**Computer Science (CSC)**

**CSC Courses**

**CSC 101. Fundamentals of Computer Science. 4 units**
Prerequisite: Appropriate Math Placement Level; or MATH 117 with a grade of C- or better; or MATH 118 with a grade of C- or better; or consent of instructor.

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

**CSC 105. Fundamentals of Computer Science I Supplemental Instruction. 1 unit**
CR/NC
Concurrent: CPE/CSC 101.
Facilitated study and discussion of fundamental concepts of computer science and familiarization with programming environments. Credit/No Credit grading only. 1 laboratory. Crosslisted as CPE/CSC 105.

**CSC 108. Accelerated Introduction to Computer Science. 4 units**
Prerequisite: MATH 118 (or equivalent) with a grade of C- or better, significant experience in computer programming, and consent of instructor.

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

**CSC 121. Computing for All I. 4 units**
2020-21 or later catalog: GE Area B4
2019-20 or earlier catalog: GE Area B1
Prerequisite: MATH 115; or appropriate Math Placement Level.
Fundamentals of computational thinking in the study of non-computing disciplines. Ethical and social considerations of computing. Reading code and identifying patterns. Problem Decomposition. Algorithms and automation. Software Engineering. Creative Computing. 3 lectures, 1 laboratory. Fulfills GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs); a grade of C- or better is required in one course in this GE Area.

**CSC 122. Computing for All II. 4 units**
2020-21 or later catalog: GE Area B4
2019-20 or earlier catalog: GE Area B1
Prerequisite: CSC 121.
Fundamentals of computational thinking in the study of non-computing disciplines. Ethical and social considerations of computing. Reading code and identifying patterns. Problem Decomposition. Algorithms and automation. Software Engineering. Creative Computing. 3 lectures, 1 laboratory. Fulfills GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs); a grade of C- or better is required in one course in this GE Area.

**CSC 123. Introduction to Computing. 4 units**
Prerequisite: Basic computer literacy.
Use of a supportive software development environment to design, develop, and test applications in a selected topic domain that demonstrates the potential of careers in computing. An introduction to computing and to the selected topic domain. The Class Schedule will list topic selected. No programming experience required. Not for students with credit in CPE/CSC 103 or CPE/CSC 203. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 123.

**CSC 171. Introduction to Interactive Entertainment. 4 units**
Use of click-and-drag software application to create an entertaining or informative, socially responsible application, such as a game. Team collaboration to design, develop, and test applications. Focus on design, teamwork, and using an iterative development process. An enjoyable introduction to both computer science and interactive entertainment. No computer science experience required. 3 lectures, 1 laboratory.

**CSC 200. Special Problems for Undergraduates. 1-2 units**
Prerequisite: Consent of instructor.
Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

**CSC 202. Data Structures. 4 units**
Prerequisite: CPE/CSC 101 with a grade of C- or better; MATH 141 or MATH 221 with a grade of C- or better; or consent of instructor.
Introduction to data structures and analysis of algorithms. Abstract datatypes. Specification and implementation of advanced data structures. Theoretical and empirical analysis of recursive and iterative algorithms. Software performance evaluation and testing techniques. Not open to students with credit in CSC/CPE 108. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 202.

**CSC 203. Project-Based Object-Oriented Programming and Design. 4 units**
Prerequisite: CPE/CSC 202 with a grade of C- or better or consent of instructor.
Object-oriented programming and design with applications to project construction. Introduction to class design, interfaces, inheritance, generics, exceptions, streams, and testing. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 203.
CSC 209. Problem Solving with Computers. 1 unit
CR/NC
Prerequisite: CSC/CPE 101 or CSC/CPE 108 with a grade of C- or better, or consent of instructor.

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

CSC 225. Introduction to Computer Organization. 4 units
Prerequisite: CSC/CPE 202.

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

CSC 231. Programming for Engineering Students. 2 units
Prerequisite: MATH 142; PHYS 121 or PHYS 131 or PHYS 141.

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

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

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

CSC 234. C and Unix. 3 units
Prerequisite: MATH 142.

The C programming language and the UNIX programming environment. Operators, standard I/O functions, strings, pointers and arrays, data types and storage classes. Unix shell programming and basic I/O system calls. Credit not allowed for CSC, Software Engineering or CPE majors. 3 lectures.

CSC 235. Fundamentals of Computer Science for Scientists and Engineers I. 4 units
Prerequisite: MATH 141 or MATH 161 with a grade of C- or better, or consent of instructor.

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

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

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

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

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

CSC 300. Professional Responsibilities. 4 units
Prerequisite: CSC/CPE 357 and junior standing.

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

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

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

CSC 302. Computers and Society. 4 units
2020-21 or later: Upper-Div GE Area B
2019-20 catalog catalog: GE Area B7
2017-19 or earlier catalog: GE Area F
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and completion of GE Areas B1 through B4, with a grade of C- or better in one course in GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs).

Social, ethical, political and technological implications and effects of computers in the modern world. Examination of the benefits and side-effects of computer applications and automation. Case study review and analysis. 4 lectures. Fulfills GE Upper-Division B (GE Area B7 for students on the 2019-20 catalog; GE Area F for students on earlier catalogs).
CSC 303. Teaching Computer Science. 2 units
Prerequisite: CSC/CPE 102 and CSC/CPE 103, with a grade of C- or better or consent of instructor, or CSC/CPE 202 and CSC/CPE 203, with a grade of C- or better or consent of instructor.

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

CSC 305. Individual Software Design and Development. 4 units
Prerequisite: CSC 308.

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

CSC 307. Introduction to Software Engineering. 4 units
Prerequisite: CSC 141 or CSC 348; and CPE/CSC 357.

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

CSC 308. Software Engineering I. 4 units
Prerequisite: CSC 141 or CSC 348.

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

CSC 309. Software Engineering II. 4 units
Prerequisite: CSC 308 and CSC/CPE 357.

Continuation of the software lifecycle. Methods and tools for the implementation, integration, testing and maintenance of large software systems. Software development and test environments. Software quality assurance. Group laboratory project. Technical presentation methods and practice. 3 lectures, 1 laboratory.

CSC 310. Computers for Poets. 4 units
2020-21 or later: Upper-Div GE Area B
2019-20 catalog catalog: GE Area B7
2017-19 or earlier catalog: GE Area F
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and completion of GE Areas B1 through B4, with a grade of C- or better in one course in GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs).

How computers and computer devices work. Introduction to software systems and applications. How computers connect with various media including images, speech and data. How information is encoded and transmitted across networks. Relationship between the computer and human information processing. 4 lectures. Crosslisted as CSC 310/HNRS 311. Fulfills GE Upper-Division B (GE Area B7 for students on the 2019-20 catalog; GE Area F for students on earlier catalogs).

CSC 311. Computational Art. 4 units
2020-21 or later: Upper-Div GE Area B
2019-20 catalog catalog: GE Area B7
2017-19 or earlier catalog: GE Area F
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and completion of GE Areas B1 through B4, with a grade of C- or better in one course in GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs).

Interdisciplinary creation of static and animated computational art using algorithms. General design principles in a digital setting, including color, shape, composition, perspective, principles of animation. Development of computational tools such as variables, iteration, logic, functions. Creative expression via coding and creative coding. 3 lectures, 1 laboratory. Fulfills GE Upper-Division B (GE Area B7 for students on the 2019-20 catalog; GE Area F for students on earlier catalogs).

CSC 313. Teaching Computing. 4 units
Prerequisite: CPE/CSC 202.

An introduction to pedagogical methods and practical techniques for computer science education: selecting appropriate content, designing assignments and activities, evaluating student learning, and evaluating teaching efficacy. Hands-on guided curricular design activities and real-world practice. 3 lectures, 1 laboratory.

CSC 320. Practical Computer Security for Everyone. 4 units
2020-21 or later: Upper-Div GE Area B
2019-20 catalog catalog: GE Area B7
2017-19 or earlier catalog: GE Area F
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and completion of GE Areas B1 through B4, with a grade of C- or better in one course in GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs).

Exploration of practical computer security in everyday life for non-majors. Covering the principles, technologies and tools used to secure the Internet and keep ourselves 'digitally' secure, including: privacy and anonymity, web and data security, cryptography, malware, authentication and access control. 3 lectures, 1 laboratory. Fulfills GE Upper-Division B (GE Area B7 for students on the 2019-20 catalog; GE Area F for students on earlier catalogs).
CSC 321. Introduction to Computer Security. 4 units
Prerequisite: CPE/CSC 357.
Survey of topics in computer system and network security, including
protection, access control, distributed access control, operating system
security, applied cryptography, network security, firewalls, secure coding
practices, and case studies from real-world systems. 3 lectures, 1
laboratory. Crosslisted as CPE/CSC 321.

CSC 322. Cryptography Engineering. 4 units
Prerequisite: CPE/CSC 357.
An introduction to the theory and practice of building secure,
cryptographic systems. Core cryptographic primitives. Implementation,
evaluation and subversion of widely deployed cryptographic products and
protocols. 3 lectures, 1 laboratory.

CSC 325. Introduction to Privacy: Policy and Technology. 4 units
Prerequisite: CSC 300.
Introduction to policies and technologies related to digital privacy. Legal
decisions and policies, domestic and global cultural expectations, and
privacy related technologies including applications to surveillance, big
data, websites, mobile, and privacy by design. 3 lectures, 1 laboratory.

CSC 344. Music Programming. 4 units
Prerequisite: CSC 141 or CSC 348; and CPE/CSC 357.
Music-producing programs. Software synthesizers: oscillators, coupled
oscillators, wavetable synthesis. Sound processing units/filters: LTI, FIR,
IIR, nonlinear. Physics of sound, mathematical foundations of sound
synthesis and filtering, existing sound formats (both sampled and MIDI).
3 lectures, 1 laboratory.

CSC 348. Discrete Structures. 4 units
Prerequisite: CSC/CPE 102 and CSC/CPE 103, with a grade of C- or better
or consent of instructor, or CSC/CPE 202 and CSC/CPE 203, with a grade
of C- or better or consent of instructor.
Structures of computer science: logic, sets, relations, functions, graphs
and trees. Propositional and predicate logic. Applications of predicate
logic to preconditions, postconditions, and proof techniques. Complexity
of algorithms. Not open to students with credit in CSC 141. 4 lectures.

CSC 349. Design and Analysis of Algorithms. 4 units
Prerequisite: CSC 141 and MATH 142; or CSC 348 and MATH 142; or CPE/
CSC 102 and CPE/CSC 103 and MATH 248; or CPE/CSC 202 and CPE/CSC
203 and MATH 248.
Intermediate and advanced algorithms and their analysis. Mathematical,
geometrical, and graph algorithms. NP-complete problems. Additional
topics will be chosen from pattern matching, file compression, crypto-logy,
dynamic and linear programming, and exhaustive search. Course may be
offered in classroom-based or online format. 3 lectures, 1 laboratory.

CSC 350. Computing for Interactive Arts Capstone I. 2 units
Prerequisite: ART 384; CSC/CPE 103 or CSC/CPE 202; and junior
standing.
Definition and specification of a team-based creative collaboration on
a digital interactive art project (e.g. animation, video game, interactive
media display, etc). Research and techniques, project planning and
project team organization, prototype creation. 1 lecture, 1 laboratory.
Crosslisted as ART/CSC 350.

CSC 357. Systems Programming. 4 units
Prerequisite: CSC/CPE 102 and CSC/CPE 103 with a grade of C- or better
or consent of instructor, or CSC/CPE 202 and CSC/CPE 203 with a grade
of C- or better or consent of instructor; and CSC 225 or CPE/EE 229 or
CPE/EE 233.
C programming language from a system programming perspective.
Standard C language including operators, I/O functions, and data types
in the context of system functions. Unix commands, shell scripting, file
system, editors. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 357.

CSC 365. Introduction to Database Systems. 4 units
Prerequisite: CSC 141; or CSC 348; or CPE/CSC 102 and CPE/CSC 103
and MATH 248; or CPE/CSC 202 and CPE/CSC 203 and MATH 248.
Basic principles of database management systems (DBMS) and of
DBMS application development. DBMS objectives, systems architecture,
database models with emphasis on Entity-Relationship and Relational
models, data definition and manipulation languages, the Structured Query
Language (SQL), database design, application development tools. 3
lectures, 1 laboratory.

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

CSC 369. Introduction to Distributed Computing. 4 units
Prerequisite: CSC/CPE 102 and CSC/CPE 103, or CSC/CPE 202 and CSC/
CPE 203; and one of the following: STAT 301, STAT 312, STAT 321 or
STAT 350.
Introduction to distributed computing paradigms and cloud computing.
Modern distributed computing infrastructures. Problem-solving in a
distributed computing environment. 3 lectures, 1 laboratory.

CSC 371. Game Design. 4 units
Prerequisite: CSC/CPE 102 and CSC/CPE 103; or CSC/CPE 202 and junior
standing.
In-depth study of game design including rules, player interaction,
and storytelling. Exploration of effective use of sound, art, and game
controls in creating meaningful play. Development of fully functioning
and engaging games, following standard domain-specific software
development processes and using physical prototyping and playtesting.
Current, industry-tested game engines. 3 lectures, 1 laboratory.

CSC 377. Introduction to Mixed Reality. 4 units
Prerequisite: CPE/CSC 202. Recommended: ART 376.
Project-based study and application of Mixed Reality (MR) topics
including integrated mixed reality development environments, Human
Computer Interaction (HCI) peripherals, 3D environment scanning,
physics interaction, diminished reality, motion capture, facial recognition,
and visualization hardware. 3 lectures, 1 laboratory.
CSC 378. Interactive Entertainment Engineering. 4 units
Prerequisite: CPE/CSC 102 and CPE/CSC 103, or CPE/CSC 202 and junior standing.

Project-based, software oriented, introductory study of interactive entertainment. Discussion and evaluation of classic and historically influential games. Exploration of concepts in game design and development. Topics may include interactive storytelling, game physics, game AI, character development, animation, and development of virtual worlds. Projects require significant programming. 3 lectures, 1 laboratory.

CSC 400. Special Problems. 1-4 units
Prerequisite: Consent of instructor.

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

CSC 402. Software Requirements Engineering. 4 units
Prerequisite: CSC 307 or CSC 309.

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

CSC 405. Software Construction. 4 units
Prerequisite: CSC 305 and CSC 402.

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

CSC 406. Senior Project - Software Deployment. 4 units
Prerequisite: CSC 405.

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

CSC 409. Current Topics in Software Engineering. 4 units
Prerequisite: CSC 307 or CSC 309.

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

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

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

CSC 422. Network and Web Security. 4 units
Prerequisite: CPE 464.

Introduction to network and web security, including denial of service, botnets, access control, routing attacks, transport layer attacks, tunneling mechanisms, VPNS, IDS, firewalls, penetration testing, key distribution, browser security, social network security, email security, jamming, and wireless security. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 422.

CSC 424. Software Security. 4 units
Prerequisite: CPE/CSC 307 or CPE/CSC 309; CPE/CSC 321.

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

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

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

CSC 430. Programming Languages. 4 units
Prerequisite: CSC 349 and CSC/CPE 357.

Programming language design through evaluator implementation. Expressions, functions, environments, closures, mutation, objects, type systems, and syntactic abstraction. Syntactic, semantic, and static analysis properties. 3 lectures, 1 laboratory.

CSC 431. Compiler Construction. 4 units
Prerequisite: CSC 430.

Intermediate code representations, memory management, functions and parameter passing, code transformations and optimizations, code generation, register allocation. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 431.

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

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

CSC 436. Mobile Application Development. 4 units
Prerequisite: CSC/CPE 357.

Inception, development, testing, and deployment of mobile applications. Introduction to tools, libraries, and frameworks for one or more mobile platforms and devices. Emphasis on software engineering best practices for developing entrepreneurial or humanitarian mobile-centric applications. 3 lectures, 1 laboratory.
CSC 437. Dynamic Web Development. 4 units
Prerequisite: CPE/CSC 357 with a grade of C- or better and CSC 365 with a grade of C- or better, or consent of instructor.

Project-based study of web-based three-tiered applications, including current best practices and tools for design, implementation and testing of browser interface, serverside business logic, object-relational mapping, databases, and web services. 3 lectures, 1 laboratory.

CSC 445. Theory of Computation I. 4 units
Prerequisite: CSC 141 or CSC 348.


CSC 448. Bioinformatics Algorithms. 4 units
Prerequisite: CSC 349.

Introduction to the use of computers to solve problems in molecular biology. The algorithms, languages, and databases important in determining and analyzing nucleic and protein sequences and their structure. 3 lectures, 1 laboratory.

CSC 450. Computing for Interactive Arts Capstone II. 2 units
Prerequisite: ART/CSC 350.

Team-based design, construction and deployment of a collaborative interactive computational art project typically found in the fields of animation, game design, and interactive media. Management of interdisciplinary teams, documentation, creative development, testing, and assessment. 2 activities. Crosslisted as ART/CSC 450.

CSC 453. Introduction to Operating Systems. 4 units
Prerequisite: CSC/CPE 357, and CSC/CPE 225 or CPE/EE 229 or CPE/EE 233.

Introduction to sequential and multiprogramming operating systems; kernel calls, interrupt service mechanisms, scheduling, files and protection mechanisms, conventional machine attributes that apply to operating system implementation, virtual memory management, and I/O control systems. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 453.

CSC 454. Implementation of Operating Systems. 4 units
Prerequisite: CSC/CPE 453.

Design and implementation of multiprogramming kernels, systems programming methodology, interprocess communications, synchronization, device drivers and network access methods. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 454.

CSC 458. Current Topics in Computer Systems. 4 units
Prerequisite: CSC/CPE 357.

Selected aspects of design, implementation and analysis of networks, advanced operating and distributed systems. Topics may include process management, virtual memory, process communication, context switching, file system designs, persistent objects, process and data migration, load balancing, security and networks. The Class Schedule will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 458.

CSC 466. Knowledge Discovery from Data. 4 units
Prerequisite: CSC 349 and one of the following: STAT 302, STAT 312, STAT 321 or STAT 350.

Overview of modern knowledge discovery from data (KDD) methods and technologies. Topics in data mining (association rules mining, classification, clustering), information retrieval, web mining. Emphasis on use of KDD techniques in modern software applications. 3 lectures, 1 laboratory.

CSC 468. Database Management Systems Implementation. 4 units
Prerequisite: CSC 365.

Data structures and algorithms used in the implementation of database systems. Implementation of data and transaction managers: access methods interfaces, concurrency control and recovery, query processors and optimizers. Introduction to implementation of distributed database systems. 3 lectures, 1 laboratory.

CSC 469. Distributed Systems. 4 units
Prerequisite: CSC/CPE 357.

Foundations of distributed systems, distributed hash tables (peerto-peer systems), failure detectors, synchronization, election, interprocess communication, consensus, replication, key-value stores, and measurements. 3 lectures, 1 laboratory. Crosslisted as CSC/CPE 469.

CSC 471. Introduction to Computer Graphics. 4 units
Prerequisite: CPE/CSC 357.

Graphics software development and use of application programming interfaces for 3D graphics. The graphics pipeline, modeling, geometric and viewing transforms, lighting and shading, rendering, interaction techniques and graphics hardware. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 471.

CSC 473. Advanced Rendering Techniques. 4 units
Prerequisite: CSC/CPE 471.

Illumination models, reflectance, absorption, emittance, Gouraud shading, Phong shading, raytracing polyhedra and other modeling primitives, coherence, acceleration methods, radiosity, form factors, advanced algorithms. 3 lectures, 1 laboratory.

CSC 474. Computer Animation. 4 units
Prerequisite: CSC/CPE 471.

Basic and advanced algorithms for generating sequences of synthetic images. Interpolation in time and space, procedural and keyframe animation, particle systems, dynamics and inverse kinematics, morphing and video. 3 lectures, 1 laboratory.

CSC 476. Real-Time 3D Computer Graphics Software. 4 units
Prerequisite: CSC/CPE 471.

Basic and advanced algorithms for real-time, interactive, 3D graphics software. Modeling (polygon mesh, height field, scene graph), real-time rendering and shading (visibility processing, LOD, texture and light maps), collision detection (bounding volumes, complexity management), interactive controls, multi-player game technology, game engine architecture. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 476.
CSC 477. Scientific and Information Visualization. 4 units
Prerequisite: CSC 349.

Basic data processing (magnitude, grouping and segmentation), visualization design, cognition and perception, spatial data visualizations (2D and 3D, e.g. GIS data, medical data) information data visualization, spatial encoding, color encoding, and interaction. 3 lectures, 1 laboratory.

CSC 478. Current Topics in Computer Graphics. 4 units
Prerequisite: CSC/CPE 471.

Selected aspects of the design, implementation and analysis of computer graphics. Topics may include rendering, modeling, visualization, animation, virtual reality, computer vision, multimedia, and perception issues. The Class Schedule will list topic selected. Total credit limited to 8 units. 3 lectures, 1 laboratory.

CSC 480. Artificial Intelligence. 4 units
Prerequisite: either CSC/CPE 102 and CSC/CPE 103 with a grade of C- or better or consent of instructor; or CSC/CPE 202 with a grade of C- or better and junior standing.

Programs and techniques that characterize artificial intelligence. Programming in a high level language. 3 lectures, 1 laboratory.

CSC 481. Knowledge Based Systems. 4 units
Prerequisite: CSC 480.

In-depth treatment of knowledge representation, utilization and acquisition in a programming environment. Emphasis on the use of domain-specific knowledge to obtain expert performance in programs. 3 lectures, 1 laboratory.

CSC 482. Speech and Language Processing. 4 units
Prerequisite: CSC 466 or CSC 480 or graduate standing. Recommended: CSC 349.

Introduction to natural language processing theory; speech processing; review of recent advancements. Topics include: tokenization, part-of-speech tagging, word-sense disambiguation, natural language understanding, natural language generation, data mining, voice processing, vocalization, semantic networks, intelligent assistants, computational linguistics, stylistics and machine learning. 3 lectures, 1 laboratory.

CSC 483. Current Topics in Human-Computer Interaction. 4 units
Prerequisite: CSC 484.

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

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

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

CSC 486. Human-Computer Interaction Theory and Design. 4 units
Corequisite: CSC 484.

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

CSC 487. Deep Learning. 4 units
Prerequisite: CSC 349, and MATH 206 or MATH 244. Recommended: CSC 466 or CSC 480.

Overview of current topics in Deep Learning. Theory and practice of Deep Learning (DL) paradigms. Convolutional Neural Networks (NN), Recurrent NN, Dropout, Momentum Gradient Descent, Batch Normalization, Adversarial and Siamese NN, and new developments. Emphasis on using DL to solve a real-world application of significant scope. 3 lectures, 1 laboratory.

CSC 489. Current Topics in Artificial Intelligence. 4 units
Prerequisite: CSC 480.

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

CSC 490. Selected Advanced Topics. 1-4 units
Prerequisite: Consent of instructor.

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

CSC 491. Senior Project I. 2 units
Prerequisite: CSC 307 or CSC 309; and consent of instructor.

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

CSC 492. Senior Project II. 2 units
Prerequisite: CSC 491 and consent of instructor.

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

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

Part-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 6 units.
CSC 494. Cooperative Education Experience. 6 units
CR/NC
Prerequisite: Sophomore standing and consent of instructor.
Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by supervisor. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

CSC 495. Cooperative Education Experience. 12 units
CR/NC
Prerequisite: Sophomore standing and consent of instructor.
Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. A more fully developed formal report and evaluation by work supervisor. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

CSC 496. Selected Advanced Laboratory. 1-4 units
Prerequisite: Consent of instructor.
Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

CSC 497. Research Senior Project I. 2 units
Prerequisite: CSC 307 or CSC 309; and consent of instructor.
Individual research activity under faculty supervision. Problem statement and literature review. Intended for those planning to pursue graduate studies or research-oriented employment.

CSC 498. Research Senior Project II. 2 units
Prerequisite: CSC 497 and consent of instructor.
Continued individual research activity under faculty supervision. Prototype development, analysis, documentation. Intended for those planning to pursue graduate studies or research-oriented employment.

CSC 500. Directed Study. 1-4 units
CR/NC
Prerequisite: Fully classified graduate standing and consent of instructor.
Individual directed study of advanced topics. Total credit limited to 4 units. Credit/No Credit grading only.

CSC 508. Software Engineering I. 4 units
Prerequisite: CSC 307 or CSC 308 and graduate standing, or consent of instructor.
In-depth study of requirements engineering, software project management, formal specifications and object-oriented analysis. 4 seminars.

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

CSC 515. Computer Architecture. 4 units
Prerequisite: CPE 315 or CPE 333, and graduate standing; or consent of instructor.
Comparative study and design of multiprocessor, dataflow, RISC, high level language and other new computer architectures. VLSI processor design techniques. 3 seminars, 1 laboratory. Crosslisted as CPE/CSC 515.

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

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

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

CSC 549. Advanced Algorithm Design and Analysis. 4 units
Prerequisite: CSC 349.
Advanced study of algorithmic topics including dynamic programming, network flows, and linear programming. Complexity classes and reductions. NP-complete problems, with the introduction of approximation algorithms. 4 lectures.

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

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

CSC 564. Computer Networks: Research Topics. 4 units
Prerequisite: CSC/CPE 464 and graduate standing, or consent of instructor.
Exploration of advanced topics in emerging computer networking technologies; focus on leading edge computer network research topics. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 564.
CSC 556. Topics in Advanced Data Mining. 4 units
Prerequisite: CSC 466 or CSC 480 or CSC 582.

Advanced topics in the areas of data mining, knowledge discovery in data, machine learning, information retrieval and intelligent analysis of information. The Class Schedule will list topic selected. Total credit limited to 8 units. 4 lectures.

CSC 569. Distributed Computing. 4 units
Prerequisite: CSC 141 or CSC 348; and CPE/CSC 357; or graduate standing and consent of instructor.

Principles and practices in distributed computing: interprocess communications, group communications, client-server model, distributed objects, message queue system, distributed services, mobile agents, object space, Internet protocols. Distributed algorithms: consensus protocols, global state protocols. Fault tolerance: classification of faults, replication. 3 lectures, 1 laboratory. Crosslisted as CPE/CSC 569.

CSC 570. Current Topics in Computer Science. 2-4 units
Prerequisite: Graduate standing and evidence of satisfactory preparation in computer science.

Directed group study of selected topics for graduate students. Topics will normally consist of continuations of those in CSC 520, CSC 530, CSC 540, CSC 550, CSC 560 and CSC 580, and other topics as needed. The Class Schedule will list topic selected. Topic credit limited to 12 units. 2 to 4 seminars.

CSC 572. Computer Graphics. 4 units
Prerequisite: Successful completion of CSC/CPE 471 and graduate standing, or consent of instructor.

Advanced topics in computer graphics with emphasis on leading edge computer graphics technologies and advanced topics in graphics fundamentals. 3 lectures, 1 laboratory.

CSC 580. Artificial Intelligence. 4 units
Prerequisite: CSC 480 and graduate standing, or consent of instructor.

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

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

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

CSC 582. Computational Linguistics. 4 units
Prerequisite: CSC 482 and graduate standing. Recommended: CSC 580.

Research-based review of recent advancements in computational linguistics and natural language processing. Topics selected from: language morphology, natural language generation, feature extraction and unification, meaning representations, stylistics, discourse analysis and machine learning methods. 3 lectures, 1 laboratory.

CSC 590. Thesis Seminar. 1 unit
Prerequisite: Graduate standing or consent of instructor.

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

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

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

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

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

CSC 595. Cooperative Education Experience. 12 units
CR/NC
Prerequisite: Graduate standing and consent of instructor.

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

CSC 596. Research in Computer Science I. 2 units
Prerequisite: Consent of instructor.

Individual research or activity under faculty supervision, beginning work in preparation for the master's thesis.

CSC 597. Research in Computer Science II. 2 units
Prerequisite: CSC 596 and consent of instructor.

Individual research activity under faculty supervision, continuing work in preparation for the master's thesis.

CSC 599. Thesis. 4 units
Prerequisite: CSC 590; CSC 498 or CSC 597; selection of thesis committee; graduate standing; and consent of instructor.

Individual research or activity under faculty supervision leading to an acceptable Master's thesis.