

ELECTRICAL AND COMPUTER ENGR (ECE)

ECE 502

Basic Network Theory

Steady-state analysis of linear networks. Introduction to topology and the derivation of mesh, nodal & terminal pair relations using topological concepts with applications to computer-aided analysis of networks. Numerical techniques for network analysis and optimization.

Lecture: 3 Lab: 0 Credits: 3

ECE 504

Wireless Communication System Design

Fundamentals of first (1G), second (2G), third (3G), and future generation cellular communication systems. This course covers the transition from 1G to 3G systems. Topics included are speech and channel encoders, interleaving, encryption, equalization, modulation formats, multi-user detection, smart antennas, technologies that are used in these transitions, and future generations of cellular systems. Compatibility aspects of digital cellular systems are discussed along with a review of the standards for the industry. TDMA and CDMA systems are covered in detail.

Lecture: 3 Lab: 0 Credits: 3

ECE 505

Applied Optimization for Engineers

Principles of optimization for practical engineering problems, linear programming, nonlinear unconstrained optimization, nonlinear constrained optimization, dynamic programming.

Lecture: 3 Lab: 0 Credits: 3

ECE 506

Analysis of Nonlinear Systems

Graphical and analytical methods, phase plane and singular points, periodic oscillations and limit cycles, forced nonlinear systems, jumps subharmonics and frequency entrainment; stability analysis using Liapunov, Popov and circle criteria; introduction to describing functions.

Lecture: 3 Lab: 0 Credits: 3

ECE 507

Imaging Theory & Applications

Image formation methods including optical (photography), tomography, image formation with arrays of sensors, interferometry, and surface imaging. Technologies of image acquisition including digital cameras, radar/sonar and medical imaging techniques such as magnetic resonance imaging, computed tomography, positron emission tomography, optical imaging, electroencephalography, and magnetoencephalography. Throughout the semester, the course will also focus on the reconstruction of images based on the raw data obtained from various imaging techniques.

Lecture: 3 Lab: 0 Credits: 3

ECE 508

Video Processing and Communications

This course covers the fundamentals of video coding and communications. The principles of source coding for the efficient storage and transmission of digital video will be covered. State-of-the-art video coding standards and error-resilient video coding techniques will be introduced. Recent technologies for robust transmission of video data over wired/wireless networks will be discussed. A detailed overview of architectural requirements for supporting video communications will be presented. Error control and cross-layer optimization techniques for wireless video communications will be covered.

Lecture: 3 Lab: 0 Credits: 3

ECE 509

Electromagnetic Field Theory

Electric and magnetic fields produced by charge and current distributions. Solution of Laplace's and Poisson's equations, time-varying fields and electromagnetic waves. Applications to waveguides and antennas.

Prerequisite(s): ECE 307 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 511

Analysis of Random Signals

Probability theory, including discrete and continuous random variables, functions and transformations of random variables. Random processes, including correlation and spectral analysis, the Gaussian process and the response of linear systems to random processes.

Lecture: 3 Lab: 0 Credits: 3

ECE 512

Hybrid Electric Vehicle Drives

Fundamentals of electric motor drives are studied. Applications of semiconductor switching circuits to adjustable speed drives, robotic, and traction are explored. Selection of motor drives, calculating the ratings, speed control, position control, starting, and braking are also covered. Simulation mini-projects and lab experiments are based on the lectures given.

Lecture: 3 Lab: 0 Credits: 3

ECE 513

Communication Engineering Fundamentals

Review of probability and random processes. AM with noise, FM with noise. Introduction to digital communication. Source coding, signal space analysis, channel modulations, optimum receiver design, channel encoding.

Lecture: 3 Lab: 0 Credits: 3

ECE 514

Digital Communication Principles

Information transmission fundamentals, including capacity, entropy, Shannon's theorems and source coding. Introduction to rate distortion theory. Advanced digital modulation and demodulation techniques, performance measures. Channel coding and introduction to trellis coded modulation.

Prerequisite(s): ECE 511 with min. grade of C and ECE 513 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 515

Modern Digital Communications

Review of modulation and coding. Trellis coded modulation. Digital signaling over fading multipath channels. Spread spectrum signals for digital communications. Multiple access systems, time-division multiple access, code-division multiple access, and frequency-division multiple access. Advanced communications systems.

Prerequisite(s): ECE 511 with min. grade of C and ECE 513 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 516

Coding for Distributed Storage Systems

Distributed storage systems, such as data centers, are becoming a vital infrastructure of today's society by allowing to store reliably large amounts of data and make it accessible anywhere and anytime. The goal of this course is to train students with the different mathematical and engineering tools that are needed when studying and designing codes and algorithms for data reliability and security in these large-scale systems. The course will cover relevant topics in information theory, coding theory, graph theory, and wireless communications in addition to the active on-going research in this area.

Prerequisite(s): ECE 511 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 517

Modern Wireless Network Protocols and Standards

This course introduces cutting-edge wireless networking technologies with focus on the network protocols and standards of the current and next generation wireless networks including cellular networks, wireless local area networks, and wireless ad hoc networks. Specifically, it will cover topics relevant to wireless communications, radio resource management, mobility management, wireless medium access control, wireless routing protocols, and wireless TCP protocols.

Prerequisite(s): ECE 407 with min. grade of C or ECE 408 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 518

Computer Cyber Security

This course covers topics such as network-related security threats and solutions, private- and public-key encryptions, authentication, digital signatures, Internet Protocol security architecture (IPSEC), firewalls, network management, wireless network security, email, and web security.

Lecture: 3 Lab: 0 Credits: 3

ECE 519

Coding for Reliable Communications

Encoders and decoders for reliable transmission of digital data over noisy channels. Linear block codes, cyclic codes, BCH codes, convolutional codes. Burst error correcting codes. Maximum likelihood decoding of convolutional codes. Performance of block and convolutional codes in additive white Gaussian channel.

Lecture: 3 Lab: 0 Credits: 3

ECE 520

Information Theory and Applications

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. Information theoretic security. Modern applications of information theory in communications, networking, and other fields.

Prerequisite(s): ECE 511 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 521

Quantum Electronics

The Schrodinger equation. Matrix formulation. Quantization of lattice vibrations and electromagnetic fields. Optical beams and resonators. The interaction of radiation and atomic systems. Lasers. Optical waveguides and devices. Frequency conversion. Quantum noise. Same as PHYS 521.

Prerequisite(s): ECE 307 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 522

Electromagnetic Compatibility

Development of design procedures for minimizing interference between electronic circuits and systems. sources of conducted and radiated interference. Interference coupling mechanisms. Shielding theory. Grounding, bonding and filtering methods. special equipment design procedures. Problems associated with digital equipment. Measurement methods.

Prerequisite(s): ECE 307 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 523

Fundamentals of Semiconductor Devices

The goals of this course are to give students an understanding of the physical and operational principles behind important electronic devices. Semiconductor electron and hole concentrations, carrier transport, and carrier generation and recombination are discussed. P-N junction operation and its application to diodes, solar cells, and LEDs, are developed. The metal-oxide-semiconductor-field-effect transistor (MOSFET) and bipolar junction transistor (BJT) are then discussed. Applications of transistors in analog and digital circuits are introduced. A term project on a particular device topic is required.

Lecture: 3 Lab: 0 Credits: 3

ECE 524**Advanced Electronic Circuit Design**

RF amplifiers and oscillators. Low and high power RF amplifier design techniques. Stability of amplifiers. LC and crystal oscillators. FM demodulators and limiters. Mixer design. Circuit design to minimize intermodulation and other forms of distortion.

Prerequisite(s): ECE 309 with min. grade of C and ECE 312 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 525**RF Integrated Circuit Design**

Essentials of contemporary RF CMOS integrated circuit analysis and design. Typical RF building blocks in CMOS and BiCMOS technologies, including passive IC components, MOS transistors, RLC tanks, distributed networks, RF amplifiers, voltage reference and biasing circuits, LNA, mixers, power amplifiers, and feedback networks. RF device modeling. Smith chart applications, bandwidth estimation, and stability analysis techniques. RF IC team design projects.

Prerequisite(s): ECE 312 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 526**Active Filter Design**

Analysis and design of linear active filters with emphasis on realizations using operational amplifiers. Sensitivity analysis. Switched capacitor filters.

Prerequisite(s): ECE 308 with min. grade of C and ECE 312 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 527**Performance Analysis of RF Integrated Circuits**

Essentials of analysis techniques for nonlinear effects and noises in contemporary RF integrated circuit design. Nonlinear and distortion behaviors including inter-modulation, cross-modulation, harmonics, gain compression, desensitization, spurious, etc. Noise effects including thermal, shot, Flicker, burst noises, etc. RF IC devices and circuits including resistors, capacitors, inductors, diodes, BJTs, FETs, low-noise amplifiers, mixers, power amplifiers, etc. Analysis skills for single-stage and multiple-stage networks. RF IC team design projects.

Prerequisite(s): ECE 312 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 528**Application Software Design**

The course provides introduction to languages and environments for application software development utilizing Software as a Service (SaaS) for electrical and computer engineers. Languages addressed include Java, Python, SQL, and JavaScript. Key topics covered include systems development life cycle, client-server architectures, database integration, RESTful service, and data visualization. Programming projects will include the development of a data-rich web application with server back-end that connects mobile devices and Internet of Things using Agile software engineering practices. Differential requirement from ECE 448 is a major final project.

Lecture: 3 Lab: 0 Credits: 3

ECE 529**Advanced VLSI Systems Design**

Advanced design and applications in VLSI systems. The topics of this course include design tools and techniques, clocking issues, complexity management, layout and floor planning, array structures, testing and testability, advanced arithmetic circuitry, transcendental function approximations, architectural issues, signal processing architecture and sub-micron design. Design projects are completed and fabricated by student teams.

Lecture: 3 Lab: 0 Credits: 3

ECE 530**High Performance VLSI IC Systems**

Background and insight into some of the most active performance-related research areas of the field is provided. Issues covered include CMOS delay and modeling, timing and signal delay analysis, low power CMOS design and analysis, optimal transistor sizing and buffer tapering, pipelining and register allocation, synchronization and clock distribution, retiming, interconnect delay, dynamic CMOS design techniques, asynchronous vs. synchronous tradeoffs, BiCMOS, low power design, and CMOS power dissipation. Historical, primary, and recent papers in the field of high-performance VLSI digital and analog design and analysis are reviewed and discussed. Each student is expected to participate in the class discussions and also lead the discussion surveying a particular topic.

Prerequisite(s): ECE 429 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 531**Linear System Theory**

Linear spaces and operators, single and multivariable continuous dynamical systems, controllability and observability. Canonical forms, irreducible realizations. Synthesis of compensators and observers. Composite systems, elements of stability.

Prerequisite(s): ECE 308 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 533**Robust Control**

Uncertain systems; multi-variable control design; linear fractional transformation; uncertainties and small-gain theorem; H-infinity norm; algebraic Riccati equations; H-infinity control; optimality and robustness; design considerations; loop shaping; uncertainty and disturbance estimator; applications and examples.

Prerequisite(s): ECE 438 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 535**Discrete Time Systems**

Discrete systems. Sampling and reconstruction procedures. Transform techniques of analysis and synthesis. State space techniques. Discrete controllability, observability and stability. Compensation and digital controllers.

Prerequisite(s): ECE 438 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 536**Analytical Methods for Power System Economics and Cybersecurity**

Analytical methods for the economic operation of power systems with consideration of transmission losses. Analytical methods for the optimal scheduling of power generation including real power and reactive power. Analytical methods for the estimation of power system state. Analytical methods for the modeling of smart grid cybersecurity. Research project on smart grid cybersecurity.

Prerequisite(s): ECE 319 with min. grade of C or ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 537**Next Generation Smart Grid**

Paradigm change of power systems; Challenges faced during the paradigm change; Concept of synchronized and democratized (SYNDEM) smart grids; SYNDEM architecture for next-generation smart grids; Technical routes to implement SYNDEM smart grids; Enabling technologies: Three generations of virtual synchronous machines (VSM); Integration of renewables/EV/storage systems through VSM; Integration of flexible loads through VSM; Illinois Tech SYNDEM prototype smart grid.

Lecture: 3 Lab: 0 Credits: 3

ECE 538**Renewable Energies**

Various renewable energy sources such as solar systems, wind powered systems, ocean tides, ocean waves, and ocean thermal are presented. Their operational principles are addressed. Grid connected interfaces for such systems are explained. Research and Simulation mini-projects with emphasis on either machine design, or power electronic circuit analysis, design, and controls, or grid connected renewable systems are assigned to student groups.

Prerequisite(s): ECE 311 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 539**Computer Aided Design of Electric Machines**

Fundamentals of energy conversion will be discussed, which are the foundation of efficient design and operation of motors & generators in modern day automotive, domestic and renewable energy systems. It will further investigate the principles of structural assessment, electromagnetic analysis, dimensional and thermal constraints. Finite Element Analysis (FEA) software-based design projects will be used to model the performance and operation of electric machines.

Lecture: 3 Lab: 0 Credits: 3

ECE 540**Reliability Theory and System Implementation**

Basic probability and modeling techniques on component, subsystem and system levels. MTBF, MTTR and downtime. Hardware, software and cost considerations. Switching systems. Multicomputer and memory configurations.

Lecture: 3 Lab: 0 Credits: 3

ECE 541**Performance Evaluation of Computer Networks**

Introduction to performance evaluation techniques for computer and communication networks. Little's theorem, birth-death processes, M/G/1 queue, product form queueing networks, approximation techniques for G/G/1 queues and non-product form queueing networks. Discrete event simulations, generation of random variables, variance reduction techniques and general purpose simulation languages.

Lecture: 3 Lab: 0 Credits: 3

ECE 542**Design and Optimization of Computer Networks**

This course provides comprehensive introduction to network flows with an integrative view of theory, algorithms, and applications. It covers shortest path, maximum flow, and minimum cost flow problems, including a description of new and novel polynomial-time algorithms. It also covers topics from basic network design to protection and restoration design, to multi-layer network design while taking into account routing and flow requirement as applicable in different network architecture, protocol and technologies.

Prerequisite(s): ECE 407 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 543**Computer Network Security**

This course introduces network security by covering topics such as network-related security threats and solutions, private- and public-key encryptions, authentication, digital signatures, Internet Protocol security architecture (IPSEC), firewalls, network management, email and web security.

Prerequisite(s): ECE 407 with min. grade of C or ECE 408 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 544**Wireless and Mobile Networks**

This course provides an overview of different wireless and mobile network standards and systems. The topics covered include cellular networks, satellite networks, wireless local area networks, wireless personal area networks, mobile IP, ad hoc networks, sensor networks, wireless mesh networks and wireless network security.

Lecture: 3 Lab: 0 Credits: 3

ECE 545**Advanced Computer Networks**

Fundamentals of computer communication networks. Overview of data communication networks and protocol architectures with emphasis on the Internet protocols and network elements. Principles of network and protocol design; error detection and correction, flow control and congestion control, delay and throughput models, QoS, service support and application interface (including remote procedure call mechanisms). Local and Wide Area Networks (Ethernet, FDDI, Wireless LAN, ATM and Internet). LAN and Wan interconnection using bridges, routers, switchers and gateways. Routing in data networks. Network and protocol design to support multimedia and multicasting connections. Network application security.

Prerequisite(s): ECE 407 with min. grade of C or ECE 408 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 546**Wireless Network Security**

This course focuses on selected research topics current interest in wireless network security. This course will cover security and privacy issues in wireless systems, including cellular networks, wireless LAN, mobile ad hoc networks (MANET), wireless mesh networks, sensor networks, vehicular networks, RFID, and ubiquitous computing.

Prerequisite(s): ECE 543 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 547**Wireless Networks Performance Analysis**

This course deals with the performance analysis techniques for the main types of wireless networks used today including cellular communication networks, wireless local area networks (WLAN), zigbee wireless networks, and wireless mesh networks. The course not only discusses the details of the related IEEE standards but also focuses on mathematical modeling and analysis to compute the quality of service metrics as well as resource utilization efficiency. Key topics include cellular system design, mobility management, conflict-free medium access, contention-based medium access, Markov chain modeling for 802.11, fixed-point based analysis, 802.15.4 modeling and analysis, and wireless mesh network capacity analysis.

Prerequisite(s): ECE 544 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 548**Energy Harvesting**

Various harvesting techniques such as solar, ocean tides, vibration, linear motion, radio frequency, passive and active human power generation are presented. Their operational principles are addressed. Research and simulations mini-projects with emphasis on power electronic circuit analysis, design, and controls are assigned to student groups.

Prerequisite(s): ECE 311 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 549**Motion Control Systems Dynamics**

Fundamentals and applications of motion control systems, control techniques for high precision motion control, state variable feedback of linear and nonlinear systems, multivariable systems, physical system modeling, graphical analysis, and numerical analysis, and system performance analysis.

Prerequisite(s): ECE 438 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 550**Power Electronic Dynamics and Control**

Modeling an analysis of solid-state switching circuits, parallel module dynamics, multi-converter interactions, resonant converters, feedback control, stability assessment, reduced parts converters, integrated structures, programmable switching regulators, digital switch-mode controllers, and power electronic converter-on-a-chip development.

Prerequisite(s): ECE 411 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 551**Advanced Power Electronics**

Advanced power electronic convertors, techniques to model and control switching circuits, resonant converts, Pulse-Width-Modulation (PWM) techniques, soft-switching methods, and low-voltage high-current design issues are studied. Single-phase and multi-phase, controlled and uncontrolled rectifiers and inverters with different operating techniques and their design and control issues are explained.

Prerequisite(s): ECE 411 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 552**Adjustable Speed Drives**

Fundamentals of electric machines, basic principles of variable speed controls, field orientation theory, direct torque control, vector of AC drives, induction machines, switched reluctance and synchronous reluctance motors, permanent magnet brushless DC drives, converter topologies of DC and AC drives, and sensorless operation.

Prerequisite(s): ECE 411 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 553**Power System Planning**

Model development. Interchange capability, interconnections, pooling. Economic generator size and site selection. Concept of reserves, transformers, relays and circuit breakers. Reactive planning AC and DC systems are explored thoroughly from a planning standpoint.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 554**Power System Relaying**

Principles of relay protection for faults on transmission lines and in transformers, rotating machines and other equipment. Use of over current, differential, distance, wire-pilot, carrier-pilot and microwave-pilot relaying systems. Solid-state relays and computer control of relaying. Determination of short-circuit currents and voltages from system studies.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 555**Power Market Operations**

Market Design in Restructured Power Systems, Short-term Load Forecasting, Electricity Price Forecasting, Price Based Unit Commitment, Arbitrage in Electricity Market, Market Power Analysis, Asset Valuation and Risk Analysis, Security Constrained Unit Commitment, Ancillary Services Auction Market Design, Power Transmission Pricing, Regional Transmission Organizations.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 556**Power Market Economics and Security**

This course covers simulation and scheduling tools used in restructured power system for studying the economics and security of power systems. Topics include modeling of generating units (thermal units, combined-cycle units, fuel-switching/blending units, hydro units, pumped-storage units, photovoltaic, wind), Lagrangian Relaxation-based scheduling, mixed integer programming-based scheduling, and Benders decomposition-based transmission security analyses. The simulation and scheduling tools consider different time scales including on-line security, day-ahead, operational planning, and long-term. The simulation and scheduling tools consider interdependency of supply (such as gas, water, renewable sources of energy) and electricity systems.

Prerequisite(s): ECE 420 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 557**Fault-Tolerant Power Systems**

Critical fault events in a large power system, sparsity techniques. Contingency screening process. Modeling of local controls in load flow. Adaptive localization method. Injection outage analysis. Security constrained dispatch. LP-based OPF. Real-time security analysis. Dynamic security analysis.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 558**Power System Reliability**

The concept of reliability, reliability indices, component reliability, generation capacity reserve evaluation, transmission system reliability, bulk power system reliability, distributed system reliability, reliability modeling in context.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 559**High Voltage Power Transmission**

Detailed analysis of transmission and distribution systems. Design of high voltage transmission lines and cables, as well as distribution lines. Flexible AC transmission Systems (FACTS) and high voltage DC links.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 560**Power Systems Dynamics and Stability**

The transient stability problem, acceleration equations, stability criteria, two-machine and multimachine problems. Perturbation analysis, eigenvalue sensitivity, Liapunov theory and application to power systems stability.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 561**Deregulated Power Systems**

Overview of key issues in electric utilities restructuring, Poolco model, bilateral contracts, market power, stranded costs, transmission pricing, electric utility markets in the United States and abroad, OASIS, tagging electricity transactions, electric energy trading, risk in electricity markets, hedging tools for managing risks, electricity pricing, volatility in power markets, and RTO.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 562**Power System Transaction Management**

Power interchange transaction management in the deregulated electric power industry. Course topics include: power system security assessment, total and available transfer capability (TTC/ATC), transaction management system (TMS), transaction information system (TIS), tagging calculator (IDC), congestion management, transmission loading relief (TLR).

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 563**Computational Intelligence in Engineering**

Introduction to soft computing, fuzzy set theory, neural networks, genetic algorithms, intelligent software agents, comparisons with traditional alternatives, and advanced engineering applications.

Lecture: 3 Lab: 0 Credits: 3

ECE 564**Control and Operation of Electric Power Systems**

Unit commitment and application of dynamic programming, fuel budgeting and planning, probabilistic production cost modeling, hydrothermal coordination, power system security and application of expert systems, state estimation, optimal power flow, interchange evaluation and power pools, reactive power planning.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 565**Computer Vision and Image Processing**

Multidimensional sampling and discrete Fourier transform; Image segmentation; Object boundary (edge) detection and description; shape representation and extraction; Matching and recognition; Image registration; Camera geometry and stereo imaging; Morphological processing; Motion detection and compensation; Image modeling and transforms; Inverse problems in image processing (restoration and reconstruction).

Lecture: 3 Lab: 0 Credits: 3

ECE 566**Statistical Pattern Recognition**

Review of appropriate math: multidimensional probability, covariance matrices, whitening transformation, diagonalization, eigenvectors, eigenvalues. Two-class and multi-class pattern separation using maximum likelihood and MAP. Linear discriminant analysis. Perception algorithm and its extensions. Feature extraction algorithms. Clustering algorithms. Introduction to neural nets. Hopfield, Hamming, feed forward models. Training of neural nets.

Prerequisite(s): ECE 511 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 567**Statistical Signal Processing**

Detection theory and hypothesis testing. Introduction to estimation theory. Properties of estimators, Gauss-Markov theorem. Estimation of random variables: conditional mean estimates, linear minimum mean-square estimation, orthogonality principle, Wiener and Kalman filters. Adaptive filtering. LMS algorithm: properties and applications.

Prerequisite(s): ECE 511 with min. grade of C and MATH 333 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 568**Digital Speech Processing**

Review of discrete statistical signal analysis. Acoustic aspects of speech and hearing. Digital models of speech production. Short-time processing in time and frequency domains. Waveform encoding and linear predictive coding of speech. Estimation of fundamental speech parameters. Applications including automatic speech recognition and enhancement.

Prerequisite(s): (ECE 437 with min. grade of C and ECE 511 with min. grade of C) or ECE 511 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 569**Digital Signal Processing II**

Review of basic DSP theory. Design of digital filters: FIR, IIR, frequency-transformation methods, optimal methods. Discrete Fourier Transform (DFT) and Fast Fourier Transform algorithms. Spectral estimation techniques, classical and parametric techniques. AR, MA, ARMA models. Estimation algorithms. Levinson, Durbin-Levinson and Burg's algorithms. eigenanalysis algorithms for spectral estimation.

Lecture: 3 Lab: 0 Credits: 3

ECE 570**Fiber-Optic Communication Systems**

Physics of optical fiber, composition, dimensioning, coupling, attenuation, dispersion. Electro-optical conversion devices. (ILDs, LEDs, APDs, PINs). Circuit considerations. Modulation techniques and implications. Overall system considerations. Coherent techniques.

Prerequisite(s): (ECE 312 with min. grade of C and ECE 307 with min. grade of C) and ECE 403 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 571**Nanodevices and Technology**

Electronic properties and quantum effects. Dielectric, magnetic, and optical properties and their characterizations. Individual nanoparticles and clusters. Carbon nanotubes. Solid disordered nanostructures. Nanostructured crystals. Quantum wells, wires, and dots. Giant magnetoresistance. Material processing techniques. Devices and systems based on nanostructures. Must have successfully passed ECE 307 Electrodynamics or equivalent course.

Lecture: 3 Lab: 0 Credits: 3

ECE 575**Electron Devices**

Electronic properties of solids. Properties of p-n junctions and junction devices. Gunn diode and IMPATT devices. Junction transistors. Schottky diode and MESFET. The MOS capacitor and MOSFET. Light-emitting diodes and junction lasers. Velocity modulation and bunching in electron beams. Klystrons, magnetrons and other microwave thermionic devices.

Prerequisite(s): ECE 307 with min. grade of C and ECE 312 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 576**Antenna Theory**

Plane and spherical waves. Electric and magnetic dipoles. Radiation patterns and impedance characteristics of antennas in free space and over perfect ground. Linear and planar driven antenna arrays. Yagi-Uda parasitic arrays.

Prerequisite(s): ECE 307 with min. grade of C or ECE 421 with min. grade of C or ECE 423 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 578**Microwave Theory**

Microwave field theory. Propagation, reflection and refraction of plane waves. Anisotropic media. Impedance concept. Hollow, surface-wave and dielectric wave guides. Discontinuities in wave guides. Microwave resonators. Transmission lines. Microwave circuit theory.

Prerequisite(s): ECE 421 with min. grade of C or ECE 423 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 579**Operations and Planning and Distributed Power Grid**

The course is divided into four sub-components: current state of the distributed power grid, outlook for the distributed power grid, operation of the distributed power grid, and planning of the distributed power grid. This course will begin by providing an overview of existing distribution systems and smart grid technologies, such as distribution automation and advanced metering infrastructure (AMI). With the emerging trends in power industry, the course will next focus on trends driving the change and the future components of distributed power grid, including but not limited to distributed generation (DG) and energy storage systems (ESSs). The next part of the course will be focused on the operation and control strategies for distributed power grid systems, including operational constraints, voltage and var control (VVC), and control of DERs and Smart Inverters. The final topic area for the course will be planning of distributed power grid with DERs, including lectures on DER impacts and their assessments, hosting capacity, and microgrid operations.

Lecture: 3 Lab: 0 Credits: 3

ECE 580**Elements of Sustainable Energy**

This course covers cross-disciplinary subjects on sustainable energy that relate to energy generation, transmission, distribution, and delivery as well as theories, technologies, design, policies, and integration of sustainable energy. Topics include wind energy, solar energy, biomass, hydro, nuclear energy, and ocean energy. Focus will be on the integration of sustainable energy into the electric power grid, the impact of sustainable energy on electricity market operation, and the environmental impact of sustainable energy.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 581**Elements of Smart Grid**

This course covers cross-disciplinary subjects on smart grid that relates to energy generation, transmission, distribution, and delivery as well as theories, technologies, design, policies, and implementation of smart grid. Topics include: smart sensing, communication, and control in energy systems; advanced metering infrastructure; energy management in buildings and home automation; smart grid applications to plug-in vehicles and low-carbon transportation alternatives; cyber and physical security systems; microgrids and distributed energy resources; demand response and real-time pricing; and intelligent and outage management systems.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 582**Microgrid Design and Operation**

Microgrids are the entities that are composed of at least one distributed energy resource and associated loads which not only operates safely and efficiently within the local power distribution network but also can form intentional islands in electrical distribution systems. This course covers the fundamentals of designing and operating microgrids including generation resources for microgrids, demand response for microgrids, protection of microgrids, reliability of microgrids, optimal operation and control of microgrids, regulation and policies pertaining to microgrids, interconnection for microgrids, power quality of microgrids, and microgrid test beds.

Prerequisite(s): ECE 418 with min. grade of C or ECE 419 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 583**High Speed Computer Arithmetic**

This course covers computer arithmetic as applied to general-purpose and application-specific processors. The focus is on developing high-speed arithmetic algorithms and understanding their implementation in VLSI technology at the gate level. Topics include fixed and floating point number systems, algorithms and implementations for addition, subtraction, multiplication, division, and square root, floating point operations, elementary function approximation, low-power design, error analysis, and interval arithmetic..

Prerequisite(s): ECE 446 with min. grade of C or ECE 485 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 584**VLSI Architecture for Signal Processing and Communication Systems**

This course aims to convey knowledge of advanced concepts in VLSI signal processing. Emphasis is on the architectural research, design and optimization of signal processing systems used in telecommunications, compression, encryption and coding applications. Topics covered include the principles of datapath design; FIR and IIR filtering architectures; communication systems including OFDM, multirate signal processing; fast transforms and algorithms including fast Fourier transform; discrete cosine transform; Walsh-Hadamard transform; and wavelet transform. Furthermore, advanced computer arithmetic methods including Galois fields, CORDIC, residue number systems, distributed arithmetic, canonic signed digit systems and reduced adder graph algorithms are examined.

Prerequisite(s): ECE 429 with min. grade of C and ECE 437 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 585**Computer Organization and Design**

This course provides the students with understanding of the fundamental concepts of computer architecture, organization, and design. It focuses on relationship between hardware and software and its influence on the instruction set and the underlying Central Processing Unit (CPU). The structural design of the CPU in terms of datapath and control unit is introduced. The technique of pipelining and hazard management are studied. Advanced topics include instruction level parallelism, memory hierarchy and cache operations, virtual memory, parallel processing, multiprocessors and hardware security. The end to end design of a typical computer system in terms of the major entities including CPU, cache, memory, disk, I/O, and bus with respect to cost/performance trade-offs is also covered. Differentiation between ECE 485 and ECE 585 is provided via use of projects / case studies at differing levels. (3-0-3)

Prerequisite(s): ECE 242 with min. grade of C and ECE 218 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 586**Fault Detection in Digital Circuits**

Essential elements in testing and testability of digital designs. Automatic tests generation algorithms and fault-simulation methods. Design methodologies to increase testability and decrease test generation costs. Techniques for built-in testing.

Prerequisite(s): ECE 446 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 587**Hardware/Software Codesign**

Computer-aided techniques for the joint design of hardware and software: specification, analysis, simulation and synthesis. Hardware/software partitioning, distributed system cosynthesis, application-specific instruction set design, interface cosynthesis, timing analysis for real-time systems.

Prerequisite(s): CS 201 with min. grade of C and ECE 441 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 588**CAD Techniques for VLSI Design**

Overview of techniques and algorithms used in Computer-Aided Design (CAD) for VLSI circuits. Physical CAD tools, including placement, routing, symbolic layout and compaction. High-level CAD tools, including logic synthesis, silicon compilers and high-level synthesis. Recent developments in the field. Design, implementation and performance analysis of prototype CAD tools.

Prerequisite(s): ECE 429 with min. grade of C

Lecture: 3 Lab: 0 Credits: 3

ECE 589**Computer-Aided Design of Analog IC**

Analog IC design optimization algorithm such as equation-based optimization and simulation-based optimization algorithms, design automation tools such as harmonic balance, projection-based surface response estimation, shooting methods, etc. will be introduced. Research and mini-projects with emphasis on analog integrated circuit design and optimization algorithms using state-of-the-art tools are assigned to student groups.

Lecture: 3 Lab: 0 Credits: 3

ECE 591**Research and Thesis for Masters Degree**

Credit: Variable

ECE 593**Masters Electrical and Computer Engineering Seminar**

Seminar course for Master students.

Lecture: 1 Lab: 0 Credits: 0

ECE 594**Special Projects**

Special projects.

Credit: Variable

ECE 597**Special Problems**

Credit: Variable

ECE 600**Continuation of Residence**

Lecture: 0 Lab: 0 Credits: 1

ECE 691**Research and Thesis for Ph.D.**

Corequisite(s): ECE 693

Credit: Variable

ECE 693**Graduate Research Seminar**

Seminar course for graduate students.

Corequisite(s): ECE 691

Lecture: 1 Lab: 0 Credits: 0

ECE 708**Technologies for Long-Term Evolution of Wireless Communications Networks**

The course discusses technologies used in long-term evolution (LTE) wireless communications systems. Fundamentals of multiple-input/multiple-output (MIMO) wireless communication systems and orthogonal frequency division modulation (OFDM) are covered. Transmission diversity concepts and principles of space-time coding are introduced. The fundamentals of space-time block and trellis coded modulation (STBCM and STTCM) are introduced along with performance analysis, code design, and simulation results. A comparison of various design techniques in different propagation environments is presented. Applications to MIMO/OFDM systems are discussed.

Prerequisite(s): ECE 513 with min. grade of C

Lecture: 2 Lab: 0 Credits: 2

ECE 718**Radio Access Technologies for 5G and Beyond**

The course introduces new radio access network (RAN) technologies and study the theoretical principles underlying the 5G new radio (NR) proposals. The course discusses the fundamentals by which channel coding and new non-orthogonal multiple access (NOMA) techniques improve throughput and reliability; and examine the current research trends and applications with emphasis on the practical implementation of 5G PHYS layer architecture. The main thrust of this course is to study designs that allow multi-user capabilities with interference, bandwidth and energy constraints. Transformations that allow transmission of multiple users and their embedded structures, will be considered. Modulation formats and access techniques that are bandwidth-energy efficient need to be considered. These new designs are studied, generalized and evaluated in different channels and interference conditions. This course has both theoretical and practical goals.

Lecture: 2 Lab: 0 Credits: 2

ECE 719**Theory and Applications of Linear Optimization in Wireless Networks**

This short course covers both the fundamental of linear optimization and applications in wireless networking research, emphasizing not only the optimization methodology but also the underlying mathematical structures. In addition to the fundamental contents of simplex method, duality theory, and network flow problems, this course also covers the integer programming techniques. This course discusses the applications of linear optimization in the wireless network, including wireless mesh networks, multi-radio multi-channel networks, and cognitive radio networks.

Prerequisite(s): (ECE 407 with min. grade of C or ECE 408 with min. grade of C) and MATH 477 with min. grade of C

Lecture: 2 Lab: 0 Credits: 2

ECE 721**Introduction to Wireless Cooperative Communications and Applications**

The course gives an introduction to wireless cooperative communication networks from the perspective of the channel and physical layer. It discusses cooperative networks protocols and application of these. It will deal with wireless channels and relay networks. Transparent and regenerative physical layer algorithms will be discussed to facilitate the analysis of different architectures. Use of distributed space time codes, multiplexing, and orthogonal frequency division multiplexing will be analyzed to achieve multi-dimensional diversity (path, frequency, and time), reduced interference, and improved QoS.

Prerequisite(s): ECE 403 with min. grade of C

Lecture: 2 Lab: 0 Credits: 2

ECE 735**Cellular Long Term Evolution**

Cellular Long Term Evolution (LTE) is a key wireless broadband technology considered as the primary path towards the next generation networks (NGNs). It is generally considered as the dominant wireless technology meeting the seamless, mobile Internet access needs of the upcoming Quadruple Play applications. This short course covers the applications, requirements, architecture, radios and antennas, protocols, network operations and management, and evolution for the LTE technology. Key topics include the functions and interfaces of the protocol layers, Quality of Service (QoS), security, network signaling, infrastructure, user equipment, spectrum, throughput, and coverage. Discussion includes the modulation schemes, frame structure, antenna and radio, and subcarrier and bandwidth allocation methods. End-to-end scenarios on connection setup, interworking with existing 3G cellular, WiFi, and WiMAX networks, and handovers are discussed. Testing and integration issues, limitations, and challenges are also mentioned. Comparative analysis with respect to WiMAX and ultra mobile broadband (UMB) are covered. The likely migration paths from current wireless and wireline networks to LTE and related HSOPA and SAE architectures are discussed.

Lecture: 1 Lab: 0 Credits: 1

ECE 738**Information Technology**

Probability and Random Process Information theory addresses information theoretic limits on data compression and reliable data communications in the presence of noise. It has fundamental contribution in communications, networking, statistical physics, computer science, statistical inference, and probability and statistics. It covers entropy, mutual information, fundamental limits on data compression, Huffman codes, channel capacity, and channel coding.

Lecture: 2 Lab: 0 Credits: 2

ECE 739**Broadband Access -- Options and Analysis**

This short course deals with requirements, options, architecture, and issues relating to the Next Generation broadband networks. The focus is on the key wireline and wireless access options with specific emphasis on its applicability to multimedia applications. The requirements placed by upcoming services on access are introduced. For the major access options, the key topics include capabilities, architectures, protocol structures, Quality of Service (QoS), security, user equipment, spectrum, throughput, and coverage. The associated signaling and modulation schemes, transport technologies and characteristics, end-to-end scenarios, and interworking are addressed. Comparative analysis in terms of various application profiles involving voice, data, and video are carried out. The modeling techniques for analyzing the interplay and technology and market relevance of xDSL, cable/coax, fiber, WiFi, WiMAX, and cellular wireless options are covered. The likely migration paths for these options towards the Next Generation Networks (NGNs) are mentioned.

Lecture: 2 Lab: 0 Credits: 2

ECE 740**Telecommunication Networks: Requirements to Deployment**

The ever-increasing customer demand for new and advanced services and the associated complexities of designing, deploying, optimizing, and managing telecom networks require advanced end to end technology and process expertise. This short course deals with the key concepts of requirements development, design processes, architecture finalization, system design, site testing, performance optimization, and network operations and management of current and upcoming Telecom networks. It provides an overview on how the process works from an idea or concept to productization and will give a view on associated complexities and challenges. Key advances in tools and techniques needed with these major steps are covered. Practical examples of the current and upcoming features which will make telecom networks competitive are addressed.

Aspects of customer management, strategies for decision making, and the migration towards future networks are also addressed. Practical examples of networks of selected service providers and how they meet the local and global needs are mentioned.

Lecture: 2 Lab: 0 Credits: 2

ECE 742**Digital System-on-Chip Design**

This short course covers digital design techniques and hardware/software realization concepts in embedded computing systems using VHDL. Topics include: basics principles of VHDL programming; designing with FPGA; design of arithmetic logic unit; VHDL models for memories and busses; CPU design; system-on-chip design; efficient hardware realizations of FFT, DCT, and DWT.

Lecture: 2 Lab: 0 Credits: 2

ECE 743**Signal and Data Compression with Embedded Systems**

This short course deals with data compression techniques and hardware/software realization concepts in embedded computing systems. Key topics: fundamentals of random signal processing and information theory, compression and decompression processes, lossy and lossless compression methods, compression standards for video and audio, modeling and signal parameter estimation, transform techniques including FFT, DCT, and DWT. Hardware realizations of compression algorithms.

Lecture: 2 Lab: 0 Credits: 2

ECE 744**Embedded Digital Systems for Time-Frequency Distribution, Signal Modeling, and Estimation**

This short course deals with time-frequency distribution, signal modeling and estimation, and hardware/software realization concepts in embedded computing systems. Key topics include fundamentals of signal processing and random processes, short-time Fourier transform, split-spectrum processing, Gabor transform, Wigner distribution, Hilbert transform, wavelet transform, cosine transform, chirplet signal decomposition, matching pursuit, parametric time-series frequency estimation, hardware/software codesign and realizations of time-frequency distributions, and signal modeling algorithms.

Lecture: 2 Lab: 0 Credits: 2

ECE 750**Synchrophasors for Power System Monitoring and Control**

The course gives an introduction to synchrophasor technology from the perspective of power system monitoring and control. It discusses the fundamentals of measurements and synchrophasor estimation. It covers the IEEE Standard C37.118. Several synchrophasor estimation algorithms will be discussed as they relate to measurement and estimation errors. Various synchrophasor applications will be presented including situational awareness, event detection, model validation, oscillation detection, WAMS, and WAMPAC.

Prerequisite(s): ECE 419 with min. grade of C

Lecture: 2 Lab: 0 Credits: 2

ECE 752**Industrial Applications of Power Electronics and Motor Drives**

Practical topologies of different types of power electronic converters are covered including industrial high-voltage and high-current applications, protection, and thermal management. Common industrial motor drives are examined with popular control techniques, simplified modeling, and worst-case design. Regulating and stabilizing methods are applied to switching power supplies, power conditioning systems, electronic ballasts, and electronic motors.

Lecture: 2 Lab: 0 Credits: 2

ECE 755**Power System Protection**

This course provides basic understanding of the role of protective relaying in the power system. It also delves into the needs of today's power systems for protection that is robust and tolerant to heavily loaded transmission systems. The students are challenged to be a part of the solution going forward including the role of wide area system protection.

Lecture: 2 Lab: 0 Credits: 2

ECE 756**Power System Maintenance Scheduling**

This short course is aimed at providing an in-depth introduction to optimal generation and transmission maintenance in the regulated and restructured power systems. The basic principles of systems operation and economics related to maintenance scheduling will be discussed along with current practices and solution methods for the electric power industry.

Prerequisite(s): ECE 420 with min. grade of C and ECE 419 with min. grade of C

Lecture: 2 Lab: 0 Credits: 2

ECE 764

Vehicular Power Systems

Conventional electrical power systems of land, sea, air, and space vehicles are detailed along with the scope for improvement. This course covers fundamental attributes of modern EV and HEV powertrains. Fundamentals of power electronic components (Inverters, DC-DC Converters, and Chargers), electric motors and energy storage systems will be presented in the context of EV powertrains. An introduction to EV/HEV operating strategies, battery chargers and controls will also be discussed. Using a combination of power electronic simulations, finite element analysis, hands-on lab experiments and vehicle benchmarking reports, powertrain configurations of popular EV and HEV powertrain components will be analyzed. State of the art, challenges and future trends will be discussed. Low voltage and high voltage systems and advanced distribution system architectures of electric and hybrid electric vehicles will be included. Current trends in the vehicular industry, such as 48V automotive systems and more electric aircraft, will be explained.

Lecture: 2 Lab: 0 Credits: 2