ECEN 600 Experimental Optics  
Credits 4. 3 Lecture Hours. 2 Lab Hours.  
Hardware, electronic interfaces, and experimental techniques for optics including optical mechanics, component mounting techniques, passive optical components, interferometers and precision alignment, basic electronics including op amps, active optical elements such as acousto-optics, servos in optics, laser intensity stabilization, lock-in amplifier and frequency stabilization.  
Prerequisite: Approval of instructor.

ECEN 601 Linear Network Analysis  
Credits 3. 3 Lecture Hours.  
Signal theory treatment of continuous and discrete signals and systems; vector spaces, projection and sampling theories, Fourier, Laplace and Z Transforms.

ECEN 602 Computer Communication and Networking  
Credits 3. 3 Lecture Hours.  
Computer communication and computer networks; use of the International Standards Organization (ISO) seven-layer Open Systems Interconnection model as basis for systematic approach; operational networks to be included in the study of each layer; homework assignments to make use of a campus computer network.  
Prerequisite: ECEN 646 or equivalent probability background.

ECEN 603 Time-frequency Analysis and Multirate Signal Processing  
Credits 3. 3 Lecture Hours.  
Basic functions; short-time Fourier transform; Gabor transform; linear time-scale/time-frequency analysis; time-frequency resolution; Wigner-Ville distribution; Ambiguity function; wavelet series; multi-rate filter bank; orthogonality and biorthogonality; subband coding and pattern recognition.

ECEN 604 Channel Coding for Communications Systems  
Credits 3. 3 Lecture Hours.  
Channel coding for error control, finite field algebra, block codes, cyclic codes; BCH codes; and convolutional codes; Trellis coded modulation, including ungerboeck codes and coset codes; performance on gaussian and rayleigh channels; applications to communications systems.  
Prerequisites: Approval of instructor and graduate classification.

ECEN 605 Linear Multivariable Systems  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Single input single output systems, multivariable systems, linear servomechanism problem and linear quadratic optimal control; emphasis on linear systems, classical linear control theory and modern state space control theory.  
Prerequisite: Graduate classification.

ECEN 606 Nonlinear Control Systems  
Credits 3. 3 Lecture Hours.  
Techniques available to analyze and synthesize nonlinear and discontinuous control systems. Modern stability theory, time-varying systems, DF, DIDF, Lyapunov Theory, adaptive control, identification and design principles for using these concepts; examples from a variety of electronic and electromechanical systems.  
Prerequisite: ECEN 605.

ECEN 607 Advanced Analog Circuit Design Techniques  
Credits 4. 3 Lecture Hours. 2 Lab Hours.  
Design of analog circuits using conventional and non-conventional voltage techniques, including floating gate, bulk driven and enhanced wide swing structures.  
Prerequisite: ECEN 474 or approval of instructor.

ECEN 608/MEEN 674 Modern Control  
Credits 3. 3 Lecture Hours.  
Vector Norms; Induced Operator Norms; Lp stability; the small gain theorem; performance/robustness trade-offs; L1 and Hoo optimal P control as operator norm minimization; H2 optimal control.  
Prerequisite: ECEN 605 or equivalent.  
Cross Listing: MEEN 674/ECEN 608.

ECEN 609/MEEN 675 Adaptive Control  
Credits 3. 3 Lecture Hours.  
Basic principles of parameter identification and parameter adaptive control; robustness and examples of instability; development of a unified approach to the design of robust adaptive schemes.  
Prerequisite: ECEN 605 or approval of instructor.  
Cross Listing: MEEN 675/ECEN 609.

ECEN 610 Mixed-Signal Interfaces  
Credits 4. 3 Lecture Hours. 2 Lab Hours.  
Mixed - Signal Interfaces. Analog-to-digital and digital-to-analog converter architectures including Nyquist rate and oversampled converters; definition of basic data converter specifications and figures of metric; background and foreground calibration techniques to improve performance of data converters; low-power (green topologies) data converters design; state of the art mixed-signal interfaces such as transmitters and receivers front-ends in wireless and wireline communications transceivers; introduction to calibration techniques for digitally-assisted transceivers.  
Prerequisite: ECEN 474 or approval of instructor.

ECEN 611 General Theory of Electromechanical Motion Devices  
Credits 3. 3 Lecture Hours.  
Winding function theory; inductances of an ideal doubly cylindrical machine; inductances of salient-pole machines, reference frame and transformation theory; dynamic equations of electric machines; steady-state behavior of electric machines.  
Prerequisite: Approval of instructor or graduate classification.

ECEN 612 Computer Aided Design of Electromechanical Motion Devices  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Magnetic circuits and field distribution of electric machines; main flux path calculation; calculation of magnetizing and leakage inductance; calculation of electric machine losses; principle of design of various electric machines; finite element design of electromechanical motion devices.  
Prerequisite: Approval of instructor or graduate classification.

ECEN 613 Rectifier and Inverter Circuits  
Credits 3. 3 Lecture Hours.  
Analysis/design of single phase, three phase rectifiers; phase control and PWM rectifiers; line harmonics; power factor; harmonic standards; passive and active correction methods; inverters; PWM methods; effect of blanking time; zero voltage switching and multilevel inverter; application of these systems in UPS and AC motor drives.  
Prerequisite: ECEN 438 or approval of instructor.
ECEN 457 or equivalent.

ECEN 612 Power System State Estimation
Credits 3. 3 Lecture Hours.
The large electric power system state estimation problem; issues of network observability, bad measurements detection/identification; sparse matrix vector techniques for computational efficiency.
Prerequisite: ECEN 460.

ECEN 615 Methods of Electric Power Systems Analysis
Credits 3. 3 Lecture Hours.
Digital computer methods for solution of the load flow problem; load flow approximations; equivalents; optimal load flow.
Prerequisite: ECEN 460 or approval of instructor.

ECEN 616 Power System Electromagnetic Transients
Credits 3. 3 Lab Hours.
Modeling of power system components for electromagnetic transient studies; digital computer methods for computation of transients.
Prerequisites: ECEN 459 and ECEN 460.

ECEN 617 Advanced Signal Processing for Medical Imaging
Credits 3. 3 Lecture Hours.
This is a graduate-level course covering several advanced signal processing topics in medical imaging: multi-dimensional signal sampling and reconstruction, bio-signal generation and optimal detection, Fourier imaging, Radon transform-based tomographic imaging, multi-channel signal processing, as well as constrained reconstruction, rapid imaging, image segmentation, registration and analysis.
Prerequisite: Approval of the instructor.

ECEN 618 Robust and Optimal Control
Credits 3. 3 Lecture Hours.
Modern design of (Proportional Integral Derivative) controllers, robust control under parametric uncertainty and optimal control using quadratic optimization.
Prerequisite: ECEN 605; graduate classification.

ECEN 619 Internet Protocols and Modeling
Credits 3. 3 Lecture Hours.
Wide spectrum of Internet protocols that make it work; analytical capabilities to evaluate the performance of complex Internet protocols; aspects of the Internet protocols, including principles, design and implementation, and performance modeling and analysis; core components of Internet protocols such as transport (TCP, UDP), network and routing (IP, RIP, OSPF, EGP, BGP-4, etc.)
Prerequisite: Approval of instructor.

ECEN 620 Network Theory
Credits 3. 3 Lecture Hours.
Development and application of advanced topics in circuit analysis and synthesis in both the continuous and discrete time and frequency domains.
Prerequisite: ECEN 326 or equivalent.

ECEN 621 Mobile Wireless Networks
Credits 3. 3 Lecture Hours.
Foundations of advanced mobile wireless networks, how they are designed, and how well they perform. Topics include fundamentals on mobile wireless networks, TCP/IP over wireless links, fading-channel modeling, CDMA, OFDM, MIMO, error control, IEEE 802.11 protocols, cross-layer optimization, wireless QoS, mobile multicast, VANETs, wireless-sensor networks, wireless networks security.
Prerequisites: Basic-level "Computer Networks" class or consent of instructor.

ECEN 622 Active Network Synthesis
Credits 3. 3 Lecture Hours.
Methods of analyzing and synthesizing active networks; sensitivity analysis, methods of rational fraction approximation, OP AMP modeling and stability.
Prerequisite: ECEN 457 or equivalent.

ECEN 625 Millimeter-wave Integrated Circuits
Credits 3. 3 Lecture Hours.
Applications of millimeter-wave integrated circuits for wireless transceiver; principles of operation, modeling, design and fabrication of the most common millimeter-wave CMOS, SiGe and RF MEMS circuits.
Prerequisite: Graduate classification; approval of instructor.

ECEN 626 Antenna Theory and Technique
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Applied electromagnetics and physical layer concepts for modern communication systems; topics include: advanced antenna theory and analytical techniques (e.g., variational and perturbational); full-wave tools for complex radiating structures and fading environments; reconfigurable antennas and device integration; multiple antenna techniques; and fabrication, measurement, and calibration methods.
Prerequisite: Approval of instructor.

ECEN 627 Convex Optimization for Electrical Engineering
Credits 3. 3 Lecture Hours.
Optimization; specific application examples in communication/optimization; selected research publications.

ECEN 628 Robust and Optimal Control
Credits 3. 3 Lecture Hours.
Modern design of (Proportional Integral Derivative) controllers, robust control under parametric uncertainty and optimal control using quadratic optimization.
Prerequisite: ECEN 605; graduate classification.

ECEN 629 Analysis of Power Electronic Systems
Credits 3. 3 Lecture Hours.
Analysis and control of semiconductor switching power converters using specialized methods such as Fourier series, state-space averaging, time domain transfer functions, sliding mode, quadrometrics and other discontinuous orthogonal functions; application of the above techniques in practice; selected research publications.
Prerequisite: Approval of instructor.

ECEN 630 Antenna Theory and Technique
Credits 3. 3 Lecture Hours.
Modern design of (Proportional Integral Derivative) controllers, robust control under parametric uncertainty and optimal control using quadratic optimization.
Prerequisite: ECEN 605; graduate classification.

ECEN 631 Fiber-Optic Devices
Credits 3. 3 Lecture Hours.
Fiber optic waveguides; directional couplers; polarization; poincare sphere fractional wave devices; PM fiber; interferometric devices and sensors fiber gyroscope; faraday effect devices; multiplexing techniques.
Prerequisite: Approval of instructor.

ECEN 632 Motor Drive Dynamics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Dynamic of electric machinery in general and in particular induction machines; scalar control as well as vector control of electric machines; direct and indirect vector control for synchronous and induction motors; parameter sensitivity and saturation effects in indirect field orientation and field weakening operation of induction machines.
Prerequisites: Graduate classification and approval of instructor.
ECEN 633 Optimum Control Systems
Credits 3. 3 Lecture Hours.
Variational approach to the development of algorithms for the solution of
optimum control problems; necessary and sufficient conditions,
numerical methods, and analysis and comparison of optimal control
results to classical theory.
Prerequisite: ECEN 605.

ECEN 635 Electromagnetic Theory
Credits 3. 3 Lecture Hours.
Maxwell's equations, boundary conditions, Poynting's theorem,
electromagnetic potentials, Green's functions, Helmholtz's equation, field
equivalence theorems; applications to problems involving transmission
scattering and diffraction of electromagnetic waves.
Prerequisites: ECEN 322; ECEN 351 or equivalent.

ECEN 636 Phased Arrays
Credits 3. 3 Lecture Hours.
Theory and application of phased array antennas, radiators and sensors;
spatial and spectral domain analysis of phased arrays including element-
by-element, infinite array and Fourier methods; applications will include
phased arrays, adaptive arrays, and synthesis array antennas; for use in
radar, imaging and biomedical treatment and diagnosis.
Prerequisite: ECEN 322 or equivalent.

ECEN 637 Numerical Methods in Electromagnetics
Credits 3. 3 Lecture Hours.
Numerical techniques for solving antenna, scattering and microwave
circuits problems; finite difference and finite element differential equation
methods with emphasis on the method of moments integral equation
technique.
Prerequisites: ECEN 351 or ECEN 635; CSCE 203 or equivalent.

ECEN 638 Antennas and Propagation
Credits 3. 3 Lecture Hours.
Application of Maxwell's equations to determine electromagnetic fields
of antennas; radiation, directional arrays, impedance characteristics,
aperture antennas.
Prerequisite: ECEN 351.

ECEN 639 Microwave Circuits
Credits 3. 3 Lecture Hours.
Introduction to high frequency systems and circuits; provides
background information needed to understand fundamentals of
microwave integrated circuits; includes usage of S-parameters, Smith
Charts, stability considerations in designing microwave circuits;
utilizes CAD program "Super Compact" demonstrating design synthesis
optimization and analysis of monolithic devices and circuits.
Prerequisite: Graduate classification.

ECEN 640 Thin Film Science and Technology
Credits 3. 3 Lecture Hours.
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: Graduate standing.

ECEN 641 Microwave Solid-State Integrated Circuits
Credits 3. 3 Lecture Hours.
Microwave two-terminal and three-terminal solid-state devices;
waveguide and microstrip solid-state circuits; theory and design of
microwave mixers, detectors, modulators, switches, phase shifters,
oscillators and amplifiers.
Prerequisite: ECEN 351.

ECEN 642 Digital Image Processing
Credits 3. 3 Lecture Hours.
Digital Image Processing techniques; stresses filtering, transmission
and coding; fast transform techniques; convolution and deconvolution of
model noise.
Prerequisites: ECEN 447 and ECEN 601.

ECEN 643 Electric Power System Reliability
Credits 3. 3 Lecture Hours.
Design and application of mathematical models for estimating various
measures of reliability in electric power systems.
Prerequisite: ECEN 460 or approval of instructor.

ECEN 644 Discrete-Time Systems
Credits 3. 3 Lecture Hours.
Linear discrete time systems analysis using time domain and transform
approaches; digital filter design techniques with digital computer
implementations.
Prerequisite: ECEN 601.

ECEN 646 Statistical Communication Theory
Credits 3. 3 Lecture Hours.
Concepts of probability and random process theory necessary for
advanced study of communications, stochastic control and other
electrical engineering problems involving uncertainty; applications to
elementary detection and estimation problems.
Prerequisite: Registration in ECEN 601 or approval of instructor.

ECEN 647 Information Theory
Credits 3. 3 Lecture Hours.
Definition of information; coding of information for transmission over a
noisy channel including additive gaussian noise channels and waveform
channels; minimum rates at which sources can be encoded; maximum
rates at which information can be transmitted over noisy channels.
Prerequisite: ECEN 646 or equivalent probability background.

ECEN 648 Principles of Magnetic Resonance Imaging
Credits 3. 3 Lecture Hours.
Introduction to the theory and design of magnetic resonance imaging
systems; fundamental physical and mathematical introduction to image
acquisition and reconstruction using magnetic resonance; overview of
imaging system design, including magnets, imaging gradients and radio-
frequency systems, contrast mechanisms, resolution.
Prerequisite: ECEN 314 or ECEN 322 or approval of instructor.

ECEN 649 Pattern Recognition
Credits 3. 3 Lecture Hours.
Introduction to the underlying principles of classification, and computer
recognition of imagery and robotic applications.
Prerequisites: MATH 601 and/or STAT 601 and approval of instructor.

ECEN 650 High Frequency GaAs/SiGe Analog IC Design
Credits 4. 3 Lecture Hours. 3 Lab Hours.
High frequency integrated circuit design using non-conventional
technologies such as GaAs and SiGe, with the emphasis on wireless and
broadband communication circuits. Device operation, basic building
blocks and typical applications.
Prerequisite: ECEN 474 or approval of instructor.
ECEN 651 Microprogrammed Control of Digital Systems  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Hardware and software concepts involved in the design and construction of microprocessor-based digital systems; microprocessor architecture; bussing; interfacing; data input/output; memories; and software development for operation and testing; design projects with microprocessors and related components.  
Prerequisites: ECEN 350/CSCE 350 and ECEN 449 or approval of instructor.

ECEN 653 Computer Arithmetic Unit Design  
Credits 3. 3 Lecture Hours.  
Digital computer arithmetic unit design, control and memory; microprocessor arithmetic logic unit (ALU) design. High-speed addition, subtraction, multiplication and division algorithms and implementations; design and simulation with integrated circuit components and VLSI circuits.  
Prerequisite: ECEN 651.

ECEN 654 Very Large Scale Integrated Systems Design  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Design and fabrication of microelectronic circuits such as registers, selectors, PLAs, sequential and microprogrammed machines via large scale integrated circuitry with emphasis on high-level, structured design methods for VLSI systems; design small to medium scale integrated circuits for fabrication by industry.  
Prerequisites: ECEN 454 or equivalent undergraduate VLSI course.

ECEN 655 Advanced Topics in Channel Coding  
Credits 3. 3 Lecture Hours.  
Advanced topics in Channel Coding including turbo codes, low density parity check codes, iterative decoding and applications of iterative decoding principles.  
Prerequisite: ECEN 604 or graduate classification.

ECEN 658 Low-Noise Electronic Design  
Credits 3. 3 Lecture Hours.  
Low-noise design; surveying the subject of handling electronic noise from theory to measurement, design, research and developments.  
Prerequisite: Approval of instructor.

ECEN 659/CSCE 659 Parallel/Distributed Numerical Algorithms and Applications  
Credits 3. 3 Lecture Hours.  
A unified treatment of parallel and distributed numerical algorithms; parallel and distributed computation models, parallel computation or arithmetic expressions; fast algorithms for numerical linear algebra, partial differential equations and nonlinear optimization.  
Prerequisite: MATH 304 or equivalent.  
Cross Listing: CSCE 659/ECEN 659.

ECEN 660 BioMEMS and Lab-on-a-Chip  
Credits 3. 3 Lecture Hours.  
Introduction to lab-on-a-chip technology; microfabrication techniques commonly used in BioMEMS device fabrication; microfluidics miniaturized systems for chemical and biomedical applications such as separation, diagnosis tools, implantable devices, drug delivery, and microsystems for cellular studies and tissue engineering; will gain a broad perspective in the area of miniaturized systems for biomedical and chemical applications.  
Prerequisite: Approval of instructor.

ECEN 661 Modulation Theory  
Credits 3. 3 Lecture Hours.  
Optimum receiver principles and signal selection for communication systems with and without coding; system implementation, and waveform communication using realistic channel models.  
Prerequisite: ECEN 646.

ECEN 662 Estimation and Detection Theory  
Credits 3. 3 Lecture Hours.  
Probabilistic signal detection theory and parameter estimation theory; Neyman-Pearson, UMP, and locally optimal tests; discrete time Markov processes and the Kalman and Wiener filters; bayesian, maximum likelihood and conditional mean estimation methods.  
Prerequisite: ECEN 646.

ECEN 663 Data Compression with Applications to Speech and Video  
Credits 3. 3 Lecture Hours.  
Characterization and representation of waveforms; digital coding of waveforms including PCM, delta modulation, DPCM, tree/trellis coding, runlength coding, sub-band coding and transform coding; rate distortion theoretic performance bounds.  
Prerequisites: ECEN 601 and ECEN 646.

ECEN 664 Nanotechnology Fabrication  
Credits 3. 3 Lecture Hours.  
Cutting edge nanostructure fabrication techniques for both top-down and bottom up approaches.  
Prerequisite: Approval of instructor.

ECEN 665 Integrated CMOS RF Circuits and Systems  
Credits 4. 3 Lecture Hours. 2 Lab Hours.  
Introduction to wireless communication systems at the theoretical, algorithmic and circuit levels; emphasis on simulation at the architecture, transistor levels of the communication systems; focus on circuits implementable on CMOS and BiCMOS technologies.  
Prerequisites: ECEN 453, ECEN 456, ECEN 474.

ECEN 666 Power System Faults and Protective Relaying  
Credits 3. 3 Lecture Hours.  
Calculation of power system currents and voltages during faults; protective relaying principles, application and response to system faults.  
Prerequisite: ECEN 460 or approval of instructor.

ECEN 667 Power System Stability  
Credits 3. 3 Lecture Hours.  
Steady-state, dynamic and transient stability of power systems; solution techniques; effect of generator control systems.  
Prerequisite: ECEN 460 or approval of instructor.

ECEN 668 High Voltage Direct Current (HVDC) Transmission  
Credits 3. 3 Lecture Hours.  
Overview of HVDC systems; comparison of AC and DC power transmission; study of six-pulse and twelve-pulse power converters; analysis and control of HVDC systems; harmonics and power factor effects; system faults and misoperations; state of the art and future developments in HVDC technology; inspection trips.  
Prerequisite: Approval of instructor.

ECEN 669 Engineering Applications in Genomics  
Credits 3. 3 Lecture Hours.  
Tutorial introduction to the current engineering research in genomics. The necessary Molecular Biology background is presented and techniques from signal processing and control are used to (i) unearth intergene relationships (ii) model genetic regulatory networks and (iii) alter their dynamic behavior.  
Prerequisite: ECEN 605 or approval of instructor.
ECEN 670 Fiber Optic Networks  
**Credits 3. 3 Lecture Hours.**  
Components, topologies and architecture for communication networks based on the optical fiber transmission medium; examples based on recent publications in technical literature.  
**Prerequisite:** Graduate classification.

ECEN 671 Solid State Devices  
**Credits 3. 3 Lecture Hours.**  
Development of mathematical analysis and systematic modeling of solid state devices; relationships of measurable electrical characteristics to morphology and material properties of solid state devices, p-n junction, bipolar and unipolar transistors.  
**Prerequisite:** ECEN 656 or approval of instructor.

ECEN 674/PHYS 674 Introduction to Quantum Computing  
**Credits 3. 3 Lecture Hours.**  
Introduces the quantum mechanics, quantum gates, quantum circuits and quantum hardware of potential quantum computers; algorithms, potential uses, complexity classes, and evaluation of coherence of these devices.  
**Prerequisites:** MATH 304, PHYS 208.  
**Cross Listing:** PHYS 674/ECEN 674.

ECEN 675 Integrated Optoelectronics  
**Credits 3. 3 Lecture Hours.**  
Light propagation and interactions in anisotropic media; electrooptic and acoustooptic effects; passive and active guided-wave devices; fabrication and characterization.  
**Prerequisite:** ECEN 464 or equivalent.

ECEN 676 Advanced Computer Architecture  
**Credits 3. 3 Lecture Hours.**  
Design of advanced computers for parallel processing; emphasis on the overall structure; interconnection networks; including single-stage and multi-stage structures; shared memory and message passing architectures; control-flow and demand-driven programming; multithreaded architectures; fine-grain and coarse-grain parallelism; SIMD and MIMD; processor designs for parallel operation.  
**Prerequisite:** ECEN 651 or CSCE 614 or approval of instructor.

ECEN 677 Control of Electric Power Systems  
**Credits 3. 3 Lecture Hours.**  
Modeling, analysis and real-time control of electric power systems to meet the requirements of economic dispatch of voltage and power.  
**Prerequisite:** Approval of instructor.

ECEN 679 Computer Relays for Electric Power Systems  
**Credits 3. 3 Lecture Hours.**  
Real-time digital computer application to protective relaying; extensive overview of digital protection algorithms; latest technological advancements as microprocessor-based relays, fiber-optic communication systems, unconventional instrument transformers, dynamic testing tools and methodologies.  
**Prerequisite:** Approval of instructor.

ECEN 680/CSCE 680 Testing and Diagnosis of Digital Systems  
**Credits 3. 3 Lecture Hours.**  
The theory and techniques of testing VLSI-based circuits and systems, and design for testability.  
**Prerequisites:** ECEN 220 or ECEN 248 or equivalent; ECEN 350/CSCE 350 or CSCE 321 or equivalent.  
**Cross Listing:** CSCE 680/ECEN 680.

ECEN 681 Seminar  
**Credit 1. 1 Lecture Hour.**  
Reports and discussion of current research and of selected published technical articles. May be taken four times for credit.  
**Prerequisite:** Graduate classification in electrical and computer engineering.

ECEN 683 Wireless Communication Systems  
**Credits 3. 3 Lecture Hours.**  
Wireless applications, modulation formats, wireless channel models and simulation techniques, digital communication over wireless channels, multiple access techniques, wireless standards.  
**Prerequisite:** ECEN 646 or approval of instructor.

ECEN 684 Professional Internship  
**Credits 1 to 4. 1 to 4 Other Hours.**  
Engineering research and design experience at industrial facilities away from the Texas A&M campus; design projects supervised by faculty coordinators and personnel at these locations; projects selected to match student’s area of specialization.  
**Prerequisites:** Graduate classification and one semester of coursework completed.

ECEN 685 Directed Studies  
**Credits 1 to 12. 1 to 12 Other Hours.**  
Research problems of limited scope designed primarily to develop research technique.

ECEN 686 Electric and Hybrid Vehicles  
**Credits 3. 3 Lecture Hours.**  
Fundamental concepts of electric and hybrid-electric vehicles introduced, component requirements and system design methodologies discussed; vehicle system analysis and simulation methods presented.  
**Prerequisite:** Graduate classification or approval of instructor.

ECEN 687 Introduction to VLSI Physical Design Automation  
**Credits 3. 3 Lecture Hours.**  
Algorithms and techniques for VLSI design automation, including basic optimization techniques, high level synthesis, logic synthesis/verification, physical design, timing verification and optimization.  
**Prerequisite:** ECEN 248.

ECEN 688 IC MEMS and Sensor Fabrication  
**Credits 4. 3 Lecture Hours. 3 Lab Hours.**  
Fundamental unit processes for the fabrication of silicon IC’s and extension of these processes to the specialized micro-machining operations used for MEMS and sensor fabrication; basic process operations used in the laboratory to build simple IC structures; devices then characterized.  
**Prerequisite:** ECEN 325, ECEN 370, or approval of instructor.

ECEN 689 Special Topics in...  
**Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours.**  
Advanced topics of current interest in electrical engineering. May be repeated for credit.  
**Prerequisite:** Approval of instructor.

ECEN 691 Research  
**Credits 1 to 23. 1 to 23 Other Hours.**  
Research for thesis or dissertation.
ECEN 694 Nanobiotechnology
Credits 3. 3 Lecture Hours.
Introduction to advances in nanobiotechnology; includes fabrication of micro or nano structures, molecular manipulation, medical diagnostic and treatment options, nano scale machines such as molecular motors for drug delivery.
Prerequisite: Graduate classification; approval of instructor.

ECEN 696 Erbium-Doped Amplifier: Technology and Applications
Credits 3. 3 Lecture Hours.
Prerequisite: ECEN 370 or approval of instructor.

ECEN 699 Advances in VLSI Logic Synthesis
Credits 3. 3 Lecture Hours.
Logic representation, manipulation, and optimization; combinational and sequential logic; Boolean function representation schemes; exact and heuristic two-level logic minimization; multi-valued logic representation and manipulation; multi-level logic representation and minimization; testing; technology mapping.
Prerequisites: Approval of instructor and graduate classification.

ECEN 704 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: Graduate classification.

ECEN 710 Switching Power Supplies
Credits 3. 3 Lecture Hours.
Operating principles of switching power supplies; analysis and in-depth design of several types of switching regulators including buck, boost, forward, flyback, half and full bridge switching regulator analysis; elements of transformer and magnetic design; state space analysis and feedback loop stabilization principles; application of these in the industry.
Prerequisite: ECEN 438 or equivalent, approval of instructor.

ECEN 711 Sustainable Energy and Vehicle Engineering
Credits 3. 3 Lecture Hours.
Forms of sustainable and unsustainable energy resources and the basic system engineering limits of each; specific problems of sustainable transportation energy on the bases of vehicle and power engineering; issues related to energy efficiency, life cycle analysis, global warming, pollution, economic and social considerations.
Prerequisite: Graduate classification in engineering.

ECEN 712 Power Electronics for Photovoltaic Energy Systems
Credits 3. 3 Lecture Hours.
Sustainable energy sources such as photovoltaic, fuel cell, wind, and others require power electronics to perform energy conversion and conditioning in order to convert their native form of electrical generation to a format compatible with the ac utility grid; exploration of the salient electrical characteristics of solar photovoltaic sources, the requirements for grid-connection and the power electronic circuits and controls needed to perform the interconnection and control.
Prerequisite: ECEN 438 or instructor approval.

ECEN 714 Digital Integrated Circuit Design
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Analysis and design of digital devices and integrated using MOS and bipolar technologies and computer aided simulation.
Prerequisite: Graduate classification.

ECEN 715 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.
Prerequisite: ECEN 214, ECEN 420, ECEN 460 or approval of instructor.

ECEN 720 High-Speed Links Circuits and Systems
Credits 4. 3 Lecture Hours. 3 Lab Hours.
System and circuit design of high-speed electrical and optical link systems; includes channel properties, communication techniques, and circuit design of drivers, receivers, equalizers, and synchronization systems; project consists of link design with a statistical bit error rate simulator and interface circuit design.
Prerequisite: ECEN 474.

ECEN 730 CMOS RFIC Engineering
Credits 3. 3 Lecture Hours.
Introduction to CMOS radio-frequency integrated circuits (RFICs) and wireless systems and networks; theory, analysis and design of RFICs using CMOS technologies; CMOS fundamentals (device, principle, models); scattering parameters, transmission lines, distributed structures, lumped elements, impedance matching, RFIC layout, processing, test, amplifiers, oscillators, mixers; CAD programs for CMOS RFIC design.
Prerequisites: ECEN 322 and graduate classification.

ECEN 735 Electromagnetic Field Theory
Credits 3. 3 Lecture Hours.
Methods in wave propagation, diffraction and scattering analysis, including surface waves, creeping waves, surface plasmons and complex environments; applications to macroscopic and nano technology such as optical wave propagation in materials and wireless device wave propagation.
Prerequisite: ECEN 635 or equivalent.

ECEN 738 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: Graduate classification or approval of instructor.

ECEN 741 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: Graduate classification.
ECEN 742 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; electromechanical motion device and DSP control implementation discussed and implemented in the lab.  
Prerequisite: Graduate classification or approval of instructor.

ECEN 749 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.  
Prerequisite: Graduate classification.

ECEN 750 Design and Analysis of Communication Networks  
Credits 3. 3 Lecture Hours.  
Analytical approach to understanding resource allocation on the Internet; study the system in a global sense, and use a deterministic approach to study congestion control protocols; study individual queues and routers, and use a stochastic approach to understanding system performance.  
Prerequisite: ECEN 646 or some probability background.

ECEN 751 Computational Methods for Integrated System Design  
Credits 3. 3 Lecture Hours.  
Integrated circuit design in a computational standpoint; VLSI circuit simulation, interconnect modeling and analysis, design and analysis of IC subsystems, parallel computing techniques for complex system design.  
Prerequisite(s): ECEN 454, ECEN 474 or equivalent.

ECEN 752 Advances in VLSI Circuit Design  
Credits 3. 3 Lecture Hours.  
Gate and wire delays, CMOS transistors, DC and AC characteristics, VLSI fabrication, Static, Dynamic, Pass-gate and PLA implementation styles, SOI and GaAs technology, DRAM, SRAM and FLASH memory design, leakage and dynamic power, sub-threshold computation, clocking, transmission lines, packaging, off-chip IO, process variation and compensation, radiation tolerance.  
Prerequisite(s): Graduate classification or Instructor approval.

ECEN 753 Theory and Applications of Network Coding  
Credits 3. 3 Lecture Hours.  
Fundamentals of network coding including concepts, models, linear and non-linear codes, code design, random and deterministic codes; wireless network coding; network coding for storage; practical implementations; current research trends.  
Prerequisite: Graduate classification or approval of instructor.

ECEN 754 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: MATH 304 or MATH 309 or MATH 311; MATH 251 or graduate classification.

ECEN 755 Stochastic Systems  
Credits 3. 3 Lecture Hours.  
Principles of stochastic systems including performance evaluation, estimation, control, scheduling, identification and adaptation, as well as electric and computer engineering applications; includes applications in communication networks and control.  
Prerequisites: MATH 411; approval of instructor and graduate classification.

ECEN 760 Introduction to Probabilistic Graphical Models  
Credits 3. 3 Lecture Hours.  
Broad overview of various probabilistic graphical models, including Bayesian networks, Markov networks, conditional random fields, and factor graphs; relevant inference and learning algorithms, as well as their application in various science and engineering problems will be introduced throughout the course.  
Prerequisites: Undergraduate level probability theory; basic programming skill in any programming language (C, C++, Python, Matlab, etc.).

ECEN 761 Biosensors Lab  
Credits 3. 2 Lecture Hours. 2 Lab Hours.  
Biosensors Lab is a hands on experience in basic concepts of biosensing and how to make miniaturized biosensors; various application examples associated with these sensing principles.  
Prerequisite: Approval of instructor.

ECEN 762 Advanced Ultrasound Imaging Techniques  
Credits 3. 3 Lecture Hours.  
Fundamental concepts at the basis of ultrasound imaging including 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 and image processing methods for medical ultrasound imaging of tissues; focus on the fundamental understanding of advanced ultrasound imaging methods and techniques and their applications; state-of-the-art ultrasound imaging techniques including ultrasound contrast agents and harmonic imaging, 3D and 4D imaging, advanced Doppler imaging methods, 2D arrays, C-MUT and HIFU technologies.  
Prerequisite: Approval of instructor.

ECEN 763/BMEN 627 Magnetic Resonance Engineering  
Credits 3. 2 Lecture Hours. 3 Lab Hours.  
Design, construction and application of instrumentation for MR Imaging: fundamentals of the architecture if an MR spectrometer and the gradient subsystem used for image localization; emphasis on the radiofrequency sensors and systems used for signal generation and reception.  
Prerequisite(s): ECEN 410, or ECEN 411, BMEN 420, or equivalent, or approval of instructor.  
Cross Listing: BMEN 627/ECEN 763.

ECEN 764 Medical Imaging  
Credits 4. 3 Lecture Hours. 2 Lab Hours.  
Physics and signals in medical imaging systems; focus on magnetic resonance imaging, x-ray computer tomography, ultrasonography, nuclear medicine imaging and optical imaging; includes system architecture, source generation, energy-tissue interaction, image formation and clinical examples.  
Prerequisite: ECEN 314 or equivalent, or approval of instructor.

ECEN 765 Machine Learning with Networks  
Credits 3. 3 Lecture Hours.  
Scientific analysis of large-scale data; introduction to advanced methods that are designed to analyze structured data represented as networks.  
Prerequisite: Approval of instructor.
ECEN 766 Algorithms in Structural Bioinformatics  
Credits 3. 3 Lecture Hours.
Fundamental concepts, modeling techniques, and computational algorithms in structural bioinformatics for algorithm development and application; focus on algorithm perspective involving optimization and machine learning; essential for those without prior domain knowledge.  
Prerequisite: Approval of instructor.

ECEN 767 Harnessing Solar Energy: Optics, Photovoltaics and Thermal Systems  
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Solar radiation characteristics and measurement; optical coatings including reflection, transmission, absorption and emissivity; concentrating optics, tracking and etendue limit; photovoltaic cells, modules and systems overview; introduction to solar thermal systems.  
Prerequisite: Graduate classification or approval of instructor.

ECEN 770 Organic Semiconductor  
Credits 3. 3 Lecture Hours.
Organic semiconductors are new semiconducting materials with huge application potentials; designed to help understand the material properties of organic semiconductors and the operation principles of organic electronic devices; gain broad knowledge in organic semiconductors, from the structure-property relationship to the design and optimization of organic devices and systems.  
Prerequisite: Approval of instructor.

ECEN 771 Fluctuations and Noise Electronics  
Credits 3. 3 Lecture Hours.
Introduction to the research of Noise and Fluctuations; Noise and Fluctuations in electronics and other systems include virtually all scientific fields, including secure and non-secure communications, microprocessors, quantum information, mesoscopic systems, chemical sensing, corrosion diagnostics, neuro- and membrane-biology, biomedicine, etc.  
Prerequisite: Approval of instructor.

ECEN 772 Introduction to Microelectromechanical Devices and Systems  
Credits 3. 3 Lecture Hours.
Provides a broad overview of the past and current developments in the emerging area of MEMS (microelectromechanical systems); discusses the fundamental working principles, designs and fabrication techniques; consists of several special topics, discussing the latest important applications in different fields.  
Prerequisite: Consent of instructor.

ECEN 773 Introduction to Nanophotonics  
Credits 3. 3 Lecture Hours.
Photonic bandgap optical circuitry, photonic crystal fiber; visible to infrared semiconductor quantum lasers; semiconductor quantum dots; plasmonic field enhancement, plasmonic optical circuitry, sub-wavelength optical lithography, negative refractive index and sub-wavelength optical imaging; nano-structure characterization techniques, atomic force microscopy, near-field optical microscopy, scanning and transmission electron microscopy.  
Prerequisite: Approval of Instructor.

ECEN 777 Photonics: Fiber and Integrated Optics  
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Optical power and spectral measurements of singlemode and multimode optical fibers, hands-on arc fusion splicing, lasers, amplifiers, interferometers, photodetectors, integrated optics, fiber-optics, fiber-optic devices, optical modulators.  
Prerequisites: Equivalent of ECEN 322 and ECEN 370 or approval of instructor.