# COMPUTER SCIENCE

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

## Department of Computer Science and Engineering

Jack Brown Hall, Room 307
(909) 537-5326   **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 110.)
Computer Engineering (see Page 136.)
Computer Science

### Minor

Computer Science

### Certificate Program

Computer Systems and Programming

### Master of Science

Computer Science
(Degree requirements can be found on Page 393.)

**FACULTY**: Richard Botting, Arturo Concepcion, George Georgiou (Chair), Ernesto Gomez, Dennis Ikenberry (Emeritus), Yasha Karant, Josephine Mendoza, Owen Murphy, Haiyan Qiao, Keith Schubert, David Turner, Kerstin Voigt, Tong Yu, Kay Zemoudeh

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 (92-99 units)

### Total units required for graduation: 180

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

Lower-division requirements (20 units)

1. CSCI 201.    Computer Science I (4)
2. CSCI 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. CSCI 313.    Machine Organization (4)
2. CSCI 330.    Data Structures (4)
3. CSCI 375.    Requirements Analysis and Design (4)
4. CSCI 455.    Software Engineering (4)
5. CSCI 482.    Senior Interdisciplinary Project (4)
6. CSCI 488.    Ethics and the Computing Professional (2)
7. COMM 311.    Business and Professional Communication (4)

Option Requirement (46-53 units)

Requirements for one of the following options must be satisfied:

**General Interdisciplinary Option (48 units)**

1. CSCI 372.    Computer Systems in Organizations (4)
2. CSCI 572.    Database Systems (4)
7. Sixteen units chosen from CSCI courses numbered 300 and above.
8. Completion of a minor in another discipline after consultation with a Computer Science and Engineering faculty advisor. (24 units minimum)

**Game Development Option (53 units)**

1. CSCI 320.    Programming Languages (4)
2. CSCI 420.    Computer Graphics (4)
3. CSCI 431.    Algorithm Analysis (4)
4. CSCI 440.    Game Design (4)
5. CSCI 441.    Game Programming (4)
6. CSCI 512.    Introduction to Artificial Intelligence (4)
7. CSCI 520.    Advanced Computer Graphics (4)
8. CSCI 535.    Numerical Computation (4)
9. CSCI 570.    Compilers (4)
10. MATH 212.    Calculus II (4)
11. MATH 372.    Combinatorics (4)
12. PHYS 221.    General Physics I (5)
13. Four units chosen from CSCI courses numbered 300 and above.

**Graphics Programming Option (48 units)**

1. ART 120.   Introduction to Two Dimensional Design (4)
2. ART 232.   Principles of Design Management (4)
3. CSCI 322.   Web Page Programming (4)
4. CSCI 420.   Computer Graphics (4)
5. CSCI 520.   Advanced Computer Graphics (4)
6. Twenty units chosen from
   ART 320.   Digital Image Editing (5)
   ART 322.   Web Design (5)
   ART 325.   Advanced Digital Image Editing (5)
   ART 326.   Interactive Multimedia Design (5)
   ART 330.   Animation and Web Motion-Graphics (5)
   ART 382.   Computer Animation: 3D Modeling (5)
   ART 383.   Computer Animation: Character Modeling (5)
   ART 388.   Digital Lighting (5)
   ART 422.   Dynamic Web Site Design (5)
7. Eight units chosen from CSCI courses numbered 300 and above.

**Web Programming Option (46 units)**

1. CSCI 292.   Java Programming (4)
2. CSCI 322.   Web Page Programming (4)
3. CSCI 365.   Systems Administration (4)
4. CSCI 366.   Systems Networking (4)
5. CSCI 372.   Computer Systems in Organizations (4)
6. CSCI 405.   Server Programming (4)
7. CSCI 572.   Database Systems (4)
8. CSCI 580.   Advanced Database Systems (4)
9. Ten units chosen from:
   ART 320.   Digital Image Editing (5)
   ART 322.   Web Design (5)
   ART 325.   Advanced Digital Image Editing (5)
   ART 326.   Interactive Multimedia Design (5)
   ART 330.   Animation and Web Motion-Graphics (5)
   ART 382.   Computer Animation: 3D Modeling (5)
   ART 383.   Computer Animation: Character Modeling (5)
   ART 388.   Digital Lighting (5)
   ART 422.   Dynamic Web Site Design (5)
10. Four units chosen from CSCI courses numbered 300 and above.

**System Administration Option (50 units)**

1. CSCI 292.   Java Programming (4)
2. CSCI 310.   Digital Logic (5)
2. CSCI 322.   Web Page Programming (4)
3. CSCI 350.   File Systems (4)
4. CSCI 360.   Script Programming (4)
5. CSCI 365.   Systems Administration (4)
6. CSCI 366.   Systems Networking (4)
7. CSCI 372.   Computer Systems in Organizations (4)
8. CSCI 401.   Contemporary Computer Architecture (5)
9. CSCI 405.   Server Programming (4)
10. CSCI 460.   Operating Systems (4)
11. CSCI 572.   Database Systems (4)

# B.S. IN COMPUTER SCIENCE

## Requirements (123 units)

## Total units required for graduation: 191

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

Lower-division requirements (53 units)

1. CSCI 201.   Computer Science I (4)
2. CSCI 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. CSCI 310.   Digital Logic (5)
2. CSCI 313.   Machine Organization (4)
3. CSCI 320.   Programming Languages (4)
4. CSCI 330.   Data Structures (4)
5. CSCI 350.   File Systems (4)
6. CSCI 401.   Contemporary Computer Architectures (5)
7. CSCI 431.   Algorithm Analysis (4)
8. CSCI 455.   Software Engineering (4)
9. CSCI 460.   Operating Systems (4)
10. CSCI 488.   Ethics and the Computing Professional (2)
11. CSCI 489.   Senior Seminar (2)
12. CSCI 500.   Introduction to Formal Languages and Automata (4)
13. MATH 372.   Combinatorics (4)

Electives (20 units)

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

# MINOR IN COMPUTER SCIENCE

## Requirements (28 units)

## Requirements for a minor in Computer Science:

1. Mathematics
   Four units chosen from:
   MATH 272.   Discrete Mathematics (4)
   MATH 372.   Combinatorics (4)
2. CSCI 201.   Computer Science I (4)
3. CSCI 202.   Computer Science II (4)
4. CSCI 330.   Data Structures (4)

5. Twelve units of upper-division CSCI courses. These units may not include CSCI 399 or 575.

## 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 CSCI 595. Independent Study or credit in CSCI 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. See Page 59 for additional certificate information.

### Certificate in Computer Systems and Programming

**Certificate Requirements (30 units)**

1. Two units chosen from:
   CSCI 123.      Using Computer Software (2)
   CSCI 124.      Exploring the Information Superhighway (2)
2. CSCI 125.      Programming in Visual Basic (4)
3. CSCI 201.      Computer Science I (4)
4. CSCI 202.      Computer Science II (4)
5. CSCI 360.      Script Programming (4)
6. Twelve units of upper-division coursework to be chosen in consultation with the chair of the Department of Computer Science and Engineering.

## COURSE OFFERINGS IN COMPUTER SCIENCE (CSCI)

### 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 CSCI 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 CSCI 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. Prerequisite: satisfactory score on the Entry Level Mathematics examination or completion of the General Education Basic Skills category in Mathematics. (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 CSCI 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: CSCI 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: CSCI 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: CSCI 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 Programming

Basic concepts of programming and how programs control the display of graphics and animation in computer games. The use of artificial intelligence in computer games. Demonstrations and experiments with game programming through the use of examples. 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. Prerequisite: satisfactory score on the Entry Level Mathematics examination, and either some prior computer programming experience, or CSCI 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: CSCI 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 CSCI 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: CSCI 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: CSCI 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**

### 303. Computer Engineering Design

Guided engineering design activity on an ongoing real world problem. Three hours activity. Must be repeated for a total of seven units. Prerequisite: PHYS 152. (1 unit)

### 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: CSCI 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: CSCI 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: CSCI 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: CSCI 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: CSCI 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: CSCI 202 and MATH 272 or 372. (4 units)

### 350. File Systems

Topics include file structures, file organization concepts and philosophies. Prerequisite: CSCI 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: CSCI 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: CSCI 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: CSCI 365. (4 units)

### 372. Computer Systems in Organizations

General system and information theory. Modeling organizational activities, hardware and software using current techniques with emphasis on human-computer interaction, systems engineering and project planning. Students will study part of an actual or hypothetical organization. Prerequisite: CSCI 202. (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. Prerequisites: CSCI 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: CSCI 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. Two hours lecture and three hours activity laboratory. Materials fee required. Prerequisites: CSCI 310, MATH 251, and PHYS 150. (3 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: CSCI 322. (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: CSCI 330. (4 units)

### 431. Algorithm Analysis

Analysis and design of algorithms, including time and space complexity, design methodologies, and taxonomic classification of problems. Formerly CSCI 331. Prerequisites: CSCI 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: CSCI 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: CSCI 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: CSCI 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: CSCI 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: CSCI 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: CSCI 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: CSCI 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 CSCI 546. Prerequisite: CSCI 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. Formerly CSCI 410. Three hours lecture and two hours laboratory. Materials fee required. Prerequisite: CSCI 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: CSCI 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 CSCI 411. Prerequisite: CSCI 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: CSCI 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: CSCI 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. Prerequisites: CSCI 420. (4 units)

### 521. Field Programmable Gate Array Design
FPGA design rules, timing, latency, optimzations, 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: CSCI 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: CSCI 202 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: CSCI 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: CSCI 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: CSCI 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: CSCI 330 or consent of instructor. (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. Prerequisites: CSCI 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. Prerequisite: CSCI 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. Prerequisite: CSCI 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: CSCI 320 and 330. (4 units)

### 565. Systems Programming
Concepts of, and implementation techniques for systems software such as assemblers, editors, interpreters, linkers, loaders and operating systems. Prerequisite: CSCI 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: CSCI 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. Formerly CSCI 480. Prerequisite: CSCI 350. (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: CSCI 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: CSCI 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 CSCI 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: CSCI 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: CSCI 330 and consent of instructor. (4 units)