Computer Engineering

Department of Computer Science and Engineering

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Overview

Computer engineering, anchored in computer science, engineering design, physics and mathematics, is primarily concerned with the creation of information processing devices and systems. Computer engineers do design and development in all aspects of computing, including software and hardware at both the circuit and system levels, emphasizing the physical principles of computing hardware.

Computer engineers are engaged in designing a wide range of devices, systems, software, and services. They design the control systems for automated production lines in industry, create software for digital telephone switching systems, and develop the installation of a local area network (LAN). Thus, computer engineers work in every sector of industry, government, and society in general.

Computer engineers are well trained to address critical interface issues between hardware and software essential to many current and future applications. Reliability and availability of systems, performance evaluation and optimization, networking and computer communication, integrated circuit power reduction, embedded systems, and VLSI (Very Large Scale Integration) are all within the scope of computer engineering.

The department aims to provide students with strong conceptual foundations, and expose them to the forefront of the developments in the field of computing and systems. Recognizing the applicability of computing to all fields of knowledge and practice, the department provides a variety of degrees and programs at each of the degree levels, and cooperates with other units of the university to provide interdisciplinary degree programs.

Graduates of the program will:

- work productively as Computer Engineers, including supportive and leadership roles on multidisciplinary teams,
- communicate effectively, recognize and incorporate societal needs and constraints in their professional endeavors, and practice their profession with high regard to legal and ethical responsibilities,
- engage in life-long learning, such as graduate study, to remain current in their profession and be leaders in our technological society.

About our Degrees

The computer science and engineering department offers instruction in all areas of computer science and computer engineering.

The computer engineering curriculum emphasizes hardware, software, and system integration issues of computing. Topics include analog and digital electronics, logic design, computer architecture, VLSI, computer networking, signal/image processing, algorithms and data structures, programming languages, software engineering, computer organization, artificial intelligence, and operating systems. The computer engineering program is accredited by ABET.

The computer science curriculum emphasizes systems (both software and hardware), computing fundamentals, and applications. Topics include software systems, databases, algorithms and data structures, programming languages, software engineering, theory of computation, computer organization, artificial intelligence, operating systems, computer networking, vision and image processing, data mining and machine learning.

Both the BA and the BS in computer science prepare students well for professional positions in computing and information technology fields and for graduate work. The primary difference is that the BS program provides a more concentrated approach to computer science, while the BA program encourages students to combine computer science with studies in another field. In addition, the CSE department offers a combined program permitting highly qualified students to graduate with a five-year program leading to a combined BS/MS degree in computer science. In conjunction with the School of Management, the department offers a five-year program leading to a combined degree in computer science and business administration (BS/MBA). A BS degree in computational physics is offered jointly with the Physics department.

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The university offers a BS degree in bioinformatics and computational biology, with options for a concentration in biology, biophysics, computer science and engineering, or mathematics. Please refer to the bioinformatics and computational biology program for further details.

Application Information
See School of Engineering and Applied Sciences Acceptance Information in the Undergraduate Catalog.
Transfer students must first apply to the university and meet the university transfer admission requirements. For admission of transfer students to engineering, see School of Engineering and Applied Sciences Transfer Policy in the Undergraduate Catalog, as well as additional departmental admission information.

Advising Information
Entering freshmen/transfers are offered a wide range of special advisement opportunities and academic help sessions by the Office of Undergraduate Education, School of Engineering and Applied Sciences (410 Bonner Hall). Students in the program obtain academic guidance jointly from a senior academic advisor in Engineering and from the Computer Science and Engineering Undergraduate Advisor (251 Bell Hall).

Upon admission, the department of computer science and engineering writes to inform students of their faculty mentors, whom they may consult regarding technical aspects of the program, future research opportunities, and academic and career goals. Students should make an appointment with one of the designated CSE advisors as soon as possible to discuss a program of study and to choose between the BA and the BS programs. Students are required to see their advisor at least once a semester thereafter, and to meet with their advisor a semester before graduation to ensure their remaining coursework satisfies the general education, design, and other program requirements needed to graduate.

To graduate with a degree from the School of Engineering and Applied Sciences, students must have a minimum GPA of 2.0 in technical classes required for the major (includes engineering, math, technical electives, and science classes). Students also must complete 30 undergraduate credit hours of junior/senior-level courses required in their major at the University of Buffalo. Please refer to the degree program sections of the catalog for additional requirements
Required courses cannot be taken Pass-Fail or Satisfactory-Unsatisfactory.

Students must obtain a minimum overall and UB GPA of 2.0 to be considered in academic good standing with the University.

Prerequisites are satisfied with grade of C- or better. If student does not obtain the required grade, the student must retake the course before proceeding to the next course it is a prerequisite for.

All CSE 300/400-level courses are for majors only.

Departmental senior standing is achieved when students complete a minimum of:
2 of CSE 300-level courses for BA Program in CS and
3 of CSE 300-level course for BS program in CS or CEN

Degree Requirements

Please see Degrees and Policies.

About our Courses

Generally, classes in the freshmen and sophomore years tend to be somewhat larger as these classes serve as the foundation for all engineering majors. Once a student enters their junior year, they take classes that are required for their particular major and class size decreases. When a student enrolls in their desired technical electives, class size usually decreases even more.

The School of Engineering's block scheduling initiative assists first-semester freshmen by providing the same coordinated schedule of classes for approximately twenty students. So even though some classes may be larger, students will become familiar with other engineering students who are in their other classes. In addition, students who opt for our small group academic support sessions interact closely with peer tutors on a weekly basis through our student excellence initiative. In the small groups, students work with professional instructors in about a 10:1 ratio. The workshop style format combines interactive instruction and student problem solving practice on material from Calculus, Physics, and Chemistry courses. In the short run, the groups provide personal attention in helping students understand challenging course material. The ultimate goal is that students learn how university level problems differ from those in high school and how to approach such problems.

The typical class size:
Freshman/introductory courses:
calculus = 60 lec/30 rec, physics = 155 lec/30 lab, chemistry = 275 lec/24 lab, computer science = 110-150 lec/20-25 rec
Sophomore /intermediate courses: 60-90 lec/20-25 rec
Upper level/advanced courses: 25-75 lec/10-25 rec

Suggested Introductory Courses

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- CHE 107 General Chemistry for Engineers
- CSE 115 Intro to Computer Science for Majors I
- CSE 116 Intro to Computer Science for Majors II
- MTH 141 College Calculus I
- MTH 142 College Calculus II
- PHY 107 General Physics I
- PHY 108 General Physics II
- PHY 158 General Physics Lab

In the Department of Computer Science and Engineering, what do teaching assistants (TAs) do?

They support instructors in lower-level undergraduate courses, cover recitations and laboratories, assist students, help grade papers, support instructional laboratories, and hold office hours.

For course descriptions, please see Courses.

About our Faculty

The faculty members of the department, all of whom have national and international reputations in their fields, are involved in research projects that have been supported by the National Science Foundation, the U.S. Postal Service, the U.S. Air Force, the Department of Defense, National Institute of Health, Advanced Research Project Agency, New York State Foundation of Science, Technical and Academic Research, and a variety of special contracts. Many have also received research funding from corporations such as Microsoft, Fujitsu, NEC, Sprint and IBM.

These projects include research in: algorithms and theory, augmentative technology for the handicapped, computer networks and distributed systems, computer security and information assurance, computer vision and information visualization, data integration and databases, high performance and grid computing, cyber infrastructure and computational science, knowledge representation, computational linguistics, medical applications and bioinformatics, human computer interaction, wireless computing, multimedia databases and informational retrieval, pattern recognition, machine learning, data mining, programming languages and software systems and VLSI and computer architecture.

Several of the faculty serve on the editorial boards of major research journals as well as the boards of major national professional societies. Many members of the department have won university awards for excellence in teaching, such as the SUNY/Chancellor's Award and the Milton Plesur Award.

See a list of our Undergraduate Faculty.

Acceptance Information

See the School of Engineering and Applied Sciences for Acceptance Information.

Note: See also the Acceptance Criteria for Computer Engineering in the degree chart below.

Transfer Policy

Transfer students must first apply to the university and meet the university transfer admission requirements. For admission of transfer students to engineering, see the School of Engineering and Applied Science Transfer Policy.

In addition, computing courses taken outside the department and offered as substitutes for computer science courses are evaluated individually by the Undergraduate Affairs Committee. Most courses taken from a recognized college-level computer science department are acceptable. Data-processing courses are generally not acceptable as substitutes for any computer science course. Experience has shown that any course with a specific programming language in its title is often a skills course rather than a computer science course. The student must provide evidence to help the department determine whether courses taken at another institution are equivalent to UB courses; course syllabi are generally preferable to catalog descriptions, as catalog descriptions do not provide enough detail for accurate evaluation. Additional information on course equivalencies may be found on the university's transfer and articulation website at: http://taurus.buffalo.edu.

Extracurricular Activities

- Computer Science and Engineering Undergraduate Student Association
- Institute of Electronic and Electrical Engineers (IEEE) Computer Society Student Chapter

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- Association for Computing Machinery (ACM Student Chapter)

See the UB Student Association.

Practical Experience and Special Academic Opportunities

Notable Program Features
As part of their undergraduate education, students are encouraged to participate in work experience classes and research opportunities.

Co-Ops

Work experience is available through the Engineering Career Institute program in the School of Engineering and Applied Sciences, as well as departmental co-op and internship classes. The Engineering Career Institute (EAS 396, 1 academic credit) provides career-effectiveness skills and co-op placement assistance during the junior year. This may be followed by one to three co-op work experiences (EAS 496, 2 academic credit hours). Co-ops may not be used to satisfy the requirements for the BS. Descriptions of co-op courses may be found at undergrad-catalog.buffalo.edu/academicprograms/eas_courses.shtml.

Internships

Internship opportunities include a field experience working on a computer science and engineering project in a real-world setting under the joint direction of a supervisor from industry and a faculty advisor from the Department of Computer Science and Engineering. Projects selected should integrate the material learned in academic courses. Upon completing the internship (CSE 496), the student is expected to have fulfilled an internship contract. Only P/F grades will be given; therefore, internships may not be used to satisfy the requirements for the B.S. program.

Independent Study

Independent study is tailored towards special projects working independently with the faculty. (May not be used to satisfy the requirements for the BS)

As part of their undergraduate education, students are encouraged to participate in work experience classes and research opportunities.

Undergraduate Research

Undergraduate research experiences are available for course credit (Undergraduate Research and Creative Activity or Independent Study) or as a paid assistant in the research laboratory of a faculty member. The Center for Undergraduate Research and Creative Activity (http://curca.buffalo.edu) serves as a clearing house for information regarding undergraduate research opportunities.

Career Information and Further Study

Graduates of this program are in high demand on the job market. The National Bureau of Labor Statistics ranks computer engineering as one of the fastest growing job categories in the United States.

Alumni of Computer Engineering have found employment in the following fields:

- Technology
- Government
- Healthcare
- Industry
- Education
- Marketing
- Academia

Salary Trends

Beginning salaries: $65,000-$73,000

What percentage of graduates goes on to graduate school?

10-20%

Formal System of Tracking Graduates

The department does not have an independent system for tracking graduates. Rather, it is accomplished through the Engineering Alumni

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Association.

What percentage of graduates goes on to find related employment?

Approximately 95-100%

Additional Resources

Engineering Career Institute

Degrees Offered

Undergraduate: BS (ABET accredited)
Graduate: MS, PhD

Links to Further Information About this Program

- Undergraduate Catalog
- Undergraduate Admissions
- Graduate Admissions
- Department of Computer Science and Engineering
- School of Engineering and Applied Sciences
- Bioinformatics and Computational Biology (Concentration in Computer Science and Engineering)

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Acceptance Criteria

See School of Engineering and Applied Sciences Acceptance Information in the Undergraduate Catalog.

Prerequisite Courses

CSE 115 Intro to Computer Science for Majors I
CSE 116 Intro to Computer Science for Majors II
MTH 141 College Calculus I
MTH 142 College Calculus II
PHY 107 General Physics I

Required Courses

CHE 107 General Chemistry for Engineers
CSE 191 Intro to Discrete Structures
CSE 241 Digital Systems
CSE 250 Data Structures
CSE 321 Real-Time & Embedded Operating Systems
CSE 341 Computer Organization
CSE 379 Intro to Microprocessors & Microcomputers
CSE 380 Intro to Microprocessors Lab
CSE 442 Software Engineering
CSE 453 Hardware/Software Integrated Systems Design
EAS 305 Applied Probability
EE 202 Circuit Analysis I
EE 205 Signal Analysis & Transform Methods
EE 310 Electronic Devices & Circuits I
EE 312 Basic Electronic Instrumentation Laboratory
MAE 204 Thermodynamics or EAS 207 Statics
MTH 241 College Calculus III
MTH 306 Intro to Differential Equations
MTH 309 Linear Algebra or MTH 437 Numerical Analysis I
PHY 108/158 General Physics II/Lab
Two additional 400-level CSE electives
(excludes CSE 494-CSE 499, CSE 492)
One CSE technical elective - choice of CSE 400-level elective not previously used for any other requirement, CSE 305, CSE 331, CSE 396,

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or other course approved by the Undergraduate Affairs Committee (excludes CSE 492, CSE 494-CSE 499)

Summary
Total required credit hours for the major: 105-106*

**Students lacking the 128 credits required to graduate are strongly urged to take an engineering design-oriented course as elective credit. See the CSE Undergraduate Advisor for an up-to-date listing of design electives.*

See Baccalaureate Degree Requirements for general education and remaining university requirements.

Note: all courses are not offered every semester. Please check the undergraduate schedule ahead for planning.

Recommended Sequence of Program Requirements

FIRST YEAR
Fall CHE 107, CSE 115, MTH 141
Spring CSE 116, MTH 142, PHY 107

SECOND YEAR
Fall CSE 191, EE 202, MTH 306, PHY 108/PHY 158
Spring CSE 241, MTH 241, CSE 250, EE 205

THIRD YEAR
Fall CSE 321, EE 310, EE 312, CSE 341
Spring CSE 379, CSE 380, MTH 309, EAS 305

FOURTH YEAR
Fall CSE 442; MAE 204 or EAS 207, CSE 400-level technical elective
Spring CSE 453, CSE 400-level technical elective, CSE technical elective

CSE 101: Computers: a General Introduction

Credits: 4
Semester(s): Fall, Spring, Summer
Type: LEC/LAB

Course critically examines popular concepts of information age computing,including:smart devices,societal implications,history,hardware function,sensors,networks,problem solving, and software concepts. Internet technologies such as Web 2.0, rich internet applications,responsible use of social networking,and cloud computing are examined. Privacy and security is an underpinning across all topics. Students will gain practical,lab-based experience with spreadsheets,database systems,HTML design,and various operating systems including Windows,Mac OS X,Linux and Android.

CSE 111: Great Ideas in Computer Science

Credits: 4
Semester(s): Fall, Spring
Type: LEC/LAB

Designed to satisfy the mathematics core requirements. Students study algorithmic problem-solving techniques and gain an appreciation for some of the most interesting and significant results of computer science, as well as its intellectual and social significance. The course has both a mathematical and a laboratory component. Topics may include algorithm design, introduction to programming, structured programming, software tools, software engineering, text manipulation, numerical computation, transistors, very large-scale integrated circuits, machine architecture, language translation, operating systems, and artificial intelligence. Admitted computer science and computer engineering majors should not enroll in this course sequence.

CSE 113: Introduction to Computer Programming I

Credits: 4
Semester(s): Fall, Spring, Summer
Type: LEC/REC

Introduction to computers and computer programming intended for nonmajors. Appropriate for those seeking a practical introduction to computer programming. Topics include the use of data types and variables, programming control constructs supported by modern languages, input/output, basic concepts of object-oriented programming (such as classes, objects, encapsulation, information hiding, and code reuse), as well as graphical user interfaces. No previous computer experience assumed. Not suitable for intended computer science or computer engineering majors. Admitted computer science and computer engineering students should not take this course.

CSE 115: Introduction to Computer Science for Majors I

Credits: 4
Semester(s): Fall, Spring, Summer
Type: LEC/REC

Provides the fundamentals of the field to computer science and computer engineering majors, introducing students to algorithm design and implementation in a modern, high-level programming

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language. Emphasizes problem solving by abstraction. Topics include object-oriented design using a formal modeling language; fundamental object-oriented principles such as classes, objects, interfaces, inheritance and polymorphism; simple event-driven programming; data types; variables; expressions; basic imperative programming techniques, including assignment, input/output, subprograms, parameters, sequencing, selection and iteration; the use of aggregate data structures, such as arrays or more general collections; simple design patterns. Prerequisite: None Notes: No previous programming experience required. Students must have completed high school pre-calculus (algebra and trigonometry)

CSE 116: Introduction to Computer Science for Majors II

Credits: 4
Semester(s): Fall, Spring, Summer
Pre-requisites: CSE 115
Type: LEC/REC

Continuation of CSE 115. Heavily emphasizes abstract data types (ADTs) and object-oriented methodology, and expects students not only to understand ADTs but also to design and implement robust ADTs using a modern object-oriented programming language. Further emphasizes object-oriented techniques, which support sound software engineering, such as encapsulation, polymorphism and inheritance as well as the use of more complex design patterns. Essential topics integrated in this framework include the use of recursion; linked data structures, including lists, stacks, queues, binary trees, and other advanced data structures; and algorithms for searching and sorting; exceptions and exception handling, event-driven programming. Introduces the analysis of algorithm complexity (0-notation).

CSE 191: Discrete Structures

Credits: 4
Semester(s): Fall, Spring
Type: LEC/REC

Foundational material for further studies in computer science. Topics include logic, proofs, sets, functions, relations, recursion, recurrence relations, mathematical induction, graphs, trees, and some basic counting theory. CSE 191 is required for computer science and computer engineering majors.

CSE 199: Honors Seminar

Credits: 3
Pre-requisites: Four years of high school mathematics, knowledge of some programming language
Type: SEM

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Specifically for students enrolled in the UB Honors Program. Enrollment is limited. Topics reflect the interest and research of the faculty member teaching the course. Offered irregularly.

CSE 241: Digital Systems

Credits: 4
Semester(s): Fall, Spring
Type: LEC/REC

A course in digital principles which includes the following topics:fundamentals of digital logic,number systems,codes,computer arithmetic,Boolean algebra,minimization techniques,basic components of digital circuits such as logic gates and flip-flops,design of combinational and sequential circuits,memory devices, and programming logic. Prerequisites:None Recommended for sophomore-level students.

CSE 250: Data Structures

Credits: 4
Semester(s): Fall, Spring
Pre-requisites: CSE 116, CSE 191
Type: LEC/REC

Provides a rigorous analysis of the design, implementation, and properties of advanced data structures. Topics include order notation and time-space analysis and tradeoffs in a list, tree and graph algorithms, and hashing. Surveys library implementations of basic data structures in a high-level language. Advanced data structure implementations are studied in detail. Illustrates the importance of choosing appropriate data structures when solving a problem by programming projects in a high-level language different from the language of CSE 115 and CSE 116; also covers instruction in this language. CSE 191 may also be used as a corequisite.

CSE 305: Introduction to Programming Languages

Credits: 4
Semester(s): Spring
Pre-requisites: CSE 250 and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Examines concepts and constructs found in programming languages. Topics include binding time, strong typing, control and data abstraction, higher-order functions, and polymorphism. The major programming paradigms (procedural, object-oriented, functional, and logic) will be studied and compared. The course will also provide an introduction to syntax and semantics, compilation vs. interpretation, and storage management.

CSE 321: Real -Time and Embedded Operating Systems

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 341 or permission of instructor; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Addresses some of the fundamental challenges in the design, implementation, and validation of these real-time and embedded systems. Topics include resource management, concurrency, secure coding practices, memory management, timeline design and analysis using metrics and schedulability tests, hardware interfacing, device driver programming, memory maps and boot kernels, firmware and ROM-resident system code, communications and networking, and debugging live systems. These concepts will be reinforced through C programming assignments using the RTLinux operating system.

CSE 331: Introduction to Algorithm Analysis and Design

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Credits: 4
Semester(s): Spring
Pre-requisites: CSE 191, CSE 250, MTH 142; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Introduces methods for algorithm design, paradigms such as divide and conquer, greedy, and dynamic programming, and techniques for algorithm analysis, such as asymptotic notations, estimates and recursions. Topics include sorting, searching, scheduling, string matching, graph algorithms, computational geometry, and more.

CSE 337: Introduction to Scientific Computing

Credits: 4
Pre-requisites: MTH 141 with a grade of C or higher
Type: LEC/LAB

Computing now plays an essential and ever-expanding role in science and mathematics. This course provides a broad introduction to computing in the sciences and in both abstract and applied mathematics. It is accessible to students early in their undergraduate program, thereby opening the door to the profitable use of computation throughout the junior and senior years. Cross-listed with MTH 337.

CSE 341: Computer Organization

Credits: 4
Semester(s): Fall, Spring
Pre-requisites: CSE 241 or EE 378 and Approved Computer Science, Computer Engineering, Bioinformatics/CS, Electrical Engineering Majors Only
Type: LEC/REC

Basic hardware and software issues of computer organization. Topics include computer abstractions and technology, performance evaluation, instruction set architecture, arithmetic logic unit design, advanced computer arithmetic, datapath and control unit design, pipelining, memory hierarchy, input-output.

CSE 379: Introduction to Microprocessors and Microcomputers

Credits: 3
Semester(s): Spring
Pre-requisites: CSE 241 or EE 378
Co-requisites: CSE 380
Approved Computer Science, Computer Engineering, Bioinformatics/CS, Electrical Engineering Majors Only
Type: LEC

Microprocessor architecture, machine language programming, microprocessor assemblers, assembly language programming, software development, memory and I/O interface, interrupts, microprocessor system design and microprocessor applications.

CSE 380: Introduction to Microprocessors and Microcomputers Lab

Credits: 3
Semester(s): Spring
Type: LEC/LAB

A microprocessor system and its application in embedded devices. This course is the laboratory component to CSE 379. Topics include: microprocessor architecture; memory organization; assembly language programming; microprocessor assemblers; software development; use of microprocessor boards; memory and I/O interfaces; programming peripherals; interrupt system programming; microprocessor system design and applications.

CSE 396: Introduction to the Theory of Computation

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 191, CSE 250 and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Covers machine models and formal specifications of the classes of computational problems they can solve. The central concepts are the Turing machine and the classes of decidable and computably enumerable languages. The Halting Problem and other natural problems are shown to be undecidable by Turing machines, implying that they are undecidable by high-level programming languages or any other known computational model. Finite automata, which are Turing machines without external memory, are shown to correspond to the class of regular languages. The course also covers regular expressions, time and space complexity of Turing machines, reducibility between problems, and NP-completeness.

CSE 410: Special Topics

Credits: 4
Pre-requisites: Permission of instructor
Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy does not apply.

Contents, format and required background vary from offering to offering. Intended for rapid introduction of timely material in computer science and engineering, which will not be repeated under this course number. Offered occasionally.

CSE 411: Introduction to Computer Systems Administration

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 241 or EE 378; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Teaches how to administer a network of computer workstations using an Operating System such as UNIX. Topics include managing user accounts, system backups, installing and configuring the operating system, setting up a computer network, shell programming, and computer security.

CSE 421: Introduction to Operating Systems

Credits: 4
Semester(s): Fall, Spring
Pre-requisites: CSE 305 or CSE 321
Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only

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Type: LEC/REC

Covers the principles and techniques in the design of operating systems. Describes concepts of operating systems in terms of functions, structure, and implementation, particularly emphasizing multiprogramming. Topics include process coordination, deadlocks, memory management, device management, file systems, scheduling policies for CPU, and network and distributed operating systems. Illustrates concepts with examples from existing operating systems.

CSE 422: Operating Systems Internals

Credits: 4
Semester(s): Spring
Pre-requisites: CSE 421 or Permission of instructor
Type: LEC/REC

Uses an operating system (such as UNIX) as an example to teach the internal workings of operating systems. The material presented is more practical than the other operating systems related classes. The laboratory component of this course provides programming projects involving modifications to an operating system kernel (such as UNIX) on computers dedicated to use for this course. Topics covered include building the operating system kernel, the system call interface, process management, kernel services provided for processes, the I/O system, the internal workings of the file system, device drivers, and the kernel support of Interprocess Communications.

CSE 431: Algorithms Analysis and Design

Credits: 4
Semester(s): Fall, Spring
Pre-requisites: CSE 331, MTH 142 and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Introduces basic elements of the design and analysis of algorithms. Topics include asymptotic notations and analysis, divide and conquer, greedy algorithms, dynamic programming, fundamental graph algorithms, NP-completeness, approximation algorithms, and network flows. For each topic, beside in-depth coverage, we discuss one or more representative problems and their algorithms. In addition to the design and analysis of algorithms, students are expected to gain substantial discrete mathematics problem solving skills essential for computer scientists and engineers.

CSE 435: Information Retrieval

Credits: 4
Pre-requisites: CSE 250, MTH 309; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

This course will focus on text-based information retrieval (IR) techniques, more popularly known as search engines. Various IR models such as the Boolean model, vector space model, probabilistic model will be studied. Efficient indexing techniques for large document collections as well as specialized collections will be examined. Various query expansion techniques such as local context analysis will be introduced. Finally, the course will also discuss search engines for the web, and the use of link analysis to determine document/page relevance. Students will work on written assignments, as well as hands-on programming projects to gain expertise in this area.

CSE 437: Introduction to Numerical Analysis I

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 113 or CSE 115; and MTH 241, MTH 306, MTH 309 with grades of C or higher, or Permission of instructor
Type: LEC/LAB

First part of a 2-semester sequence which explores the design and implementation of numerical methods to solve the most common types of problem arising in science and engineering. Most such problems cannot be solved in terms of a closed analytical formula, but many can be handled with numerical methods learned in this course. Topics for the two semesters include: how a computer does arithmetic, solving systems of simultaneous linear or nonlinear equations, finding eigenvalues and eigenvectors of (large) matrices, minimizing a function of many variables, fitting smooth functions to data points (interpolation and regression), computing integrals, solving ordinary differential equations (initial and boundary value problems), and solving partial differential equations of elliptic, parabolic, and hyperbolic types. We study how and why numerical methods work, and also their errors and limitations. Students gain practical experience through course projects that entail writing computer programs. Cross-listed with MTH 437.

CSE 438: Introduction to Numerical Analysis II

Credits: 4
Semester(s): Spring
Pre-requisites: CSE 437 or MTH 437
Type: LEC/LAB

Second part of the 2-semester sequence described under CSE 437. Cross-listed with MTH 438.

CSE 442: Software Engineering

Credits: 4
Semester(s): Fall, Spring
Pre-requisites: CSE 250 and Departmental Senior Standing; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Examines in detail the software development process. Topics include software life-cycle models; architectural and design approaches; various techniques for systematic software testing; coding and documentation strategies; project management; customer relations; the social, ethical, and legal aspects of computing; and the impact of economic, environmental, safety, manufacturability, and sustainability factors on design. Students in this course participate in a real-world project from conception to implementation.

CSE 443: Introduction to Language Processors

Credits: 4
Pre-requisites: CSE 305, CSE 396
Type: LEC/REC

Considers problems encountered in the design and implementation of a translator for high-level programming languages: lexical analysis, context-free grammars, parsing, storage allocation, code generation and optimization, and error recovery. Uses compiler

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construction tools for the programming projects. Offered occasionally.

CSE 451: Program Development

Credits: 4
Pre-requisites: CSE 305
Type: LEC/REC

A course in theoretical software engineering, covering the practical development of correct programs based on a mathematical notion of program correctness. Topics include: propositional and first-order logic; the specification of programs using Hoare triple and Dijkstra's weakest preconditions; the definition of a small imperative language; assignment, sequencing, a conditional statement, and a loop; and programming as a goal-oriented developmental activity, based on the formal definition of a small language. Offered irregularly.

CSE 452: VLSI Testing

Credits: 4
Semester(s): Spring
Pre-requisites: CSE 493 or Permission of instructor
Type: LEC

Includes topics: VLSI Testing - Why and How? Test Generation; ATPG; Fault Model; CMOS Circuits; Design for Testability; Built-in Self-Testing; Partial Scan Techniques; Simulation at various levels - Switch level, Gate level and Behavioral level; Software Tools and Equipments for Testing; Advanced Concepts - Semi-custom VLSI Chips, Wafer-Scale-Integration, Multi-Chip Modules, System-on-Chip; Case Studies - Microprocessor Testing, Testing of RAMs; Bounday Scan Technique; Analog and Mixed-signal Testing. At the end of the course, the students are expected to be able to gain the skills to modify a given circuit and make it testable using the concepts and tools learned in the class.

CSE 453: Hardware/Software Integrated Systems Design

Credits: 4
Semester(s): Spring
Pre-requisites: CSE 442 or Permission of instructor Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Software designs produced in the prerequisite CSE 442 Software Engineering course are carried here to a complete hardware realization. Bringing skills learned from previous hardware and software-oriented courses, students form multidisciplinary workgroups and are given tools, parts, goals, and constraints, all of which define the integrated design setting. These workgroups identify, formulate, and solve the hardware and software problems posed by their project, and defend their realization concepts at key intervals during the project build-out. Projects are tested, and a report analyzing the level of satisfaction of design and performance specifications submitted. Each group prepares a 'rollout' presentation, which includes a demonstration of their project in operation. This is a required course for CEN majors.

CSE 455: Introduction to Pattern Recognition

Credits: 4
Pre-requisites: CSE 250 and EAS 305 or MTH 309 or Permission of Instructor and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Foundations of pattern recognition algorithms and machines, including statistical and structural methods. Data structures for pattern representation, feature discovery and selection, classification vs. description, parametric and non-parametric classification, supervised and unsupervised learning, use of contextual evidence, clustering, recognition with strings, and small, sample-size problems.

CSE 456: Introduction to Visualization

Credits: 4
Pre-requisites: CSE 250; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Introduction to relevant topics and concepts in visualization, including computer graphics, visual data representation, physical and human vision models, numerical representation of knowledge and concept animation techniques, pattern analysis, and computational methods. Tools and techniques for practical visualization. Elements of related fields including computer graphics, human perception, computer vision, imaging science, multimedia, human-computer interaction, computational science, and information theory. Covers examples from a variety of scientific, medical, interactive multimedia, and artistic applications. Hands-on exercises and projects.

CSE 462: Database Concepts

Credits: 4
Pre-requisites: CSE 250 and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Discusses basic concepts of modern database management systems. Topics include: data models, query languages, database design, integrity constraints, indexing, query evaluation, and transaction management. Students implement small projects using modern DBMS.

CSE 463: Knowledge Representation

Credits: 4
Semester(s): Spring
Pre-requisites: CSE 305 or Permission of instructor
Type: LEC/REC

Introduces the field of knowledge representation and reasoning, the branch of artificial intelligence concerned with the techniques for representing and reasoning about the information to be used by an AI program. Topics typically include: the knowledge-representation hypothesis; propositional and first-order logic; model finding; resolution; syntactic proof theory; direct and refutation methods; relevance logic; truth maintenance and belief revision; commonsense reasoning; ontologies. Other topics that may be included as time permits are: modal logics; non-monotonic, defeasible, and default logics; logics of knowledge and belief; frames; description logics; vague and uncertain beliefs; logics of actions and time.

CSE 467: Computational Linguistics

Computer Engineering

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 305 or Permission of instructor
Type: LEC/REC

Introduces computational models for understanding natural languages. Covers topics including, but not limited to, syntactic and semantic parsing, generation, and knowledge representation techniques. Cross-listed with LIN 467.

CSE 473: Introduction to Computer Vision and Image Processing

Credits: 4
Semester(s): Fall
Pre-requisites: Departmental Senior Standing or Permission of instructor; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Introduces those areas of artificial intelligence that relate to fundamental issues and techniques of computer vision and image processing. Emphasizes physical, mathematical, and image-processing aspects of vision. Topics include image formation, edge detection, segmentation, convolution, image-enhancement techniques, extraction of features (such as color, texture, and shape), object detection, 3-D vision, and computer system architectures and applications.

CSE 474: Introduction to Machine Learning

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 250; EAS 305 or MTH 309; Permission of instructor; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Involves teaching computer programs to improve their performance through guided training and unguided experience. Takes both symbolic and numerical approaches. Topics include concept learning, decision trees, neural nets, latent variable models, probabilistic inference, time series models, Bayesian learning, sampling methods, computational learning theory, support vector machines, and reinforcement learning.

CSE 484: Philosophy of Computer Science

Credits: 4
Type: LEC/REC

Introduces philosophical issues in computer science. Examines the nature of computer science (e.g., whether it is a science or a branch of engineering, whether it is the study of physical computers or abstract computing); the nature of computation, algorithms, and software, and their implementation in computer programs; the nature of computer programs (e.g., whether they are theories, models, or simulations; whether they can or should be patented or copyrighted; whether they can be verified). Also briefly explores the philosophy of artificial intelligence and issues in computer ethics. Offered irregularly. Cross listed with PHI 484.

CSE 486: Distributed Systems

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 250 or permission of instructor and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Addresses some of the fundamental challenges in the design, implementation and deployment of large-scale distributed systems. Concepts covered include concurrency, synchronization, connection establishment, event handling, inter process communication, storage management, and service registration, discovery, and lookup. Also covers issues related to distributed objects such as life cycle management, mobility, security, naming, location, evolution, and autonomy. Analyses and implements possible solutions using objects, processes, services, components and frameworks. Offered irregularly.

CSE 487: Information Structures

Credits: 4
Semester(s): Spring
Pre-requisites: CSE 305 programming languages, object-oriented design and programming in Java; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/REC

Overview of information technology in large-scale commercial and scientific systems, emphasizing state of the art computing in realizing various services and the frameworks supporting these services. Concepts covered include: enterprise modeling, process modeling, process automation and streamlining, workflow management, messaging, persistent message queues, transaction monitoring, document exchange, application servers, service definition (web services, web services definition language: WSDL), connection and resource reservation protocols (TCP, grid computing), integration technologies and architectures (Java 2 Enterprise Edition: J2EE, extensible Markup Language: XML, and Globus toolkit).

CSE 489: Modern Networking Concepts

Credits: 4
Pre-requisites: CSE 250, and EAS 305 or MTH 411 and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Introduces basic elements of modern computer and telecommunications networks. Discusses a hybrid five-layer reference model resembling the popular TCP/IP model. In each layer, the course introduces the state-of-the-art hardware and software technologies. These include, for example, fiber-optic and wireless/mobile/cellular communications at the physical layer, to network security in the application layer. Offered once a year.

CSE 490: Computer Architecture

Credits: 4
Semester(s): Fall
Pre-requisites: CSE 341 or CSE 379 and Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors Only
Type: LEC/REC

Examines system architecture with 32- and 64-bit microprocessors. Topics include the design of high-performance computer systems, such as workstations and multiprocessor systems using recent

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advanced microprocessor. Considers the internal architecture of recent microprocessors, followed by vector processing, memory hierarchy design, and communication subsystems for I/O and interprocessor communication.

CSE 492: Undergraduate Peer Mentoring

Credits: 1-3
Type: TUT

This course provides the opportunity for undergraduate students to serve as undergraduate mentors for students entering the Computer Science & Engineering department. Students that are interested in becoming mentors are asked to contact the mentor program coordinators. Registration in the course is by permission of the coordinators only. (May not be used to satisfy the requirements for the BA or BS.)

CSE 493: Introduction to VLSI Electronics

Credits: 4
Semester(s): Fall
Pre-requisites: Senior standing; Approved Computer Science, Computer Engineering, Bioinformatics/CS Majors only.
Type: LEC/LAB

Introduces VLSI electronics. VLSI is the integration of a large number of logic gates on a single semiconductor chip. Applications of VLSI include memory, microprocessors, and signal processing. Topics include digital system design; VLSI systems; CMOS circuits; use of CAD tools in the layout of full-custom and semi-custom integrated circuits. Project required. Emphasizes designing a working chip and understanding various steps in design. Typical projects: ALU, games, controllers.

CSE 494: Senior Capstone/Seminar

Credits: 3
Pre-requisites: Completion of year 1-3 major requirements
Type: SEM

Course for senior-level majors intended to provide a learning experience that integrates knowledge from lower-level courses. Topics may vary. (May not be used to satisfy the requirements for the BA or BS unless specifically used as capstone or senior seminar.)

CSE 495: Supervised Teaching

Credits: 1-4
Pre-requisites: Junior status, 3.0 QPA, A- or better in course teaching, permission of instructor
Type: TUT

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy *does not apply.*

Students participating in this course serve as undergraduate teaching assistants. Responsibilities include leading lab and recitation sections, and holding study sessions. (May not be used to satisfy the requirements for the BA or BS.)

CSE 496: Internship

Credits: 1-5
Semester(s): Fall, Spring
Pre-requisites: Accepted CSE major and personal interview with an adviser in computer science and engineering
Type: TUT

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy *does not apply.*

Field experience working on a computer science project in a real-world setting under the joint direction of a supervisor from industry and a faculty advisor from the Department of Computer Science and Engineering. Projects selected should integrate the material learned in academic courses. Upon completing the internship the student is expected to have fulfilled an internship contract. Only S/U grades are given (therefore, internships may not be used to satisfy requirements for the BA or BS.) No more than 5 credit hours of CSE 498 may be taken. Offered every semester.

CSE 497: Departmental Honors Thesis or Project

Credits: 3
Pre-requisites: Acceptance into departmental honors program and permission of instructor
Type: TUT

Accepted seniors pursue a specialized independent study leading to an honors thesis or project.(May not be used to satisfy the requirements for the BA or BS.)

CSE 498: Undergraduate Research and Creative Activity

Credits: 1-4
Pre-requisites: Permission of instructor
Type: TUT

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy *does not apply.*

Students collaborate with faculty research mentors on an ongoing project in a faculty member's laboratory or conduct independent research under the guidance of a faculty member. This experience provides students with an inquiry based learning opportunity and engages them as active learners in a research setting. (May not be used to satisfy the requirements for the BA or BS.)

CSE 499: Independent Study

Credits: 1-4
Semester(s): Fall, Spring
Pre-requisites: Permission of instructor, preferably during the previous semester
Type: TUT

The content of this course is variable and therefore it is repeatable for credit. The University Grade Repeat Policy *does not apply.*

Independent study is tailored towards special projects working independently with the faculty. (May not be used to satisfy the requirements for the BA or BS.)