Computer Engineering (ECE)
Major in Computer Engineering

Department of Electrical and Computer Engineering, College of Engineering and Applied Sciences

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Minors of particular interest to students majoring in Electrical or Computer Engineering: Applied Mathematics and Statistics (AMS), Computer Science (CSE), Science and Engineering (LSE)

Computer Engineering (ECE)
The Department of Electrical and Computer Engineering offers two majors leading to the Bachelor of Engineering (B.E.) degree. The Department's teaching and research areas include computer engineering, computer networks, microprocessors, computer architecture, communications, signal and image processing, pattern recognition, electronic circuits, solid-state electronics, lasers and fiber-optics, electromagnetics, microwave electronics, systems and control, biomedical engineering, VLSI, computer-aided design, parallel and distributed processing, computer vision, and computer graphics. Both program majors are accredited by the Accreditation Board of Engineering and Technology (ABET).

The objective of the electrical and computer engineering programs is to give students an excellent preparation for professional careers or graduate studies in the electrical and computer engineering fields. The programs provide students with depth and breadth of knowledge in engineering science and engineering design as well as in mathematics and the natural sciences. Development of non-technical skills such as communication and teamwork is also emphasized. The curriculum of the two programs is shared in the freshman year, and diverges in the sophomore year. See the Electrical Engineering entry in the alphabetical listings of Approved Majors, Minors, and Programs for the requirements for that major.

Program Educational Objectives

The undergraduate program in Computer Engineering has the following five specific program educational objectives (PEOs):

1. Our graduates should excel in engineering positions in industry and other organizations that emphasize design and implementation of engineering systems and devices.

2. Graduates should excel in the best graduate schools, reaching advanced degrees in engineering and related disciplines.

3. Within several years from graduation alumni should have established a successful career in an engineering-related multidisciplinary field, possibly leading or participating effectively in interdisciplinary engineering projects, as well as continuously adapting to changing technologies.

4. We expect graduates to continue personal development through professional study and self-learning.

5. We expect graduates to be good citizens and cultured human beings, as well as to appreciate the importance of professional, ethical, and societal responsibilities.

Program Outcomes

To prepare students to meet the above program educational objectives, a set of program outcomes that describes what students should know and be able to do when they graduate, have been adopted. We expect our graduates to attain:

a. an ability to apply knowledge of mathematics, science, and engineering;

b. an ability to design and conduct experiments, as well as to analyze and interpret data;

c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

d. an ability to function on multidisciplinary teams;

e. an ability to identify, formulate, and solve engineering problems;

f. an understanding of professional and ethical responsibility;

g. an ability to communicate effectively;

h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i. a recognition of the need for ability to engage in life-long learning;

j. a knowledge of contemporary issues; and

k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

More details about program educational objectives and outcomes can be found at http://www.ece.sunysb.edu/peos

Following graduation many students choose immediate employment in industry from Long Island to the West Coast. Electrical and computer engineers are recruited in diverse fields for a variety of challenging positions: a communications engineer may work on improving the flow of traffic in communications networks; a command and control engineer may work on systems in tactical and traffic control, satellite and surveillance systems, or in commercial applications; a circuit design engineer designs, develops, and manufactures electronic circuits for many applications including microcomputers; and computer engineers design microprocessor-based systems that include a range of consumer products, industrial machinery, and specialized systems such as those used in flight control, automobiles, and in financial institutions. Graduates also pursue advanced degrees in engineering, business, finance, medicine, law, and other professions in which their problem-solving skills and technical knowledge are valuable qualities.

Requirements for the Major in Computer Engineering (ECE)

Acceptance into the Computer Engineering Major

Freshman and transfer applicants who have specified their interest in the major in Computer Engineering may be accepted into the major upon admission to the University. Applicants admitted to the University but not immediately accepted into the Computer Engineering major may apply for acceptance at any time during the academic year. The Department's undergraduate committee will consider an application only if the following conditions have been met:

1. the student has completed at least 11 credits of mathematics, physics, electrical and computer engineering, or computer science courses required for the major;
2. the student has earned a grade point average of 3.00 or higher in these courses with no grade in any of them lower than C;
3. no courses required for the major have been repeated;
4. all transfer courses have been evaluated.

Completion of the major requires approximately 110 credits.

1. Mathematics

AMS 151, 161 Applied Calculus I, II
AMS 210 or MAT 211 Applied Linear Algebra
AMS 361 or MAT 303 Applied Calculus IV
AMS 301 Finite Mathematical Structures

Note: The following alternate calculus course sequences may be substituted for AMS 151, 161 in major requirements or prerequisites:
MAT 125, 126, 127
or MAT 131, 132
or MAT 141, 142
or MAT 171

2. Natural Sciences

PHY 131/133, 132/134 Classical Physics I, II and laboratories
CHE 131 General Chemistry I and laboratory

Note: The physics course sequence PHY 125, 126, 127 or 141, 142 is accepted in lieu of PHY 131/133, 132/134. (Students are advised to take PHY 127 before PHY 126.) CHE 141/143 or ESG 198 are accepted in lieu of CHE 131/133.

3. Freshman Introduction to Electrical Engineering

ESE 123 Introduction to Electrical and Computer Engineering
ESE 124 Computer Techniques for Electronic Design I

4. Engineering Topics

Engineering topics include engineering science and engineering design. Content of the former category is determined by the creative application of basic science skills, while the content of the latter category focuses on the procedure of devising systems, components, or processes.

a. Engineering Sciences

ESE 211 Electronics Laboratory A
ESE 218 Digital Systems Design
ESE 271 Electrical Circuit Analysis
ESE 305 Deterministic Signals and Systems
ESE 345 Computer Architecture
ESE 372 Electronics

b. Engineering Design

ESE 314 Electronics Laboratory B
ESE 380 Embedded Microprocessor Systems Design I
ESE 382 Digital Design Using VHDL and PLDs
ESE 440 Engineering Design I
ESE 441 Engineering Design II

Note: ESE 440 and 441 are engineering design projects that must be carried out at Stony Brook under the supervision of an Electrical and Computer Engineering faculty member.

5. Probability and Statistics
ESE 306 Random Signals and Systems

6. Computer Science

CSE 114 Computer Science I
CSE 214 Computer Science II
CSE 219 Computer Science III
CSE 230 Intermediate Programming in C and C++
ESE 333 Real-time Operating Systems

7. Engineering Technical Electives

4 ESE electives chosen from:
ESE 311 Analog Integrated Circuits
ESE 319 Electromagnetics and Transmission Line Theory
ESE 330 Integrated Electronics
ESE 337 Digital Signal Processing Theory
ESE 344 Software Techniques for Engineers
ESE 346 Computer Communications
ESE 347 Digital Signal Processing
ESE 349 Introduction to Fault Diagnosis of Digital Systems
ESE 355 VLSI System Design
ESE 356 Digital System Specification and Modeling
ESE 357 Digital Image Processing
ESE 358 Computer Vision
ESE 360 Network Security Engineering
ESE 366 Design using Programmable Mixed-Signal Systems-on-Chip
ESE 381 Embedded Microprocessor Systems Design II
ESE 476 Undergraduate Instructional Laboratory Development Practicum

8. Upper-Division Writing Requirement: ESE 300 Writing in Electrical/Computer Engineering
All degree candidates must demonstrate skill in written English at a level acceptable for computer engineering majors. Students must register for the writing course ESE 300 concurrently with or after completion of ESE 314, 324, 380, or 382. Students whose writing does not meet the required standard are referred for remedial help. Detailed guidelines are provided by the Department.

Grading
All courses taken to satisfy requirements 1 through 7 must be taken for a letter grade. A letter grade of C or higher is required in the following courses:

AMS 151 and 161 (or MAT 125, 126, and 127 or MAT 131 and 132)
PHY 131/133 and 132/134 (or PHY 125, 126, and 127)
ESE 211, 218, 271, 300, 345, 372, 380, and 382
CSE 114, 214, and 230
Four ESE technical electives

Requirements for the Combined B.E. Computer Engineering/M.S. Electrical Engineering Degrees
The intent of the combined five-year Bachelor of Engineering in Computer Engineering and Master of Science in Electrical Engineering program is to prepare high-achieving and highly motivated undergraduate computer engineering students for either doctoral studies or a variety of advanced professional positions. Computer engineering students interested in the combined program should apply through the undergraduate office of the Department of Electrical and Computer Engineering. The program is highly selective and is offered to the top 10 to 20 percent of the junior undergraduate class. Admission is based on academic performance (a major g.p.a. of at least 3.40) as well as undergraduate research and professional activities. The combined program is as rigorous as the current B.E. and M.S. programs taken separately. The requirements for the combined program are the same as the requirements for the B.E. and M.S. programs except that two 300-level electives in the B.E. program
are substituted by two 500-level graduate courses. Therefore six graduate credits will be counted towards the undergraduate degree. Detailed guidelines and sample course sequences are provided by the Department.

Sample Course Sequence for the Major in Computer Science

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ESE

Electrical Engineering

ESE 123: Introduction to Electrical and Computer Engineering
Introduces basic electrical and computer engineering concepts in a dual approach that includes: laboratories for hands-on wired and computer simulation experiments in analog and logic circuits, and lectures providing concepts and theory relevant to the laboratories. Emphasizes physical insight and applications rather than theory.
Pre- or Corequisites: AMS 151 or MAT 125 or 131 or 141; PHY 125 or 131 or 141
4 credits

ESE 124: Computer Techniques for Electronic Design I
An extensive introduction to problem solving in electrical engineering using the ANSI C language. Topics covered include data types, operations, control flow, functions, data files, numerical techniques, pointers, structures, and bit operations. Students gain experience in applying the C language to the solution of a variety of electrical engineering problems, based on concepts developed in ESE 123. Knowledge of C at the level presented in this course is expected of all electrical engineering students in subsequent courses in the major.
Pre- or Corequisites: AMS 151 or MAT 125 or 131 or 141; ESE 123 or equivalent
3 credits

ESE 211: Electronics Laboratory A
Introduction to the measurement of electrical quantities; instrumentation; basic circuits, their operation and applications; electronic devices; amplifiers, oscillators, power supplies, wave-shaping circuits, and basic switching circuits.
Prerequisite: ESE 271
Corequisite for ESE and ECE majors: ESE 372
2 credits

ESE 218: Digital Systems Design
Develops methods of analysis and design of both combinational and sequential systems regarding digital circuits as functional blocks. Utilizes demonstrations and laboratory projects consisting of building hardware on breadboards and simulation of design using CAD tools. Topics include: number systems and codes; switching algebra and switching functions; standard combinational modules and arithmetic circuits; realization of switching functions; latches and flip-flops; standard sequential modules; memory, combinational, and sequential PLDs and their applications; design of system controllers.
Prerequisite for engineering majors: PHY 127 or 132/134 or 142 or ESE 124
Prerequisite for computer science majors: CSE 220
4 credits

ESE 224: Computer Techniques for Electronic Design II
Introduces C++ programming language for problem solving in electrical and computer engineering. Topics include C++ structures, classes, abstract data types, and code reuse. Basic object-oriented programming concepts as well as fundamental topics of discrete mathematics and algorithms are introduced.
Prerequisite: ESE 124
3 credits

ESE 231: Introduction to Semiconductor Devices
The principles of semiconductor devices. Energy bands, transport properties and generation recombination phenomena in bulk semiconductors are covered first, followed by junctions between semiconductors and metal-semiconductor. The principles of operation of diodes, transistors, light detectors, and light emitting devices based on an understanding of the nature of the physical phenomena in semiconductors. Provides background for subsequent courses in electronics.
Prerequisites: AMS 361 or MAT 303; PHY 127 or 132/134 or 142
3 credits

ESE 271: Electrical Circuit Analysis I
Kirchoff's Laws, Ohm's Law, nodal and mesh analysis for electric circuits, capacitors, inductors, and steady-state AC; transient analysis using Laplace Transform. Fundamentals of AC power, coupled inductors, and two-ports.
Prerequisites: AMS 161 or MAT 127 or 132 or 142 or 171; PHY 127 or 132/134 or 142
4 credits

ESE 290: Transitional Study
A vehicle used for transfer students to remedy discrepancies between a Stony Brook course and a course taken at another institution. For example, it allows the student to take the laboratory portion of a course for which he or she has had the theoretical portion elsewhere. Open elective credit only.
Prerequisite: Permission of department
1-3 credits

ESE 300: Technical Communication for Electrical and Computer Engineers
Topics include how technical writing differ from other forms of writing, the components of technical writing, technical style, report writing, technical definitions, proposal writing, writing by group or team, instructions and manuals, transmittal letters, memoranda, abstracts and summaries, proper methods of documentation, presentations and briefings, and analysis of published engineering writing. Also covered are the writing of resumes and cover letters.
Prerequisite: WRT 102; ESE or ECE major, U3 standing;
Pre- or Corequisite: ESE 314 or 324 or 380 or 382
3 credits

ESE 304: Applications of Operational Amplifiers
Design of electronic instrumentation: structure of basic measurement systems, transducers, analysis and characteristics of operational amplifiers, analog signal conditioning with operational amplifiers, sampling, multiplexing, A/D and D/A conversion; digital signal conditioning, data input and display, and automated measurement systems. Application of measurement systems to pollution and to biomedical and industrial monitoring is considered.
Prerequisite: ESE 372
3 credits

ESE 305: Deterministic Signals and Systems
Pre- or Corequisite: ESE 271
3 credits

ESE 306: Random Signals and Systems
Random experiments and events; random variables, probability distribution and density functions, continuous and discrete random processes; Binomial, Bernoulli, Poisson, and Gaussian processes; system reliability; Markov chains; elements of queuing theory;
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detection of signals in noise; estimation of signal parameters; properties and application of auto-correlation and cross-correlation functions; power spectral density; response of linear systems to random inputs.

*Pre- or Corequisite: ESE 305*

4 credits

**ESE 307: Analog Filter Design**
Introduces basic concepts of analog filter theory and implementation. Topics include: filter types; transfer functions; Bode plots; implementation of first- and second-order filters using op amps, maximally flat, and equal-ripple filters; frequency transformations; LC ladders; transconductance-C realizations; switched capacitor circuits; and filter sensitivity.

*Prerequisites: ESE 305 and 372*

3 credits

**ESE 310: Electrical Circuit Analysis II**
Network elements, graph theory, linear network analysis; fundamental loops and cutsets, matrix solutions, nonlinear network analysis; state variables, small and large signal analysis, numerical methods.

*Prerequisite: ESE 271*

3 credits

**ESE 311: Analog Integrated Circuits**
Engineering design concepts applied to electronic circuits. Basic network concepts, computational analysis and design techniques: models of electronic devices; biasing and compensation methods; amplifiers and filters designed by conventional and computer-aided techniques.

*Prerequisite: ESE 372*

3 credits

**ESE 314: Electronics Laboratory B**
Coordinated with, and illustrates and expands upon, concepts presented in ESE 372. Experiments include diode circuits, class A BJT, FET and differential amplifiers as well as analogous signal processing. Laboratory fee required.

*Prerequisites: ESE 211 and 372*

3 credits

**ESE 315: Control System Design**

*Prerequisite: ESE 271*

3 credits

**ESE 319: Electromagnetics and Transmission Line Theory**
Fundamental aspects of electromagnetics wave propagation and radiation, with application to the design of high speed digital circuits and communications systems. Topics include: solutions of Maxwell's equations for characterization of EM wave propagation in unbounded and lossy media; radiation of EM energy; guided wave propagation with emphasis on transmission lines theory.

*Prerequisite: ESE 271*

3 credits

**ESE 321: Electromagnetic Waves and Wireless Communication**
Covers the wireless radio signal environment; electromagnetic wave propagation in free space and in other media; effects of reflection, scattering, diffraction, and multi-path interference on the characteristics and quality of the received signal; cellular wireless network planning; efficient use and reuse of assigned radio frequency spectrum; effects of transmitting and receiving antenna design; introduction of basic wireless communication techniques to achieve reliable communication.

*Prerequisite: ESE 319*

3 credits

**ESE 322: Introduction to Auto ID Technologies**
Introduces theory and application of important data-capture technologies namely barcodes, biometrics and RFID. Topics to be covered include: architecture of data-capture / Auto ID systems, barcodes; overview of 1-D and 2-D barcodes and other LOS technologies biometrics; fingerprints, iris-scan, voice recognition and smart-cards; radio frequency identification (RFID); fundamentals, near-field vs. far field, UHF read range estimation, reader sensitivity limits, tag singulation and multiple access protocols, standards, privacy and security issues in RFID, real time location systems (RTLS).

*Prerequisites: ESE 218, 305, and 372; Corequisite: ESE 319*

3 credits

**ESE 323: RFID Technology for Automatic Identification**
This course covers the analysis and design of RFID technologies for automatic identification. Included are the theory of operation, analysis of RFID system components, passive and active tags, frequencies used, air interfaces, coding structures, antenna design, and regulatory compliance.

*Prerequisites: ESE 319*

3 credits

**ESE 324: Electronics Laboratory C**
Illustrates and expands upon advanced concepts presented in ESE 372. Experiments include multistage amplifiers, class B and class C power amplifiers, speech processing, active RC and switched-capacitor filters, oscillators, and switching power supplies. Laboratory fee required.

*Prerequisites: ESE or ECE major; U3 standing; ESE 211 and 372*

2 credits

**ESE 330: Integrated Electronics**
An overview of the design and fabrication of integrated circuits. Topics include gate-level and transistor-level design; fabrication material and processes; layout of circuits; automated design tools. This material is directly applicable to industrial IC design and provides a strong background for more advanced courses.

*Prerequisite: ESE 372*

3 credits

**ESE 332: Semiconductor Device Characterization**
Basic experimental experience in characterization of microelectronic and optoelectronic semiconductor devices including diodes, transistors, light emitting diodes, lasers, and photodetectors. Measurement of I-V and I-I (light-current) device characteristics; practice in the techniques of determining various device parameters; analysis of aggregate experimental data to determine the relationships between device and output characteristics, device band diagrams, and device designs. Includes study of modern methods of silicon and compound semiconductor devices and systems technologies.

*Prerequisite: ESE 372*

3 credits

**ESE 333: Real-Time Operating Systems**
Introduces basic concepts and principles of real-time operating systems. Topics include structure, multiple processes, interprocess communication, real-time process scheduling, memory management, virtual memory, file system design, security, protection, and
programming environments for real-time systems.

Prerequisites: ESE 124; CSE 214; ESE 380 or CSE 220
3 credits

ESE 337: Digital Signal Processing: Theory
Introduces digital signal processing theory sequences, discrete-time convolution, difference equations, sampling and reconstruction of signals, one- and two-sided Z-transforms, transfer functions, and frequency response. Design of FIR and IIR filters. Discrete and fast Fourier transforms and applications.
Prerequisite: ESE 305
3 credits

ESE 340: Basic Communication Theory
Basic concepts in both analog and digital data communications; signals, spectra, and linear networks; Fourier transforms, energy and power spectra, and filtering; AM, FM, and PM; time and frequency multiplexing; discussion of problems encountered in practice; noise and bandwidth considerations; pulse modulation schemes.
Prerequisites: ESE 305 and 306
3 credits

ESE 341: Introduction to Wireless and Cellular Communication
Basic concepts of wireless cellular communications, radio frequency, spectrum reuse, radio channel characterization, path loss and fading, multiple access techniques, spread spectrum systems, channel coding, specific examples of cellular communication systems.
Prerequisite: ESE 340
3 credits

ESE 342: Digital Communications Systems
Prerequisite: ESE 340
3 credits

ESE 344: Software Techniques for Engineers
Trains students to use computer systems to solve engineering problems. Includes C/C++ programming languages, UNIX programming environment, basic data structures and algorithms, and object oriented programming.
Prerequisites: ESE 218; CSE 230 or ESE 224
3 credits

ESE 345: Computer Architecture
Starts with functional components at the level of registers, buses, arithmetic, and memory chips, and then uses a register transfer language to manipulate these in the design of hardware systems up to the level of complete computers. Specific topics included are microprogrammed control, user-level instruction sets, I/O systems and device interfaces, control of memory hierarchies, and parallel processing organizations.
Prerequisites for CSE majors: CSE 220 and ESE 218
Prerequisite for ESE and ECE majors: ESE 380
3 credits

ESE 346: Computer Communications
Basic principles of computer communications. Introduction to performance evaluation of protocols. Protocols covered include those for local, metropolitan, and wide area networks. Introduction to routing, high speed packet switching, circuit switching, and optical data transport. Other topics include TCP/IP, Internet, web server design, network security, and grid computing. Not for credit in addition to CSE/ISE 310. This course is offered as both CSE 346 and ESE 346.

Pre- or corequisite for ESE and ECE majors: ESE 306
Pre- or corequisite for CSE majors: AMS 310 or 311
3 credits

ESE 347: Digital Signal Processing: Implementation
Fundamental techniques for implementing standard signal-processing algorithms on dedicated digital signal-processing chips. Includes a review of discrete-time systems, sampling and reconstruction, FIR and IIR filter design, FFT, architecture and assembly language of a basic signal processing chip, and an introduction to adaptive filtering.
Prerequisites: ESE 337, or ESE 305 and 380
4 credits

ESE 350: Electrical Power Systems
Fundamental engineering theory for the design and operation of an electric power system. Modern aspects of generation, transmission, and distribution are considered with appropriate inspection trips to examine examples of these facilities. The relationship between the facilities and their influence on our environment is reviewed. Topics include power system fundamentals, characteristics of transmission lines, generalized circuit constants, transformers, control of power flow and of voltage, per unit system of computation, system stability, and extra-high voltage AC and DC transmission.
Prerequisite: ESE 271
3 credits

ESE 352: Electromechanical Energy Converters
Basic principles of energy conversion; DC, induction, and synchronous rotary converters; the three-phase system and symmetrical components; the relationships between voltage, current, flux, and m.m.f.; equivalent circuits and operating characteristics of rotary converters; and analysis of saturation effects.
Prerequisite: ESE 372
3 credits

ESE 355: VLSI System Design
Introduces techniques and tools for scalable VLSI design and analysis. Emphasis is on physical design and on performance analysis. Includes extensive laboratory experiments and hands-on use of CAD tools.
Prerequisite: ESE 218
4 credits

ESE 356: Digital System Specification and Modeling
Introduces concepts of specification and modeling for design at various levels of abstraction. High Level specification language is used for executable models creation, representing possible architecture implementations. Topics include design space exploration through fast simulation and re-use of models and implementation.
Prerequisites: ESE 124 and ESE 380
3 credits

ESE 357: Digital Image Processing
Covers digital fundamentals, image transforms, image enhancement, image restoration, image compression, segmentation, representation and description, recognition and interpretation.
Prerequisites for ESE and ECE majors: ESE 305; ESE 224 or CSE 230
Prerequisites for CSE majors: CSE 214 and 220
3 credits

ESE 358: Computer Vision
Introduces fundamental concepts, algorithms, and computational techniques in visual
ESE 360: Network Security Engineering
An introduction to computer network and telecommunication network security engineering. Special emphasis on building security into hardware and software working with software. Topics include encryption, public key cryptography, authentication, intrusion detection, digital rights management, firewalls, trusted computing, encrypted computing, intruders and viruses. Not for credit in addition to CSE 408.
Prerequisite: ESE/CSE 346 or CSE/ISE 310
3 credits

ESE 363: Fiber Optic Communications
Design of single and multi-wavelength fiber optic communications systems. Topics include analysis of optical fibers, optical transmitters and receiver design, optical link design, single-wavelength fiber optic networks with analysis of FDDI and SONET/SDH, and wavelength division multiplexing.
Prerequisite: ESE 372
4 credits

ESE 366: Design using Programmable Mixed-Signal Systems-on-Chip
This course focuses on development of mixed-signal embedded applications that utilize systems on chip (SoC) technology. The course discusses design issues such as: implementation of functionality; realizing new interfacing capabilities; and improving performance through programming the embedded microcontroller and customizing the reconfigurable analog and digital hardware of SoC.
Prerequisites: ESE 380 and ESE 372; ESE 224 or CSE 230
4 credits

ESE 372: Electronics
The pertinent elements of solid-state physics and circuit theory are reviewed and applied to the study of electronic devices and circuits, including junction diodes, transistors, and gate and electronic switches; large- and small-signal analysis of amplifiers; amplifier frequency response; and rectifiers and wave-shaping circuits.
Prerequisites for ESE and ECE majors: ESE 305; ESE 224 or CSE 230
Prerequisites for CSE majors: CSE 214 and 220
3 credits

ESE 373: RF Electronics for Wireless Communications
Introduces basic concepts and key circuits of radio-frequency systems. Taught within the design and construction of a transceiver for wireless communications, the course covers fundamental principles which apply to all radio devices. Essential theoretical background, with additional emphasis on practical implementation using commercially-available integrated circuits for double-balanced mixers, oscillators, and audio power amplifiers. Basic components and circuits: key elements of radio electronics, including filters, matching networks, amplifiers, oscillators, mixers, modulators, detectors, and antennae. Computer simulation via Pspice and Puff is emphasized as an integral part of the design process.
Prerequisite: ESE 372
3 credits

ESE 380: Embedded Microprocessor Systems Design I
Fundamental concepts and techniques for designing electronic systems that contain a microprocessor or microcontroller as a key component. Topics include system level architecture, microprocessors, ROM, RAM, I/O subsystems, address decoding, PLDs and programmable peripheral ICs, assembly language programming and debugging. Hardware-software trade-offs in implementation of functions are considered. Hardware and software design are emphasized equally. Laboratory work involves design, implementation, and testing of microprocessor controlled circuits.
Prerequisite: ESE 218
4 credits

ESE 381: Embedded Microprocessor Systems Design II
A continuation of ESE 380. The entire system design cycle, including requirements definition and system specifications, is covered. Topics include real-time requirements, timing, interrupt driven systems, analog data conversion, multi-module and multi-language systems. The interface between high-level language and assembly language is covered. A complete system is designed and prototyped in the laboratory.
Prerequisites: ESE 271 and 380
4 credits

ESE 382: Digital Design Using VHDL and PLDs
Digital system design using the hardware description language VHDL and system implementation using complex programmable logic devices (CPLDs) and field programmable gate arrays (FPGAs). Topics include design methodology, VHDL syntax, entities, architectures, testbenches, subprograms, packages, and libraries. Architecture and characteristics of PLDs and FPGAs are studied. Laboratory work involves writing the VHDL descriptions and testbenches for designs, compiling, and functionally simulating the designs, fitting and timing simulation of the fitted designs, and programming the designs into a CPLD or FPGA and bench testing.
Prerequisite: ESE 218
4 credits

ESE 440: Engineering Design I
Lectures by faculty and visitors on typical design problems encountered in engineering practice. During this semester each student will choose a senior design project for Engineering Design II. A preliminary design report is required. Not counted as a technical elective. Laboratory fee required.
Prerequisites: ESE or ECE major, U4 standing; two ESE technical electives (excluding ESE 390 and 499); ESE 300. Students may need additional prerequisites depending on the design project undertaken.
3 credits

ESE 441: Engineering Design II
Student groups carry out the detailed design of the senior projects chosen during the first semester. A comprehensive technical report of the project and an oral presentation are required. Not counted as a technical elective. Laboratory fee required.
Prerequisite: ESE 440
3 credits

ESE 475: Undergraduate Teaching Practicum
Students assist the faculty in teaching by conducting recitation or laboratory sections that supplement a lecture course. The student receives regularly scheduled supervision from the faculty instructor. May be used as an open elective only and repeated once.
COMPUTER ENGINEERING (ECE) - COURSES

Fall 2009

Prerequisites: U4 standing; a minimum g.p.a. of 3.00 in all Stony Brook courses, and a grade of B or better in the course in which the student is to assist; permission of department. 3 credits

ESE 476: Instructional Laboratory Development Practicum
Students work closely with a faculty advisor and staff in developing new laboratory experiments for scheduled laboratory courses in electrical and computer engineering. A comprehensive technical report and the instructional materials developed must be submitted at the end of the course. May be used as a technical elective for electrical and computer engineering majors. May be repeated as an open elective.
Prerequisites: U4 standing; minimum cumulative g.p.a. of 3.0 and minimum grade of A- in the course for which the students will develop material; permission of department and instructor
3 credits

ESE 488: Internship in Electrical/Computer Engineering
An independent off-campus engineering project with faculty supervision. May be repeated but only three credits of internship electives may be counted toward the non-ESE technical elective requirement.
Prerequisites: ECE or ESE major; U3 or U4 standing; 3.00 g.p.a. minimum in all engineering courses; permission of department
3 credits

ESE 499: Research in Electrical Sciences
An independent research project with faculty supervision. Permission to register requires a 3.00 g.p.a. in all engineering courses and the agreement of a faculty member to supervise the research. May be repeated but only three credits of research electives (AMS 487, BME 499, CSE 487, MEC 499, ESM 499, EST 499, ISE 487) may be counted toward the non-ESE technical elective requirements.
Requirements: U4 standing. 3.00 g.p.a. minimum in all engineering courses, permission of department
0-3 credits

CSE

Computer Science

CSE 101: Introduction to Computers and Information Technologies
An introduction to the basics of personal computing and information technologies intended primarily for students majoring in humanities, social and behavioral sciences, or business management. Topics include principles of personal (single-user) computer systems, office automation, and information in a modern, networked (multi-user) computing environment. Emphasis is on conceptual understanding of personal computing rather than use of specific hardware or software. Required participation in computer laboratories. May not be taken for credit in addition to EST 100 or after any CSE or ISE course.
Prerequisite: Satisfaction of entry skill in mathematics requirement (Skill 1) or satisfactory completion of D.E.C. C
3 credits

CSE 102: Introduction to Web Design and Programming
An introduction to the design of Web pages, specifically the development of browser and device independent HTML, with an emphasis on the XHTML standards. Includes the use of style sheets (CSS) and tools for page layout and verification. HTML is presented as a mark-up language, exploring the rules of HTML elements and attributes. Students learn the separation of page viewing information from the HTML through CSS style sheets as well as the use of block layout without using HTML tables. Addresses HTML display properties including text, color, image, and graphic elements as well as approaches to HTML validation and techniques.
Advisory Prerequisite: CSE 101 or basic computer skills
3 credits

CSE 110: Introduction to Computer Science
An introduction to fundamentals of computer science. Topics covered include algorithmic design, problem-solving techniques for computer programming, fundamentals of digital logic and computer organization, the role of the operating system, introductory programming methodology including variables, assignment statements, control statements and subroutines (methods), programming paradigms, the compilation process, theoretical limits of computation, social and ethical issues. Intended for students who have not taken any college-level computer science course containing programming assignments in a high-level programming language.
Prerequisite: Level 3 or higher on the mathematics placement examination
3 credits

CSE 114: Computer Science I
An introduction to procedural and object-oriented programming methodology. Topics include program structure, conditional and iterative programming, procedures, arrays and records, object classes, encapsulation, information hiding, inheritance, polymorphism, file I/O, and exceptions. Software debugging and testing techniques are emphasized including an introduction to formal verification methods. Includes required laboratory.
Prerequisite: one of the following: CSE 110 or CSE 130 or ESE 124 or ESG 111 or MEC 111 or MEC 112
4 credits

CSE 130: Introduction to Programming in C
Introduces programming concepts using the C language. Variables, data types, and expressions. Conditional and iterative statements, functions, and structures. Pointers, arrays, and strings. Scope of variables and program organization. Includes programming projects of an interdisciplinary nature. Suitable as an introductory programming course for non-CSE majors.
Prerequisite: Level 3 or higher on the mathematics placement examination
3 credits

CSE 150: Foundations of Computer Science: Honors
Introduction to the logical and mathematical foundations of computer science for computer science honors students. Topics include functions, relations, and sets; recursion and functional programming; basic logic; and mathematical induction and other proof techniques.
Prerequisites: One MAT course that satisfies DEC category C or score of level 4 on the math placement exam; admission to the Computer Science Honors Program or the Honors College or WISE or permission of the instructor
4 credits

CSE 160: Computer Science A: Honors
First part of a two-semester sequence, CSE 160 and CSE 260. Emphasizes a higher-level, object-oriented approach to the construction of software. Focus on software engineering issues such as programming style, modularity, and code reusability. Includes the way in which software tools can be used to aid the program development process. First considers the construction of small programs, continues
by treating the design and implementation of program modules, and culminates in an introduction to object-oriented design techniques suitable for larger programs.

Prerequisite: CSE 110 or 114 or MEC 112 or ESG 111

4 credits

CSE 213: Foundations of Computer Science II

A continuation of CSE 113 focusing on the descriptive formalisms relevant to computing, including set theory and its application to quantifiers, relations and graphs, combinatorics, and finite state machines.

Prerequisite: CSE 113

3 credits

CSE 214: Computer Science II

An extension of programming methodology to data storage and manipulation on complex data sets. Topics include: programming and applications of data structures; stacks, queues, lists, binary trees, heaps, priority queues, balanced trees and graphs. Recursive programming is heavily utilized. Fundamental sorting and searching algorithms are examined along with informal efficiency comparisons.

Prerequisite: C or higher in CSE 114

3 credits

CSE 215: Foundations of Computer Science

Introduction to the logical and mathematical foundations of computer science. Topics include functions, relations, and sets; recursion and functional programming; elementary logic; and mathematical induction and other proof techniques.

Prerequisite: AMS 151 or MAT 125 or MAT 131

3 credits

CSE 219: Computer Science III

Development of the basic concepts and techniques learned in CSE 114 Computer Science I and CSE 214 Computer Science II into practical programming skills that include a systematic approach to program design, coding, testing, and debugging. Application of these skills to the construction of robust programs of 1000 to 2000 lines of source code. Use of programming environments and tools to aid in the software development process.

Prerequisite: C or higher in CSE 214

3 credits

CSE 220: Computer Organization

Explores the physical structure of a computer; internal representation of information; processor organization, instruction cycle, and memory hierarchy. Introduces assembly/machine language programming and its relation to execution of high level language programs. Elementary digital logic design and its application to design of arithmetic and logic unit, and simple data paths. Input and output devices and their interface with processor and memory.

Prerequisite: CSE 160 or 214

3 credits

CSE 230: Intermediate Programming in C and C++

Intermediate programming concepts using the C language in a UNIX environment. Files, systems calls, stream I/O, the C preprocessor, bitwise operations, the use of makefiles, advanced formatting of input and output, conversions. Introduction to object-oriented programming using C++; classes, objects, inheritance, aggregation, and overloading. Suitable for all majors.

Prerequisite: CSE 130 or ESE 124 or ESG 111 or MEC 112

3 credits

CSE 260: Computer Science B: Honors

Second part of a two-semester sequence. CSE 160 and CSE 260. Further development of the object-oriented design strategies presented in CSE 160. Continues with introductions to event-driven programming, graphical user interfaces, and design patterns. Includes an extended design and programming project.

Prerequisite: CSE 160

4 credits

CSE 300: Writing in Computer Science

See Requirements for the Major in Computer Science, Upper-Division Writing Requirement.

Prerequisites: WRT 102; CSE major; U3 or U4 standing

1 credit

CSE 301 - H: History of Computing

A study of the history of computational devices from the early ages through the end of the 20th century. Topics include needs for computation in ancient times, development of computational models and devices through the 1800's and early 1900's, World War II and the development of the first modern computer, and early uses in business. Creation of programming languages and the microchip. Societal changes in computer usage due to the microcomputer, emergence of the Internet, the World Wide Web, and mobile computing. Legal and social impacts of modern computing. Cannot be used as a technical elective for the CSE major or minor. This course is offered as both CSE 301 and ISE 301.

Prerequisite: U2 standing or higher

Advisory Prerequisite: one course in computing

3 credits

CSE 302: Professional Ethics for Computer Science

Familiarizes students with professional practice in Information Technology. Enables them to identify ethical conflicts, their responsibilities and options, and to think through the implications of possible solutions to ethical conflicts.

Prerequisites: CSE 219 or CSE 260 or ISE 305

1 credit

CSE 303: Introduction to the Theory of Computation

An introduction to the abstract notions encountered in machine computation. Topics include finite automata, regular expressions, and formal languages, with emphasis on regular and context-free grammars. Questions relating to what can and cannot be done by machines are covered by considering various models of computation, including Turing machines, recursive functions, and universal machines.

Prerequisites: CSE 214 and CSE 213 or 215

3 credits

CSE 304: Compiler Design

Topics studied include formal description of programming languages, lexical analysis, syntax analysis, symbol tables and memory allocation, code generation, and interpreters. Students undertake a semester project that includes the design and implementation of a compiler for a language chosen by the instructor.

Prerequisites: CSE 219 or CSE 260, CSE 220, and CSE 303

3 credits

CSE 305: Principles of Database Systems

The design of database management systems to obtain consistency, integrity, and availability of data. Conceptual models and schemas of data: relational, hierarchical, and network. Students undertake a semester project that includes the design and implementation of a database system.

Prerequisites: CSE 219 or CSE 260; CSE 220

3 credits

CSE 306: Operating Systems
Students are introduced to the structure of modern operating systems. Topics include virtual memory, resource allocation strategies, concurrency, and protection. The design and implementation of a simple operating system are performed.

Prerequisites: CSE 219 or CSE 260; CSE 220 or ESE 380
3 credits

CSE 307: Principles of Programming Languages

Presents examples of important programming languages and paradigms such as LISP, ALGOL, ADA, ML, Prolog, and C++. Students write sample programs in some of the languages studied. The languages are used to illustrate programming language constructs such as binding, binding times, data types and implementation, operations (assignment data-type creation, pattern matching), data control, storage management, parameter passing, and operating environment. The suitability of these various languages for particular programming tasks is also covered.

Prerequisite: CSE 219 or CSE 260; CSE 220
3 credits

CSE 308: Software Engineering

Introduces the basic concepts and modern tools and techniques of software engineering. Emphasizes the development of reliable and maintainable software via system requirements and specifications, software design methodologies including object-oriented design, implementation, integration, and testing; software project management; life-cycle documentation; software maintenance; and consideration of human factor issues. This course is offered as both CSE 308 and ISE 308.

Prerequisites: CSE 219 or CSE 260 or ISE 305
3 credits

CSE 310: Data Communication and Networks

Study of communication networks. Local area networks (LAN), integrated voice and data systems (IVDS), and wide area networks (WAN). Their topologies: bus, token passing, tree, point to point. Protocols, speed, and distance limitations: RS232, TCP/IP, MAP/TOP, ONS, OSI. Network design and management will be studied in various environments. May not be taken by students with credit for CSE/ESE 346.

Prerequisites: CSE 214 or 260; CSE 220
Advisory Pre- or Corequisite: AMS 310
3 credits

CSE 311: Systems Administration

This course covers practical techniques to manage information systems, also known as IT Systems Administration. Students will learn how to install computers for assorted hardware and software platforms (Windows, Unix/Linux, OS-X). Install networking equipment and configure it. Install server software on several systems (e.g. web, database, mail) and configure it. Secure the network, hosts, and services, and apply system patches. Set up redundant computing services, virtual machines/services, and hardware so that services can survive some hardware/software failures. Evaluate the performance, reliability, and security of the overall system.

Prerequisites: CSE 214 or CSE 230 or CSE 260 or ISE 208
3 credits

CSE 315: Database Transaction Processing Systems

Theory and practice of design for applications involving transactional access to a database. Transaction design, schema design, restart and recovery, journaling, concurrency control, distributed databases. Student groups perform design and implementation of significant database application. This course is offered as both CSE 315 and ISE 315.

Prerequisite: CSE 219 or CSE 260 or ISE 305
3 credits

CSE 320: Computer Architecture

Covers the detailed physical implementation techniques for floating-point data path, advanced pipeline control, multi-level memory hierarchy, I/O and disk subsystem, architectural support for operating systems and programming languages, and multiprocessor/multicomputer architectures.

Prerequisite: CSE 220
3 credits

CSE 321: Human-Computer Interaction

A survey course designed to introduce students to Human-Computer Interaction and prepare them for further study in the specialized topics of their choice. Students will have the opportunity to delve deeper in the course through a course project, and through a two-three week special topic selected at the instructor's discretion.

Prerequisites: CSE 214 or CSE 230 or CSE 260
3 credits

CSE 322: Human-Computer Interaction

A survey course designed to introduce students to Human-Computer Interaction and prepare them for further study in the specialized topics of their choice. Students will have the opportunity to delve deeper in the course through a course project, and through a two-three week special topic selected at the instructor's discretion.

Prerequisites: CSE 214 or CSE 230 or CSE 260
3 credits

CSE 325: Computers and Sculpture

This multidisciplinary class surveys how computer science and computer technology are used in sculpture. Case studies with slides, videos, and software demonstrations illustrate a range of approaches of sculptors incorporating computers in their creative process. Various state-of-the art fabrication technologies are studied (with site visits if available on campus). Mathematical foundations are emphasized so students can recognize them when analyzing sculpture and choose the right tool when designing. In the weekly laboratory, these ideas are reinforced with projects using a range of available software and inexpensive construction materials, e.g., paper, cardboard, and foamcore. Prerequisites: CSE 110 or permission of instructor
3 credits

CSE 326: Fundamentals of Digital Image Processing

Covers fundamentals of image transforms, image enhancement, image restoration, image compression, segmentation, representation and description, recognition and interpretation.

Prerequisites: CSE 214 or CSE 230 or CSE 260; AMS 210 or MAT 211
3 credits

CSE 327: Fundamentals of Computer Vision

Introduces fundamental concepts, algorithms, and techniques in visual information processing. Covers image formation, binary image processing, image features, model fitting, optics, illumination, texture, motion, segmentation, and object recognition.

Prerequisites: CSE 214 or CSE 230 or CSE 260; AMS 210 or MAT 211
3 credits

CSE 328: Fundamentals of Computer Graphics

An introduction to computer graphics including graphics application programming; data structures for graphics; representing and specifying color; fundamental hardware and software concepts for calligraphic and raster displays; two-dimensional, geometric transformations; introduction to three-dimensional graphics; graphics standards; and input devices, interaction handling, and user-computer interface.

Prerequisites: CSE 219 or CSE 260; CSE 220; permission of instructor
3 credits

CSE 332: Introduction to Visualization

Visualization of scientific, engineering, medical, and business data sets. Mechanisms
Basic principles of computer communications. Introduction to performance evaluation of protocols. Protocols covered include those for local, metropolitan, and wide area networks. Introduction to routing, high speed packet switching, circuit switching, and optical data transport. Other topics include TCP/IP, Internet, web server design, network security, and grid computing. Not for credit in addition to CSE/ISE 310. This course is offered as both CSE 346 and ESE 346.

Pre- or corequisite for ESE and ECE majors: ESE 306
Pre- or corequisite for CSE majors: AMS 310 or 311
3 credits

CSE 350: Theory of Computation: Honors
Introduces the abstract notions of machine computation for honors students. Includes finite automata, regular expressions, and formal languages, with emphasis on regular and context-free grammars. Explores what can and cannot be computed by considering various models of computation including Turing machines, recursive functions, and universal machines.

Prerequisites: CSE 150; CSE Honors Program or Honors College or WISE or permission of instructor
4 credits

CSE 352: Artificial Intelligence
Topics covered include critique of artificial intelligence research; state-space problem representations and search algorithms; game-playing programs; theorem-proving programs; programs for the study and simulation of cognitive processes and pattern recognition. Further topics in current research as time permits.

Prerequisites: CSE 219 or CSE 260
3 credits

CSE 355: Computational Geometry
The design and analysis of efficient algorithms to solve geometric problems that arise in computer graphics, robotics, geographical information systems, manufacturing, and optimization. Topics include convex hulls, triangulation, Voronoi diagrams, visibility, intersection, robot motion planning, and arrangements. This course is offered as both AMS 345 and CSE 355.

Prerequisites: AMS 301: programming knowledge of C or C++ or Java
3 credits

CSE 364: Advanced Multimedia Techniques
Digital media production techniques for high-bandwidth applications such as electronic magazine illustration, broadcast television, and motion picture special effects. Students explore techniques such as 3D modeling and character animation, video compositing, and high-resolution image processing in a state-of-the-art multimedia computing laboratory. High-capacity multimedia storage, high-speed networks, and new technologies such as DVD, HDTV, and broadband will be reviewed. This course is offered as both CSE 364 and ISE 364.

Prerequisites: CSE/ISE 334 and permission of the instructor
3 credits

CSE 366: Introduction to Virtual Reality
An introduction to the practical issues in the design and implementation of virtual environments. Topics covered include the fundamentals of systems requirements, transformations, user-interaction models, human vision models, tracking systems, input/output devices and techniques, and augmented reality. The topics covered are explained through the use of real-life applications of virtual-reality systems in engineering, science, and medicine.

Prerequisites: CSE 328, CSE/ISE 332, 333
3 credits

CSE 370: Wireless and Mobile Networking

Prerequisite: CSE 310 or 346
3 credits

CSE 371: Logic
A survey of the logical foundations of mathematics: development of propositional calculus and quantification theory, the notions of a proof and of a model, the completeness theorem, Goedel's incompleteness theorem. This course is offered as both CSE 371 and MAT 371.

Prerequisite: CSE 150 or CSE 215 or MAT 200
3 credits

CSE 373: Analysis of Algorithms
Mathematical analysis of a variety of computer algorithms including searching, sorting, matrix multiplication, fast Fourier transform, and graph algorithms. Time and space complexity. Upper-bound, lower-bound, and average-case
analysis. Introduction to NP completeness. Some machine computation is required for the implementation and comparison of algorithms. This course is offered as CSE 373 and MAT 373.

**Prerequisites:** MAT 211 or AMS 210; CSE 214

**CSE 375: Concurrency**
The concurrent execution of asynchronous processes in the abstract using state diagrams and a related language. The concurrent aspects of Java are discussed as a practical implementation of these issues and program logic is introduced to describe them formally. Examples are drawn from operating systems, database systems, and communication systems.

**Prerequisite:** CSE 305 or 306 or ESE 333

**CSE 376: Advanced Systems Programming in UNIX/C**
Focuses on several aspects of producing commercial-grade system software: reliability, portability, security, and survivability. Uses Unix and C, heavily used in industry when developing systems and embedded systems code. Emphasizes techniques and tools to produce reliable, secure, and highly portable code. Requires substantial programming as well as a course project.

**Prerequisite:** CSE 214 or 230 or 260

**CSE 377: Introduction to Medical Imaging**
An introduction to the mathematical, physical, and computational principles underlying modern medical imaging systems. Covers fundamentals of X-ray computer tomography, ultrasonic imaging, nuclear imaging, and magnetic resonance imaging (MRI), as well as more general concepts required for these, such as linear systems theory and the Fourier transform. Popular techniques for the visualization, segmentation, and analysis of medical image data are discussed, as well as applications of medical imaging, such as image-guided intervention. The course is appropriate for computer science, biomedical engineering, and electrical engineering majors.

**Prerequisites:** AMS 161 or MAT 127 or 132 or 142; AMS 210 or MAT 211 or MEC 262

**CSE 378: Introduction to Robotics**
Introduces basic concepts in robotics including coordinate transformation, kinematics, dynamics, Laplace transforms, equations of motion, feedback and feedforward control, and trajectory planning. Covers simple and complex sensors (such as cameras), hybrid and behavior based control and path planning. Concepts are illustrated through laboratories using the LEGO Robot Kit.

**Prerequisites:** AMS 161 or MAT 127 or 132 or 142; AMS 210 or MAT 211 or MEC 262

**CSE 380: Computer Game Programming**
An introduction to the fundamental concepts of computer game programming. Students design and develop original games for PCs applying proven game design and software engineering principles.

**Prerequisite:** CSE 214 or CSE 230 or CSE 260

**CSE 381: Advanced Game Programming**
This course explores the concepts and technologies behind making 3D, networked games. This will include the examination of game engine creation as well as the use of middleware to build graphically sophisticated game systems.

**Prerequisites:** CSE 328 or CSE 380

**CSE 390: Special Topics in Computer Science**
A lecture or seminar course on a current topic in computer science. Semester supplements to this Bulletin contain specific description when course is offered. May be repeated as the topic changes, but cannot be used more than twice to satisfy CSE major requirements.

**Prerequisites:** CSE or ISE major

**CSE 391: Special Topics in Computer Science**
A lecture or seminar course on a current topic in computer science. Semester supplements to this Bulletin contain specific description when course is offered. May be repeated as the topic changes, but cannot be used more than twice to satisfy CSE major requirements.

**Prerequisites:** CSE or ISE major

**CSE 392: Special Topics in Computer Science**
A lecture or seminar course on a current topic in computer science. Semester supplements to this Bulletin contain specific description when course is offered. May be repeated as the topic changes, but cannot be used more than twice to satisfy CSE major requirements.

**Prerequisites:** U4 standing as an undergraduate major within the college; a minimum g.p.a. of 3.00 in all Stony Brook courses and the grade of B or better in the course in which the student is to assist; or permission of department
3 credits

**CSE 487: Research in Computer Science**
An independent research project with faculty supervision. Only three credits of research electives (AMS 487, CSE 487, BME 499, ESE 499, ESM 499, ISE 487, and MEC 499) may be counted toward technical elective requirements. May not be taken for more than six credits.

*Prerequisites: Permission of instructor and department*

0-6 credits

**CSE 488: Internship in Computer Science**
Participation in local, state, national, or international private enterprise, public agencies, or nonprofit institutions. Students are required to submit a written proposal, progress reports, and a final report on their experience to the client and to the department. May be repeated up to a limit of 12 credits but CSE and ISE 488 cannot be used as electives to satisfy CSE major requirements.

*Prerequisites: CSE major, U3 or U4 standing; permission of department*

3 credits, S/U grading

**CSE 495: Senior Honors Research Project I**
A two-semester research project carried out under the supervision of a computer science faculty member. Students who enroll in CSE 495 must complete CSE 496 in the subsequent semester and receive only one grade upon completion of the sequence.

*Prerequisite: Admission to the Computer Science Honors Program*

3 credits

**CSE 496: Senior Honors Research Project II**
A two-semester research project carried out under the supervision of a computer science faculty member. Students must submit a written project report and make a presentation to the department at the year-end Honors Project Colloquium.

*Prerequisite: CSE 495*

3 credits