COMPUTER SCIENCE AND SOFTWARE ENGINEERING

Computer Science Bldg. (14), Room 254
Phone: 805.756.2824
https://csc.calpoly.edu

Department Chair: Franz Kurfess

College of Engineering Advising Center
Engineering South (40), Room 114
Phone: 805.756.1461

Academic Programs

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The Computer Science Department educates students in the discipline of computer science and teaches them to apply their education to solve practical problems in a socially responsible way. To support the department’s educational mission, faculty engage in research and professional development.

In all of the department’s programs, laboratory experiences ensure that students have both a theoretical and practical understanding of computer science. Individual and team projects, culminating in the capstone experience of a senior project, reinforce concepts and provide students the opportunity to apply and communicate their knowledge.

The department has active student chapters of the Association for Computing Machinery, IEEE Computer Society and Upsilon Pi Epsilon (the national computer honor society). Student teams compete in national competitions and student organizations sponsor industry/student events.

The department, with industry support, provides a modern computing environment that includes the most current software tools running on a variety of workstations and servers. Projects in advanced courses are supported by specialized laboratories for databases, computer architecture, operating systems, software engineering, computer networks, computer graphics, and human/computer interaction.

Undergraduate Programs

BS Computer Science

The BS Computer Science program provides in-depth study of computer science fundamentals and practice, including programming concepts and languages, software engineering, operating systems and computer architecture.

In addition, the major offers a wide choice of technical electives that allows students to focus on particular areas of computer science and their application. Typical areas of emphasis include databases, distributed computing, software engineering, programming languages, graphical user interfaces, operating systems, computer networks, computer graphics, and artificial intelligence.

The curriculum is project-oriented and develops students’ ability to solve problems using modern computing concepts. Students can expect to complete many projects in a variety of programming languages and on a variety of computer systems. During their last year of study, students complete a senior project, either individually or as members of a team, spanning two academic quarters.

Graduates of the computer science program are well prepared to become successful professionals and to pursue graduate study. They are sought by the computer industry for positions as software developers, quality assurance and test engineers, and other technical positions in computer-related industries.

The Computer Science program has four broad program educational objectives (PEOs) that graduates are expected to attain within five years of graduation:

- Technical Competence. Graduates have applied current technical knowledge and skills to develop effective computer solutions, using state-of-the-art technologies.
- Interpersonal Skills. Graduates have communicated effectively and worked collaboratively in a team environment.
- Professional Awareness. Graduates have maintained a positive and ethical attitude concerning the computing profession and its impact on individuals, organizations and society.
- Intellectual Growth. Graduates have continued to grow intellectually and professionally in their chosen field, including successful pursuit of graduate study if such study was a desired goal.

The BS Computer Science program is accredited by the Computing Accreditation Commission of ABET, http://www.ABET.org.

Concentration

Interactive Entertainment

The Interactive Entertainment concentration focuses on providing the preparation necessary to succeed in technical-oriented careers relating to computer graphics, digital animation, video games and interactive experiences. Students will take part in multiple project-based courses involving significant programming and design work, and will employ relevant industry practices.

BS Software Engineering

The BS in Software Engineering prepares students to become software professionals who develop software products on time, within budget, and that meet customer requirements. Building on the fundamentals of computer science, the program focuses on practical aspects of building and deploying software systems in a socially responsible way. The program’s educational mission supports the faculty in research and professional development that keeps them current in their field and in touch with current industry practices and trends.

The hallmark of the program is “hands on” experience where students follow a curriculum that builds on traditional computer science but differs from the BS in Computer Science in the following ways:

1. Classes emphasize the team approach to building software and provide leadership opportunities for every student.
2. Classes place an emphasis on software processes and lifecycles.
3. Classes include significant learning in engineering and management areas such as quality assurance, testing, metrics, maintenance, configuration management and interpersonal management skills.

4. The curriculum has a stronger emphasis on mathematics and the use of engineering methods in software design.

The software engineering curriculum culminates in a year-long capstone sequence where the students work in teams to build a large software system. Students are required to develop an ability to work in a significant application domain through the requirement of an advisor approved cooperative education experience.

Department programs are designed to be flexible. Although freshmen choose their major when they apply for admission, students can easily switch among software engineering, computer engineering and computer science since the lower division curricula are similar.

The software industry increasingly requires both a software and an engineering background for their cutting edge projects. Graduates with a BS in Software Engineering can expect to find significant opportunities in software development and management, software engineering and marketing.

The Software Engineering program has four broad program educational objectives (PEOs) that graduates are expected to attain within five years of graduation:

- Technical Competence. Graduates have applied the software engineering body of knowledge and other technical skills to specify, design, and implement complex software systems, doing so with state-of-the art technologies.
- Interpersonal Skills. Graduates have communicated effectively and worked collaboratively in a multi-disciplinary team environment.
- Professional Awareness. Graduates have maintained a positive and ethical attitude concerning the computing profession and its impact on individuals, organizations and society.
- Intellectual Growth. Graduates have continued to grow intellectually and professionally in their chosen field, including successful pursuit of graduate study if such study was a desired goal.

The BS Software Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.ABET.org.

**BS Computer Engineering**

This program is jointly administered by the Computer Science Department and the Electrical Engineering Department. For information regarding this program, please refer to Computer Engineering (http://catalog.calpoly.edu/collegesandprograms/collegeofengineering/computerengineering).

**Computer Science Minor**

Nearly all disciplines use the capabilities of computers. The minor consists of a core and upper-division courses selected in consultation with an advisor. The core provides common knowledge and skills needed by anyone who wishes to advance further in computer science. The remaining courses enable students to specialize in areas relevant to their goals.

Admission to the minor is limited and selection is based upon the applicant’s performance in:

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<th>Course</th>
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<th>Units</th>
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<td>Fundamentals of Computer Science</td>
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Students who intend to minor in computer science should consult the College of Engineering Advising Center website for GPA and course grade requirements for admission to the minor. In addition, they should contact the Advising Center for further information before planning to enter the minor.

Before formally applying, students must make an appointment at the College of Engineering Advising Center. The computer science minor is not open to CSC, CPE or Software Engineering (SE) major students. Questions concerning the minor should be directed to the Advising Center.

**Computing for Interactive Arts Minor**

The minor in Computing for Interactive Arts (CIA) is a Cross Disciplinary Studies Minor jointly offered by the Department of Art and Design and the Computer Science Department. The CIA minor fosters a collaborative, cross-disciplinary environment in which Art and Design students integrate coding and algorithmic thinking in creative works and Computer Science students apply the principles and methodology of design thinking to visual applications. The minor enables students from different disciplines to collaborate on projects requiring both a technical and a creative perspective.

**Cross Disciplinary Studies Minor in Data Science**

An interdisciplinary minor sponsored by the departments of Statistics and Computer Science. For more information, see the Statistics (http://catalog.calpoly.edu/collegesandprograms/collegeofsciencemathematics/statistics) section.

**Graduate Program**

**MS Computer Science**

The MS program in Computer Science offers students the opportunity to prepare for careers in several areas of emphasis including software engineering, computer architecture, programming languages, theory of computing, operating systems, database systems, distributed computing, computer networks, artificial intelligence, computer graphics, and human computer interaction. The program is designed for maximum flexibility to allow students to concentrate in one or more areas of study.

Eligibility for admission to the program requires a baccalaureate degree from an accredited institution and good standing at the last college attended. Admission can be granted in either classified or conditionally classified status. Classified admission can be granted to domestic and overseas applicants who satisfy the following conditions: applicants with a bachelor’s degree in computer science, software engineering, or computer engineering are required to have a minimum 3.0 grade point average, including a minimum 3.0 grade point average in major courses; applicants with a bachelor’s degree in a different field must have completed the required preliminary coursework listed in the table below and have a minimum grade point average of 3.25 for all undergraduate coursework. Conditionally classified admission can be granted to domestic applicants who satisfy the following conditions:
The applicant must hold a Computer Science minor obtained as part of their undergraduate study, or they must have successfully completed introductory and upper-division Computer Science coursework in the amount equivalent to the Computer Science minor (an equivalent of about 28-32 quarter units). Specifically, applicants are expected to have completed the equivalent of 24 units of coursework (6 courses) from the below list, prior to starting their MS in Computer Science study.

Eligibility
Students majoring in BS Computer Science, BS Software Engineering, and BS Computer Engineering are eligible to apply to the blended program if they meet the following minimum eligibility requirements:

- Junior status and completion of 20 units of CSC/CPE courses past CSC 203/CPE 203; and
- Meet the minimum GPA requirement of 3.0

Participation in the program is based on prior academic performance and other measures of professional promise. Students are selected by a faculty committee.

Program of Study
Students in the blended program complete all courses required for the MS degree and all courses required for the BS degree. Completion of the MS thesis may satisfy the senior project requirement. Please refer to your undergraduate degree department office for any restrictions on the master's thesis where a major design experience is required to complete the undergraduate degree.

Upon completion of the program, students are awarded the BS and the MS degrees at the same graduation ceremony and at the same time. Degrees are earned concurrently.

CSC Courses

CSC 101. Fundamentals of Computer Science. 4 units
Term Typically Offered: F, W, SP
Prerequisite: Completion of ELM requirement, and passing score on MAPE or MATH 117 with a grade of C- or better or MATH 118 with a grade of C- or better, or consent of instructor.

Basic principles of algorithmic problem solving and programming using methods of top-down design, stepwise refinement and procedural abstraction. Basic control structures, data types, and input/output. Introduction to the software development process: design, implementation, testing and documentation. The syntax and semantics of a modern programming language. Credit not available for students who have taken CSC/CPE 108. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 101.

CSC 105. Fundamentals of Computer Science I Supplemental Instruction. 1 unit
CR/NC
Term Typically Offered: TBD
Concurrent: CPE/CSC 101.

Facilitated study and discussion of fundamental concepts of computer science and familiarization with programming environments. Credit/No Credit grading only. 1 laboratory. Crosslisted as CPE/CSC 105.
CSC 108. Accelerated Introduction to Computer Science. 4 units
Term Typically Offered: TBD
Prerequisite: MATH 118 (or equivalent) with a grade of C- or better, significant experience in computer programming, and consent of instructor.

Accelerated introduction to basic principles of algorithmic and object-oriented problem solving and programming. Introduction to programming language concepts including control structures, data types, classes, and inheritance. Program design principles. Use and implementation of algorithms (searching, sorting, recursion) and data structures (lists, stacks, and queues). Intended for students with experience in algorithmic problem solving and using basic control structures and data types in a modern programming language (CPE/CSC 101), but who are not ready for CPE/CSC 202. Not open to students with credit in CPE/CSC 102 or CPE/CSC 202. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 108.

CSC 123. Introduction to Computing. 4 units
Term Typically Offered: F
Prerequisite: Basic computer literacy.

Use of a supportive software development environment to design, develop, and test applications in a selected topic domain that demonstrates the potential of careers in computing. An introduction to computing and to the selected topic domain. The Schedule of Classes will list topic selected. Not for programming experience required. Not for students with credit in CPE/CSC 103 or CPE/CSC 203. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 123.

CSC 171. Introduction to Interactive Entertainment. 4 units
Term Typically Offered: W
Prerequisite: Basic computer literacy.

Use of click-and-drag software application to create an entertaining or informative, socially responsible application, such as a game. Team collaboration to design, develop, and test applications. Focus on design, teamwork, and using an iterative development process. An enjoyable introduction to both computer science and interactive entertainment. No computer science experience required. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 123.

CSC 200. Special Problems for Undergraduates. 1-2 units
Term Typically Offered: TBD
Prerequisite: Consent of instructor.

Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

CSC 202. Data Structures. 4 units
Term Typically Offered: F, W, SP
Prerequisite: CPE/CSC 101 with a grade of C- or better; MATH 141 or MATH 221 with a grade of C- or better; or consent of instructor.

Introduction to data structures and analysis of algorithms. Abstract datatypes. Specification and implementation of advanced data structures. Theoretical and empirical analysis of recursive and iterative algorithms. Software performance evaluation and testing techniques. Not open to students with credit in CSC/CPE 108. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 202. Formerly CPE/CSC 103.

CSC 203. Project-Based Object-Oriented Programming and Design. 4 units
Term Typically Offered: F, W, SP
Prerequisite: CPE/CSC 202 with a grade of C- or better or consent of instructor.

Object-oriented programming and design with applications to project construction. Introduction to class design, interfaces, inheritance, generics, exceptions, streams, and testing. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 203. Formerly CPE/CSC 102.

CSC 209. Problem Solving with Computers. 1 unit CR/NC
Term Typically Offered: TBD
Prerequisite: CSC/CPE 101 or CSC/CPE 108 with a grade of C- or better, or consent of instructor.

Reinforcement of computer science fundamentals. Review of important algorithms, language features, design, syntax, and testing techniques. Repeated application of techniques to solve problems in a constrained amount of time. Primarily intended to support students preparing for the Association for Computing Machinery's International Collegiate Programming Contest. Credit/No Credit grading only. Total credit limited to 15 units. 1 laboratory.

CSC 225. Introduction to Computer Organization. 4 units
Term Typically Offered: F, W, SP
Prerequisite: CSC/CPE 202 (formerly CSC/CPE 103).

Introduction to computer systems. Simple instruction set architecture and the computer hardware needed to implement that architecture. Machine and assembly language programming. 3 lectures, 1 laboratory.

CSC 231. Programming for Engineering Students. 2 units
Term Typically Offered: F, W, SP
Prerequisite: MATH 142; PHYS 121 or PHYS 131 or PHYS 141.

Programming techniques and procedures with applications to engineering problems. Introduction to numerical methods and simulation. Credit not allowed for CSC, Software Engineering or CPE majors. 2 activities.

CSC 232. Computer Programming for Scientists and Engineers. 3 units
Term Typically Offered: TBD
Prerequisite: MATH 118 or equivalent.

Computer programming, with an emphasis on procedural programming, taught using a language hosted by applications commonly used in science and engineering. Credit not allowed for CSC, CPE or Software Engineering majors. 2 lectures, 1 activity.

CSC 234. C and Unix. 3 units
Term Typically Offered: TBD
Prerequisite: MATH 142.

The C programming language and the UNIX programming environment. Operators, standard I/O functions, strings, pointers and arrays, data types and storage classes. Unix shell programming and basic I/O system calls. Credit not allowed for CSC, Software Engineering or CPE majors. 3 lectures.
CSC 235. Fundamentals of Computer Science for Scientists and Engineers I. 4 units
Term Typically Offered: TBD
Prerequisite: MATH 141 or MATH 161 with a grade of C- or better, or consent of instructor.

Introduction to the fundamentals of computer programming with an emphasis on mathematical, scientific and engineering applications: principles of algorithmic problem solving and procedural programming using a modern programming language, data types, elementary data structures, input/output and control structures. Not a substitute for CSC/CPE 101 for CSC/CPE majors or minors. 3 lectures, 1 laboratory.

CSC 236. Fundamentals of Computer Science for Scientists and Engineers II. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 235 with a grade of C- or better, or consent of instructor.

Further study of computer program development with an emphasis on mathematical, scientific and engineering applications. Introduction to more complicated data types and structures. Practice of more complicated techniques of procedural programming. Introduction to the principles of object-oriented programming using a modern programming language. Detailed discussion of lists and classic list algorithms, algorithm analysis, multidimensional arrays, records, dynamic data structures, file input/output, classes. Not a substitute for CSC/CPE 202 for CSC/CPE/SE majors or minors. 3 lectures, 1 laboratory.

CSC 290. Selected Topics. 1-4 units
Term Typically Offered: TBD
Prerequisite: Open to undergraduate students and consent of instructor.

Directed group study of selected topics. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 lectures.

CSC 300. Professional Responsibilities. 4 units
Term Typically Offered: F, W, SP
Prerequisite: CSC/CPE 357 and junior standing.

The responsibilities of the computer science professional. The ethics of science and the IEEE/ACM Software Engineering Code of Ethics. Quality tradeoffs, software system safety, intellectual property, history of computing and the social implications of computers in the modern world. Applications to ethical dilemmas in computing. Technical presentation methods and practice. 3 lectures, 1 laboratory.

CSC 301. Personal Software Process. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 102 and CSC/CPE 103, or CSC/CPE 202 and CSC/CPE 203.

Principles and practices for defining and applying software processes to individual software development tasks. Quantitative methods for the measurement and analysis of software development cost and quality. Interpretation and evaluation of process metrics for creation of improvement plans. Adaptation of processes to individual styles. 3 lectures, 1 laboratory.

CSC 302. Computers and Society. 4 units
GE Area F
Term Typically Offered: TBD
Prerequisite: Junior standing and completion of GE Area B.

Social, ethical, political and technological implications and effects of computers in the modern world. Examination of the benefits and side-effects of computer applications and automation. Case study review and analysis. 4 lectures. Fulfills GE Area F.

CSC 303. Teaching Computer Science. 2 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 102 and CSC/CPE 103, with a grade of C- or better or consent of instructor, or CSC/CPE 202 and CSC/CPE 203, with a grade of C- or better or consent of instructor.

Practical coverage of educational techniques appropriate for tutoring in CSC/CPE undergraduate courses, including Socratic methods for tutoring of technical topics, design of test questions and grading rubrics, and lecture presentation. Intended for CSC/CPE/SE students interested in tutoring, grading, or a career in teaching computer science. 1 lecture, 1 laboratory. Not available for technical elective credit.

CSC 305. Individual Software Design and Development. 4 units
Term Typically Offered: F
Prerequisite: CSC/CPE 357.

Practical software development skills needed for construction of mid-sized production-quality software modules, using the CSC upper division programming language. Topics include inheritance, exceptions, and memory and disk-based dynamic data structures. Students must complete an individual programming project of mid-level complexity. 3 lectures, 1 laboratory.

CSC 307. Introduction to Software Engineering. 4 units
Term Typically Offered: F, SP
Prerequisite: CSC 141 or CSC 348; and CPE/CSC 357.

Requirements, specification, design, implementation, testing and verification of large software systems. Study and use of the software process and software engineering methodologies; working in project teams. Not open to students with credit in CSC 308. 3 lectures, 1 laboratory.

CSC 308. Software Engineering I. 4 units
Term Typically Offered: F
Prerequisite: CSC/CPE 141 or CSC 348; and CPE/CSC 357.

Principles for engineering requirements analysis and design of large complex software systems. Software process models. Methods of project planning, tracking, documentation, communication, and quality assurance. Analysis of engineering tradeoffs. Group laboratory project. Technical oral and written presentations. 3 lectures, 1 laboratory.

CSC 309. Software Engineering II. 4 units
Term Typically Offered: W, SP
Prerequisite: CSC 308.

Continuation of the software lifecycle. Methods and tools for the implementation, integration, testing and maintenance of large software systems. Software development and test environments. Software quality assurance. Group laboratory project. Technical presentation methods and practice. 3 lectures, 1 laboratory.
CSC 310. Computers for Poets. 4 units  
GE Area F  
Term Typically Offered: TBD  
Prerequisite: Junior standing and completion of GE Area B.

How computers and computer devices work. Introduction to software systems and applications. How computers connect with various media including images, speech and data. How information is encoded and transmitted across networks. Relationship between the computer and human information processing. 4 lectures. Crosslisted as CSC 310/HNRS 311. Fulfills GE Area F.

CSC 311. Computational Art. 4 units  
GE Area F  
Term Typically Offered: SP  
Prerequisite: Junior standing and completion of GE Area B.

Interdisciplinary creation of static and animated computational art using algorithms. General design principles in a digital setting, including color, shape, composition, perspective, principles of animation. Development of computational tools such as variables, iteration, logic, functions. Creative expression via coding and creative coding. 3 lectures, 1 laboratory. Fulfills GE Area F.

CSC 320. Practical Computer Security for Everyone. 4 units  
GE Area F  
Term Typically Offered: W  
Prerequisite: Junior standing and completion of GE Area B.

Exploration of practical computer security in everyday life for non-majors. Covering the principles, technologies and tools used to secure the Internet and keep ourselves ‘digitally’ secure, including: privacy and anonymity, web and data security, cryptography, malware, authentication and access control. 3 lectures, 1 laboratory. Fulfills GE Area F.

CSC 321. Introduction to Computer Security. 4 units  
Term Typically Offered: TBD  
Prerequisite: CPE/CSC 357.

Survey of topics in computer system and network security, including protection, access control, distributed access control, operating system security, applied cryptography, network security, firewalls, secure coding practices, and case studies from real-world systems. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 321.

CSC 323. Cryptography Engineering. 4 units  
Term Typically Offered: F  
Prerequisite: CPE/CSC 357.

An introduction to the theory and practice of building secure, cryptographic systems. Core cryptographic primitives. Implementation, evaluation and subversion of widely deployed cryptographic products and protocols. 3 lectures, 1 laboratory.

CSC 325. Introduction to Privacy: Policy and Technology. 4 units  
Term Typically Offered: SP  
Prerequisite: CSC 300.

Introduction to policies and technologies related to digital privacy. Legal decisions and policies, domestic and global cultural expectations, and privacy related technologies including applications to surveillance, big data, websites, mobile, and privacy by design. 3 lectures, 1 laboratory.

CSC 344. Music Programming. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 141 or CSC 348; and CPE/CSC 357.


CSC 348. Discrete Structures. 4 units  
Term Typically Offered: F, W, SP  
Prerequisite: CSC/CPE 102 and CSC/CPE 103, with a grade of C- or better or consent of instructor, or CSC/CPE 202 and CSC/CPE 203, with a grade of C- or better or consent of instructor.

Structures of computer science: logic, sets, relations, functions, graphs and trees. Propositional and predicate logic. Applications of predicate logic to preconditions, postconditions, and proof techniques. Complexity of algorithms. Not open to students with credit in CSC 141. 4 lectures.

CSC 349. Design and Analysis of Algorithms. 4 units  
Term Typically Offered: F, SP  
Prerequisite: CSC 141 and MATH 142; or CSC 348 and MATH 142; or CPE/CSC 102 and CPE/CSC 103 and MATH 248; or CPE/CSC 202 and CPE/CSC 203 and MATH 248.

Intermediate and advanced algorithms and their analysis. Mathematical, geometrical, and graph algorithms. NP-complete problems. Additional topics will be chosen from pattern matching, file compression, cryptology, dynamic and linear programming, and exhaustive search. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory.

CSC 350. Computing for Interactive Arts Capstone I. 2 units  
Term Typically Offered: W  
Prerequisite: ART 384; CPE/CSC 102 and CSC/CPE 103, or CSC/CPE 202 and CSC/CPE 203; and junior standing.

Definition and specification of a team-based creative collaboration on a digital interactive art project (e.g. animation, video game, interactive media display, etc). Research and techniques, project planning and project team organization, prototype creation. 1 lecture, 1 laboratory. Crosslisted as ART/CSC 350.

CSC 357. Systems Programming. 4 units  
Term Typically Offered: F, W, SP  
Prerequisite: CSC/CPE 102 and CSC/CPE 103 with a grade of C- or better or consent of instructor, or CSC/CPE 202 and CSC/CPE 203 with a grade of C- or better or consent of instructor; and CSC 225 or CPE/EE 229 or CPE/EE 233.

C programming language from a system programming perspective. Standard C language including operators, I/O functions, and data types in the context of system functions. Unix commands, shell scripting, file system, editors. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 357.
CSC 365. Introduction to Database Systems. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 141; or CSC 348; or CPE/CSC 102 and CPE/CSC 103 and MATH 248; or CPE/CSC 202 and CPE/CSC 203 and MATH 248.  

Basic principles of database management systems (DBMS) and of DBMS application development. DBMS objectives, systems architecture, database models with emphasis on Entity-Relationship and Relational models, data definition and manipulation languages, the Structured Query Language (SQL), database design, application development tools. 3 lectures, 1 laboratory.

CSC 366. Database Modeling, Design and Implementation. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 365.  
The database modeling problem. Database modeling levels: external, conceptual, logical and physical. Database models: entity-relationship, relational, object-oriented, semantic, and object-relational. Normal forms. Distributed database design. Functional analysis of database applications and transaction specification, design, and implementation. 3 lectures, 1 laboratory.

CSC 369. Introduction to Distributed Computing. 4 units  
Term Typically Offered: F, SP  
Prerequisite: CSC/CPE 102 and CSC/CPE 103, or CSC/CPE 202 and CSC/ CPE 203; and one of the following: STAT 301, STAT 312, STAT 321 or STAT 350.  

Introduction to distributed computing paradigms and cloud computing. Modern distributed computing infrastructures. Problem-solving in a distributed computing environment. 3 lectures, 1 laboratory.

CSC 371. Game Design. 4 units  
Term Typically Offered: F  
Prerequisite: CSC/CPE 102 and CSC/CPE 103; or CSC/CPE 202 and CSC/ CPE 203.  

In-depth study of game design including rules, player interaction, and storytelling. Exploration of effective use of sound, art, and game controls in creating meaningful play. Development of fully functioning and engaging games, following standard domain-specific software development processes and using physical prototyping and playtesting. Current, industry-tested game engines. 3 lectures, 1 laboratory.

CSC 378. Interactive Entertainment Engineering. 4 units  
Term Typically Offered: TBD  
Prerequisite: CPE/CSC 102 and CPE/CSC 103, or CPE/CSC 202 and CPE/ CPE 203.  

Project-based, software oriented, design of interactive entertainment applications. Topics may include interactive storytelling, game physics, game AI, scripting, and development of virtual worlds using modeling and rendering tools. Projects require significant programming. 3 lectures, 1 laboratory.

CSC 400. Special Problems. 1-4 units  
Term Typically Offered: TBD  
Prerequisite: Consent of instructor.  

Individual investigation, research, studies or surveys of selected problems. Total credit limited to 4 units.

CSC 402. Software Requirements Engineering. 4 units  
Term Typically Offered: F  
Prerequisite: CSC 307 or CSC 309.  

Software requirements elicitation, analysis and documentation. Team process infrastructure and resource estimation to support appropriate levels of quality. Software architectural design. 3 lectures, 1 laboratory.

CSC 405. Software Construction. 4 units  
Term Typically Offered: W  
Prerequisite: CSC 305 and CSC 402.  

Design and construction of sizeable software products. Technical management of software development teams. Software development process models, software design, documentation, quality assurance during development, software unit and integration testing; CASE tools, development environments, test tools, configuration management. 3 lectures, 1 laboratory.

CSC 406. Software Deployment. 4 units  
Term Typically Offered: SP  
Prerequisite: CSC 405.  

Deployment of a sizeable software product by a student team. Software maintenance and deployment economic issues. Management of deployed software: version control, defect tracking and technical support. 3 lectures, 1 laboratory.

CSC 409. Current Topics in Software Engineering. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 307 or CSC 309.  

Selected topics in software engineering. Topics may include program generation, quality assurance, formal methods, software metrics, design methods, testing, or software development processes. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory.

CSC 410. Software Evaluation. 4 units  
Term Typically Offered: F  
Prerequisite: CSC 349; STAT 301, STAT 312, STAT 321 or STAT 350.  

Theory and practice of evaluation of software and software systems. Design of experiments for measuring software performance, measuring software output quality, comparing multiple implementations of the same algorithm, and evaluation of software heuristics. Selection of appropriate software evaluation measures and criteria. 3 lectures, 1 laboratory.

CSC 422. Network and Web Security. 4 units  
Term Typically Offered: W  
Prerequisite: CPE 464.  

Introduction to network and web security, including denial of service, botnets, access control, routing attacks, transport layer attacks, tunneling mechanisms, VPNs, IDS, firewalls, penetration testing, key distribution, browser security, social network security, email security, jamming, and wireless security. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 422.
CSC 424. Software Security. 4 units  
Term Typically Offered: SP  
Prerequisite: CPE/CSC 307 or CPE/CSC 309; CPE/CSC 321.  

Principles behind secure software design including threat models, trust management, common vulnerabilities and mitigation techniques, robust software development, isolation of untrusted code, auditability, and testing. 3 lectures, 1 laboratory.

CSC 429. Current Topics in Computer Security. 4 units  
Term Typically Offered: SP  
Prerequisite: CPE/CSC 321 and CPE/CSC 357.  

Selected topics in emerging areas of computer security. Potential topics include: network and web security, critical infrastructure protection, embedded systems security, malware analysis, mobile security, and digital forensics, among others. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory.

CSC 430. Programming Languages I. 4 units  
Term Typically Offered: F, W, SP  
Prerequisite: CSC 349 and CSC/CPE 357.  

Construction of the front end of a compiler including lexical analysis, syntactic analysis, type checking, and formal semantics. Introduction to regular languages, finite automata, and context-free grammars. 3 lectures, 1 laboratory.

CSC 431. Programming Languages II. 4 units  
Term Typically Offered: SP  
Prerequisite: CSC 430.  

Language principles and design issues: bindings, conversion, parameter passing, and dynamic semantics. Language implementation: intermediate code representation, memory management, code optimization, and code generation. Functional programming languages. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 431.

CSC 435. Introduction to Object Oriented Design Using Graphical User Interfaces. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 305.  

Principles of object-oriented design, with emphasis on use of these principles in the design of graphical interfaces. Comparison and contrasting of two major object-oriented languages and their corresponding GUI class libraries. Language-independent object-oriented design methods, and application of these methods in the construction of a GUI-based project. Course may be offered in classroom-based or online format. 3 lectures, 1 laboratory.

CSC 436. Mobile Application Development. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC/CPE 357.  

Inception, development, testing, and deployment of mobile applications. Introduction to tools, libraries, and frameworks for one or more mobile platforms and devices. Emphasis on software engineering best practices for developing entrepreneurial or humanitarian mobile-centric applications. 3 lectures, 1 laboratory.
CSC 458. Current Topics in Computer Systems. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 357.
Selected aspects of design, implementation and analysis of networks, advanced operating and distributed systems. Topics may include process management, virtual memory, process communication, context switching, file system designs, persistent objects, process and data migration, load balancing, security and networks. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 458.

CSC 466. Knowledge Discovery from Data. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 349 and one of the following: STAT 302, STAT 312, STAT 321 or STAT 350.
Overview of modern knowledge discovery from data (KDD) methods and technologies. Topics in data mining (association rules mining, classification, clustering), information retrieval, web mining. Emphasis on use of KDD techniques in modern software applications. 3 lectures, 1 laboratory.

CSC 468. Database Management Systems Implementation. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 365.
Data structures and algorithms used in the implementation of database systems. Implementation of data and transaction managers: access methods interfaces, concurrency control and recovery, query processors and optimizers. Introduction to implementation of distributed database systems. 3 lectures, 1 laboratory.

CSC 469. Distributed Systems. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 357.
Foundations of distributed systems, distributed hash tables (peer-to-peer systems), failure detectors, synchronization, election, inter-process communication, consensus, replication, key-value stores, and measurements. 3 lectures, 1 laboratory. Crosslisted as CSC/CPE 469.

CSC 471. Introduction to Computer Graphics. 4 units
Term Typically Offered: TBD
Prerequisite: CPE/CSC 357.
Graphics software development and use of application programming interfaces for 3D graphics. The graphics pipeline, modeling, geometric and viewing transforms, lighting and shading, rendering, interaction techniques and graphics hardware. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 471.

CSC 473. Advanced Rendering Techniques. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 471.
Illumination models, reflectance, absorption, emittance, Gouraud shading, Phong shading, raytracing polyhedra and other modeling primitives, coherence, acceleration methods, radiosity, form factors, advanced algorithms. 3 lectures, 1 laboratory.

CSC 474. Computer Animation. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 471.
Basic and advanced algorithms for generating sequences of synthetic images. Interpolation in time and space, procedural and keyframe animation, particle systems, dynamics and inverse kinematics, morphing and video. 3 lectures, 1 laboratory.

CSC 476. Real-Time 3D Computer Graphics Software. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 471.
Basic and advanced algorithms for real-time, interactive, 3D graphics software. Modeling (polygon mesh, height field, scene graph), real-time rendering and shading (visibility processing, LOD, texture and light maps), collision detection (bounding volumes, complexity management), interactive controls, multi-player game technology, game engine architecture. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 476.

CSC 477. Scientific and Information Visualization. 4 units
Term Typically Offered: F
Prerequisite: CSC 349.
Basic data processing (magnitude, grouping and segmentation), visualization design, cognition and perception, spatial data visualizations (2D and 3D, e.g. GIS data, medical data) information data visualization, spatial encoding, color encoding, and interaction. 3 lectures, 1 laboratory.

CSC 478. Current Topics in Computer Graphics. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 471.
Selected aspects of the design, implementation and analysis of computer graphics. Topics may include rendering, modeling, visualization, animation, virtual reality, computer vision, multimedia, and perception issues. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory.

CSC 480. Artificial Intelligence. 4 units
Term Typically Offered: TBD
Prerequisite: either CSC/CPE 102 and CSC/CPE 103 with a grade of C- or better or consent of instructor; or CSC/CPE 202 and CSC/CPE 203 with a grade of C- or better or consent of instructor.
Programs and techniques that characterize artificial intelligence. Programming in a high level language. 3 lectures, 1 laboratory.

CSC 481. Knowledge Based Systems. 4 units
Term Typically Offered: TBD
Prerequisite: CSC/CPE 480.
In-depth treatment of knowledge representation, utilization and acquisition in a programming environment. Emphasis on the use of domain-specific knowledge to obtain expert performance in programs. 3 lectures, 1 laboratory.
CSC 483. Current Topics in Human-Computer Interaction. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 484.

Selected aspects of the field of human-computer interaction. Topics may include dynamic information visualization, universal access, social impact of technology usage, educational technology, human cognition and performance studies, and extended usability evaluation techniques. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory.

CSC 484. User-Centered Interface Design and Development. 4 units
Term Typically Offered: W
Prerequisite: CSC 307 or CSC 308; junior standing.

Introduction to the importance of user-centered principles in the design of good interfaces and effective human-computer interaction. Topics include: study of human characteristics affected by interface design, effective requirements data collection and analysis, user-centered approaches to software engineering, and evaluation of interface and interaction quality. 3 lectures, 1 laboratory.

CSC 486. Human-Computer Interaction Theory and Design. 4 units
Term Typically Offered: TBD
Corequisite: CSC 484.

Application of the theories of human-computer interaction to the task of user-centered design. Survey of techniques for studying and involving users in different aspects of the design process, and demonstration of where and when applicable. Combining of theoretical understanding with practical experience to design solutions to problems facing interactive systems designers. 3 lectures, 1 laboratory.

CSC 489. Current Topics in Artificial Intelligence. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 480.

Selected aspects of the design, implementation and analysis of advanced systems and concepts in the area of artificial intelligence. Topics may include knowledge representation, reasoning, learning, or planning, and specific techniques like intelligent agents, genetic algorithms, semantic web, or robotics. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory.

CSC 490. Selected Advanced Topics. 1-4 units
Term Typically Offered: TBD
Prerequisite: Consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. Class schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

CSC 491. Senior Project I. 2 units
Term Typically Offered: F, W, SP
Prerequisite: CSC 307 or CSC 309; and consent of instructor.

Selection and completion of a project by individuals or team which is typical of problems which graduates must solve in their fields of employment. Project may include students from other disciplines. Formulation of outline, literature review, and project schedule.

CSC 492. Senior Project II. 2 units
Term Typically Offered: F, W, SP
Prerequisite: CSC 491 and consent of instructor.

Selection and completion of a project by individuals or team which is typical of problems which graduates must solve in their fields of employment. Project may include students from other disciplines. Project results are presented in a formal report.

CSC 493. Cooperative Education Experience. 2 units
CR/NC
Term Typically Offered: TBD
Prerequisite: Sophomore standing and consent of instructor.

Part-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 6 units.

CSC 494. Cooperative Education Experience. 6 units
CR/NC
Term Typically Offered: TBD
Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 18 units.

CSC 495. Cooperative Education Experience. 12 units
CR/NC
Term Typically Offered: TBD
Prerequisite: Sophomore standing and consent of instructor.

Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. A more fully developed formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

CSC 496. Selected Advanced Laboratory. 1-4 units
Term Typically Offered: TBD
Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Schedule of Classes will list title selected. Total credit limited to 8 units. 1 to 4 laboratories.

CSC 500. Directed Study. 2-3 units
CR/NC
Term Typically Offered: TBD
Prerequisite: Fully classified graduate standing and consent of instructor.

Individual directed study of advanced topics. Total credit limited to 4 units. Credit/No Credit grading only.
CSC 508. Software Engineering I. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 307 or CSC 308 and graduate standing, or consent of instructor.  
In-depth study of requirements engineering, software project management, formal specifications and object-oriented analysis. 4 seminars.

CSC 509. Software Engineering II. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 508 and graduate standing, or consent of instructor.  
In-depth study of software modeling and design. Formal design methodologies. Design patterns. Detailed case studies of existing projects. Tools and methods for designing large software systems. 4 seminars.

CSC 515. Computer Architecture. 4 units  
Term Typically Offered: TBD  
Prerequisite: CPE 315 and graduate standing, or consent of instructor.  
Comparative study and design of multiprocessor, dataflow, RISC, high level language and other new computer architectures. VLSI processor design techniques. 3 seminars, 1 laboratory. Crosslisted as CPE/CSC 515.

CSC 521. Computer Security. 4 units  
Term Typically Offered: TBD  
Prerequisite: CPE/CSC 321 and graduate standing.  
Exploration of advanced topics in computer security with an emphasis on research topics. 3 lectures, 1 laboratory.

CSC 530. Languages and Translators. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 430 and graduate standing, or consent of instructor.  
Advanced programming language and translator concepts. Language concepts to be covered will be selected from current state-of-the-art languages and current issues in language design. Compiler concepts will include retargetable code generation, use of translator-writing systems, and error recovery. 4 seminars.

CSC 540. Theory of Computation II. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 445 and graduate standing, or consent of instructor.  
Advanced topics in theoretical computer science from such areas as automata theory, cellular automata theory, computational complexity, and program verification. 4 seminars.

CSC 550. Operating Systems. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC/CPE 453 and graduate standing, or consent of instructor.  
General concepts of computer architecture and operating systems. Design features of advanced computers, general time-sharing systems and schemes for dynamic memory allocation, scheduling and protection. Dynamic linkage between subroutines. Intercommunication between input/output and processors. 4 seminars.

CSC 560. Database Systems. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 365 and graduate standing, or consent of instructor.  
Current topics in database systems: distributed databases and transactions, nested and long-running transactions, distributed concurrency control, semantic and object-oriented data models, database systems for non-traditional applications: engineering design databases, active, logic, temporal, multimedia, and real-time databases. 4 seminars.

CSC 564. Computer Networks: Research Topics. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC/CPE 464 and graduate standing, or consent of instructor.  
Exploration of advanced topics in emerging computer networking technologies; focus on leading edge computer network research topics. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 564.

CSC 566. Topics in Advanced Data Mining. 4 units  
Term Typically Offered: F  
Prerequisite: CSC 466 or CSC 480 or CSC 582.  
Advanced topics in the areas of data mining, knowledge discovery in data, machine learning, information retrieval and intelligent analysis of information. The Schedule of Classes will list topic selected. Total credit limited to 8 units. 4 lectures.

CSC 569. Distributed Computing. 4 units  
Term Typically Offered: TBD  
Prerequisite: CSC 141 or CSC 348; and CPE/CSC 357; or graduate standing and consent of instructor.  
Principles and practices in distributed computing: interprocess communications, group communications, client-server model, distributed objects, message queue system, distributed services, mobile agents, object space, Internet protocols. Distributed algorithms: consensus protocols, global state protocols. Fault tolerance: classification of faults, replication. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 569.

CSC 570. Current Topics in Computer Science. 2-4 units  
Term Typically Offered: TBD  
Prerequisite: Graduate standing and evidence of satisfactory preparation in computer science.  
Directed group study of selected topics for graduate students. Topics will normally consist of continuations of those in CSC 520, CSC 530, CSC 540, CSC 550, CSC 560 and CSC 580, and other topics as needed. Class Schedule will list topic selected. Topic credit limited to 12 units. 2 to 4 seminars.

CSC 572. Computer Graphics. 4 units  
Term Typically Offered: TBD  
Prerequisite: Successful completion of CSC/CPE 471 and graduate standing, or consent of instructor.  
Advanced topics in computer graphics with emphasis on leading edge computer graphics technologies and advanced topics in graphics fundamentals. 3 lectures, 1 laboratory.
CSC 580. Artificial Intelligence. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 480 and graduate standing, or consent of instructor.

Current research in the field of artificial intelligence with emphasis on cooperative agents, distributed agents, and decision making in complex, concurrent environments. AI programming in a distributed environment. 3 lectures, 1 laboratory.

CSC 581. Computer Support for Knowledge Management. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 480 or CSC 484 or consent of instructor.

Methods and techniques that computer-based systems can provide to make the management of knowledge and information in digital form easier for the user. Emphasis on support for knowledge-intensive activities performed by users. 3 lectures, 1 laboratory.

CSC 582. Introduction to Natural Language Processing. 4 units
Term Typically Offered: TBD
Prerequisite: CSC 466 or CSC 480 or graduate standing. Recommended: CSC 580.

Classic Natural Language Processing systems and techniques; review of recent advancements in the subject. Topics selected from: parsing, tagging, word-sense disambiguation, natural language generation, data mining, voice recognition, vocalization, knowledge management, semantic networks, stylistics and machine learning. 3 lectures, 1 laboratory.

CSC 590. Thesis Seminar. 1 unit
Term Typically Offered: F, W, SP
Prerequisite: Graduate standing or consent of instructor.

Preparation for conducting research in the field of computer science, through discussions, selected readings, and student presentations. 1 seminar.

CSC 593. Cooperative Education Experience. 2 units
CR/NC
Term Typically Offered: TBD
Prerequisite: Graduate standing and consent of instructor.

Advanced study analysis and part-time work experience in student's career field; current innovations, practices, and problems in administration, supervision, and organization of business, industry, and government. Must have demonstrated ability to do independent work and research in career field. Credit/No Credit grading only.

CSC 594. Cooperative Education Experience. 6 units
CR/NC
Term Typically Offered: TBD
Prerequisite: Graduate standing and consent of instructor.

Advanced study analysis and full-time work experience in student's career field; current innovations, practices, and problems in administration, supervision, and organization of business, industry, and government. Must have demonstrated ability to do independent work and research in career field. Credit/No Credit grading only.