DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

- Undergraduate Courses
- Postgraduate Courses

Undergraduate Courses:

ELEC 001 Electronic and Information Technology [2-1-0:3]
This course provides exposure to the basics of electronic and information technology to non-engineering students. Contents include AM and FM radio broadcasting; telephone and wireless communication systems; coding and signal processing for multimedia technology; displays and VLSI technology.

ELEC 002 Academic and Professional Development I [0 credit]
A compulsory, one year course for Electronic Engineering and EE (Information and Communication Engineering) students only. This course is designed to provide academic advising to students and/or to develop students' communication skills in interacting with the technical and non-technical audiences in their professional careers. Graded P or F.

ELEC 003 Academic and Professional Development II [0 credit]
Continuation of ELEC 002. Graded P or F.

ELEC 010 Academic and Professional Development I [0 credit]
A compulsory, one year course for Computer Engineering students only. This course is intended to offer advice to students on academic and professional matters, and to improve the students' communication skills. This will be achieved through: (1) Small student group meetings with an assigned advisor; (2) Professional and academic seminars, and (3) Social activities. Graded P or F.

ELEC 020 Academic and Professional Development II [0 credit]
Continuation of ELEC 010. This is a compulsory, one year course for Computer Engineering students only. Graded P or F.

ELEC 030 Academic and Professional Development III [0 credit]
Continuation of ELEC 020. This is a compulsory, one year course for Computer Engineering students only. Graded P or F.

ELEC 095 Research Work Experience [0 credit]
Each undergraduate student enrolled in the Honors Research Option of the BEng program in Electronic Engineering is required to have R&D work experience in a company or research lab. The job and the nature of work has to be approved by the department for fulfilling this course requirement. Graded P or F.

ELEC 098 Industrial Training [0 credit]
For Computer Engineering and EE (Information and Communication Engineering) students only. A practical training course for a total duration of about six to seven weeks covering basic electronic practices, testing and maintenance, UNIX system and network administration, Windows server implementation and administration, software engineering practice, and safety. Graded P or F.

ELEC 099 Industrial Training [0 credit]
For Electronic Engineering students only. A practical training course for a total duration of about seven weeks covering basic electronic practice, basic electrical engineering practice, engineering system appreciation, UNIX system and network administration, software engineering practice, CAD, drawing, and safety. Graded P or F.

ELEC 101 Basic Electronics [3-1-3:4]
Covers basic electronic concepts, DC and AC electric circuits, basic analogue electronics: theories and applications of semiconductor diodes, transistors and operational amplifiers, and basic digital electronics. *Exclusion*: ELEC 102 *Prerequisite*: AL Pure Mathematics/AL Applied Mathematics/AS Applied Mathematics/AS Mathematics and Statistics, or MATH 001 as co-requisite.
References: J.D. Irwin and D.V. Kerns, *Introduction to Electrical Engineering*, 1995
R.J. Smith, *Circuits, Devices and Systems*, Fifth Edition, 1992

ELEC 102 Electronic Circuits I [3-1-3:5]
Fundamental concepts, Ohm's law, passive and active components, KVL and KCL, Thevenin and Norton Theroems, linearity and superposition, nodal analysis, transient analysis, sinusoidal steady state and phasor, transfer functions, op-amps, diodes, MOS transistors and related circuits. *Exclusion*: ELEC 101 *Prerequisites*: AL Pure Mathematics; and one of AL/AS Physics, AL Engineering Science or AL Computer Studies
Reference: J.D. Irwin and D.V. Kerns, *Introduction to Electrical Engineering*, 1995

ELEC 151 Digital Circuits and Systems [3-1-2:4]
Design of combinatorial and sequential logic circuits; introduction to logic families (TTL and CMOS); programmable logic devices; special digital systems. Laboratory assignments make extensive use of computer-aided design (CAD) tools for design, simulation and testing.
Reference: Randy Katz, *Contemporary Logic Design*

ELEC 152 Computer Organization [3-0-1:3]
This is an introductory course to computer organization. The topics covered include instruction-set-design, digital design and computer arithemtic, controller and datapath design, memory systems, input-output systems, interrupts, pipelining, performance analysis, assembly language programming, and survey of advanced architectures. *Exclusion*: COMP 180 *Pre-/Co-requisite*: ELEC 151

References: D. Patterson, J. Hennessy, *Computer Organization and Design: The Hardware/Software Interface*, 1994
B.B. Brey, *The Intel Microporcessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, and Pentium Pro Processor: Architecture, Programming, and Interfacing*

ELEC 190 Introduction to Electronic and Computer Technology [2-0-0:1]
For Engineering and Computer Engineering students. Topics of current interest presented by faculty and guest speakers. Selected from various fields of Electronic and Computer Engineering to provide a broad exposure. Graded P or F.

ELEC 202 Electronic Circuits II [3-1-3:5]
Bipolar and MOS transistor basics: Modes of operation, large-and small-signal analyses; Analogue circuits: Single-transistor amplifiers, differential pairs and multi-transistor amplifiers; CMOS digital circuits: Performance analysis of CMOS inverter, NAND gate, NOR gate; Applications: A/D and D/A converters, comparators, oscillator circuits. *Prerequisite*: ELEC 101 or ELEC 102
Reference: A.S. Sedra and K.C. Smith, *Microelectronic Circuits,* Fourth Edition, 1997

ELEC 210 Probability and Random Processes in Engineering [3-1-0:4]
An introduction to statistical inference and random processes in electrical engineering, including the necessary probabilistic background. Random variables, distribution and density functions, characteristic functions, conditional statistics, expectation, moments, stochastic processes. *Exclusion*: MATH 246 *Prerequisite*: MATH 001 or AL Pure Mathematics
Reference: Leon-Garcia, *Probability and Random Processes for Electrical Engineering,* Second Edition, 1993

ELEC 211 Signals and Systems [3-1-0:4]
This is an introductory course for signal and system analysis. The course covers signal analysis tools such as Fourier series, Fourier transform, Laplace transform and z-transform; interactions between signals and linear time invariant (LTI) systems; sampling theorem; differential and difference equations. MATLAB CAD tools are introduced as an integral part of this course. *Prerequisites*: MATH 150 /151/152, and ELEC 101/102
Reference: Alan V. Oppenheim, Alan S. Wilsky and S.H. Nawab, *Signals and Systems,* Second Edition

ELEC 212 Digital Signal Processing [2-1-2:4]
Discrete-time signal and systems; discrete Fourier transform and related discrete time orthogonal transform, and related fast algorithm; IIR and FIR filter design techniques, and realizations; multirate digital signal processing; response of linear systems to random processes. Laboratory experiments are designed so that the students can apply theory learnt in the class to physical problems. MATLAB CAD tools are being used as an integral part of this course. *Prerequisite*: ELEC 211

ELEC 214 Communication Systems [3-1-3:5]
This course provides a broad treatment of communication theory, beginning with communication networks, physical noise characteristics, probability theory and random signals, and noiseless modulation theory, proceeding through a treatment of the effects of noise in communication systems, and ending with an introductory treatment of digital communications, source coding and reliable communication in the presence of noise. *Prerequisite*: ELEC 211
Reference: R.E. Zeimer and W.H. Tranter, *Principles of Communications: Systems; Modulation, and Noise,* Fourth Edition, 1995

ELEC 221 Semiconductor Materials and Devices [3-1-1:3]
This is an introductory course for semiconductor materials and devices. The course content includes the following topics: the growth and properties of semiconductor crystals; the theory of the electronic structures of atoms and solids; the energy band and conduction mechanisms in semiconductors; the physics of junction diodes; excess carriers; bipolar junction transistors (BJT); metal oxide semiconductor field-effect transistors (MOSFET). *Prerequisite*: ELEC 102
Reference: Streetman, *Solid State Electronic Devices*, Fourth Edition

ELEC 241 Electromagnetism [3-1-0:4]
Electromagnetic wave concepts. Gauss's, Faraday's and Ampere's laws; electrostatics; Maxwell's equations; plane waves in dielectric and lossy media; transmission lines; radiation and antenna fundamentals. *Prerequisite*: MATH 150
References: Matthew N. O. Sadiku, *Elements of Electromagnetics*, 3rd Edition
N. N. Rao, *Elements of Engineering Electromagnetics*, 5th Edition

ELEC 254 Microprocessor Experiments [1-1-3:3]
This course covers the integration of software and hardware in Intel x86 family microprocessor and 8051 microcontroller based systems. The tasks of the course will be mainly to complete some laboratory experiments which address different aspects of software/hardware input/output interfacing, and a class project which should result in the design, implementation and test of a significant microprocessor-controlled device. *Prerequisites*: COMP 180/ELEC 152, and ELEC 151

ELEC 271 Automatic Control Systems [3-0-1:3]
This is an introductory course on the modeling, analysis, and design of single-input-single-output feedback control systems. The emphasis is on the design of controllers for linear time-invariant systems using combined classical and modern methods, such

as roots locus method, frequency response method, optimal control and robust control. MATLAB CAD tools are introduced as an integral part of this course. Laboratory experiments are designed so that the students can apply theory learnt in the class to the control of real physical systems. *Exclusions*: CENG 302, MECH 261 *Prerequisite*: ELEC 101 or ELEC 102

ELEC 300 Special Topics [1-4 credit(s)]
Selected topics in Electrical and Electronic Engineering. May be repeated for credit, if different topics taken.

ELEC 301 CMOS VLSI Design [2-0-3:3]
CMOS process and design rules; MOS device electronics; CMOS circuit and logic circuit characterization and performance estimation; VLSI design and verification tools. Laboratory work will be centered on industry standard tools. *Prerequisite*: ELEC 151

ELEC 303 ASIC Design with Field Programmable Gate Arrays [2-0-3:3]
This course introduces both design and testing of Application Specific Integrated Circuit (ASIC) with Field Programmable Gate Array (FPGA). Major topics include ASIC technology, FPGA design, placement and routing, design for testability and VLSI testing. Students will go through a complete ASIC design cycle, from specification, design, implementation to testing in this course. *Prerequisite*: ELEC 151

ELEC 304 Analogue Integrated Circuits Design and Analysis [3-1-0:4]
Multiple-stage operational amplifiers, frequency response, feedback analysis, stability and compensation, Slew rate, advanced amplifier design techniques, analog VLSI building blocks. *Prerequisites*: ELEC 202 and ELEC 221
Reference: P. Gray, P. J. Hurst, S. H. Lewis and R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 2001

ELEC 308 Physical Optics [3-1-0:3]
An introductory course in optics covering the basic concepts and principles of light. Topics include: electromagnetic theory, wave theory, geometrical optics, dispersion, polarized light, interference, diffraction, coherence, and birefringence. Special topics in modern optical devices and systems. *Exclusion*: PHYS 241
Reference: Hecht, *Optics*, Second Edition

ELEC 314 Digital Communications [3-1-0:3]
Representation of signals, optimum detection of signals in noise, matched filtering, error probability calculations for digital modulation. Multilevel modulation schemes, comparison of digital communications systems, signaling through band-limited channels, equalization, mobile and wireless channels, spread-spectrum communications, CDMA for cellular mobile and wireless communications. *Prerequisite*: ELEC 214
Reference: R. E. Ziemer and R. L. Peterson, *Introduction to Digital Communication*, 2nd Edition, 2001

ELEC 315 Computer Communication Networks [3-1-0:3]
Overview of computer networks: network architecture and switching techniques. Introduction to the Internet, network programming, and layer architecture. Application layer: HTTP, FTP, SMTP, and CDN. Transport layer: TCP and UDP. Network layer: IP routing, NAT, and DHCP. Data link layer and local area networks: MAC protocols, Ethernet, and hubs/bridges/switches. *Exclusion*: COMP 361
References: W. Richard Stevens, *UNIX Network Programming*, 1998
Andrew S. Tanenbaum, *Computer Networks*, 4th Edition, 2003

ELEC 317 Digital Image Processing [3-0-0:3]
This course provides an introduction to basic concepts and methodologies for digital image processing and develops the foundation for further study in this diverse and rapidly evolving field. The topics covered range from visual perception and image formation/geometry through image enhancement and restoration to image encoding, segmentation, description, recognition, and interpretation. The course will be complemented by several (mini) projects. *Prerequisite*: ELEC 211
Reference: R.C. Gonalez and R.E. Woods, *Digital Image Processing*, 1993

ELEC 321 Integrated Circuit Devices [3-1-0:3]
This course is intended to provide an understanding on the device operation principles in common electronic products such as integrated circuit, camcorder, solar cell, memory elements, smartcard, etc. Emphasis are on design and applications instead of fundamental physics. Topics covered include PN junctions, BJT, MOSFET, JFET, MESFET, FLASH EPROM and the future technology trend in the electronic industry. *Prerequisites*: ELEC 202 and ELEC 221

ELEC 331 Speech and Image Compression [3-0-0:3]
This course begins with an overview of some fundamental information theory related to data compression. Lossless techniques, including Huffman/arithmetic coding, LZ coding, and their applications; and lossy techniques, including quantization (both scalar and vector), transform coding, predictive coding and their applications will be discussed. Several international standards (such as GIF, and JPEG for image coding, and LPC vocoder and its variants) will be discussed. Programming exercises on various image and speech codes will be an integral part of this course. *Prerequisite*: ELEC 211

ELEC 332 Information Theory and Error-Correcting Codes [3-0-0:3]
Communication and information theory; self and mutual information measures; channel models and capacity; source coding; hamming codes; cyclic codes; BCH and Reed-Solomon codes; convolutional codes and the Viterbi algorithm; burst error correction; Turbo coding. *Prerequisite*: ELEC 214

ELEC 333 Introduction to Digital Speech Recognition [3-0-0:3]
This is a UG final year introductory course to digital speech processing. The focus will be on speech recognition techniques. Topics to be covered include general paradigm for speech recognition, approaches to speech recognition, signal processing and analysis methods for speech recognition, pattern recognition techniques, speech recognition system design and implementation issues, hidden Markov Model, connected word and continuous speech recognition issues including training and language modeling. *Prerequisite*: ELEC 211

ELEC 341 Introduction to Intelligent Systems [3-0-0:3]
Introduction to the fundamental concepts of fuzzy systems and neural networks. Fuzzy sets, t-norms and s-norms, fuzzy relations, approximate reasoning, structure analysis of fuzzy systems, construction of fuzzy systems from data, applications of fuzzy systems to control, signal processing, and communication problems. Structures of neural networks, Hopfield neural nets with applications, competitive learning networks, perception and back-propagation learning algorithm. *Prerequisite*: ELEC 211

ELEC 342 Optoelectronics and Optical Fiber Communications [3-0-3:4]
To introduce optoelectronics and fiber optics for communications. Topics include optical fibers, optical sources, optical detectors, and passive components for wavelength-division multiplexing. Laboratory gives hands-on experience in handling optical fibers, lasers and detectors, micro-optical components, opto-mechanical equipment, and building wavelength-division-multiplexed optical links. *Exclusion*: PHYS 242 *Prerequisites*: ELEC 241 and ELEC 221
Reference: Djafar K. Mynbaev, Lowell L. Scheiner, *Fiber-Optic Communications Technology*

ELEC 343 Wireless Communication Engineering [3-0-0:3]
Introduction to issues and solutions in wireless communications; path loss, shadowing, and multi-path fading effects of the mobile radio propagation channel; cell planning and various capacity improvement techniques; time, frequency and antenna diversity; high level description of various practical systems including GSM, CDMA and WLAN. *Prerequisite*: ELEC 214

ELEC 344 Microwave Engineering [3-0-3:4]
Techniques of radio-frequency/microwave circuit technology. S-parameter design of passive components; computer-aided analysis and design of microwave circuits. Component structures such as microstrip lines, waveguides, power divider and directional combiner, resonators and filters. *Prerequisite*: ELEC 241

ELEC 351 Introduction to Power Electronics [3-0-0:3]
Magnetic components, power devices, diodes and rectifier circuits, voltage references, linear regulators, switch mode power converters, power factor and correction, integrated circuit techniques for controller design. *Prerequisite*: ELEC 102
Reference: D. W. Hart, *Introduction to Power Electronics, Prentice Hall,* 1997

ELEC 360 Digital Media and Multimedia Applications [3-1-2:4]
This course provides students with a background in digital media, multimedia applications development, and multimedia systems. Topics include digital media fundamentals, authoring, and multimedia systems design issues. Weekly laboratory and programming assignments introduce students to media editing tools and programming issues. A final project challenges students to apply what they learn. Enrollment in the course requires approval of the course instructor. *Exclusion*: COMP 343 *Prerequisite*: COMP 103 or COMP 104/104H

ELEC 374 Introduction to Robotics [3-0-1:3]
Introduction to the fundamental concepts of robotics. Rigid body motion, forward and inverse kinematics of open-chain manipulators, force relations, dynamics and position control robot manipulators. Force control and trajectory generation. Collision-avoidance and motion planning. Second or third year standing required. *Exclusions*: ELEC 564, MECH 371
Reference: J.Craig, *Introduction to Robotics: Mechanics and Control*

ELEC 377 Digital Control Systems [3-0-0:3]
Digital computers for design and implementation of feedback control systems. State-space models, sampling, z-transform, stability, controllability and observability, design of digital control systems using state-space methods, digital PID controllers and tuning. *Prerequisite*: ELEC 211 or ELEC 271

ELEC 383 Introduction to Biosensors and Bioinstrumentation [3-0-2:3]
This course builds on the fundamental knowledge of biosensors and bioinstrumentation. Lectures and hands-on laboratory experiments cover: (1) Basic concepts of biomedical signal analysis; (2) Measurements of bioelectrical, biomechanical and biochemical signals for medical diagnosis and clinical monitoring; (3) Principles of biosensors and biochips; (4) Simple design of new bioinstrumentation and biosensor to solve biomedical problems. *Prerequisite*: ELEC 101 or ELEC 102
Reference: J. W. Webster, *Medical Instrumentation*

ELEC 384 Medical Imaging [3-0-0:3]
Basic physics and hardware of medical imaging; Clinical applications of medical imaging; X-ray projection imaging; Computed tomography; Magnetic resonance imaging; Radioisotope imaging; Diagnostic ultrasound; Image processing and analysis. *Exclusion*: ELEC 381 (prior to 2000-01) *Prerequisite*: ELEC 211
Reference: Steve Webb (Ed.), *The Physics of Medical Imaging*

ELEC 387 Computer Engineering Final Year Thesis I [0-0-6:2]
Only for students taking the Honors Research Option of the BEng Computer Engineering program. Students must take the whole course series comprising ELEC 387, ELEC 388 and ELEC 389 in sequence. They will conduct research work under the supervision of a faculty member and summarize their work in an individual thesis at the end of the sequence. In addition to the written thesis, students will also be examined by the thesis examination committee in an oral thesis presentation. Work on ELEC 387 normally commences in the summer following the second year. May be graded PP.

ELEC 388 Computer Engineering Final Year Thesis II [0-0-9:3]
Continuation of ELEC 387. May be graded PP. *Prerequisite*: ELEC 387

ELEC 389 Computer Engineering Final Year Thesis III [0-0-9:3]
Continuation of ELEC 388. *Prerequisite*: ELEC 388

ELEC 391 Final Year Thesis I [0-0-6:1]
Each undergraduate student taking the Honors Research Option of the Electronic Engineering program is required to take ELEC 391, ELEC 392 and ELEC 393 in sequence. The student is expected to complete an individual thesis after taking the sequence and the thesis should summarize his work conducted under the supervision of a faculty member. Work normally commences in the summer following the second year. May be graded PP.

ELEC 392 Final Year Thesis II [0-0-9:4]
Continuation of ELEC 391. May be graded PP. *Prerequisite*: ELEC 391

ELEC 393 Final Year Thesis III [0-0-12:4]
Continuation of ELEC 392. *Prerequisite*: ELEC 392

ELEC 394 Computer Engineering Project I [0-0-6:2]
[Also COMP 394] Each Computer Engineering student is required to take COMP/ELEC 394, 395 and 396. The project is conducted under the supervision of a Computer Science and/or Electrical and Electronic Engineering faculty member. May be graded PP.

ELEC 395 Computer Engineering Project II [0-0-9:3]
[Also COMP 395] Continuation of ELEC 394. May be graded PP. *Prerequisite*: ELEC 394

ELEC 396 Computer Engineering Project III [0-0-9:3]
[Also COMP 396] Continuation of ELEC 395. *Prerequisite*: ELEC 395

ELEC 397 Final Year Project I [0-0-6:1]
Each undergraduate student is required to take ELEC 397, ELEC 398 and ELEC 399 in sequence. The project is conducted under the supervision of a faculty member. Work normally commences in the summer following the second year. May be graded PP.

ELEC 398 Final Year Project II [0-0-9:4]
Continuation of ELEC 397. May be graded PP. *Prerequisite*: ELEC 397

ELEC 399 Final Year Project III [0-0-12:4]
Continuation of ELEC 398. *Prerequisite*: ELEC 398

Postgraduate Courses:

ELEC 504 Advanced Analog IC Analysis and Design [3-0-0:3]
Noise analysis; Advanced op-amp design techniques; Analog VLSI building blocks: multipliers, oscillators, mixers, phase-locked loops, A/D and D/A converters; Passive filter design; Frequency scaling; Active filter design. *Background*: ELEC 221 and ELEC 304 *Exclusion*: EESM 504

ELEC 505 Advanced CMOS Devices [3-0-0:3]
Principles and characteristics of semiconductor devices found in State-of-the-Art ICs. Emphasis is on deep-submicron MOS device design, characterization and modeling. Important issues such as short channel effects, high-field behavior, hot carrier effects, reliability and device scaling for present and future technology will be covered. *Exclusion*: EESM 505 *Prerequisite*: ELEC 321

ELEC 507 Microelectronics Fabrication Technology [3-0-0:3]
Process technologies in IC fabrication: epitaxial growth; chemical-vapor and physical-vapor deposition of films; thermal oxidation; diffusion; ion implantation; microlithography; wet/dry etching processes; process integration of MOS and bipolar technologies. *Exclusions*: CENG 582, EESM 507

ELEC 508 Integrated-Circuit Fabrication Laboratory [2-0-6:4]
Laboratory course requiring hands-on work in fabricating MOS transistors. Process modules including photolithography, dry etching, wet etching, metal sputtering, oxidation, diffusion and low-pressure chemical-vapor deposition will be covered. Student will also learn to characterize the fabricated devices. *Background*: ELEC 321 or equivalent

ELEC 509 Advanced Photonics Technologies [3-0-0:3]
A brief review of modern optics theories, Fourier optics based devices and systems, fundamentals of laser physics, optoelectronics, nonlinear optics and laser spectroscopy.

ELEC 516 Digital VLSI System Design and Design Automation [3-0-0:3]
Structured design styles; specification, synthesis and simulation using Hardware Descriptive Language (HDL); Structural chip design and system design; Circuit design of system building blocks: arithmetic unit, memory systems; clocking and performance issues in system design; Design-Automation tools and their applications. *Background*: ELEC 151 *Exclusion*: EESM 516 *Prerequisite*: ELEC 301

ELEC 518 RF/Microwave Circuit Design and Measurement [3-0-3:4]
Introduction to techniques for analyzing, engineering and testing of circuits for RF/microwave frequencies using CAD tools. The lab provides hands-on CAD/simulation, building and testing of low-noise amplifier, mixer, VCO, filter, IF AGC, detectors and other circuits discussed in lecture. *Background*: ELEC 202, ELEC 214, ELEC 241 and ELEC 304

ELEC 519 Solid State and Semiconductor Electronics [3-0-0:3]
[Previous Course Code: ELEC 691A] Crystal Lattices; lattice vibration and thermal properties of crystals; free-electron theory; electrons in periodic lattices; carrier transport; metal semiconductor contacts and semiconductor surfaces; optical processes. *Background*: ELEC 221 *Exclusion*: ELEC 515 (prior to 1998-99)

ELEC 520 Liquid Crystal Devices: Physics and Applications [3-0-0:3]
[Previous Course Code: ELEC 691G] Liquid crystals: basic physical properties. LC materials and their physical-chemical characterization. Electro-optical Effects in Liquid Crystal Materials: dependence on LC symmetry and parameters, LC cell configuration and driving conditions. Liquid Crystal Displays: comparison with other display types, passive and active-matrix addressed LCDs, projection displays, LCD components, advances in LCD technology. Non-display applications of LCs.

ELEC 525 Flat-Panel Displays [3-0-0:3]
Discussions on various flat-panel display technologies including plasma display panels, electroluminescence, field emission and liquid-crystal displays. Optics and electronics of display devices. *Exclusion*: EESM 525

ELEC 528 High Frequency Circuit Design [3-0-0:3]
High frequency circuit design for wireless applications. S-parameters, front-end amp, VCO, PLL, power amplifier, and integration issues will be covered. *Background*: ELEC 202, ELEC 214, ELEC 343 and ELEC 344

ELEC 529 Wavelets [3-0-0:3]
Multirate signal processing. Multirate Filter Banks and the construction of discrete wavelets. Various design issues of discrete wavelets. Applications of discrete wavelets. *Background*: ELEC 212

ELEC 530 Stochastic Processes [3-0-0:3]
Borel/sigma fields. Sequences of random variables and convergence. Spectral factorization. Karhunen-Loeve Expansion. Stationarity, ergodicity and spectral estimation. Mean square estimation and Kalman filtering. Entropy. System identification. *Background*: ELEC 210 or MATH 246

ELEC 531 Topics In Digital Signal Processing [3-0-0:3]
Selected topics in the fundamentals of digital signal processing such as: multidimensional digital signal processing, parametric estimation of signals, multirate digital signal processing, wavelet-based digital signal processing, adaptive digital signal processing, linear and nonlinear filter theory. *Exclusion*: EESM 531

ELEC 532 Digital Image Processing [3-0-0:3]
Two-dimensional signals and systems; image perception; image sampling and transforms; image enhancement and restoration; linear and nonlinear image filtering; image representation and recognition; image compression; computer vision. *Background*: ELEC 211 *Exclusion*: COMP 520 Note: This course is usually cross-listed with COMP.

ELEC 533 Video-Signal Processing [3-0-0:3]
Characteristics of video signals; compression techniques; differential pulse-code modulation; predictive coding; transform coding; motion-estimation techniques; vector quantization; subband coding; pyramid coding; entropy coding; coding standards; real-time video signal processing; system examples and applications. *Background*: ELEC 317

ELEC 534 Advanced Digital Speech Processing [3-0-0:3]
Vocal tract modeling, speech modeling, language phonetics, time-frequency representation of speech, spectrogram, filtering, linear predictive analysis, cepstral analysis, speech measures, speech waveform coding, vocoders, speech recognition, dynamic time warping, hidden Markov Model, language modeling. *Background*: ELEC 211 *Prerequisite*: ELEC 333

ELEC 536 Digital Communications [3-0-0:3]
This course provides a comprehensive coverage of digital communication theory and design. Emphasis placed on system goals and trade-offs. Review of signals and systems, probability and stochastic processes; optimal detection of signals in noise; basic information theory concepts; coding; basic and advanced digital modulation schemes; signaling through band-limited and wireless channels; spread-spectrum communications. *Background*: Probability theory *Exclusion*: EESM 536

ELEC 537 Communication Networks [3-0-0:3]
The first half of the course covers the fundamentals of queuing theory: Poisson processes, M/M/1 queues, state-dependent queues, M/G/1 queues and mean-value analysis. The second half of the course focuses on the applications of queuing theory to performance evaluation of computer networks and switching systems. *Background*: probability theory

ELEC 538 Broadband Networks and Switching Systems [3-0-0:3]
This course covers the design principles on which the broadband networks and switching systems are based. Various multi-rate circuit switching and ATM cell-based packet switching systems are studied. *Background*: ELEC 315

ELEC 539 Broadband Communication Networks [3-0-0:3]
Systems and protocols for high-speed communication networks; from ATM to new IP protocols; optical and DWDM networks; broadband access technologies; traffic modeling and performance analysis. *Background*: ELEC 537 *Exclusion*: EESM 539

ELEC 541 Adaptive Fuzzy-Logic Control [3-0-0:3]
Crisp and fuzzy set theory, fuzzy logic, fuzzy graphs, calculi of fuzzy graphs, fuzzy measure theory, fuzzy integral, fuzzy c-mean, fuzzy-logic control, applications, adaptive fuzzy logic, learning rules, neuronal implementations, current research issues.

ELEC 546 Wireless Communication Systems [3-0-0:3]
Overview of cellular structure and frequency reuse; mobile radio propagation and path loss models; statistical nature of radio channels; coding and time or frequency diversity; spread spectrum CDMA techniques and 3G Systems; OFDM and wireless LAN standards; fast frequency hopping technology and Bluetooth. *Background*: ELEC 343 or equivalent *Exclusion*: EESM 546

ELEC 548 Coding and Information Theory [3-0-0:3]
Properties of information measures. Source coding theorem. Lossless data compression. Channel coding theorem. Block and convolutional codes. Trellis decoding. Concatenated codes. Iterative decoding. Rate-distortion theorem. Quantization and lossy data compression. *Background*: ELEC 332

ELEC 550 Computer-Aided Design of Digital Systems [3-0-0:3]
Basic computer algorithms and optimization methods; Algorithms for physical design of digital circuits; System, behavioral and logic-level synthesis of digital systems; Timing and power analysis algorithms; Simulation tools and algorithms for different design-abstraction levels. *Background*: ELEC 301 and ELEC 306 or ELEC 516

ELEC 551 Switch Mode Power Converters [3-0-0:3]
DC-DC conversion: topologies, modes of operation, steady state analysis, perturbation analysis and relevant mathematical tools, stability and compensation; AC-DC conversion: power factor correctors; DC-AC conversion: resonant circuits and ballasts. *Background*: ELEC 202 and ELEC 211

ELEC 560 Linear-System Theory [3-0-0:3]
Introduces modern system theory, with applications to control, signal processing and related topics. Basic system concepts, state-space and I/O representation, properties of linear systems, controllability, observability, minimality, transfer-function matrices, state and output feedback, stability, observers, optimal regulators. *Background*: MATH 151, MATH 152 and ELEC 211

ELEC 561 Multivariable Control [3-0-0:3]
Analysis and synthesis techniques for multi-input and multi-output control systems; stabilization theory; performance specification; system robustness; LQR problem; Kalman filtering; LQG problem; H-2 optimal control; H-infinity control. *Background*: ELEC 371 and ELEC 560

ELEC 562 Nonlinear Systems: Analysis, Stability and Control [3-0-0:3]
Introduction to nonlinear dynamical systems, differential equations, second-order systems, index theory, Poincare-Bendixson theorem, stability by direct and indirect methods of Lyapunov, input-output stability, geometric theory of control for nonlinear systems, exact linearization by nonlinear feedback.

ELEC 564 Robot Manipulation [3-0-3:3]
Extensive introduction to robot manipulation theory from a geometric viewpoint. Rigid-body kinematics; spatial and body representation of rigid-body velocities; coordinate transformations; forward kinematics of open-chain manipulators; solution of inverse kinematics; robot workspaces; nonlinear decoupling control and force control. *Exclusions*: ELEC 374, MECH 371

ELEC 580 Signal and Image Analysis in Medicine [3-0-0:3]
[Previous Course Code: ELEC 691J] Biomedical signal analysis: physiological origins and data acquisition; temporal, frequency, and wavelet analysis; complexity, scaling, and fractals. Biomedical image analysis: imaging modalities and acquisition; object segmentation; data fusion; kinematics analysis; statistical interpretation; augmented and virtual reality. *Background*: ELEC 211, ELEC 212, ELEC 317

ELEC 690 Independent Study [1-3 credit(s)]
Selected topics in electrical and electronic engineering studied under the supervision of a faculty member. Graded P or F.

ELEC 691-694 Special Topics [1-4 credit(s)]
Selected topics of current interest. May be repeated for credit, if different topics are covered.

ELEC 695 Departmental Seminar [1-0-0:0]
Series of seminar topics presented by students, faculty and guest speakers. Graded P or F.

ELEC 698 MSc Project [3 credits]
Independent project carried out under the supervision of a faculty member. *Exclusion*: EESM 698

ELEC 699 MPhil Thesis Research
Master's thesis research supervised by a faculty member. A successful defense of the thesis leads to the grade Pass. No course credit is assigned.

ELEC 799 Doctoral Thesis Research
Original and independent doctoral thesis research. A successful defense of the thesis leads to the grade Pass. No course credit is assigned.