ECEN - ELECTRICAL & COMP ENGR

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 Mathematical Methods in Signal Processing

Credits 3. 3 Lecture Hours. Representations and algorithms for signal processing; linear algebra, vector spaces, normed and inner product spaces; projection, orthogonalization, rank-nullity theorem; matrix representations, singular value decomposition; sampling, Fourier analysis, spectral methods; statistical signal processing and linear estimation.

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 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 3. 3 Lecture 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 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.

ECEN 609 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 equivalent.

ECEN 610 Mixed-Signal Interfaces

Credits 4. 3 Lecture Hours. 2 Lab Hours. 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 614 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 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 approval 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 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 Applied Convex Optimization

Credits 3. 3 Lecture Hours. Introduction to convex optimization including convex set, convex functions, convex optimization problems, KKT conditions and duality, unconstrained optimization, and interior-point methods for constrained optimization; applications in information science, digital systems, networks and learning. **Prerequisites:** ECEN 601 or equivalent.

ECEN 630 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 632 Motor Drive Dynamics

Credits 3. 3 Lecture 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:** Approval of instructor.

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 methods of engineering electromagnetics, including finite differencing, finite difference time domain, finite elements, the method of moments and parabolic equation. **Prerequisite:** ECEN 322.

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 322.

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. 1 Lab Hour. 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 classification.

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 322.

ECEN 642 Digital Image Processing and Computer Vision

Credits 3. 3 Lecture Hours. Digital Image Processing and computer vision techniques; stresses filtering, intensity transformations, compression, restoration and reconstruction, morphology, segmentation, feature extraction and pattern classification. **Prerequisite:** ECEN 447 and ECEN 601, or approval of instructor.

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, or approval of instructor.

ECEN 646 Probability and Random Processes for Information Science

Credits 3. 3 Lecture Hours. Concepts of probability and random processes necessary for advanced study of information science, digital communications, networks, stochastic control and other engineering systems involving uncertainty; applications to detection, channel coding, queuing, optimization and inference.

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. **Prerequisite:** MATH 601 or STAT 601, and 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 micoprogrammed 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 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 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 Advanced Digital Communications

Credits 3. 3 Lecture Hours. Digital communication systems; coding for discrete sources and quantization; source and channel waveforms, signal spaces; modulation and demodulation, random noise; detection, error control coding, efficient decoding algorithms. **Prerequisite:** ECEN 646 or equivalent.

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. **Prerequisite:** ECEN 601 and ECEN 646, or approval of instructor.

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; necessary molecular biology background 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 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. **Prerequisites:** Graduate classification.

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 248 or equivalent; ECEN 350/CSCE 350 or CSCE 350/ECEN 350 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.

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 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.**Prerequisites:** 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 713 Data Sciences and Applications for Modern Power

Credits 3. 3 Lecture Hours. Introduction to the foundation of high dimensional statistics; data analytical tools necessary to model and operate a modern power system; projects offer realistic data sets to construct tools and models for smart grid operations. **Prerequisite:** ECEN 420 or ECEN 460, or equivalent.

ECEN 714 Digital Integrated Circuit Design

Credits 3. 2 Lecture Hours. 2 Lab Hours. Analysis and design of digital devices and integrated circuits using metal-oxide semiconductor (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 718 Neuro-electronics System

Credits 3. 3 Lecture Hours. Introduction to neuro-electronics system; provide basic knowledge for interests in designing electrical system interacting with human nervous system and human body; basics of neuroscience, action potential and nervous, muscular and skeletal systems of humans; design process of the neuro-electronics system that can communicate with the nervous system and replace, assist and augment the body function. **Prerequisites:** ECEN 325 and ECEN 314.

ECEN 719 Advanced Digital System Design

Credits 4. 3 Lecture Hours. 3 Lab Hours. Introduction to the design, modeling and verification of complex digital systems using hardware description language and electronic system level language.

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 721 Optical Interconnects Circuits and Systems

Credits 3. 3 Lecture Hours. . High-speed optical interconnect, links, circuits and systems issues; optical channel properties and modeling, link measurements and communications techniques, and drivers, receivers, equalizers and synchronization circuits; comprehensive final design project includes systems analysis and circuit design of key link circuit blocks. **Prerequisite:** ECEN 474 or ECEN 704, or approval of instructor.

ECEN 722 Field Programmable Gate Arrays Information Processing Systems

Credits 4. 3 Lecture Hours. 2 Lab Hours. Signal processing and neural network implementations on field programmable gate arrays (FPGA); FPGA designs of digital filters, Fourier transform, JPEG decoding, fast convolution, Kalman filter and Viterbi decoding; circuit design techniques commonly used in signal processing and neural network, such as pipelining, parallel processing, folding, unfolding and systolic array. **Prerequisites:** Graduate classification.

ECEN 723 Introduction to Formal Verification

Credits 3. 3 Lecture Hours. Formal verification techniques for hardware and concurrent systems; binary decision diagrams; Boolean satisfiability; equivalence checking; model checking; temporal logic; design assertions; probabilistic model checking. **Prerequisites:** Graduate classification.

ECEN 725 Data Science Capstone

Credits 3. 3 Lecture Hours. Application of data science methods including machine learning to research problems; team project-based training for project management, interdisciplinary collaboration and communication skills. **Prerequisite:** Two or more of CSCE 633, CSCE 636, CSCE 666, CSCE 676, ECEN 758, ECEN 649, ECEN 740, ECEN 743, ECEN 765, ECEN 760, STAT 616, STAT 618 or STAT 639; Python programming experience is highly recommended. **Cross Listing:** STAT 683 and CSCE 725.

ECEN 732 Online Decision Making and Learning

Credits 3. 3 Lecture Hours. Study of the design and analysis of online decision making policies in the presence of unknown future events; topics include online learning, prima-dual techniques, online convex optimization and multi-armed bandit problem; focus on the application for emerging computer systems and networks. **Prerequisites:** Graduate classification.

ECEN 733 Advanced Micromachining Technologies for the Informational Era

Credits 3. 3 Lecture Hours. . In-depth discussion of state-of-the-art fabrication and assembly techniques for micro sensors and actuators to be used in today and future's smart electronics and intelligent systems. **Prerequisite:** Graduate classification in engineering.

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 740 Machine Learning Engineering

Credits 3. 3 Lecture Hours. Emphasis on fundamental theory for learning supervised classification-regression models; covers Bayes classifier, maximum-likelihood estimation, least squares, Probably Approximately Correct Learning, empirical risk minimization, Vapnik-Chervonenkis dimension, computational learning, structural risk minimization, regularization, cross-validation, acyclic feedforward networks, completeness of neural networks, backpropagation algorithm, gradient descent, stochastic gradient descent, Convolutional Neural networks, Auto-encoders, Generative Adversarial Networks, support vector machines, kernel-based methods, learning from experts, boosting, Gaussian process-based learning, word embeddings, recurrent neural networks, decision trees, random forests and nearest neighbor classification. **Prerequisite:** ECEN 303, MATH 411, STAT 614, STAT 615, 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 743 Reinforcement Learning

Credits 3. 3 Lecture Hours. Introduction to the theory and practice of reinforcement learning; including Markov decision processes, dynamic programming, Q-Learning, policy gradient algorithms, neural networks, deep reinforcement learning, imitation learning and multi-agent learning. **Prerequisite:** Graduate classification.

ECEN 744 Scientific Machine Learning

Credits 3. 3 Lecture Hours. Introduction to the algorithmic and computational foundations of Scientific Machine Learning (SciML); regularizing scientific laws in Machine Learning algorithms; interpretable models, leading to improved verification and validation in mission-critical applications; fundamental concepts of scientific computation, including ODE and PDE numerical methods and high-performance computing; introduction to the basic SciML algorithms (Automatic Differentiation, Physically Informed Neural Networks, and Physically-Informed Gaussian Processes) and their application to forward prediction, inverse modeling, and uncertainty quantification; educational activities of the TAMIDS SciML Thematic Lab. **Prerequisites:** Graduate classification.

ECEN 748 Data Stream Algorithms and Applications

Credits 3. 3 Lecture Hours. Study of algorithms to sample, sketch and summarize high rate data streams, including applications to measuring internet traffic and services and transactional graph streaming data; quantify the trade-offs between computational and storage resources and accuracy that are inherent in these methods. **Prerequisites:** Graduate classification; ECEN 303 or previous undergraduate or graduate course in probability or statistics; 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 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 756 Game Theory

Credits 3. 3 Lecture Hours. Fundamentals of game theory, strategic behavior and concepts of equilibria; utilization of concepts in realistic application scenarios, as well as algorithms and learning methods to compute such equilibria. **Prerequisite:** Graduate classification.

ECEN 757/CSCE 678 Distributed Systems and Cloud Computing

Credits 3. 3 Lecture Hours. Fundamental concepts of distributed systems with a focus on the emerging application of cloud computing; design, analyze, and optimize distributed systems; includes MapReduce, synchronization, peer-to-peer systems, election, distributed agreement, replication, job assignment. **Cross Listing:** CSCE 678/ECEN 757.

ECEN 758 Data Mining and Analysis

Credits 3. 3 Lecture Hours. Broad overview of data mining, integrating related concepts from machine learning and statistics; exploratory data analysis, pattern mining, clustering and classification; applications to scientific and online data. **Cross Listing:** CSCE 676 and STAT 639.

ECEN 759/CYBR 630 Hardware Security

Credits 3. 3 Lecture Hours. Cryptography and cryptographic algorithms such as AES, DES etc.; techniques to optimize hardware implementation of cryptographic systems; different types of side-channel attacks and countermeasures; supply-chain vulnerabilities – hardware Trojans, IP piracy, and reverse engineering; security modules for system-on-chip; physical unclonable function. **Prerequisites:** ECEN 350/CSCE 350 or approval of instructor. **Cross Listing:** CYBR 630/ECEN 759.

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 of an MR spectrometer and the gradient subsystem used for image localization; emphasis on the radiofrequency sensors and systems used for signal generation and reception. **Prerequisites:** BMEN major; graduate classification 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 768 Bioelectronics

Credits 3. 3 Lecture Hours. Basic biological systems from individual neuron to neural networks in the brain/nervous system by leveraging engineering principles, basic electrical circuit theory and electromagnetic theory; applications include biosensors including electrodes, chemical, mechanical and optical sensors and bioelectronic systems.

ECEN 769/MSEN 660 Materials Informatics

Credits 3. 3 Lecture Hours. Use of informatics approaches to establish quantitative structure-property relations (QSPRs) in materials and materials systems; basic concepts of QSPRs and probability, supervised learning, unsupervised learning, optimal prediction and applications in materials discovery. **Prerequisite:** Approval of instructor. **Cross Listing:** MSEN 660/ECEN 769.

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 774 Laser Principles and Applications

Credits 3. 3 Lecture Hours. Quantum properties of light and matter as related to optical and optoelectronic devices such as lasers and their applications; Maxwell's equations, classical optics and optical devices; basic quantum theory of light and atoms; laser resonators and short pulse generation.

ECEN 776 Unconditionally Secure Electronics

Credits 3. 3 Lecture Hours. Data security; cryptography; key exchange; conditional security; unconditional (information-theoretic) security; quantum key distribution; the Kirchhoff-law-Johnson-noise (KLJN) key exchange, electronic noise; advanced issues of KLJN including schemes, protocols, attacks, defense, privacy amplification, credit cards, PUF, autonomous vehicles and smart grids. **Prerequisites:** ECEN 214, ECEN 303, or STAT 211; graduate classification.

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, interferometrs, photodetectors, integrated optics, fiber-optics, fiber-optic devices, optical modulators. **Prerequisites:** Equivalent of ECEN 322 and ECEN 370 or approval of instructor.