Graduate Courses

EECE 601 Biomedical Engineering I 3 cr.
This course includes an introduction to: general instrumentation configuration, performance of instrumentation systems; types and characteristics of transducers; sources and characteristics of bioelectric signals; types and characteristics of electrodes; temperature regulation and measurement; cardiovascular system, measurements, and diagnostic equipment; blood instruments; patient care and monitoring; and electrical safety of medical equipment. Prerequisites: EECE 210 and BIOL 210 or consent of the instructor.

EECE 602 Biomedical Engineering II 3 cr.
This course covers respiratory system and measurements; nervous system and measurements; sensory and behavior measurements; biotelemetry; instrumentation for the clinical laboratory; x-rays and radioisotope instrumentation; magnetic resonance; and special surgical techniques. Prerequisite: EECE 601 or consent of the instructor.

EECE 603 Biomedical Signal and Image Processing 3 cr.
A course that introduces the fundamentals of digital signal processing as implemented in biomedical applications. It provides a concise treatment of the tools utilized to describe deterministic and random signals as the basis of analyzing biological signals: data acquisition; imaging; denoising and filtering; feature extraction; modeling. The course is tightly coupled with a practical component as it looks at and assigns several laboratory projects. Examples include the auditory system, speech generation, electrocardiogram, neuronal circuits, and medical imaging. Students should have reasonable software skills in Matlab. Prerequisites: STAT 230 and EECE 340, or equivalent.

EECE 604 Communications Engineering for Genetics and Bioinformatics 3 cr.
This course presents current research efforts in the emerging interdisciplinary field of communications engineering for genetics and bioinformatics. It shows how concepts and techniques from the field of communications engineering can be applied to central problems from the fields of genetics and bioinformatics. As a basic analogy, voice information is digitized, transmitted, and processed in communications, and DNA information is replicated, transmitted, and processed in genetics. The main topics covered include DNA compression, mutual information for functional genomics, channel coding for gene expression, genomic signal processing, and biological computation. Prerequisite: Senior standing or consent of the instructor.

EECE 605 Neuroengineering I 3 cr.
A course that focuses on the importance of biological systems from the engineering viewpoint; living cells and mechanisms; introduction to the nervous system; the resting membrane potential; generation and propagation of the action potential; motor systems; synaptic transmission; control of movement. Prerequisite: BIOL 210 or consent of instructor.
EECE 611  Introduction to Analog VLSI Systems  3 cr.
This course covers an introduction to digital electronic circuits; models, current equations and parasitic of CMOS transistors for digital design; study of CMOS inverter and logic gates, including analysis, design, simulation, layout and verification; advanced circuit styles; sequential circuits; advanced topics: semiconductor memories, power grid, clocking strategies, datapath building blocks, deep-submicron design issues, and interconnect. Prerequisites: EECE 310 and EECE 320 or consent of the instructor.

EECE 612  Digital Integrated Circuits  3 cr.
A course on digital electronic circuits; models, current equations, and parasitics of CMOS transistors for digital design; study of CMOS inverter and logic gates, including analysis, design, simulation, layout, and verification; advanced circuit styles; sequential circuits; advanced topics: semiconductor memories, power grid, clocking strategies, datapath building blocks, deep-submicron design issues, interconnect. Prerequisites: EECE 311 and EECE 320 or consent of the instructor.

EECE 613  RF and Microwave Circuits for Communications  3 cr.
The course focuses on the analysis and design of high-frequency electronic circuits, with emphasis on RF and microwave circuits and components for communication systems. The course covers the basic principles of radio-frequency (RF) and microwave circuits design, as applied to the design of microstrip and coplanar lines, impedance transformers, low-pass and band-pass filters, directional couplers, power dividers, amplifiers, mixers, and diode detectors. It provides understanding of S-parameters and signal-flow graph analysis techniques. The course enables the student to get hands-on experience in RF and microwave circuit design through the use of computer-aided design tools to simulate and analyze high frequency circuits, build them as part of a course project, and perform measurements in the lab using network and spectrum analyzers. Prerequisites: EECE 311, EECE 340, and EECE 380 or consent of the instructor.

EECE 614  Computer-Aided Analysis and Design of VLSI Circuits and Systems  3 cr.
A course on circuit and logic simulation; timing analysis and verification; testing and fault simulation; logic and high-level synthesis; physical design automation. Prerequisite: EECE 311 or consent of the instructor.

EECE 615  Computer Methods for Circuit and System Analysis  3 cr.
This course covers numerical methods and techniques for computer simulation of linear and nonlinear circuits and systems. This includes formulation methods, solution of linear equations and systems (DC analysis or static analysis), time-domain solution (transient analysis), solution of large systems, and sensitivity analysis. Application areas include simulation of electronic integrated circuits, power systems, electro-mechanical systems, mechatronics, and systems that can be modeled by sets of algebraic-differential equations. Prerequisites: EECE 210, MATH 202, and MATH 218 or 219 or consent of the instructor.
EECE 616 Advanced Digital Integrated Circuits 3 cr.
A graduate level course on advanced digital integrated circuits. The following topics are covered: impact of physical technology on architecture; technology issues: CMOS scaling and issues in deep submicron regimes, process variations; device and interconnect modeling; optimization for speed; high-speed logic families; low-power design: leakage reduction techniques, voltage scaling; power distribution; clocking strategies; timing concepts; memory design: clocked storage elements, SRAM, DRAM, flash memory; and high-speed arithmetic circuits. Prerequisite: EECE 412 or EECE 612 or consent of the instructor.

EECE 617 Reliability and Statistical Design 3 cr.
This course explores major aspects of statistical design methodologies with particular emphasis on electrical and computer engineering problems. It covers various topics in the domain of reliability and yield estimation, and encompasses both geometrical-based approximation methods as well as sampling-based methods. The course focuses on variance reduction methods for purposes of extreme statistics and rare fail event estimation. Case studies will be provided to analyze the manufacturability and robustness challenges of advanced circuits and the implications on low power design. Students will learn about the impact of new physical effects on the traditional circuit design solutions and methods, and the rising need for statistical design methodologies. Other applications in electrical and computer engineering will also be covered. Prerequisite: Senior standing or consent of instructor.

EECE 621 Advanced Computer Architecture 3 cr.
This course focuses on modern advancements in parallel computer architecture, with emphasis on advanced instruction level parallelism (ILP) and multiprocessor architectures. Topics include: advanced branch prediction, data speculation, computation reuse, memory dependence prediction, trace caches, dynamic optimizations, checkpoint architectures, latency-tolerant processors, simultaneous multithreading, speculative multithreading, virtual machines, message passing multiprocessors, UMA, NUMA and COMA shared-memory multiprocessors, single-chip multiprocessors, wormhole routing techniques, cache coherence, memory consistency models, high performance synchronization methods, speculative lock elision and transactional memory. A key component of the course is a research project in which students use architecture performance simulator to investigate novel architecture techniques. Prerequisite: EECE 421 or consent of the instructor.

EECE 622 VLSI for Communications and Signal Processing 3 cr.
This course introduces concepts in the design and implementation of digital signal processing systems using integrated circuits. The main emphasis is on the architectural exploration, design and optimization of signal processing systems for communications. Algorithm, architecture, and circuit design techniques are introduced that enable joint optimization across the algorithmic, architectural, and circuit domains. A key component of the course is a project in which students investigate problems in the design and implementation of low-power and high-performance communication systems. Prerequisite: Senior standing or consent of the instructor.
EECE 623  Reconfigurable Computing  3 cr.
A course dealing with the design issues pertaining to the implementation of application specific architectures using the reconfigurable computing paradigm allowing the same circuit to be reused in order to run different applications. Emphasis is on the systematic design of reconfigurable computing platforms that exploit a high degree of parallelism. Prerequisite: EECE 321 or consent of instructor.

EECE 624  Digital Systems Testing  3 cr.
This course covers an overview of digital systems testing and testable design; test economics, fault modeling, logic and fault simulation, testability measures, test generation for combinational circuits, memory test, delay test, IDDQ test, scan design, and boundary scan. Prerequisite: EECE 320 or consent of the instructor.

EECE 625  Embedded Systems Design  3 cr.
A course on embedded hardware and software design; the system design process: requirements analysis, specification, hardware/software co-design, testing; embedded computing platforms: general- and special-purpose processors, hardware accelerators, systems-on-a-chip, intellectual property (IP) core-based design, embedded networks; software design tools and technologies: CAD tools, compilers, and assemblers; hardware design tools and technologies: hardware-description languages, high-level synthesis tools, ASIC and FPGA design flows; real-time operating systems: multiple tasks and processes, context switching, task scheduling, interprocess communication mechanisms; low-power computing: circuit, architecture, and application techniques; system reliability and fault tolerance. Prerequisites: EECE 321 and EECE 321L or consent of the instructor.

EECE 630  Distributed and Object Database Systems  3 cr.
A course that covers design techniques used for distributing databases among multiple sites. The fundamental topics include fragmentation, replication, and allocation. The course also discusses the strategies used in executing distributed queries subject to given criteria and the commit protocols for managing transactions in a distributed environment. Other topics covered include parallel database implementations and the design of object database management systems. The course enables students to get hands-on experience in designing distributed database systems using a design project that requires the implementation of low-level functionality associated with the functions of distributed database system. Prerequisite: EECE 433 or consent of the instructor.

EECE 631  Advanced Topics in Algorithms  3 cr.
This is a second course on the general principles of algorithm design and analysis. The course is a continuation of EECE 431. Topics include: computability theory; complexity theory: time complexity, P versus NP, circuit complexity, and space complexity; randomized algorithms; linear programming; approximation algorithms; and selected topics. Prerequisite: EECE 431 or consent of the instructor.
EECE 632 Cryptography and Computer Security 3 cr.
This course includes an overview of encryption and computer security; classical encryption techniques, block ciphers and the data encryption standard, finite fields, advanced encryption standard, confidentiality using symmetric encryption, public-key cryptography, key management, hash and MAC algorithms, digital signatures, authentication applications, email security, and Web security. Prerequisite: Senior standing or consent of the instructor.

EECE 633 Data Mining 3 cr.
This course is an introduction to data mining. Data mining refers to knowledge discovery from huge amounts of data to find non-trivial conclusions. Topics will range from statistics to machine learning to database, with a focus on analysis of large data sets. The course will target at least one new data mining problem involving real data, for which the students will have to find a solution. Prerequisite: EECE 433 or consent of the instructor.

EECE 634 Introduction to Computational Arabic 3 cr.
This course will focus on knowledge necessary to develop software applications and systems that deals with Arabic data and tends to Arabic users. The course will discuss computational challenges specific to the Arabic language including representation, display, rendering, processing, directionality, structure, interface, and recognition. The course will also discuss multilingual texts where Arabic takes part. We will visit several text processing techniques and algorithms such as encoding, matching, tokenization, search, indexing, and pattern matching and introduce the necessary changes to accommodate the Arabic language. The last part of the course will discuss the state of the art in automating Arabic language processing, understanding, and recognition. Prerequisite: EECE 330 or consent of the instructor.

EECE 636 Analysis and Verification of Software 3 cr.
This course discusses the basic concepts needed to guarantee the correctness of logic systems whether software programs or hardware designs. The course discusses the basic representations of propositional logic, first order logic, and variations of them. The course discusses how expressive (amenable to express the intent of designers) and how realizable (amenable to automated implementation techniques into circuits) the different logics are. In the course we learn practical tools that take logic descriptions of systems, prove their correctness, either fully or partially, and if possible synthesize or suggest correct circuit implementations. Prerequisites: EECE 431 or consent of instructor.

EECE 637 Advanced Programming Practice 3 cr.
This course is an advanced course on programming practices with a focus on verification. The course introduces programming tools and techniques that make individual engineers more effective and productive and help them develop quality code. Teams will work in Agile and eXtreme programming environments with a focus on design by contract. They will use formal specifications, design patterns and aspect oriented programming. Projects will use tools for code control, building, configuration, language recognition, dynamic documentation, fast
prototyping, refinement, coverage, automated and manual debugging, and dynamic and static verification. **Prerequisite:** EECE 330 or consent of the instructor.

**EECE 638  Software Testing  3 cr.**
The course focuses on concepts, techniques and tools for testing software. It provides practical knowledge of a variety of ways to test software and an understanding of some of the tradeoffs between testing techniques. The topics include: software testing at the unit, module, and system levels; functional and structural testing; regression testing; mutation testing; test suite minimization and prioritization; automatic test case generation. **Prerequisite:** Senior or graduate standing.

**EECE 639  Advanced Data Mining  3 cr.**
A course that covers advanced topics in data mining and recent progress in this field. Discussions will include which techniques fit best for complex applications in data mining. Mining complex data will include general text mining, Arabic text mining, social network analysis, spatial data mining, mining of the World Wide Web, stream data, time-series data, and sequence data. We will also discuss recent application sectors and trends in data mining such as for the telecommunication, biological, and financial sectors. **Prerequisites:** EECE 330, and one of the following EECE 633, EECE 667, or EECE 693 or consent of the instructor.

**EECE 640  Wireless Communications  3 cr.**
A course that covers the fundamentals of wireless communications with emphasis on wireless channel modeling; digital modulation in wireless channels; diversity techniques; channel coding and interleaving in fading channels; adaptive equalization; multiple access techniques; the cellular concept; overview of current wireless communications systems. **Prerequisite:** EECE 442 or consent of the instructor.

**EECE 640L  Wireless Communications Laboratory  1 cr.**
A laboratory course that covers the following topics: basics of radio network planning and optimization, radio network planning for the GSM cellular system, radio network planning for the UMTS cellular system, GSM-UMTS co-existence and co-citing, radio network planning for the WiMAX broadband system, indoor GSM drive testing measurements and analysis, outdoor GSM drive testing measurements and analysis, UMTS drive testing measurements and analysis, and measurement-based wireless channel modeling. **Prerequisite:** EECE 640 or consent of the instructor.

**EECE 641  Information Theory  3 cr.**
In this course students study “data transmission” through introducing the field of information theory. The theory is introduced in a gradual fashion and students study its applications to communications theory, computer science, statistics and probability theory. Covering all the essential topics in information theory, students are introduced to the basic quantities of entropy, relative entropy, and mutual information to show how they arise as natural answers to questions of data compression, channel capacity, rate distortion and large deviation theory.
EECE 642 Introduction to Coding Theory 3 cr.
This course introduces the theory of error-correcting codes with a focus on the asymptotic, algorithmic, and algebraic aspects. Topics include: background material from combinatorics and algebra; Shannon's coding theorem; linear codes; coding bounds; classical algebraic codes: Hamming and Hadamard codes, Reed-Solomon codes and Justesen codes, and decoding algorithms; codes from graphs: low density parity check codes, expander codes, explicit constructions, and decoding algorithms; and an introduction to Turbo codes. Prerequisite: Senior standing or consent of the instructor.

EECE 643 RF System Engineering for Wireless Communications 3 cr.
This course introduces students to system blocks, system parameters, and architectures of RF systems for wireless communications. It focuses on the design of a radio system for transmission and reception of voice and data information: receivers and transmitters system topologies, key system blocks in a wireless system, determination of system block parameters from radio requirements and system analysis, tradeoffs between various blocks in a radio system, and frequency planning. It discusses how modulation and demodulation schemes and multiple-access techniques used in present wireless applications influence RF systems requirements. The last part of the course focuses the link budget analysis of RF radio links. Prerequisites: EECE 311, EECE 380, and EECE 442 or consent of the instructor.

EECE 644 Stochastic Processes, Detection, and Estimation 3 cr.
This is a graduate-level introduction to the fundamentals of detection and estimation theory involving signal and system models in which there is some inherent randomness. The concepts that we develop are extraordinarily rich, interesting, and powerful, and form the basis for an enormous range of algorithms used in diverse applications. The material in this course constitutes a common foundation for work in the statistical signal processing, communication, and control areas. Prerequisites: STAT 230 and EECE 340 or consent of the instructor.

EECE 645 The UMTS Cellular System 3 cr.
A course on the evolution of cellular technologies; UMTS standardization and services; WCDMA transmitter and receiver link level design; access and core network architectures; physical channels and signaling procedures; power control and soft/softer handover; capacity/coverage tradeoffs and cell breathing; capacity/coverage enhancement techniques; antenna diversity and MIMO techniques; multiuser detection techniques; high speed packet access (HSDPA and HSUPA); and basic principles of LTE. Prerequisite: EECE 640 or consent of the instructor.

EECE 646 Advanced Digital and Data Communications 3 cr.
A course that addresses digital communication principles and techniques aimed at achieving improved reliability. The course examines information measures; such as entropy and mutual information for discrete and waveform channels, source coding, channel capacity and coding...
theorem, linear block and cyclic codes, hard and soft decision decoding, spread spectrum modulation. **Prerequisite: Senior standing or consent of the instructor.**

**EECE 647**  
**Queuing Theory**  
3 cr.  
A course that covers Poisson counting and renewal processes; Markov chains and decision theory, branching processes, birth death processes, and semi-Markov processes; simple Markovian queues, networks of queues, general single and multiple-server queues, bounds and approximations. **Prerequisite: Senior standing or consent of the instructor.**

**EECE 651**  
**Internet Engineering**  
3 cr.  
A course that examines major protocols used in internet engineering: IP, ICMP, TCP, UDP; new technologies introduced on the internet, such as IP Multicast, Mobile IP, IPv6, VPNs, and quality of service; routing on the Internet; network security and firewall design; and an overview of the application protocols such as SMTP, HTTP, RTP, and SNMP. **Prerequisite: EECE 350 or 450, or consent of the instructor.**

**EECE 651L**  
**Internetworking Laboratory**  
1 cr.  
This laboratory course covers the technologies and protocols of the internet. The experiments cover the internet protocol (IP), address resolution protocol (ARP), internet control message protocol (ICMP), user datagram protocol (UDP) and transmission control protocol (TCP), the domain name system (DNS), routing protocols (RIP, OSPF, BGP), network address translation (NAT), dynamic host configuration (DHCP), network management protocols (SNMP), and IP multicast. **Prerequisite: EECE 350 or EECE 450, or consent of the instructor.**

**EECE 652**  
**Web Server Design and Programming**  
3 cr.  
This course concentrates on major technologies used in building Web servers. Alternate versions are to be given each year: the Windows-based IIS Server and the Linux-based Apache server. For IIS, ASP.NET along with C# are used for programming Web servers. For Apache, PHP is the language of choice. The course starts with a fast track on client programming, the HTTP protocol, SQL database servers, and XML programming. A weekly lab, two application projects, and a research project constitute the major requirements of the course. **Prerequisite: Senior standing or consent of the instructor.**

**EECE 653**  
**Multimedia and Networking**  
3 cr.  
This course covers topics in multimedia such as system requirements, performance requirements, representation and compression. Multimedia networking is emphasized by discussing multicasting, streaming, multimedia networking protocols and quality of service-based traffic management protocols. Other topics covered include synchronization, VoIP, and Internet 2. Multimedia networking applications are designed and implemented as student projects. **Prerequisite: EECE 350 or EECE 450, or consent of the instructor.**

**EECE 654**  
**Pervasive Computing Systems and Applications**  
3 cr.  
This course covers the technologies involved in integrating front-end mobile devices into local and global networks. An emphasis is placed on the underlying technologies and standards
applied when building pervasive solutions. The course has a strong programming component in that it dedicates a significant portion of the time covering the development of mobile applications for three platforms: Windows CE for Pocket PCs, Palm OS for Palm PDAs, and Java 2 Micro Edition (J2ME) for wireless phones that run the Symbian OS. To emphasize this last component, code demonstrations will be held in class, and students will be required to complete three projects targeting the three platforms, designed to cover the different aspects of mobile applications (user interface, local database implementations, and networking).

Prerequisite: EECE 430 or consent of the instructor.

EECE 655 \hspace{1cm} \textbf{Internet Security} \hspace{1cm} 3 cr.

The course covers topics in internet security. The course discusses security threats, vulnerabilities of protocols and the different types of attacks. Preventive and defensive mechanisms are covered; such as: e-mail security, web security, IP security, network management security, wireless security, intrusion detection techniques, firewalls, VPNs and tracing the source of attacks. The course briefly introduces the basics of cryptography and its application to network security. Student projects will be composed of implementation, simulation and research components. \textit{Prerequisite: EECE 350, or EECE 450, or consent of the instructor.}

EECE 655L \hspace{1cm} \textbf{Network and Computer Security Laboratory} \hspace{1cm} 1 cr.

A laboratory that addresses advanced network and computer security topics. Experiments include the execution of attacks, the setup of intrusion detection and prevention, securing computers and wired and wireless networks, and digital forensics. \textit{Prerequisite: EECE 350 or EECE 450, or consent of instructor.}

EECE 656 \hspace{1cm} \textbf{Mobile Ad hoc and Sensor Networks} \hspace{1cm} 3 cr.

This course covers all aspects of ad hoc and sensor networking, from design through performance issues to application requirements. The course starts with the design issues and challenges that are associated with implementations of ad hoc and sensor network applications. This includes dealing with mobility, disconnections, and awareness of battery power consumption. The course then provides a detailed treatment of proactive, reactive, and hybrid routing protocols, in addition to the various clustering approaches. Next, it covers the IEEE 802.11 Wireless LAN and Bluetooth standards and discusses their characteristics and operations. The course also discusses research topics that involve collaboration among mobile devices, service discovery, and data caching. Through a project, the course gives students hands-on experience in designing a mobile ad hoc network using available Pocket PCs and simulation tools. \textit{Prerequisite: EECE 350 or EECE 450, or consent of the instructor.}

EECE 657 \hspace{1cm} \textbf{Wireless Security} \hspace{1cm} 3 cr.

A course that covers wireless network security; security challenges in wireless networks; security problems facing existing and upcoming wireless networks; security in naming, addressing, neighbor discovery, and routing; and trust and privacy. \textit{Prerequisites: EECE 350 or EECE 450, and EECE 632 or consent of the instructor.}
EECE 660  System Analysis and Design  3 cr.
A course that outlines state-space models of discrete and continuous, linear and nonlinear systems; controllability; observability; minimality; Eigenvector and transforms analysis of linear time invariant multi-input multi-output systems; pole shifting; computer control; design of controllers and observers. Prerequisite: Senior standing or consent of the instructor.

EECE 661  Robotics  3 cr.
A course that examines robotic manipulators classification and work envelope; robot kinematics, dynamics and forces; joints trajectory planning for end effector desired tracking and constrained motion; control of robots using linear, non-linear, and adaptive controllers. Prerequisite: EECE 460 or MECH 433 or consent of the instructor.

EECE 662  Optimal Control  3 cr.
A course on optimization theory and performance measures, calculus of variations, the maximum principle, dynamic programming, numerical techniques, LQR control systems. Prerequisite: Senior standing or consent of the instructor.

EECE 663  System Identification  3 cr.
This course introduces the fundamentals of system identification as the basic mathematical tools to fit models into empirical input-output data. While rooted in control theory, applications extend to general time-series modeling and forecasting, such as stock prices, biological data and others. Topics covered include nonparametric identification methods: time and frequency response analysis; parametric identification methods: prediction error methods, least squares, linear unbiased estimation and maximum likelihood; Convergence, consistency and asymptotic distribution of estimates; properties and practical modeling issues: bias distribution, experiment design and model validation. Prerequisite: Senior standing or consent of the instructor.

EECE 664  Fuzzy Sets, Logic and Applications  3 cr.
A course that outlines fuzzy sets and related concepts; logical connectives; mapping of fuzzy sets; extension principle; fuzzy relations and fuzzy set ordering; fuzzy logic inference; applications: fuzzy control, signal processing, pattern recognition, decision-making, and expert systems. Prerequisite: Senior standing or consent of the instructor.

EECE 665  Adaptive Control  3 cr.
A course that includes the control of partially known systems; analysis and design of adaptive control systems; self-tuning regulators; model reference adaptive control of uncertain dynamic systems; typical applications. Prerequisite: EECE 460 or consent of the instructor.

EECE 667  Pattern Recognition  3 cr.
The course provides an overview of the theory, principles and algorithms used in pattern recognition to construct high performance information processing systems that learn from experience. The course covers traditional and modern concepts for model selection and parameter estimation in recognition, decision making, multi-agent and statistical learning.
problems. Special emphasis will be given to regression, classification, regularization, feature selection, dimensionality reduction and density estimation in supervised, unsupervised and semi-supervised modes of learning. Students will be assigned typical pattern recognition problems to investigate as projects. Prerequisite: Senior standing or consent of the instructor.

**EECE 668  Game Theory and Decision making  3 cr.**
Game theory provides a set of tools, approaches, and perspectives on decision making to mimic the human elements of decision making that is best described by strategy, coercion and cooperation. This course offers an introduction to fundamentals of game theory and decision making with a special emphasis on the foundations of the mathematical background. Topics covered include: static, evolutionary, supermodular, repeated, cooperative, network, potential and congestion games as well as bargaining and uncertainty in games. Students will be assigned real-world examples of game theory and strategic decision making to investigate as projects. Prerequisite: Senior standing or consent of the instructor.

**EECE 670  Power System Planning  3 cr.**
A course that investigates electric energy and peak demand forecasts using weather sensitive, time curve, autoregressive and causal models; generation reliability evaluation, loss of energy expectation, energy limited units, probabilistic production costing, generating capacity expansion analysis, and maintenance scheduling; operational planning, unit commitment, Hydrothermal coordination; power system security classification, contingency analysis, external equivalents, optimal power flow; planning in a competitive electric power environment. Prerequisite: EECE 471 or consent of the instructor.

**EECE 671  Environmental Aspects of Energy Systems  3 cr.**
A course that examines world energy resources and classifications; sources and effects of air pollution; air quality modeling, Gaussian dispersion models for pollution estimation; motor vehicle emissions and noise pollution; environmental impacts of electricity generation, pollution control systems, electromagnetic radiation, production and impacts in high-voltage applications; environmental impact assessment; basic concepts. Prerequisite: Senior standing or consent of the instructor.

**EECE 672  Energy Planning and Policy  3 cr.**
A course that focuses on features of modern energy planning and policy. Topics covered include the interaction among the technological, economic, environmental, and sociopolitical aspects of energy supply and use; electricity, oil, and gas industries, and their market structures; elements of energy planning on the sector and national levels; energy decision-making under conditions of uncertainty, risk management in energy planning; liberalization of energy markets; case studies. Prerequisite: Senior standing or consent of the instructor.

**EECE 673  Power Electronics Systems and Applications  3 cr.**
A course that reviews converter topologies for AC/DC, DC/AC, and DC/DC; power supply applications; converter applications to motor drives; utility interface of distributed energy systems; static VAR systems; flexible AC transmission; high voltage DC; power quality control;
active and passive harmonics compensation. *Prerequisite: EECE 473 or EECE 471 or consent of the instructor.*

**EECE 675 Renewable Energy Systems 3 cr.**
A course that covers the principles of renewable energy, solar radiation, solar water heating, building and other thermal applications, photovoltaic generation, wind power, fuel cells and the hydrogen cycle, biomass, and institutional and economic factors. *Prerequisite: Senior standing or consent of the instructor.*

**EECE 677 Electric Power System Stability and Control 3 cr.**
A course on synchronous machine modeling and simulation, response to small disturbances, and voltage instability. Topics include Park's transformation, flux linkage, voltage, and state-space equations, subtransient and transient parameters, simplified models of the synchronous machine, treatment of saturation, system reference frame, small-signal stability, power system stabilizers, and bifurcation analysis. *Prerequisite: EECE 678, or consent of instructor.*

**EECE 678 Advanced Power System Analysis 3 cr.**
A course on optimal dispatch of generation, symmetrical components and unbalanced faults, transient stability, control of generation, state estimation in power systems and power system simulation. *Prerequisite: EECE 471 or consent of the instructor.*

**EECE 679 Energy Efficiency in the Power Sector 3 cr.**
Topics covered in the course include: Utility companies and energy supply, energy sustainability, cogeneration systems: combined heat and power (CHP) and combined cycle gas turbines (CCGT), reciprocating engines, distributed generation, demand side management, energy audit: types and data analysis, monitoring and targeting of energy, energy-efficient rotating machines, design and performance optimization. Case studies. *Pre-requisite: EECE370 and EECE471 or consent of the instructor.*

**EECE 680 Antenna Theory and Design 3 cr.**
This course provides the students with an understanding of the basic principles of antenna analysis and design; an overview of the fundamental characteristics and parameters of antennas; an overview of analytical and numerical methods used to analyze and design antennas with application to some basic antenna structures such as linear antennas, loop antennas, and antenna arrays. *Prerequisite: EECE 380 or consent of the instructor.*

**EECE 681 Advanced Antenna Design 3 cr.**
This course provides the students with an understanding of advanced antenna structures and presents an overview of analytical and numerical methods used to analyze and design these antenna structures. The course includes broadband antennas, frequency-independent antennas, aperture antennas, horn antennas, microstrip antennas, and reflector antennas. Students will work on a research paper on a selected antenna design topic. *Prerequisite: EECE 680 or consent of the instructor.*

**EECE 682 Time-Harmonic Electromagnetic Fields 3 cr.**
A course on time-varying and time-harmonic EM fields; electrical properties of matter; wave
propagation and polarization; construction of solutions; reflection and transmission; electromagnetic theorems and principles in particular equivalence; rectangular waveguides and cavities; dielectric waveguide, circular waveguides, spherical waveguide; radiation from structures; scattering by wedges, cylinders and spheres; radiation from apertures, and perturbational and variational techniques.  

**EECE 683  Numerical Methods in Electromagnetics  3 cr.**

This course examines the principles and applications of numerical techniques for solving practical electromagnetics problems. It covers the moment methods, finite difference methods, finite element methods, and hybrid methods. The course also investigates the application of the finite-volume control method in electromagnetics.  

Prerequisite: EECE 682 or consent of the instructor.

**EECE 691  Digital Signal Processing  3 cr.**

Course topics include a review of signals, systems, and transforms; design of digital filters: FIR and IIR; sampling and reconstruction of signals; multi-rate signal processing with applications; effects of finite word length; discrete random signals and spectral estimation; and an introduction to 2D signal and image processing.  

Prerequisite: Senior standing or consent of the instructor.

**EECE 691L  Digital Signal Processing Lab  1 cr.**

This graduate lab is comprised of a set of lab experiments in MATLAB, C and Assembly covering a series of real-time signal processing topics. The developed laboratory material is intended to complement the digital signal processing course (EECE 691). Upon completion of the lab, the student will have acquired the required knowledge and skills to develop real-time DSP systems.  

Prerequisites: EECE 691 Digital Signal Processing (may be waived upon approval of course instructor).

**EECE 693  Neural Networks  3 cr.**

The course provides a comprehensive foundation to artificial neural networks and machine learning with applications to pattern recognition and data mining; learning processes: supervised and unsupervised, deterministic and statistical; clustering; single layer and multilayer perceptrons; least-mean-square, back propagation, and Al-Alaoui algorithms; radial-basis function networks; committee machines; principal component analysis; self-organizing maps; and current topics of interest.  

Prerequisite: Senior standing or consent of the instructor.

**EECE 694  Digital Image Processing  3 cr.**

A course on two-dimensional signals and systems; image formation and perception; representation, coding, filtering restoration, and enhancements; feature extraction and scene analysis; introduction to computer vision.  

Prerequisite: Senior standing or consent of the instructor.

**EECE 694L  Image Processing Lab  1 cr.**

The EECE 694L graduate lab comprises a set of MATLAB/C++ based lab experiments in different image processing topics covering image pre and post processing techniques, image
compression, morphological transformations, image restoration and enhancement techniques, color image processing, computer vision basics, and geographical image processing. In addition, students will be exposed to software optimizations for real time image processing using SIMD instructions. *Prerequisite: EECE 694, or EECE 603, or consent of instructor.*

**EECE 695 Adaptive Filtering**  
3 cr.  
A course that examines the fundamentals of optimal filtering and estimation, Wiener filters, linear prediction, steepest-descent and stochastic gradient algorithms; frequency-domain adaptive filters; method of least squares, recursive least squares, fast fixed order and order-recursive (lattice) filters; misadjustment, convergence and tracking analyses, stability issues, finite precision effects; connections with Kalman filtering; and nonlinear adaptive filters. *Prerequisite: Senior standing or consent of the instructor.*

**EECE 696 Applied Parallel Programming**  
3 cr.  
This course is an introduction to parallel programming, and GPU computing. Topics include: GPU as a part of the PC architecture; CUDA, CUDA threads, and CUDA memory; floating point performance; OpenCL; MPI; and reductions and their implementation. The course also includes application case studies, current topics, and a course project. Senior or Graduate Standing, *Prerequisites: EECE 321 or consent of the instructor.*

**EECE 731 Advanced Topics in Complexity Theory**  
3 cr.  
The course covers advanced topics in computational complexity theory. Topics include: Hierarchy theorems; Relativization; Non-uniform models of computations: branching programs and circuits, relations, and lower bounds; Alternation and the Polynomial Hierarchy; Interactive Proofs; Probabilistically checkable proofs; Pseudorandomness: hardness versus randomness paradigm, generators for space bounded computations, special purpose generators. *Prerequisite EECE 631 or consent of the instructor.*

**EECE 732 Pseudorandomness**  
3 cr.  
Pseudorandomness is a branch of computational complexity theory whose aim is to construct randomness generators which use little randomness, but still appear random to computations with limited time, space, or circuit resources. This course covers the basics of the area of pseudorandomness. Topics include: Randomized complexity classes review; Background material from coding theory; Computational indistinguishability and pseudorandom generators; Hardness versus randomness: Nisan-Wigderson generator, Impagliazzo-Wigderson theorem; Simple generators: k-wise independence, almost k-wise Independence, and small-bias spaces; Unconditional generators for constant depth circuits, low-degree polynomials, and space-bounded computation; DNF counting algorithms; Weak random sources, randomness extractors, and Trevisan's extractor. *Prerequisites: EECE 631 or consent of the instructor.*
Special Courses and Thesis

EECE 700  Approved Experience for EICT students  0 cr.

EECE 796  Special Project  3 cr.
This is a graduate course given to one student. The grade in such a course will be reported as Excellent (E), Pass (P), or Fail (F), in accordance with University Regulations on Graduate Study. The course designation will be EECE 796-Special Project followed by an appropriate subtitle in brackets.

To offer a course as Special Project, the instructor giving the course must submit a proposal to the chairperson of the department for approval. The chairperson’s decision should be based on consultations with faculty members of the concerned department, or with the group of faculty members whose area of specialty is relevant to the subject matter.

Every Special Project course must have a report on the work done and the basis on which the grade was given. This report must be kept in the course file of the department.

A graduate student may take only one Special Project course during his/her graduate program. If the subject matter of the Special Project is relevant to the thesis topic, the thesis committee should take the work done into consideration in its evaluation of the thesis of the student.

EECE 797  Seminar  0 cr.
The seminar course is offered every semester by each department/graduate program on a biweekly basis.

All graduate students are required to register for the seminar course offered by their department/program in accordance with each program's policy.

At the beginning of a semester, every department/program should issue a schedule for the seminar course showing for each session the date, speaker, topic, and chairperson.

The speakers could be graduate students or faculty members.

Graduate students are expected to present progress reports on their thesis or project research. The time allocated to a presentation should not exceed 30 minutes, the remaining time being left for discussion.

Attendance is mandatory. A student registered in the course is not allowed more than one unexcused absence.

The grade (P/F) is based solely on attendance. A single ‘F’ is cleared by a ‘P’ in the following semester. A student who accumulates two failures (F) will be dropped from the faculty.

EECE 798  Special Topics  3 cr.
The course may be given as a conventional course to a number of students on a topic that is not in the mainstream of faculty curricula but may arise due to a special interest on the part of a faculty member or a visiting faculty member. Grades in such a course will be reported in the usual numeric format, and the course designation will be EECE 798-Special Topics followed by an appropriate subtitle in brackets.
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<td>EECE 999</td>
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