

COMPUTER SCIENCE

Computer science is an exciting and challenging field that has impact on many parts of our lives. Computer scientists craft the technologies that enable the digital devices we use every day. They develop the large-scale software that powers business and industry, advance the computational techniques, and write the software that supports scientists in their study of the world around us. Many new applications of computing technology remain to be discovered. Computing will be at the heart of future revolutions in business, science and society. Students who study computer science will be at the forefront of these important advances.

Computer science offers study in the fields of computer systems, cyber security, robotics, algorithm design, artificial intelligence, software and web engineering, programming languages, database design, human-computer interaction, machine learning, data science, numerical and parallel computing, speech and language processing and theoretical computer science.

Computer science is concerned with how computers are constructed, how they store and process data, how they are used in problem solving and how the quality of those solutions is assessed. It is about the science of creating software for a variety of users, and understanding how that software interacts with the hardware on which it is run and goes well beyond the machine to the study of how people interact with the technologies around them. Applications of computer science reach far and wide.

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

The course code for this program is CSCI.

Career Possibilities

Computer science graduates from CU Boulder are engaged in a wide variety of jobs with many different companies in locations all over the world. They produce the software and systems that touch lives every day in fields as diverse as scientific exploration, communication, finance, medicine, manufacturing, entertainment and research. Many are software developers, but others become teachers, writers, doctors, lawyers, scientists, military leaders and entrepreneurs. They work at some of the largest, most influential companies in the world, at research institutions, nonprofits and at the smallest start-ups of every type imaginable.

Facilities, Programs and Opportunities

The Department of Computer Science uses a modern computing infrastructure that supports its research and educational missions. This includes general purpose computing labs provided by the university, additional instructional labs and administrative computing resources provided by the department, and specialized labs dedicated to the work of individual research groups. A wide variety of computing resources are available so that students have the opportunity to learn about and use cutting-edge equipment and software. The university research computing service maintains a supercomputer, high-speed networking and advanced computing infrastructure for the campus. The computer science educational culture emphasizes the use of individual laptop computers, including their use in courses and group work.

There are many networking opportunities available with companies offering paid internships. Boulder's tech start-up community, tech companies, and research labs provide students with many employment

opportunities while earning their degrees. There are also extensive opportunities for undergraduate students to participate in research projects across the campus.

The Undergraduate Research Opportunities Program (UROP) offers students a chance to work alongside a faculty sponsor on original research. Students learn to write proposals, conduct research, pursue creative work, analyze data and present the results. For more information, call UROP at 303-492-2596 or visit the UROP (<http://www.colorado.edu/suep/urop>) website.

Bachelor's Degree

- Computer Science - Bachelor of Arts (BA) (catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/computer-science/computer-science-bachelor-arts-ba)

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.

Alistar, Mirela
Assistant Professor; PhD, Danmarks Tekniske Universitet (Denmark)

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, Elle (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, Jed (https://experts.colorado.edu/display/fisid_153965)
Assistant Professor; DSc, ETH Zürich (Switzerland)

Brubaker, Jed Richards (https://experts.colorado.edu/display/fisid_156193)
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Byrd, Richard H.
Professor Emeritus

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)
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Clauset, Aaron (https://experts.colorado.edu/display/fisid_147554)
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Colunga, Eliana (https://experts.colorado.edu/display/fisid_129477)
Associate Professor; PhD, Indiana University Bloomington

Constantine, Paul (https://experts.colorado.edu/display/fisid_159755)
Assistant Professor; PhD, Stanford University

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

Cox, Rachel
Instructor

D'Mello, Sidney (https://experts.colorado.edu/display/fisid_159117)
Professor; PhD, University of Memphis

Do, Ellen Yi-Luen (https://experts.colorado.edu/display/fisid_159925)
Professor; PhD, Georgia Institute of Technology

Dowell, Robin D. (https://experts.colorado.edu/display/fisid_147779)
Associate Professor; DSc, Washington University

Ehrenfeucht, Andrzej
Professor Emeritus

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

Fiesler, Casey Lynn (https://experts.colorado.edu/display/fisid_155950)
Assistant Professor; PhD, Georgia Institute of Technology

Fischer, Gerhard
Professor Emeritus

Fleming, Ioana (https://experts.colorado.edu/display/fisid_154718)
Instructor; PhD, Johns Hopkins University

Fosdick, Lloyd D.
Professor Emeritus

Frew, Eric W. (https://experts.colorado.edu/display/fisid_134685)
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

Grochow, Joshua A. (https://experts.colorado.edu/display/fisid_158240)
Assistant Professor; PhD, University of Chicago

Gross, Mark D. (https://experts.colorado.edu/display/fisid_100095)
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Gruchalla, Kenny
Assistant Professor Adjunct

Grunwald, Dirk C. (https://experts.colorado.edu/display/fisid_102261)
Professor, Faculty Director; PhD, University of Illinois at Urbana-
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Assistant Professor; PhD, North Carolina State University

Hajič, Jan
Professor Adjunct; PhD, Charles University in Prague (Czech Republic)

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Hammer, Matthew A. (https://experts.colorado.edu/display/fisid_156066)
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Han, Richard (https://experts.colorado.edu/display/fisid_122947)
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Hauser, Thomas
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Hayes, Bradley H. (https://experts.colorado.edu/display/fisid_159810)
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Keegan, Brian (https://experts.colorado.edu/display/fisid_158122)
Assistant Professor; PhD, Northwestern University

Keller, Eric Robert (https://experts.colorado.edu/display/fisid_151647)
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King, Roger A.
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Lv, Qin (https://experts.colorado.edu/display/fisid_145832)
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Main, Michael G.
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- Massey, Daniel (https://experts.colorado.edu/display/fisid_159491)
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- Mathew, Tarek
Professor Adjunct
- McBryan, Oliver
Professor Emeritus
- Mishra, Shivakant (https://experts.colorado.edu/display/fisid_118376)
Professor, Associate Chair; PhD, University of Arizona
- Monteleoni, Claire Elizabeth (https://experts.colorado.edu/display/fisid_163979)
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- Morrison, Rebecca
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- Mozer, Michael C. (https://experts.colorado.edu/display/fisid_105922)
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- Nelson, Thomas
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- Nutt, Gary J.
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- Paradise, Alan (https://experts.colorado.edu/display/fisid_158849)
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- Paul, Michael J. (https://experts.colorado.edu/display/fisid_156070)
Assistant Professor; PhD, Johns Hopkins University
- Peleg, Orit (https://experts.colorado.edu/display/fisid_159998)
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- Phillips, Caleb Timothy (https://experts.colorado.edu/display/fisid_152384)
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- Roque, Ricarose (https://experts.colorado.edu/display/fisid_158315)
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- Rozner, Eric
Assistant Professor; PhD, University of Texas at Austin
- Sanders, Bruce W.
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- Sankaranarayanan, Sriram (https://experts.colorado.edu/display/fisid_147413)
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- Schnabel, Robert B. (https://experts.colorado.edu/display/fisid_100499)
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- Shapiro, Ben (https://experts.colorado.edu/display/fisid_156418)
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- Szafir, Danielle N. (https://experts.colorado.edu/display/fisid_156317)
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- Tan, Chenhao (https://experts.colorado.edu/display/fisid_158938)
Assistant Professor; PhD, Cornell University
- Trivedi, Ashutosh (https://experts.colorado.edu/display/fisid_156589)
Assistant Professor; PhD, University of Warwick (UK)
- Tufo, Henry (https://experts.colorado.edu/display/fisid_127040)
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
- Vu, Tam Ngoc (https://experts.colorado.edu/display/fisid_159772)
Assistant Professor; PhD, Rutgers University
- 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.
Senior Instructor Emeritus
- Wong, Tony (https://experts.colorado.edu/display/fisid_159678)
Instructor; PhD, University of Colorado Boulder
- Wustrow, Eric A. (https://experts.colorado.edu/display/fisid_156419)
Assistant Professor; BE, University of Michigan Ann Arbor
- Yeh, Tom (https://experts.colorado.edu/display/fisid_151584)
Assistant Professor; PhD, Massachusetts Institute of Technology
- Zagrodzki, Maciej
Instructor; MSc, Colorado School of Mines

Courses

CSCI 1000 (1) Computer Science as a Field of Work and Study

Introduces curriculum, learning techniques, time management and career opportunities in Computer Science. Includes presentations from alumni and others with relevant educational and professional experience. Does not count as Computer Science credit for the Computer Science BA.

Requisites: Restricted to students with 0-26 credits (Freshmen) Computer Science (CSEN-BS, CSEN-ADL, CSCI-BA or CSCI-ADL) majors only.

Additional Information: Departmental Category: General Computer Science

CSCI 1200 (3) Introduction to Computational Thinking

Teaches computational thinking and techniques for writing computer programs using the Python programming language. Intended for students who realize that computational skills are beneficial to all fields of study, but who have little or no experience in programming or are not Computer Science majors. Students will be expected to create computer programs to solve problems in a range of disciplines. Does not count as Computer Science credit for the Computer Science BA, BS, or minor.

Equivalent - Duplicate Degree Credit Not Granted: INFO 1201

Additional Information: Departmental Category: General Computer Science

CSCI 1220 (4) Virtual Worlds: An Introduction to Computer Science

Introduces the fundamental principles of computer science using an online virtual world called Second Life as the "Laboratory" for this course. Students will learn how to program by creating objects of interest in Second Life. In-class and in-world discussions and readings will introduce the students to important ideas and concepts that shape the field of computer science. Does not count as Computer Science credit for the Computer Science BA, BS or minor.

Additional Information: Departmental Category: General Computer Science

CSCI 1240 (3) The Computational World

Introduces and explores the "computational style of thinking" and its influence in science, mathematics, engineering and the arts. Does not focus on the nuts and bolts of any particular programming language, but rather the way in which computing has affected human culture and thought in the past half century. Does not count as Computer Science credit for the Computer Science BA, BS, or minor.

Additional Information: Departmental Category: General Computer Science

CSCI 1300 (4) Computer Science 1: Starting Computing

Teaches techniques for writing computer programs in higher level programming languages to solve problems of interest in a range of application domains. Appropriate for students with little to no experience in computing or programming.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 1310 or CSCI 1320 or ECEN 1310 CSPB 1300

Requisites: Requires a prerequisite or corequisite course of APPM 1235 or APPM 1340 or APPM 1345 or APPM 1350 or MATH 1150 or MATH 1300 or MATH 1310 (all minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 1320 (4) Computer Science 1: Starting Computing-Engineering Applications

Uses problems and tools from Engineering. Teaches techniques for writing computer programs in higher level programming languages to solve problems of interest in Engineering and other domains. Appropriate for students with little or no prior experience in programming.

Requisites: Requires a prerequisite or corequisite course of APPM 1235 or APPM 1340 or APPM 1345 or APPM 1350 or MATH 1150 or MATH 1300 or MATH 1310 (all minimum grade C-). Restricted to College of Engineering or Pre-Engineering Arts and Science (PREE) majors only.

Additional Information: Departmental Category: General Computer Science

CSCI 2270 (4) Computer Science 2: Data Structures

Studies data abstractions (e.g., stacks, queues, lists, trees, graphs) and their representation techniques (e.g., linking, arrays). Introduces concepts used in algorithm design and analysis including criteria for selecting data structures to fit their applications.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 2275 CSPB 2270

Requisites: Requires prerequisite course of CSCI 1300 or CSCI 1310 or CSCI 1320 or ECEN 1310 and prerequisite or corequisite course of MATH 1300 or MATH 1310 or APPM 1345 or APPM 1350 (all minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 2275 (4) Programming and Data Structures

Combines the content in CSCI 1300 and CSCI 2270 and is intended for students with experience with at least one object oriented programming language. The course includes an expedited instruction to the C++ programming language and then primarily focuses on the content in CSCI 2270. Assumes knowledge of programming constructs- data types, conditionals, loops and classes. Students must pass a programming competency exam administered by the computer science department to take this class.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 2270 or CSPB 2270

Requisites: Requires prerequisite or co-requisite of MATH 1300 or MATH 1310 or APPM 1345 or APPM 1350 (all minimum grade C-).

CSCI 2400 (4) Computer Systems

Covers how programs are represented and executed by modern computers, including low-level machine representations of programs and data, an understanding of how computer components and the memory hierarchy influence performance.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 2400

Requisites: Requires prerequisite of CSCI 2270 or CSCI 2275 (minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 2820 (3) Linear Algebra with Computer Science Applications

Introduces the fundamentals of linear algebra in the context of computer science applications. Includes vector spaces, matrices, linear systems, and eigenvalues. Includes the basics of floating point computation and numerical linear algebra.

Requisites: Requires prerequisite courses of (CSCI 2270 or CSCI 2275) and APPM 1360 or MATH 2300 (all minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 2824 (3) Discrete Structures

Covers foundational materials for computer science that is often assumed in advanced courses. Topics include set theory, Boolean algebra, functions and relations, graphs, propositional and predicate calculus, proofs, mathematical induction, recurrence relations, combinatorics, discrete probability. Focuses on examples based on diverse applications of computer science.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 2824

Requisites: Requires prerequisite courses of (CSCI 1200 or CSCI 1300 or CSCI 1310 or CSCI 1320 or CSCI 2275 or ECEN 1030 or ECEN 1310) and (APPM 1345 or APPM 1350 or MATH 1300 or MATH 1310) (all minimum grade C-).

Additional Information: Departmental Category: Theory of Computation

CSCI 2830 (1-3) Special Topics in Computer Science

Covers topics of interest in computer science at the sophomore level. Content varies from semester to semester. Does not count as Computer Science credit for Computer Science majors or minors.

Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

Additional Information: Departmental Category: General Computer Science

CSCI 2834 (1) Discrete Structures Workgroup

Provides additional problem-solving practice and guidance for students enrolled in CSCI 2824. Students work in a collaborative environment to further develop their problem-solving skills with the assistance of facilitators.

Repeatable: Repeatable for up to 3.00 total credit hours.

Requisites: Requires corequisite course of CSCI 2824.

Grading Basis: Pass/Fail

CSCI 2900 (1-3) Lower Division, Undergraduate Level Independent Study

Offers selected topics at the elementary level for students with little or no previous computing experience. Does not count as Computer Science credit for Computer Science majors or minors.

Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

Additional Information: Departmental Category: General Computer Science

CSCI 3002 (4) Fundamentals of Human Computer Interaction

Introduces the practice and research of human-computer interaction, including its history, theories, the techniques of user-centered design, and the development of interactive technologies. Covers computing in society at large with respect to domains such as health, education, assistive technology, ethics, environment, and more.

Requisites: Requires prerequisite course of CSCI 2270 or CSCI 2275 (both minimum grade C-). Restricted to students with 27-180 credits (Sophomores, Juniors or Seniors).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 3010 (3) Programming Project Workshop

Explores concepts and techniques for design and construction of larger, reliable, and maintainable software systems. Covers various topics including: specifications, program structure and design, program-correctness approaches, and working with established code bases. Emphasizes coding individually and in pairs and will include multiple weeks-long projects.

Requisites: Requires a prerequisite course of CSCI 2270 or CSCI 2275 (both minimum grade C-).

CSCI 3022 (3) Introduction to Data Science with Probability and Statistics

Introduces students to the tools methods and theory behind extracting insights from data. Covers algorithms of cleaning and munging data, probability theory and common distributions, statistical simulation, drawing inferences from data, and basic statistical modeling.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 3022

Requisites: Requires prerequisite course of (CSCI 2270 or CSCI 2275) and (APPM 1360 or MATH 2300) and (CSCI 2824 or ECEN 2703 or APPM 3170 or MATH 2001) (all minimum grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 3090 (3) Introduction to Quantum Computing

Covers the basics of quantum computation, including the basics of quantum information; axioms of quantum mechanics; quantum circuits and universality; the relationship between quantum and classical complexity classes; simple quantum algorithms such as the quantum Fourier transform; Shor factoring algorithm; Grover search algorithm; physical implementation of quantum computation; error correction and fault tolerance.

Equivalent - Duplicate Degree Credit Not Granted: PHYS 3090

Requisites: Requires prerequisite course of APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135 (minimum grade C-).

CSCI 3100 (1) Software and Society

Provides students with an understanding of the professional, ethical, legal and social issues and responsibilities of software developers, as well as providing them with the ability to analyze the local and global impacts of computing on individuals, organizations and society.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 4308 and CSCI 4328 and CSCI 4338 and CSCI 4348

Requisites: Requires prerequisite course of CSCI 3308 (minimum grade C-). Restricted to Computer Science (CSEN-BS, CSEN-ADL, CSEN-BSCS) majors only.

Grading Basis: Letter Grade

Additional Information: Departmental Category: General Computer Science

CSCI 3104 (4) Algorithms

Covers the fundamentals of algorithms and various algorithmic strategies, including time and space complexity, sorting algorithms, recurrence relations, divide and conquer algorithms, greedy algorithms, dynamic programming, linear programming, graph algorithms, problems in P and NP, and approximation algorithms.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 3104

Requisites: Requires prerequisite courses of (CSCI 2270 or CSCI 2275) and (APPM 1360 or MATH 2300) and (one of the following: CSCI 2824 or ECEN 2703 or APPM 3170 or MATH 2001) (all minimum grade C-).

Additional Information: Departmental Category: Theory of Computation

CSCI 3112 (1-3) Human-Centered Computing Professional Development

Supports students in developing professional skills and practices in human-computer interaction, design of interactive systems, computer supported cooperative work, computer supported collaborative learning, educational technology, tools that support creativity, user-developed knowledge collections and gaming.

Equivalent - Duplicate Degree Credit Not Granted: ATLS 3112

Repeatable: Repeatable for up to 3.00 total credit hours.

Additional Information: Departmental Category: Artificial Intelligence

CSCI 3155 (4) Principles of Programming Languages

Studies fundamental concepts on which programming of languages are based, and execution models supporting them. Explores values, variables, bindings, type systems, control structures, exceptions, concurrency, and modularity. Learn how to select a language and to adapt to a new language.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 3155

Requisites: Requires prerequisite courses of (CSCI 2270 or CSCI 2275) and (CSCI 2824 or ECEN 2703 or APPM 3170 or MATH 2001) (all minimum grade C-).

Additional Information: Departmental Category: Programming Languages

CSCI 3202 (3) Introduction to Artificial Intelligence

Surveys artificial intelligence techniques of search, knowledge representation and reasoning, probabilistic inference, machine learning, and natural language.

Requisites: Requires prereqs of (CSCI 2270 or CSCI 2275) and (APPM 3170 or CSCI 2824 or ECEN 2703 or MATH 2001) and APPM 3570 or STAT 4520 or APPM 4570 or CHEN 3010 or CSCI 3022 or CVEN 3227 or ECEN 3810 or ECON 3818 or MATH 3510 or MATH 4510 (all min grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 3287 (3) Design and Analysis of Data Systems

Introduces the fundamental concepts of database requirements analysis, database design, and database implementation with emphasis on the relational model and the SQL programming language.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 3287

Requisites: Requires prerequisite course of CSCI 2270 or CSCI 2275 (minimum grade C-).

Additional Information: Departmental Category: Database Systems

CSCI 3302 (3) Introduction to Robotics

Introduces students to fundamental concepts in autonomous robotics: mechanisms, locomotion, kinematics, control, perception and planning. Consists of lectures and lab sessions that are geared toward developing a complete navigation stack on a miniature mobile robotic platform.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 3303

Requisites: Requires prerequisite courses of (CSCI 2270 or CSCI 2275) and (APPM 3170 or CSCI 2824 or ECEN 2703 or MATH 2001) and (APPM 2360 or APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135) (all minimum grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 3308 (3) Software Development Methods and Tools

Covers tools and practices for software development with a strong focus on best practices used in industry and professional development, such as agile methodologies, pair-programming and test-driven design. Students develop web services and applications while learning these methods and tools.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 3308

Requisites: Requires prerequisite course of CSCI 2270 or CSCI 2275 (both minimum grade C-).

Additional Information: Departmental Category: Software Engineering

CSCI 3352 (3) Biological Networks

This course examines the computational representation and analysis of biological phenomena through the structure and dynamics of networks, from molecules to species. Attention focuses on algorithms for clustering network structures, predicting missing information, modeling flows, regulation, and spreading-process dynamics, examining the evolution of network structure, and developing intuition for how network structure and dynamics relate to biological phenomena.

Requisites: Requires the following (ASTR 2600/CSCI 2270/2275/ INFO 2201/PHYS 2600) and (APPM 1345/1350/MATH 1300/1310) and (APPM 3570/4570/CHEN 3010/CSCI 3022/CVEN 3227/EBIO 4410/ ECEN 3810/ECON 3818/IPHY 2800/MATH 3510/4510/4520/ STAT 2600/3100/4000/4520)(all min C-)

CSCI 3403 (4) Introduction to CyberSecurity for a Converged World

Introduces core concepts in cybersecurity including confidentiality, integrity, authentication, risk management, and adversarial thinking. The concepts will be applied to both traditional information technology (IT) systems and cyber physical systems (CPS). At the conclusion of the course students should have a solid foundation in cybersecurity and hands-on experience.

Requisites: Requires prerequisite course of CSCI 2400 or ECEN 3350 (minimum grade C-).

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 3434 (3) Theory of Computation

Introduces the foundations of formal language theory, computability, and complexity. Shows relationship between automata and various classes of languages. Addresses the issue of which problems can be solved by computational means, and studies complexity of solutions.

Requisites: Requires prerequisite course of CSCI 3104 (minimum grade C-).

Additional Information: Departmental Category: Theory of Computation

CSCI 3656 (3) Numerical Computation

Covers development, computer implementation, and analysis of numerical methods for applied mathematical problems. Explores topics such as floating point arithmetic, numerical solution of linear systems of equations, root finding, numerical interpolation, differentiation, and integration.

Requisites: Requires prerequisite courses of (CSCI 1300 or CSCI 1310 or CSCI 1320 or CSCI 2275 or ECEN 1310) and (APPM 1360 or MATH 2300) and (APPM 2360 or APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135) (all minimum grade C-).

Additional Information: Departmental Category: Numerical Computation

CSCI 3702 (3) Cognitive Science

Introduces cognitive science, drawing from psychology, philosophy, artificial intelligence, neuroscience, and linguistics. Studies the linguistic relativity hypothesis, consciousness, categorization, linguistic rules, the mind-body problem, nature versus nurture, conceptual structure and metaphor, logic/problem solving and judgment. Emphasizes the nature, implications and limitations of the computational model of mind.

Equivalent - Duplicate Degree Credit Not Granted: LING 3005 and PHIL 3310 and PSYC 3005 and SLHS 3003

Recommended: Prerequisites two of the following CSCI 1300 or CSCI 2275 or LING 2000 or PHIL 2440 or PSYC 2145.

Additional Information: Arts Sci Gen Ed: Distribution-Arts Humanities

Arts Sci Gen Ed: Distribution-Natural Sciences

Arts Sci Gen Ed: Distribution-Social Sciences

CSCI 3753 (4) Design and Analysis of Operating Systems

Analyzes the software that extends hardware to provide a computing environment, including the role of linkers, file systems, resource sharing, security and networking. Studies the history of operating system organization and design and their influence on security, functionality and reliability.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 3753

Requisites: Requires prerequisite courses of (CSCI 2270 or CSCI 2275) and (CSCI 2400 or ECEN 3350) (all minimum grade C-).

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 3832 (3) Natural Language Processing

Explores the theoretical and practical issues that arise in getting computers to perform useful and interesting tasks with human languages. Topics include information extraction, dialog systems and machine translation. Focus is on the use of language data and machine learning algorithms to build robust systems.

Requisites: Requires prerequisite courses of (CSCI 2270 or CSCI 2275) and (CSCI 2824 or MATH 2001 or ECEN 2703 or APPM 3170) (all minimum grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 4022 (3) Advanced Data Science

Introduces students to advanced tools, methods, and theory for extracting insights from data. Covers computational tools for storing and working with large data sets and computational techniques for common big data scenarios like graph data, streaming data, recommender systems, and dimensionality reduction. Emphasizes both the efficient implementation of algorithms as well as the mathematical foundations behind techniques.

Requisites: Requires prereqs of (CSCI 2820 or MATH 2130 or MATH 2135 or APPM 3310) and (CSCI 3022 or APPM 3570 or APPM 4520 or APPM 4570 or CHEN 3010 or CVEN 3227 or MATH 3510 or MATH 4510 or ECEN 3810 or ECON 3818 or MCEN 4120) and CSCI 3104 (all min grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 4113 (3) Linux System Administration

Introduces Linux system administration and related topics, including troubleshooting system and network problems, hardware and software configuration and installation, basic scripting and security aspects of internet hosts. Students build Linux servers from the ground up, using provided computing resources, and must maintain and secure the servers themselves.

Requisites: Requires prerequisite courses of CSCI 3308 and (CSCI 2400 or ECEN 3350) and CSCI 3753 (minimum grade C-).

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 4114 (3) Practical Algorithmic Complexity

When coming across an algorithmic problem, how do we think about how hard it is? Beyond just how much time or memory it takes, computational complexity offers a plethora of concepts for understanding this fundamental question. This leads to the appropriate choice of algorithm for the job, the development of new algorithms, and understanding the role of algorithmic complexity in natural settings such as biology and physics.

Requisites: Requires a prerequisite course of CSCI 3104 (minimum grade C-).

CSCI 4122 (3) Information Visualization

Studies interactive visualization techniques that help people analyze data. This course introduces design, development, and validation approaches for interactive visualizations with applications in various domains, including the analysis of text collections, software visualization, network analytics, and the biomedical sciences. It covers underlying principles, provides an overview of existing techniques, and teaches the background necessary to design innovative visualizations.

Equivalent - Duplicate Degree Credit Not Granted: CSPB 4122

Requisites: Requires prerequisite or corequisite of CSCI 1300 and CSCI 2824 (both minimum grade C-).

CSCI 4229 (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 5229

Requisites: Requires prerequisite course of CSCI 2270 or CSCI 2275 (minimum grade C-).

Additional Information: Departmental Category: Graphics

CSCI 4239 (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 5239

Requisites: Requires prerequisite course of CSCI 4229 (minimum grade C-).

Additional Information: Departmental Category: Graphics

CSCI 4250 (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 as CS credit for the Computer Science BA, BS or minor.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5250

Requisites: Restricted to students with 57-180 credits (Juniors or Seniors).

Additional Information: Departmental Category: General Computer Science

CSCI 4253 (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 5253

Requisites: Requires prerequisite course of CSCI 3753 (minimum grade C-).

Recommended: Prerequisite CSCI 4273.

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 4273 (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 or Linux is required.

Requisites: Requires prerequisite course of CSCI 3753 (minimum grade C-).

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 4302 (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 5302

Requisites: Requires prerequisite course of CSCI 3302 (minimum grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 4308 (4) Software Engineering Project 1

Advanced practicum in which students design, implement, document and test software systems for use in industry, non-profits, government and research institutions. Also offers extensive experience in oral and written communication throughout the development process. Department enforced prerequisite: successful completion of a minimum of 36 credit hours of Computer Science coursework and approved WRTG. CSCI-BA students interested in taking this course should contact their advisor(s) early in their major.

Requisites: Requires prerequisite courses of CSCI 3155 and CSCI 3308 (all minimum grade C-). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Computer Science (CSEN) majors or Computer Science Concurrent Degree majors only.

Additional Information: Departmental Category: Software Engineering

CSCI 4314 (3) Dynamic Models in Biology

Surveys computational and mathematical modeling to illuminate biological processes. Students work together to learn to build and analyze models using a variety of numerical tools, tackle meaningful biological problems, and communicate effectively across disciplines. Specific topics: Langevin dynamics of protein folding, agent-based models, finite difference models of organismal growth, stochastic and deterministic cellular automata game of life, models of behavior.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5314

Requisites: Requires a prerequisite course of CSCI 3104 (minimum grade C-).

Recommended: Prerequisite comfort with mathematics and/or programming experience, and more advanced understanding (upper undergraduate level) of any relevant discipline.

Additional Information: Departmental Category: Theory of Computation

CSCI 4318 (4) Software Engineering Project 2

Second semester of an advanced practicum in computer science. Students must take this course and CSCI 4308 contiguously as the project spans the entire academic year.

Requisites: Requires prerequisite course of CSCI 4308 (minimum grade C-).

Additional Information: Departmental Category: Software Engineering

CSCI 4328 (4) Software Project Management and Mentoring

Review software project management and discuss the latest approaches, methodologies and standards of software development. Learn to develop software quality, documentation, testing and prototype goals. Study project risk management and cost estimation approaches. Experience mentoring Senior Software Project Team. Intended for professional software developers. Department consent required, see Senior Project Director for permission.

Requisites: Requires prerequisite courses of CSCI 3155 and CSCI 3308 (all minimum grade C-). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Computer Science (CSEN) majors or Computer Science Concurrent Degree majors only.

Grading Basis: Letter Grade

Additional Information: Departmental Category: Software Engineering

CSCI 4338 (2) Software Project Management

Review software project management and discuss the latest approaches, methodologies and standards of software development. Learn to develop software quality, documentation, testing, and prototype goals. Study project risk management and cost estimation approaches. Intended for double majors doing interdisciplinary projects in other departments. Department consent required, see Senior Project Director for permission.

Requisites: Requires prerequisite courses of CSCI 3155 and CSCI 3308 (all minimum grade C-). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Computer Science (CSEN) majors or Computer Science Concurrent Degree majors only.

Grading Basis: Letter Grade

Additional Information: Departmental Category: Software Engineering

CSCI 4348 (4) Startup Essentials: Entrepreneurial Projects in Computing

Provide 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. Department enforced restriction, successful completion of a minimum of 36 credit hours of Computer Science coursework and approved WRTG. Formerly CSCI 4000.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5340

Requisites: Requires prerequisite courses of CSCI 3155 and CSCI 3308 (all minimum grade C-). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) Computer Science (CSEN) majors or Computer Science Concurrent Degree majors only.

Additional Information: Departmental Category: General Computer Science

CSCI 4358 (4) Entrepreneurial Projects II

Follows CSCI 4348. 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.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5350

Requisites: Requires a prerequisite course of CSCI 4348 (minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 4413 (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 5413

Requisites: Requires prerequisite course of CSCI 4273 (minimum grade C-).

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 4446 (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 5446 and ECEN 4423 and ECEN 5423

Requisites: Requires prerequisite course of (CSCI 1300 or CSCI 1310 or CSCI 1320 or CSCI 2275 or ECEN 1310) and (APPM 2350 or MATH 2400) (all minimum grade C-).

Recommended: Prerequisites PHYS 1120 and CSCI 3656 and (MATH 2130 or MATH 2135).

Additional Information: Departmental Category: Numerical Computation

CSCI 4448 (3) Object-Oriented Analysis and Design

An applied analysis and design class that addresses 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 5448

Requisites: Requires prerequisite courses of CSCI 3155 and CSCI 3308 (all minimum grade C-).

Additional Information: Departmental Category: Software Engineering

CSCI 4502 (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 5502 and CSPB 4502

Requisites: Requires prerequisite course of CSCI 2270 or CSCI 2275 (minimum grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 4555 (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 build a complete compiler for a simple language.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 5523 and ECEN 4553 and CSCI 5525

Requisites: Requires prerequisite courses of CSCI 3155 and CSCI 2400 or ECEN 3350 (all minimum grade C-).

Additional Information: Departmental Category: Programming Languages

CSCI 4576 (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.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5576

Recommended: Prerequisite CSCI 3656.

Additional Information: Departmental Category: Numerical Computation

CSCI 4593 (3) Computer Organization

Studies computer design at the gate level. Discusses instruction set architecture design, arithmetic and logic unit design, control logic, memory design and caches, simple pipelining, I/O and peripheral devices. Briefly covers aspects of modern computer architecture, such as multicore processors and cache coherence for these.

Equivalent - Duplicate Degree Credit Not Granted: ECEN 4593

Requisites: Requires prerequisite course of ECEN 3350 or CSCI 2400 (minimum grade C-).

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 4622 (3) Machine Learning

Introduces students to tools, methods, and theory to construct predictive and inferential models that learn from data. Focuses on supervised machine learning technique including practical and theoretical understanding of the most widely used algorithms (decision trees, support vector machines, ensemble methods, and neural networks). Emphasizes both efficient implementation of algorithms and understanding of mathematical foundations.

Requisites: Requires prerequisites of (APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135) (APPM 3570 or STAT 4520 or APPM 4570 or CHEN 3010 or CSCI 3022 or CVEN 3227 or ECEN 3810 or ECON 3818 or MATH 3510 or MATH 4510 or MCEN 4120) and CSCI 3104 (all min grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 4753 (3) Computer Performance Modeling

Presents a broad range of system measurement and modeling techniques, emphasizing applications to computer systems. Covers topics including system measurement, workload characterization and analysis of data; design of experiments; queuing theory and queuing network models; and simulation.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5753 and ECEN 4753 and ECEN 5753

Requisites: Requires prerequisites of (APPM 1360 or MATH 2300) and CSCI 3753 (all minimum grade C-).

Recommended: Prerequisite a course in statistics.

Additional Information: Departmental Category: Operating Systems and Hardware

CSCI 4802 (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.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5802

Repeatable: Repeatable for up to 3.00 total credit hours.

Requisites: Requires a prerequisite course of APPM 3310 or APPM 3570 or APPM 4520 or APPM 4570 or MATH 2130 or MATH 3510 or MATH 4510 or CSCI 2820 or CSCI 3022 or CVEN 3227 or ECEN 3810 or MCEN 4120 (minimum grade C-).

Additional Information: Departmental Category: Artificial Intelligence

CSCI 4809 (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: ATLS 5809 and ATLS 4809 and CSCI 5809

Additional Information: Departmental Category: Graphics

CSCI 4830 (1-4) Special Topics in Computer Science

Covers topics of interest in computer science at the senior undergraduate level. Content varies from semester to semester. Only 9 credit hours from CSCI 4830 and/or CSCI 4831 can count toward Computer Science BS or BA.

Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

Requisites: Requires prerequisite course of CSCI 2400 or ECEN 3350 (minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 4831 (1-3) Special Topics in Algorithms

Covers topics of interest in computer science at the upper-division undergraduate level. Content varies from semester to semester.

Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

Requisites: Requires prerequisite courses of CSCI 3104 and (APPM 3310 or CSCI 2820 or MATH 2130 or MATH 2135) (all minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 4849 (3) Input, Interaction, and Accessibility

Explores input and interaction techniques with an emphasis on universal design and alternative interfaces. Students explore traditional input methods such as keyboard and mouse input, and alternative techniques such as voice and eye gaze. Students conduct performance evaluations of existing techniques, and prototype new interaction methods. Students design technologies to support people with varying abilities and disabilities.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5849

Requisites: Requires prerequisite of CSCI 3002 (minimum grade C-).

CSCI 4889 (3) Interactive Machine Learning for Customizable and Expressive Interfaces

Introduces students to techniques for applying machine learning in the development of customizable human-computer interfaces. Students learn to process a wide variety of input data (e.g. video and accelerometer streams) using different machine learning algorithms to detect semantically meaningful events that can afford the construction of new interactive systems. Students complete substantial projections within the domains of assistive or creative technologies. Does not fulfill Breadth Requirement for CSEN graduate students.

Equivalent - Duplicate Degree Credit Not Granted: CSCI 5880, ATLS 4889 and ATLS 5880

Requisites: Requires prerequisites of (APPM 3570 or APPM 4570 or CHEN 3010 or CSCI 3022 or CVEN 3227 or ECEN 3810 or ECON 3818 or MATH 3510 or MATH 4510 or MCEN 4120 or STAT 4520) and (CSCI 3002 or CSCI 3202 or CSCI 4448) (all minimum grade C-).

Grading Basis: Letter Grade

Additional Information: Departmental Category: Artificial Intelligence

CSCI 4900 (1-3) Upper Division, Undergraduate Level Independent Study

Provides opportunities for independent study at the upper-division undergraduate level. Students work on a small research problem or tutor lower-division computer science students. Department consent required.

Repeatable: Repeatable for up to 8.00 total credit hours. Allows multiple enrollment in term.

Requisites: Requires prerequisite course of CSCI 1300 or CSCI 1310 or CSCI 1320 or CSCI 2275 (all minimum grade C-).

Additional Information: Departmental Category: General Computer Science

CSCI 4950 (2-4) Senior Thesis

Provides an opportunity for senior computer science majors to conduct exploratory research in computer science. Department enforced restriction, successful completion of a minimum of 36 credit hours of Computer Science coursework and approved WRTG.

Repeatable: Repeatable for up to 8.00 total credit hours.

Requisites: Requires a prerequisite or corequisite course of CSCI 3100 (minimum grade C-). Restricted to students with 87-180 credits (Senior, Fifth Year Senior).

Additional Information: Departmental Category: General Computer Science

CSCI 4960 (2-4) Computer Science Honors Thesis

Provides an opportunity for senior Computer Science majors to complete an honors thesis by conducting exploratory research in computer science. Department enforced prerequisites: successful completion of a minimum of 36 credit hours of Computer Science foundation and Computer Science electives and a writing requirement.

Repeatable: Repeatable for up to 8.00 total credit hours.

Requisites: Restricted to students with 87-180 credits (Senior, Fifth Year Senior).

Grading Basis: Letter Grade

Additional Information: Departmental Category: General Computer Science