

**CS 470 ADVANCED SOFTWARE DESIGN PROJECT (3)**

Lecture, 3 hours. This course is a project based course designed to provide a "real world, team oriented" capstone experience for computer science majors. Coursework will be organized around large programming projects. The content of the projects may vary depending on the interests of the instructor and may include industry, government, non-profit organization, or other affiliations. Prerequisites: CS 315, CS 370, and senior standing in the major, or consent of instructor.

**CS 480 ARTIFICIAL INTELLIGENCE (3)**

This course is a survey of techniques that simulate human intelligence. Topics may include: pattern recognition, general problem solving, adversarial game-tree search, decision-making, expert systems, neural networks, fuzzy logic, and genetic algorithms. Prerequisite: CS 315 or consent of instructor.

**CS 495 SPECIAL STUDIES (1-4)**

This course is intended for students who are doing advanced work in an area of computer science (e.g., a senior project). Prerequisite: an upper-division CS course in the area of interest and consent of instructor.

**CS 496 SENIOR SEMINAR (1-4)**

Discussion of a topic of current importance in computer science. Independent student projects or oral presentations may be required. Prerequisite: senior standing in CS curriculum.

**CS 497 INTERNSHIP (1-3)**

Student projects conceived and designed in conjunction with an off-campus organization or group. The internship is intended to provide on-the-job experience in an area of computer science in which the student has no prior on-the-job experience. Computer hardware or computer time required for the internship, as well as regular supervision of the internship, must be provided by the off-campus organization. Prerequisite: student must be within 30 units of completion of the CS major. May be taken Cr/NC only. No more than 3 units can be applied to the CS major.

**Computer and Engineering Science (CES)**

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**CES 400 LINEAR SYSTEMS THEORY (3)**

Lecture, 3 hours. Analysis of linear time-invariant systems, correlation, convolution, impulse response, complex variables, Fourier series and transform, sampling, filtering, modulation, stability and causality, feedback and control systems, Laplace and Z-transform, fast Fourier transforms. Prerequisite: MATH 241 or consent of instructor. (Crosslisted with MATH 430 and ES 400).

**CES 430 PHOTONICS (3)**

Lecture, 3 hours. Lasers, diode lasers and LED's, fiber optics, optical radiation detectors. Prerequisites: A course in modern Physics (such as PHYS 314) and electromagnetism (such as PHYS 430). (Crosslisted with PHYS 445 and ES 445).

**CES 432 PHYSICS OF SEMICONDUCTOR DEVICES (3)**

Lecture, 3 hours. Semiconductor materials, crystal structure and growth, energy bands and charge carriers, conductivity and mobility; metal semiconductor and p-n junctions, p-n junction diodes, bipolar junction transistors, field effect transistors, CCD's, photonic devices and integrated circuits. Projects in photolithography; conductivity and contact resistance measurements; I-V and C-V characteristics of diodes; characterization of transistors may be assigned. Prerequisites: ES 230 or PHYS 314 or consent of instructor. (crosslisted with PHYS 475 and ES 432).

**CES 440 INTRODUCTION TO NETWORKING AND NETWORK MANAGEMENT (3)**

Lecture, 2 hours; laboratory, 3 hours. The ISO reference model, theoretical basis for data communications, data transmission theory and practice, telephone systems, protocols, networks, internetworks, with examples. Prerequisites: ES 440 or consent of instructor. (Crosslisted with ES 465).

**CES 490 SELECTED TOPICS IN CES (1-3)**

Special topics to introduce new emerging fields, provide foundation for advanced graduate level courses or augment other courses in computer and engineering science. Prerequisite: consent of instructor.

**CES 494 DIRECTED READINGS (1-3)**

Independent study under a faculty member. The proposal must be approved by the graduate advisor if the course is to apply towards degree requirements. Prerequisite: consent of instructor.

**CES 500 QUEUING AND TRANSFORM THEORY (3)**

Lecture, 3 hours. Review of probability theory, fundamentals of transform theory, Fourier and Z-transforms. Markovian and discrete time queuing systems, single and multi server queuing networks and their applications. The course may require significant lab and/or project activity. Prerequisites: ES 314 or consent of instructor.

**CES 506 OPERATIONS MANAGEMENT (3)**

Production/operations management of manufacturing and service operations. Topics include forecasting and scheduling, material requirements planning, and quality assurance. Additional tools include inventory control, project management, and product development. Modern techniques such as Supply Chain Management, e-business, Just-in-Time, and Total Quality Management are illuminated. Crosslisted with BUS 516.

**CES 510 INTELLIGENT SYSTEMS DESIGN (3)**

Lecture, 3 hours. Introduction to adaptive systems: neural networks, genetic algorithms (GAs), fuzzy logic, simulated annealing, tabu search, etc. Specific topics include perceptions, backpropagation, Hopfield nets, neural network theory, simple GAs, parallel GAs, cellular GAs, schema theory, mathematical models of simple GAs, and using GAs to evolve neural networks. Prerequisites: ES 314 and CES 400, or consent of instructor.

**CES 512 THEORY OF SOFTWARE SYSTEMS (3)**

Lecture, 3 hours. Review of data structures and basic algorithms for sorting, searching and string processing. Basics of logic, formal systems, grammars and automata. Applications to some of the following areas: design of language processing tools (editor, translator etc.), software specification, testing and verification, non-numerical problem solving. The course may require significant lab and/or project activity. Prerequisite: ES 314 or consent of instructor.

**CES 514 DATA MINING (3)**

Lecture, 3 hours. Introduction to data models, data warehousing, association-rule mining, searching the Web, Web Mining: Clustering. AI techniques (neural networks, decision trees), applications and case studies. The course may require significant lab and/or project activity. Prerequisite: ES 314 or consent of instructor.

**CES 516 HIGH-PERFORMANCE COMPUTING (3)**

Lecture, 3 hours. Algorithmic tools and techniques for problems hard to solve on a standard uniprocessor model such as problems involving large data sets or real-time constraints; development of computational models to analyze the requirements and solutions and special hardware based solutions; case studies to illustrate the developed models, tools and techniques. The course may require significant lab and/or project activity. Prerequisite: ES 314 or consent of instructor.

**CES 520 EMBEDDED SYSTEMS (3)**

Lecture, 3 hours. Three major topics covered in this course are: controlling specialized I/O devices with particular attention to bit patterns and priority interrupts; waveshapes and measurement tools, both hardware and software; and real time operating systems. Prerequisites: ES 230, 231 and 310 or consent of instructor.

**CES 522 VLSI DESIGN (3)**

Lecture, 3 hours. IC technology review; hardware description languages and describing hardware using one of the languages, modern VLSI design flow; circuit partitioning; clustering. Floorplanning; placement; global routing; area efficient design, area-time trade-offs. The course may require significant lab and/or project activity. Prerequisite: CES 530 or consent of instructor.

**CES 524 ADVANCED COMPUTER ARCHITECTURE (3)**

Lecture, 3 hours. Concept of advanced computing architectures, pipelining; multiprocessing and multiprogramming. Single and multi-stage interconnection networks, applications/algorithms for parallel computers; local and system business architectures; CPU and computer system performance analysis. The course may require significant lab and/or project activity. Prerequisite: ES 310 or consent of instructor.

**CES 530 ANALOG AND DIGITAL MICROELECTRONICS (3)**

Lecture, 3 hours. Introduction to analog/digital integrated circuits, bipolar and MOS transistor models, analysis and design of monolithic operational amplifiers, frequency response, non-linear circuits and CMOS and Bipolar Logic Circuits. The course requires lab and/or project activity. Prerequisites: ES 230-231 and CES 432 or consent of instructor.

**CES 532 ADVANCED PHOTONICS DEVICES (3)**

Lecture, 3 hours. Optical resonators, interaction of photons with materials, LEDs, laser diodes, optical amplifiers, optical noise, photoconductors, electrooptic modulators, photonic switches, nonlinear optical materials and devices. The course requires lab and/or project activity. Prerequisite: CES 430 or equivalent.

**CES 540 DIGITAL DATA TRANSMISSION (3)**

Characteristics of base-band and bandpass channels, optimum signaling sets, and receivers for digital communications; effect of noise and intersymbol interference on probability of error; channel capacity; introduction to phase-locked loop analysis for timing and carrier synchronization. Prerequisites: CES 400 and CES 440 or consent of instructor.

**CES 542 DIGITAL SIGNAL PROCESSING (3)**

Lecture, 3 hours. Time/frequency analysis of discrete-time signals and systems. Fast implementations of the DFT and its relatives. IIR and FIR digital filter design, implementation and quantization error analysis. Decimation, interpolation, and multirate processing. Prerequisite: CES 400 or consent of instructor.

**CES 543 OPTICAL FIBER COMMUNICATIONS (3)**

Lecture, 3 hours. Lightwave fundamentals, optical fiber as transmission media, losses and bandwidth, fiber cables. Optical sources, detectors. Optical components such as switches, access couplers, wavelength multiplexers and demultiplexers. Analog and digital transmission techniques, line coding techniques, optical heterodyne receivers, thermal and shot noise, bit error rates, optical transmission system design. Optical T-carrier systems and SONET, future directions. The course may require significant lab and/or project activity. Prerequisite: PHYS 230-231 and CES 440, or consent of instructor.

**CES 544 WIRELESS COMMUNICATION (3)**

Lecture, 3 hours. Introduction to mobile/wireless communication systems, cellular communication, data transmission and signaling, noise and intelligence, analog and digital techniques, multiple-access architecture. The course requires lab and/or project activity. Prerequisites: ES 230-231 and CES 440, or consent of instructor.

**CES 546 DATA COMPRESSION (3)**

Lecture, 3 hours. Information theory, models, lossless compression (statistical, dictionary, static, dynamic, Huffman, arithmetic, context-modeling), lossy compression (scalar quantization, vector quantization, differential encoding, subband transform, predictive), compression standards (JPEG, MPEG). Prerequisites: ES 314 or consent of instructor.

**CES 547 DIGITAL SWITCHING: TECHNIQUES AND ARCHITECTURES (3)**

Lecture, 3 hours. Review of switching techniques, synchronous and asynchronous transfer modes (i.e., STM and ATM) and various switch architectures. Multi rate and multipoint-to-multipoint switching, ATM switching, signaling and call set-up, ATM switch-architectures and their performance evaluation, multicasting techniques. VLSI implementation considerations, future directions. The course may require significant lab and/or project activity. Prerequisites: MATH 345, ES 230-231 and CES 440 or consent of instructor.

**CES 550 INTEGRATED DIGITAL NETWORKS (3)**

Lecture, 3 hours. Information types and signals, definitions of services and integration, narrow ISDN and frame relay protocols, broadband ISDN concept and protocol. Integrated environment and ATM, principles of SONET and ATM transmission, broadband ATM networking, future trends. The course may require significant lab and/or project activity. Prerequisite: CES 440 or consent of instructor.

**CES 552 NETWORK ARCHITECTURE AND PROTOCOLS (3)**

Lecture, 3 hours. ISO model, review of the physical and data link layers, network layer and routing including for internet, multicast routing, TCP and UDP protocols and their characteristics, performance and limitations, TCP/IP stack, applications such as FTP, e-mail and DNS, voice over IP. The course may require significant lab and/or project activity. Prerequisite: CES 440 or consent of instructor.

**CES 554 BROADBAND ACCESS TECHNOLOGY (3)**

Lecture, 3 hours. Review of ISDN and B-ISDN Protocols, digital subscriber loops, digital modems. The xDSL technology, xDSL family of protocols, ADSL standardization, its architecture, operation, implementation and management, ATM, TCP/IP, Ethernet transmissions using ADSL, optical access. The course may require significant lab and/or project activity. Prerequisite: CES 440 or consent of instructor.

**CES 558 MULTICASTING ON THE INTERNET (3)**

Lecture, 3 hours. Multicasting fundamentals, multicast routing algorithms, IP multicast, architecture and operation of MOSPF, PIM, CBT, OCBT, HDVMP, HPIM, BGMP, and, Mbone protocols. Real-time transport protocol and scalable reliable multicast, reliable multicast transport protocols. Multicasting in ATM networks, IP multicast over ATM, future directions. The course may require significant lab and/or project activity. Prerequisite: CES 552 or consent of instructor.

**CES 561 COMPUTATIONAL TECHNIQUES FOR BIOMOLECULES (3)****CES 562 BIOMEDICAL INSTRUMENTATION (3)****CES 563 BIOPHOTONICS (3)****CES 564 MEDICAL IMAGE PROCESSING (3)****CES 590 SELECTED TOPICS IN COMMUNICATIONS AND PHOTONICS (3)**

Special topics to augment regularly scheduled graduate courses in communications and photonics will be presented. Prerequisites depend on subject material.

**CES 591 INTERNSHIP (1)**

Internship will be done at an industry, R&D laboratory, government organization or a laboratory or center at an academic institution to gain professional training, teamwork experience, communication skills and project opportunities that will prepare students for a successful career in the real world.

**CES 592 SELECTED TOPICS IN HARDWARE AND SOFTWARE SYSTEMS (3)**

Special topics to augment regularly scheduled graduate courses in hardware and software systems will be presented. Prerequisites depend on subject material.

**CES 592B SELECTED TOPICS IN BIOENGINEERING (3)**

Lecture: 3 hours; laboratory: 0 hours. Special topics to augment regularly scheduled graduate courses in bioengineering will be presented. Prerequisite: consent of the instructor.

**CES 593 LAB AND TECH REPORT EXPERIENCE (3)**

Lecture, 1 hour, laboratory, 6 hours. In this course, students will learn to operate state-of-the art equipment in at least 6 laboratories, perform experiments and write lab reports. In addition, students will write a technical report on a state-of-the art topic within the scope of the master's program of at least 3000 words excluding figures and tables. (The course cannot be taken to meet 30-unit requirement under thesis or project option unless approved by the Program Director). Prerequisite: permission of student's advisor.

**CES 594 DIRECTED READINGS (1-3)**

Independent study under a faculty member: The proposal must be approved by the graduate advisor if it is to apply towards degree requirements. Prerequisite: consent of instructor.

**CES 595 DESIGN PROJECT (1-3)**

The project plan, timetable, necessary resources and the expected outcome must be approved by a faculty project advisor and the program advisor at least one semester before taking the course. Prerequisite: Admission of candidacy for the Master's degree and approval of the faculty advisor.

**CES 596 PROJECT CONTINUATION (1-3)**

Designed for students working on their thesis or design project but who have otherwise completed all graduate coursework toward their degree. This course cannot be applied toward the minimum number of units needed for completion of the master's degree. Prerequisites: Consent of faculty thesis/project advisor.

**CES 597 GRADUATE SEMINAR (1)**

Series of lectures presented by experts from academia and industries.

**CES 598 COMPREHENSIVE EXAMINATION (1)**

In this four-hour examination, the student's overall understanding of important concepts of the core courses and the main subjects of each track will be tested. Prerequisite: Advancement to candidacy for the master's degree and approval of the graduate advisor.

**CES 599 RESEARCH AND THESIS (1-6)**

Prerequisites: Admission of candidacy for the master's degree and approval of the thesis advisor.