Computer Science

Department of Computer Science and Engineering

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Overview

Computer science is a systematic study of the concepts, foundations and applications of software, hardware, and intelligent systems. Typical subjects include: programming languages, data structure, algorithms, computer organization, operating systems and machine learning. Computer scientists are engaged in understanding the algorithmic complexity of problems and the limits of computability, automating human intelligence, providing ubiquitous access to information, or designing secure and effective software, computer, and communication systems. Computer scientists work in every sector of industry, government, and society in general.

The department aims to provide students with strong conceptual foundations (theoretical and experimental), and also expose them to the forefront of the developments in the field of computing. 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.

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 such diverse areas as 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.

Computer science curriculum emphasizes systems (both software and hardware), computing fundamentals and applications. Topics include such diverse areas as software systems, database, algorithm 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.

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.

Acceptance Criteria - BS and BA

See the School of Engineering and Applied Sciences for acceptance criteria.

Acceptance Information

See the School of Engineering and Applied Sciences for acceptance 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

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jointly from a senior academic advisor in Engineering and from the Computer Science and Engineering Undergraduate Advisor (338R Davis 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, as well as future research opportunities, and academic, and career goals. Students are required see an advisor at least once a semester. A semester before graduation, students are required to meet with an advisor 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). Please refer to the degree program sections of the catalog for additional requirements.

Computer science majors are exempt from the SEAS residency requirement.

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 prerequisite course before proceeding to the next course.

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

At least six of our required CSE courses must be taken at UB, and at least four of these courses should be 300 or 400-level CSE courses (excludes CSE 492, CSE 494-CSE 499).

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 many engineering majors. Once students enter their junior year, they take classes that are required for their particular major and class size 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 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 them.

Typical class size:
Freshman/introductory courses:
calculus = 60 lec/30 rec, physics = 155 lec/30 lab, chemistry = 275 lec/24 lab, computer science = 110-120 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
For the BA:

- CSE 115 Intro to Computer Science for Majors I
- CSE 116 Intro to Computer Science for Majors II
- One of: MTH 121/MTH 122 Survey of Calculus & Its Applications I & II; MTH 131 Mathematical Analysis for Management; or MTH 141/ MTH 142 College Calculus I & II
- CSE 191 Discrete Structures

For the BS:

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- 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
- CSE 191 Discrete Structures

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.

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 School of Engineering and Applied Sciences Transfer Policy in the Undergraduate Catalog, as well as additional departmental admission information.

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
- Association for Computing Machinery (ACM) Student Chapter

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See the UB Student Association.

Practical Experience and Special Academic Opportunities

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 in the Undergraduate Catalog.

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 BS program.

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 serves as a clearing house for information regarding undergraduate research opportunities.

Independent Study

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.)

Career Information and Further Study

Skills gained in this program include:

- Communication
- Group/team work experience & special project knowledge
- Teaching
- Programming language concepts
- Knowledge of operating systems
- Designing
- Testing/analyzing/problem solving
- Abstract & formal reasoning
- Selling and marketing concepts

Career Choices

At the undergraduate level, Computer Science and Engineering offers programs leading to the Bachelor of Arts (BA) in Computer Science and the Bachelor of Science (BS) in Computer Science. Both programs prepare students equally well for graduate work or professional positions in the computing field. The primary difference between the two programs is one of depth vs. breadth: 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.

We provide a solid and general foundation for our graduates so their knowledge will not become obsolete in the rapidly changing world of computing.

Most students with bachelor's degrees obtain jobs in programming or related areas such as systems analysis. Some of the jobs are in scientific or technical industries for which a considerable knowledge of mathematics is also desirable. Others are involved in programming for business and other administrative applications where the mathematics background is less necessary. There are also a number of jobs in systems programming which are not concerned directly with applications, but with writing programs that facilitate the use of computers for applications.

Salary Trends

Beginning salaries: $63,400-$73,000

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What percentage of graduates goes on to graduate school?

10-20%

Additional Resources

Engineering Career Institute

Degrees Offered

Undergraduate: BA, BS, Minor
Graduate: MS, PhD
Combined: BS/MS (accelerated), BA/MBA

Links to Further Information About this Program

- Undergraduate Catalog
- Undergraduate Admissions
- Department of Computer Science and Engineering
- CSE Graduate Admissions
- 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
CSE 191 Introduction to Discrete Structures

Required Courses

CSE 241 Digital Systems
CSE 250 Data Structures
CSE 305 Intro to Programming Languages
CSE 331 Intro to Algorithm Analysis & Design
CSE 341 Computer Organization
CSE 396 Intro to the Theory of Computation
CSE 421 Intro to Operating Systems
CSE 442 Software Engineering
One calculus-based probability or statistics course (e.g., EAS 305, MTH 411)
One CSE course in the Artificial Intelligence area:
CSE 463 Knowledge Representation
CSE 467 Computational Linguistics
CSE 473 Intro to Computer Vision & Image Processing
CSE 474 Intro to Machine Learning
One CSE course in the Software Systems area:
CSE 321 Real-Time & Embedded Operating Systems
CSE 451 Program Development
CSE 462 Database Concepts
CSE 486 Distributed Systems
CSE 489 Modern Networking Concepts
MTH 141 College Calculus I
MTH 142 College Calculus II
One 400-level CSE course from any area (except CSE 492, CSE 494-CSE 499, a required CSE 400-level courses, or a course already used to satisfy the Artificial Intelligence or Software Systems areas above)
One mathematical course from any dept. (approval of CSE faculty advisor is required for course selection)

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Any two-course science and engineering sequence (from Biology, Chemistry, Geology, Physics, or any department in the School of Engineering and Applied Sciences, except CSE)

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

Summary
Total required credit hours for the major: 78-80

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

Recommended Sequence of Program Requirements

FIRST YEAR
Fall CSE 115, MTH 141
Spring CSE 116, CSE 191, MTH 142

SECOND YEAR
Fall CSE 241, CSE 250, one science and engineering sequence course
Spring CSE 305, one calculus-based probability or statistics course (e.g., EAS 305, MTH 411), one science and engineering sequence course

THIRD YEAR
Fall CSE 331, one MTH course (approval of CSE faculty advisor)
Spring CSE 341, CSE 396

FOURTH YEAR
Fall CSE 442, one CSE course (SYS or AI), one CSE 400-level course
Spring CSE 421, one CSE course (SYS or AI)

Computer Science - B.A.

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
CSE 191 Intro to Discrete Structures

Required Courses

CSE 241 Digital Systems
CSE 250 Data Structures
One of the following: MTH 121/MTH 122 Survey of Calculus & Its Applications I & II; MTH 131 Mathematical Analysis for Management; or MTH 141/MTH 142 College Calculus I & II
Two of the following: CSE 305 Intro to Programming Languages; CSE 321 Real Time and Embedded Operating Systems; CSE 331 Intro to Algorithm Analysis and Design; CSE 341 Computer Organization; or CSE 396 Intro to the Theory of Computation
Three CSE courses at the 300 level or above with minimum two at the 400 level (excludes CSE 494 - CSE 499, CSE 492)
One of the following: STA 111 Intro to Probability and Statistics I; STA 119 Statistical Methods; MGQ 301 Statistical Decisions in Management; MTH 411 Probability Theory; EAS 305 Applied Probability; or other probability/statistics courses that may be subject to approval upon request
Any two-course science and engineering sequence (from Biology, Chemistry, Geology, Physics, or any department in the School of Engineering and Applied Sciences, except CSE).
Five external concentration courses from one department other than CSE [five courses at the 200-level or above, with at most, two 200-level for a total of at least 15 credits]. Courses must be lecture based. Seminar and tutorial-type courses are not acceptable. External concentration courses must be approved by the CSE Director of Undergraduate Studies.

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

Summary
Total required credit hours for the major: 67-77

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

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Recommended Sequence of Program Requirements

FIRST YEAR
Fall CSE 115, one of (MTH 121, MTH 131 or MTH 141)
Spring CSE 116, CSE 191, MTH 122 or MTH 142 (unless completed MTH 131)

SECOND YEAR
Fall CSE 241, CSE 250, one science and engineering sequence course
Spring one of: (CSE 305, CSE 321, CSE 331, CSE 341, or CSE 396), one probability or statistics course (e.g., STA 111, MTH 411), one science and engineering sequence course

THIRD YEAR
Fall one of: (CSE 305, CSE 321, CSE 331, CSE 341, or CSE 396), one external concentration course
Spring *one CSE 300 or 400-level course, one external concentration course

FOURTH YEAR
Fall *one CSE 300 or 400-level course, two external concentration courses
Spring *one CSE 300 or 400-level course, one external concentration course

*maximum of one CSE 300-level course required of the three total required

Computer Engineering - B.S.

About the Program

The computer engineering B.S. degree combines the study of mathematics, computer science, and electrical engineering. Computer engineering emphasizes those topics that bridge the electrical engineering and computer science disciplines: computer hardware, device-oriented software, and the interface between hardware and software. General education is integrated into the curriculum consistent with other engineering programs at UB. For further information, see the Computer Engineering entry in this catalog, http://undergrad-catalog.buffalo.edu/academicprograms/comeng.shtml.

Computer Science / Computer Science And Engineering - B.S./M.S.

Acceptance Criteria

Completion of at least 56 credits with a minimum GPA of 3.0 (five-year path), or a minimum GPA of 3.3 (four-year path) among all required CSE, MTH, and EAS courses. Transfer students must complete at least one semester at the university before applying.

Application must be accompanied by two letters of recommendation from our faculty and reviewed by the department.

It is recommended that candidates complete CSE 115, CSE 116, CSE 191, CSE 241, CSE 250, *MTH 141 or *MTH 142 and a calculus-based probability or statistics course prior to applying.

**Unless exempted by an SAT score, Advanced Placement credits, or transfer credits.*

Advising Notes

In addition to university-wide graduation requirements, a minimum GPA of 3.0 is required for each of the following three sets of courses: (a) all undergraduate CSE, EAS, MTH, and STA required courses; and (b) all graduate courses; and (c) one of [CSE 505, CSE 521], one of [CSE 531, CSE 596], one of [CSE 555, CSE 563, CSE 573, CSE 574], one of [CSE 552, CSE 589, CSE 590, CSE 593). In addition, no more than 2 Cs and no Ds or Fs are allowed in graduate courses used in the program.

No required courses may be taken Pass-Fail or Satisfactory-Unsatisfactory.

A minimum of 30 graduate credits is required by the Graduate School to satisfy MS university requirements. A total of 134 credits (both undergraduate and graduate) is required for this program, which includes the university general education courses.

Students enrolled in the BS/MS program must take all courses that are cross-listed 400/500 at the 500-level, with the exception of CSE 542, which cannot be used as a requirement towards the MS portion of this program. Students enrolled in the BS/MS program are not allowed to take the same CSE course at the 400 and 500 level with both counting towards their degree requirements.

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Prerequisite Courses

CSE 115 Intro to Computer Science for Majors I
CSE 116 Intro to Computer Science for Majors II
CSE 191 Intro to Discrete Structures
CSE 241 Digital Systems
CSE 250 Data Structures
MTH 141 College Calculus I
MTH 142 College Calculus II
One calculus-based probability or statistics course (e.g., EAS 305, MTH 411)

Required Courses

undergraduate:
CSE 331 Intro to Algorithm Analysis & Design
CSE 341 Computer Organization
CSE 396 Intro to the Theory of Computation
CSE 442 Software Engineering
One 300-level or higher MTH or STA course
Any two-course science and engineering sequence (from Biology, Chemistry, Geology, Physics, or any department in the School of Engineering and Applied Sciences, except CSE).

Graduate*:
CSE 505 Fundamentals of Programming Languages
CSE 521 Intro to Operating Systems
One of the following:
CSE 531 Analysis of Algorithms
CSE 596 Intro to the Theory of Computation
One of the following:
CSE 555 Intro to Pattern Recognition
CSE 563 Knowledge Representation
CSE 573 Intro to Computer Vision & Image Processing
CSE 574 Intro to Machine Learning
One of the following:
CSE 552 VLSI (Very Large Scale Integration) Testing
CSE 589 Modern Networking Concepts
CSE 590 Computer Architecture
CSE 593 Intro to VLSI Electronics
One additional 500-level CSE course (excluding CSE 501 Graduate Studies in CS I, CSE 503 Computer Science for Nonmajors I, CSE 504 Computer Science for Nonmajors II, or CSE 507 Object Oriented Applications & Systems Design (for nonmajors) and one additional 600-level CSE course**
Capstone event (MS Thesis or MS Project)***
Additional CSE graduate courses to ensure 30 credits hours at the graduate level****

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

Summary
Total required credit hours for the undergraduate portion: 58-60
Total required credit hours for the BS/MS: 88-90

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

Refer to the graduate school's policies and procedures manual for requirements for master's degree candidates.

*Students in the BS/MS program must change status from undergraduate to graduate while completing the program. Student status will change to graduate after the completion of two graduate level courses. When the student changes status to graduate, all graduate school rules and policies apply; therefore, the student must be familiar with and adhere to the graduate school's policies and procedures manual as well as the CSE department's Graduate Handbook.

**Core areas are defined in the CSE Graduate Handbook. The following courses cannot be counted towards the MS degree: CSE 501, CSE 503, CSE 504, CSE 507, CSE 699. At most, one credit of CSE 598 - Internship can be counted towards the MS degree. At most, one of the following can be counted towards the MS degree (CSE 519, CSE 522, CSE 523, CSE 525, CSE 539, CSE 553).

***Please refer to the CSE Graduate Handbook for further information about the MS Thesis or MS Project.

****Additional graduate-level courses are required to equal 30 or more credits. (Excludes CSE 501, CSE 503, CSE 504, and CSE 507). Courses outside of CSE can be counted towards a graduate degree, but there are limitations and restrictions. Refer to the CSE Graduate Handbook for further information.

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Recommended Sequence of Program Requirements

FIRST YEAR
Fall CSE 115, MTH 141
Spring CSE 116, CSE 191, MTH 142

SECOND YEAR
Fall CSE 250, CSE 241, one science and engineering sequence course
Spring one calculus-based probability or statistics course (e.g., EAS 305, MTH 411), one science and engineering sequence course

THIRD YEAR
Fall CSE 331, one 3XX or 4XX MTH or STA course (approved by faculty advisor)
Spring CSE 396, CSE 341

FOURTH YEAR
Fall CSE 442, CSE 505
Spring CSE 521, one of: [CSE 555, CSE 563, CSE 573, CSE 574,] one 5XX or 6XX CSE course

FIFTH YEAR
Fall one of: [CSE 552, CSE 589, CSE 590, CSE 593], one CSE seminar, one 5XX or 6XX-level CSE course
Spring one of: [CSE 531 or CSE 596], two 5XX or 6XX level CSE courses
*Additional graduate-level courses are required to equal 30 or more credits (excludes CSE 501, CSE 503, CSE 504, and CSE 507).

Note: Exceptional accelerated students may be able to complete this program in 4 years with the consultation, guidance, and approval of CSE advisor.

Computer Science - B.A./M.B.A

Acceptance Criteria

Prior admission into the CS major and acceptance as a graduate student by the School of Management.

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

Advising Notes

In addition to university-wide graduation requirements, a minimum GPA of
2.5 is required in technical courses. This is the GPA among all CSE, MTH, STA, EAS and MGQ courses used below as required courses.

No required courses may be taken Pass-Fail or Satisfactory-Unsatisfactory.

Prerequisites are satisfied with a grade of C- or better.

Students apply directly to the School of Management during their junior year to be admitted to the MBA Program. The MBA courses shown below are representative of those currently required but may change prior to a student's acceptance into the MBA Program. Students should confirm MBA program requirements with the School of Management upon their application and acceptance to that program.

Required Courses

CSE 115 Intro to Computer Science for Majors I
CSE 116 Intro to Computer Science for Majors II
One of: MTH 121/MTH 122 Survey Of Calculus & Its Applications I & II; MTH 131 Mathematical Analysis for Management; or MTH 141/MTH 142 College Calculus I & II
CSE 191 Intro to Discrete Structures
CSE 241 Digital Systems
CSE 250 Data Structures
Two of: CSE 305 Intro to Programming Languages
CSE 321 Real-Time and Embedded Operating Systems
CSE 331 Intro to Algorithm Analysis and Design
CSE 341 Computer Organization

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CSE 396 Intro to the Theory of Computation
Three CSE courses at the 300-level or above with minimum two at the 400-level (excludes CSE 494 - CSE 499, CSE 492)
Any two-course science and engineering sequence (from Biology, Chemistry, Geology, Physics, or any department in the School of Engineering and Applied Sciences, except CSE).
MGA 603 Financial Accounting for Managers
MGA 605 Accounting for Management Decision Making
MGB 610 Organizational Behavior
MGB 611 Team Skills
MGE 604 Business Economics
MGF 611 Financial Analysis for Managers
MGG 601 Corporate Social Responsibility/Sustainability
MGG 635 Management Communication
MGM 615 Marketing for Managers
MGO 620 Operations Management
MGO 640 Business Strategy
MGO 642 Integration of Business Functions
MGO 644 Business Practice
MGQ 608 Statistical Analysis for Managers
MGQ 609 Analytics for Managers
MGS 605 IT Management
Seven MGT electives (may include internship)

*MGQ 606 satisfies a requirement in the School of Management as well as the probability/statistics requirement in computer science.

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

Summary
Total required credit hours for the undergraduate portion: 79-84
Total required credit hours for the BA/MBA: 130-135

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

Refer to the School of Management's MBA handbook for requirements for MBA candidates.

Recommended Sequence of Program Requirements

FIRST YEAR
Fall CSE 115, one of: MTH 121, MTH 131 or MTH 141
Spring CSE 116, CSE 191, one of: MTH 122 or MTH 142 (unless completed MTH 131)

SECOND YEAR
Fall CSE 250, CSE 241, one science and engineering sequence course
Spring one of: CSE 305, CSE 321, CSE 331, CSE 341, or CSE 396; one science and engineering sequence course

THIRD YEAR
Fall one of: CSE 305, CSE 321, CSE 331, CSE 341, or CSE 396; one CSE 300 or 400-level or higher courses (min. 2 CSE 400-level)
Spring two CSE 300 or 400-level or higher courses (min. 2 CSE 400-level)

FOURTH YEAR
Fall MGA 603, MGB 610, MGB 611, MGF 611, MGG 601, MGG 635, MGM 615, MGQ 608, MGQ 609
Spring MGA 605, MGE 604, MGO 620, MGO 640, MGS 605

FIFTH YEAR
Fall four MGT electives
Spring MGO 642, MGO 644, three MGT electives

Computer Science - Minor

About the Minor

Six CSE courses (excluding CSE 494 - CSE 499, CSE 492), with at least two at the 300- level or above. A minimum GPA of 2.5 overall in those courses is required. At least three courses must be taken at UB. A maximum of two of these courses may be used for a student's major.

Admission into the computer science minor is based on completion of any three of the courses that constitute a minor in computer science

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with a minimum combined GPA of 2.5 in those courses. Applicants to the computer science minor should bring a copy of their current UB DARS report directly to the Department of Computer Science and Engineering during the semester after three of the six required courses are completed.

SAMPLE MINOR PROGRAMS
Software track: CSE 115, CSE 116, CSE 191, CSE 250, CSE 305, CSE 442
Hardware track: CSE 115, CSE 116, CSE 191, CSE 241, CSE 379, CSE 380

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 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

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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

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

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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
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

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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 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

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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

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

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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 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.

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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.)