS) approaches, Kalman filtering, and eigenanalysis algorithms. Applications of the statistical signal processing techniques in wireless communications will be explored.
Prerequisite(s)/Corequisite(s): ECEN 4240 or ECEN 8246, ECEN 4760 or ECEN 8766, and ECEN 8800. Not open to non-degree graduate students.

ECEN 9320  ADVANCED POWER ELECTRONICS AND APPLICATIONS (3 credits)
Analysis and design of power electronic circuits and their applications, including: snubber circuits, resonant converters and soft switching techniques, pulse-width modulation techniques, control of power electronic circuits, power electronics and control for electric machines and wind energy systems, flexible AC transmission system (FACTS) devices, and high-voltage DC (HVDC) transmission.
Prerequisite(s)/Corequisite(s): ECEN 4360 or ECEN 8366, ECEN 4280 or ECEN 8286, and ECEN 4260 or ECEN 8366.

ECEN 9350  COMPUTATIONAL INTELLIGENCE (3 credits)
Computational intelligence paradigms and their applications, including: artificial neural networks, fuzzy logic systems, swarm intelligence, evolutionary computation (e.g. genetic algorithms), machine learning (e.g., supervised learning, unsupervised learning, and reinforcement learning), neurocontrol and adaptive critic designs, and applications of computational intelligence for system identification, state estimation, time series prediction, signal processing, adaptive control, optimization, diagnostics, prognostics, etc.
Prerequisite(s)/Corequisite(s): MATH 1970, 2350 and 2050. Good skills using MATLAB. Not open to non-degree graduate students.

ECEN 9460  OPTIMAL FILTERING ESTIMATION AND PREDICTION (3 credits)
Techniques for optimally extracting information about the past, present, or future status of a dynamic system from noise-corrupted measurements on that system.
Prerequisite(s)/Corequisite(s): ECEN 8106 or permission. Not open to non-degree graduate students.

ECEN 9570  ADVANCED COMPUTER METHODS IN POWER SYSTEM ANALYSIS (3 credits)
Power System matrices, sparsity techniques, network equivalents, contingency analysis, power flow optimization, state estimation, and power system restructuring examined via computer methods.
Prerequisite(s)/Corequisite(s): ECEN 8066. Not open to non-degree graduate students.

ECEN 9590  WIRELESS COMMUNICATIONS (3 credits)
Principles of wireless communications, including: description of the wireless channel characteristics; ultimate performance limits of wireless systems; performance analysis of digital modulation techniques over wireless channels; diversity techniques; adaptive modulation; multiple-antenna communications; multi-carrier modulation; and multi-user wireless communications.
Prerequisite(s)/Corequisite(s): ECEN 8646 and permission. Not open to non-degree graduate students.

ECEN 9600  SOLID STATE DEVICES (3 credits)
Gallium arsenide and silicon devices. Device properties based on structure and physical properties of the materials.
Prerequisite(s)/Corequisite(s): ECEN 3150, not open to non-degree graduate students.

ECEN 9650  PASSIVE MICROWAVE COMPONENTS (3 credits)
Application of Maxwell’s Equations to the analysis of waveguides, resonant cavities, filters and other passive microwave devices.
Prerequisite(s)/Corequisite(s): ECEN 8676 or ECEN 8686. Not open to non-degree graduate students.

ECEN 9670  INTRODUCTION TO QUANTUM ELECTRONICS (3 credits)
Introduction to the quantum aspects of electron devices.
Prerequisite(s)/Corequisite(s): Not open to non-degree graduate students.

ECEN 9710  SEMINAR (1-12 credits)
Selected topics.
Prerequisite(s)/Corequisite(s): Permission. Not open to non-degree graduate students.

ECEN 9750  OPTICAL PROPERTIES OF MATERIALS (3 credits)
Quantum mechanical description of the optical properties of solids (complex refractive index and its dispersion, effects of electric and magnetic fields, temperature, stress; additional special topics as desired.
Prerequisite(s)/Corequisite(s): ECEN 6760 or permission. Not open to non-degree graduate students.
ECEN 9770 SPACE-TIME WIRELESS COMMUNICATIONS (3 credits)
Theory of space-time (ST) wireless communication systems. Emphasis will be placed on spatial diversity, smart antenna systems, MIMO capacity of multi-antenna fading channels, space-time signaling, space-time receivers and interference mitigation. Includes overview of more advanced topics such as MIMO-OFDM and current trends in research and industry.
Prerequisite(s)/Corequisite(s): ECEN 4610, ECEN 4630, ECEN 4760.

ECEN 9790 NON-LINEAR FIBER OPTIC SYSTEMS (3 credits)
Linear and non-linear propagations in optical fibers. Topics include fiber non-linearity, fundamentals of optical amplifiers, semiconductor and fiber amplifiers, soliton communications. Applications include high capacity and long distance transmissions, all-optical networks.
Prerequisite(s)/Corequisite(s): CEEN 4790 or CEEN 8796 or permission.

ECEN 9860 OPTOELECTRONICS (3 credits)
Modern phenomena associated with optoelectronics. Electro-optical effect such as Pockel effect, Kerr effect, and nonlinear optical phenomena. Material and devices used in modern communications, femtosecond lasers, and optical computer systems.
Prerequisite(s)/Corequisite(s): ECEN 8866. Not open to non-degree graduate students.

ECEN 9910 INDEPENDENT STUDY (1-24 credits)
Selected topic under the direction and guidance of a faculty member.
Prerequisite(s)/Corequisite(s): Permission. Not open to non-degree graduate students.

ECEN 9920 RESEARCH OTHER THAN THESIS (1-6 credits)
Supervised non-thesis research and independent study.
Prerequisite(s)/Corequisite(s): Permission and graduate standing.

ECEN 9960 TOPICS IN ELECTRICAL ENGINEERING (3 credits)
Selected topics in electrical engineering.
Prerequisite(s)/Corequisite(s): Permission. Not open to non-degree graduate students.

ECEN 9980 ADVANCED SPECIAL TOPICS (1-3 credits)
Advanced topics in computer and electronics engineering not covered in other 9000 level courses.
Prerequisite(s)/Corequisite(s): Permission.

ECEN 9990 DOCTORAL DISSERTATION (1-24 credits)
Dissertation research.
Prerequisite(s)/Corequisite(s): Admission to doctoral degree program and permission of supervisory committee chair. Not open to non-degree graduate students.