

# COMPUTER SCIENCE (CSC)

## CSC 101 Computers for Everyone (Units: 3)

Comprehensive and basic overview of computers and their use for everyday tasks such as information retrieval, internet, writing, presentations, communication, web publishing, e-commerce, entertainment, computation. No prior knowledge required.

## CSC 110 Computational Thinking and Quantitative Reasoning (Units: 3)

Prerequisites: Category I or II placement for QR/Math, or satisfactory completion of ELM requirement, or MATH 70 or ESM 70 with a grade of C or better. Students with Category III or IV placement for QR/Math or students who have not passed MATH 70 or ESM 70 with a C or better must concurrently enroll in MATH 112.

Basic building blocks of programming and computational thinking practices including analyzing the effects of computation, creating computational artifacts, using abstractions and models, analyzing problems and artifacts, communicating processes and results, and working effectively in teams. Mathematical models and information retrieval from real-world datasets will be used as vehicles to practice programming and computation thinking.

(Note: For this course to satisfy General Education, students must earn a grade of C- or CR or higher.)

### Course Attributes:

- B4: Math/QR

## CSC 203 JAVA Programming (Units: 3)

Prerequisite: CSC 210 or consent of the instructor.

JAVA language and object-oriented programming. Use of inheritance, polymorphism, exception handling and libraries, and JAVA applets and GUI development using Swing.

## CSC 206 Python Programming (Units: 3)

Prerequisite: CSC 210 or consent of the instructor.

Python language programming with basic principles of interpretative languages. The use of basic Python constructs and standard libraries (e.g., networking, regular expressions, GUI). Simple apps such as WWW and games.

## CSC 208 C++ for Java Programmers (Unit: 1)

Prerequisites: Java programming courses or consent of the instructor.

Hands-on exercises in C++ programming. Emphasis on the features common to C++ and Java and features unique to C++. (CR/NC grading only)

## CSC 210 Introduction to Computer Programming (Units: 3)

Prerequisite: Concurrent enrollment in CSC 211 required for Computer Science majors and recommended for non-majors.

Design, implementation, testing, debugging, maintenance, and documentation of Java programs. Algorithms, programming concepts, and data types in Java. Concepts of object-oriented programming. Numerical and non-numerical problems.

## CSC 211 Introduction to Software Lab (Unit: 1)

Prerequisite: Concurrent enrollment in CSC 210.

Hands-on exercises in programming, and the use of basic software development tools. Covers procedural, object-oriented, C++, and JAVA programming. Students are encouraged to bring their laptops. Activity. May be repeated for a total of 3 units. (CR/NC grading only)

## CSC 219 Data Structures for Data Science Application Development (Units: 3)

Prerequisite: CSC 210 or equivalent.

Focuses on learning about and utilizing data structures and algorithms effectively for developing data science applications. Utilizes Python and Jupyter Notebook.

## CSC 220 Data Structures (Units: 3)

Prerequisite: CSC 210 or CSC 306 or CSC 309 with a grade of C or better.

Linear and non-linear data structures in Java, including lists, stacks, queues, trees, tables, and graphs. Recursion, iteration over collections, sorting, searching, Big O notation, and hash tables.

## CSC 221 Data Structure Lab (Unit: 1)

Prerequisites: CSC 210 and CSC 211; concurrent enrollment in CSC 220.

Training on the principles of object-oriented programming, data structures (such as stacks, queues, lists, trees, sets, HashMaps, etc.), implementation, and usage in solving real-life problems, recursion, and algorithm analysis. Activity. (CR/NC grading only)

## CSC 230 Discrete Mathematical Structures for Computer Science (Units: 3)

Prerequisites: CSC 210 and MATH 227 (may be taken concurrently) with grades of C or better.

Review of set algebra, relations and functions, permutations, propositional logic, proof techniques, introduction to graph theory, and infinite sets, and their applications to computer science.

## CSC 256 Machine Structures (Units: 3)

Prerequisite: CSC 230 with a grade of C or better.

Digital logic circuits, data representation, assembly language programming, subroutine linkage, machine language encoding, interrupt and exception handling, memory system concepts, and CPU organization and performance.

## CSC 300GW Ethics, Communication, and Tools for Software Development - GVAR (Units: 3)

Prerequisites: Restricted to upper-division Computer Science majors and minors; GE Area A2; CSC 210.

Privacy, security, legal, and ethical issues in Software development. Communication relevant to SW development (e.g., reports, contracts, requirements, documentation, collaboration, e-mail, presentations). Study and use of basic tools for SW development and collaboration. (ABC/NC grading only)

### Course Attributes:

- Graduation Writing Assessment

## CSC 306 An Interdisciplinary Approach to Computer Programming (Units: 3)

Prerequisites: Restricted to Biology, Chemistry, and Biochemistry majors and pre-majors; upper-division standing; or consent of the instructor.

Basics of programming for interdisciplinary problem-solving. Topics include basic building blocks of programming (variable, control statement, iterative statement, array, function, and abstraction) and problem-solving approaches. Use of App Inventor and Java.

**CSC 307 An Interdisciplinary Approach to Web Programming (Units: 3)**

Prerequisite: Upper-division standing or consent of the instructor.

Basics of WWW engineering relevant to studies in interdisciplinary problem-solving. Topics include the basics of developing web and database applications, HTML, PHP, Python, SQL, and MySQL database.

**CSC 308 Introduction to Machine Learning for Interdisciplinary Data Scientists (Units: 3)**

Prerequisite: CSC 219.

Introduction to the basic machine learning concepts and tools. Focus on applying them for application development, linear model, deep neural network and transfer learning using Python, Tensorflow, and Keras. (Plus-minus letter grade only)

**CSC 309 Computer Programming (Units: 3)**

Prerequisite: MATH 226 or consent of the instructor.

Procedural programming for scientific applications. Good programming practices and basic numerical and nonnumerical algorithms for scientists and engineers.

**CSC 310 Computer Programming Lab (Unit: 1)**

Prerequisite: Concurrent enrollment in CSC 309 is recommended.

Exercises in Python programming and use of basic software development tools.

**CSC 317 Introduction to Web Software Development (Units: 3)**

Prerequisite: CSC 220 or consent of the instructor.

Introduction to topics in UNIX and creating web pages including reading and processing user input submitted through web pages, client side and server side programming, connecting a web page to a database, and building an e-commerce site or Internet Application.

**CSC 340 Programming Methodology (Units: 3)**

Prerequisites: CSC 220, CSC 230, and MATH 227 with grades of C or better.

Advanced data structures and algorithms for manipulation in C++ with an emphasis on design and implementation, practical applications, and algorithms for sorting, searching, and graphs.

**CSC 412 Advanced Software Lab (Unit: 1)**

Prerequisites: CSC 220; concurrent enrollment in CSC 340 recommended.

Hands-on exercises in advanced programming, software development tools, and web technologies. Students are encouraged to bring their laptops. Activity. May be repeated for a total of 2 units. (Plus-minus letter grade only)

**CSC 413 Software Development (Units: 3)**

Prerequisite: CSC 220 with grade of C or better.

Modern software applications. Object-oriented techniques: encapsulation, inheritance, and polymorphism as a mechanism for data design and problem solution. Software design, debugging, testing, and UI design. Software maintenance. Software development tools. Extra fee required. (Plus-minus letter grade only)

**CSC 415 Operating System Principles (Units: 3)**

Prerequisites: CSC 256, CSC 340\*, MATH 324, and PHYS 230 with grades of C or better or graduate standing\*.

Operating system concepts: concurrent processes, basic synchronization techniques, deadlock, memory management, file systems, security, networks, and distributed processing. Extra fee required.

**CSC 510 Analysis of Algorithms I (Units: 3)**

Prerequisites: CSC 340 and MATH 324 with grades of C or better.

Notions of main algorithm design methods. Measures of algorithm complexity in space and time. Algorithms of classic problems including sorting and scheduling and complexity analysis of such algorithms.

**CSC 520 Theory of Computing (Units: 3)**

Prerequisites: CSC 220, CSC 230, and MATH 325 with grades of C or better.

Automata, formal languages, and the notion of computability. Sequential machines as language acceptors. Context-free and context-sensitive grammars. Recursive functions and universal Turing machines. Unsolvable problems.

**CSC 600 Programming Paradigms and Languages (Units: 3)**

Prerequisites: CSC 413\* and CSC 510\* with grades of C or better or graduate-level standing\*.

Concepts for high-level programming languages. Procedural, logic, functional, and object-oriented programming paradigms. Comparative study of several languages and an introduction to grammars and parsing techniques. Extra fee required.

**CSC 615 UNIX Programming (Units: 3)**

Prerequisite: CSC 415 with a grade of C or better or consent of the instructor.

Programming in a UNIX environment. Topics include regular expressions, utilities such as awk, sed, grep, csh, sh, and ksh, system calls such as signals, sockets, POSIX IPC, and POSIX threads, and kernel internal structures. Extra fee required. (Plus-minus letter grade only)

**CSC 620 Natural Language Technologies (Units: 3)**

Prerequisite for CSC 820: Graduate standing or consent of the instructor. Prerequisites for CSC 620: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Natural language parsing technology and grammars. Elements of computational semantics, discourse structure, and generation. Survey of related topics such as information retrieval, question-answering, machine translation, and speech processing. Extra fee required. (Plus-minus letter grade only)

(CSC 820/CSC 620 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 621 Biomedical Imaging and Analysis (Units: 3)**

Prerequisites for CSC 821: Graduate standing or consent of the instructor. Prerequisites for CSC 621: Upper-division standing; CSC 510 and MATH 325 with grades of C or better; GPA of 3.0 or higher; or consent of the instructor.

Introduction to medical and biological imaging, imaging physics, 3D image formats, and visualization. Basic digital image processing and analysis, filtering, registration, segmentation, quantification, and performance evaluation. (Plus-minus letter grade only) (CSC 821/CSC 621 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 630 Computer Graphics Systems Design (Units: 3)**

Prerequisites: CSC 340 and MATH 325 with grades of C or better.

Graphics system design and display hardware architecture. Overview of device-independent graphic systems, 2- & 3-dimensional viewing pipelines, hidden line and surface removal algorithms, raster graphics techniques, and color space models. Webpage design and Flash exercises for an introduction to animation and multimedia. Course fee required. (Plus-minus letter grade only)

**CSC 631 Multiplayer Game Development (Units: 3)**

Prerequisite for CSC 831: Graduate standing or consent of the instructor. Prerequisites for CSC 631: Upper-division standing; CSC 413; GPA of 3.0 or higher; or consent of the instructor.

Computer graphics and network characteristics of multiplayer games. Design and development of a game as a team project. (CSC 831/CSC 631 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 637 Software Techniques for Computer Music (Units: 3)**

Prerequisite: CSC 413 with a grade of C or better or consent of the instructor.

Algorithms and software design for digital audio and computer music. Analysis and synthesis techniques. Real-time control and interaction. Extra fee required.

**CSC 641 Computer Performance Evaluation (Units: 3)**

Prerequisite for CSC 841: Graduate standing or consent of the instructor. Prerequisites for CSC 641: Upper-division standing; CSC 415; GPA of 3.0 or higher; or consent of the instructor.

Computer performance analysis problems related to system design, selection, and tuning. Modeling using stochastic and operational queuing models. Workload characterization, design, and performance measurement methods. Design of simulation models for computer systems. Extra fee required. (Plus-minus letter grade only) (CSC 841/CSC 641 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 642 Human-Computer Interaction (Units: 3)**

Prerequisite for CSC 842: Graduate standing or consent of the instructor. Prerequisite for CSC 642: Upper-division standing; CSC 413 with a grade of C or better or consent of the instructor.

The design, implementation, and evaluation of human-computer interfaces. Topics include interface devices, interface metaphors, interaction styles, user-centered design, testing, and quality assessment. Extra fee required. (CSC 842/CSC 642 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 644 Computer Measurements (Units: 3)**

Prerequisites: CSC 413 and CSC 415.

Software measurement and experimentation tools. Data collection and analysis. Web measurements. Benchmarking and design of benchmarks. Use of software monitors. Extra fee required. (Plus-minus letter grade only)

**CSC 645 Computer Networks (Units: 3)**

Prerequisites: Upper-division standing; CSC 415 with a grade of C or better; GPA of 3.0 or better; or consent of the instructor.

Computer network design, evaluation, and testing. Computer network standards and implementation. Hardware and software design and compatibility issues. Extra fee required.

**CSC 648 Software Engineering (Units: 3)**

Prerequisite for CSC 848: Graduate standing or consent of the instructor. Prerequisites for CSC 648: Upper-division standing; CSC 317\* and CSC 413\* with grades of C or better; GPA of 3.0 or higher; or consent of the instructor.

Practical methods and tools for SW engineering including organizational teamwork.

(CSC 848/CSC 648 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 649 Search Engines (Units: 3)**

Prerequisite for CSC 849: Graduate standing or consent of the instructor. Prerequisite for CSC 649: Upper-division standing or CSC 413 with a grade of B or better or consent of the instructor.

Introduction to the internals of modern search engines. Methods and tools for representation, storage, organization of, and access to textual data. Extra fee required. (Plus-minus letter grade only) (CSC 849/CSC 649 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 651 System Administration (Units: 3)**

Prerequisites: CSC 413 and CSC 415 with grades of C or better.

User administration. Operating system installation, tuning, and control. Network administration. Security management. Performance tuning and management. Extra fee required. (ABC/NC grading only)

**CSC 652 Introduction to Security and Data Privacy (Units: 3)**

Prerequisite for CSC 852: Graduate standing or consent of the instructor. Prerequisite for CSC 652: CSC 415 with a grade of C or better or consent of the instructor.

Introduction to fundamental concepts in cybersecurity, cryptography, and data privacy. Practice different privacy mechanisms in databases and present applications to a wide range of data analysis tasks. (CSC 852/CSC 652 [formerly CSC 650] is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 656 Computer Organization (Units: 3)**

Prerequisite: CSC 415 (may be taken concurrently) or consent of the instructor.

Instruction set design. Pipelined datapath and control. Cache and memory system design. Input and output subsystems. Parallel processing. Software and hardware interactions. Extra fee required.

**CSC 657 Bioinformatics Computing (Units: 3)**

Prerequisite: Upper-division or graduate standing in a science program or consent of the instructor.

A broad range of topics in computational biology as practiced in the life science industry and leading research organizations. Provides computational background required to participate in R&D. Extra fee required.

(CSC 857/CSC 657 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 658 Programming Cafe (Units: 3)**

Prerequisite: CSC 413 with a grade C or better or consent of the instructor.

Extensive programming practice to advance programming skills and processes including pair programming exercises and code review techniques and practice.

**CSC 664 Multimedia Systems (Units: 3)**

Prerequisite for CSC 864: Graduate standing or consent of the instructor.  
Prerequisites for CSC 664: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Comprehensive topics in multimedia such as basics of image and video processing, compression, multimedia databases, standard, synchronization, formats in the perspective of systems, and algorithms. Extra fee required. (Plus-minus letter grade only)  
(CSC 864/CSC 664 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 665 Artificial Intelligence (Units: 3)**

Prerequisite for CSC 865: Graduate standing or consent of the instructor.  
Prerequisite for CSC 665: Upper-division standing or CSC 413 with a grade of C or better or consent of the instructor.

Overview of algorithms and approaches to artificial intelligence. Study of fundamental concepts needed to attain human-level intelligence in computer systems, and gain experience in working with these concepts through assignments and programming exercises. Topics include problem-solving methods, heuristic search, game playing, agent architectures, machine learning, and various topics selected from knowledge representation, symbolic reasoning, computational models of virtual humans, neural networks, and genetic algorithms. Extra fee required.  
(CSC 665/CSC 865 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 667 Internet Application Design and Development (Units: 3)**

Prerequisite for CSC 867: Graduate standing or consent of the instructor.  
Prerequisites for CSC 667: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Fundamental technologies on which the World Wide Web is based. Extra fee required.  
(CSC 867/CSC 667 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 668 Advanced Object Oriented Software Design and Development (Units: 3)**

Prerequisite for CSC 868: Graduate standing or consent of the instructor.  
Prerequisites for CSC 668: Senior standing; CSC 413 with a grade of C or better; GPA of 3.0 or better; or consent of the instructor.

Object-oriented analysis and design utilizing UML, design patterns, frameworks, and toolkits. Agile software design processes. Development of a mid-size programming project working in teams. (Plus-minus letter grade only)  
(CSC 868/CSC 668 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 671 Neural Networks (Units: 3)**

Prerequisite for CSC 871: Graduate standing or consent of the instructor.  
Prerequisites for CSC 671: Upper-division standing; CSC 510 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Artificial neural networks including associative memories, learning, search, databases, fuzzy set techniques, pattern recognition, and adaptive processing.  
(CSC 871/CSC 671 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 675 Introduction to Database Systems (Units: 3)**

Prerequisite for CSC 775: Graduate standing or consent of the instructor.  
Prerequisites for CSC 675: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Relational query languages. Semantic data models. Logical and physical database design. Privacy issues. Implementation techniques (catalogs, query optimization, concurrency control, security, and integrity enforcement). Extra fee required.  
(CSC 775/CSC 675 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 676 Soft Computing and Decision Support Systems (Units: 3)**

Prerequisite for CSC 876: Graduate standing or consent of the instructor.  
Prerequisite for CSC 676: Upper-division standing; GPA of 3.0 or better; or consent of the instructor.

Development of software systems for decision support including applications of soft computing. Topics include fuzzy sets, fuzzy logic, fuzzy systems, fuzzy decision-making, fuzzy controllers, approximate reasoning, possibility theory, rough sets, graded evaluation logic, logic aggregation operators, information fusion models, decision engineering methods, computing with words, perceptual computing, granular computing, and the LSP method for evaluation and optimization of complex systems. (Plus-minus letter grade only)  
(CSC 876/CSC 676 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 680 Application Development for Mobile Devices (Units: 3)**

Prerequisite for CSC 780: Graduate Computer Science students or consent of the instructor.  
Prerequisites for CSC 680: Restricted to senior Computer Science majors; CSC 415 with a grade of B or better; or consent of the instructor.

Introduction to and comparison of different popular mobile application frameworks. Conceptual and hands-on experience in writing mobile applications using native and cross-platform tools. (Plus-minus letter grade only)  
(CSC 780/CSC 680 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 690 Interactive Multimedia Application Development (Units: 3)**

Prerequisite: CSC 340 with a grade of C or better or consent of the instructor.

Basics of multimedia data formats and algorithms to build applications using non-standard interfaces such as game controllers and multi-touch surfaces. (Plus-minus letter grade only)

**CSC 693 Cooperative Education Program (Units: 6-12)**

Prerequisite: Upper-division standing or consent of the instructor.

Units do not count toward the major. May be repeated for a total of 24 units. Contact the Cooperative Education office for information. (CR/NC grading only)

**CSC 694 Cooperative Education: Computer Science (Units: 1-3)**

Prerequisite: Consent of the instructor.

Projects in a business, government, or industrial position of at least one semester's duration. May be repeated for a total of 3 units.

**CSC 695 Computing in the Community (Units: 2)**

Prerequisites: Upper-division standing; computer experience; consent of the instructor.

Extensive fieldwork training Bay Area non-profit agencies in the use of computer tools such as conferencing and database systems. Development of user documentation. (CR/NC grading only)

**CSC 697 Senior Project in Computer Science (Units: 3)**

Prerequisites: CSC 415 and CSC 510, or CSC 648; or consent of the instructor.

Culminating experience in individual design, implementation, and professional documentation of a software product under the close supervision of a faculty member. (Plus-minus letter grade only)

**CSC 698 Topics in Computing (Units: 3)**

Prerequisite: Upper-division standing or consent of the instructor.

Current topics in computer hardware and software technologies. Topics to be specified in the Class Schedule. May be repeated for a total of 9 units when topics vary.

**CSC 699 Independent Study (Units: 1-3)**

Prerequisites: Consent of the department and instructor. An approved study proposal must be on file by the time of registration.

Library and laboratory research and development projects. A final report must be approved by the instructor and filed with the department. May be repeated for a total of 9 units. (Plus-minus letter grade only)

**CSC 720 Advanced Operating Systems (Units: 3)**

Prerequisites: Written English Proficiency Level I or concurrent enrollment in SCI 614; CSC 415 with a grade of B or better; or consent of the instructor.

Analysis of scheduling and memory management algorithms and the use of concurrent languages for systems development and distributed systems. Design and implementation of major components of an operating system. Extra fee required.

**CSC 730 Advanced Database Systems (Units: 3)**

Prerequisites: CSC 413 and CSC 675 with grades of C or better.

Standard SQL, query optimization, concurrency control, crash recovery, authorization, and integrity enforcement. Object-oriented, extensible, deductive, and distributed database systems. Extra fee required.

**CSC 746 High-Performance Computing (Units: 3)**

Prerequisite: CSC 656 with a grade of B or better or consent of the instructor.

Principles and current practices in high-performance computing. Basics of multiprocessor systems such as clusters and graphics processors. Message-passing and shared memory-based software development. Cloud computing.

**CSC 775 Introduction to Database Systems (Units: 3)**

Prerequisite for CSC 775: Graduate standing or consent of the instructor. Prerequisites for CSC 675: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Relational query languages. Semantic data models. Logical and physical database design. Privacy issues. Implementation techniques (catalogs, query optimization, concurrency control, security, and integrity enforcement). Extra fee required.

(CSC 775/CSC 675 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 780 Application Development for Mobile Devices (Units: 3)**

Prerequisite for CSC 780: Graduate Computer Science students or consent of the instructor.

Prerequisites for CSC 680: Restricted to senior Computer Science majors; CSC 415 with a grade of B or better; or consent of the instructor.

Introduction to and comparison of different popular mobile application frameworks. Conceptual and hands-on experience in writing mobile applications using native and cross-platform tools. (Plus-minus letter grade only)

(CSC 780/CSC 680 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 810 Analysis of Algorithms II (Units: 3)**

Prerequisite: Graduate standing or consent of the instructor.

Review major design strategies and theory of NP-Completeness. Approximation algorithms. Online Algorithms. Parallel and distributed algorithms. Algorithms for specific areas of interest. Extra fee required.

**CSC 820 Natural Language Technologies (Units: 3)**

Prerequisite for CSC 820: Graduate standing or consent of the instructor. Prerequisites for CSC 620: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Natural language parsing technology and grammars. Elements of computational semantics, discourse structure, and generation. Survey of related topics such as information retrieval, question-answering, machine translation, and speech processing. Extra fee required. (Plus-minus letter grade only)

(CSC 820/CSC 620 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 821 Biomedical Imaging and Analysis (Units: 3)**

Prerequisites for CSC 821: Graduate standing or consent of the instructor. Prerequisites for CSC 621: Upper-division standing; CSC 510 and MATH 325 with grades of C or better; GPA of 3.0 or higher; or consent of the instructor.

Introduction to medical and biological imaging, imaging physics, 3D image formats, and visualization. Basic digital image processing and analysis, filtering, registration, segmentation, quantification, and performance evaluation. (Plus-minus letter grade only)

(CSC 821/CSC 621 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 825 Advanced Automata Theory (Units: 3)**

Prerequisite: CSC 520 or equivalent.

Advanced topics in theoretical computer science and their application to a broad range of areas including bioinformatics, compilers, data and image compression, natural language processing, networking, and web applications. Extra fee required. (Plus-minus letter grade only)

**CSC 830 Advanced Computer Graphics (Units: 3)**

Prerequisite: CSC 630 or consent of the instructor.

Roster graphics principles and scanning algorithms, pixel fill algorithms, anti-aliasing, clipping, hidden line and surface display, rendering of surfaces, and fractal techniques. Extra fee required.

**CSC 831 Multiplayer Game Development (Units: 3)**

Prerequisite for CSC 831: Graduate standing or consent of the instructor. Prerequisites for CSC 631: Upper-division standing; CSC 413; GPA of 3.0 or higher; or consent of the instructor.

Computer graphics and network characteristics of multiplayer games. Design and development of a game as a team project. (CSC 831/CSC 631 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 835 Distributed Systems (Units: 3)**

Prerequisite: CSC 415 with a grade of B or better or consent of the instructor.

Introduction to the concepts and design of distributed systems. Includes a term project in using current middleware technologies. Extra fee required.

**CSC 837 Advanced Sound Synthesis (Units: 3)**

Prerequisite: CSC 637 with a grade of B or better or consent of the instructor.

Current algorithms and practices in sound synthesis and timbral control for music, sound effects, and interactive environments. Design of real-time software synthesis systems. Extra fee required.

**CSC 840 Software Metrics and Quality Assurance (Units: 3)**

Prerequisite: CSC 648 or consent of the instructor.

Measurement and modeling in software engineering. Software performance evaluation methods. Techniques and tools for software quality assurance. Software quality standards. Design and use of software metrics tools. Extra fee required. (Plus-minus letter grade only)

**CSC 841 Computer Performance Evaluation (Units: 3)**

Prerequisite for CSC 841: Graduate standing or consent of the instructor. Prerequisites for CSC 641: Upper-division standing; CSC 415; GPA of 3.0 or higher; or consent of the instructor.

Computer performance analysis problems related to system design, selection, and tuning. Modeling using stochastic and operational queuing models. Workload characterization, design, and performance measurement methods. Design of simulation models for computer systems. Extra fee required. (Plus-minus letter grade only) (CSC 841/CSC 641 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 842 Human-Computer Interaction (Units: 3)**

Prerequisite for CSC 842: Graduate standing or consent of the instructor. Prerequisite for CSC 642: Upper-division standing; CSC 413 with a grade of C or better or consent of the instructor.

The design, implementation, and evaluation of human-computer interfaces. Topics include interface devices, interface metaphors, interaction styles, user-centered design, testing, and quality assessment. Extra fee required.

(CSC 842/CSC 642 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 845 Advanced Computer Networks (Units: 3)**

Prerequisites: CSC 415 and CSC 645; or consent of the instructor.

Design and implementation of networking protocols and technologies in wireless and mobile networks. Introduction to emerging design, algorithms, protocols, and applications in wireless and mobile networks. Extra fee required.

**CSC 846 Systems Architecture (Units: 3)**

Prerequisite: CSC 656 with a grade of B or better or consent of the instructor.

Principles of computer systems architecture with an emphasis on hardware and software interactions for large applications and design for performance. Extra fee required. (Plus-minus letter grade only)

**CSC 847 Cloud and Distributed Computing: Concepts and Applications (Units: 3)**

Prerequisites: Restricted to senior and graduate Computer Science students; consent of the instructor.

Infrastructure, platform, and software as a service. Includes enabling techniques behind cloud computing including virtualization, multi-tenancy, and service-oriented architecture. Cloud storage options such as NoSQL databases, emerging technologies such as containers and Kubernetes, parallel and distributed computing platforms including MapReduce and Apache Sparc, and hands-on experience on public clouds such as the Amazon Cloud and Google Cloud. (Plus-minus letter grade only)

**CSC 848 Software Engineering (Units: 3)**

Prerequisite for CSC 848: Graduate standing or consent of the instructor. Prerequisites for CSC 648: Upper-division standing; CSC 317\* and CSC 413\* with grades of C or better; GPA of 3.0 or higher; or consent of the instructor.

Practical methods and tools for SW engineering including organizational teamwork.

(CSC 848/CSC 648 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 849 Search Engines (Units: 3)**

Prerequisite for CSC 849: Graduate standing or consent of the instructor. Prerequisite for CSC 649: Upper-division standing or CSC 413 with a grade of B or better or consent of the instructor.

Introduction to the internals of modern search engines. Methods and tools for representation, storage, organization of, and access to textual data. Extra fee required. (Plus-minus letter grade only) (CSC 849/CSC 649 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 850 Compiler Design (Units: 3)**

Prerequisites: CSC 413 with a grade of B or better; consent of the instructor.

Design and implementation of compilers including lexical scanners, top-down and bottom-up parsers, precedence grammars, symbol table manipulation, LR (k) grammars, semantics routines, and code generators.

**CSC 852 Introduction to Security and Data Privacy (Units: 3)**

Prerequisite for CSC 852: Graduate standing or consent of the instructor.  
Prerequisite for CSC 652: CSC 415 with a grade of C or better or consent of the instructor.

Introduction to fundamental concepts in cybersecurity, cryptography, and data privacy. Practice different privacy mechanisms in databases and present applications to a wide range of data analysis tasks. (CSC 852/CSC 652 [formerly CSC 650] is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 856 Advanced Computer Architecture (Units: 3)**

Prerequisites: Written English Proficiency Level I or concurrent enrollment in SCI 614; CSC 656 with a grade of B or better; or consent of the instructor.

Advanced pipelining. Instruction-level parallelism. Advanced memory system design. Compiler techniques for performance. New technologies and applications. Extra fee required.

**CSC 857 Bioinformatics Computing (Units: 3)**

Prerequisite: Upper-division or graduate standing in a science program or consent of the instructor.

A broad range of topics in computational biology as practiced in the life science industry and leading research organizations. Provides computational background required to participate in R&D. Extra fee required.

(CSC 857/CSC 657 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 858 Foundations of Biotechnology and Life Sciences (Units: 3)**

Prerequisite: Graduate standing in a science program; a background in life sciences or biology is not required.

Foundations in biotechnology and life sciences. Prepare for further study and careers in biotechnology and computational life sciences R&D and industry.

**CSC 859 AI Explainability and Ethics (Units: 3)**

Prerequisite: CSC 865\* or CSC 869\* or CSC 872\* or CSC 876\* or consent of the instructor.

The impact of Artificial Intelligence on society and business. The need for explainable and ethical AI systems and related problems in current AI applications. Analysis and evaluation of technologies and methods for the design, development, evaluation, and deployment of explainable and ethical AI systems. (Plus-minus letter grade, RP only)

**CSC 864 Multimedia Systems (Units: 3)**

Prerequisite for CSC 864: Graduate standing or consent of the instructor. Prerequisites for CSC 664: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Comprehensive topics in multimedia such as basics of image and video processing, compression, multimedia databases, standard, synchronization, formats in the perspective of systems, and algorithms. Extra fee required. (Plus-minus letter grade only) (CSC 864/CSC 664 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 865 Artificial Intelligence (Units: 3)**

Prerequisite for CSC 865: Graduate standing or consent of the instructor. Prerequisite for CSC 665: Upper-division standing or CSC 413 with a grade of C or better or consent of the instructor.

Overview of algorithms and approaches to artificial intelligence. Study of fundamental concepts needed to attain human-level intelligence in computer systems, and gain experience in working with these concepts through assignments and programming exercises. Topics include problem-solving methods, heuristic search, game playing, agent architectures, machine learning, and various topics selected from knowledge representation, symbolic reasoning, computational models of virtual humans, neural networks, and genetic algorithms. Extra fee required.

(CSC 665/CSC 865 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 867 Internet Application Design and Development (Units: 3)**

Prerequisite for CSC 867: Graduate standing or consent of the instructor. Prerequisites for CSC 667: Upper-division standing; CSC 413 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Fundamental technologies on which the World Wide Web is based. Extra fee required.

(CSC 867/CSC 667 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 868 Advanced Object Oriented Software Design and Development (Units: 3)**

Prerequisite for CSC 868: Graduate standing or consent of the instructor. Prerequisites for CSC 668: Senior standing; CSC 413 with a grade of C or better; GPA of 3.0 or better; or consent of the instructor.

Object-oriented analysis and design utilizing UML, design patterns, frameworks, and toolkits. Agile software design processes. Development of a mid-size programming project working in teams. (Plus-minus letter grade only)

(CSC 868/CSC 668 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 869 Data Mining (Units: 3)**

Prerequisite: Graduate standing or consent of the instructor.

Knowledge discovery process, basic data mining concepts, key mining algorithms, and data mining in practical domains such as bioinformatics. (Plus-minus letter grade only)

**CSC 870 Computational Discrete Geometry (Units: 3)**

Prerequisites: CSC 210, CSC 230, and MATH 325, or consent of instructor.

A comprehensive overview of basic topics in computational discrete geometry including generating functions, complexity theory, convex hull, nearest-neighbor problems, and efficient algorithms. (This course is offered as MATH 870 and CSC 870. Students may not repeat the course under an alternate prefix.)

**CSC 871 Neural Networks (Units: 3)**

Prerequisite for CSC 871: Graduate standing or consent of the instructor. Prerequisites for CSC 671: Upper-division standing; CSC 510 with a grade of C or better; GPA of 3.0 or higher; or consent of the instructor.

Artificial neural networks including associative memories, learning, search, databases, fuzzy set techniques, pattern recognition, and adaptive processing.

(CSC 871/CSC 671 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 872 Pattern Analysis and Machine Intelligence (Units: 3)**

Prerequisite: Graduate standing or consent of the instructor.

Foundation of pattern analysis and machine intelligence. Artificial intelligence: agent, logic, and search. Machine learning: Bayesian classification. Neural network: simulated annealing. Imaging: image segmentation and object recognition. (Plus-minus letter grade only)

**CSC 874 Topics in Big Data Analysis (Units: 3)**

Prerequisite: Graduate standing or consent of the instructor.

Introduction to current topics in data sciences and big data analysis. (Plus-minus letter grade only)

**CSC 875 Advanced Topics in Database Systems (Units: 3)**

Prerequisite: Graduate standing or consent of the instructor.

Advanced aspects of selected topics in database systems. May be repeated for a total of 6 units.

**CSC 876 Soft Computing and Decision Support Systems (Units: 3)**

Prerequisite for CSC 876: Graduate standing or consent of the instructor.  
Prerequisite for CSC 676: Upper-division standing; GPA of 3.0 or better; or consent of the instructor.

Development of software systems for decision support including applications of soft computing. Topics include fuzzy sets, fuzzy logic, fuzzy systems, fuzzy decision-making, fuzzy controllers, approximate reasoning, possibility theory, rough sets, graded evaluation logic, logic aggregation operators, information fusion models, decision engineering methods, computing with words, perceptual computing, granular computing, and the LSP method for evaluation and optimization of complex systems. (Plus-minus letter grade only)  
(CSC 876/CSC 676 is a paired course offering. Students who complete the course at one level may not repeat the course at the other level.)

**CSC 890 Graduate Seminar (Units: 3)**

Prerequisite: Consent of the instructor or graduate advisor.

Explore a variety of current advanced research trends in Computer Science. Topics to be specified in the Class Schedule. May be repeated for a total of 6 units when topics vary. (Plus-minus letter grade only)

**CSC 893 Supervised Industrial Research (Unit: 1)**

Prerequisite: Consent of the instructor.

Supervised computer science employment in software research and development. Objectives are career development and occupational experience. May be repeated for a total of 3 units. Subsequently, may be repeated on a CR/NC basis. Must be approved by a graduate adviser. (Plus-minus letter grade, CR/NC, RP)

**CSC 895 Applied Research Project (Units: 3)**

Prerequisites: Consent of the instructor and approval of Advancement to Candidacy (ATC) for the MS in CS and Culminating Experience (CE) forms by Graduate Studies. Advancement to candidacy and Proposal for Culminating Experience Requirement forms must be approved by the Graduate Division before registration.

(CR/NC grading only)

**CSC 897 Research (Units: 3-6)**

Prerequisite: Consent of the Computer Science Department.

Independent and original investigation under the supervision of a faculty member. May be repeated for a total of 6 units. (Plus-minus letter grade, CR/NC, RP)

**CSC 898 Master's Thesis (Units: 3)**

Prerequisites: Consent of the instructor and graduate adviser and approval of Advancement to Candidacy (ATC) for the Master of Science in Computer Science and Culminating Experience (CE) forms by Graduate Studies. Advancement to Candidacy (ATC) and Proposal for Culminating Experience Requirement forms must be approved by the Graduate Division before registration.

(CR/NC grading only)

**CSC 899 Independent Study (Units: 1-3)**

Prerequisite: Approval of the department and instructor.

Special study of a particular problem under the direction of a faculty member. A written, detailed report of the work accomplished must be submitted to the staff of the department. May be repeated for a total of 6 units. (AB/NC only)