COMPUTER SCIENCE

The CU Boulder graduate computer science program is one of the top-ranked programs in the U.S. News & World Report ranking of public universities. As a student, you will receive a strong education and conduct groundbreaking tier-one research. We have 40+ faculty members conducting fundamental and applied research in artificial intelligence, robotics, computational biology, human centered computing, numerical & scientific computing, programming languages, software engineering, systems and networking, and theory of computing.

Boulder is also home to research and development operations for many large companies, and four federal research labs: the National Center for Atmospheric Research, the National Institute for Standards and Technology, the National Oceanic and Atmospheric Administration, and the National Renewable Energy Laboratory.

Recent doctoral and master’s graduates accepted employment at companies including but not limited to the following: Microsoft, Apple, Google, Facebook, Twitter, Cisco, Raytheon, HP, NASA, Amazon, Sandia National Laboratories, Northrop Grumman and Seagate. Many of our graduating PhD students also enter careers in academia.

For more information, visit the Computer Science (http://www.colorado.edu/cs) website.

Master's Degrees

- Computer Science - Master of Science (MS) (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/computer-science/computer-science-master-science-ms)
- Computer Science - Professional Master of Science (MSCPS) (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/computer-science/computer-science-professional-master-science-mscps)
- Computer Science - Master of Engineering (ME) (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/computer-science/computer-science-master-engineering-me)

Doctoral Degree

- Computer Science - Doctor of Philosophy (PhD) (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/computer-science/computer-science-doctor-philosophy-phd)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member’s home department.

Anderson, Kenneth M (https://experts.colorado.edu/display/fisid_113566)  
Professor; PhD, University of California-Irvine

Bennett, John Knox (https://experts.colorado.edu/display/fisid_116933)  
Professor; PhD, University of Washington

Black, John (https://experts.colorado.edu/display/fisid_126540)  
Associate Professor; PhD, University of California-Davis

Boese, Elizabeth Sugar (https://experts.colorado.edu/display/fisid_154230)  
Instructor; MS, Colorado State University

Bradley, Elizabeth (https://experts.colorado.edu/display/fisid_100546)  
Professor; PhD, Massachusetts Institute of Technology

Brown, Timothy X (https://experts.colorado.edu/display/fisid_107534)  
Professor; PhD, California Institute of Technology

Brubaker, Jed Richards (https://experts.colorado.edu/display/fisid_156193)  
Assistant Professor; PhD, University of California-Irvine

Byrd, Richard H.  
Professor Emeritus; PhD, Rice University

Cai, Xiao-Chuan (https://experts.colorado.edu/display/fisid_100636)  
Professor; PhD, New York University

Cerny, Pavol (https://experts.colorado.edu/display/fisid_151749)  
Assistant Professor; PhD, University of Pennsylvania

Chang, Bor-Yuh Evan (https://experts.colorado.edu/display/fisid_146087)  
Assistant Professor; PhD, University of California-Berkeley

Chen, Lijun (https://experts.colorado.edu/display/fisid_149472)  
Assistant Professor; PhD, California Institute of Technology

Colunga, Eliana (https://experts.colorado.edu/display/fisid_129477)  
Associate Professor; PhD, Indiana University Bloomington

Correll, Nicolaus J (https://experts.colorado.edu/display/fisid_147555)  
Assistant Professor; PhD, Ecole Polytech Federale de Lausanne (Switzerland)

Dowell-Deen, Robin DeAnne (https://experts.colorado.edu/display/fisid_147779)  
Assistant Professor; DSc, Washington University

Ehrenfeucht, Andrzej  
Professor Emeritus

Eisenberg, Michael A (https://experts.colorado.edu/display/fisid_100427)  
Professor; PhD, Massachusetts Institute of Technology

Ellis, Clarence A.  
Professor Emeritus

Fischer, Gerhard  
Professor Emeritus; PhD, University of Hamburg

Fosdick, Lloyd D.  
Professor Emeritus

Frew, Eric W (https://experts.colorado.edu/display/fisid_134685)  
Associate Professor; PhD, Stanford University

Frongillo, Rafael M (https://experts.colorado.edu/display/fisid_156416)  
Assistant Professor; PhD, University of California-Berkeley

Gabow, Harold  
Professor Emeritus; PhD, Stanford University

Gross, Mark D (https://experts.colorado.edu/display/fisid_100095)  
Professor; PhD, Massachusetts Institute of Technology
Grunwald, Dirk C (https://experts.colorado.edu/display/fisid_102261)
Professor; PhD, University of Illinois at Urbana-Champaign

Ha, Sangtae (https://experts.colorado.edu/display/fisid_153246)
Assistant Professor; PhD, North Carolina State University at Raleigh

Hall, David Matthew (https://experts.colorado.edu/display/fisid_147474)
Asst Research Professor

Hammer, Matthew A (https://experts.colorado.edu/display/fisid_156066)
Assistant Professor; PhD, University of Chicago

Han, Richard Yehwhei (https://experts.colorado.edu/display/fisid_122947)
Associate Professor; PhD, University of California-Berkeley

Hoenigman, Rhonda Olcott (https://experts.colorado.edu/display/fisid_152997)
Instructor; PhD, University of Colorado Boulder

Hunter, Lawrence E (https://experts.colorado.edu/display/fisid_143568)
Professor

Jansen, Kenneth E (https://experts.colorado.edu/display/fisid_147360)
Professor; PhD, Stanford University

Jessup, Elizabeth R (https://experts.colorado.edu/display/fisid_102065)
Professor; PhD, Yale University

Kallen-Brown, Jedediah A (https://experts.colorado.edu/display/fisid_153965)
Assistant Professor; DSc, ETH Zurich (Switzerland)

Kane, Shaun Kevin (https://experts.colorado.edu/display/fisid_154603)
Assistant Professor; PhD, University of Washington

Keegan, Brian (https://experts.colorado.edu/display/fisid_158122)
Assistant Professor; PhD, Northwestern University

Keller, Eric Robert (https://experts.colorado.edu/display/fisid_151647)
Assistant Professor; PhD, Princeton University

Ketelsen, Christian W (https://experts.colorado.edu/display/fisid_147863)
Instructor; PhD, University of Colorado Boulder

King, Roger A.
Professor Emeritus

Knox, David Allen (https://experts.colorado.edu/display/fisid_158054)
Instructor; PhD, University of Colorado Health Sciences Center

Lewis, Clayton H (https://experts.colorado.edu/display/fisid_100307)
Professor; PhD, University of Michigan Ann Arbor

Lv, Qin (https://experts.colorado.edu/display/fisid_145832)
Associate Professor; PhD, Princeton University

Main, Michael G.
Professor Emeritus; PhD, Washington State University

Martin, James H (https://experts.colorado.edu/display/fisid_100495)
Professor; PhD, University of California-Berkeley

McBryan, Oliver
Professor Emeritus

Mishra, Shivakant (https://experts.colorado.edu/display/fisid_118376)
Professor; PhD, University of Arizona

Mozer, Michael C (https://experts.colorado.edu/display/fisid_105922)
Professor; PhD, University of California-San Diego

Nutt, Gary J.
Professor Emeritus

Palen, Leysia A (https://experts.colorado.edu/display/fisid_114604)
Professor; PhD, University of California-Irvine

Paul, Michael J (https://experts.colorado.edu/display/fisid_156070)
Assistant Professor; PhD, Johns Hopkins University

Repenning, Alexander (https://experts.colorado.edu/display/fisid_104946)
Research Professor; PhD, University of Colorado Boulder

Sanders, Bruce W.
Professor Emeritus

Sankaranarayanan, Sriram (https://experts.colorado.edu/display/fisid_147413)
Associate Professor; PhD, Stanford University

Schnabel, Robert B.
Professor Emeritus

Schreuder, Willem A (https://experts.colorado.edu/display/fisid_143834)
Asst Professor Adjunct

Shapiro, Ryan Benjamin (https://experts.colorado.edu/display/fisid_156418)
Assistant Professor; PhD, Northwestern University

Sibley, Gabriel T (https://experts.colorado.edu/display/fisid_154632)
Assistant Professor; PhD, University of Southern California

Sicker, Douglas C. (https://experts.colorado.edu/display/fisid_123114)
Professor; PhD, University of Pittsburgh

Sumner, Tammy R (https://experts.colorado.edu/display/fisid_105742)
Professor; PhD, University of Colorado Boulder

Szafr, Daniel James (https://experts.colorado.edu/display/fisid_156420)
Assistant Professor; PhD, University of Wisconsin-Madison

Szafr, Danielle N (https://experts.colorado.edu/display/fisid_156317)
Assistant Professor; PhD, University of Wisconsin-Madison

Tufo, Henry (https://experts.colorado.edu/display/fisid_127040)
Research Professor; PhD, Brown University

Voida, Amy Kathryn Mitchell (https://experts.colorado.edu/display/fisid_155855)
Assistant Professor; PhD, Georgia Institute of Technology

Voida, Stephen A (https://experts.colorado.edu/display/fisid_155856)
Assistant Professor; PhD, Georgia Institute of Technology

Waite, William M.
Professor Emeritus
Ward, Wayne Hinson (https://experts.colorado.edu/display/fisid_114680)  
Research Professor; PhD, University of Colorado Boulder

Winklmann, Karl A.  
Professor Emeritus

Wustrow, Eric A. (https://experts.colorado.edu/display/fisid_154440)  
Assistant Professor; BE, University of Michigan Ann Arbor

Yeh, Pei Hsiu (https://experts.colorado.edu/display/fisid_151584)  
Assistant Professor; PhD, Massachusetts Institute of Technology

Ying, Jordan Boyd-Graber (https://experts.colorado.edu/display/fisid_154440)  
Assistant Professor; PhD, Princeton University

Courses

CSCI 5135 (3) Computer-Aided Verification  
Covers two-level and multilevel minimization, optimization via expert systems, algebraic and Boolean decomposition, layout methodologies, state assignment, encoding and minimization, silicon compilation.  
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5139  
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Recommended: Prerequisites ECEN 2703 and general proficiency in discrete mathematics and programming.  
Additional Information: Departmental Category: Programming Languages

CSCI 5229 (3) Computer Graphics  
Studies design, analysis and implementation of computer graphics techniques. Topics include interactive techniques, 2D and 3D viewing, clipping, segmentation, translation, rotation and projection. Involves removal of hidden edges, shading and color. Knowledge of basic linear algebra is required.  
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4229  
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Additional Information: Departmental Category: Graphics

CSCI 5239 (3) Advanced Computer Graphics  
Studies design, analysis and implementation of advanced computer graphics techniques. Topics include shaders, using the GPU for high performance computing, graphics programming on embedded devices such as mobile phones; advanced graphics techniques such as ray tracing.  
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4239  
Requisites: Requires prerequisite course of CSCI 5229 (minimum grade B). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Additional Information: Departmental Category: Graphics

CSCI 5250 (3) Computer Science: The Canon  
Explores the "great works" of computer science through intensive reading and discussion. Readings include works by Babbage, Turing, Von Neumann, Goedel, Shannon and Minsky, among others. Does not count toward breadth requirement for Computer Science MS/ME degree.  
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4250  
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Additional Information: Departmental Category: General Computer Science

CSCI 5253 (3) Datacenter Scale Computing - Methods, Systems and Techniques  
Covers the primary problem solving strategies, methods and tools needed for data-intensive programs using large collections of computers typically called "warehouse scale" or "data-center scale" computers. Examines methods and algorithms for processing data-intensive applications, methods for deploying and managing large collections of computers in an on-demand infrastructure and issues of large-scale computer system design.  
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4253  
Requisites: Restricted to graduate student Computer Sciences (CSEN) students only.  
Recommended: Prerequisite CSCI 5273.  
Grading Basis: Letter Grade  
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 5254 (3) Convex Optimization and Its Applications  
Discuss basic convex analysis (convex sets, functions and optimization problems), optimization theory (linear, quadratic, semidefinite and geometric programming; optimality conditions and duality theory), some optimization algorithms (descent methods and interior-point methods), basic applications (in signal processing, control, communications, networks, statistics, machine learning, circuit design and mechanical engineering, etc.), and some advanced topics (distributed decomposition, exact convex relaxation, parsimonious recovery).  
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Additional Information: Departmental Category: Theory of Computation

CSCI 5273 (3) Network Systems  
Focuses on design and implementation of network programs and systems, including topics in network protocols, file transfer, client-server computing, remote procedure call and other contemporary network system design and programming techniques. Familiarity with C and Unix is required.  
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4273 and ECEN 5273  
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 5302 (3) Advanced Robotics  
Exposes students to current research topics in the field of robotics and provides hands-on experience in solving a grand challenge program.  
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4302  
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Recommended: Prerequisite CSCI 3302 or instructor consent required.  
Additional Information: Departmental Category: Artificial Intelligence

CSCI 5314 (3) Algorithms for Molecular Biology  
Surveys molecular biology and combinatorial algorithms used to understand DNA, RNA, and proteins. Students work in groups to define and tackle meaningful biological problems and learn to collaborate effectively with scientists in other disciplines.  
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4314  
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
Additional Information: Departmental Category: Theory of Computation
CSCI 5340 (3) Startup Essentials: Entrepreneurial Projects in Computing
Provides students with the tools to be successful technical co-founders of their own startups. Explores the initial stages of founding a startup, including team formation, idea validation, pivoting and pitching, while employing an iterative methodology. Student teams will develop a minimum viable product, pitch their final startup concept and be evaluated on product/market fit. CS coding concepts relevant for startups, including potentially cloud programming, mobile programming and agile software engineering, will be taught. Does not satisfy breadth requirement.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4348
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: General Computer Science

CSCI 5350 (3) Entrepreneurial Projects II
Follows CSCI 5340. In the second semester of this entrepreneurial project capstone, student teams will seek to find market traction for a high-fidelity Minimum Viable Product (MVP), software and/or hardware, that they will develop as part of their startup project. Teams will further learn to incorporate principles of marketing, business finance and legal issues into the business model for their startup concept. Does not satisfy breadth requirement.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4358
Requisites: Requires a prerequisite course of CSCI 5340 (minimum grade B). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: General Computer Science

CSCI 5352 (3) Network Analysis and Modeling
Examines modern techniques for analyzing and modeling the structure and dynamics of complex networks. Focuses on statistical algorithms and methods, and emphasizes model interpretability and understanding the processes that generate real data. Applications are drawn from computational biology and computational social science. No biological or social science training is required.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisites CSCI 3104 and APPM 3570.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 5413 (3) Computer Security and Ethical Hacking
Teaches basic exploit design and development through hands-on experimentation and testing. Uses a controlled environment to give students a "playground" in which to test penetration skills that are normally not allowed on live networks.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4413
Requisites: Requires a prerequisite course of CSCI 5340 (minimum grade B). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 5417 (3) Information Retrieval Systems
Addresses practical issues in the design, implementation and analysis of modern information retrieval systems. The major focus is on Web-based applications including ad hoc retrieval, classification, and clustering. Introduces the use of open source retrieval systems, standard evaluation metrics and gold-standard evaluation collections.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Database Systems

CSCI 5444 (3) Introduction to Theory of Computation
Reviews regular expressions and finite automata. Studies Turing machines and equivalent models of computation, the Chomsky hierarchy, context-free grammars, push-down automata, and computability.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Theory of Computation

CSCI 5446 (3) Chaotic Dynamics
Explores chaotic dynamics theoretically and through computer simulations. Covers the standard computational and analytical tools used in nonlinear dynamics and concludes with an overview of leading-edge chaos research. Topics include time and phase-space dynamics, surfaces of section, bifurcation diagrams, fractal dimension and Lyapunov exponents.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4446 and ECEN 4423 and ECEN 5423
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Numerical Computation

CSCI 5448 (3) Object-Oriented Analysis and Design
An applied analysis and design class addressing the use of object-oriented techniques. Topics include domain modeling, use cases, architectural design and modeling notations. Students apply the techniques in analysis and design projects.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4448
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite CSCI 2270 or equivalent.
Additional Information: Departmental Category: Software Engineering

CSCI 5454 (3) Design and Analysis of Algorithms
Techniques for algorithm design, analysis of correctness and efficiency; divide and conquer, dynamic programming, probabilistic methods, advanced data structures, graph algorithms, etc. Lower bounds, NP-completeness, intractability.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Theory of Computation

CSCI 5502 (3) Data Mining
Introduces basic data mining concepts and techniques for discovering interesting patterns hidden in large-scale data sets, focusing on issues relating to effectiveness and efficiency. Topics covered include data preprocessing, data warehouse, association, classification, clustering, and mining specific data types such as time-series, social networks, multimedia, and Web data.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4502
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 5525 (3) Compiler Construction
Introduces the principles and techniques for compiling high-level programming languages to assembly code. Topics include parsing, instruction selection, register allocation, and compiling high-level features such as polymorphism, first-class functions, and objects. Students will build a complete compiler for a simple language.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4555 and ECEN 4553 and ECEN 5523
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisites CSCI 3155 and CSCI 2400 or ECEN 3350.
Additional Information: Departmental Category: Programming Languages
CSCI 5535 (3) Fundamental Concepts of Programming Languages
Considers concepts common to a variety of programming languages—how they are described (both formally and informally) and how they are implemented. Provides a firm basis for comprehending new languages and gives insight into the relationship between languages and machines.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5533
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite CSCI 3155 or instructor consent required.
Additional Information: Departmental Category: Programming Languages

CSCI 5548 (3) Software Engineering of Standalone Programs
Applies engineering principles to phases of software product development, project planning, requirements definition, design, implementation, validation and maintenance. Emphasizes practical methods for communicating and verifying definitions and designs: prototyping, inspections and modeling. Includes relation to RTS and object-oriented programming.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5543
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisites CSCI 1300 and CSCI 2270 or instructor consent required.
Additional Information: Departmental Category: Software Engineering

CSCI 5551 (3) Parallel Processing
Examines a range of topics involved in using parallel operations to improve computational performance. Discusses parallel architectures, parallel algorithms and parallel programming languages. Architectures covered include vector computers, multiprocessors, network computers and data flow machines.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5553
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite background in computer organization, introduction to programming languages, elementary numerical analysis, or instructor consent required.
Additional Information: Departmental Category: Parallel Processing

CSCI 5573 (3) Advanced Operating Systems
Intended to create a foundation for operating systems research or advanced professional practice. Examines the design and implementation of a number of research and commercial operating systems and their components, system organization and structure, threads, communication and synchronization, virtual memory, distribution, file systems, security and authentication, availability and Internet services.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5573
Requisites: Requires prerequisite course of CSCI 2400 and CSCI 3753 (all minimum grade C). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 5576 (4) High-Performance Scientific Computing
Introduces computing systems, software and methods used to solve large-scale problems in science and engineering. Students use high-performance workstations and a supercomputer. First course in a two-semester sequence.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4576
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Numerical Computation

CSCI 5593 (3) Advanced Computer Architecture
Provides a broad-scope treatment of important concepts in the design and implementation of high-performance computer systems. Discusses important issues in the pipelining of a machine and the design of cache memory systems. Also studies current and historically important computer architectures.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5593
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite CSCI 4593 or instructor consent required.
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 5606 (3) Principles of Numerical Computation
Highlights computer arithmetic, solution of linear systems, least-squares approximations, nonlinear algebraic equations, interpolation, and quadrature.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisites CSCI 3656 and three semesters of calculus or equivalent.
Additional Information: Departmental Category: Numerical Computation

CSCI 5608 (3) Software Project Management
Presents topics and techniques critical to the management of software product development, including estimating, planning, quality, tracking, reporting, team organization, people management and legal issues. Gives special attention to problems unique to software projects.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5603 and EMEN 5031
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisites ECEN 4583 and CSCI 5548 and CSCI 4318 or equivalent industrial experience.
Additional Information: Departmental Category: Software Engineering

CSCI 5622 (3) Machine Learning
Trains students to build computer systems that learn from experience. Includes the three main subfields: supervised learning, reinforcement learning and unsupervised learning. Emphasizes practical and theoretical understanding of the most widely used algorithms (neural networks, decision trees, support vector machines, Q-learning). Covers connections to data mining and statistical modeling. A strong foundation in probability, statistics, multivariate calculus, and linear algebra is highly recommended.
Requisites: Requires prerequisite courses of CSCI 2400 and CSCI 3104 (all minimum grade C). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 5636 (3) Numerical Solution of Partial Differential Equations
Focuses on parallel algorithms for partial differential equations, iterative solvers such as Krylov subspace methods, domain decomposition and multilevel methods.
Requisites: Requires prerequisite course of CSCI 2820 or CSCI 3656 (minimum grade B). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Numerical Computation
CSCI 5646 (3) Numerical Linear Algebra
Offers direct and iterative solutions of linear systems. Also covers eigen value and eigenvector calculations, error analysis, and reduction by orthogonal transformation. A sound knowledge of basic linear algebra, experience with numerical computation, and programming experience is required.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Numerical Computation

CSCI 5654 (3) Linear Programming
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite linear algebra.
Additional Information: Departmental Category: Theory of Computation

CSCI 5673 (3) Distributed Systems
Examines systems that span multiple autonomous computers. Topics include system structuring techniques, scalability, heterogeneity, fault tolerance, load sharing, distributed file and information systems, naming, directory services, resource discovery, resource and network management, security, privacy, ethics and social issues.
Equivalent - Duplicate Degree Credit Not Granted: ECEN 5673
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite CSCI 5573 or a course in computer networks.
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 5676 (3) Numerical Optimization
Focuses on computational methods for solution of unconstrained and some constrained optimization problems, nonlinear least-squares problems and systems of nonlinear equations. Formerly CSCI 6676.
Requisites: Requires prerequisite course of CSCI 2820 or CSCI 3656 (minimum grade B). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Numerical Computation

CSCI 5714 (3) Formal Languages
Explores context-free languages: pumping lemma and variants, closure properties, and decision properties. Involves parsing algorithms, including general and special languages, e.g., LR. Additional topics chosen by instructor.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite CSCI 5444 or instructor consent required.
Additional Information: Departmental Category: Theory of Computation

CSCI 5722 (3) Computer Vision
Explores algorithms that can extract information about the world from images or sequences of images. Topics covered include: imaging models and camera calibration, early vision (filters, edges, texture, stereo, optical flow), mid-level vision (segmentation, tracking), vision-based control and object recognition.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite probability, multivariate calculus and linear algebra.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 5753 (3) Computer Performance Modeling
Presents a broad range of system measurement and modeling techniques, emphasizing applications to computer systems. Topics include system measurement, work load characterization and analysis of data; design of experiments; simulation; and queuing theory and queuing network models.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4753 and ECEN 4753 and ECEN 5753
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 5802 (1) Data Science Team Companion Course
Gives students hands-on experience applying data science techniques and machine learning algorithms to real-world problems. Students work in small teams on internal challenges, many of which will be sponsored by local companies and organizations and will represent the university in larger teams for external challenges at the national and global level, such as those hosted by Kaggle. Students will be expected to participate in both internal and external challenges, attend meetings and present short presentations to the group when appropriate. Instructor consent required.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4802
Repeatable: Repeatable for up to 3.00 total credit hours.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 5809 (3) Computer Animation
Develops a firm understanding of the general principles of computer animation. Lectures cover the creation of models, materials, textures, surfaces, and lighting. Path and key frame animation, particle dynamics, and rendering are introduced. Students are assigned a number of animation tutorials to carry out.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4809 and ATLS 4809 and ATLS 5809
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: Graphics

CSCI 5817 (3) Database Systems
Provides an advanced treatment of basic database concepts.
Requisites: Requires prerequisite course of CSCI 3287 (minimum grad C-). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite CSCI 3753.
Additional Information: Departmental Category: Database Systems

CSCI 5822 (3) Probabilistic Models of Human and Machine Learning
Introduces a set of modeling techniques that have become a mainstay of modern artificial intelligence, cognitive science and machine learning research. These models provide essential tools for interpreting the statistical structure of large data sets and for explaining how intelligent agents analyze the vast amount of experience that accumulates through interactions with an unfamiliar environment.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Recommended: Prerequisite undergraduate course in probability and statistics.
Additional Information: Departmental Category: Artificial Intelligence
CSCI 5828 (3) Foundations of Software Engineering  
Provides an introduction to software engineering concepts and techniques. Topics include the history of software engineering, fundamental software engineering principles and theory, software life cycles, software testing, and the design and implementation of concurrent and large-scale software systems.  
**Requisites:** Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Software Engineering

CSCI 5832 (3) Natural Language Processing  
Explores the field of natural language processing as it is concerned with the theoretical and practical issues that arise in getting computers to perform useful and interesting tasks with natural language. Covers the problems of understanding complex language phenomena and building practical programs.  
**Equivalent - Duplicate Degree Credit Not Granted:** LING 5832  
**Requisites:** Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Artificial Intelligence

CSCI 5839 (3) User-Centered Design and Development 1  
Develops the skills and practices necessary to apply user-centered approaches to software requirements analysis, and the design and evaluation of computer applications.  
**Requisites:** Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Artificial Intelligence

CSCI 5854 (3) Theoretical Foundations for Cyber-Physical Systems  
**Requisites:** Requires prerequisite course of CSCI 3434 or ECEN 3300 (minimum grade C). Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Theory of Computation

CSCI 5900 (1-6) Master's Level Independent Study  
Provides opportunities for independent study at the master's level.  
**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.  
**Requisites:** Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
**Additional Information:** Departmental Category: General Computer Science

CSCI 5919 (3) HCC Survey and Synthesis: Foundations and Trajectories  
Examines interdisciplinary field of human-computer interaction through a comprehensive content and historical survey. Considers new trajectories of inquiry and how the field merges with others. "Social computing" is emphasized as a central topic. Students across disciplines will find the course foundational for understanding human-centered technology matters, including computer scientists; social scientists; and business and media arts students.  
**Requisites:** Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
**Additional Information:** Departmental Category: Graphics

CSCI 5922 (3) Neural Networks and Deep Learning  
Introduces modern approaches to machine learning using neural networks. Neural nets, popular in the early 1990s, have undergone a resurgence due to significant advances in computing power and the availability of very large data sets. Now rechristened 'deep learning', the field has produced state-of-the-art results in a range of artificial intelligence problems, including vision, speech and natural language processing.  
**Grading Basis:** Letter Grade  
**Additional Information:** Departmental Category: Artificial Intelligence

CSCI 5929 (3) HCC Survey and Synthesis: New Disciplinary Directions  
Studies recent advances in human-computer interaction through critical analysis of influential papers and self-guided research. Examines new paradigms in input, output, and visualization for technology design and interaction. Considers innovative methods to assess various population design and technological needs. Studies in computer-related fields, social science, business, media arts and communications benefit learning about human-centered computing research.  
**Requisites:** Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.  
**Recommended:** Prerequisite CSCI 5919.  
**Additional Information:** Departmental Category: Graphics

CSCI 6000 (1) Introduction to the Computer Science PhD Program  
Instructs new Ph.D students in Computer Science how to obtain a Ph.D and how to become an effective member of the computer science research community. Makes students aware of formal requirements, educational objectives, and research themes. Provides evaluative criteria and guidelines for all objectives to be achieved.  
**Requisites:** Restricted to graduate students only.  
**Additional Information:** Departmental Category: General Computer Science

CSCI 6268 (3) Foundations of Computer and Network Security  
Studies methods to protect information, and the ability to process and move information, from theft, misuse, tampering, destruction and unauthorized access. Introduces foundational topics of computer and network security, including security models, cryptography and authentication protocols.  
**Equivalent - Duplicate Degree Credit Not Granted:** TLEN 5550  
**Requisites:** Requires prerequisite course of CSCI 5273 (minimum grade B). Restricted to graduate students only.  
**Additional Information:** Departmental Category: Software Engineering

CSCI 6302 (3) Speech Recognition and Synthesis  
Introduction to automatic speech recognition and understanding, conversational agents, dialogue systems, and speech synthesis/text-to-speech. Topics include the noisy channel model, Hidden Markov Models, A* and Viterbi decoding, language modeling (N-grams, entropy), concatenative synthesis, text normalization, dialogue and conversation modeling.  
**Requisites:** Restricted to graduate students only.  
**Recommended:** Prerequisites CSCI 5832 or LING 5200 or instructor consent required.  
**Additional Information:** Departmental Category: Artificial Intelligence
CSCI 6402 (3) Issues and Methods in Cognitive Science
Interdisciplinary introduction to cognitive science, examining ideas from cognitive psychology, philosophy, education, and linguistics via computational modeling and psychological experimentation. Includes philosophy of mind; learning; categorization; vision and mental imagery; consciousness; problem solving; decision making, and game-theory; language processing; connectionism. No background in Computer Science will be presumed.
Equivalent - Duplicate Degree Credit Not Granted: EDUC 6504 and LING 6200 and PHIL 6310 and PSYC 6200 and SLHS 6402
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: General Computer Science

CSCI 6454 (3) Advanced Algorithms
Topics include matching and network flows, matroids, computational geometry, parallel computation (PRAM, hypercube, mesh). Also includes VLSI, database theory, distributed computation, cryptography, robotics, scheduling, probabilistic algorithms, approximation algorithms, average case, and amortized analysis, time permitting.
Requisites: Requires prerequisite course of CSCI 5454 (minimum grade B). Restricted to graduate students only.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 6622 (3) Advanced Machine Learning
Covers advanced theoretical and practical topics in machine learning and latest developments in the field. Students conduct original research, either applied or theoretical, and present their results.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite CSCI 5622 or instructor consent required.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 6686 (3) Numerical Methods for Constrained Optimization
Covers computational methods for constrained optimization. Topics include basic theory, methods for quadratic programming, active set strategies for linear constraints, and penalty and successive quadratic programming methods for nonlinearly constrained problems.
Requisites: Requires prerequisite course of CSCI 5606 (minimum grade B). Restricted to graduate students only.
Additional Information: Departmental Category: General Computer Science

CSCI 6800 (1-6) Master of Engineering Project
Students seeking the master of engineering degree must complete a creative investigation project, including a written report, supervised by a member of the graduate faculty. Department enforced prerequisite: completion of 21 hours towards the ME degree.
Repeatable: Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate student Computer Sciences (CSEN) students only.
Additional Information: Departmental Category: General Computer Science

CSCI 6810 (1) Seminar in Computational Biology
Provides an overview of current research topics in computational biology and health informatics, with a focus on research conducted on campus. Each week students will attend an on-campus seminar or a presentation by an on-campus research group. Prepares students to participate in a research project.
Equivalent - Duplicate Degree Credit Not Granted: CSCI 4810
Additional Information: Departmental Category: General Computer Science

CSCI 6940 (1) Master's Degree Candidacy
For students who need to be registered for the purpose of taking the master's comprehensive exam and who are not otherwise registered. Credit does not count toward degree requirements.
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Grading Basis: Pass/Fail
Additional Information: Departmental Category: General Computer Science

CSCI 6950 (1-6) Master's Thesis
Requisites: Restricted to Computer Science (CSEN) graduate students or Computer Science Concurrent Degree majors only.
Additional Information: Departmental Category: General Computer Science

CSCI 7000 (1-4) Current Topics in Computer Science
Covers research topics of current interest in computer science that do not fall into a standard subarea.
Repeatable: Repeatable for up to 8.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: General Computer Science

CSCI 7123 (3) Topics in Operating Systems
Topics selected by instructor. Possible topics are system design, measurement and evaluation, simulation, mathematical modeling, and parallelism.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Requires prerequisite course of CSCI 5573 (minimum grade B). Restricted to graduate students only.
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 7135 (3) Topics in Programming Languages
Topics selected by instructor. Possible topics are syntax, semantics, metacompilers, compiler design, and translator writing systems. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Programming Languages

CSCI 7143 (3) Topics in Computer Systems
Topics selected by instructor. Possible topics are online systems, multiprocessing, microprogramming, architecture, data communications, and computing networks. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 7154 (3) Topics in Theory of Computation
Selected topics of current interest in theory of computation.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Requires prerequisite course of CSCI 5454 (minimum grade B). Restricted to graduate students only.
Additional Information: Departmental Category: Theory of Computation
CSCI 7176 (3) Topics in Numerical Computation
Topics selected by instructor. Possible topics are numerical linear algebra, solution of differential equations, nonlinear algebra and optimization, data fitting, linear and nonlinear programming, and solution of large problems. Department consent required.
Repeatable: Repeateable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Numerical Computation

CSCI 7222 (3) Topics in Nonsymbolic Artificial Intelligence
Topics vary from year to year. Possible topics include human and machine vision, signal and speech processing, artificial life, mathematical foundations of connectionism, and computational learning theory.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite CSCI 5622 or instructor consent required.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 7412 (2) Cognitive Science Research Practicum
Independent, interdisciplinary research project in cognitive science for advanced graduate students pursuing a joint Ph.D. in an approved core discipline and cognitive science. Research projects integrate at least two areas within the cognitive sciences: psychology, computer science, linguistics, education, philosophy. Students need commitments from two mentors for their project.
Equivalent - Duplicate Degree Credit Not Granted: EDUC 6506 and LING 7415 and PHIL 7415 and PSYC 7415 and SLHS 7418
Requisites: Requires a prerequisite course of CSCI 6402 or EDUC 6504 or LING 6200 or PHIL 6310 or PSYC 6200 (minimum grade B). Restricted to graduate students only.
Recommended: Prerequisite EDUC 6505.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 7422 (2) Cognitive Science Research Practicum 2
Independent, interdisciplinary research project in cognitive science for advanced graduate students pursuing a joint Ph.D in an approved core discipline and cognitive science. Research projects integrate at least two areas within the cognitive sciences: psychology, computer science, linguistics, education, philosophy. Students need commitments from two mentors for their project.
Equivalent - Duplicate Degree Credit Not Granted: EDUC 6516 and LING 7425 and PHIL 7425 and PSYC 7425 and SLHS 7428
Requisites: Requires a prerequisite course of LING 7415 or PSYC 7415 or CSCI 7412 or EDUC 6506 (minimum grade B). Restricted to graduate students only.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 7717 (3) Topics in Database Systems
Studies topics such as distributed databases, database interfaces, data models, database theory, and performance measurement in depth.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Requires prerequisite course of CSCI 5817 (minimum grade B). Restricted to graduate students only.
Additional Information: Departmental Category: Database Systems

CSCI 7772 (1) Topics in Cognitive Science
Reading of interdisciplinary innovative theories and methodologies of cognitive science. Students participate in the ICS Distinguished Speakers series that hosts internationally recognized cognitive scientists who share and discuss their current research. Session discussions include analysis of leading edge and controversial new approaches in cognitive science.
Equivalent - Duplicate Degree Credit Not Granted: EDUC 7775 and LING 7775 and PHIL 7810 and PSYC 7775 and SLHS 7775
Repeatable: Repeatable for up to 4.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Artificial Intelligence

CSCI 7818 (3) Topics in Software Engineering
Studies selected topics of current interest in software engineering. Department consent required.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Software Engineering

CSCI 8990 (1-10) Doctoral Dissertation
Investigates some specialized field of computer science. Approved and supervised by faculty members.
Repeatable: Repeatable for up to 30.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: General Computer Science

CSCI 9990 (1-10) Doctoral Dissertation
Investigates some specialized field of computer science. Approved and supervised by faculty members.
Repeatable: Repeatable for up to 30.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: General Computer Science