ELECTRICAL AND COMPUTER ENGR (ECE)

ECE 100
Introduction to the Profession I
Introduces the student to the scope of the engineering profession and its role in society and develops a sense of professionalism in the student. Provides an overview of electrical engineering through a series of hands-on projects and computer exercises. Develops professional communication and teamwork skills.
Lecture: 2 **Lab:** 3 **Credits:** 3
Satisfies: Communications (C)

ECE 211
Circuit Analysis I
Ohm's Law, Kirchhoff's Laws, and network element voltage-current relations. Application of mesh and nodal analysis to circuits. Dependent sources, operational amplifier circuits, superposition, Thevenin's and Norton's Theorems, maximum power transfer theorem. Transient circuit analysis for RC, RL, and RLC circuits. Introduction to Laplace Transforms. Laboratory experiments include analog and digital circuits; familiarization with test and measurement equipment; combinational digital circuits; familiarization with latches, flip-flops, and shift registers; operational amplifiers; transient effects in first-order and second-order analog circuits; PSpice software applications. Concurrent registration in MATH 252 and ECE 218.
Prerequisite(s): MATH 252*, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 213
Circuit Analysis II
Sinusoidal excitation and phasors. AC steady-state circuit analysis using phasors. Complex frequency, network functions, pole-zero analysis, frequency response, and resonance. Two-port networks, transformers, mutual inductance, AC steady-state power, RMS values, introduction to three-phase systems and Fourier series. Design-oriented experiments include counters, finite state machines, sequential logic design, impedances in AC steady-state, resonant circuits, two-port networks, and filters. A final project incorporating concepts from analog and digital circuit design will be required. Prerequisites: ECE 211 with a grade C or better.
Prerequisite(s): ECE 211 with min. grade of C
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: Communications (C)

ECE 216
Circuit Analysis II
Sinusoidal excitation and phasors. AC steady-state circuit analysis using phasors. Complex frequency, network functions, pole-zero analysis, frequency response, and resonance. Two-port networks, transformers, mutual inductance, AC steady-state power, RMS values, introduction to three-phase systems and Fourier series. Note: ECE 216 is for non-ECE majors.
Prerequisite(s): ECE 211 with min. grade of C
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 218
Digital Systems
Number systems and conversions, binary codes, and Boolean algebra. Switching devices, discrete and integrated digital circuits, analysis and design of combinational logic circuits. Karnaugh maps and minimization techniques. Counters and registers. Analysis and design of synchronous sequential circuits.
Lecture: 3 **Lab:** 1 **Credits:** 4
Satisfies: Communications (C)

ECE 222
Introduction to Cybersecurity Engineering
Students will receive an introductory overview of major issues related to offensive and defensive cybersecurity. Key topics for this course include ethical hacking tools, penetration testing basics, exploit development, intrusion detection, cyber forensics, and cybersecurity law and regulations. Course projects will provide a hands-on experience using open-source tools and software to support concepts taught during the lecture. Students need to have basic programming skills.
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 242
Digital Computers and Computing
Basic concepts in computer architecture, organization, and programming, including: integer and floating point number representations, memory organization, computer processor operation (the fetch/execute cycle), and computer instruction sets. Programming in machine language and assembly language with an emphasis on practical problems. Brief survey of different computer architectures.
Prerequisite(s): (CS 116 and ECE 218) or CS 201
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 307
Electrodynamics
Analysis of circuits using distributed network elements. Response of transmission lines to transient signals. AC steady-state analysis of lossless and lossy lines. The Smith Chart as an analysis and design tool. Impedance matching methods. Vector analysis applied to static and time-varying electric and magnetic fields. Coulomb's Law, electric field intensity, flux density and Gauss's Law. Energy and potential. Biot-Savart and Ampere's Law. Maxwell's equations with applications including uniform-plane wave propagation.
Prerequisite(s): ECE 213 and PHYS 221 and MATH 251
Lecture: 3 **Lab:** 3 **Credits:** 4

ECE 308
Signals and Systems
Time and frequency domain representation of continuous and discrete time signals. Introduction to sampling and sampling theorem. Time and frequency domain analysis of continuous and discrete linear systems. Fourier series convolution, transfer functions. Fourier transforms, Laplace transforms, and Z-transforms.
Prerequisite(s): MATH 252 and MATH 251
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 311
Engineering Electronics
Physics of semiconductor devices. Diode operation and circuit applications. Regulated power supplies. Bipolar and field-effect transistor operating principles. Biasing techniques and stabilization. Linear equivalent circuit analysis of bipolar and field-effect transistor amplifiers. Laboratory experiments reinforce concepts.
Prerequisite(s): ECE 213
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: Communications (C)

ECE 319
Fundamentals of Power Engineering
Principles of electromechanical energy conversion. Fundamentals of the operations of transformers, synchronous machines, induction machines, and fractional horsepower machines. Introduction to power network models and per-unit calculations. Gauss-Seidel load flow. Lossless economic dispatch. Symmetrical three-phase faults. Laboratory considers operation, analysis, and performance of motors and generators. The laboratory experiments also involve use of PC-based interactive graphical software for load flow, economic dispatch, and fault analysis.
Prerequisite(s): ECE 213
Lecture: 3 **Lab:** 3 **Credits:** 4

ECE 401
Communication Electronics
Radio frequency AM, FM, and PM transmitter and receiver principles. Design of mixers, oscillators, impedance matching networks, filters, phase-locked loops, tuned amplifiers, power amplifiers, and crystal circuits. Nonlinear effects, intermodulation distortion, and noise. Transmitter and receiver design specification.
Prerequisite(s): (ECE 307 and ECE 312 and ECE 403*) or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 403
Digital and Data Communication Systems
Introduction to Amplitude, Phase, and Frequency modulation systems. Multiplexing and Multi-Access Schemes; Spectral design considerations. Sampling theorem. Channel capacity, entropy; Quantization, wave shaping, and Inter-Symbol Interference (ISI), Matched filters, Digital source encoding, Pulse Modulation systems. Design for spectral efficiency and interference control. Probability of error analysis, Analysis and design of digital modulators and detectors.
Prerequisite(s): Graduate standing and ECE 308
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 405
Digital and Data Communication Systems with Laboratory
Introduction to Amplitude, Phase, and Frequency modulation systems. Multiplexing and Multi-Access Schemes; Spectral design considerations. Sampling theorem. Channel capacity, entropy; Quantization, wave shaping, and Inter-Symbol Interference (ISI), Matched filters, Digital source encoding, Pulse Modulation systems. Design for spectral efficiency and interference control. Probability of error analysis, Analysis and design of digital modulators and detectors.
Prerequisite(s): Graduate standing and ECE 308
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 406
Wireless Communications Systems
The course addresses the fundamentals of wireless communications and provides an overview of existing and emerging wireless communications networks. It covers radio propagation and fading models, fundamentals of cellular communications, multiple access technologies, and various wireless networks including past and future generation networks. Simulation of wireless systems under different channel environments will be an integral part of this course.
Prerequisite(s): ECE 403 or Graduate standing
Lecture: 3 **Lab:** 3 **Credits:** 3

ECE 407
Introduction to Computer Networks with Laboratory
Emphasis on the physical, data link, and medium access layers of the OSI architecture. Different general techniques for networking tasks, such as error control, flow control, multiplexing, switching, routing, signaling, congestion control, traffic control, scheduling will be covered along with their experimentation and implementation in a laboratory. Credit given for ECE 407 or ECE 408, not both.
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 408
Introduction to Computer Networks
Emphasis on the physical, data link and medium access layers of the OSI architecture. Different general techniques for networking tasks, such as error control, flow control, multiplexing, switching, routing, signaling, congestion control, traffic control, scheduling will be covered. Credit given for ECE 407 or ECE 408, not both.
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 411
Power Electronics
Power electronic circuits and switching devices such as power transistors, MOSFET's, SCR's, GTO's, IGBT's and UJT's are studied. Their applications in AC/DC DC/DC, DC/AC and AC/AC converters as well as switching power supplies are explained. Simulation mini-projects and lab experiments emphasize power electronic circuit analysis, design and control.
Prerequisite(s): ECE 311 or Graduate standing
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 412
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.
Prerequisite(s): (ECE 311 and ECE 319) or Graduate standing
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 417
Power Distribution Engineering
This is an introduction into power distribution systems from the utility engineering perspective. The course looks at electrical service from the distribution substation to the supply line feeding a customer. The course studies the nature of electrical loads, voltage characteristics and distribution equipment requirements. The fundamentals of distribution protection are reviewed including fast/relay coordination. Finally, power quality and reliability issues are addressed.
Prerequisite(s): ECE 319 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 418
Power System Analysis
Transmission systems analysis and design. Large scale network analysis using Newton-Raphson load flow. Unsymmetrical short-circuit studies. Detailed consideration of the swing equation and the equal-area criterion for power system stability studies. Credit will be given for ECE 418 or ECE 419, but not for both.
Prerequisite(s): ECE 319 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 419
Power Systems Analysis with Laboratory
Transmission systems analysis and design. Large scale network analysis using Newton-Raphson load flow. Unsymmetrical short-circuit studies. Detailed consideration of the swing equation and the equal-area criterion for power system stability studies. Use of commercial power system analysis tool to enhance understanding in the laboratory.
Prerequisite(s): ECE 319 or Graduate standing
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 420
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.
Prerequisite(s): ECE 319 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 421
Microwave Circuits and Systems
Maxwell's equations, waves in free space, metallic and dielectric waveguides, microstrips, microwave cavity resonators and components, ultra-high frequency generation and amplification. Analysis and design of microwave circuits and systems. Credit will be given for either ECE 421 or ECE 423, but not for both.
Prerequisite(s): ECE 307 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 423
Microwave Circuits and Systems with Laboratory
Maxwell's equations, waves in free space, metallic and dielectric waveguides, microstrips, microwave cavity resonators and components, ultra-high frequency generation and amplification. Analysis and design of microwave circuits and systems. Credit will be given for either ECE 421 or ECE 423, but not for both.
Prerequisite(s): ECE 307 or Graduate standing
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 425
Analysis and Design of Integrated Circuits
Contemporary analog circuit analysis and design techniques. Bipolar, CMOS and BICMOS IC fabrication technologies, IC Devices and Modeling, Analog ICs including multiple-transistor amplifiers, biasing circuits, active loads, reference circuits, output buffers; their frequency response, stability and feedback consideration.
Prerequisite(s): ECE 311
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 429
Introduction to VLSI Design
Processing, fabrication, and design of Very Large Scale Integration (VLSI) circuits. MOS transistor theory, VLSI processing, circuit layout, layout design rules, layout analysis, and performance estimation. The use of computer aided design (CAD) tools for layout design, system design in VLSI, and application-specific integrated circuits (ASICs). In the laboratory, students create, analyze, and simulate a number of circuit layouts as design projects, culminating in a term design project.
Prerequisite(s): (ECE 218 and ECE 311) or Graduate standing
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 430
Fundamentals of Semiconductor Devices
The goals of this course are to give the student an understanding of the physical and operational principles behind important electronic devices such as transistors and solar cells. 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 field-effect transistor (FET) and bipolar junction transistor (BJT) are then discussed and their terminal operation developed. Application of transistors to bipolar and CMOS analog and digital circuits is introduced.
Prerequisite(s): ECE 311
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 436
Digital Signal Processing I with Laboratory
Discrete-time system analysis, discrete convolution and correlation, Z-transforms. Realization and frequency response of discrete-time systems, properties of analog filters, IIR filter design, FIR filter design. Discrete Fourier Transforms. Applications of digital signal processing. Credit will be given for either ECE 436 or ECE 437, but not for both.
Prerequisite(s): ECE 308 or Graduate standing or BME 330
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 437
Digital Signal Processing I
Discrete-time system analysis, discrete convolution and correlation, Z-transforms. Realization and frequency response of discrete-time systems, properties of analog filters, IIR filter design, FIR filter design. Discrete Fourier Transforms. Applications of digital signal processing. Credit will be given for either ECE 436 or ECE 437, but not for both.
Prerequisite(s): ECE 308 or Graduate standing or BME 330
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 438
Control Systems
Signal-flow graphs and block diagrams. Types of feedback control. Steady-state tracking error. Stability and Routh Hurwitz criterion. Transient response and time domain design via root locus methods. Frequency domain analysis and design using Bode and Nyquist methods. Introduction to state variable descriptions.
Prerequisite(s): ECE 308 or BME 330 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 441
Smart and Connected Embedded System Design
This is a culminating major design experience course that involves smart and connected system applications including Internet of Things, healthcare system, artificial intelligence and machine vision, wireless sensor network, smart security system, smart city, smart power grid, smart power electronic devices, smart transportation, factory automation, agriculture automation, and home automation. Smart and connected system entails human machine interface, embedded computing, interrupt/exception handling, fault detection and recovery, standard and special peripheral interfacing to sensors and actuators, hardware and software codesign for data acquisition, encryption/decryption for secure system, information processing, data storage, and network communication protocols. The design project incorporates engineering standards and multiple constraints, building on knowledge and skills acquired from 100 to 300 level ECE coursework.
Lecture: 3 **Lab:** 3 **Credits:** 4
Satisfies: ECE Professional Elective (P)

ECE 442
Internet of Things and Cyber Physical Systems
To introduce students to the fundamentals of Internet of Things (IoT) and embedded computing. This course covers IoT applications, Wireless protocols, Wearable sensors, Home environment sensors, Behavior detection sensors, Data fusion, processing and analysis, Data communications, Architectural design issues of IoT layers, Security and privacy issues in IoT.
Prerequisite(s): ECE 242 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 443
Introduction to Computer Cyber Security
This course gives students a clear understanding of computer and cyber security as threats and defense mechanisms backed by mathematical and algorithmic guarantees. Key topics covered include introductory number theory and complexity theory, cryptography and applications, system security, digital forensics, software and hardware security, and side-channel attacks. Course projects will provide hand-on experiences on languages, libraries, and tools supporting state-of-theart cryptography applications. Students registering for ECE 518 are required to complete additional projects in advanced areas.
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 444
Computer Network Security
This course studies computer network security by covering topics such as fundamental cryptographic algorithms; protocol design and analysis for secure communications over Internet; efficient key management infrastructure; strong password protection; attack and security models; practical security protocols in application layer, transport layer, network layer, and link layer. Students registering for ECE 543 are required to complete additional projects in advanced areas.
Prerequisite(s): ECE 407 or ECE 408
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 446

Advanced Logic Design

Design and implementation of complex digital systems under practical design constraints. Timing and electrical considerations in combinational and sequential logic design. Digital system design using Algorithmic State Machine (ASM) diagrams. Design with modern logic families and programmable logic. Design-oriented laboratory stressing the use of programmable logic devices.

Prerequisite(s): (ECE 218 and ECE 311) or Graduate standing

Lecture: 3 **Lab:** 3 **Credits:** 4

Satisfies: ECE Professional Elective (P)

ECE 447

Artificial Intelligence and Edge Computing

This course introduces methods in designing contemporary smart systems utilizing artificial intelligence, machine vision, and their applications. Topics include linear regression, logistic regression, multilayer neural networks, supervised/unsupervised learning, convolutional networks, and recurrent neural networks. This course also covers topics in deep learning algorithms and artificial intelligence structures optimized for low power embedded computing platforms (Edge Artificial Intelligence) with applications in machine vision, robotics, internet of things, smart grids and autonomous systems.

Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 448

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.

Prerequisite(s): ECE 242

Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 449

Object-Oriented Programming and Machine Learning

This course gives students a clear understanding of the fundamental concepts of object-oriented design/programming (OOD/OOP). Languages addressed include C++ and Python. Key topics covered include introduction to machine and deep learning, software development life cycle, core language and standard library of C++ and Python, class design and design patterns, OpenMP and CUDA platforms. Students will design a complex learning application using these concepts and Agile software engineering practices.

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

Lecture: 3 **Lab:** 0 **Credits:** 3

Satisfies: ECE Professional Elective (P)

ECE 460

Introduction to Signals and Systems for Advanced Studies

This course provides an introduction to Signals and Systems and illustrates the concepts using representative examples and applications. Basic concepts, including continuous-time and discrete-time signals and their properties, are covered. Properties and applications of continuous-time and discrete-time convolution, Fourier series, Fourier transform, Discrete Fourier transform, Laplace transform, and Z-transform are also covered. A significant number of examples are used to illustrate the basic concepts. This course is intended to provide a strong foundation for students who are entering graduate programs in Electrical and Computer Engineering (ECE) without an undergraduate degree in ECE. This course is not intended for credits as part of the degree programs at Illinois Tech.

Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 461

Introduction to Probability and Random Variables for Advanced Studies

This course provides introduction to Probability and Random Variables and illustrates the concepts using representative examples and applications. Basic concepts including probability axioms, random and repeated experiments, conditional probability, discrete, continuous, and mixed random variables, moments and characteristic function, and a function of multiple random variables are covered. Significant number of examples are used to illustrate the basic concepts. The intent of this course is to provide strong foundation for students who are entering the graduate programs in Electrical and Computer Engineering (ECE) without an undergraduate degree in ECE. This course is not intended for credits as part of the degree programs at Illinois Tech.

Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 473

Cloud Computing and Cloud Native Systems

This course introduces students to cloud native systems that build on top of the cloud computing architecture to provide scalable services in dynamic environments. Key topics covered include virtualization and containerization, distributed database systems, communication mechanisms, batch and stream processing, resource management, consensus, security, and system design techniques for scalability, resilience, manageability, and observability. Course projects will provide hand-on experiences on state-of-the-art languages, libraries, and tools.

Prerequisite(s): ECE 242

Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 481

Image Processing

Mathematical foundations of image processing, including two-dimensional discrete Fourier transforms, circulant and block-circulant matrices. Digital representation of images and basic color theory. Fundamentals and applications of image enhancement, restoration, reconstruction, compression, and recognition.

Prerequisite(s): (ECE 308 and MATH 374*) or Graduate standing, An asterisk (*) designates a course which may be taken concurrently.

Lecture: 3 **Lab:** 0 **Credits:** 3

Satisfies: ECE Professional Elective (P)

ECE 485
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) Undergraduate students can only be admitted to ECE 485 Graduate students can only be admitted to ECE 585.
Prerequisite(s): (ECE 218 and ECE 242) or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3
Satisfies: ECE Professional Elective (P)

ECE 491
Undergraduate Research
Independent work on a research project supervised by a faculty member of the department. Prerequisite: Consents of academic advisor and instructor.
Credit: Variable
Satisfies: ECE Professional Elective (P)

ECE 494
Undergraduate Projects
Students undertake a project under the guidance of an ECE department faculty member. (1-4 variable) Prerequisite: Approval of the ECE instructor and academic advisor.
Credit: Variable
Satisfies: ECE Professional Elective (P)

ECE 497
Special Problems
Design, development, analysis of advanced systems, circuits, or problems as defined by a faculty member of the department. Prerequisite: Consents of academic advisor and instructor.
Credit: Variable
Satisfies: ECE Professional Elective (P)

ECE 501
Artificial Intelligence and Edge Computing
This course introduces methods in designing contemporary smart systems utilizing artificial intelligence, machine vision, and their applications. Topics include linear regression, logistic regression, multilayer neural networks, supervised/unsupervised learning, convolutional networks, and recurrent neural networks. This course also covers topics in deep learning algorithms and artificial intelligence structures optimized for low power embedded computing platforms (Edge Artificial Intelligence) with applications in machine vision, robotics, internet of things, smart grids and autonomous systems. In addition, students are required to complete an open-ended design project in one of the advanced topics, for example, numerical in Deep Neural Networks, Convolutional Networks, and Recurrent Neural Networks.
Lecture: 3 **Lab:** 0 **Credits:** 3

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 503
5G Wireless Network: Architecture, New Radio, and Security
The primary distinguishing features of 5th Generation (5G) wireless network are its operations in the mm wave region for effectively handling Machine Type Communication (MTC) for supporting secure and tactile Internet of Things (IoT) and cloud based virtualization and operations. This course covers the details of 5G Cloud based Radio Access Network (C-RAN) and the 5G Core along with how the cloud infrastructure creates a very powerful flexible, secure, and reliable network through virtualization and Network Slicing. Unique features of 5G New Radio (NR) including accessing and duplexing schemes, mm wave operation, and enhanced coverage are discussed. The capabilities of the 5G Core which provides a very flexible usage of network resources are discussed. Projects will entail application to a selected set of use cases in the domains of smart city, smart transportation, and e-Health among others.
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 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 510
Internet of Things and Cyber Physical Systems
To introduce students to the fundamentals of Internet of Things (IoT) and embedded computing. This course covers IoT applications, Wireless protocols, Wearable sensors, Home environment sensors, Behavior detection sensors, Data fusion, processing and analysis, Data communications, Architectural design issues of IoT layers, Security and privacy issues in IoT. Simulation mini-projects and lab experiments are based on the lectures given.
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) or Graduate standing
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) or Graduate standing
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 gives students a clear understanding of computer and cyber security as threats and defense mechanisms backed by mathematical and algorithmic guarantees. Key topics covered include introductory number theory and complexity theory, cryptography and applications, system security, digital forensics, software and hardware security, and side-channel attacks. Course projects will provide hand-on experiences on languages, libraries, and tools supporting state-of-theart cryptography applications. Students registering for ECE 518 are required to complete additional projects in advanced areas.
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 or Graduate standing
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 or Graduate standing
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) or Graduate standing
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.
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) or Graduate standing
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, short, 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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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
Communications Networks Performance Analysis
This course will cover the probability and queueing theory fundamentals for modern communication networks performance analysis. Applications of the theoretical analysis to modern Internet protocols and machine learning are to be studied. The main topics include: Probability and distributions, random processes, discrete and continuous Markov Chains, queueing systems, probability in machine learning, and applications of theories in modern mobile access control protocols.
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 studies computer network security by covering topics such as fundamental cryptographic algorithms; protocol design and analysis for secure communications over Internet; efficient key management infrastructure; strong password protection; attack and security models; practical security protocols in application layer, transport layer, network layer, and link layer. Students registering for ECE 543 are required to complete additional projects in advanced areas.
Prerequisite(s): ECE 407 with min. grade of C or ECE 408 with min. grade of C or Graduate standing
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
Modern Internet Technologies
This course covers the key technologies that enable the modern Internet with a top-down approach. The main topics include multimedia application and protocols, content distribution networks, edge computing, methodologies for reliable communications, next generation network architecture based on software defined networking, resource virtualization, and key techniques for mobile Internet. This course also deals with the concept of layer based design, strategy for quality of service provisioning, performance analysis based on mathematical modeling, and performance evaluation via practical simulations.
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 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 548
Energy Harvesting
Various harvesting techniques such as solar, ocean ides, 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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 563
Artificial Intelligence in Smart Grid
Introduction to artificial intelligence, artificial neural networks, machine learning, and advanced engineering applications in smart grid, including but not limited to energy forecasting, smart meter data analytics, nonintrusive load monitoring.
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 or Graduate standing
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
Machine and Deep Learning
Overview of machine learning and deep learning; principle of learning; Bayesian methods; non-parametric classifiers, Fisher's linear discriminant analysis, principal component analysis; training, validation, and testing; support vector machines; neural networks; history of deep learning; and applications of deep learning.
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) or Graduate standing
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 and Graduate standing)
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) or Graduate standing) and (ECE 403 with min. grade of C or Graduate standing)
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 572
Secure Machine Learning Design and Applications
Adversarial robustness, which is centered on attack and defense, has become an emerging topic to promote trust in machine learning (ML)/deep learning (DL) and enable a better understanding of the pros and cons of DL systems. More generally, the idea of learning with adversaries is crucial for expanding the learning capability, ensuring trustworthy decision-making, and enhancing the generalizability of ML in many applications. This course teaches students how to adapt fundamental techniques of robustness evaluation and enhancement into different use cases of adversarial ML in computer vision, signal processing, and power system.
Prerequisite(s): ECE 566
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 573
Cloud Computing and Cloud Native Systems
This course introduces students to cloud native systems that build on top of the cloud computing architecture to provide scalable services in dynamic environments. Key topics covered include virtualization and containerization, distributed database systems, communication mechanisms, batch and stream processing, resource management, consensus, security, and system design techniques for scalability, resilience, manageability, and observability. Course projects will provide hand-on experiences on state-of-the-art languages, libraries, and tools. Students registering for graduate course section are required to complete additional project sections in advanced areas and review research papers in this field.
Lecture: 0 **Lab:** 3 **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) or Graduate standing
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 or Graduate standing
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 or Graduate standing
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 exiting 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.
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 or Graduate standing
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) or Graduate standing
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)
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 586
Hardware Security and Advanced Computer Architectures
This course focuses on designing computers and embedded computing devices from security and threat-mitigation perspectives. Advanced architecture topics such as instruction level parallelism, multi-threading and multi-instruction, multi-data stream processing are presented. Design for testability, hardware attacks, threat modeling and countermeasures against attacks are covered for the major entities for a computer system; including CPU, memory, and I/O. Case studies on recent examples of hardware security issues are discussed. * Students registering for this course should have a prior knowledge of Computer Organization and Design or equivalent course and be familiar with hardware description languages such as Verilog or VHDL.
Prerequisite(s): ECE 485 or Graduate standing or ECE 585 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): ECE 441 with min. grade of C or Graduate standing
Lecture: 3 **Lab:** 0 **Credits:** 3

ECE 588
Hardware Acceleration for Machine Learning
Students will learn the design of complex and high-performance AI systems from system level to circuit level. Introduction to Deep Learning, deep neural network architecture, deep learning system: hardware and software in CPU, GPU, and FPGA. FPGA fundamentals, arithmetic hardware, CIM and PIM memory structure for AI, RTL programming and optimization, power consumption, design techniques for low power at system-level and RT-level.
Prerequisite(s): ECE 429 or ECE 529 or Graduate standing
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 590
Object-Oriented Programming and Machine Learning
This course gives students a clear understanding of the fundamental concepts of object-oriented design/programming (OOD/OOP). Languages addressed include C++ and Python. Key topics covered include introduction to machine and deep learning, software development life cycle, core language and standard library of C++ and Python, class design and design patterns, OpenMP and CUDA platforms. Students will design a complex learning application using these concepts and Agile software engineering practices. Students are required to complete an open- ended project in one of the advanced areas, for example numerical optimization, tool integration, heterogeneous acceleration.
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
Introduction to Digital Transformation Architecture and Technologies
This project oriented short course equips the students with the architectural and technological foundation for the upcoming advanced and intelligent applications including smart city, smart energy, smart transportation, and smart health. The digital transformation architecture will be introduced. Key enabling technologies including Internet of Things (IoT), distributed data management and analytics, ubiquitous wireless access, Artificial Intelligence (AI) percepts especially computer vision and machine learning, and cyber security will be highlighted. Leveraging of datasphere which extends across user devices, edge/fog computing, and cloud computing will be addressed. The topics of how various hardware and software constituents interact to provide application solutions will be covered. Specific case studies summarizing the architectures for e-Health and intelligent transportation including autonomous automobile will be discussed. The course requires graduate standing.
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