Electrical and Computer Engineering

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Interim Chair: Aleksandar Milenkovic, Ph.D.
Associate Chair: Laurie Joiner, Ph.D.

Mission
The mission of the Electrical and Computer Engineering (ECE) Department is to develop and maintain high quality undergraduate and graduate programs in electrical, computer, and cybersecurity engineering to meet the needs of its constituents, and to participate in scholarly and productive research that contributes to the economic well-being and quality of life for the residents of Huntsville, the State of Alabama, and the citizens of the United States of America.

Degree Programs
The ECE Department supports several degree programs that provide a unique academic and research experience for students including:

- Master of Science in Engineering (Computer Engineering)
- Master of Science in Engineering (Electrical Engineering)
- Master of Science in Software Engineering
- Master of Science in Cybersecurity
- Doctor of Philosophy in Computer Engineering (Shared with UAB)
- Doctor of Philosophy in Electrical Engineering (also offered with Optical Sciences and Engineering Interdisciplinary program)

The ECE Department offers opportunities for advanced work in a variety of fields, including radar and radar systems, digital signal processing, digital communications, digital and analog electronics, computer architecture, cybersecurity, parallel processing, software engineering, software safety, optics, and photonics.

Co-located in one of the nation’s largest research parks, UAH has the intellectual and social environment to provide a well-rounded, technologically oriented degree. ECE graduate students have outstanding opportunities for research, collaboration, cooperative employment, and future employment with government research centers and high-tech businesses. In addition, a number of UAH research centers collaborate with the ECE Department, including the Center for Rotorcraft Systems Engineering and Simulation, the Center for Modeling, Simulation and Analysis, the Center for Applied Optics, and the Nano and Micro Devices Center.

Prospective and current students are encouraged to visit the ECE Department website at www.uah.edu/eng/departments/ece (http://www.uah.edu/eng/departments/ece/) for information about faculty research interests, ongoing research projects, funding opportunities and course availability. Other information about the ECE graduate programs are available in the department office.

MSE in Computer or Electrical Engineering
The MSE in Computer or Electrical Engineering each require 30 credit hours and consist of two options. The thesis option requires 24 credit hours of graduate coursework and a minimum of six credit hours of thesis coursework. Students under this option must complete a written thesis and an oral defense. The non-thesis option requires 30 credit hours of graduate coursework.

Students wishing to pursue an MSE degree in Computer or Electrical Engineering must meet the admission requirements of the UAH Graduate School as well as the College of Engineering. Students who are admitted to these programs must file a Program of Study made in consultation with their Faculty Advisor.

MS in Software Engineering (MSSE)
The MSSE degree program has two options: Plan I and Plan II. Plan I requires 24 credit hours of graduate coursework and a minimum of six semester hours of thesis. Plan II students must also write and defend a thesis as a final examination. Plan II requires 24 credit hours of coursework as well as a capstone and elective course. Students who are admitted to these programs must file a Program of Study made in consultation with their Faculty Advisor. Students wishing to pursue the MSSE degree must meet the admission requirements of the UAH Graduate School, as well as the College of Engineering.
MS in Cybersecurity (MSCBS)

The MSCBS degree program is an interdisciplinary program with the Colleges of Science and Business with a distinct computer engineering track. The MSCBS has one option: 30 credit hours of graduate coursework with no thesis. Students who are admitted to this program must file a Program of Study made in consultation with their Faculty Advisor. Students wishing to pursue the MSCBS degree must meet the admission requirements of the UAH Graduate School, as well as the College of Engineering.

PhD in Computer or Electrical Engineering

The ECE Department offers a program leading to the degree of Doctor of Philosophy (Ph.D.) in Computer or Electrical Engineering. The Ph.D. is a research-oriented degree awarded upon completion of a defined program of study, demonstration of scholarly competence, distinctive achievement in a special field, and demonstrated ability to do an independent, original investigation. Demonstration of substantial scholarly research accomplishments, rather than mere accumulation of residence and course credits, is an essential consideration in awarding the Ph.D. degree.

The ECE Department doctoral programs require 48 credit hours of approved coursework. Students must register for a minimum of 18 credit hours of dissertation research. Students must meet with their Doctoral Advisors to develop a Program of Study (POS), which lists the approved coursework required for the Ph.D. In addition, students must register for dissertation research every semester after the completion of the POS until the dissertation defense. At the end of the coursework, a student must pass a Qualifying Examination. Finally, a student must write an acceptable dissertation that must be defended in front of the supervisory committee. More details about these examinations are available in the department office.

Students wishing to pursue a Ph.D. must meet the admission requirements of the UAH Graduate School as well as the College of Engineering. Students who do not have the appropriate bachelor's or master's degree from an ABET-accredited Computer or Electrical Engineering program must complete the foundation courses described below or demonstrate proficiency by completing similar courses or providing evidence based on employment experience.

Foundation Courses

The Computer and Electrical Engineering degree programs described above assume that students have a bachelor's degree and/or master's degree in Computer or Electrical Engineering, respectively.

To pursue the MSE or Ph.D. in Computer Engineering, students who do not have a bachelor's degree in Computer Engineering should complete coursework or demonstrate knowledge in the following CPE foundation areas:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Semester Hours</th>
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<tbody>
<tr>
<td>CPE 211</td>
<td>INTRO COMPUTER PROG FOR ENGR</td>
<td>3</td>
</tr>
<tr>
<td>CPE 212</td>
<td>FUNDAMENTALS SOFTWARE ENGRG</td>
<td>3</td>
</tr>
<tr>
<td>CS 317</td>
<td>INTRO DESIGN/ANALYSIS OF ALG</td>
<td>3</td>
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</tbody>
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Digital Logic Design/Electronics

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Semester Hours</th>
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</thead>
<tbody>
<tr>
<td>EE 202</td>
<td>INTRO DIGITAL LOGIC DSGN</td>
<td>3</td>
</tr>
<tr>
<td>EE 315</td>
<td>INTRO ELECTRONIC ANAL &amp; DESIGN</td>
<td>3</td>
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</table>

Computer Organization/Microprocessors

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>CPE 221</td>
<td>COMPUTER ORGANIZATION</td>
<td>3</td>
</tr>
<tr>
<td>CPE 323</td>
<td>INTRO TO EMBEDDED COMPUTER SYS</td>
<td>3</td>
</tr>
<tr>
<td>CPE 431</td>
<td>INTRO COMPUTER ARCHITECTURE</td>
<td>3</td>
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</table>

Total Semester Hours 24

1 An entering student can demonstrate knowledge of the material in one of the following ways: completing the courses at UAH, completing similar courses at another institution, or by providing evidence based on employment experience. A student may be required to successfully pass a placement exam to demonstrate their knowledge of the material.

To pursue the MSE or Ph.D. in Electrical Engineering, students who do not have a bachelor's degree in Electrical Engineering must complete coursework or demonstrate knowledge in the following subjects:

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<tbody>
<tr>
<td>EE 202</td>
<td>INTRO DIGITAL LOGIC DSGN</td>
<td>3</td>
</tr>
<tr>
<td>EE 213</td>
<td>ELECTRICAL CIRCUIT ANALYSIS I</td>
<td>3</td>
</tr>
<tr>
<td>EE 307</td>
<td>ELECTRICITY &amp; MAGNETISM</td>
<td>3</td>
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</tbody>
</table>
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To pursue either the MSSE or the MSCBS degrees, students who do not have a Computer Science or Computer Engineering bachelor's degree from an ABET-accredited program must complete the following courses or demonstrate knowledge in these subject areas. Experience in the development of a large scale, industrial strength software system is highly desirable.

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<tr>
<td>CPE 211</td>
<td>INTRO COMPUTER PROG FOR ENGR (or programming in C, C++ or Java)</td>
<td>3</td>
</tr>
<tr>
<td>CPE 212</td>
<td>FUNDAMENTALS SOFTWARE ENGRG (Data Structures)</td>
<td>3</td>
</tr>
<tr>
<td>CS 214</td>
<td>INTRO DISCRETE STRUCTURE</td>
<td>3</td>
</tr>
<tr>
<td>CS 317</td>
<td>INTRO DESIGN/ANALYSIS OF ALG</td>
<td>3</td>
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<tr>
<td>CPE 348</td>
<td>INTRO TO COMPUTER NETWORKS</td>
<td>3</td>
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<tr>
<td>CPE 431</td>
<td>INTRO COMPUTER ARCHITECTURE</td>
<td>3</td>
</tr>
<tr>
<td>CPE 434</td>
<td>OPERATING SYSTEMS</td>
<td>3</td>
</tr>
</tbody>
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Master's Programs in Electrical & Computer Engineering

- Computer Engineering, MSE (http://catalog.uah.edu/grad/colleges-departments/engineering/electrical-computer-engineering/computer-engineering-mse/)
- Electrical Engineering, MSE (http://catalog.uah.edu/grad/colleges-departments/engineering/electrical-computer-engineering/electrical-engineering-mse/)
- Master of Science in Cybersecurity (http://catalog.uah.edu/grad/colleges-departments/interdisciplinary-programs/cybersecurity-ms-interdisciplinary-computer-engineering-track/)
- Master of Science in Software Engineering, MSSE (http://catalog.uah.edu/grad/colleges-departments/engineering/electrical-computer-engineering/software-engineering-msse-master-of-science/)

Doctoral Programs in Electrical & Computer Engineering

- Computer Engineering, PhD (http://catalog.uah.edu/grad/colleges-departments/engineering/electrical-computer-engineering/computer-engineering-phd-shared-with-uab/)
- Electrical Engineering, PhD (http://catalog.uah.edu/grad/colleges-departments/engineering/electrical-computer-engineering/electrical-engineering-phd/)

CPE 512 - INTRO PARALLEL PROGRAMMING
Semester Hours: 3


CPE 523 - HARDWARE/SOFTWARE CO-DESIGN
Semester Hours: 3

Study and design of Systems On a Chip (SOC). Emphasis on Field Programmable realizations of SOC systems. Prerequisite: CPE 522 or CPE 526.
CPE 526 - VLSI HARDWARE DESC LANG/MODL/S
Semester Hours: 3
Modern VLSI design techniques and tools, such as silicon compilers, (V)HDL modeling languages, placement and routing tools, synthesis tools, and simulators. Students will design, simulate, and layout using both programmable logic families and ASIC libraries.

CPE 527 - VLSI DESIGN I
Semester Hours: 3
Introduction to VLSI design using CAD tools, CMOS logic, switch level modeling, circuit characterization, logic design in CMOS, systems design methods, test subsystem design, design examples, and student design project. Design project to be fabricated and tested in CPE 528. Students enrolling in CPE 527 must enroll concurrently in CPE 527L.

CPE 527L - LABORATORY
Semester Hours: 0
Students enrolling in CPE 527L must enroll concurrently in CPE 527.

CPE 528 - VLSI DESIGN II
Semester Hours: 3
Advanced experience with CAD tools for VLSI design, IC testing. Design project from CPE 527 will be fabricated and tested. Implementation and verification of test programs, IC testing and troubleshooting, legal, economic, and ethical design issues. Oral presentations and written reports are required. Students enrolling in CPE 528 must enroll concurrently in CPE 528L.

CPE 528L - LABORATORY
Semester Hours: 0
Students enrolling in CPE 528L must enroll concurrently in CPE 528.

CPE 531 - INTRO COMPUTER ARCHITECTURE
Semester Hours: 3
Existing computer structures. Computer organization with emphasis on busing systems, storage systems, and instruction sets. Special purpose architecture, performance models and measures, VLSI influence on architecture.

CPE 534 - OPERATING SYSTEMS
Semester Hours: 3
Study of the fundamentals of operating systems. Emphasis on processes, file management, interprocess communication, input-output, virtual memory, networking and security.

CPE 536 - INTERNALS OF MODERN OPER SYS
Semester Hours: 3
In depth study of the design of modern operating systems such as Unix, NT, and Linux. Emphasis on the internals and implementation details of interrupt processing, real-time clocks, device independent I/O, process management, memory management, and file management.

CPE 538 - REAL TIME & EMBEDDED SYSTEMS
Semester Hours: 3
Study of design methodologies for reliable real time systems.

CPE 549 - INTRO TO CYBERSECURITY ENG/INRG
Semester Hours: 3
Introduction to cryptography and computer security through hardware and physical security to a knowledge of audit methods, security management, and public law. The course will introduce security engineering skills such as business process analysis, software security, IAE evaluation, and IAE testing.

CPE 555 - SECURE SOFTWARE DEV
Semester Hours: 3
Overview of methodologies for development of high-assurance software. Major topics include analysis of security and safety risks, software certification criteria, the software development lifecycle, risk mitigation, design and coding best practices, verification techniques, and auditing of software for insecure and unsafe coding constructs.
CPE 557 - SOFTWARE REVERSE ENGR
Semester Hours: 3

This course provides fundamental knowledge of software reverse engineering. The course provides the ability (a) to understand software of unknown origin or software for which source code is unavailable, (b) to determine how something works, (c) to discover data used by software, and (d) to aid in the analysis of software. The course introduces tools for reverse engineering, including disassemblers, debuggers, monitors, virtual machines and modern tools for software analysis.

CPE 559 - SYSTEMS SECURITY
Semester Hours: 3

This course (1) introduces cyber physical, industrial control, embedded and Supervisory Control and Data Acquisition (SCADA) control systems, (2) examines common vulnerabilities and threats associated with these systems, and (3) examines techniques to defend these systems from cyber-attacks.

CPE 561 - TRANSLATION SYSTEMS
Semester Hours: 3

Grammars, parsers, and lexical analyzers; implementation of translators via top-down and bottom up techniques; grammar analysis to identify ambiguities. Practical applications of translators including conversion of file formats and compilation of traditional computer languages.

CPE 590 - SPECIAL TOPICS IN COMP ENGR
Semester Hours: 1-3

CPE 590L - SELECTED TOPICS LABORATORY
Semester Hours: 0

CPE 601 - SURVEY INFORMATION ASSURANCE
Semester Hour: 1

CPE 610 - SELECTED TOPICS IN COMPUTER EN
Semester Hours: 1-6

CPE 612 - PARALLEL ALGORITHMS
Semester Hours: 3

Introduction to metrics describing the performance and scalability of parallel algorithms. Performance analysis of parallel algorithms for performing sorting, matrix multiplication, solving linear equations, and FFT.

CPE 613 - GEN PURPOSE GPU COMPUTING
Semester Hours: 3

The focus of this course is to introduce emerging techniques and programming paradigms that can be used to accelerate the processing speed of scientific and other high performance applications using Graphics Processing Units, GPUs. GPUs represent low-cost highly parallel video processing hardware that can be programmed for general purpose applications using CUDA/OpenCL software architecture. The course will survey the current state of research and industrial activity and will give student's hands-on experience implementing design applications on real-world GPU facilities for a wide range of scientific applications. Prerequisite: CPE 512.

CPE 619 - MODELING & ANAL COMPU/COMMUN S
Semester Hours: 3


CPE 621 - ADVANCED EMBEDDED SYSTEMS
Semester Hours: 3

Deeply embedded low-power wireless sensors. Low-power microcontroller architectures, sensor platform architecture, wireless intelligent sensors, low power wireless communication standards, battery powered systems, resource constrained operating systems, data aggregation/sensor synergy, and collaborative signal processing.

CPE 625 - CMOS ANALOG CIRCUIT DESIGN
Semester Hours: 3

CPE 626 - ADVANCED VLSI DESIGN
Semester Hours: 3
Advanced VLSI Design. Case study of the VLSI design of a modern RISC processor using a Hardware Description Language. Prerequisite: CPE 526.

CPE 628 - TESTING OF HARDWARE SYSTEMS
Semester Hours: 3
Introduction to testing of digital electronic circuits and systems. Topics include: fault modeling, testing problems, testing schemes, test generation for combinational and sequential circuits, the complexity of testing, design for testability, built-in self-testing and boundary scan.

CPE 631 - ADV COMP SYSTEMS ARCHITECTURE
Semester Hours: 3
Study of architectural features of modern processors, including cache memories and memory systems, pipeline designs, branch prediction techniques. Design of superscalar, multithreaded VLIW processors, code optimization for such systems will be studied. Quantitative evaluation of architectural features are emphasized throughout the course. Prerequisite: CPE 512 and CPE 531.

CPE 633 - FAULT-TOLERANT COMPUTING SYS
Semester Hours: 3
Analysis and design of very high reliability and availability systems. Fault types, reliability techniques, and maintenance techniques. Case studies of high-availability long-life, life-critical systems. Both hardware and software techniques for achieving fault-tolerance will be studied.

CPE 635 - SYSTOLIC ARRAY PROCESSING
Semester Hours: 3
Systolic structure of fast algorithms and switchable array realizations.

CPE 645 - COMPUTER NETWORK SECURITY
Semester Hours: 3
Principles and concepts of computer network security. Introduction to cryptography, confidentiality, authentication, digital signatures, E-mail security, IP security, web security, intruders, malicious software, firewall, and other network security-related issues.

CPE 647 - UBIQUITOUS COMPUTING
Semester Hours: 3
The course is based on the new "anytime, anywhere" computing paradigm, also known as ubiquitous computing. This course is project oriented, and explores issues of mobile, wireless, and distributed computing in Internet environment, advanced human-computer interfaces, and power efficient computing.

CPE 648 - ADVANCED COMPUTER NETWORKS
Semester Hours: 3
Advanced principles and concepts of general-purpose computer networks, with a special emphasis to internetworking and Internet. Transport and higher level protocols emphasis. Programming issues. High-speed networking, congestion control, data compression, security and distributed processing will be covered.

CPE 649 - ADV CYBERSECURITY ENGINEERING
Semester Hours: 3
Introduction to topics ranging from how to attack computer systems and networks to how to protect and recover from attacks on computer systems and networks. Basic process utilized by computer attackers in order to develop a complete understanding and appreciation of the threat to information assurance. Process of detecting, preventing, and recovering from information assurance attacks. Intrusion Detection and Prevention Systems, Auditing, Security Vulnerability Assessments, and the Incident Response process. Prerequisite: CPE 549.

CPE 649L - ADV CYBERSECURITY ENG LAB
Semester Hours: 0
Students enrolling CPE 649 must enroll concurrently in CPE 649L.
CPE 656 - SOFTWARE ENGRG STUDIO I
Semester Hours: 3

This is the first course in a two course studio series required for the MSSE degree in the College of Engineering. Students will work in small design teams on medium sized software projects. Activities include developing requirements, designing and constructing system prototypes, developing and implementing test and verification plans, and presenting the project for evaluation. The practice of software design and evaluation will be conducted in an iterative cycle using best software engineering practices, so that design and execution can be refined over the lifecycle of the project. Prerequisite: CS 650.

CPE 657 - SOFTWARE STUDIO
Semester Hours: 3

Graduate software studio is a capstone course in the MSSE program which requires students to present mastery of software development through completion of an extensive software project which follows a defined process. Students work in collaborative teams which will require extensive collaboration outside of class through meetings, teleconferencing, and documentation. Prerequisites: CS 650 plus 9 graduate credits or approval of instructor.

CPE 658 - SOFTWARE ENGRG STUDIO II
Semester Hours: 3

This is the second course in a two course studio series required for the MSSE degree in the College of Engineering. Students will work in small design teams on medium sized software projects. Activities include developing requirements, designing and constructing system prototypes, developing and implementing test and verification plans, and presenting the project for evaluation. The practice of software design and evaluation will be conducted in an iterative cycle using best software engineering practices, so that design and execution can be refined over the lifecycle of the project. Prerequisite: CPE 656.

CPE 690 - SELECTED TOPICS COMPUTER ENGRG
Semester Hours: 1-6

CPE 692 - CYBERSECURITY CAPSTONE
Semester Hours: 3

A capstone course emphasizing the integration of various principles, theories, and techniques for developing, implementing and using cybersecurity strategies and applications in organizations. Includes readings, lectures, tours, situation analysis, cases, and the completion of a major practical project. Normally taken in the last semester of a student's program. Minimum grade B required. Prerequisites: CS 585, CPE 549, IS 660, IS 663.

CPE 695 - PROJECTS IN COMPUTER ENGRG
Semester Hours: 3

CPE 699 - MASTER'S THESIS
Semester Hours: 9

Required each semester student is working and receiving direction on a master's thesis. Minimum of two semesters and 6 hours required for M.S.E. students. A maximum of 9 hours credit is awarded upon successful completion of master's thesis. The 0 hour option is only available to students who have successfully defended their thesis and submitted it for approval, but do not meet the deadlines for graduation in the semester submitted. Students may only use the 0 hour option once in their career.

CPE 710 - SEL TOPICS IN PARALLEL PROC
Semester Hours: 3

CPE 715 - SELECTED TOPICS IN COMPUTAT TH
Semester Hours: 3

CPE 720 - SELECTED TOPICS IN VLSI DESIGN
Semester Hours: 3

Prerequisite: CPE 626.

CPE 726 - ALGORITHMS FOR VLSI DESIGN TOO
Semester Hours: 3

Tools for VLSI Design. This course is concerned with the algorithms found in VLSI design tools.

CPE 730 - SELECTED TOPICS IN COMPUTER SY
Semester Hours: 3

Prerequisite: CPE 631.
CPE 731 - DISTRIBUTED SHARED MEMORY SYS  
Semester Hours: 3  
Study issues related to performance, granularity of sharing, multithreading, cache coherence, memory consistency models, pull vs push caching, false sharing, thread migration. Case studies systems, including DASH, FLASH ThreadMarks, SHRIMP, Calypso, Alewife to understand these issues.

CPE 735 - SELECTED TOPICS IN OPERATING S  
Semester Hours: 3

CPE 740 - SPEC TOPICS COMPUTER NETWORKS  
Semester Hours: 3  
Prerequisite: CPE 648.

CPE 742 - PARALLEL PROCESS DESIGN  
Semester Hours: 3

CPE 748 - MOBILE & WIRELESS NETWORKS  
Semester Hours: 3  
High-level issues in mobile and wireless networks. The main topics are mobile IP, Mobile Ad hoc NETworks (MANETs), wireless sensor networks, wireless LAN, Bluetooth, cellular networks, satellite systems, and security issues in mobiles and wireless networks. Prerequisite: CPE 648 or CS 670.

CPE 760 - SEL TOPICS COMPILER/TRANSLAT S  
Semester Hours: 3

CPE 790 - SEL TOPICS COMPUTER ENGRG  
Semester Hours: 1-6

CPE 795 - RESEARCH IN COMPUTER ENGRG  
Semester Hours: 1-6

CPE 799 - DOCTORAL DISSERTATION  
Semester Hours: 9  
Required each semester student is enrolled and receiving direction on doctoral dissertation. The 0 hour option is only available to students who have successfully defended their dissertation and submitted it for approval, but do not meet the deadlines for graduation in the semester submitted. Students may only use the 0 hour option once in their career.

EE 501 - DIGITAL SIGNAL PROC ARCHITECTU  
Semester Hours: 3  
Introduction to digital signal processor architecture, applications, assembly language programming, and development tools for designing and implementing DSP systems.

EE 504 - INTRO DATA COMMUNICA NETWORKS  
Semester Hours: 3  
Overview of historic development of modern telephone and data communication system, system architecture, standards, broadband switching systems, modems, protocols, personal and mobile communications, digital modulation techniques.

EE 506 - COMMUNICATION THEORY  
Semester Hours: 3  

EE 510 - SELECTED TOPICS/ECE  
Semester Hours: 1-6

EE 514 - ANALOG & DIGITAL FILTER DESIGN  
Semester Hours: 3  
Analog filter design via Butterworth, Chebyshev, and elliptical approximation. Active filter design using operational amplifiers. Digital filter design methods.
EE 516 - DIGITAL ELECTRONICS  
Semester Hours: 3  

EE 518 - NONLINEAR DYNAMICS & CHAOS  
Semester Hours: 3  
Topics: system stability, linearization, equilibrium/steady-state solutions, bifurcations, periodic solutions, limit cycles, oscillators, chaos, iterated maps and chaos control/synchronization. Various tools and methods used for analysis and design of nonlinear circuits and systems will be covered. Students should have prerequisite knowledge of electronics and signals and systems such as covered in EE 315 and EE 382.

EE 521 - ANTENNA DESIGN & ANALYSIS  
Semester Hours: 3  
Covers analytical methods and mathematical foundations for solving antenna radiation problems, based on Maxwell's equations. Different types of antennas will be studied, including wire, phased array, aperture, microstrip, and reflector antennas. Students should have prerequisite knowledge of electromagnetics, such as that covered in EE 308.

EE 525 - FUNDAMENTALS OF RADAR SYSTEMS  
Semester Hours: 3  
An introduction to radar systems and basic radar analysis. Topics include common radar topologies and construction methods, transmission, reception and processing of radar signals that are embedded in noise. Particular focus on analysis of the radar range equation and its various terms. Students are expected to have prerequisite knowledge of signals and systems and random signals such as covered in EE 382 and EE 385.

EE 532 - OPTICAL SYSTEMS DESIGN  
Semester Hours: 3  
Introduction to the geometrical design and analysis of optical systems, and to the design principles of lens systems.

EE 534 - OPTICAL FIBER COMMUNICATIONS  
Semester Hours: 3  
Introduction to optical fibers and their transmission characteristics, optical fiber measurements, sources and detectors, noise considerations for digital and analog communications, optical fiber systems.

EE 541 - OPTICS I  
Semester Hours: 3  
Foundations and physics of geometrical optics, Fermat's principles and Huygen wavelets, refraction and reflection. The many forms of Snell's Law. Optical path lengths, geometrical wavefronts and rays. Ray tracing, ynu-chart and matrix methods. Gaussian imagery and paraxial optics, conjugate elements, cardinal points, and image-object relations. Stops and pupils, chief and marginal rays, vignetting, and the optical or Lagrange invariant. The y-ybar diagram, design of common systems: objectives, magnifiers, microscopes, collimators and detectors. Optical glasses and chromatic aberrations, wavefront and transverse aberrations, spot diagrams and ray fan plots.

EE 542 - PHYSICAL OPTICS  
Semester Hours: 3  
Scalar and electromagnetic waves, polarization, coherence, reflection and refraction; two beam and multiple beam interference, interferometers, Fabry-Perots, thin films, diffraction, and absorption and dispersion.

EE 543 - OPTICAL COMM SYS & NETWORKS  
Semester Hours: 3  
EE 553 - LASER SYSTEMS  
Semester Hours: 3  
Spontaneous and stimulated emission, population inversion, optical resonators, three- and four-level systems, Q-switching and modelocking, semiconductor lasers, integrated optic waveguides and couplers, scanning systems, high power industrial applications. Includes a research project and oral presentation.

EE 570 - OPT & PHOTONIC SYSTEMS DESIGN  
Semester Hours: 3
EE 586 - INTRO MODERN CONTROL SYSTEMS  
Semester Hours: 3  

EE 603 - RANDOM SIGNALS IN COMMUNICATION  
Semester Hours: 3  
Random processes applied to communication and control. Concepts covered include stationarity, correlation, power spectrum, Brownian motion, thermal noise, Markov processes, and queuing theory. Emphasis on systems with noisy excitation.

EE 604 - DIGITAL IMAGE PROCESSING  
Semester Hours: 3  

EE 605 - CLASSICAL CONTROL DESIGN  
Semester Hours: 3  
Design of feedback, feedforward, and minor-loop controllers/compensators using classical control engineering techniques and classical performance criteria. Frequency domain synthesis of lead, lag, lead-lag, etc. compensators; tuning of PD and PID controllers; error budgets; use of commercial CAD software for classical control design and performance evaluation; digital simulation techniques. CAD laboratory sessions.

EE 607 - ROBOTIC SYSTEMS CONTROL  
Semester Hours: 3  
In-depth study of information, decision and control problems associated with robotic system design. Sensor systems, recognition and decision algorithms, kinematics and dynamics, trajectory planning, analog and digital controllers, adaptive and optimal control.

EE 609 - ELECTROMAGNETIC FIELD THEORY  
Semester Hours: 3  

EE 610 - SELECTED TOPICS/ECE  
Semester Hours: 1-6

EE 612 - GRADUATE DESIGN PROJECT  
Semester Hours: 3  
Graduate design project in support of an M.S.E. program.

EE 613 - LASER ELECTRONICS  
Semester Hours: 3  

EE 614 - DATA COMPRESSION  
Semester Hours: 3  
Introduction to the fundamental theories and techniques of lossless and lossy data compression. Topics include Huffman codes, arithmetic codes, Golomb-Rice code, dictionary techniques, context-based compression, scalar quantization, vector quantization, transform coding, subband coding, wavelets, compression standards, and selected advanced topics of data compression.

EE 615 - ANALOG CIRCUIT DESIGN  
Semester Hours: 3  
Use of operational amplifiers to synthesize special-purpose filters and circuits for analog signal processing and conditioning; linear and switching power supplies; high-frequency effects; circuits for transmitters and receivers; digital circuits from an analog viewpoint; A/D and D/A converters; selected topics.
EE 616 - MICROELECT DEV/INTE CIRC
Semester Hours: 3

EE 617 - VLS INTEGRATION DEVICES
Semester Hours: 3
Operation and modeling of the MOS transistor. Second-order considerations for a MOSFET, VLSI device fundamentals and scaling laws. Micron-length and submicron-length semiconductor devices. Basic technology and applications of VLSI. Impact of VLSI on computer architecture. VLSI computer aided design.

EE 618 - VLSI CIRCUITS
Semester Hours: 3

EE 619 - RADAR SYSTEMS
Semester Hours: 3
Radar range equation, noise & noise figure, radar losses, false alarm and detection probability, detection probability improvement techniques, matched filter theory, ambiguity function. Prereq: EE 525.

EE 620 - CMOS ANALOG CIRCUIT DESIGN
Semester Hours: 3

EE 622 - HARDWARE RELIABILITY
Semester Hours: 3
The objective for this course is to provide students with an understanding of the essential reliability physics of electronic devices as well as some of the practical technological considerations.

EE 629 - ANAL & COMP METH IN ELEC ENG I
Semester Hours: 3
Analytic and numerical solution techniques applicable to problems arising in engineering, utilizing complex variable theory, linear algebra, matrix theory, and transform methods.

EE 630 - ANAL & COMP METHODS ELEC EG II
Semester Hours: 3
Analytical and numerical solution techniques applicable to problems arising in electrical engineering. Partial differential equations, vector differential and integral calculus, special functions, Fourier analysis with applications and integral equations.

EE 632 - FOURIER OPTICS
Semester Hours: 3
Introducing the optical system as an invariant linear system, convolution, Sommerfield's diffraction integral, Fourier Transform, angular spectrum, coherent and incoherent imaging, optical transfer function.

EE 633 - ELECTRO-OPTICAL ENGINEER
Semester Hours: 3
Propagation of optical beams in homogeneous and guiding media, optical resonators, and spectrum analyzers, theory of laser oscillation, some specific laser systems, parametric oscillators, electro-optical and acousto-optical modulators.

EE 634 - OPTICAL COMMUNICATIONS
Semester Hours: 3
Optical communication systems; counting statistics; the optical detector response process; direct detection; heterodyne detection parameter estimation in optical communications; pointing, spatial acquisition and tracking.
EE 642 - DATA & DIGITAL COMMUNICATION
Semester Hours: 3

Introduction to digital and data communications; transmission channels; modulation and coding; telephone networks; data communication standards; noise and distortion; computer interfacing; protocols. Prerequisite: EE 603.

EE 648 - DIGITAL SIGNAL PROCESSING
Semester Hours: 3

Theory and applications of signal processing by digital techniques. Difference equations, Z-transform theory, digital-filter design, fast Fourier transform, quantization effects, and discrete estimation. Applications in digital filtering, signal processing, data analysis and smoothing, and image processing. Students should have prerequisite knowledge of signals and systems such as covered in EE 383.

EE 654 - OPTICAL TESTING
Semester Hours: 3

EE 672 - DIGITAL PROC RANDOM SIGNALS I
Semester Hours: 3

Discrete signals, linear systems, spectral analysis and probability; and random discrete-time signals. Introduction to statistical interference, time-series analysis and spectral estimation of random discrete-time signals. Cross correlation and cross spectra, multitaper spectrum estimation and multivariable spectral analysis.

EE 673 - DIGITAL PROC RANDOM SIGNALS II
Semester Hours: 3

Parametric models for random signal processing; AR (autoregressive), MA (moving average), ARMA (autoregressive moving average), and Prony method. Two-dimensional spectral estimation; higher-order spectral analysis and multiresolution signal analysis.

EE 690 - UNIFORM GEOM THY DIFFRACT
Semester Hours: 3

Geometrical optics fields, geometrical optics reflected fields, two-dimensional wedge diffraction (GTD and UTD), three-dimensional wedge diffraction and corner diffraction, equivalent currents, diffraction at a smooth convex conducting surface, radar cross section.

EE 696 - GRAD INTERN EE ENGR
Semester Hours: 1-9

Active involvement in an engineering project in an engineering enterprise, professional organization or government agency that has particular interest and relevance to the graduate student. Permission of EE faculty member is required.

EE 699 - MASTER'S THESIS
Semester Hours: 9

Required each semester student is working and receiving direction on a master's thesis. Minimum of two semesters and 6 hours required for M.S.E. students. A maximum of nine hours of credit is awarded upon successful completion of master's thesis. The 0 hour option is only available to students who have successfully defended their thesis and submitted it for approval, but do not meet the deadlines for graduation in the semester submitted. Students may only use the 0 hour option once in their career.

EE 700 - SAMPLED DATA CONT SYS
Semester Hours: 3

Classical and modern methods for analysis and design of sampled data-control systems; Ztransforms, transport lags, z and w plane analysis, state variables, and the transition matrix.

EE 701 - ADV LINEAR CONTROL THRY
Semester Hours: 3

Modern techniques for analysis and design of linear control systems. Matrix formulation, multivariable control systems, state variable concepts. Linear transformation, controllability, observability, discrete-time systems. Prerequisite: EE 586.

EE 703 - MODERN CONTROL DESIGN
Semester Hours: 3

Use of modern (state-variable) control concepts and theories to design high-performance controllers for multi-input/multi-output set-point regulation and servo-tracking/pointing problems. Modeling of uncertain disturbances; design of disturbance-accommodating controllers; introduction to adaptive and stochastic control. Use of commercial CAD software for modern control design and performance evaluation. CAD laboratory sessions. Prerequisite: EE 701.
EE 704 - NONLINEAR CONTROL SYSTEM
Semester Hours: 3
Classical and modern methods for analysis and design of nonlinear automatic control systems. State variables, phase plane, limit cycles, stability, describing functions, relay control, stabilization theory. Prerequisite: EE 701.

EE 705 - THEORY OPTIMAL CONTROL
Semester Hours: 3

EE 706 - KALMAN FILTERS
Semester Hours: 3
Review of continuous and discrete time systems, random variables and processes; matrix random processes; derivation of the first order, linear Kalman filter; derivation of the linear vector Kalman filter; derivation of the extended Kalman filter; design and implementation of specific Kalman filters. Prerequisite: EE 525 or EE 586.

EE 707 - INFORMATION THEORY
Semester Hours: 3
Self-information, entropy, mutual information, and channel capacity, encoding, error detecting and correcting codes. Sampling theorem. Discrete and continuous channels.

EE 710 - SELECTED TOPICS/ECE
Semester Hours: 1-6

EE 711 - ANTENNA THEORY
Semester Hours: 3
Antennas and antenna arrays. Radiation patterns and impedance characteristics. Spheres, cylinders, horns, slots, microwave lenses, traveling-wave, and frequency independent antennas.

EE 716 - DEVICE MOD INTEG CIR DSG
Semester Hours: 3

EE 717 - SPACE APPLI/ELECTROMAGNE
Semester Hours: 3
Plasma as a dielectric; dielectric functions for cold, warm, isotropic and anisotropic plasmas, body-plasma interaction; space craft electrodynamics, antennas in plasmas; mode of radiation, input impedance and radiation pattern, scattering problems involving plasmas.

EE 718 - MICROWAVE TECHNIQUES
Semester Hours: 3

EE 721 - ROBUST AND ADAPTIVE CONTROL
Semester Hours: 3
Introduction to fundamental ideas of robust and adaptive control. Effects of parameter and disturbance uncertainties, H-infinity and mu-synthesis ideas; parameter estimation techniques; adaptive control algorithms; stability considerations; model-reference and linear adaptive control techniques.

EE 722 - SLIDING MODE CONTROL
Semester Hours: 3
The basic and advanced theories and analytical techniques for modeling and analysis of systems dynamics in sliding manifolds. Traditional and High Order Sliding mode controller design. Discontinuous and equivalent control, robustness. Applications to control of electro-mechanical systems, reusable launch vehicle, air craft, spacecraft, and DC-to-DC power converters. Prerequisite: EE 701.

EE 723 - RADAR TRACKING
Semester Hours: 3
Alpha-Beta and Alpha-Beta-Gamma track filters, range, angle, Doppler frequency measurement and discriminators; implementation of range, angle, Doppler, and combined range/angle/Doppler trackers; tracking the presence of multipath, multiple target effects. Prerequisite: EE 619.
EE 724 - RADAR WAVEFORMS & SIGNAL PROCESSING  
Semester Hours: 3

Stretch Processing, Synthetic Aperture Radar and SAR signal processing, Space-time adaptive processing (STAP). Phase coded waveforms and processing. Frequency hop waveforms. Prerequisite: EE 619.

EE 725 - ADVANCED RADAR TECHNIQUE  
Semester Hours: 3

Modern radar systems for search and tracking are analyzed with emphasis on signal processing. Modeling and simulation of system and environment. Advanced techniques include CFAR, binary modulation, frequency agility, polarization agility, and synthetic aperture. Prerequisite: EE 619.

EE 726 - DECISION/ESTIMATION THEORY  
Semester Hours: 3

Classical detection theory, including maximum likelihood, Neyman-Pearson, Bayes and minimax criteria. Estimation theory concepts and criteria, linear estimators, Kalman filters, maximum likelihood and least-squares estimator, matched filters, Cramer-Rao lower bound. Introduction to pattern recognition.

EE 727 - NUMERICAL METHODS ELECTROMAGNETICITY  
Semester Hours: 3


EE 728 - NONLINEAR OPTICS APPLICATIONS  
Semester Hours: 3

Modeling of optical nonlinearities: Kerr, thermal and photorefractive effects; nonlinearity-induced beam distortion; applications of nonlinearities in crystals and fibers; quantum well and SEED devices; soliton-based communication system; nonlinear optical switches, deflectors and limiters; measurements of nonlinearities.

EE 733 - FIBER OPTICS  
Semester Hours: 3

Propagation in dielectric slab and fibers with step and graded index of refraction; electromagnetic and ray optical methods; eikonal equations; ray trajectory; WKB method; paraxial approximation; weakly guiding structures.

EE 734 - STATISTICAL OPTICS  
Semester Hours: 3

Introduction to random variables and random processes; first-order properties of light waves; coherence of optical waves, partial coherence and imaging systems, imaging in randomly inhomogeneous media, fundamental limits in photoelectric detection of light.

EE 738 - OPTICAL TRANSFER FUNCTION RECOGNITION  
Semester Hours: 3

Systems and transforms in diffraction theory; two-dimensional Fourier transform; Hankel transforms; generalized Hankel transforms; optical signals, correlation coherence; filtering; apodization; applications to optical pattern recognition.

EE 742 - WIRELESS TRANSMISSION SYSTEMS  
Semester Hours: 3

Design and analysis of wireless transmission systems. Prerequisite: EE 642.

EE 744 - ERROR CONTROL CODING  
Semester Hours: 3

Linear block coding techniques, convolutional codes and the Viterbi decoding algorithm, iterative decoding algorithms and the codes to which they are applied, including Turbo Codes, Low-Density Parity-Check Codes, and Serially-Concatenated Codes. Prerequisite: EE 504.

EE 745 - MODULATION/PHASE LOCK TECHNOLOGY COMMUNICATIONS  
Semester Hours: 3


EE 747 - PATTERN RECOGNITION ALGORITHMS  
Semester Hours: 3
EE 799 - DOCTORAL DISSERTATION
Semester Hours: 9

Required each semester student is enrolled and receiving direction on doctoral dissertation. The 0 hour option is only available to students who have successfully defended their dissertation and submitted it for approval, but do not meet the deadlines for graduation in the semester submitted. Students may only use the 0 hour option once in their career.