

# Department of Electrical and Computer Engineering

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Lecturers:	Abdallah, Rima; Droubi, Ghassan; Ladan, Mohammad; Meskaoui, Nada; Mohtar, Taan; Moukallid, Ali.
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## Graduate Programs

The Department of Electrical and Computer Engineering offers the degree of Master of Engineering (ME) in Electrical and Computer Engineering, and the degree of Doctor of Philosophy (PhD) in Electrical and Computer Engineering.

## Master of Engineering in Electrical and Computer Engineering

The department offers the following graduate programs, all leading to the Master of Engineering in Electrical and Computer Engineering (ME in ECE) degree:

- ECE Thesis Program
- ECE Non-thesis Program
- Information and Communications Technology Program

All programs must satisfy either the thesis program requirements or the non-thesis program requirements. The program is indicated on the student's transcript.

## Requirements

All relevant requirements and regulations of the University and the Faculty of Engineering and Architecture for the master's degree apply to the ME in ECE programs.

- In order to be eligible for admission, a student must have a bachelor's degree from an accredited university.
- Students whose undergraduate degree is in an area other than engineering, and students whose undergraduate degree is a three-year degree are considered prospective graduate students.
- Applicants to the graduate programs must sit for the GRE general test.
- Students applying to the thesis programs are normally interviewed by members of the ECE Graduate Committee, and are asked to provide a statement of research describing their experience and research interests.

## ECE Thesis Program Requirements

Thirty (30) credit hours: 24 course credit hours and 6 thesis credit hours:

- a minimum of 21 credits in graduate courses
- a minimum of 18 credits in ECE courses
- a minimum of 9 graduate credits in the major area
- a minimum of 6 graduate credits in the minor area
- the seminar course

## ECE Non-Thesis Program Requirements

Thirty-three (33) credit hours in graduate courses:

- a minimum of 12 graduate credits in the major area
- a minimum of 6 graduate credits in the minor area
- a minimum of 24 credits in ECE courses
- the seminar course

## Information and Communications Technology Program

The Information and Communications Technology (ICT) Program is consistent with the requirements for the ME in ECE thesis program, and consists of 30 credits distributed as follows:

- 15 credits in core courses
- 9 credits in elective courses
- an internship (no credits) with a minimum duration of 10 weeks and a maximum duration of six months
- 6 credits for the master thesis
- the seminar course

The courses are divided into three areas: software systems, telecommunications, and business/management. The 15-credit core courses should satisfy the following conditions:

- 6 credits in software systems selected from a set of core courses
- 6 credits in telecommunications selected from a set of core courses
- 3 credits in business/management selected from a set of core courses

The 9-credits in elective courses should satisfy the following conditions:

- one regular 3-credit course from either the software systems elective pool or the telecommunications elective pool
- the remaining 6 credits should include a minimum of one graduate level lab course and two special courses (technical and/or business/management)

All elective courses should be taken from the three defined pools of elective courses (software systems pool, telecommunications pool, and business/management pool).

## Core Courses

- **Software Systems:** EECE 625, EECE 630, EECE 635, EECE 654
- **Telecommunications:** EECE 640, EECE 643, EECE 651, EECE 653, EECE 655
- **Business/Management:** DCSN 315, INFO 300

## Elective Courses

- **Software Systems:** EECE 625, EECE 630, EECE 631, EECE 632, EECE 634, EECE 635, EECE 650, EECE 652, EECE 654
- **Telecommunications:** EECE 640, EECE 641, EECE 642, EECE 643, EECE 644, EECE 645, EECE 646, EECE 647, EECE 651, EECE 653, EECE 655, EECE 656, EECE 680, EECE 681
- **Business/Management:** BUSS 310, DCSN 350A, INFO 300, MNGT 306, MNGT 319, MKTG 306, MNGT 348, ENMG 654, ENMG 656, ENMG 657
- **Lab courses:** EECE 640L, EECE 651L

## Master's Degree—Major and Minor Areas

The major and minor areas for the ME in ECE programs are shown below, with their corresponding courses.

- **Biomedical Engineering:** EECE 601, EECE 602, EECE 603, EECE 604, EECE 605, EECE 693
- **Integrated Circuits and Computer Systems:** EECE 611, EECE 612, EECE 614, EECE 615, EECE 620, EECE 621, EECE 622, EECE 623, EECE 624, EECE 625, EECE 626
- **Software Systems and Networks:** EECE 625, EECE 630, EECE 631, EECE 632, EECE 634, EECE 635, EECE 650, EECE 651, EECE 652, EECE 653, EECE 654, EECE 655, EECE 656.
- **Control and Intelligent Systems:** EECE 660, EECE 661, EECE 662, EECE 663, EECE 664, EECE 665, EECE 693
- **Communications:** EECE 604, EECE 640, EECE 641, EECE 642, EECE 643, EECE 644, EECE 645,

EECE 646, EECE 647, EECE 651, EECE 691

- **Signal and Image Processing:** EECE 603, EECE 622, EECE 644, EECE 663, EECE 691, EECE 693, EECE 694, EECE 695
- **Energy and Power Systems:** EECE 670, EECE 671, EECE 672, EECE 673, EECE 675, EECE 676, EECE 677
- **Applied Electromagnetics and RF Systems:** EECE 611, EECE 613, EECE 643, EECE 680, EECE 681, EECE 682, EECE 683

## PhD in Electrical and Computer Engineering

### Mission

The mission of the doctoral program is to provide high quality education in electrical and computer engineering which prepares students for employment and leadership roles in academic, industrial, or research positions.

### Objectives

The objectives of the program are to

- provide the student with the research opportunities to acquire a depth of knowledge in one specialization area of electrical and computer engineering, and familiarity with allied areas;
- provide opportunities for the doctoral student to develop competence in performing independent research, communicating effectively, and learning independently;
- advance the state of electrical and computer engineering research at AUB, in Lebanon, and the region;
- and advance the state of the art in electrical and computer engineering.

### Program Outcomes

Graduates of the program are expected to have

- a breadth of knowledge in electrical and computer engineering, and a depth of knowledge in their specific area of research
- an ability to identify and define research problems
- experience in performing research and communicating the results effectively
- experience in doing independent academic work
- a published contribution to the existing knowledge in electrical and computer engineering

## Admission Requirements

Applicants to the PhD program must hold a master's degree in electrical and computer engineering or in a related discipline from AUB or another recognized institution of higher education, with a minimum cumulative average of 85.0 over 100 or its equivalent. Admission is determined by evaluating the following:

- Transcripts of academic record from the institution(s) of higher education attended by the applicant
- Graduate Record Examination (GRE) general test scores
- A written statement of purpose
- Three letters of recommendations
- A portfolio that includes a resume and samples of work
- An interview, conducted either in person, by phone, or over the Internet

All applicants must also satisfy the University requirements for admission to PhD programs.

## Program Requirements

The completion of at least forty-eight (48) credits of graduate study consisting of combined course work and research beyond the master's degree is required for the PhD degree in Electrical and Computer Engineering. A minimum of eighteen (18) credits of course work and a minimum of eighteen credits (18) of research and thesis work are required.

The basic program of study for the PhD degree is built around one major area and a minimum of one minor area. Students take courses to satisfy the major and minor area requirements and to acquire the knowledge needed for the required written and oral examinations. Students should take at least six graduate courses, including courses prior to admission to the PhD program, in their PhD major area, which corresponds to one of the fields shown on page 248. Students should also take at least three graduate courses in their PhD minor area, including courses taken prior to admission to the PhD program. The minor courses may be taken in one of the ECE areas, or an area outside the ECE department, or a combination of courses taken in the department and outside the department that defines a minor area.

Each student must maintain an 85.0/100 cumulative average in order to remain in good standing. The cumulative average is calculated for courses taken beyond the master's degree. A student will be placed on probation if s/he fails a course (below 70), or her/his cumulative average falls below 85.0. A student has one semester to raise his/her cumulative average to 85.0 or better and has to repeat failed courses as soon as they are offered. Failure to do so will result in academic dismissal. A student cannot earn the PhD with a cumulative average below 85.0.

## The PhD Comprehensive Examination

After taking at least twelve credits of course work and mastering the knowledge defined in the PhD major area, the student must take a comprehensive written examination. The exam is given twice a year, at the end of the fall and spring semesters. Most of the questions in the examination will be from the student's major field of study; the student is informed beforehand of the subjects that will be covered on the examination. A student who does not pass may repeat the exam only once. The exam should be repeated during the following semester. The comprehensive examination, together with the three courses in the PhD minor area must be completed within the first two years after admission to the PhD program.

## Dissertation Committee

The PhD dissertation committee is composed of at least four faculty members from the student's major area, recommended by the dissertation advisor and approved by the ECE Graduate Committee (EGC), FEA Graduate Studies Committee (GSC), and the Board of Graduate Studies (BGS). Changes in the committee, including the dissertation advisor, are possible with the approval of the EGC, FEA GSC, and BGS. It is advisable that the dissertation committee include one member from outside AUB. All committee members should hold professorial rank. The dissertation committee approves the dissertation topic and research agenda and conducts the oral qualifying examination, and the dissertation defense examination. The proposal of the dissertation topic and the selection of the members of the dissertation committee should be approved at least two semesters before the student defends the dissertation.

## The PhD Dissertation Proposal and Oral Qualifying Examination

Within two semesters after passing the comprehensive examination, the student must take an oral qualifying examination, conducted by his/her dissertation committee. The defense of the PhD dissertation proposal is considered a part of the oral qualifying examination. In addition to reviewing the prospectus of the dissertation, the nature and the content of the examination are related to the student's field of research.

## Admission to Candidacy

Students must be admitted to candidacy at least two semesters before obtaining the PhD degree. For admission to candidacy, students are expected to have:

- submitted a program approved by the dissertation committee, the EGC, the FEA GSC, and the BGS
- passed the oral qualifying examination
- completed at least 12 credits of graduate courses beyond the master's degree
- attained a cumulative average of at least 85.0 in all courses taken beyond the master's degree
- maintained good academic standing.

## PhD Dissertation

The student must submit a dissertation based on the results of original, independent research. The PhD dissertation is expected to make a significant contribution in electrical and computer engineering. Upon completion of the dissertation and after its approval by the dissertation advisor, the dissertation must be defended orally.

## Dissertation Defense

The dissertation defense is open to the public and must be scheduled no later than October 30, March 1, and June 10, for students who wish to graduate at the end of the fall, the spring semester, or the summer session respectively. "Pass" or "Fail" is reported for the combined dissertation and defense. If "Fail" is reported, the student may resubmit the dissertation and defend it after a period of at least three months. Failure on the second attempt results in the discontinuation of graduate work.

A student must be registered for the dissertation or at least one course in the session in which they expect to graduate.

## Residence Requirements

A student must register for at least four semesters beyond the completion of the master's degree. Requirements for the PhD degree must be completed within a period of five years after starting graduate work beyond the master's degree. Extension beyond the five-year limit requires the approval of the EGC, the FEA GSC, and the BGS.

## Seminar Requirement

A student must register for EECE 797: Seminar, as long as s/he is in the program.

## Program Completion Requirements

To earn the PhD degree in electrical and computer engineering, the student must complete the following requirements:

- Have at least one journal paper, based on the PhD dissertation, accepted in a leading international journal in his or her field of specialty that requires at least two reviews. Additionally at least two refereed conference papers, based on the dissertation, must have appeared in conference proceedings.
- Have a cumulative average, beyond the master's degree, of 85.0 or above, and be in good academic standing.
- Satisfy the course and research credit requirements.
- Pass the comprehensive and oral qualifying examinations.
- Complete and successfully defend a PhD dissertation.
- Satisfy the residence requirement and all other pertinent AUB regulations.

## PhD Major and Minor Areas

The PhD major and minor areas with their corresponding courses are the following:

- **Computer and Software Systems:** EECE 612, EECE 614, EECE 615, EECE 620, EECE 621, EECE 622, EECE 623, EECE 624, EECE 625, EECE 626, EECE 630, EECE 631, EECE 632, EECE 634, EECE 635, EECE 650, EECE 651, EECE 652, EECE 653, EECE 654, EECE 655, EECE 656.
- **Communications and Signal Processing:** EECE 603, EECE 604, EECE 622, EECE 640, EECE 641, EECE 642, EECE 643, EECE 644, EECE 645, EECE646, EECE 647, EECE 651, EECE 663, EECE 691, EECE 693, EECE 694, EECE 695
- **Control, Biomedical, and Intelligent Systems:** EECE 601, EECE 602, EECE 603, EECE 604, EECE 605, EECE 660, EECE 661, EECE 662, EECE 663, EECE 664, EECE 665, EECE 693
- **Electrical Energy Systems:** EECE 670, EECE 671, EECE 672, EECE 673, EECE 675, EECE 676, EECE 677
- **Electromagnetics and RF Circuits and Systems:** EECE 611, EECE 613, EECE 643, EECE 680, EECE 681, EECE 682, EECE 683

## Courses

- EECE 601 Biomedical Engineering I 3 cr.**  
A course that introduces general instrumentation configuration, living cells, and performance of instrumentation systems; types and characteristics of transducers; sources and characteristics of bioelectric signals and electrodes; cardiovascular system, measurements, and diagnostic equipment; patient care and monitoring. *Prerequisite: BIOL 210 or consent of instructor.*
- EECE 602 Biomedical Engineering II 3 cr.**  
A course on the respiratory system; non-invasive diagnostic instrumentation; nervous system; bio-telemetry; clinical laboratory; x-ray and radioisotopes; magnetic resonance; electro-surgery; computers in medicine. *Prerequisite: EECE 601.*
- 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: BIOL 210 and STAT 230, or equivalent.*
- EECE 604 Communications Engineering for Genetics and Bioinformatics 3 cr.**  
A course that presents current research efforts in the emerging interdisciplinary field of communications engineering for genetics and bioinformatics. It will show 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.

- 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.**  
A course that focuses on basic analog IC building blocks; current mirrors, voltage, current references, and amplifiers; digital to analog converters, analog to digital converters, continuous-time filters, and switch capacitor filters; modulators and multiplexers, oscillators, and phase-locked loops. *Prerequisite: EECE 311.*
- 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.*
- 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.*
- 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.*
- EECE 615 Computer Methods for Circuit and System Analysis 3 cr.**  
A course that 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.*
- EECE 620 Computer Graphics 3 cr.**  
A course on interactive graphics; graphics hardware; graphical input devices; windowing; clipping; viewports; zooming, geometrical transformations (2D and 3D); data structures; advanced raster display architectures; raster algorithms; special graphics techniques; applications.

**EECE 621      Advanced Computer Architecture      3 cr.**

A course that focuses on the allocation of hardware and software resources in solving large-scale computing problems, with emphasis on the relationships between hardware organization, system programming, and language support in the evolution of advanced computer architectures. *Prerequisite: EECE 421.*

**EECE 622      VLSI for Communications and Signal Processing      3 cr.**

A course that 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.

**EECE 623      Reconfigurable Computing      3 cr.**

A course that deals 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.**

A course on digital systems testing and testable design: test economics, fault modeling, logic and fault simulation, testability measures, test generation for combinational and sequential circuits, memory test, delay test, scan design, built-in self test, and boundary scan. *Prerequisite: EECE 320.*

**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.*

**EECE 626      Computer System Analysis      3 cr.**

A course on the development of analytical models of computer systems and application of such models to performance evaluation. Topics covered include scheduling policies, paging algorithms, multi-programmed resource management, and queuing theory. *Prerequisite: EECE 421.*

**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.*

**EECE 631      Advanced Topics in Algorithms      3 cr.**

A course that covers general principles of algorithm design and analysis; linear programming; randomized algorithms; advanced graph algorithms; NP completeness; introduction to complexity theory; approximation algorithms; number theoretic algorithms; selected topics. *Prerequisite: EECE 431.*

**EECE 632      Cryptography and Computer Security      3 cr.**

A course that focuses on 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, intruders, and malicious software.

**EECE 634      Optimizing Compilers      3 cr.**

A course on theoretical and practical aspects of building modern optimizing compilers. Topics: intermediate representations, basic blocks and flow graphs, data flow analysis, partial evaluation and redundancy elimination, loop optimizations, register allocation, instruction scheduling, and interprocedural analysis. Students will implement significant optimizations within the framework of a modern research compiler. *Prerequisites: EECE 330 and EECE 421, or consent of the instructor.*

**EECE 635      Advanced Software Engineering      3 cr.**

A course that provides the students with an understanding of current topics in software engineering with an emphasis on software architectural design, software development, and autonomic computing. *Prerequisite: EECE 430.*

**EECE 640      Wireless Communications      3 cr.**

A course on wireless channel models; performance of digital modulation schemes in wireless channels; diversity techniques; channel coding and interleaving in fading channels; adaptive equalization in wireless channels; multiple access techniques; fundamentals of cellular communications; current wireless communication systems. *Prerequisite: EECE 442.*

**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.*

**EECE 641      Information Theory      3 cr.**

A course that introduces the field of information theory and its application to communications theory, computer science, statistics, and probability theory. Covering all the essential topics in information theory, the course introduces the basic quantities of entropy, relative entropy, and mutual information, and shows how they arise as natural answers to questions of data compression, channel capacity, rate distortion, and hypothesis testing.

**EECE 642      Introduction to Coding Theory      3 cr.**

A course that introduces the theory of error-correcting codes. The course focuses on results of asymptotic or algorithmic significance. Topics include: construction and existence results for error-correcting codes; limitations on the combinatorial performance of error-correcting codes; low density parity check codes; algebraic geometric codes; turbo codes; and decoding algorithms.

- EECE 643 RF and Microwave Communication Systems 3 cr.**  
A course that introduces students to hardware components, system parameters, and architectures of RF and microwave wireless systems. It focuses on the design of a radio system for transmission and reception of information: types of receivers and transmitters, matching techniques, antenna types in wireless systems, RF and microwave radio components, receiver and transmitter RF system parameters, and radio links; basic modulation and demodulation schemes and multiple-access techniques used in present RF systems, and includes an overview of different RF and microwave point-to-point, mobile, and satellite communications systems. *Prerequisites: EECE 311 and EECE 340.*
- EECE 644 Stochastic Processes, Detection, and Estimation 3 cr.**  
A course on types of random processes, series representation, and filtering; hypothesis testing and parameter estimation from a probabilistic point of view; extension to detection and estimation of known signals in white and non-white noise; prediction and filtering problems. *Prerequisites: STAT 230 and EECE 340.*
- 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.*
- EECE 646 Advanced Digital and Data Communications 3 cr.**  
A course that examines measures of information, source coding, channel coding, channel capacity, soft and hard decision decoding, digital signaling over a channel with intersymbol interference, and other topics. *Prerequisite: EECE 442.*
- 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.
- EECE 650 Client-Server Computing 3 cr.**  
A course that covers internet and intranet technologies, the client-server model of interaction, design and implementation of clients and servers, interactive and concurrent servers, distributed computing, application gateways, and includes a design project. *Prerequisite: EECE 450.*
- 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 450.*
- EECE 651L Internetworking Laboratory 1 cr.**  
A laboratory course that 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 450.*

- EECE 652 Web Server Design and Programming 3 cr.**  
A course that 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.
- EECE 653 Multimedia and Networking 3 cr.**  
A course that 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 Internet2. Multimedia networking applications are designed and implemented as student projects. *Prerequisite: EECE 450.*
- EECE 654 Pervasive Computing Systems and Applications 3 cr.**  
A course that covers the technologies involved in integrating front-end mobile devices into local and global networks. A strong emphasis is placed on the programmability and networking of mobile phones, PDAs, and Pocket PCs. Hands-on experience involves programming in Java2 ME, C/C++ for Palm OS, and .NET Compact Framework for Windows CE. The course provides a general coverage of underlying technologies and standards, including XML, WAP, UMTS, GPRS, Bluetooth, and Jini.
- EECE 655 Internet Security 3 cr.**  
A course that 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. *Prerequisite: EECE 450.*
- EECE 656 Mobile Ad hoc and Sensor Networks 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. *Prerequisites: EECE 450.*
- 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.
- EECE 661 Robotics 3 cr.**  
A course that examines robot manipulators: kinematics, control, programming, task planning, and effect of load; design of robot controllers: path tracking, force feedback control, real-time computation issues; and includes a set of laboratory experiments and a design project. *Prerequisite: EECE 460.*

**EECE 662 Optimal Control 3 cr.**  
A course on optimization theory and performance measures, calculus of variations, the maximum principle, dynamic programming, numerical techniques, and LQR control systems.

**EECE 663 System Identification 3 cr.**  
A course that focuses on an introduction to time series; auto regressive moving average models and their characteristics; modeling; forecasting; stochastic trends and seasonality; multiple series and optimal control; and applications.

**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.

**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.*

**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.

**EECE 670 Power System Planning 3 cr.**  
A course that investigates energy and peak load forecasts, weather-sensitive forecasts, generation reliability, load duration curves, loss-of-load expectation, capacity reserve evaluation, generation and transmission expansion, power flow analysis, reliability of bulk supply, and cost-benefit analysis. *Prerequisite: EECE 471.*

**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.

**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 uncertainties, risk management in energy planning; liberalization of energy markets; case studies.

**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.*

**EECE 675 Renewable Energy Systems 3 cr.**  
A course that covers wind, solar, hydro, biomass, and geothermal resources; resource assessment, electric drive options, control problems, environmental aspects of electricity generation, and stand-alone and utility applications; institutional and policy issues, and integrated energy systems.

**EECE 676 Computer Analysis of Power Systems 3 cr.**  
A course on large scale power systems, power system matrices, and programming considerations; advanced power flow studies, voltage, and reactive flow control; fault analysis, transient analysis, and power system stability. *Prerequisite: EECE 471.*

**EECE 677 Electric Power System Operation and Control 3 cr.**  
A course on short-term load forecasting, generation unit commitment, economic load dispatch, loss formula coefficients, nonlinear programming, optimal power flow, security assessment, security dispatch, spinning reserve evaluation, automatic generation control, reactive power and voltage control, and state estimation.

**EECE 680 Antenna Theory and Design 3 cr.**  
A course on radiation systems, wire antennas, aperture antennas, arrays, input impedance, microstrip antennas, dielectric antennas, and antennas in material layers.

**EECE 681 Advanced Antenna Design 3 cr.**  
A course that provides 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. This 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.*

**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; perturbational and variational techniques. *Prerequisites: EECE 380.*

**EECE 683 Numerical Methods in Electromagnetics 3 cr.**  
This course examines the principles and applications of numerical techniques for solving practical electromagnetic 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.*

**EECE 691 Digital Signal Processing 3 cr.**  
A course on the 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. Introduction to 2D signal and image processing.

