

# COMPUTER SCIENCE AND ENGINEERING

Accredited by ABET (B.S. in Computer Science)

## School of Computer Science and Engineering

Jack Brown Hall, Room 307  
(909) 537-5326 [cse.csusb.edu](http://cse.csusb.edu)

### Bachelor of Arts

Computer Systems  
General Interdisciplinary Option  
Game Development Option  
Graphics Programming Option  
Web Programming Option  
System Administration Option

### Bachelor of Science

Bioinformatics (See [Page 114.](#))  
Computer Engineering (see [Page 144.](#))  
Computer Science

### Minor

Computer Science

### Certificate Program

Computer Systems and Programming

### Master of Science

Computer Science  
(Degree requirements can be found on [Page 409.](#))

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Computer science is a discipline with historical foundations in science, mathematics and engineering. It is concerned with the study of a variety of topics including computer design, computer programming, information processing, data communication, machine intelligence, robotics, the algorithmic solution of problems, and the various representations of information including numeric, alphabetic, visual, audio and sensory. This discipline deals with effective ways to represent and display information, algorithms to process information, languages in which to express algorithms, hardware systems to interpret such languages, theoretical techniques for insuring the accuracy and cost effectiveness of these processes and the philosophical foundations of computing and machine intelligence.

The Bachelor of Science in Computer Science is a degree program accredited by ABET/CAC guidelines, and as such provides both intellectual depth and breadth in the discipline of computer science. The program emphasizes both fundamentals of computer science and the skills required to apply computer science to application areas, as well as professional ethics. The objective of the program is to prepare the student upon graduation for: immediate entry into a programming, software engineering, systems and network administration or similar position in either the public or private sectors; or for graduate education in computer science or a closely related discipline leading to a Master or Doctoral degree. Graduates of the program have been successful both in industry and in graduate school.

The Bachelor of Arts in Computer Systems program emphasizes the application of principles to practical problem solving in a domain of interest. Students complete a core set of foundation courses and coursework in one of the following concentrations: web programming, system administration, game development, graphics

programming. Students also have the ability to combine the study of computer systems with another field of study through the general interdisciplinary option.

The Minor in Computer Science is designed to give students from all academic disciplines a foundation in computing which will enrich and support the student's own field of study.

The Certificate Program in Computer Systems and Programming is a short course of study provided for those individuals who desire a career in the computer science field which does not require a formal degree.

To stay ahead in today's increasingly competitive computer marketplace and to broaden each student's computer applications horizon, the department encourages student affiliation with the California State University's International Programs. For further information, see [Page 20.](#)

## B.A. IN COMPUTER SYSTEMS

### Requirements (94-96 units)

**Total units required for graduation: 180**

### Requirements for the B.A. in Computer Systems:

Lower-division requirements (20 units)

1. CSE 201. Computer Science I (4)
2. CSE 202. Computer Science II (4)
3. MATH 211. Basic Concepts of Calculus (4)
4. MATH 262. Applied Statistics (4)
5. MATH 272. Discrete Mathematics (4)

Upper-division requirements (26 units)

1. CSE 313. Machine Organization (4)
2. CSE 330. Data Structures (4)
3. CSE 375. Requirements Analysis and Design (4)
4. CSE 455. Software Engineering (4)
5. CSE 482. Senior Interdisciplinary Project (4)
6. CSE 488. Ethics and the Computing Professional (2)
7. COMM 311. Business and Professional Communication (4)

Option Requirement (48-49 units)

Requirements for one of the following options must be satisfied:

### General Interdisciplinary Option (48 units)

1. Twenty-four units chosen from CSE courses numbered 300 and above.
2. Twenty-four units of coursework in another discipline such as a minor or other cohesive program of study; subject to approval by the School of Computer Science and Engineering.

### Game Development Option (49 units)

1. CSE 420. Computer Graphics (4)
2. CSE 431. Algorithm Analysis (4)
3. CSE 440. Game Design (4)
4. CSE 441. Game Programming (4)
5. CSE 512. Introduction to Artificial Intelligence (4)
6. CSE 520. Advanced Computer Graphics (4)
7. CSE 535. Numerical Computation (4)
8. MATH 212. Calculus II (4)
9. MATH 372. Combinatorics (4)
10. PHYS 221. General Physics I (5)
11. Eight units of related project-oriented coursework subject to approval by the School of Computer Science and Engineering.

### Graphics Programming Option (48 units)

1. ART 120. Introduction to Two Dimensional Design (4)
2. ART 232. Principles of Design Management (4)
3. CSE 322. Web Page Programming (4)
4. CSE 420. Computer Graphics (4)

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- 5. CSE 440. Game Design (4)
- 6. CSE 441. Game Programming (4)
- 7. CSE 520. Advanced Computer Graphics (4)
- 8. Twenty units of courses covering graphical and digital media subject to approval by the School of Computer Science and Engineering.

**Web Programming Option (48 units)**

- 1. CSE 292. Java Programming (4)
- 2. CSE 322. Web Page Programming (4)
- 3. CSE 365. Systems Administration (4)
- 4. CSE 366. Systems Networking (4)
- 5. CSE 405. Server Programming (4)
- 6. CSE 557. Computer Systems in Organizations (4)
- 7. CSE 572. Database Systems (4)
- 8. CSE 580. Advanced Database Systems (4)
- 9. Eight units chosen from CSE courses numbered 300 and above.
- 10. Eight units of courses covering graphical and digital media subject to approval by the School of Computer Science and Engineering.

**System Administration Option (50 units)**

- 1. CSE 292. Java Programming (4)
- 2. CSE 310. Digital Logic (5)
- 2. CSE 322. Web Page Programming (4)
- 3. CSE 350. File Systems (4)
- 4. CSE 360. Script Programming (4)
- 5. CSE 365. Systems Administration (4)
- 6. CSE 366. Systems Networking (4)
- 7. CSE 401. Contemporary Computer Architecture (5)
- 8. CSE 405. Server Programming (4)
- 9. CSE 460. Operating Systems (4)
- 10. CSE 557. Computer Systems in Organizations (4)
- 11. CSE 572. Database Systems (4)

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**B.S. IN COMPUTER SCIENCE**

**Requirements (123 units)**

**Total units required for graduation: 191**

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**Requirements for the B.S. in Computer Science:**

Lower-division requirements (53 units)

- 1. CSE 201. Computer Science I (4)
- 2. CSE 202. Computer Science II (4)
- 3. MATH 211. Basic Concepts of Calculus (4)
- 4. MATH 212. Calculus II (4)
- 5. MATH 213. Calculus III (4)
- 6. MATH 262. Applied Statistics (4)
- 7. MATH 272. Discrete Mathematics (4)
- 8. PHYS 221. General Physics I (5)
- 9. PHYS 222. General Physics II (5)
- 10. PHYS 223. General Physics III (5)
- 11. Five units chosen from:
  - BIOL 100. Topics in Biology (5)
  - BIOL 200. Biology of the Cell (5)
- 12. One additional science course (with lab component), not previously taken, from the following areas:
  - Biology (5)
  - Chemistry (5)
  - Geological Sciences (5)
  - Physics (5)

Upper-division requirements (50 units)

- 1. CSE 310. Digital Logic (5)
- 2. CSE 313. Machine Organization (4)
- 3. CSE 320. Programming Languages (4)
- 4. CSE 330. Data Structures (4)

- 5. CSE 350. File Systems (4)
- 6. CSE 401. Contemporary Computer Architectures (5)
- 7. CSE 431. Algorithm Analysis (4)
- 8. CSE 455. Software Engineering (4)
- 9. CSE 460. Operating Systems (4)
- 10. CSE 488. Ethics and the Computing Professional (2)
- 11. CSE 489. Senior Seminar (2)
- 12. CSE 500. Introduction to Formal Languages and Automata (4)
- 13. MATH 372. Combinatorics (4)

Electives (20 units)

- 1. Theory
  - Four units chosen from:
    - CSE 501. Introduction to Theory of Computation (4)
    - CSE 511. Expert Systems (4)
    - CSE 512. Introduction to Artificial Intelligence (4)
    - CSE 515. Automated Reasoning (4)
    - CSE 535. Numeric Computation (4)
- 2. Systems
  - Four units chosen from:
    - CSE 540. Systems Simulation (4)
    - CSE 565. Systems Programming (4)
    - CSE 570. Compilers (4)
    - CSE 572. Database Systems (4)
    - CSE 580. Advanced Data Base Systems (4)
- 3. Hardware
  - A minimum of four units chosen from:
    - CSE 510. Advanced Computer Architecture (4)
    - CSE 524. Supercomputing and Visualization (4)
    - CSE 525. Parallel Algorithms and Programming (4)
    - CSE 530. Data Communications and Networks (4)
    - CSE 531. High Performance Networks (4)
- 4. Eight units chosen from 400-level and above courses not previously counted as electives above.

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**MINOR IN COMPUTER SCIENCE**

**Requirements (28 units)**

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**Requirements for a minor in Computer Science:**

- 1. Mathematics
  - Four units chosen from:
    - MATH 272. Discrete Mathematics (4)
    - MATH 372. Combinatorics (4)
- 2. CSE 201. Computer Science I (4)
- 3. CSE 202. Computer Science II (4)
- 4. CSE 330. Data Structures (4)
- 5. Twelve units of upper-division CSE courses. These units may not include CSE 399 or 575.

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**DEPARTMENTAL HONORS**

The department faculty will determine whether a student is to be awarded departmental honors based upon the following criteria:

- 1. Demonstration of independent work by achieving a grade of "C" (2.0) or better in a four-unit CSE 595. Independent Study or credit in CSE 575. Internship in Computer Science;
- 2. Attainment of a minimum overall grade point average of 3.0 ("B") in all university courses attempted and a minimum grade point average of 3.5 in all computer science courses required by the major (as defined above);
- 3. At least five computer science courses required by the major must be taken at this university.

Candidacy for honors in computer science is voluntary and must be applied for at the beginning of the senior year. Approval of honors rests solely with the department and other factors may weigh in their judgment.

## **CERTIFICATE PROGRAM**

Certificates may be earned by regularly matriculated or extended learning students and denote successful completion of a prescribed program of study designed to a) impart specified professional/vocational/career competencies; or b) produce mastery of the content of a sub-field of an academic major (discipline); or c) provide exposure to the range of materials in a traditional or emerging interdisciplinary field. Certain certificate programs contain 600-level courses as requirements and/or electives. These 600-level courses may not be taken by undergraduate students. Candidates must receive two-thirds of their certificate-applicable credit from the university. The transferring of credit or the substitution of courses may occur only after application to the appropriate campus authority. See [Page 60](#) for additional certificate information.

### **Certificate in Computer Systems and Programming**

#### **Certificate Requirements (28 units)**

1. CSE 125. Programming in Visual Basic (4)
  2. CSE 201. Computer Science I (4)
  3. CSE 202. Computer Science II (4)
  4. CSE 292. JAVA Programming (4)
- Note:** Students who select an option requiring CSE 330 MUST substitute MATH 272 for either CSE 125 or 292.
5. Choose 12 units from one of the following options:

#### **General Option**

1. Twelve units of upper-division coursework chosen in consultation with the director of the School of Computer Science and Engineering.

#### **Database Programming Option**

1. CSE 330. Data Structures (4)
2. CSE 350. File Structures (4)
3. CSE 572. Database Systems (4)

#### **Web Programming Option**

1. CSE 322. Web Page Programming (4)
2. CSE 360. Script Programming (4)
3. CSE 405. Server Programming (4)

#### **System Administration Option**

1. CSE 360. Script Programming (4)
2. CSE 365. Systems Administration (4)
3. CSE 366. Systems Networking (4)

#### **Game Programming Option**

1. CSE 330. Data Structures (4)
2. CSE 420. Computer Graphics (4)
3. CSE 441. Game Programming (4)

#### **Graphics Option**

1. CSE 330. Data Structures (4)
2. CSE 420. Computer Graphics (4)
3. CSE 520. Advanced Computer Graphics (4)

#### **Software Engineering (System Analysis) Option**

1. CSE 330. Data Structures (4)
2. CSE 375. Requirements Analysis and Design (4)
3. CSE 455. Software Engineering (4)

## **COURSE OFFERINGS IN**

### **COMPUTER SCIENCE AND ENGINEERING (CSE)**

Effective Fall 2010, the designation for Computer Science and Engineering courses changes from CSCI to CSE.

#### **Lower Division**

#### **121. Computer Technology and People**

Computer technology: background, contemporary uses, implications and trends, impact on society and ethics. No previous computer background required. May not be taken for credit by students who have received credit for CSE 100, 120 or 127. (2 units)

#### **122. Bioinformatics**

Introduction to natural sciences and its interplay with computer science. Description of bioinformatics and the application of computer science and problems in the life sciences. (GE=B4) (2 units)

#### **123. Using Computer Software**

Word processor, spreadsheet, and database as an aid to personal productivity. One hour lecture and two hours laboratory. Materials fee required. No previous computer background required. May not be taken for credit by students who have received credit for CSE 100 or 127. (2 units)

#### **124. Exploring the Information Superhighway**

Familiarization, use and customization of software tools to explore and publish information on the Internet. This includes Electronic Mail, the World Wide Web and USENET news groups. One hour lecture and two hours laboratory. Materials fee required. (2 units)

#### **125. Programming in Visual Basic**

Programming techniques in an event-driven and object-oriented environment. Graphical user interfaces, controls, properties, procedures, and functions. Multiple forms, menus, file access, and applications. Three hours lecture and two hours activity laboratory. Materials fee required. (4 units)

#### **127. Introduction to Computer Technology for Educators**

Operations, terminology and components. Implications for a democratic society, impacts on quality-of-life including economics, morality, legality and ethics. Hands-on use of computers for word processing, etc. Three hours lecture and two hours laboratory. Materials fee required. No programming involved. No previous computer experience required. May not be taken for credit by students who have received credit for CSE 100, 121 and 123. (4 units)

#### **128. Application Programming**

Developing applications using a current graphical user programming environment. Three hours lecture and two hours activity laboratory. Materials fee required. (4 units)

#### **129. Science, Computing and Society**

Understanding physical science in terms of information and information processing. Use of computer as both a tool and metaphor for understanding life, physics, and existence, and its implications and impact on society and ethics. (GE=B4) (2 units)

#### **133. Using Word Processors and Presentation Software**

Advanced features and applications of word processing and presentation software. Includes desktop publishing, building macros, building custom presentation templates and proper presentation techniques. One hour lecture and two hours laboratory. Materials fee required. Prerequisite: CSE 123 or consent of instructor. (2 units)

#### **134. Using Spreadsheet and Database Software**

Advanced features and applications of spreadsheets and end-user database applications, including advanced formula programming, spreadsheet linking and database access. One hour lecture and two hours laboratory. Materials fee required. Prerequisite: CSE 123 or consent of instructor. (2 units)

#### **136. HTML Programming**

Using the Hyper Text Markup Language to create Web pages. One hour lecture and two hours laboratory. Materials fee required. Prerequisite: CSE 124 or consent of instructor. (2 units)

**140. Introduction to Game Design**

Elements of games, including theme, game play and presentation. The process by which game concepts are transformed into actual computer games, including the use of scripting languages to incorporate sound and graphics into a game, design documents, project management, evaluation, game play parameters and artificial intelligence. Several examples will be used to demonstrate game design concepts and practice. One hour lecture and two hours laboratory. Materials fee required. (2 units)

**141. Introduction to Game Level Editing**

Basic concepts on level editing of games and how a game is fine-tuned and balanced to improve game play and fun. Use of a level editor to demonstrate application of physics and artificial intelligence is included. One hour lecture and two hours laboratory. Materials fee required. (2 units)

**201. Computer Science I**

Computer software design, implementation, methods and environments using a current high-level language. Survey of computers, applications and other areas of computer science. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisites: satisfactory score on the Entry Level Mathematics examination, and either some prior computer programming experience, or CSE 125. (4 units)

**202. Computer Science II**

Analysis of problems and the formulation, documentation and implementation of their solutions; an introduction to data structures with abstract data types; software engineering principles for both individual and group projects. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisites: CSE 201 and satisfactory score on the Entry Level Mathematics examination. (4 units)

**240. FORTRAN Programming**

FORTRAN language with emphasis on computer solution of problems reducible to algebraic models and elementary numerical methods. Prerequisites: MATH 211 and either some computer programming experience or CSE 125. (4 units)

**280. Low Level Language**

Study of the assembly language for selected processors such as 8086/88, 68000, PDP II, VAX II, etc. May be repeated twice for credit as topics change. Prerequisite: CSE 202. (4 units)

**290. High Level Language**

Study of a selected high-level programming language, such as ADA, COBOL, C, Prolog or LISP. May be repeated for credit as topics change. Prerequisite: CSE 202. (4 units)

**292. JAVA Programming**

Study of object oriented programming and techniques using JAVA programming language. Prerequisite: prior course in computer programming. (4 units)

**295. Computer Science Project**

Production of documented computer programs under the direction of a faculty member. May be repeated twice for credit using different projects, a total of four units may apply toward graduation. Prerequisites: a minimum overall grade point average of 3.0 ("B"), consent of instructor, and departmental approval of a written proposal of a project submitted on a standard application filed in advance of the quarter in which the course is to be taken. (1-4 units)

**298. Application Software Topics**

Applications software in areas such as word processing, database, graphics, desk top publishing, planning and communications will be examined under specific operating systems. This is a how-to course and hands-on experience will be stressed. May be repeated for credit as topics change. No previous computing experience is required. One hour lecture and two hours laboratory. Materials fee required. Graded credit/no credit. (2 units)

**Upper Division****310. Digital Logic**

Boolean algebra, flip-flops, combinational and sequential circuits, arithmetic-logic units, memory devices, and I/O peripherals. Laboratory experiments include bread-board assembly of finite state machine circuits, registers and arithmetic-logic processors. Four hours lecture and three hours laboratory. Materials fee required. Prerequisites: CSE 202 and MATH 272. (5 units)

**311. Advanced Digital Design**

Transistor circuits, MOS and CMOS characteristics, design of logic families, CPLDs and FPGAs, timing, propagation, hazards, bistability and metastability, ASM charts, skew, reliability and testing, and transmission line behavior. Materials fee required. Three hours discussion and three hours laboratory. Prerequisite: CSE 310. (4 units)

**313. Machine Organization**

Typical components of von Neumann computer architectures; their organization, interrelated activities and control are emphasized and demonstrated using low-level languages. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 202. (4 units)

**320. Programming Languages**

Topics include formal language specification, data types and their implementation, abstract mechanisms, control structures, run-time representations and storage management. Several high-level languages will be examined. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 202. (4 units)

**322. Web Page Programming**

Current protocols, technology, languages, and methodologies for the browser side of web-based systems; performance issues; human factors, page and site design. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 202 or consent of instructor. (4 units)

**330. Data Structures**

Abstract data structures including lists, stacks, queues and trees; their storage allocation and associated application algorithms. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisites: CSE 202 and MATH 272 or 372. (4 units)

**350. File Systems**

Topics include file structures, file organization concepts and philosophies. Prerequisite: CSE 330. (4 units)

**360. Script Programming**

Getting started; terminal types; e-mail; command line and GUI interfaces; advanced editing; macros; text processing and programmer's tools. Two hours lecture and four hours activity laboratory. Materials fee required. Prerequisite: CSE 201. (4 units)

**365. Systems Administration**

Responsibilities and skills of the system administrator; managing accounts, system files and mail; security, reliability and backups; emergencies; ethics and usability. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 201. (4 units)

**366. Systems Networking**

Planning and configuring networks; file transfer; network file servers; bridges and routers. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 365. (4 units)

**375. Requirements Analysis and Design**

Requirements analysis, including organizational objectives, functional characteristics, technology, use cases and conceptual models. The use of aspects, patterns, objects and structure in architectural design specifications. Includes analysis and design of a software system for an organization, and fieldwork. Prerequisite: CSE 202. (4 units)

**399. Community Service Project**

Credit for performing academically related tasks in such agencies as educational, governmental and social service institutions. May be repeated for a total of six units. No more than six units of credit for Community Service Project courses may be applied toward degree requirements. Graded credit/no credit. Prerequisite: consent of department. (1-2 units)

**401. Contemporary Computer Architectures**

Design methodology; processor units and control units of von Neumann computer architectures; RISC architectures, including pipelining and parallel-processing. Laboratory experiments consist of the use of computer-aided design tools for VLSI layout and simulation. Four hours lecture and three hours laboratory. Materials fee required. Prerequisites: CSE 310 and 313. (5 units)

**403. Circuit Design and Analysis**

Analysis and design of digital and analog circuits, active and passive elements, diodes, FET and BJT transistor circuits, introduction to VLSI, two port networks, transmission lines, three phase circuits, filtering circuits in continuous and discrete time, Laplace and Z transform analysis and design, spectrum and power characterization of signals and systems. Three hours lecture and three hours activity laboratory. Materials fee required. Prerequisites: CSE 310, MATH 251, and PHYS 150. (4 units)

**405. Server Programming**

Current operating system technology; languages and methodologies of controlling servers; performance analysis; interfaces to databases; security, monitoring, and maintainability. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 322. (4 units)

**406. Introduction to Computer Engineering Design**

Introduction to the principles in engineering design and design issues of sustainability, environmental impact, human interface, accessibility and inclusive of a product, and effectiveness of the technique. One hour lecture and three hours laboratory. Materials fee required. Formerly CSE 152 and PHYS 152. Prerequisite: junior standing. (2 units)

**407. Computer Engineering Design**

Guided engineering design activity on an ongoing real world problem. Two hours lecture and three hours laboratory. Materials fee required. Formerly CSE 303. Prerequisite: CSE 406. (3 units)

**408. Sustainable Engineering Design**

Guided engineering design project on an ongoing real world problem. Examines issues of sustainability, energy, pollution, ethics, accessibility and effects of products on various stakeholders, analysis of designs and failure modes, as well as technical report writing and presentations. Three hours lecture and three hours laboratory. Materials fee required. Prerequisite: CSE 407. (4 units)

**420. Computer Graphics**

Survey of computer graphics hardware. Topics include animation, two-dimensional and three-dimensional transformation, hidden surface removal algorithm, business charts and applications. Prerequisite: CSE 330. (4 units)

**431. Algorithm Analysis**

Analysis and design of algorithms, including time and space complexity, design methodologies, and taxonomic classification of problems. Prerequisites: CSE 330 and MATH 372. (4 units)

**440. Game Design**

Study of game design concepts and game design specification. Topics include principles of user interface layout, game design techniques, game design methodologies, artificial intelligence in gaming, and game design tools. Prerequisite: CSE 330. (4 units)

**441. Game Programming**

Techniques and technology used to produce games. Topics include game engine design, mathematical foundations of game programming, game physics, artificial intelligence, and application of software engineering principles to a game development environment. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 420. (4 units)

**455. Software Engineering**

Advanced techniques and technology used to produce large software systems. Laboratory work with a software development environment. Three hours lecture and three hours laboratory. Materials fee required. Prerequisite: CSE 330. (4 units)

**460. Operating Systems**

An overview of operating systems. Principles of resource management and control. Multiprogramming, distributed systems and multiprocessor systems will be included. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisites: CSE 313 and 330. (4 units)

**482. Senior Interdisciplinary Project**

Analysis, design and implementation of a software system that solves an interdisciplinary problem related to the student's chosen program option or minor field of study. Presentation techniques and communication skills to support project planning and execution. Prerequisites: CSE 375 and consent of department. (4 units)

**488. Ethics and the Computing Professional**

Professionalism, ethics, legal issues and the social impact and role of computer technology. Prerequisite: senior standing. (2 units)

**489. Senior Seminar**

A series of weekly seminars covering a wide range of computer science topics and formats including presentations from industry and university personnel, and students regarding projects and research work. Graded credit/no credit. Prerequisite: completion of all required 300-level computer science courses for the B.S. in Computer Science degree. (2 units)

**492. Topics in Computer Science**

Consideration of a selected area of computer science. May be repeated for credit as topics change. Prerequisite: CSE 431 or consent of instructor. (2 units)

**500. Introduction to Formal Languages and Automata**

Introduction to formal language theory. Finite state machines, regular grammars, context-free grammars, context-sensitive grammars, push-down automata, closure properties. Prerequisite: CSE 431 or consent of instructor. (4 units)

**501. Introduction to Theory of Computation (S)**

Theoretical foundations of computer science: deterministic and non-deterministic Turing machines, models of computation; recursive functions, Church's thesis and undecidable problems; complexity classes P, NP, CO-NP and PSPACE. Formerly CSE 546. Prerequisite: CSE 500 or consent of instructor. (4 units)

**510. Advanced Computer Architecture**

High performance computer architectures and algorithms including pipeline, vector, array, multiprocessor computer designs, applications, and programming. Also covered are data flow and systolic machines, interconnection networks, and graph and parallel graph algorithms. Three hours lecture and two hours laboratory. Materials fee required. Prerequisite: CSE 401. (4 units)

**511. Expert Systems**

Expert systems components, problems and applications. Knowledge bases, inference "engines," and their integration within expert systems. Tools for building expert systems, system algorithms as related to hardware, implementation languages and examples of systems in operation. Prerequisite: CSE 330. (4 units)

**512. Introduction to Artificial Intelligence**

Problems and issues of artificial intelligence, current techniques and methods, and future prospects of machine intelligence. Three hours lecture and two hours activity laboratory. Materials fee required. Formerly CSE 411. Prerequisite: CSE 330. (4 units)

**513. Advanced Artificial Intelligence**

Advanced issues and techniques in artificial intelligence; intelligent agents for problem solving, reasoning and learning; advanced artificial intelligence programming in LISP. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 512 or consent of instructor. (4 units)

**515. Automated Reasoning**

Study of deduction algorithms for expert systems and the limitations thereof, propositional calculus, quantification theory, completeness and incompleteness theorems, Herbrand-Gödel computability, resolution principle, equality and inequality relations. Prerequisite: CSE 431. (4 units)

**520. Advanced Computer Graphics**

Advanced computer graphics concepts, theory and implementation techniques. Topics include shading models, parametric curves and surfaces, hidden edge and surface removal, and anti-aliasing. Prerequisite: CSE 420. (4 units)

**521. Field Programmable Gate Array Design**

FPGA design rules, timing, latency, optimizations, ASIC conversion, state machines, implementing arithmetic, counters, memory, error detection and correction, simulation, and layout. Materials fee required. Three hours lecture and three hours laboratory. Prerequisite: CSE 401. (4 units)

**524. Supercomputing and Visualization**

Design and implementation of scientific applications on high performance computers emphasizing graphics and visualization techniques. Topics include parallel algorithm development, multiprocessor and multicomputer programming, and real-time visualization programming of computationally intensive problems in the sciences. Prerequisite: CSE 330 or consent of instructor. (4 units)

**525. Parallel Algorithms and Programming**

Topics include algorithm design, analysis, and programming of high performance computers. Also covered are control-parallel versus data-parallel approaches, PRAM algorithm design, and selected parallel programming languages. Four hours lecture. Prerequisite: CSE 401. (4 units)

**530. Data Communications and Networks**

Topics include baseband and broadband signals and modulation schemes. Error detecting and correcting codes, ISO protocol standard, packet switching and various local network schemes. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisites: CSE 313 or 598, and 330. (4 units)

**531. High Performance Networks**

High performance network methodologies. Methods to develop network performance measures and models. Introduction to path cost estimation and service reliability issues. Three hours lecture and two hours laboratory. Materials fee required. Prerequisite: CSE 530 or consent of instructor. (4 units)

**535. Numerical Computation**

Introduction to scientific computing. Algorithms related to approximations, zero findings, numerical differentiation and integration, data fitting and interpolation, nonlinear equations. Three hours lecture and two hours laboratory. Materials fee required. Prerequisite: senior standing or consent of instructor. (4 units)

**540. System Simulation**

Theory and implementation of computerized modeling. Examples will include administrative, physical and biological systems. Prerequisite: CSE 330 or consent of instructor. (4 units)

**541. Robotics and Control**

Theory and practice of robotic modeling, control, programming, and construction. Three hours lecture and three hours laboratory. Materials fee required. Prerequisites: CSE 310 and 313. (4 units)

**550. Advanced Bioinformatics I: Sequence Analysis**

Pairwise and multiple sequence alignment of strings and relations to biology. Building phylogenetic trees from sequences. Predicting and analyzing RNA secondary structure. Three hours discussion and two hours activity. Materials fee required. Prerequisites: CSE 431 and senior standing or consent of instructor. (4 units)

**551. Advanced Bioinformatics II: Numerical Modeling**

Numerical techniques for the modeling and simulation of biological and chemical systems using ordinary and partial differential equations, and stochastic variables. Three hours discussion and two hours activity. Materials fee required. Prerequisite: CSE 535. (4 units)

**555. Software Design and Architecture**

Common patterns of architectural design, tradeoff analysis at the architectural level, domain-specific architectures, automatic support for architectural design, and formal methods of software architecture. Three hours lecture and two hours laboratory. Materials fee required. Prerequisite: CSE 330. (4 units)

**556. Introduction to Formal Methods, Models and Languages**

Applications of logic and mathematics in documenting problems, requirements, specifications, designs, and software. Formal modeling languages. Diagrammatic, algebraic, and tabular models. Model checking. Students prepare, check, and present models using techniques in the literature. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisites: CSE 320 and 330. (4 units)

**557. Computer Systems in Organizations**

General system and information theory. Modeling organizations, activities, hardware, data, and software using current techniques with emphasis on human-computer interaction, systems engineering and project planning. Students will study parts of actual organizations. Formerly CSE 372. Prerequisites: CSE 330, MATH 262, or consent of instructor. (4 units)

**565. Systems Programming**

Concepts of, and implementation techniques for systems software such as assemblers, editors, interpreters, linkers, loaders and operating systems. Prerequisite: CSE 460. (4 units)

**570. Compilers**

Interpreter and compiler structures. Topics include symbol tables, lexical and syntactic analyzers, and object code generation. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisites: CSE 313, 320 and 330. (4 units)

**572. Database Systems**

Basic concepts of database design and theory, including underlying storage structures and alternative approaches to database models (relational, object-relational, network and hierarchical). Hands-on applications with one or more commercial database management systems. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 330. (4 units)

**575. Internship in Computer Science**

Supervised work and study in private or public organizations. Graded credit/no credit. Prerequisites: a minimum grade point average of 3.0 and departmental approval of a written proposal submitted on a standard application filed in advance of the quarter in which the course is to be taken. (4 units)

**580. Advanced Database Systems**

Advanced description: advanced study of components of general database systems and other topics such as implementation methods, query language design, reliability, integrity, performance measures, distributed database systems and database machines. Three hours lecture and two hours activity laboratory. Materials fee required. Prerequisite: CSE 572. (4 units)

**594. Topics in Computer Science**

An in-depth consideration of selected areas of computer science. May be repeated for credit as topics change. Prerequisite: CSE 431 or consent of instructor. (4 units)

**595. Independent Study**

Laboratory and/or library research conducted under the direction of a faculty member. A total of four units in CSE 595 may be applied toward the computer science, computer systems, computer engineering, and bioinformatics majors. Prerequisites: a minimum overall grade point average of 3.0, consent of instructor and departmental approval of a written proposal of a project submitted on a standard application filed in advance of the quarter in which the course is to be taken. (1-4 units)

**598. Foundations of Computer Architecture**

Boolean algebra and logic gates; combinational and sequential logic; processor design; data path design; control design; memory organization; and system organization. May not be counted as upper-division elective units for the B.S. in Computer Science, B.A. in Computer Systems, B.S. in Computer Engineering, or B.S. in Bioinformatics. Prerequisites: CSE 202, MATH 272, and consent of instructor. (4 units)

**599. Foundations of Software Systems**

Software development process which includes software life-cycles, software techniques and technologies used to produce large software systems; operating systems including processes, input/output, memory management, and file systems. May not be counted toward the B.S. in Computer Science, B.A. in Computer Systems, B.S. in Computer Engineering, or B.S. in Bioinformatics. Prerequisites: CSE 330 and consent of instructor. (4 units)