Department of Electrical and Computer Engineering

Chairperson:	Kabalan, Karim
Professors:	Al-Alaoui, Mohamad Adnan; Chaaban, Farid; Chedid, Riad; Diab, Hassan; El-Hajj, Ali; Hajj, Ibrahim; Kabalan, Karim; Karaki, Sami; Kayssi, Ayman; *Mrad, Fouad; Saade, Jean; Sabah, Nassir
Associate Professors:	Artail, Hassan; Bazzi, Louay; Chehab, Ali; Jabr, Rabih; Karameh, Fadi; Mansour, Mohamed
Assistant Professors:	Abou-Faycal, Ibrahim; Akkary, Haitham; Awad, Mariette; Dawy, Zaher; Elhajj, Imad; Hajj, Hazem; Masri, Wassim; Zaraket, Fadi
Adjunct Professor:	Khoury, Shahwan
Senior Lecturers:	Chahine, Hazem; Hamandi, Lama; Huijer, Ernst; Khaled, Mohamad
Lecturers:	Droubi, Ghassan; Gurunian, Mehran; Mohtar, Taan; Moukallid, Ali; Nasrallah, Danielle
Instructors:	Kanafani, Zaher; Khaddaj, Sara; Marmar, Ali; Selim, Bassel

The Department of Electrical and Computer Engineering offers two undergraduate programs leading to the degree of Bachelor of Engineering, and a minor in Biomedical Engineering.

Undergraduate Programs

The Department of Electrical and Computer Engineering offers the degree of Bachelor of Engineering in two majors:

- Computer and Communications Engineering (CCE)
- Electrical and Computer Engineering (ECE)

The mission of the undergraduate programs is to impart a basic understanding of electrical and computer engineering built on a foundation of mathematics, physical sciences, and technology; to expose students to practical and major design experiences; and to provide students with a global perspective and an awareness of their leadership role in regional development. This preparation is augmented by the liberal arts education offered to all undergraduates at the American University of Beirut.

The Electrical and Computer Engineering program provides the students with options to explore, and specialize in, one or more areas of electrical and computer engineering.

The Computer and Communications Engineering program prepares its graduates for careers and graduate studies in information and communication technologies.

The department also offers one minor:

- Minor in Biomedical Engineering

* On leave

Computer and Communications Engineering Program

Program Educational Objectives

The objectives of the CCE program are to graduate students able to

- achieve their employment or post graduate educational goals and
- advance in their careers through leadership, life-long learning, innovation, critical thinking, integrity, and civic responsibility.

Program Requirements

- **Mathematics:** MATH 201, MATH 202, MATH 211 or CMPS 211, MATH 218 or 219, STAT 230, and one of MATH 210, 224, 227, or 251
- **Sciences:** PHYS 210, PHYS 210L, CHEM 201 or 202, CHEM 203 or 205, and one additional science elective
- **General Education Program:** Arabic course (according to APT), ENGL 206 and one other English course, two social sciences courses, three humanities courses, and a course on ethics approved for the GE program
- **ENMG 400:** Engineering Economy
- **ECE Core Courses:** EECE 200, EECE 210, EECE 230, EECE 290, EECE 310, EECE 311, EECE 320, EECE 321, EECE 330, EECE 340, EECE 370, EECE 380, EECE 411 or 412, EECE 421, EECE 442, EECE 450, and two courses from EECE 430, 431, 432, 433, 434
- **ECE Laboratories:** EECE 310L, EECE 321L, EECE 413L, EECE 442L, and one additional laboratory elective
- **Technical Electives:** Six courses, at least two of which must be in ECE, subject to approval of adviser No more than two technical electives may be taken from the same department and/or program
- **Approved Experience:** EECE 500
- **Final Year Project:** EECE 501 and EECE 502

The program requirements can be completed according to the following proposed schedule:

Term I (Fall)			**Credits**
EECE	200	Introduction to Electrical and Computer Engineering	3
EECE	210	Electric Circuits	3
ENGL		English Course	3
MATH	201	Calculus and Analytic Geometry III	3
MATH/CMPS	211	Discrete Structures	3
			Total 15

Term II (Spring)			**Credits**
EECE	230	Introduction to Programming	3
EECE	290	Analog Signal Processing	3
MATH	202	Differential Equations	3
MATH	218/219	Linear Algebra	3
PHYS	210	Introductory Physics II	3
PHYS	210L	Introductory Physics Laboratory II	1
			Total 16
			31

Term III(Summer)			**Credits**
CHEM	201/202	Chemistry Course	3
CHEM	203/205	Chemistry Laboratory	2
Humanities or Social Science Elective			3
			Total 8

Term IV (Fall)			**Credits**
EECE	310	Electronics	3
EECE	310L	Electric Circuits Laboratory	1
EECE	320	Digital Systems Design	3
EECE	330	Data Structures and Algorithms	3
EECE	370	Electric Machines and Power Fundamentals	3
STAT	230	Introduction to Probability and Random Variables	3
			Total 16

Term V (Spring)			**Credits**
EECE	311	Electronic Circuits	3
EECE	321	Computer Organization	3
EECE	321L	Computer Organization Laboratory	1
EECE	340	Signals and Systems	3
EECE	380	Engineering Electromagnetics	3
Science Elective			3
			Total 16
			71

Term VI (Summer)			Credits
ENGL		English Course	3
ARAB		Arabic Course	3
Humanities or Social Science Elective			3
			Total 9

Term VII (Fall)			Credits
EECE	421	Computer Architecture	3
EECE	430/1/2/3/4	Software Elective	3
EECE	442	Communication Systems	3
MATH		Math Elective	3
ENMG	400	Engineering Economy	3
			Total 15

Term VIII (Spring)			Credits
EECE	411/412	Analog or Digital Integrated Circuits	3
EECE	430/1/2/3	Software Elective	3
EECE	450	Computer Networks	3
EECE	413L	Electronics Laboratory	1
Ethics Elective (an approved GE Humanities Course)			3
Humanities or Social Science Elective			3
			Total 16
			111

Term IX (Summer)			Credits
EECE	500	Approved Experience	1[b]

Term X (Fall)			Credits
EECE	501	Final Year Project	3
EECE	442L	Communications Laboratory	1
EECE		EECE Elective	3
Technical Electives**		EECE or Other	6
Humanities or Social Science Elective			3
			Total 16

Term XI (Spring)			Credits
EECE	502	Final Year Project	3
EECE		Laboratory Elective	1
EECE		EECE Elective	3
2 Electives		EECE or Other	6
Humanities or Social Science Elective			3
			Total 16
			Total =143 credit hours

*b. stands for billing
** No more than two technical electives may be taken from the same department and/or program.

List of Pre-approved Technical Electives

- Any EECE course with a number equal to or greater than 400
- CIVE 672
- MECH 633, 634, 642
- Any ENMG course with a number equal to, or greater than 500, with the exception of ENMG 504
- CMPS 251, 257, 258, 272, 274, 277, 281, 283, 286, 287, 288, 350, 357, 366, 367, 368, 372, 373, 378, 387
- PHYS 223, 226, 235, 236, 249
- MATH 213, 214, 220, 227, 241, 242, 261, 271, 303, 304, 306, 314, 315, 341, 344
- Any STAT course with a number equal to, or greater than 234

List of Science Electives

- BIOL 201, BIOL 202, BIOL 210, CHEM 201, CHEM 211, GEOL 201, GEOL 205, GEOL 211, PHYL 246, PHYS 212, PHYS 217, PHYS 223, PHYS 235, PHYS 236

Electrical and Computer Engineering Program

Program Educational Objectives

The objectives of the ECE program are to graduate students able to

- achieve their employment or post graduate educational goals and
- advance in their careers through leadership, life-long learning, innovation, critical thinking, integrity, and civic responsibility.

Program Requirements

- **Mathematics:** MATH 201, MATH 202, MATH 211 or CMPS 211, MATH 218 or 219, STAT 230, and one of MATH 210, 224, 227, 251
- **Sciences:** PHYS 210, PHYS 210L, CHEM 201 or 202, CHEM 203 or 205, and one additional science elective
- **General Education Program:** Arabic course (according to APT), ENGL 206 and one other English course, two social sciences courses, three humanities courses, and a course on ethics approved for the GE program
- **ENMG 400:** Engineering Economy
- **ECE Core Courses:** EECE 200, EECE 210, EECE 230, EECE 290, EECE 310, EECE 311, EECE 320, EECE 321, EECE 330, EECE 340, EECE 370, and EECE 380
- **ECE Laboratories:** EECE 310L, EECE 321L, and three additional laboratory electives
- **Restricted Electives:** six courses from the list below
  - **Integrated Circuits:** EECE 411 or 412
  - **Computer Architecture:** EECE 421
  - **Software 1:** EECE 430, 431, 432, 433, or 434
  - **Software 2:** EECE 430, 431, 432, 433, or 434
  - **Communication Systems:** EECE 442
  - **Computer Networks:** EECE 450

- **Control Systems:** EECE 460
- **Power Systems:** EECE 471
- **Power Electronics:** EECE 473
- **Other Technical Electives:** six courses, at least two of which must be in EECE, subject to approval of adviser. No more than two technical electives may be taken from the same department and/or program.

- **Approved Experience:** EECE 500
- **Final Year Project:** EECE 501 and EECE 502

The program requirements can be completed according to the following proposed schedule:

Term I (Fall)			**Credits**
EECE	200	Introduction to Electrical and Computer Engineering	3
EECE	210	Electric Circuits	3
ENGL		English Course	3
MATH	201	Calculus and Analytic Geometry III	3
PHYS	210	Introductory Physics II	3
PHYS	210L	Introductory Physics Laboratory II	1
			Total 16

Term II (Spring)			**Credits**
EECE	230	Introduction to Programming	3
EECE	290	Analog Signal Processing	3
MATH	202	Differential Equations	3
MATH	218/219	Linear Algebra	3
MATH/ CMPS	211	Discrete Structures	3
			Total 15
			31

Term III (Summer)			**Credits**
CHEM	201/202	Chemistry Course	3
CHEM	203/205	Chemistry Laboratory	2
Humanities or Social Science Elective			3
			Total 8

Term IV (Fall)			**Credits**
EECE	310	Electronics	3
EECE	310L	Electric Circuits Laboratory	1
EECE	320	Digital Systems Design	3
EECE	330	Data Structures and Algorithms	3
EECE	370	Electric Machines and Power Fundamentals	3
STAT	230	Introduction to Probability and Random Variables	3
			Total 16

Term V (Spring)			Credits
EECE	311	Electronic Circuits	3
EECE	321	Computer Organization	3
EECE	321L	Computer Organization Laboratory	1
EECE	340	Signals and Systems	3
EECE	380	Engineering Electromagnetics	3
Science Elective			3
			Total 16
			71

Term VI (Summer)			Credits
ENGL		English Course	3
ARAB		Arabic Course	3
Humanities or Social Science Elective			3
			Total 9

Term VII (Fall)			Credits
EECE		Restricted Elective	3
EECE		Restricted Elective	3
EECE		Restricted Elective	3
MATH		Math Elective	3
ENMG	400	Engineering Economy	3
			Total 15

Term VIII (Spring)			Credits
EECE		Restricted Elective	3
EECE		Restricted Elective	3
EECE		Restricted Elective	3
EECE		Laboratory Elective	1
Ethics Elective			3
Humanities or Social Science Elective			3
			Total 16
			111

Term IX (Summer)			Credits
EECE	500	Approved Experience	1[*b]

Term X (Fall)			Credits
EECE	501	Final Year Project	3
EECE		EECE Elective	3
EECE		Laboratory Elective	1
Technical Electives[**]		EECE or Other	6
Humanities or Social Science Elective			3
			Total 16

Term XI (Spring)			Credits
EECE	502	Final Year Project	3
EECE		EECE Elective	3
EECE		Laboratory Elective	1
Technical Electives**		EECE or Other	6
Humanities or Social Science Elective			3
			Total 16
			Total =143 credit hours

List of Pre-approved Technical Electives

- Any EECE course with a number equal to, or greater than 400
- CIVE 672
- MECH 633, 634, 642
- Any ENMG course with a number equal to, or greater than 500, with the exception of ENMG 504
- CMPS 251, 257, 258, 272, 274, 277, 281, 283, 286, 287, 288, 350, 357, 366, 367, 368, 372, 373, 378, 387
- PHYS 223, 226, 235, 236, 249
- MATH 213, 214, 220, 227, 241, 242, 261, 271, 303, 304, 306, 314, 315, 341, 344
- Any STAT course with a number equal to, or greater than 234

List of Science Electives

- BIOL 201, BIOL 202, BIOL 210, CHEM 201, CHEM 211, GEOL 201, GEOL 205, GEOL 211, PHYL 246, PHYS 212, PHYS 217, PHYS 223, PHYS 235, PHYS 236

Minor in Biomedical Engineering

The minor in Biomedical Engineering is open to all AUB students. Students who have completed at least 60 credits at the sophomore level and higher, and who have a cumulative average of 70 or more, may apply by completing a minor application form available in the ECE department. The minor will be indicated on the transcript of the student who completes all the requirements described below, and who obtains an average in the minor courses of 70 or more.

The minor requirements are divided into a set of core courses, and a set of elective courses.

For engineering students, the requirements are as follows:

- EECE 401 [1 cr.]
- BIOL 201 [4 cr.]
- BIOL 202 or PHYL 246 [4 cr.]
- One core course [3 cr.] chosen from EECE 601, EECE 603, or MECH 633
- One elective course from list A below [3 cr.]
- One elective course from list A, B, or C below [3 cr.]

Minimum number of credits: 18

* b. stands for billing
** No more than two technical elective may be taken from the same department and/or program

For biology students, the requirements are as follows:

- EECE 401 [1 cr.]
- BIOL 201 [4 cr.]
- BIOL 202 [4 cr.]
- (EECE 210 [3 cr.] (or equivalent) and EECE 601 [3 cr.])
  or (CIVE 210 [3 cr.] (or equivalent) and MECH 634 [3 cr.])
- One elective course from list A or B below [3 cr.]

Minimum number of credits: 18

For other students, the requirements are as follows:

- EECE 401 [1 cr.]
- BIOL 201 [4 cr.]
- BIOL 202 or PHYL 246 [4 cr.]
- (EECE 210 [3 cr.] (or equivalent) and EECE 601 [3 cr.])
  or (CIVE 210 [3 cr.] (or equivalent) and MECH 634 [3 cr.])
- One elective course from list A, B, or C below [3 cr.]

Minimum number of credits: 18

Elective Courses

List A: EECE 601, EECE 602, EECE 603 (unless the student takes EECE 694, in which case either EECE 694 or EECE 603 counts toward the minor), EECE 604, EECE 605, MECH 633, MECH 634

List B: MECH 606, MECH 607, MECH 624, MECH 631, MECH 641/EECE 661, EECE 693, EECE 694 (unless the student takes EECE 603, in which case either EECE 694 or EECE 603 counts toward the minor)

List C: BIOL 202, BIOL 223, BIOL 225, BIOL 244, BIOL 263, BIOL 268, PHYL 202, PHYL 246

Course Descriptions

EECE 200 Introduction to Electrical and Computer Engineering 3 cr.
Thiscourse includes the following topics: an overview of electrical and computer engineering; engineering as a profession; introduction to the different areas of ECE such as biomedical systems, circuits, communications, computer design, control, distributed systems, electromagnetics, energy, machines, and signal processing; basic computer tools such as SPICE, MATLAB, and LabVIEW; basic laboratory instruments; laboratory experiments and a design project.

EECE 210 Electric Circuits 3 cr.
This course includes the following topics: circuit variables and elements, Kirchoff's laws, basic analysis of resistive circuits, Thevenin's and Norton's equivalent circuits, circuit simplification, sinusoidal steady-state analysis, linear and ideal transformers, power relations, Fourier series and responses to periodic inputs, and circuit simulation using SPICE.

EECE 230 Introduction to Programming 3 cr.
A course on the basic principles of programming and their application to the solution of engineering problems using a high level programming language. This course introduces structured and object-oriented programming, and covers the basic data types, control structures, functions, arrays, pointers, and classes. Weekly laboratory assignments are an integral part of this course.

EECE 290 Analog Signal Processing 3 cr.
A course on circuits solution and analysis in the s and frequency domains. It includes operational amplifiers, step and steady-state response of RL, RC, and RLC circuits, Laplace transform and its use in circuit analysis; frequency-selective circuits; active filter circuits; Fourier transform, and two-port circuits; and circuit simulation using SPICE. *Prerequisite: EECE 210*.

EECE 310 Electronics 3 cr.
A course on semiconductors; PN junctions; diodes and diode circuits; MOS transistor and applications such as amplifier and switch; bipolar junction transistor and applications such as amplifier and switch; and circuit simulation using SPICE. *Prerequisites: EECE 290, and pre- or co-requisite: EECE 200*.

EECE 310L Electric Circuits Laboratory 1 cr.
A laboratory course that covers passive electronic components; laboratory instruments; voltage-divider circuits; sources and Thevenin's theorem; RC lead-lag networks; series resonance; the transformer; op-amp circuits; single-phase rectifier circuits; LEDs; Zener diode regulator; diode clamping and clipping; BJT and MOSFET characteristics. *Pre- or co-requisite: EECE 310*.

EECE 311 Electronic Circuits 3 cr.
A course on BJT amplifiers; MOSFET amplifiers; differential amplifiers; frequency response of amplifiers; feedback; operational amplifiers; oscillators; digital CMOS circuits; SPICE simulations. *Prerequisite: EECE 310*.

EECE 312 Electronics (for Mechanical Engineering students) 3 cr.
This course introduces the fundamentals of electronics and electronic circuits to non-majors. Its objectives are to provide a concise treatment of the basic concepts of electronic components and to introduce the student to the basic analog and digital electronic circuits. The course covers the fundamentals of semiconductor diodes, transistors, operational amplifiers and their applications, digital circuits and systems, and basic instrumentation. *Prerequisites: EECE 210 and MATH 202*.

EECE 312L Circuits and Electronics Lab 1 cr.
A laboratory course for non-majors that covers passive electronic components, laboratory instruments, voltage-divider circuits, sources and Thevenin's Theorem, diode rectifier circuits, BJT and FET applications, op-amp circuits, filters, digital circuits, and instrumentation. *Pre- or co-requisite EECE 312*.

EECE 320 Digital Systems Design 3 cr.
This course introduces digital systems design concepts. Topics include basic combinational building blocks and design methods to construct synchronous digital systems; alternative representations for digital systems; standard logic (SSI, MSI) vs. programmable logic (PLD, FPGA); finite state machine design; digital computer building blocks as case studies; introduction to computer-aided design software in VHDL. The course also includes a substantial design project. *Prerequisite: EECE 210*.

EECE 321 Computer Organization 3 cr.
This course covers the organization of modern computer systems. In addition to learning how to program computers at the assembly level, students learn how to design the main components of a von Neumann computer system, including its instruction set architecture, datapath, control unit, memory system, input/output interfaces, and system buses. To consolidate the material presented in class, students work on assembly-language programming and datapath design assignments, and a major computer interfacing project. *Prerequisites: EECE 230 and EECE 320*.

EECE 321L Computer Organization Laboratory 1 cr.
A laboratory course with experiments in computer organization and interfacing techniques; digital hardware design using CAD tools and FPGAs; program-controlled and interrupt-driven I/O; memory organization; simple peripheral devices and controllers; bus interfaces; microcontroller-based designs. *Pre- or co-requisite: EECE 321*.

EECE 330 Data Structures and Algorithms 3 cr.
This course covers fundamental algorithms and data structures that are used in software applications today. Particular emphasis is given to algorithms for sorting, searching, and indexing. Data structures such as linked lists, binary trees, heaps, B-Trees, and graphs will also be covered along with their associated algorithms. The course also covers basic algorithmic analysis techniques and seeks to promote student programming skills. *Prerequisite: EECE 230*.

EECE 340 Signals and Systems 3 cr.
This course covers basic concepts and methods related to continuous and discrete-time signals and systems. The course includes: signals and systems and their properties, linear time-invariant systems, stability analysis, sampling of continuous-time signals, z-transform, discrete Fourier transform, time and frequency domain representations of discrete-time signals and systems, and introductory concepts in communications. *Prerequisite: EECE 290*.

EECE 370 Electric Machines and Power Fundamentals 3 cr.
This course covers three-phase circuits and power calculation, magnetic circuits, transformers: single-phase ideal and real transformers, construction, operation, autotransformers, and 3-pbase transformers; fundamentals of AC and DC machines: construction and basic concepts, DC machine: types, characteristics, and performance of series motor; synchronous generators: construction, equivalent circuits, testing and performance characteristics; induction motors construction, principle of operations, tests, power efficiency and torque. *Prerequisite: EECE 210*.

EECE 380 Engineering Electromagnetics 3 cr.
This course covers the fundamentals of applied electromagnetics by emphasizing physical understanding and practical applications in electrical and computer engineering systems. It deals with the study of static electric fields in vacuum and dielectrics, conductors, capacitance, electrostatic energy and forces, Poisson's equation, static magnetic fields, Biot-Savart law, Ampere's law, vector magnetic potential, inductance, Maxwell's equations for time varying fields, Faraday's law, plane wave propagation, time-harmonic fields, propagation in lossless media, and wave reflection and transmission at normal incidence. The bridge between electric circuits and electromagnetics is done through the study of transmission lines and their lumped-element model, transmission line input impedance, and power flow on lossless transmission line. *Prerequisites: EECE 210 and MATH 202*.

EECE 401 Biomedical Engineering Seminar 1 cr.
Biweekly seminars given by members of the Faculty of Engineering and Architecture or by guest speakers. The seminars cover a range of biomedical engineering topics of theoretical and professional interest. Students are required to submit an assignment based on each seminar, which will be graded. The seminar is required of all students taking the Biomedical Engineering Minor. *Prerequisites: EECE 601, or EECE 603, or MECH 633*.

EECE 411 Analog Integrated Circuits 3 cr.
A course on the design of analog integrated circuits with an emphasis on MOS circuits; op-amp design; feedback and stability; applications of analog integrated circuits such as filtering and A/D conversion; comparison with bipolar circuits; extensive use of SPICE for circuit simulation. *Prerequisite: EECE 311*.

EECE 412 Digital Integrated Circuits 3 cr.
This course includes the following topics: 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; and the advanced topics: semiconductor memories, power grid, clocking strategies, datapath building blocks, deep-submicron design issues, and interconnect. *Prerequisites: EECE 310 and EECE 320*.

EECE 413L Electronics Laboratory 1 cr.
A laboratory course that covers electronic circuits used in control, communications, power, and computer interfacing. Experiments include amplifier characterization, PCB manufacturing, sensors and signal processing circuits, communication link, voltage-to-frequency conversion, and a human-computer interface. Students work in teams to complete a design project to build a product by integrating several electronic components. *Prerequisites: EECE 311 and EECE 340*.

EECE 421 Computer Architecture 3 cr.
A laboratory course that covers electronic circuits used in control, communications, power, and computer interfacing. Experiments include amplifier characterization, PCB manufacturing, sensors and signal processing circuits, communication link, voltage-to-frequency conversion, and a human-computer interface. Students work in teams to complete a design project to build a product by integrating several electronic components. *Prerequisites: EECE 311 and EECE 340*.

EECE 430 Software Engineering 3 cr.
A course that teaches students the formal processes employed for carrying out software projects, including the design, development, testing, and deploying of practical software systems. Students are exposed to the realities involved in developing software for clients and the requirements this imposes on quality, timing, and coordination. Students will develop hands-on experience with practical tools used in real-life applications. The course requires the completion of a group-based real-life software project. *Prerequisite: EECE 330*.

EECE 431 Design and Analysis of Algorithms 3 cr.
This course covers techniques for the design and analysis of efficient algorithms. Topics include: sorting algorithms including merge-sort, quick-sort, and counting-sort; median and order statistics algorithms; sorting lower bound; divide-and-conquer design strategy; polynomial and matrix multiplication algorithms; balanced search trees; hash tables; augmenting data structures; number-theoretic algorithms; dynamic programming; greedy algorithms; graph algorithms including graph traversal algorithms and applications, minimum spanning tree, shortest path algorithms; introduction to NP-completeness and intractability; selected topics. *Prerequisite: EECE 330*.

EECE 432 Operating Systems 3 cr.
This course covers the principles of operating systems and systems programming. The topics discussed in class are processes, threads, concurrency and synchronization, scheduling, deadlocks, memory management, file systems, i/o devices, parallel and distributed systems, and security. The course will be accompanied with hands on assignments involving contemporary linux kernels. *Prerequisites: EECE 321 and EECE 330. Students cannot receive credit for both EECE 432 and CMPS 272*.

EECE 433 Database Systems 3 cr.
This course covers the nature and purposes of database systems and an introduction to data modeling: entity relationship model, relational model with relational algebra, relational calculus and SQL, integrity constraints, file organization and index files, and normalization. *Prerequisite: EECE 330. Students cannot receive credit for both EECE 433 and CMPS 277*.

EECE 434 Programming Language Design and Implementation 3 cr.
This course will provide an introduction to the design and implementation of various programming paradigms, namely object-oriented (Java, C++ and C#), functional (Haskell), and logic (Prolog). Compiler construction will be covered, in addition to topics such as, virtual machines, intermediate languages, and concurrency. *Prerequisite: EECE 330. Students cannot receive credit for both EECE 434 and CMPS 258, or for both EECE 434 and CMPS 274*.

EECE 442 Communication Systems 3 cr.
This course introduces the students to the transmission and reception of analog signals; performance of analog communication systems in the presence of noise; analog to digital conversion and pulse coded modulation; transmission and reception of digital signals; performance of digital communication systems in the presence of noise and inter-symbol interference. *Prerequisites: EECE 340 and STAT 230*.

EECE 442L Communications Laboratory 1 cr.
A laboratory course with experiments covering the following topics: AM and FM modulation/demodulation, sampling and quantization, digital modulation (PSK, FSK, MSK, GMSK), digital demodulation, and inter-symbol interference. *Prerequisite: EECE 442*.

EECE 450 Computer Networks 3 cr.
A course that outlines data communications; wide area networks; circuit and packet switching; routing; congestion control; local area networks; communications architecture and protocols; internetworking. *Prerequisites: EECE 330 and STAT 230*.

EECE 451L 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 450*.

EECE 460 Control Systems 3 cr.
This course seeks to impart in students a sound understanding of fundamental principles in control engineering, based on analog technologies. The course includes: mathematical modeling of linear continuous time invariant single input, single output dynamical systems; transfer functions and state space models, performance specifications, analysis and design of closed loop analog control systems. *Prerequisite: EECE 340*.

EECE 460L Control Systems Laboratory 1 cr.
This course involves students in the practical implementation of the concepts acquired in EECE 460 by analyzing different types of dynamical systems, designing and understanding controllers suitable to specific models, simulating system responses, and experimentally verifying the effectiveness of various control schemes. *Pre- or co-requisite: EECE 460*.

EECE 461 Instrumentation 3 cr.
A design course for complete instrumentation systems, including measurements, sensors, data acquisition, and component integration. Application areas and course projects include industrial control, laboratory measurements, automation systems, and the like. This course is completed with a set of laboratory experiments. *Prerequisite: EECE 460*.

EECE 470L Electric Machines Laboratory 1 cr.
Transformers: open circuit, short circuit, and load test; unbalanced loading and parallel operation of transformers; speed control and load characteristics of shunt, series and compound DC machines; induction machines: blocked rotor, no-load, and loading tests; operation of single-phase induction motors; operation of a synchronous machine connected to a large external source. *Prerequisite: EECE 370*.

EECE 471 Fundamentals of Power Systems Analysis 3 cr.
This course covers the basic concepts of three-phase systems, generation modeling review, and generation capability curve; transformers, autotransformers, three-winding transformers, and regulating transformers. calculation of transmission line parameters, evaluation of steady state operation of transmission lines, reactive power compensation, line capability, power flow analysis using Gauss-Seidel and Newton-Raphson methods, economic load dispatch with generation limits and line losses, symmetrical fault analysis, symmetrical components and unsymmetrical fault analysis. *Prerequisite: EECE 370*.

EECE 471L Power Systems Laboratory 1 cr.
This lab course includes nine experiments to study various aspects of power systems: measurement of the characteristics data of a transmission line and an assessment of its voltage drop and losses; synchronization and steady state operation of a generator connected to an infinite bus system; load characteristics of a synchronous motor and effect of field excitation on reactive power load; effect of voltage levels on power transmission and effects of various load types on power plants; load flow data preparation and system study; system analysis of symmetrical and unsymmetrical faults; Transient stability data preparation and system study. *Prerequisite: EECE 471*.

EECE 473 Power Electronics 3 cr.
This lab course includes an overview of power electronics devices used and their desired characteristics; diode circuits and rectifiers, effect of source inductance, three-phase rectifiers; dc-dc switched mode converters, buck, boost, and buck-boost circuits, bridge converter; pulse-width modulated inverters, voltage control, harmonics, three-phase inverters; introduction to gate and base drive circuits, snubber circuits. *Prerequisites: EECE 210 and EECE 310, and MATH 218 or 219*.

EECE 473L Power Electronics and Drives Laboratory 1 cr.
This lab course includes experiments to study the following: induction motor torque-speed curve and starting characteristic, induction motor speed control through a 4-quandrant drive, single phase capacitor-start induction motor, ac to dc converter, dc to dc converters; buck, boost, and buck-boost regulators, dc to ac inversion, ac to ac converter. *Prerequisite: EECE 473*.

EECE 474 Electric Drives 3 cr.
A course that covers steady-state analysis of dc and poly-phase induction motors, starting, and control; AC drives: solid-state control, dc link in adjustable speed drives, voltage and frequency controls, braking and plugging; DC drives: rectifier and chopper drives, dynamic and regenerative braking, plugging; stepper motors: types, operational characteristics, control algorithms, power drive configurations; and special-purpose motors. *Prerequisite: EECE 370*.

EECE 475 Industrial Electrification 3 cr.
A course that outlines medium and low voltage installations; lighting, practical applications of electric machines; motor control centers; emergency power supplies; and auxiliary systems. *Prerequisite: EECE 370.*

EECE 476 Power System Protection and Switchgear 3 cr.
A course that covers current and voltage transformer theories, construction, and applications, electro-mechanical relay, solid state relay, and numeric relay; analogue to digital converter (ADC), digital to analogue converter (DAC), memories, protection systems for electric machines, transformers, bus bars, overhead and underground transmission lines; over-voltage protection system; and a brief introduction to data transmission. *Prerequisite: EECE 370*.

EECE 499 Undergraduate Research 3 cr.
This course requires participation, under supervision of a faculty member, in a research project. Before registering, the student must create a proposal regarding the nature of the research, the specific goals of the research, and the desired final report outcome; this proposal must be submitted to and approved by the supervising faculty member and the department before registering. *Prerequisites: Completion of 65 required credits in the major, and a cumulative average of 85.0 or above*.

EECE 500 Approved Experience 1 b.
This is an eight-week professional training course in electrical and computer engineering.

EECE 501 Final Year Project 3 cr.
A supervised project in groups of normally 3 students aimed at providing practical experience in some aspects of computer, communications and electrical engineering. Students are expected to define the project, state its objectives, complete a literature survey, set project specifications and select a design method. They are also expected to do some preliminary modeling and analysis and to acquire the necessary material needed for the completion of the project in the spring term. A professional report and an oral presentation are also required from the students.

EECE 502 Final Year Project 3 cr.
This is a continuation of EECE 501. Students are asked to deliver a product that has passed through the design, analysis, testing and evaluation stages. The course also requires the production of a professional report that includes a description of the design process, implementation and testing, verification and validation and a critical appraisal of the project. An oral presentation and a poster are also within the project deliverables. *Prerequisite: EECE 501*.

EECE 503 Special Topics in ECE 3 cr.

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 EECE 210 and BIOL 202 for students doing a minor in biomedical engineering*.

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 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: BIOL 210 and STAT 230, 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 or graduate 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*.

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.
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*.

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*.

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. *Prerequisite: Senior or graduate standing*.

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*.

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 or graduate standing*.

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*.

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.
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*.

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: Junior standing.*

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 instructor.*

EECE 634 Optimizing Compilers 3 cr.
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.
This course 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 636 Analysis and Verification of Software 3 cr.
This course introduces the basics needed to understand automation techniques for the analysis and verification of computing systems including logics behind programming languages. We will present tools for automated analysis that improve the reliability and correctness of software that reflect state of the art design and validation techniques that are changing the way software is designed and implemented today. The students will have the chance to practice and possibly advance these techniques in small projects. *Prerequisites: EECE 330 and senior standing*.

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*.

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 Techniques and Applications in 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*.

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*.

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.
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. *Prerequisite: EECE 442*.

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 or graduate standing*.

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*.

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*.

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 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 or graduate standing*.

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 or graduate standing*.

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.
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 450*.

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 or graduate standing*.

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 450*.

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*.

EECE 655 Internet Security 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. Student projects will be composed of implementation, simulation and research components. *Prerequisites: EECE 450 and EECE 632*.

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. *Prerequisite: EECE 450*.

EECE 657 Wireless Security 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. *Prerequisites: EECE 450 and EECE 632*.

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 or graduate standing*.

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*.

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 or graduate standing*.

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: EECE 460*.

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 or graduate standing*.

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 machine learning to construct high performance information processing systems that learn from experience. The course discusses main and modern concepts for model selection and parameter estimation in recognition, decision making and statistical learning problems. Special emphasis will be given to regression, classification, regularization, feature selection and density estimation in supervised modes of learning. Students will be assigned typical machine learning problems to investigate as projects. *Prerequisite: Senior or graduate standing*.

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 or graduate standing*.

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. *Prerequisite: Senior or graduate standing*.

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 or graduate standing*.

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 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 or graduate standing*.

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. *Prerequisite: Senior or graduate standing*.

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*.

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*.

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*.

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. *Prerequisite: EECE 380*.

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*.

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 or graduate standing*.

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), and senior or graduate standing*.

EECE 693 Neural Networks 3 cr.
The course provides a comprehensive foundation to artificial neural networks and machine leaning 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 or graduate standing*.

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 or graduate standing*.

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 or graduate standing*.