ELECTRICAL ENGINEERING (EE)

EE 8: Introduction to Digital Music

1 Credits

First-year seminar that discusses digital music from an electrical engineering perspective; topics include sampling, digital filtering, compression, and music synthesis. E E 008S Introduction to Digital Music (1) (FYS) E E 008S is a lab-oriented first-year seminar course aimed at students interested in the field of digital music. Specifically, this course discusses how the various digital music formats (and other types of digital audio) relate to the electrical engineering sub-discipline of digital signal processing. Students will come out of this course with a more technical understanding of the digital audio formats that they listen to every day.This course is structured to have alternating periods of lecture and lab. New concepts are first covered in the lectures and then reinforced with a variety of laboratory activities. In the laboratory experiments, students will use various computer programs and will also get exposure to standard test equipment used by electrical engineers.Topics covered in the lectures/labs include investigating the physics of sound, sampling and quantization of music signals, generating audio special effects through the use of digital filters, compression techniques used in digital audio, and mathematically synthesizing instrument sounds. Current popular digital audio formats such as compact disc audio, WAV, MP3, and MIDI will also be investigated throughout this course.No musical experience/talent is necessary.

First-Year Seminar

EE 9: First-Year Seminar in Electrical Engineering

1 Credits

First-year seminar covering a variety of Electrical Engineering topics that vary from year to year. E E 009S First-Year Seminar in Electrical Engineering (1) (FYS) The overall objectives of Engineering First-Year Seminars are to engage students in learning about engineering and orient them to the scholarly community in a way that will bridge to, and enhance their benefit from, later experiences in the College and the University.Seminars adhere to the two specific goals identified below by including one or more of the three strategies following each goal: (1)Introduce students to a specific field, or encourage their exploration of a number of fields, of study in engineering; familiarization with the engineering majors and career options and with the objectives of general education and other components of the curriculum; development of a particular topic, contemporary issue, emerging or interdisciplinary field of concentration, or professional responsibilities in engineering; plant tours or demonstrations of engineering facilities(2)Acquaint students with tools, resources and opportunities available to them in the department(s), College and University; exposure to learning support services and career development resources

First-Year Seminar

EE 199: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)

EE 200: Design Tools

3 Credits

A working knowledge of electrical engineering design tools and hardware realization of electrical engineering systems. E E 200 Design Tools (3) E E 200 provides students with a working set of design tools that are required to complete subsequent courses in the electrical engineering design curriculum. This course directly builds upon circuit analysis/ design concepts in the required introductory courses in electrical circuits, digital systems and computer programming. Specific topics covered in this course include automated instrument control, hardware realization using field programmable devices, hardware realization using embedded microcontroller systems, circuit simulation and printed circuit board layout. Student performance is evaluated using exams, homework assignments, and projects. Concepts introduced in lecture are reinforced with hands-on experience provided by laboratory projects.

Prerequisite: E E 210 , CMPEN270 or CMPEN271 and CMPEN275 , CMPSC201 or CMPSC121 ; Prerequisite or concurrent E E 310

EE 210: Circuits and Devices

4 Credits

Introduction to electrical circuit analysis, electronic devices, amplifiers, and time-domain transient analysis.

Prerequisite: PHYS 212 . Prerequisite or concurrent: MATH 250

EE 211: Electrical Circuits and Power Distribution

3 Credits

D.C. and A.C. circuits, transformers, single and three-phase distribution systems, A.C. motors and generators.

Prerequisite: PHYS 212

EE 212: Introduction to Electronic Measuring Systems

3 Credits

Electronic devices and characteristics, amplifiers and feedback, electronic instruments and recording systems. Designed for non-electrical engineering students.

Prerequisite: PHYS 212

EE 296: Independent Studies

1-18 Credits/Maximum of 18

Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses.

EE 297: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to exlore, in depth, a comparatively narrow subject which may be topical or of special interest.

EE 299: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)

EE 300: Design Process

3 Credits

Introduction to the electrical engineering design process, project teaming and management, and technical communication. E E 300W Design Process (3) E E 300W course will introduce students to the electrical engineering design process, project teaming, and project management in preparation for conducting a senior design project. In the lab, students will get practice managing a project from pre-definition to completion within constraints of customer needs, technical parameters and budgets. The principles of systems engineering will be introduced. The student-engineer will gain professional skills (in areas such as technical communication, teaming, conflict resolution and life-long learning) important for a successful career in a wide range of engineering environments. There will also be discussion of engineering ethics and the responsibilities of the engineer in the emerging global marketplace. A series of lectures by outside speakers will provide perspectives on life as an engineer.

Prerequisite: E E 200 Concurrent: ENGL 202C
Writing Across the Curriculum

EE 310: Electronic Circuit Design I

4 Credits

Properties of fundamental electronic devices, analysis of DC, AC small-signal and nonlinear behavior, analog and digital circuit design applications.

Prerequisite: E E 210 or E E 315

EE 310H: Electronic Circuit Design I

4 Credits

Properties of fundamental electronic devices, analysis of DC, AC small-signal and nonlinear behavior, analog and digital circuit design applications.

Honors

EE 311: Electronic Circuit Design II

3 Credits

Electronic circuit design with consideration to single and multi-device subcircuits, frequency response characteristics, feedback, stability, efficiency, and IC techniques. E E 311 Electronic Circuit Design II (3) E E 311 is intended to provide competency in the application of basic electronic principles to design with operational amplifiers and integrated circuits. The course will include passive and active filter design, and feedback principles and non-ideal aspects of operational amplifiers (op-amps) including compensation, stability, and sensitivity needed for advanced design with op-amps, as well as some nonlinear op-amp circuits including comparators, Schmitt triggers, pulse width modulators, and waveform generators.

Prerequisite: E E 310 ; E E 350 or E E 352

EE 312: Electrical Circuit Analysis

3 Credits

Circuit analysis techniques; mutual inductance; frequency response; FOURIER series; LAPLACE transform.

Prerequisite: E E 210

EE 313: Electronic Circuit Design II

4 Credits

Design/analysis of electronics circuits including: single/multistage transistor amplifiers, op amp circuits, feedback amplifiers, filters, A/D and D/A converters. E E 313W Electronic Circuit Design II (4) The prerequisite course, E E 310 - Microelectronics 1, covers the basic operation of microelectronic devices and their use in logic circuit design. This course focuses on the design of electronic circuits for amplification, filtering, and A/D and D/A conversion. Advanced circuit design concepts, such as IC biasing, feedback, and frequency response, are covered. This course is designated as writing intensive, and students are required to produce a variety of technical documents based on laboratory work.

Prerequisite: E E 310
Writing Across the Curriculum

EE 314: Signals and Circuits II

3 Credits

Circuit analysis including op-amps, and ideal transformers; one/two port network models; three-phase and industrial loads; engineering professionalism.

Prerequisite: E E 210 ; CMPSC201 or CMPSC121

EE 315: Electrical Signals and Circuits with Lab

5 Credits

Introduction to circuits, signals, energy, circuit analysis; frequency response, Bode diagrams, two-port networks; Laplace transforms, Polyphase circuits.

Prerequisite: or concurrent: MATH 250

EE 316: Introduction to Embedded Microcontrollers

3 Credits

Introduction to microcontrollers in electronic and electromechanical systems. Hardware and software design for user/system interfaces, data acquisition, and control.

Prerequisite: CMPSC201 or CMPSC121 ; CMPEN271; Concurrent: E E 310

EE 317: Circuits II and Data Acquisition

2 Credits

E E 317 Circuits II and Data Acquisition This course is a follow up to the introductory circuit analysis course. The first part of this course is devoted to the study of multi-phase circuits, magnetic coupling, two-port networks and their applications. The second part of the course is devoted to automated instrument control with emphasis on data acquisition and processing, and printed circuit boards manufacturing. Student performance is evaluated using exams, homework assignments, and projects. Concepts introduced in lecture are reinforced with hands-on experience provided by laboratory projects.

Prerequisite: E E 210; CMPSC 201 or CMPSC 121 or CMPSC 101

EE 320: Introduction to Electro-Optical Engineering

3 Credits

An introduction covering several fundamental areas of modern optics, optical PROCESSES, AND DEVICES.

Prerequisite: E E 330

EE 330: Engineering Electromagnetics

4 Credits

Static electric and magnetic fields; solutions to static field problems, Maxwell's equations; electromagnetic waves; boundary conditions; engineering applications.

Prerequisite: E E 210 or E E 315 ; MATH 230

EE 330H: Engineering Electromagnetics

4 Credits

Static electric and magnetic fields; solutions to static field problems, Maxwell's equations; electromagnetic waves; boundary conditions; engineering applications.

Honors

EE 331: Electromagnetic Fields and Waves

3 Credits

Electromagnetic field theory and applications; Maxwell's equations; plane wave propagation; boundary conditions; basic antenna theory; impedance matching. E E 331 Electromagnetic Fields and Waves (3) After completing this course the student should understand, and be able to demonstrate a working knowledge of the following topics: 1)Vector Calculus 2)Coulomb's Law and applications 3)Gauss's Law and applications 4)Electric potential and electric fields 5)Static boundary conditions 6)Computation of capacitance 7)Laplace's equation 8)Current density and Ohm's Law 9)The Biot-Savart Law 10)Magnetic field characteristics 11)Computation of Inductance 12)Faraday's Law of electromagnetic induction 13)Maxwell's equations 14)Time-harmonic fields 15)Plane electromagnetic waves in various media 16)Plane waves at boundaries 17)Transmission lines 18)Smith charts 19)Basic antenna theory 20)Impedance matching.

Prerequisite: E E 210 , MATH 230

EE 340: Introduction to Nanoelectronics

4 Credits

Introduction to the physics and technology of nanoelectronic devices. E E 340 Introduction to Nanoelectronics (4) This is a required course for junior-level electrical engineering students. The first part of the course provides an introduction to the key aspects of electronic materials, quantum mechanics, and solid state physics needed to understand nanoelectronic devices. The second part is devoted to the fundamental theory of carrier transport including ballistic transport, drift, diffusion, and recombination/generation. The third part of the course applies the fundamentals to describe the operation of several basic semiconductor devices: p-n junctions, metal-semiconductor junctions, and metal oxide semiconductor field effect transistors (MOSFETs), and provides an introduction to fabrication methods used to create these devices. This portion of the course also highlights contemporary concepts in thin film electronics, optoelectronic devices, and solar energy conversion.The course includes several in-class demonstrations and also web-based remote device measurement laboratories. One of the in-class demonstrations uses a Breeze interface to link a field emission scanning electron microscope session to the classroom. The students can see and communicate with the microscope operator to visualize real nanoelectronic materials and devices at different levels of magnification. The remote device measurement laboratories use web-based labview software to collect device characteristics from silicon p-n junctions and MOSFETs fabricated in the senior level device technology class. The students are given microscope images of the devices and an assignment to analyze the device performance. This allows the students to compare ideal text book performance to non-ideal device response.

Prerequisite: PHYS 214 , E E 210

EE 341: Semiconductor Device Principles

3 Credits

Quantitative description of properties and behavior of materials with application to integrated circuits, photonic devices, and quantum wellf devices.

Prerequisite: E E 210 or Prerequisite or concurrent: E E 315

EE 350: Continuous-Time Linear Systems

4 Credits

Introduction to continuous-time linear system theory: differential equation models, sinusoidal steady-state analysis, convolution, Laplace transform and Fourier analysis.

Prerequisite: E E 210 , MATH 220 , MATH 250

EE 351: Discrete-Time Linear Systems

3 Credits

Introduction to discrete-time signal processing: sampling, linear time-invariant systems, discrete-time Fourier transform and discrete Fourier transform, Z transform.

Prerequisite: E E 350

EE 351H: Discrete-Time Linear Systems

3 Credits

Introduction to discrete-time signal processing: sampling, linear time-invariant systems, discrete-time Fourier transform and discrete Fourier transform, Z transform.

Honors

EE 352: Signals and Systems: Continuous and Discrete-Time

4 Credits

Transient response, frequency response, Bode plots, resonance, filters, Laplace transform, Fourier series and transform, discrete-time signals/ systems; sampling z-transform. E E 352 Signals and Systems (4) E E 352 is a course designed to study the characteristics of continuous and discrete time linear systems. These include signal and power input/output relationships in both domains, impulse responses, and the differential equations that describe these systems. Convolution is an essential component of any linear systems course, therefore several classes will be devoted to this topic in order that students fully understand the concept. Fourier series is used to determine the spectral content of periodic signals thus illustrating how a signal is distributed in frequency. This is very important when determining bandwidth requirements. There will be a brief refresher on the trigonometric Fourier series then the exponential series will be studied extensively. The Fourier transform can be used to determine the spectral content of virtually any signal encountered in the undergraduate curriculum, aperiodic, or periodic. It is also valuable in determining the frequency response characteristics of linear systems. Some filter theory is included in the course along with the Laplace transform. Much of the signal processing performed today is done digitally so the remainder of the course will approach most of the aforementioned topics from the viewpoint of the discrete domain with a strong emphasis on sampling and aliasing. Finite impulse response filters will be introduced along with recursive filters using the bilinear transform method.

Prerequisite: MATH 250 ; E E 210 or E E 314 or E E 315

EE 353: Signals and Systems: Continuous and Discrete-Time

3 Credits

Fourier series and Fourier transform; discrete-time signals and systems and their Fourier analysis; sampling; z-transform. E E 353Signals and Systems: Continuous and Discrete Time (3) is a core course taken by all computer engineering students that provides exposure to a variety of topics in linear systems. The material in this course is needed for further study in image processing and data communications, both of which are major areas of specialization within the computer engineering curriculum.This course is divided into three main sections - continuous-time linear system analysis, sampling and reconstruction, and discrete-time (digital)linear system analysis. Although the material covered in the first and last sections is similar, fundamental differences between continuous- and discrete-time exist. One of the goals of this course is to make the student aware of these differences.The first part of the course discusses continuous-time linear system analysis. It begins with basic time-domain mathematical descriptions of various signals and systems. The bulk of the analysis, however, is in frequency domain approaches such as the Fourier Series and the Fourier Transform. Applications such as modulation and multiplexing are understood much easier using frequency-domain analysis approaches.The middle part of the course deals with the bridge between continuous- and discrete-time, namely signal sampling and reconstruction. Theoretical and practical approaches to sampling/reconstruction are covered. Finally the Nyquist sampling theorem, which is the key to all digital signals, is developed. At this point, students are ready to study discrete-time systems.The final part of this course revisits system analysis, although now discrete-time (or digital) systems are considered. As in the continuous-time case, both time-domain and frequency-domain approaches to the analysis problem are discussed. The course ends with select topics in the z-transform, which is the digital counterpart to the Laplace transform.

Prerequisite: E E 210 ; CMPSC201 or CMPSC121 ; MATH 250

EE 360: Communications Systems I

3 Credits

Generic communication system; signal transmission; digital communication systems; amplitude modulation; angle modulation. E E 360 Communications Systems (3) E E 360 is a junior-level elective course in the electrical engineering curriculum that provides a detailed foundation of communications systems, expanding on the topics covered in a standard linear systems class. The first part of the course deals with analog communications. First, analog amplitude modulation (AM) is presented, covering double-sideband suppressed carrier, double-sideband large carrier, single sideband, and vestigial sideband modulation formats. Detection techniques for these modulation schemes are also covered. The phase-locked loop for coherent carrier tracking is also presented. Second, analog angle modulation is presented in the forms of frequency modulation (FM) and phase modulation (PM). Estimating the bandwidth of the angle modulated carrier is covered, as well as various generation and detection methods. After analog communications are covered, the basics of digital modulation are presented. Sampling theory and analog-to-digital conversion are covered. Particular attention is paid to the signal-to-noise ratio and the aggregate bit rate at the output of the digital modulator. The principles of Nyquist pulse shaping are presented. Particular topics include intersymbol interference, line coding, and power spectral density. A presentation of emerging digital communications technologies concludes the course. Topics may include mobile radio, high definition television, broadband services, video compression, and high-speed local area networks.

Prerequisite: E E 350 or E E 352

EE 362: Communication Networks

3 Credits

Data transmission, encoding, link control techniques; communication network architecture, design; computer communication system architecture, protocols. CMPEN 362CMPEN (E E) 362 Communication Networks (3)CMPEN (E E) 362 is an elective course in both the electrical and computer engineering curricula which provides an overview of the broad field of data and computer communications. First, a general model of the communication task is presented, including the layered concept by which each layer provides services for the layer above. First, the lowest (physical) layer is studied. This involves signal design, Fourier analysis representations, bandwidth concepts, transmission impairments and communication media properties. Then the next higher (link) layer is considered which involves organizing bits into frames, data link and error control methods (including frame sequence numbering and error detection principles). Multiplexing to share a link is studied, including frequency division multiplexing, dedicated time division multiplexing, and statistical time multiplexing.At the network layer level, there are two categories: broadcast (usually local area) and switching networks. Broadcast and local area network studies include bus, tree and star topologies, Ethernet, optical fiber bus networks, ring networks, and medium access control protocols.Switching and routing concepts for networks are explained, including both circuit and packet switching, datagrams and virtual circuits. Properties of frame relay and asynchronous transfer mode (ATM) networks are described. Internetworking frame structures, routing and protocols are studied. Also, bridge routing for local networks is described.At the still higher transport (network end-to-end control) layer, transport protocols, including TCP/EP, are described.

Prerequisite: CMPEN270 or CMPEN271; Concurrent: STAT 301or STAT 318 or STAT 401 or STAT 414 or STAT 418
Cross-listed with: CMPEN 362

EE 380: Introduction to Linear Control Systems

3 Credits

State variables; time-domain and frequency-domain design and analysis; design of feedback control systems; Root Locus.

Prerequisite: MATH 220 ; E E 350 or E E 312

EE 383: Signals and Controls Laboratory

1 Credits

Design, computer simulation, and practical implementation of systems in the areas of filtering, digital signal processing, and controls. E E 383 Signals and Controls Laboratory (1) In this course, students will be exposed to designing, simulating and implementing practical circuits for filtering of signals, digital signal processing, and control of physical processes. The design aspect of the course will be a direct extension of the two associated lecture courses (E E 352 and E E 380). The simulations will use industry standard software tools (e.g., MATLAB, Hyperception, C/C++) while the actual implementation will be accomplished using PC based DSP hardware in addition to analog circuitry. This will be a hands-on laboratory intended to augment the material presented in E E 352 and E E 380. Students will be expected to do a large portion of pre-lab work before starting the laboratory session.

Concurrent: E E 352; E E 380

EE 387: Energy Conversion

3 Credits

Modeling of induction machines, synchronous machines, transformers, and transmission lines. E E 387 Energy Conversion (3) E E 387 is an electrical engineering technical elective course intended for students with an interest in energy conversion in electrical, electromagnetic, electromechanical, and electrochemical systems.The course begins with a review of static and quasi-static electromagnetics. In particular, methods of determining electromagnetic forces and torques will be discussed in detail. The course will then present methods of developing models for electromagnetic, electromechanical, and electrochemical systems and discuss the use of these models in the analysis and design of devices such as inductors, transformers, actuators, transducers, and rotating machines. Furthermore, fundamental concepts related to the operation of power electronic circuits, which often interface with these types of devices, will be presented.The course includes a lab component where students gain experience with the analysis and design of energy conversion systems. E E 350, Continuous-Time Linear Systems, is a prerequisite for this course.

Prerequisite: E E 350 or E E 312

EE 395: Internship

1-18 Credits/Maximum of 18

Supervised off-campus, nongroup instruction including field experiences, practica, or internships. Written and oral critique of activity required.

Prerequisite: prior approval of proposed assignment by instructor
Full-Time Equivalent Course

EE 396: Independent Studies

1-4 Credits/Maximum of 4

Junior-level honors course involving special individual projects under the direction of an electrical engineering faculty member.

Prerequisite: junior standing
Honors

EE 397: Special Topics

1-9 Credits/Maximum of 9

FORMAL COURSES GIVEN INFREQUENTLY TO EXPLORE, IN DEPTH, A COMPARATIVELY NARROW SUBJECT THAT MAY BE TOPICAL OR OF SPECIAL INTEREST.

EE 399: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)

EE 400: Engineering Design Concepts

3 Credits

Engineering design and modelling, engineering economy, project planning, capstone project selection, and technical communication skills. E E 400 Engineering Design Concepts (3) This course prepares senior electrical engineering students for industrial engineering design and project management. It covers the engineering design process, project planning and evaluation, engineering ethics, and engineering economy. . In addition, students select, specify, and start their capstone design project which is completed in the follow-up course, EE BD 481. Students are expected to carry out a group design project that is on par with industrial expectations. Upon completion of this course a student should have a solid understanding of the engineering design process, a clear capstone project description, should have completed some preliminary design work, and be adequately prepared to complete the project in E E 401.

Prerequisite: E E 313W ; E E 316 ; E E 352 ; E E 380 ; seventh-semester standing

EE 401: Electrical Design Projects

3 Credits

Group design projects in the areas of electronics and electrical/computer systems. E E 401 Electrical Design Projects (3) In this course students complete their senior design project started in E E 400. Design groups meet regularly with a faculty advisor to report progress and resolve design issues. Oral and written progress reports are expected at selected times. The class culminates with a final technical defense of the project.

Prerequisite: E E 400 ; eighth-semester standing

EE 403: Capstone Design

3 Credits

Design projects in the various areas and subdisciplines of electrical engineering, with an emphasis on technical communication skills. EE 403 Capstone Design (3) will give electrical engineering students a "real-world simulation" of a total design experience. Students will address design challenges in one of several ways: a. Projects submitted by corporate sponsors which emphasize teaming and interaction with a customer and with professional engineers in a pseudo-professional engineering environment. Some of these projects require multi-disciplinary teams. b. Projects in "Special Focus" sections in which all of the projects will loosely deal with a particular electrical engineering topic . Examples of Special Focus topics include: Microwave engineering, RF engineering, Acoustics and Microcontrollers. Small-team projects or class-wide projects will be offered at the discretion of the instructor. c. "Projects with Faculty" are arranged on the initiative of individual students or student teams, who solicit a mentoring relationship with faculty in an area of shared interest. Projects with faculty may include research projects, projects associated with internship experiences, and projects associated with student organization competitions or activities. In addition to the completion of a capstone project, EE 403 includes an emphasis on technical communication and professional behavior. Students will develop their skills at conveying technical information through technical writing, oral presentation and graphics (such as a project poster or web page). Students will be expected to conduct themselves in a professional manner during project-related interactions with fellow students, faculty, and practicing engineers. Student work is evaluated on the technical merit of the completed project and the degree to which constraints and priorities (as expressed in the engineering requirements) are acknowledged throughout the design process.

Prerequisite: E E 300;ENGL 202C
Writing Across the Curriculum

EE 405: Capstone Proposal Preparation

1 Credits

Performing the initial research needed for the capstone course, and the preparation of the written project proposal. E E 405 Capstone Proposal Preparation (1) The capstone design course will incorporate engineering standards and realistic constraints including most of the following considerations: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political. While engineering constraints are included in the earlier courses, the senior capstone design requires integration of the appropriate engineering constraints into the capstone design course. This course will mimic the problems encountered by an engineer working in commercial, industrial, and governmental entities. This basically requires that students in the Electrical Engineering BS program select a topic prior to starting the semester of their capstone design course, do the initial research for the topic, prepare a timeline, and prepare a well written proposal that would make a suitable capstone project. The time devoted to the careful topic selection, research, timeline, and proposal preparation, makes for a much better capstone design experience.

Prerequisite: senior level standing; ENGL 202C ; CAS 100

EE 406: Electrical Engineering Capstone Design

3 Credits

Project designs of analog and digital systems, interfacing, and relevant electronic circuits, with an emphasis on technical communications skills. EE 406 Electrical Engineering Capstone Design(3) is designed with the following goals and objectives: * The students will enter the course with a well-defined capstone design proposal and a timeline for which the first task will be to write the specifications. Upon the specifications' approval, the student teams will begin designing and building the projects. * Each student will maintain a laboratory notebook that documents the day-to-day activities of the project in a style that could be used for patent documentation. * Team members will provide short oral and written reports every week for the first five to six weeks, and then, every two weeks until the end of the semester. * The students will incorporate engineering standards and constraints, i.e., consideration of economic, environmental, sustainability, manufacturability, ethical, safety, etc., in their project and final report. * A draft copy of the final report will be collected, critiqued, and returned to students with comments and suggestions for changes. * A final project oral report (20 - 25 minutes) will be given by the project team during the last week of the semester. * An extensive well-written report describing the project that has been designed and built, is the major outcome of the capstone design course. This course is a required course in the Electrical Engineering BS curriculum and is intended to be taken by seniors as the capstone course for the major. As such, the course integrates materials from many of the undergraduate electrical courses in addition to related math, engineering, and science courses.

Prerequisite: E E 405
Writing Across the Curriculum

EE 410: Linear Electronic Design

3 Credits

Linear circuit design via integrated circuit processes; A/D converters, switched capacitor filters, phase lock loops, multipliers, and voltage-controlled oscillators. E E 410 Linear Electronic Design (3) E E 410 is a technical elective intended for electrical engineering students who wish to specialize in semiconductor circuits, especially in linear circuit design. The course emphasizes integrated circuit process-compatible circuit design techniques in recognition of the amazing synergy that has characterized the relationship between modern circuits and integrated circuit processing technology. This course is the third in a series of three courses dealing with the analysis and design of electronics circuits, following E E 310 and E E 311. E E 410 includes three lectures and a two-hour laboratory each week.E E 410 begins with a deeper look into several key concepts previously considered in earlier course work, such as node voltage and mesh current methods for solving circuits, which are emphasized throughout the course. The small-signal method is revisited and thoroughly examined. The more advanced Ebers-Moll bipolar junction transistor model is introduced and the metal oxide semiconductor field effect transistor device model is reviewed.The next phase of the course introduces the vertical geometries of integrated circuit devices commonly used in linear circuits. Unwanted parasitic devices that are introduced as a result of the integrated circuit processes are revealed and their effects on circuit sign techniques operation are discussed. Both the limitations and the opportunities provided by integrated circuit technology are examined, particularly in the light of de used to minimize the problems and to take advantage of the features.The last half of the course is devoted to applications of linear circuits, especially those which students have not previously encountered. The first topics in this series are analog-to-digital and digital-to-analog conversion. Various methods of accomplishing each of these functions are examined. The inverse relationship between speed and accuracy is emphasized. These topics are followed by studies of switched capacitor filters, phase lock loops, analog multipliers, and voltage-controlled oscillators.The emphasis of the laboratory component of the course is to successfully accomplish a student-chosen linear circuit design project. Students work in two- or three-person teams to select their project and do the design and evaluation. A three-way methodology is emphasized; mathematical analysis by hand, computer simulation, and laboratory breadboarding and measurement. At the end of the project students give an oral presentation and submit a formal engineering report.

Prerequisite: E E 311

EE 413: Power Electronics

3 Credits

Switch-mode electrical power converters. Electrical characteristics and thermal limits of semiconductor switches. E E 413 Power Electronics (3) E E 413 is an elective course taken by undergraduate and graduate electrical engineering students. The objective of E E 413 is to introduce techniques for the analysis, design, and application of the switch-mode power converters that are used in power supplies, motor and actuator drives, and the interface between power distribution systems and emerging energy sources such as fuel cells, photovoltaics, and superconducting magnetic energy storage systems. Several laboratory experiments provide an opportunity to characterize the switching behavior of semiconductor devices, build and test various dc/dc and ac/dc converters, and consider alternatives for gate/base drive and feedback isolation circuits required to build practical converters.This course draws upon the students' background in time-domain circuit analysis, electronic devices and circuits, Fourier analysis, and use of software such as PSPICE and MATLAB. It does not require a background in power or electric machinery, although students with such a background will be able to appreciate many of the applications more fully.The course is divided into four major areas: rectifiers and phase-controlled converters, dc-to-dc converters, inverters, and design considerations for practical converters. The focus in each of the first three areas is to determine the relationship between the magnitude of the fundamental frequency component and/or average value of the voltages and currents at the two ports of the particular converter. Additional harmonic or ripple components are then considered and design guidelines for the switching and reactive components are derived. The fourth area encompasses the study of power device characteristics, the design of gate drive and feedback circuits, and the analysis/design of elementary controllers.As the name implies, students interested in either electronics or power will find this course worthwhile. Electronics students will gain a new perspective on the operation and analysis of electronic circuits as well as an opportunity to discover what has powered the circuits that they have studied up until this course. Power students will see how and why power electronics are revolutionizing motor control and power distribution as well as the power quality issues associated with electronic power conversion.

Prerequisite: E E 310 ; E E 350 or E E 352

EE 416: Digital Integrated Circuits

3 Credits

Analyses and design of digital integrated circuit building blocks, including logic gates, flip-flops, memory elements, analog switches, multiplexers, and converters. CMPEN 416CMPEN 416 Digital Integrated Circuits (3)CMPEN 416 is a technical elective available to electrical and computer engineering students. It is intended for students who wish to specialize in the field of digital circuits. This course introduces the basic concepts involved in the design of digital circuits, which find practical application as logic and memory circuits in computers and other digital processing systems. The course emphasizes integrated circuit process-compatible circuit design techniques in recognition of the amazing synergy that has characterized the relationship between computer circuits and integrated circuit processing technology. This course includes three lectures and a two-hour laboratory each week. The only prerequisite is E E 310, a basic circuits course required for both electrical engineering and computer engineering students.CMPEN 416 begins with a review of the bipolar junction transistor (BJT) device and proceeds into the more advanced Ebers-Moll device model. This is followed by an examination of a series of BJT-based saturating and non-saturating digital circuits of ever increasing complexity illustrating the evolution of the modern bipolar logic circuit families. The next phase of the course reviews the metal oxide semiconductor field effect transistor (MOSFET) and proceeds along the same path taken for the bipolar transistor circuits. Various MOSFET logic circuit families are introduced and analyzed. Computer semiconductor memory circuits are considered next. Both BJT and MOSFET versions of both static and dynamic read-write and read-only memories are considered. The cell array, memory addressing circuits, and sense amplifier designs are all examined in detail. This is followed by the related subject of programmable logic arrays, the final topic.The emphasis of the laboratory component of the course is to compare the performance of representatives of each class of circuits to computer simulations of the same circuits. Parameters such as input-output voltage transfer characteristics, noise margins, and propagation delays are evaluated by building and measuring laboratory models. Most of the laboratory exercises require the student to evaluate a specified circuit, but the final exercise requires the student to design a circuit to meet a predefined set of specifications, then to prove that the design meets the requirements by measuring the circuit performance. Students are required to write a formal engineering report detailing the results of each laboratory exercise.

Prerequisite: E E 310
Cross-listed with: CMPEN 416

EE 417: Digital Design Using Field Programmable Devices

3 Credits

Field programmable device architectures and technologies; rapid prototyping using top down design techniques; quick response systems. CMPEN 417CMPEN (E E) 417 Digital Design Using Field Programmable Devices (3)Field Programmable Devices, such as Field Programmable Gate Arrays (FPGAs) and Complex Programmable Logic Devices (CPLDs) are widely used for rapid prototyping and quick response-time designs. The objective of this course is to introduce the student to digital design using Field Programmable ICs, and to provide an understanding of the underlying technologies and architectures of these Integrated Circuits.The course begins by introducing design alternatives for modern electronic systems identifying and classifying alternative system solutions, and evaluating when particular design solutions are optimal.

These alternatives include microprocessors, microcontrollers, off-the-shelf digital ICs, Programmable logic ICs (FPGAs and CPLDs), and various forms of Application Specific Integrated Circuit (ASIC) designs. A homework assignment requires the student to quantitatively evaluate the cost, complexity, packaging, and time-to-market issues for a complex system design specification.Next, the underlying Field Programmable Logic IC architectures and technologies are studied in detail. Following a broad survey of available programmable IC vendors and on-chip programming technologies (and their cost/performance trade-offs), several specific case studies are presented in the class. The first is the Xilinx XC4000xl line, because of the target boards used in the CAD laboratory component for this class. The initial lab portions of the class help the students to specify their design using various forms of design entry tools and also allows them to see how their design map on to the underlying FPGA architecture. The students also learn the underlying algorithms used by the design software they use in their Labs.Next, the systematic top-down method for specifying complex designs using VHDL is introduced. Students are given a supporting homework assignment to develop high-level behavioral models for a simple digital system to reinforce this segment of the course. VHDL behavioral synthesis is now introduced as a preferred path to go from high-level system behavior to actual implementation on the FPGA. The strengths and weaknesses of synthesis are discussed, as are the emerging CAD tool trends. Additional VHDl-based homework assignments reinforce behavioral design and synthesis using commercial CAD tools.The final segment of the class covers special topics that identify current trends in digital system architecture and programmable logic design. These include such topics as partially reconfigurable architectures and dynamic reconfiguration techniques, system design for testability, and field programmable analog arrays. Applications of FPGAs in special purpose computing environments such as signal processing, Java acceleration and image processing are also introduced. In the laboratory, student design project assignments explore larger and more complete system specifications of such things as controllers, CPU and memory design, and signal processing blocks. These assignments reinforce the lecture content as the students model, synthesize and implement their digital designs on the target Xilinx FPGA boards.

Prerequisite: CMPEN331
Cross-listed with: CMPEN 417

EE 420: Electro-optics: Principles and Devices

3 Credits

Spatially linear system and transform; diffraction theory, partial coherence theory, optical image detection, storage and display, holography.

Prerequisite: E E 320

EE 421: Optical Fiber Communications

3 Credits

Operational principles of optical components, including sources, fibers and detectors, and the whole systems in optical fiber communications. E E 421 Optical Fiber Communications (3) E E 421 is an introduction course to fiber optic communications. This course is designed as an elective course for both the E E senior undergraduate students and E E graduate students. Students are expected to have a general knowledge on fiber optic communications after taking this course. The content of this course focuses on the engineering aspects of fiber optic communications. This course is offered once a year.This course basically consists of four major parts:The first part introduces the motivations of using fiber optic communication systems, which include the huge bandwidth, low attenuation, immune from the electromagnetic field interference, et al. (1 week)The second part of this course deals with light propagation in the optical waveguides. Both the simple geometrical approach and wave optics approach are used to calculate the light propagation in the optical fiber. The geometrical approach (i.e., total internal reflection) provides an intuitive feeling about light propagation in the fiber while the wave optics approach (i.e., Maxwell" equations) provides more accurate solutions. In particular, it can explain important concepts such as the conditions for single mode fiber and intramodal dispersions in single mode optical fiber. With the help of popular calculation software (e.g., Matlab, Mathcad), students are required to solve waveguide equations for single shape optical fibers (such as step index fiber). (5 weeks)The third part of this course introduces some critical components that are needed in fiber optic communication systems. This includes the optical transmitter (laser diode), optical receiver (i.e., photodetector), modulators and demodulators (such as driving current approach and optical waveguide modulators), optical coupler (how to connect more than two fibers together), optical amplifier (including the basic principle of erbium doped fiber optic amplifiers), fiber optic gratings (a critical component for the multiple wavelengths fiber optic network systems), dispersion compensation device (such as chirped fiber optic grating based device) et al. (6 weeks)The fourth part of this course talks about fiber optic networks. The major contents include fiber optic network architectures (such as star connect), multiplexing techniques in fiber optic networks (such as wavelength division multiplexing and time division multiplexing), connection fiber optic networks with non-fiber optic networks (such as copper wire based networks), current trends in fiber optic networks, et al. (2 weeks).

Prerequisite: E E 320 ; E E 350 ; E E 340 or E E 341 or E SC 314

EE 422: Optical Engineering Laboratory

3 Credits

Hands-on experience covering areas of optical transforms, electro-optics devices, signal processing, fiber optics transmission, and holography.

Prerequisite: E E 320

EE 424: Principles and Applications of Lasers

3 Credits

Principles of lasers--generation, propagation, detection and modulation; applications in fiber optics communication, remote sensing, holography, optical switching and processing.

Prerequisite: E E 330 , E SC 400H , or PHYS 400

EE 430: Principles of Electromagnetic Fields

3 Credits

Laws of electrodynamics, boundary value problems, relativistic effects, waves in dielectrics and ferrites, diffraction and equivalence theorems.

Prerequisite: E E 330

EE 432: RF and Microwave Engineering

3 Credits

Transmission line and waveguide characteristics and components; design of RF and microwave amplifiers, oscillators, and filters; measurement techniques; design projects.

Prerequisite: E E 310 , E E 330

EE 438: Antenna Engineering

3 Credits

Radiation from small antennas, linear antenna characteristics, arrays of antennas, impedance concepts and measurements, multifrequency antennas, and aperture antennas. E E 438 Antenna Engineering (3) E E 438 is an electrical engineering technical elective course intended for students with a specialization in electromagnetics. This course presents antenna engineering concepts including in-depth studies of various antennas and arrays and computer modeling of antennas for analysis and design. The course has three lectures each week as well as an additional period for demonstrations and discussions of outside lab and computer projects. This course requires E E 330, the undergraduate electromagnetics course, as a prerequisite.E E 438 begins with a review of electromagnetics which leads into an introduction of antennas. A lecture is given which shows how the evolution of a guided wave on a transmission line eventually leads into a device that can act as a wave launcher or antenna. A series of lectures are then given introducing the various classes and types of antennas. Performance parameters such as input impedance, radiation patterns, directivity, gain, polarization, and efficiency are then discussed. Examples and pictures of many antennas and their respective patterns are shown as part of these lectures.Next, extensive lectures are given which describe definitions and antenna parameters in detail. Much time is spent on how to visualize radiation patterns and beamwidth. Derivations are carried out for directivity and gain adhering to IEEE standard definitions.Theorems are discussed on the subject of reciprocity and how it can be related to practical measurements of patterns. Another lecture deals with the subject of antenna polarization and cross-polarization. Link analysis is discussed for communication systems and real-world examples are given for its use.The second half of the course involves extensive study of various types of antennas including center-fed dipoles, monopoles, loops, phased arrays, broadband antennas, Yagi antennas, traveling wave antennas, frequency antennas, and aperture antennas.Throughout the course, students are introduced to and utilize an advanced antenna computer modeling software package for carrying out assigned projects and use in homework problems. They are also assigned a group design project during the last third of the course where extensive use of the software package is required. Each group gives an oral presentation of the project and the results during the last week of class and turns in a final report.

Prerequisite: E E 330

EE 438H: Antenna Engineering

3 Credits

Radiation from small antennas, linear antenna characteristics, arrays of antennas, impedance concepts and measurements, multifrequency antennas, and aperture antennas.

Honors

EE 439: Radiowave Propagation in Communications

3 Credits

Radiowave propagation in mobile, terrestrial, and satellite communications; applications at microwave and lower frequencies.

Prerequisite: E E 330

EE 441: Semiconductor Integrated Circuit Technology

3 Credits

An overview of fundamentals of processes involved in silicon integrated circuit fabrication through class lectures and hands-on laboratory. E E 441 Semiconductor Integrated Circuit Technology (3) E E 441 is an elective electrical engineering course typically taken by seniors and graduate students from various majors including electrical engineering, materials engineering, engineering science, physics, and chemistry. Its objective is to introduce students to the processes and procedures involved in the manufacture of advanced silicon integrated circuits (IC) using tools and methods of semiconductor nanotechnology. In the sequence corresponding to the order of IC fabrication steps, the lecture portion of the course covers fundamentals of the formation of single-crystal silicon wafers, epitaxial deposition of thin silicon layers, fundamentals of thin film semiconductors, dielectric and metal deposition techniques, patter definition by photolithography and etching, dopant introduction, and finally, contact and interconnect metallization. In selected cases theoretical considerations regarding manufacturing steps discussed are supported by process simulation using dedicated software. Besides the specific objectives listed above this course has a more general goal. Manufacturing methods and tools used to process nanochips represent the most advanced technology across a broad range of engineering domains. Experiences gained in this course advance student’s knowledge and understanding of state-of-the-art manufacturing technology that is applicable in several other domains such as nanomaterials, including nanowires, nanotubes, and nanodots, MEMS fabrication, as well as in bioelectronics, molecular electronics, spintronics and others. In addition to lectures, EE 441 has a laboratory portion that gives students an opportunity to gain hands-on experience with key processes used to manufacture advanced silicon integrated circuits. The laboratory experience helps students appreciate the intricacies of the integrated circuit fabrication procedures as well as establish connection between theoretical concepts and the outcome of the real-life manufacturing process. In the course of ten laboratory sessions students first process from scratch a simple MOS integrated circuit and then test its performance by carrying out a set of electrical tests.

Prerequisite: E E 310 ; E E 340 or E E 341 or E SC 314

EE 442: Solid State Devices

3 Credits

The physics of semiconductors as related to the characteristics and design of solid state electronic devices. E E 442 Solid State Devices (3) The objective of E E 442, an electrical engineering elective course taken by seniors and graduate students, is to develop a rigorous introduction to the relevant concepts in quantum mechanics and statistical mechanics pertaining to understanding the key physical mechanisms that govern the electrical, optical and even mechanical behavior of semiconductor materials and devices. This course explicitly deals with the physics of operation of electronic and optoelectronic devices, and expounds on the practical aspects of device design given the inherently non-ideal nature of semiconductor devices in real life. The course typically features a couple of invited guest lectures from leading experts involved in the state-of-the-art research on semiconductor materials and devices so that seniors and first year graduate students learn about the recent advances in electronic and optoelectronic devices which reside outside the scope of the recent text books. Nanoelectronics today is a very broad discipline that extends the traditional solid-state devices such as transistors, diodes, resistors, capacitors, photodetectors, laser diodes commonly found in electronic and optoelectronic integrated circuits to a variety of emerging technologies such as large area flexible electronics, energy conversion devices, chemical and biological sensors, microelectromechanical devices. A continuous trend of fundamental breakthroughs at the materials and device architecture level keeps this field exciting and opens up new application space hitherto unexplored. The opportunity exists for the students taking this course to get introduced at a broad level to each of these areas. This course will serve as a cornerstone of the students’ electronics education should they join the 275 billion dollar global semiconductor industry or should they decide to pursue graduate education in the area of advanced materials and devices.

Prerequisite: E E 310 ; E E 340 or E E 341 or E SC 314

EE 453: Fundamentals of Digital Signal Processing

3 Credits

Design of FIR and IIR filters; DFT and its computation via FFT; applications of DFT; filter implementation; finite arithmetic effects. E E 453 Fundamentals of Digital Signal Processing (3) The objective of E E 453, an electrical engineering elective course taken by seniors and graduate students, is to develop a rigorous, yet elementary, introduction to the fundamentals of one-dimensional discrete-time (digital) signal processing. The main topics in the course are the analysis and design of finite impulse response (FIR) and infinite impulse response (IIR) digital filters, the discrete Fourier transform (DFT) and its computation via the fast Fourier transform (FFT), and error analysis due to the constraints of finite arithmetic.The emphasis on the analysis and design of linear time-invariant discrete-time filters rests on the background acquired in the time as well as transform domain analysis of continuous-time and discrete-time signals and systems interfaced via the Shannon sampling theory.The students are alerted about topics outside the main thrust of the course mentioned above and these peripheral issues (that lead to more advanced subject matter pursued in depth in subsequent signal processing courses) include interpolation, decimation, and multirate digital signal processing.There is also a laboratory portion of E E 453 that exposes students to the use of digital signal processing workstations -- a collection of hardware and software that is used to acquire, digitize, filter, analyze, and display a variety of real-life signals. This hands-on experience helps the student appreciate and understand theoretical concepts covered in class like the sampling and reconstruction of continuous-time signals, IIR and FIR filter design, and error analysis.

Prerequisite: E E 351 or E E 352 or E E 353

EE 454: Fundamentals of Computer Vision

3 Credits

Introduction to topics such as image formation, segmentation, feature extraction, matching, shape recovery, object recognition, and dynamic scene analysis. CMPEN 454CMPEN 454 Fundamentals of Computer Vision (3)CMPEN 454 is an introduction to computer vision. The goal of computer vision is to make computers understand and interpret visual information. Computer vision systems bring together imaging devices, computers, and sophisticated algorithms for solving problems in areas such as industrial inspection, medicine, document analysis, autonomous navigation, and remote sensing. The course involves both pedagogical written assignments and computer projects.The beginning of the course gives an overview of computer vision and introduces low level image analysis techniques for binary images. Binary vision systems are useful when the silhouette of imaged objects convey enough information to recognize them. Examples can be found in optical character recognition, chromosome analysis and recognition of industrial parts. Moreover, many techniques developed for binary systems can be applied to gray level or color images. Next, the course covers image segmentation and contours. These topics are the foundation of most computer vision techniques. For an image to be correctly interpreted, it must be partitioned into regions that correspond to distinct objects or parts of objects. First, region based techniques such as thresholding, split and merge, region growing and texture analysis are introduced. Next, edge based techniques using gradient and Laplacian operators are discussed. Finally, contour representations and curve approximations linking edges into region boundaries are studied.Next, depth from vision, with emphasis in stereo vision, is considered. Calculating distances to and among various points in the scene is important in many computer vision tasks such as inspection, robot manipulation, and autonomous navigation. In this part of the course the geometry of stereo systems and how to obtain depth maps from stereo image pairs is studied. Also, alternative 3D imaging sensors such as laser based range finders and radars are discussed.Following stereo, the topic of computer vision is broaden to understand sequences of images over time. In this section techniques using information on spatial and temporal changes are used to design computer vision systems capable of coping with moving and changing objects, changing illumination and changing viewpoints. Visual motion is important primarily for two reasons. First, motion is a very important cue to understand the scene structure. Second, biological systems do use motion to infer properties of the surrounding world with very little a priori knowledge.Finally, the topic of 3D object recognition is discussed. Object recognition entails two main issues: object identification and object localization. Identification determines the objects being imaged while localization determines their position in the world and with respect to the sensors. This topic builds upon all the different techniques discussed until this point.

Prerequisite: MATH 230 or MATH 231 ; CMPSC121 or CMPSC201
Cross-listed with: CMPEN 454

EE 455: An Introduction to Digital Image Processing

3 Credits

Overview of digital image processing techniques and their applications; image sampling, enhancement, restoration, and analysis; computer projects. E E (CMPEN) 455 An Introduction to Digital Image Processing (3) E E/CMPEN 455, a technical elective available to both electrical and computer engineering seniors and graduate students, discusses many current techniques for processing and manipulating digital images. The course involves both pedagogical written assignments and computer projects.The beginning of the course gives an overview of digital image processing systems and digital image fundamentals. During this unit, important elements of human visual perception are reviewed; these ideas help motivate many of the computer-based techniques described in subsequent units. Also, the standard model for a digital image, in addition to the concepts of sampling and quantization, are described. Finally, basic topological concepts between digital image pixel are discussed.The next unit considers image transform analysis, with a primary focus on Fourier-based techniques. The one-dimensional Fourier transform is reviewed, and then two-dimensional Fourier transform analysis is discussed. To bridge the gap from the continuous world to the digital world, the sampling theorem is introduced. Next, the Discrete Fourier Transform and its properties are described. Fourier-based filtering techniques, such as the ideal low-pass and Butterworth filters are then introduced. The Fast Fourier Transform is also discussed. Finally, the Discrete Cosine Transform, used later in JPEG and MPEG, is introduced.The next unit discusses techniques for image enhancement and segmentation. These techniques include point-based techniques based on histogram analysis. They also involve linear and nonlinear mask-based methods for noise reduction and region sharpening. Further, techniques of mathematical morphology, which involve an application of set-theoretic concepts to image processing, are described. Finally, image segmentation methods, based on edge detection and thresholding, are described.The final unit considers the concept of image compression. Techniques for image encoding and decoding are discussed. A brief model of the encoding-decoding process is described. Next, compression techniques, such as run-length encoding and Huffman coding, are described. Finally, the multimedia image-compression methodologies, JPEG and MPEG, are discussed.

Prerequisite: E E 350 or E E 353 ; CMPSC201 or CMPSC121
Cross-listed with: CMPEN 455

EE 456: Introduction to Neural Networks

3 Credits

Artificial Neural Networks as a solving tool for difficult problems for which conventional methods are not applicable. E E (E SC/EGEE) 456 Introduction to Neural Networks (3) This course is in response to students needs to learn Artificial Neural Networks (ANN) as a solving tool for difficult problems for which conventional methods are not available. The objective of this course is to give students hands-on experiences in identifying the best types of ANN, plus developing and applying ANN to solve difficult problems. Students will be introduced to a variety of ANN and will use their training skills to solve their own applications. During this course the students will develop a final project, in which they will apply ANN to widely varied problems.Examples: I) students from E E may be interested in applying ANN to solve control problems; II) students from Material Sciences may be interested in applying ANN to predict the pitting corrosion of components; III) students from Petroleum Engineering may be interested in applying ANN to characterize the life of a reservoir; IV) students from Agricultural Engineering may be interested in applying ANN to sort apples automatically, etc.

Prerequisite: CMPSC201 or CMPSC202 ; MATH 220
Cross-Listed

EE 458: Digital Image Processing and Computer Vision

3 Credits

Principles of DSP and computer vision, including sensing preprocessing, segmentation, description, recognition, and interpretation. E E (CSE) 458 Communication Networks (3) E E (CSE) 458 is an elective course in both the electrical and computer engineering curricula which provides an overview of the broad field of data and computer communications. First, a general model of the communication task is presented, including the layered concept by which each layer provides services for the layer above. Next, the lowest (physical) layer is studied. This involves signal design, Fourier analysis representations, bandwidth concepts, transmission impairments and communication media properties. Then the next higher (link) layer is considered which involves organizing bits into frames, data link and error control methods (including frame sequence numbering and error detection principles). Multiplexing to share a link is studied, including frequency division multiplexing, dedicated time division multiplexing, and statistical time multiplexing.At the network layer level, there are two categories: broadcast (usually local area) and switching networks. Broadcast and local area network studies include bus, tree and star topologies, Ethernet, optical fiber bus networks, ring networks, and medium access control protocols.Switching, and routine, concepts for networks are explained, including both circuit and packet switching, datagrams and virtual circuits. Properties of frame relay and asynchronous transfer mode (ATM) networks are described. Internetworking, frame structures, routing and protocols are studied. Also, bridge routing for local networks is described.At the still higher transport (network end-to-end control) layer, transport protocols, including TCP/IP, are described.

Prerequisite: E E 352
Cross-Listed

EE 460: Communication Systems II

3 Credits

Probability fundamentals, digital/analog modulation/demodulation, system noise analysis, SNR and BER calculations, optimal receiver design concepts, introductory information theory. E E 460 Communication Systems Performance Analysis (3) E E 460 is an elective course in the electrical engineering curricula that provides detailed performance analysis of communications systems studied in E E 360.First a review of axiomatic approach to probability theory is presented, including review of random variables, their statistics, central-limit theorem and correlation function. This is followed by a review of the theory of random processes including power spectral density, multiple random processes, their transmission through linear systems and band-pass random processes.Then, behavior of analog systems in the presence of additive white Gaussian noise (AWGN) is analyzed. As a benchmark, signal-to-noise ratio is derived for a base band system. This is followed by a performance assessment of amplitude modulated and frequency modulated systems and comparison is made to the base band system performance. Concepts of optimum pre-and de-emphasis systems are explained.Behavior of digital communication systems in AWGN is studied. This includes optimum threshold detection and general analysis of optimum binary receivers. Performance of carrier modulation systems ASK, FSK, PSK and DPSK is derived in terms of average bit error rate (BER) as a function of bit-energy-to-noise density height. M-ary communications systems are analyzed. Synchronization issues are discussed.This is followed by the theory of optimum signal detection; geometrical representation of signals and signal spaces, Gaussian processes, optimum receiver and equivalent signal sets are illustrated by several examples. BER performance analysis of complex digital modulated systems is demonstrated, using the developed signal space concepts.

Prerequisite: E E 360

EE 461: Communications I

4 Credits

Element of analog and digital communication systems, AM, FM, and digital modulation techniques, receivers, transmitters, and transmission systems, noise.

Prerequisite: E E 352

EE 466: Introduction to Software-Defined Radio

3 Credits

An overview of the principles of software-defined radio systems with laboratory component.

Prerequisite: E E 351 or E E 352 or E E 353 , E E 360 or E E 461

EE 471: Introduction to Plasmas

3 Credits

Plasma oscillations; collisional phenomena; transport properties; orbit theory; typical electric discharge phenomena.

Prerequisite: E E 330 or PHYS 467
Cross-listed with: AERSP 490, NUCE 490

EE 472: Space Astronomy and Introduction to Space Science

3 Credits

The physical nature of the objects in the solar system; the earth's atmosphere, ionosphere, radiation belts, magnetosphere, and orbital mechanics.

Prerequisite: E E 330 or PHYS 400
Cross-listed with: AERSP 492

EE 474: Satellite Communications Systems

3 Credits

Overview of satellite communications systems, principles, space platforms, orbital mechanics, up/down links and link budgets, modulation techniques. E E 474 Satellite Communications Systems (3) This course is designed to give seniors and graduate students an overview of the principles of satellite communications systems. Building on junior-level courses in electromagnetics and communications, it shows how complex satellite systems operate and provide services that we depend on, such as telephone, television, weather forecasting, and global positioning. Specific topics include: historical background on how satellite systems came to be, present uses of satellite systems, and future trends in satellite systems design, construction, and uses; orbital mechanics and launch systems and vehicles; earth stations; radio propagation and link analysis; signals and satellite access methods. Student performance is evaluated via exams, homework assignments, and projects. Hands-on experience in the design of satellite communications links is gained through the use of industry-standard satellite system analysis software. In their design, the student must achieve specific goals of satellite accessibility, earth coverage footprint, orbital launch and stability, and communications link budget.

Prerequisite: E E 330 and E E 360

EE 477: Fundamentals of Remote Sensing Systems

3 Credits

The review of fundamental physical properties leads into discussions of various techniques, including imaging, spectroscopy, radiometry, and active sensing.

Prerequisite: E E 330 or METEO436
Cross-listed with: METEO 477

EE 480: Linear Systems: Time Domain and Transform Analysis

3 Credits

Signals and systems representations, classifications, and analysis using; Difference and Differential equations, Laplace transform, z-transform, Fourier series, FT, FFT, DFT. E E 480 Linear Systems: Time Domain and Transform Analysis (3) Linear Systems: Time Domain and Transform Analysis, is a recommended graduate level course for the Master of Engineering in Electrical Engineering at Capital College, since it is a prerequisite for most of the E E prefixed courses offered at this location. The major topics covered in this course include; Signals and Systems representations, classifications, and analysis using; Difference and Differential Equations, Laplace Transform, z-transform, Fourier series, Fourier Transform, Fast Fourier Transform (FFT), Discrete-Time Fourier Transform (DTFT) and Discrete Fourier Transform (DFT). The objective of this course is to develop intuitive and practical understanding of the essentials in signals and systems. The stress is on fundamentals of representation, and analysis of signals and their applications to systems in both discrete and continuous time and frequency domains. This course is designed to prepare the graduate students for more advanced work in broad range areas including communications, control systems, power systems, computer engineering, signal processing and image processing. The quality of students' performances and therefore their course grades are determined via their performance in a midterm exam, a comprehensive final exam, homework assignments, and a course project in accordance with the university's grading policy.

Prerequisite: graduate standing

EE 481: Control Systems

4 Credits

Classical/modern approaches to system analysis/design; time/frequency domain modeling, stability, response, optimization, and compensation. E E 481 Control Systems (4) This course presents both classical and modern approaches to the modeling, analysis and control system design for continuous time systems. Students learn how to model both mechanical and electrical systems in the time and frequency domains using differential equations, transfer functions, state space methods and frequency domain (Bode) techniques. The goal of developing linear system models is to facilitate system analysis and control design. Modeling is followed by an in-depth study of systems analysis, including stability, transient response and steady state characteristics. The study of stability involves examining the effects of pole and zero placement, and the Routh criterion is used extensively. In the consideration of transient response characteristics, students investigate rise time, peak time, overshoot, and settling time. The primary steady state feature studied is the error between the reference signal input and the system output, and students learn to characterize steady state error through the determination of system type and computation of the error constants. Design of control systems focuses on altering one or more of the system characteristics by adding compensation. Students employ a variety of root locus techniques, proportional-plus integral-plus-derivative (PID), state feedback, and frequency response methods. Students begin with simple proportional, closed-loop control and examine pole migration through root locus plots. They then learn to apply more robust pole placement techniques using proportional and derivated (PD) control. Next, PID controllers are examined with a number of opportunities for design. After learning the classical control techniques, students then concentrate on state feedback control methods, including the design of partial- and full-order observers. Finally, students learn the relationship between time domain analysis and design and frequency domain (Bode) analysis of both magnitude and phase. This course includes a laboratory in which students use MATLAB and Simulink for modeling, analysis and control system design. A minimum of seven laboratory exercises offer students the opportunity to experiment with nearly every concept in a powerful simulation environment. To be successful in this course, students should have a solid background in differential equations, Laplace transform techniques, Bode analysis, linear algebra, complex variables, and they should have a familiarity with MATLAB.

Prerequisite: PHYS 211 ; E E 352

EE 482: Introduction to Digital Control Systems

3 Credits

Sampling and hold operations; A/D and D/A conversions; modeling of digital systems; response evaluation; stability; basis of digital control; examples. E E 482 Introduction to Digital Control Systems (3) E E 482 introduces fundamental concepts that will enable the student to analyze, design, and synthesize closed-loop systems that contain a digital computer. In order to successfully complete this course the student must have a foundation in classical control (E E 380 or equivalent) and discrete-time system concepts (E E 351 or equivalent). Problem solving is emphasized. Concepts introduced in lecture are reinforced by a series of laboratory projects and weekly problem sets. Through these exercises the student will acquire competence in analytical and computer aided analysis techniques.The course covers several topic areas including modeling of sampled-data systems, system identification using the batch least squares method, time response characteristics, stability analysis techniques, discrete-time approximation of continuous-time controllers, classical design methods based on root locus and frequency response, and modern design methods including state and observer feedback design.Laboratory projects include system identification and control design based on the root locus, frequency response, and state-feedback methods. Each project involves the use of either a servomechanism or a fluid testbed. Laboratory projects and problem sets will develop the student's appreciation for computer aided control system analysis and design techniques. Student performance is assessed using homework, laboratory projects, hour exams, and a final exam.

Prerequisite: E E 380 ; E E 351 or E E 352

EE 483: Introduction to Automation and Robotics Systems

3 Credits

Introduction to robotics systems with emphasis on robotic motion and control, and robotic components such as actuators and sensors.

Prerequisite: E E 481

EE 484: Control System Design

3 Credits

Analysis and design of automatic control systems using time, frequency domain and state variable methods.

Prerequisite: E E 481

EE 485: Energy Systems and Conversion

3 Credits

Overview of energy alternatives available, and study of theory of operation and models of major energy conversion devices. E E 485 Energy Systems and Conversion (3) The course is designed to give students an overview of available energy alternatives, and to study the fundamental theory of operation and system models for major energy conversion devices. The topics covered give students the tools to assess the viability of various energy options, their applications, and their impact on the environment. Various forms of raw energy sources used in powering conventional electric generating plants such as coal, natural gas, oil, and uranium will be studied, along with worldwide distribution and reserves. The analytical tools for determining quantities of energy that could be extracted from the wind, water falls, and solar energy sources using practical devices will be presented in the course as well as various case studies. The state of the art in energy storage technology and its impact on electrical vehicle range will be presented in the first half of the semester. The second half of the semester 's devoted to studying the theoretical fundaments and applications of major energy conversion devices. Magnetic circuits covers the electrical circuit model and analog for studying energy transfer involving magnetic systems. The link to a direct application - power transformers is established, and then to rotating magnetic machines in general. The poly-phase AC induction motor circuit model, energy flow, and selection for various load types will be covered. Modem speed control techniques using inverters will also be covered. The principles of operation of the synchronous energy converter will be explored and its unique features. The power angle characteristics and its relationship to stability of a power system will be covered. Presentation on theory and applications of classical DC motors and generators, and the newer permanent magnet (PM) machines with their superior performance characteristics and energy density will conclude the semester.

Prerequisite: E E 314 or E E 315 ; MATH 250
Cross-Listed

EE 487: Electric Machinery and Drives

3 Credits

Analysis of variable-speed drives comprised of AC electric machines, power converters, and control systems. E E 487 Electric Machinery and Drives (3) This course is a technical elective intended for seniors and graduate students interested in electromechanical systems. The first part of the course (approximately two thirds) is devoted to fundamental theory in the modeling and analysis of power converters and AC electric machines. The second part is devoted to the theory and implementation of two specific control schemes: simple volts-per-hertz control applied to the induction machine and high-performance field-oriented control applied to the induction machine and to the permanent magnet machine. The course includes a significant laboratory component consisting of hands-on experience with DSP-based control of drives. Each station in the Electric Machinery and Drives Laboratory is comprised of a dynamometer, an induction machine, a permanent magnet machine, a 3-phase inverter with built-in diode rectifier, a 3-phase power supply, and a DSP-based controller. The DSP-based controller is programmed in the MATLAB/ Simulink graphical environment, allowing a student to modify control algorithms easily. Separate computer software allows easy access to controller variables for modification and display. This course builds upon basic knowledge of continuous-time linear systems theory and electric machine modeling. The materials in this course has applications in hybrid/electric vehicles and other transportation systems, industrial processes and automation, and power generation/energy storage systems.

Prerequisite: E E 387

EE 488: Power Systems Analysis I

3 Credits

Fundamentals, power transformers, transmission lines, power flow, fault calculations, power system controls.

Prerequisite: E E 387 or E E 485

EE 489: Power Systems Analysis II

3 Credits

Symmetrical components, unbalanced networks, unsymmetrical faults, unbalanced operation of rotating machines, transient transmission line modeling, system protection.

Prerequisite: E E 488

EE 494: Senior Thesis

1-9 Credits/Maximum of 9

Students must have approval of a thesis adviser before scheduling this course.

EE 494H: Senior Thesis

1-9 Credits/Maximum of 9

Students must have approval of a thesis adviser before scheduling this course.

Honors

EE 495: Internship

1-18 Credits/Maximum of 18

Supervised off-campus, nongroup instruction including field experiences, practica, or internships. Written and oral critique of activity required.

Prerequisite: prior approval of proposed assignment by instructor
Full-Time Equivalent Course

EE 496: Independent Studies

1-18 Credits/Maximum of 18

Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses.

EE 496A: **SPECIAL TOPICS**

1-18 Credits

EE 497: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

EE 499: Foreign Studies

1-12 Credits/Maximum of 12

Courses offered in foreign countries by individual or group instruction.

International Cultures (IL)