COMPUTER SCIENCE AND ENGINEERING

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Overview

Mission Statement

With the advances in technology and the rapid and prevalent growth of the information-based economy, computer science has become an enabling science for nearly all disciplines that impact engineering, science, business, health and government. The future of the discipline promises even more innovative advances. The Department of Computer Science and Engineering at the University of Colorado Denver is committed to providing outstanding education and research training to our diverse undergraduate and graduate students for productive careers in industry, academia and government in the Denver metropolitan area, state and beyond. Our faculty strives for excellence in teaching, research and service by covering a broad spectrum of the discipline's core fundamentals, as well as applied aspects including those of interdisciplinary nature. We actively engage our students in classroom and out-of-classroom research and help them develop the skills needed to solve complex real-world technological problems of modern society.

The Department of Computer Science and Engineering offers MS and PhD degrees:

- The MS degree (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/computer-science-ms/) is awarded in computer science (CS) to those students who wish to pursue graduate studies to further develop their education. The MS in CS graduate program covers the core knowledge of key concepts of computer science as well as offers flexibility to pursue specializing in various fields of interests.
- A **track in Data Science in Biomedicine** is offered as a MS thesis option. Students who choose this track will adopt biomedical applications of data science to learn data science methodologies and technologies.
- The graduate certificate in software engineering (https://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/software-engineering-graduate-certificate/) is designed for working professionals, or computer science students beginning their careers, who are in the field of software engineering and/or software development.
- The graduate certificate in cybersecurity & defense (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/cyber-security-defense-graduate-certificate/) is designed for working professionals in the field of computer science, network and/or security operations. The certificate program in Cyber Security and Defense will prepare Computer Science professionals to identify, analyze, and mitigate technical cybersecurity related vulnerabilities, exploits and attacks against network and critical cyber infrastructure.
- The **Computer Science and Information Systems PhD (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/computer-science-information-systems-phd/)** is awarded from the College of Engineering, Design and Computing.
- The multidisciplinary Engineering and Applied Science PhD (https://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/engineering-applied-science-phd/) degree is available through the Department of Computer Science and Engineering.

Most up-to-date information on all programs offered through the Computer Science and Engineering Department can be obtained from the department's website at: engineering.ucdenver.edu/cse (http://engineering.ucdenver.edu/cse/).

Graduate Programs

The Department of Computer Science and Engineering (CSE) offers a master of science in computer science (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/computer-science-ms/). The CSE department also offers a doctoral degree in computer science and information systems (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/computer-science-information-systems-phd/). In addition, the engineering and applied science doctor of philosophy degree (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/engineering-applied-science-phd/) is available through the CSE department.

Expertise expand several areas of research including algorithms, artificial intelligence, big data management & mining, cloud computing, computer architectures, computer graphics, computer networks, computer security, cyber-physical systems, cyber security & defense, data science, database systems, distributed computing, graph theory, high-performance computing, Internet, machine learning, mobile computing, operating systems, parallel and distributed systems, software engineering and virtual reality.

Computer Science and Information Systems (CSIS) PhD

The Computer Science and Information Systems PhD is awarded from the College of Engineering, Design and Computing. The CSIS PhD supports interdisciplinary research between computer science and many fields of interest.

Our students work with research centers and researchers from a variety of disciplines, including the CU School of Medicine, chemistry, mathematics, biology, all engineering disciplines, economics, health, and education, in addition to industry and businesses. This distinctive infrastructure supports basic research in both computer science and information systems as well as the demand of computing and IT integration with all other scientific and business fields.

Advisor

Upon entering the program, each student must find an advisor to provide mentoring and guidance throughout the program and work with the

student to prepare a program of study. Requests to change advisors must be approved by the program director, and this happens in very rare circumstances.

Program Requirements and Milestones

For details about program requirements in the computer science track, see the CSIS PhD Handbook (https://engineering.ucdenver.edu/docs/librariesprovider29/college-of-engineering-and-applied-science/computer-science/academic-and-program-materials/phd-handbook-2022-2023-final.pdf?sfvrsn=816aa0ba_2).

Engineering, Design and Computing PhD

The multidisciplinary Engineering and Applied Science Doctor of Philosophy degree program is offered by the College of Engineering, Design and Computing and consists of a primary and secondary concentration. Applicants apply and enter the program through one of four departments, called the host department, which is chosen based on the applicant's intended primary concentration of study. The four departments that serve as host departments are:

- Civil Engineering
- Computer Science and Engineering
- Electrical Engineering
- Mechanical Engineering

Each host department offers several concentrations. A list of concentrations can be found on each department's website. Go to engineering.ucdenver.edu (http://engineering.ucdenver.edu) to learn more.

The required secondary concentration can be chosen from any remaining department within the college, including the Department of Bioengineering. The secondary concentration may also be chosen from another CU Denver school or college. A student chooses his/her secondary concentration with the help of a faculty advisor after entering the program.

Degree Requirements

The minimum degree requirements consist of 30 semester hours of course work in the primary and secondary areas of concentration, as well as 30 semester hours of research/dissertation credit. Each candidate for the degree is expected to take a preliminary examination by the end of the second year. After successful completion of this exam, the student is required to take the comprehensive examination and the doctoral dissertation defense examination. Additional requirements are outlined in the Rules and Regulations document that each student signs after being admitted to the program. Each student must also satisfy the degree requirements of the CU Denver Graduate Education.

Program Requirements and Milestones

For details about program requirements in the computer science track, see the CSE PhD Handbook (https://engineering.ucdenver.edu/docs/librariesprovider29/college-of-engineering-and-applied-science/computer-science/academic-and-program-materials/phd-handbook-2022-2023-final.pdf?sfvrsn=816aa0ba_2).

Admissions to Computer Science and Engineering Graduate Programs

Requests for applications for graduate study in computer science and engineering should be addressed to:

Office of Admissions
Campus Box 167
P.O. Box 173364
Denver, CO 80204

Courier Address (UPS, FEDEX, etc.):
Office of Admissions
1201 Larimer Street, Suite 1005
Denver, CO 80204

Contact Email: graduateadmissions@ucdenver.edu
Phone: 303-315-5969

All applicants for admission must submit complete credentials as outlined in the instructions that accompany the application materials.

Master of Science (MS) in Computer Science

Admission Requirements

Applicants should hold a bachelor's degree from an institution comparable to the University of Colorado. They need to have sufficient programming experience and mathematical maturity to understand advanced courses. Qualified applicants holding a degree outside computer science or equivalent fields may need to take additional foundational undergraduate courses before starting the graduate program.

Admission decisions are based on prior academic performance, letters of recommendation, English proficiency, if applicable, as well as the applicant's written statement of purpose.

Additional requirements include:

1. 10 credit hours, on the semester basis, of university-level calculus
2. at least one math course beyond calculus, such as advanced calculus, differential equations, linear algebra, probability, statistics or combinatorial analysis.

Students lacking some of these requirements, whose background is otherwise satisfactory, may be admitted with the understanding that the certain undergraduate courses have to be completed after admission. Additional information regarding the admissions process may be found at engineering.ucdenver.edu/cse (http://engineering.ucdenver.edu/cse/).

Required GPA

Regular admission: Applicants should have an undergraduate GPA of at least 3.0.

Transfer Credit

A maximum of 9 semester hours of graduate course work may be transferred into the program based on department approval. In principle, core courses must be taken from the CSE department at CU Denver.

Note: Candidates applying for MS study will be individually evaluated by the department's graduate committee. A letter with a decision will be sent to the applicant by the graduate committee chair.

Computer Science and Information Systems (CSIS) PhD

Admission

Admission criteria include GPA (undergraduate and graduate), letters of recommendation, prior achievements in academia and industry and an application portfolio essay describing an applicant's motivation and an initial plan for doctoral study. The application portfolio is important to gauge an applicant's motivation for research training.

Exceptionally motivated students with BS degrees in computer science, information systems, or closely related fields may apply to the CSIS PhD program directly. Students without a master's degree must complete at least 30 hours of CSIS PhD required course work in addition to the 30 hours of dissertation.

Engineering and Applied Science PhD

Graduate Education Policies and Procedures apply to this program.

Requirements for Admission

Requirements for admission to the Engineering and Applied Science PhD program can be found under the Degree Programs link on each host department's website.

- Civil Engineering (engineering.ucdenver.edu/civil (http://engineering.ucdenver.edu/civil/))
- Computer Science and Engineering (engineering.ucdenver.edu/cse (http://engineering.ucdenver.edu/cse/))
- Electrical Engineering (engineering.ucdenver.edu/electrical (http://engineering.ucdenver.edu/electrical/))
- Mechanical Engineering (engineering.ucdenver.edu/mechanical (http://engineering.ucdenver.edu/mechanical/))

Programs

- Computer Science and Information Systems, PhD (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/computer-science-information-systems-phd/)
- Computer Science, MS (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/computer-science-ms/)
- Cybersecurity and Defense Graduate Certificate (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/cyber-security-defense-graduate-certificate/)
- Engineering and Applied Science, PhD (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/engineering-applied-science-phd/)
- Software Engineering Graduate Certificate (http://catalog.ucdenver.edu/cu-denver/graduate/schools-colleges-departments/college-engineering-design-computing/computer-science-engineering/software-engineering-graduate-certificate/)

Faculty

Professors

Gita Alaghband, PhD, University of Colorado
Research areas: parallel and distributed systems, parallel algorithms, applications and languages, high-performance computing

Tom Altman, PhD, University of Pittsburgh
Research areas: algorithms, optimization, theory

Min-Hyung Choi, PhD, University of Iowa
Research areas: computer graphics, animation, virtual reality, human computer interface

Dave Ogle, PhD, Ohio State University, Clinical Teaching Track
Research areas: networks

Douglas Sicker, PhD, University of Pittsburgh
Research areas: cybersecurity and wireless systems

Associate Professors

Farnoush Banaei-Kashani, PhD, University of Southern California
Research areas: big data, data science, data management and mining, database systems, applied machine learning, computational biomedicine and biology

Ellen Gethner, PhD, University of British Columbia; PhD, Ohio State University
Research areas: graph theory, number theory, combinatorics, discrete geometry, computational geometry, visualization, algorithms

Ilkyeun Ra, PhD, Syracuse University
Research areas: computer networks, cloud computing, high-performance computing, distributed computing systems

Assistant Professors

Mazen Al Borno, PhD, University of Toronto
Research areas: computational motor control and mobile health

Ashis Biswas, PhD, University of Texas at Arlington
Research areas: machine learning, data mining, big data analysis, bioinformatics

Madhuri Debnath, PhD, University of Texas at Arlington, Clinical Teaching Track
Research areas: data mining, spatio-temporal data analysis, data science, machine learning

Liang He, PhD, Nankai University
Research areas: cyber-physical systems, cognitive battery management, IoTs, mobile computing

Haadi Jafarian, PhD, University of North Carolina Charlotte
Research areas: proactive security for cyber threats, big data analytics for cyber threat intelligence, security for cyber-physical systems & critical infrastructures, security for IoTs, security analytics & automation, science of security

Salim Lakhani, PhD, Purdue University, Clinical Teaching Track
Research areas: cloud computing and security, distributed computing & database systems

Zhengxiong Li, PhD, SUNY Buffalo
Research areas: Internet of Things, cybersecurity, emerging technologies and applications

Senior Instructor

Sung-Hee Nam, MS, University of Colorado Denver, Clinical Teaching Track
Research areas: programming languages, distributed computing

Diane Ricciardella, MS, University of Colorado Denver, Clinical Teaching Track
Research areas: artificial intelligence, linguistic geometry, natural language processing

Professor Emeriti

Boris Stilman, PhD, National Research Institute for Electrical Engineering, Moscow, Russia

Computer Science (CSCI)

CSCI 5010 - Software Architecture (3 Credits)
This course will focus on two major areas. The first part of the course will cover Software Requirements Analysis and Development as well as Software Architecture and the Soft Skills needed by high level Software Architects. The second part of the course will cover how Persistent Data fits into different types of Software Systems. The primary focus of the second part of the course will be on incorporating larger scale Enterprise Data Systems into Software Systems and will be an application of the first part of the course material. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5011 - Software Project Management Support (3 Credits)
Large Software Systems must be Planned, Scheduled, and Staffed. To accomplish these tasks Software Engineers must understand the Software Architecture, the Software System Dependencies, Effort Estimation and the various Project Development Models that might be used. This course will look at different Project Models, Project Management Needs, and various Effort Estimation tools and techniques. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5098 - Computer Science for Bioscientists (3 Credits)
Provides a broad but detailed overview of the computer science field to graduate students in the biosciences, with emphasis on web technologies, programming languages, algorithms and database systems. No credit for CS graduate students. Prereq: Working knowledge of programming language (e.g., Java). Max Hours: 3 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 3.

CSCI 5110 - Applied Number Theory (3 Credits)
Every year, Topics include divisibility, prime numbers, congruences, number theoretic functions, quadratic reciprocity, special diophantine equations, cryptography, computer security, and engineering applications. Cross-listed with CSCI 4110. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5172 - Complexity and Problem Solving (3 Credits)
Theoretical and practical aspects of solving complex problems, in particular, but not limited to, NP-complete and PSPACE-complete problems. Various heuristic and approximation algorithms, including greedy, ant, and Genetic Algorithms will be studied. This course is by instructor's permission only. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5173 - Computational Complexity and Algorithms (3 Credits)
A solid, in-depth theoretical foundations in computing, computational complexity, and algorithmics. Various algorithms, including both discrete and non-discrete problem domains. NP-complete and other complete classes of problems/languages. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5203 - Simulation (3 Credits)
This class in simulation spans three different disciplines: Computer Science, Modeling and Simulation, and Analysis. These will have approximately equal weight with respect to this class, but with more breadth in the Modeling and Simulation and Analysis disciplines and more depth in the supporting Computer Science topics. Excursions are planned for agent-based simulations, knowledge-based simulations, and animation and visualization of simulation results. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 4203. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.
Typically Offered: Fall.

CSCI 5211 - Mobile Computing and Programming (3 Credits)
This course contains two main simultaneous tracks, namely mobile computing and mobile programming. A series of lectures on various aspects of mobile computing provides an understanding of challenges and solutions in design and implementing mobile systems. The main topics include mobile sensing, human mobility and its technical implication. Students are expected to have undergraduate knowledge of operating systems and computer networks. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5217 - Information Theory (3 Credits)
Introduces information theory and its application in computer science, communication theory, coding and applied mathematics. Entropy, mutual information, data compression and storage, channel capacity, rate distortion, hypothesis testing. Error detecting and correcting codes, block codes and sequential codes. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5220 - Social Networks & Informatics (3 Credits)
The main topics covered by the course will include 1) social network data structures, 2) basic random graph models and graph algorithms; 3) recommendation systems and predictive models 4) query suggestion and content analysis 5) link analysis and community detection 6) the spread of information, disease, and influence on networks. This course builds a solid foundation in social informatics technology. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 4220. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5255 - Object Oriented Design (3 Credits)
Software system design using object-oriented techniques, responsibility driven design and agile development practices. Topics include objects, classes, interfaces, inheritance, polymorphism, exception handling and testing. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5407 - Security & Cryptography (3 Credits)
A broad overview of cryptography and its relation to computer security. Topics include basic standard cryptographic techniques, a history of codes and ciphers, RSA, DES, AES, Elliptic Curve Cryptography, ElGammal, and applications to current and future technologies. Restriction: Restricted to Graduate Standing. Cross-listed with CSCI 7407 and CSCI 4407. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5408 - Applied Graph Theory (3 Credits)
Introduces discrete structures applications of graph theory to computer science, engineering and operations research. Topics include connectivity, coloring, trees, Euler and Hamiltonian paths and circuits. Matching and covering problems, shortest route and network flows. Restriction: Restricted to students with graduate standing. Note: Expected knowledge of abstract mathematics including discrete structures. Cross-listed with MATH 4408. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5409 - Graph Theory and Graph Algorithms (3 Credits)
Studies geometric graphs and other geometric objects, both analysis and algorithmic construction, leads to interesting connections among VLSI design, graph theory and graph algorithms. Studies a subset of the recent literature, with special emphasis on visibility graphs, thickness of graphs, graph coloring and the surprising and elegant connections among them all. Other topics are introduced as time permits. Prereq: CSCI 5408. Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CSCI 5408. Restricted to student with graduate standing.

CSCI 5411 - Computational Geometry (3 Credits)
Many practical and aesthetic algorithmic problems have their roots in geometry. Applications abound in the areas of computer graphics, robotics, computer-aided design, and geographic information systems, for example. A selection of topics from convex hull, art gallery problems, ray tracing, point location, motion planning, segment intersection, Voronoi diagrams, visibility and algorithmic folding will be covered. Cross-listed with CSCI 4411. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5446 - Theory of Automata (3 Credits)
Studies the relationships between classes of formal languages (regular, context-free, context-sensitive, phrase-structure) and classes of automata (finite-state, pushdown, Turing machines). Additional topics include decidability and computability issues. Restriction: Restricted to students with graduate standing. Note: Expected knowledge of algorithms equivalent to CSCI 3412.Cross-listed with MATH 5446. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5451 - Algorithms (3 Credits)
Advanced design and analysis techniques: dynamic programming, greedy algorithms, amortized analysis. Advanced data structures: Fibonacci heaps, union-find data structures. Study of variety of special topics, which may include: graph algorithms, optimization problems, Fast Fourier Transform, string matching, geometric algorithms, NP-completeness and approximation algorithms. Restriction: Restricted to students with graduate standing. Note: Expected knowledge of algorithms equivalent to CSCI 3412. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5455 - Data Mining (3 Credits)
Introduces concepts, techniques and methodologies to discover patterns in data. Topics include (but are not limited to) data preprocessing and cleansing, data warehousing, pattern mining, classification, prediction, cluster analysis, outlier detection, and online data analytics. Restriction: Graduate Standing. Cross-listed with CSCI 4455. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5542 - Neural Networks (3 Credits)
Parallel distributed representations, dynamics of Hopfield-style networks, content addressable memories, and Hebrian learning are the major topics of the first half. The last half consists of simulated annealing back propagation, competitive learning, and self-organizing networks. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5551 - Parallel and Distributed Systems (3 Credits)
Examines a range of topics involving parallel and distributed systems to improve computational performance. Topics include parallel and distributed programming languages, architectures, networks, algorithms and applications. Prereq: Graduate standing. Cross-listed with CSCI 7551. Max hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 5552 - Advanced Topics in Parallel Processing (3 Credits)
Examines the advances of sequential computers for gaining speed and application of these techniques to high-speed supercomputers of today. Programming methodologies of distributed and shared memory multiprocessors, vector processors and systolic arrays are compared. Performance analysis methods for architectures and programs are described. Cross-listed with CSCI 7552. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5559 - Database Systems (3 Credits)
Introduces database system concepts, with examination of relational database systems from conceptual design through relational schema design and physical implementation. Topics include database design and implementation for large database systems, transaction management, concurrency control, object-oriented and distributed database management systems. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5565 - Introduction to Computer Graphics (3 Credits)
Introduces two and three dimensional computer graphics. Topics include scan conversion, geometric primitives, transformation, viewing, basic rendering, and illumination. Emphasis is on the programming using C and C++ Open GL. Cross-listed with CSCI 4565. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5570 - Virtual and Augmented Reality (3 Credits)
This course covers the fundamental concepts and technologies of virtual and augmented reality, and it introduces recent advances in the field. Topics include 3D user interaction, immersive environments, tele-presence, mobile AR, human perception, and VR/AR applications. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 4570. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5573 - Operating Systems (3 Credits)
Students study the principles of computer operating systems and their essential components. Team projects expose students to a variety of system design issues as they relate to the functionality and performance of the system. Topics include I/O devices, Disk Scheduling, File System Organizations, Directory Systems, Sequential and Concurrent process, CPU Scheduling, Memory Management, Deadlock, Process and Threading, and review of some related articles in the literature. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5574 - Advanced Topics in Operating Systems (3 Credits)
Covers the advanced topics in operating systems by examining functionality and performance issues in CPU Scheduling, communications, distributed file systems, distributed operating systems, shared-memory multiprocessors and real-time operating systems. In addition to studying papers, reviews and presentations, students carry out a semester long team project within the scope of one of the above topics. Cross-listed with CSCI 7574. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5575 - Cyber-Physical Systems (3 Credits)
Cyber-physical systems (CPS) bridge the cyber-world of computing, communication and control with the physical world. This course offers an interdisciplinary perspective of CPS within computer science and its applications to understand the issues in the full lifecycle of CPS. Prereq: Graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5580 - Data Science (3 Credits)
Introduces concepts and techniques that enable data cycle from data extraction to knowledge discovery, including but not limited to data exploration, hypotheses testing, data organization, data featurization, supervised and unsupervised data modeling and learning, scaling-up analytics, and data visualization. Restriction: Graduate Standing. Cross-listed with CSCI 4580. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5582 - Artificial Intelligence (3 Credits)
Approaches to design of systems for solving problems usually solved by humans, especially those related to intelligent decision making. Emphasis on various types of knowledge representation. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 7582. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5585 - Advanced Computer Graphics (3 Credits)
An in-depth study of active research topics in computer graphics. Topics include advanced rendering, global illumination, scientific visualization, geometric modeling, simulation and animation. Emphasis is on readings from literature and on a term project. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5593 - Advanced Computer Architecture (3 Credits)
Important concepts in the structural design of computer systems are covered. Topics include memory hierarchy, super pipelining and super scalar techniques, dynamic execution, vector computers and multiprocessors. Expected knowledge of Computer Architecture equivalent to CSCI 4591. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5595 - Computer Animation (3 Credits)
This course introduces the state of the art techniques for modern computer animation focused on a practical, example driven approach to learning the unique art of 3D animation. Topics include modeling, kinematics, rigging, textures, physically based dynamics, and rendering. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5610 - Computational Biology (3 Credits)
Designed to introduce a broad range of computational problems in molecular biology. Solution techniques draw from several branches of mathematics: combinatorics, probability, optimization, and dynamical systems. No prior knowledge of biology is critical, but it would be at least helpful to have the equivalent of BIOL 5099. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 3.
Restriction: Restricted to students with graduate standing.

CSCI 5619 - Complex Intelligent Systems (3 Credits)
Presents the cutting-edge results of research in AI: advanced topics in linguistic geometry. LG is an approach to construction of mathematical models for reasoning about large-scale multi-agent concurrent games. The purpose of LG is to provide strategies to guide the participants of a game to reach their goals. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5620 - Computational Motor Control (3 Credits)
This course introduces techniques for the modeling, simulation and control of movement. These techniques come from computer graphics, robotics and machine learning. The topics that we will cover include robot modeling, trajectory optimization, feedback control, deep reinforcement learning, the neuroscience of movement, and neural network models of the brain. At the end of the course, students will learn how train control policies for virtual agents in computer animation or robotics applications. Restriction: Restricted to Graduate Standing. Cross-listed with CSCI 4620. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5625 - Computer Vision (3 Credits)
An introduction to computer vision (no prior background in vision required). Topics include camera models, multi-view geometry, image processing, feature detection, motion estimation, shape reconstruction and applications of deep learning. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Graduate level students.
Typically Offered: Fall.

CSCI 5630 - Linguistic Geometry (3 Credits)
Linguistic Geometry (LG) is a type of Game Theory in Artificial Intelligence, which permits to overcome combinatorial explosion and generate optimal strategies in real time. LG is currently changing the paradigm of military command and control in the USA and abroad. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5640 - Universal Compiler: Theory and Construction (3 Credits)
Theoretical foundations and step-by-step hands-on experience in the development of a compiler, which can tune itself to a new programming language. This is a must-take course for future software developers as well as those interested in applications of the theory of Computer Science. Cross-listed with CSCI 4640. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5654 - Algorithms for Communication Networks (3 Credits)
Algorithmic and mathematical underpinnings of communication networks. A taxonomy of data-packet networks depending on modes of communication: fixed-interconnection networks, radio networks and multiple-access channel. Algorithms to implement packet routing and broadcasting. Cross-listed with CSCI 7654. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5660 - Numerical Analysis I (3 Credits)
A first semester course in numerical methods and analysis fundamental to many algorithms encountered in scientific computing, data science, machine learning, and computational models in science and engineering. Rounding errors and numerical stability of algorithms; solution of linear and nonlinear equations; data modeling with interpolation and least-squares; and optimization methods. This course assumes that students have the equivalent of differential and integral calculus (e.g., MATH 2411), linear algebra (e.g., MATH 3191 or 3195), and computer programming (e.g., MATH 1376 or CSCI 1410). Cross-listed with CSCI 4650, MATH 4650, and MATH 5660. Restriction: Restricted to students with graduate standing. Term offered: fall, spring, summer. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.
Typically Offered: Fall, Spring, Summer.

CSCI 5661 - Numerical Analysis II (3 Credits)
A second semester course in numerical methods and analysis fundamental to many algorithms encountered in scientific computing, data science, machine learning, and computational models in science and engineering. Numerical differentiation and integration; random numbers and stochastic modeling; Fast Fourier Transform; data compression; eigenvalues and singular value decompositions with application to regression and dimension reduction. This course assumes that students have the equivalent of differential and integral calculus (e.g., MATH 2411), linear algebra (e.g., MATH 3191 or 3195), and computer programming (e.g., MATH 1376 or CS 1410). Cross-listed with CSCI 4660, MATH 4660 and 5661. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.
Typically Offered: Spring.

CSCI 5667 - Introduction to Approximation Theory (3 Credits)
Normed linear spaces, convexity, existence and uniqueness of best approximations. Tchebychev approximation by polynomials and other related families. Least squares approximation and splines. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5682 - Expert Systems (3 Credits)
Reviews and analyzes many expert systems documented in the literature, such as Mycin, Macsyma, and Xcon. Emphasis is given to the design of rule-based systems, the use of uncertain and incomplete information and system shells. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5690 - Knowledge Representation for Intelligent Systems (3 Credits)
An in-depth study of different types of knowledge representation in artificial intelligence for the efficient control of complex real-world systems like autonomous robots, space vehicles, and military units. Major emphasis is on search algorithms and heuristics, logical representation with applications to planning, formal linguistic representation. At the conclusion, all the theories studied are combined in the form of introduction to the state-of-the-art linguistic geometrical representation of complex control systems. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5701 - High-Performance Communication Systems and Network Analysis (3 Credits)
Protocols and architectures related to high performance communication systems as well as network performance analysis techniques are covered. Topics include Integrated Services Digital Networks (ISDN), Broadband ISDN, protocols such as ATM and SONET, and high performance network architectures such as optical networks. Analytical analysis of network performance includes queuing theory and stochastic processes. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5702 - Big Data Mining (3 Credits)
Introduces techniques to discover patterns in Big Data. Selected topics: scalable high-dimensional data clustering, scalable dimensionality reduction, locality sensitive hashing, PageRank, scalable data stream filtering and querying, and scalable classification, in the context of different applications such as Social Network Analysis, Spam Detection, Association Rule Analysis, and Recommender Systems. Cross-listed with CSCI 4702 and CSCI 7702. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5704 - Introduction to Distributed Systems (3 Credits)
Studies design, implementation and management of distributed systems, including communication issues, security reliability, resource sharing, and remote execution. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5728 - Software Engineering (3 Credits)
Groups of students plan, analyze and design large software projects. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5741 - Principles of Cybersecurity (3 Credits)
Focuses on the most common threats to cybersecurity as well as ways to prevent security breaches or information loss. Topics will include: understanding and thwarting hacker methods, authentication, cryptography, programming security, malware analysis, web, database and file server security, network and enterprise security methods. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5742 - Cybersecurity Programming and Analysis (3 Credits)
Focuses on cybersecurity related programming and analysis skills. Topics include: network and security application development, intrusion detection, automating security hardening. Students will design and develop security applications in multiple programming languages. Undergraduate algorithms and programming knowledge expected. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 4742. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5743 - Cyber and Infrastructure Defense (3 Credits)
Presents analytical study of state-of-the-art attack and defense paradigms in cyber systems and infrastructures. Analysis will focus on: theoretical foundations of cybersecurity, practical development of novel technical defense techniques and analysis of alternatives. Knowledge of undergraduate-level networking. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 4743. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5765 - Computer Networks (3 Credits)
An in-depth study of active research topics in computer networks. Topics include: Internet protocols, TCP/UDP, congestion and flow control, IP routings, mobile IP, P2P overlay networks, network security, performance, and other current research topics. Prereq: Graduate standing. Cross-listed with CSCI 7765. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5771 - Introduction to Mobile Computing (3 Credits)
Provides the fundamentals of mobile computing. Studies existing and proposed solutions for ubiquitous computing. This course focuses on systems and networking issues involved with supporting mobility. Cross-listed with CSCI 4771. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5772 - Mobile and IoT Security (3 Credits)
This course concentrates on the computing of emerging mobile and IoT systems security in the Computer Science domain. The seminar will discuss recent research on computing for mobile user authentication, vulnerability risk detection of mobile/IoT systems, and software based defense mechanism. Restriction: Restricted to graduate school standing. Cross-listed with CSCI 4772. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5773 - Introduction to Emerging System Security (3 Credits)
This course concentrates on the security of the emerging system in the Computer Science domain. It focuses on radically novel systems, relatively fast-growing and potentially exerting a considerable impact on society, such as mobile systems, AI systems, and quantum systems. The security topics cover adversarial attacks, side/covert-channel attacks, covert-channel attacks, user authentication, biometrics, vulnerability risk detection, and defense countermeasure. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 4773. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5780 - Theory of Distributed Computing (3 Credits)
Elements of the theory of distributed computing through fundamental algorithmic ideas, lower bound techniques, and impossibility results. Timing assumptions (asynchrony and synchrony), simulations between models (message passing and shared memory), failure types (crash and Byzantine). Restriction: Restricted to students with graduate standing. Note: Expected knowledge of algorithms equivalent to CSCI 3412. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5799 - Cloud Computing (3 Credits)
This course studies fundamental designs and key technologies in Cloud Computing by reading technical articles, and conducting a semester group project. Topics include cloud computing design and architectures, service models, virtualization, advanced computer networks, programming, often software, and security. Note: Operating System, Computer Networks, and programming experience are recommended for success in this course. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 7799. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5800 - Special Topics (3 Credits)
These special topics courses cover recent developments in an aspect of computer science. Restriction: Restricted to students with graduate standing. Repeatable. Max hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.
Restriction: Restricted to students with graduate standing.

CSCI 5840 - Independent Study (1-3 Credits)
For graduate computer science students. Repeatable. Max Hours: 8 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 8.

CSCI 5866 - Advanced Mobile and Ubiquitous Systems (3 Credits)
This course covers various aspects of mobile and ubiquitous systems to provide an in-depth understanding of principles, state-of-the-art solutions and challenges in design and implementation of such systems. Restriction: Restricted to students with graduate standing. Cross-listed with CSCI 4866. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5920 - Computer Game Design and Programming (3 Credits)
Computer Game Design and Programming introduces practical and example driven approaches to modern 3D game development. Topics include 3D modeling, character animation, UI design, level design, scripting, texture mapping, and sound effect. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5930 - Machine Learning (3 Credits)
Provides theoretical and computational foundations in machine learning to design and develop intelligent applications to perform object recognition, personalized recommendations, improve cybersecurity, fact-checking, forecasting and finding communities based on three classes of algorithms: supervised, unsupervised, semi-supervised and reinforcement learning. Restriction: Graduate Standing. Cross-listed with CSCI 4930. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5931 - Deep Learning (3 Credits)
Provides a foundation on deep learning; a sought-after skill in machine learning. Topics include neural network design & learning, restricted Boltzmann machine, convolution neural network, recurrent neural network, LSTMs, deep reinforcement learning, autoencoders, and evolving computation frameworks like TensorFlow, Keras. Restriction: Graduate Standing. Cross-listed with CSCI 4931. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5939 - Internship (1-3 Credits)
Faculty or employer-supervised employment in industry. Enrollment is limited to students who fully complete a contract for cooperative education credit by the last day of the drop or add period. Students who want to enroll this course should submit an official job description that must clearly show the level of work requires a bachelor's degree in the computer science field or equivalent work experience. This course will not be counted towards either MSCS or PhD in CSIS or EAS. Prereq: Complete at least two of category A courses (for MS) or complete Preliminary exam (for PhD) and 3.0 or better GPA. Restricted to students with a minimum of 1 full academic year of study at the graduate level. Repeatable. Max Hours: 3 Credits.
Grading Basis: Satisfactory/Unsatisfactory
Repeatable. Max Credits: 3.

CSCI 5941 - Directed Study: Programming Project (3 Credits)
Software development project supervised by a faculty member approved by the Center for Computational Biology. Used towards a certificate in Computational Biology. Counts as an independent study. Prereq: CSCI 5451 and CSCI 5610. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 5951 - Big Data Systems (3 Credits)
Presents a practical while in-depth review of the principles of a series of modern data processing systems (e.g., Hadoop, Spark, TensorFlow) designed to address the Big Data challenges. In combination, these systems enable the data to knowledge (Big) data lifecycle. Restriction: Restricted to Graduate standing. Cross-listed with CSCI 5951. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 5952 - Big Data Science (3 Credits)
Introduces methodologies that enable Big Data lifecycle. Selected topics: topic modeling, causality analysis, structure learning, learning with less supervision, and massive-scale data analytics, with applications in social media analysis, computational biology, climate modeling, health care, and traffic monitoring. Restriction: Graduate standing. Cross-listed with CSCI 7952. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 6010 - Principles of Programming (3 Credits)
This course introduces students to fundamental principles and techniques in the design and implementation of modern programming such as C++, Java. Students learn how to write programs in an object oriented high level programming language. Weekly laboratory assignments will provide hands-on experience in this course. (non-CS majors) Prereq: meet MAPS requirements and familiarity with computer use. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 6020 - Data Structures and Algorithms (3 Credits)
This course introduces students to fundamental skills in computer science such as data structures and computer algorithms. Students will learn how to design efficient algorithms and analyze them. (non-CS majors) Max Hours: 3 Credits.
Grading Basis: Letter Grade
D-EN-Pre: CSCI 6010

CSCI 6030 - Computer Systems & Application (3 Credits)
This course surveys essential technologies such operating systems, database systems, and the Internet. Students study the basic of operating systems, database systems, and the Internet. Weekly laboratory experiments will provide hands-on experience. (non-CS majors) Max Hours: 3 Credits.
Grading Basis: Letter Grade
D-EN-Pre: CSCI 6010

CSCI 6040 - Teaching Practice of Computer Science (3 Credits)
This course provides students the opportunity for practicing and developing courses for adolescents using previously acquired knowledge. Students will design and develop a computer science class of their interest and appropriate to their area of expertise which they will offer at their school. (non-CS majors) Max Hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CSCI 6020 and 6030

CSCI 6595 - Computational Methods in Nonlinear Programming (3 Credits)
Introduces fundamental algorithms and theory for nonlinear optimization problems. Topics include Newton, quasi-Newton and conjugate directional methods; line search and trust-region methods; active set, penalty and barrier methods for constrained optimization; convergence analysis and duality theory. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 6664 - Numerical Linear Algebra (3 Credits)
Offered every other year. Solution of linear equations, eigenvector and eigenvalue calculation, matrix error analysis, orthogonal transformation, iterative methods. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 6950 - Master's Thesis (1-9 Credits)
Repeatable. Max hours: 12 Credits.
Grading Basis: Letter Grade with IP
Repeatable. Max Credits: 12.
Additional Information: Report as Full Time.

CSCI 6960 - Master's Report (3 Credits)
Students seeking a Master of Science in computer science, who do not choose to do a thesis, must complete an individual project of an investigative and creative nature under supervision of a full-time CS graduate faculty. Student must present their results to a faculty committee. Max hours: 3 Credits.
Grading Basis: Letter Grade with IP
Additional Information: Report as Full Time.

CSCI 6970 - MS Course Project Report (0 Credits)
This course is for students who select Plan III (Course Only) option to complete their MS degree requirements. Graduating students must register for this course concurrent with a corresponding three credit CSCI course sponsoring course projects and submit a final written research paper on a subject approved by a CSE faculty. Prereq: Completion of at least 3 of the following courses with a B- or higher: CSCI 5446, CSCI 5451, CSCI 5573, and CSCI 5593.
Grading Basis: Satisfactory/Unsatisfactory
Prereq: Completion of at least 3 of the following courses with a B- or higher: CSCI 5446, CSCI 5451, CSCI 5573, and CSCI 5593.
Typically Offered: Fall, Spring.

CSCI 7002 - Computer Security (3 Credits)
A broad overview of computer security, roughly divided into three unequal components: a) the history of codes and ciphers; b) basic cryptographic techniques, for example, symmetric cryptography, authentication techniques, and asymmetric crypto systems, and: c) applications to current and future computer-related technologies, for example, network security, wireless communication, quantum cryptography, and more.
Prereq: CSCI 5451. Max hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7173 - Computational Complexity and Algorithms (3 Credits)
A solid, in-depth theoretical foundations in computing, computational complexity, and algorithmics. Various algorithms, including both discrete and non-discrete problem domains. NP-complete and other complete classes of problems/languages. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Prereq: CSCI 5446

CSCI 7200 - Advances in Management Information Systems (3 Credits)
Provides a broad coverage of research on the management of information technology. The course covers the systems-oriented research, organizational-oriented research, and information systems economics research. Prereq: PhD standing. Max hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7210 - Topics in Analytical Research in Management Information Systems (3 Credits)
Covers a variety of analytical research topics of interest to the IS research community including the evaluation of data mining algorithm performance, cost sensitive learning and outlier detection. Prereq: Admission to the CSIS PhD program. Max hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7211 - Topics in Behavioral-Organizational Research in Management Information Systems (3 Credits)
Provides in-depth exposure to some key behavioral, management and organizational theories and models used in Information Systems research. Covers topics in socio-technical, trust, computer self-efficacy, organizational transformation, organizational learning, resource-based and coordination theories. Prereq: Admission to the CSIS PhD program. Max hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7407 - Security & Cryptography (3 Credits)
A broad overview of cryptography and its relation to computer security. Topics include basic standard cryptographic techniques, a history of codes and ciphers, RSA, DES, AES, Elliptic Curve Cryptography, ElGammal, and applications to current and future technologies. Restriction: Restricted to Graduate Standing. Cross-listed with CSCI 5407. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 7502 - Research Methods (3 Credits)
Promotes research skills. Involves presenting a research topic and discussions of its merits, reviewing journal articles, writing a paper and/or a proposal in the NIH/NSF format in the student's area of research. Prereq: PhD student standing or permission of instructor for MS students who are writing a thesis. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7551 - Parallel and Distributed Systems (3 Credits)
Examines a range of topics involving parallel and distributed systems to improve computational performance. Topics include parallel and distributed programming languages, architectures, networks, algorithms and applications. Prereq: Graduate standing. Cross-listed with CSCI 5551. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7552 - Advanced Topics in Parallel Processing (3 Credits)
Examines the advances of sequential computers for gaining speed and application of these techniques to high-speed supercomputers of today. Programming methodologies of distributed and shared memory multiprocessors, vector processors and systolic arrays are compared. Performance analysis methods for architectures and programs are described. Cross-listed with CSCI 5552. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7574 - Advanced Topics in Operating Systems (3 Credits)
Covers the advanced topics in operating systems by examining functionality and performance issues in CPU Scheduling, communications, distributed file systems, distributed operating systems, shared-memory multiprocessors and real-time operating systems. In addition to studying papers, reviews and presentations, students carry out a semester long team project within the scope of one of the above topics. Cross-listed with CSCI 5574. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 7582 - Artificial Intelligence (3 Credits)
Approaches to design of systems for solving problems usually solved by humans, especially those related to intelligent decision making. Emphasis on various types of knowledge representation. Cross-listed with CSCI 5582. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 7595 - Computer Animation (3 Credits)
This course introduces the state of the art techniques for modern computer animation focused on a practical, example driven approach to learning the unique art of 3D animation. Topics include modeling, kinematics, rigging, textures, physically based dynamics, and rendering. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 7654 - Algorithms for Communication Networks (3 Credits)
Algorithmic and mathematical underpinnings of communication networks. A taxonomy of data-packet networks depending on modes of communication: fixed-interconnection networks, radio networks and multiple-access channel. Algorithms to implement packet routing and broadcasting. Cross-listed with CSCI 5654. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 7702 - Big Data Mining (3 Credits)
Introduces techniques to discover patterns in Big Data. Selected topics: scalable high-dimensional data clustering, scalable dimensionality reduction, locality sensitive hashing, PageRank, scalable data stream filtering and querying, and scalable classification, in the context of different applications such as Social Network Analysis, Spam Detection, Association Rule Analysis, and Recommender Systems. Cross-listed with CSCI 4702 and CSCI 5702. Restriction: Restricted to students with graduate standing. Max hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 7711 - Bioinformatics I (4 Credits)
(BIOL 7711-Offered on a semester basis from H.S.C.) What is Bioinformatics and why study it? How is large-scale molecular biology data generated, where and how can researchers gain access to it, what computational analyses are possible and computational techniques for solving inference problems in molecular biology? Prereq: Permission of instructor. Max Hours: 4 Credits.
Grading Basis: Letter Grade
Typically Offered: Fall.

CSCI 7712 - Bioinformatics II (4 Credits)
(BIOL 7712-offered on a semester basis from H.S.C.) Inference problems and computational techniques for molecular biology, with emphasis on machine learning approaches. Use of computational induction techniques focused on information extraction from biomedical literature, inference of biochemical networks from high-throughput data and prediction of protein function. Estimation, clustering, discrimination and regression. Prereq: CSCI 7711. Max Hours: 4 Credits.
Grading Basis: Letter Grade
Typically Offered: Spring.

CSCI 7765 - Computer Networks (3 Credits)
An in-depth study of active research topics in computer networks. Topics include: Internet protocols, TCP/UDP, congestion and flow control, IP routings, mobile IP, P2P overlay networks, network security, performance, and other current research topics. Prereq: Graduate standing. Cross-listed with CSCI 5765. Max Hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7799 - Cloud Computing (3 Credits)
This course studies fundamental designs and key technologies in Cloud Computing by reading technical articles, and conducting a semester group project. Topics include cloud computing design and architectures, service models, virtualization, advanced computer networks, programming, often software, and security. Note: Operating System, Computer Networks, and programming experience are recommended for success in this course. Prereq: Graduate standing. Cross-listed with CSCI 5799. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 3.

CSCI 7800 - Special Topics (3 Credits)
These special topics courses cover recent developments in an aspect of computer science. Prereq: As determined by instructor. Max hours: 3 Credits.
Grading Basis: Letter Grade

CSCI 7840 - Independent Study (1-6 Credits)
Offers doctoral students opportunity for independent, creative work under supervision of a CSE full-time graduate faculty. Repeatable. Max Hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.

CSCI 7866 - Advanced Mobile and Ubiquitous Systems (3 Credits)
This course covers various aspects of mobile and ubiquitous systems to provide an in-depth understanding of principles, state-of-the-art solutions and challenges in design and implementation of such systems. Restriction: Restricted to students with graduate standing. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 7952 - Big Data Science (3 Credits)
Introduces methodologies that enable Big Data lifecycle. Selected topics: topic modeling, causality analysis, structure learning, learning with less supervision, and massive-scale data analytics, with applications in social media analysis, computational biology, climate modeling, health care, and traffic monitoring. Restriction: Graduate standing. Cross-listed with CSCI 5952. Max Hours: 3 Credits.
Grading Basis: Letter Grade
Restriction: Restricted to students with graduate standing.

CSCI 8990 - Doctoral Dissertation (1-9 Credits)
Repeatable. Max hours: 9 Credits.
Grading Basis: Letter Grade with IP
Repeatable. Max Credits: 9.
Additional Information: Report as Full Time.

Engineering (ENGR)

ENGR 5001 - Foundations of the Smart City (1 Credit)
The Foundations badge explores the history of "smart" cities and what has enabled them to succeed or fail. Special attention is paid matters of civic and community engagement as focal points of technological innovation. Finally the implications on governance, personal privacy, and equity -- often considered secondary by technologists -- are centered and explored as primary drivers in problem-solving. Max hours: 1 Credit.
Grading Basis: Letter Grade
Typically Offered: Fall, Spring, Summer.

ENGR 5002 - Technologies of the Smart City (1 Credit)
The Technologies badge explores recent developments in software and hardware and their implications for the urban experience. Open data, analytics, machine learning, the Internet of Things, and advanced mobility (electric, autonomous, and connected vehicles) are reviewed from a non-technical perspective. Prereq: ENGR 5001. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ENGR 5001.
Typically Offered: Fall, Spring, Summer.

ENGR 5003 - Building the Smart City (1 Credit)
The Building badge explores areas of smart city design and development not traditionally considered central. These include the growing field of urban science, urban gaming and simulation, the economics/financing of smart city projects, and finally trends in architecture and construction relevant to next-generation, technology-assisted cities.
Prereq: ENGR 5001 & ENGR 5002. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ENGR 5001 ENGR 5002.
Typically Offered: Fall, Spring, Summer.

ENGR 5004 - Living in the Smart City (1 Credit)
The Living badge explores aspects of urban technologies that affect quality-of-life. Energy, sustainability, resiliency, public health and public safety are all considered through the lens of technologies that may accelerate or impede personal and collective goals. Finally, a review of emerging technologies and trends is provided as a possible roadmap for the future. Prereq: ENGR 5001, ENGR 5002, & ENGR 5003. Max hours: 1 Credit.
Grading Basis: Letter Grade
Prereq: ENGR 5001, ENGR 5002, ENGR 5003.
Typically Offered: Fall, Spring, Summer.

ENGR 5150 - Seminar: Special Topics in Engineering (1 Credit)
A flexible seminar format dealing with topics of special interest in engineering on a graduate level. Topics vary from semester to semester. Prereq: Graduate standing. Cross-listed with ENGR 4150 and 7150. Max hours:1 Credit.
Grading Basis: Letter Grade
Restriction: Restricted to graduate students
Typically Offered: Fall, Spring.

ENGR 5208 - Special Topics (1-3 Credits)
Repeatable. Max Hours: 9 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 9.

ENGR 5301 - Systems Engineering: Principles and Practice (3 Credits)
Max Hours: 3 Credits.
Grading Basis: Letter Grade

ENGR 5302 - Systems Engineering: Planning and Management (3 Credits)
Max Hours: 3 Credits.
Grading Basis: Letter Grade

ENGR 5303 - Special Topics: Systems Engineering (3 Credits)
Repeatable. Max Hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.

ENGR 5700 - Introduction to Artificial Intelligence and Machine Learning for Engineers (3 Credits)
Introduces the concepts used in current artificial intelligence models, and machine learning approaches. Students will be able to understand and participate in discussions about these important areas. No previous programing experience required. Topics include: The roles of AI & ML, programing languages, frameworks, and libraries, deep look into Neural Network types, specialized hardware for AI/ML, areas for optimizing the AI/ML pipeline, positions in AI/ML teams, market leaders and their products, AI Regulations. Max hours: 3 Credits.
Grading Basis: Letter Grade

ENGR 5800 - Long Range Infrastructure Planning and Design: Colorado 2050 (3 Credits)
The goal of this course is to equip students to address the problems of long term future resource limitation and its influence on urban infrastructure in Colorado. Repeatable. Max Hours: 6 Credits.
Grading Basis: Letter Grade
Repeatable. Max Credits: 6.

ENGR 6299 - Introduction to Smart Cities (3 Credits)
This course will explore some of the most change-making technological innovations in the 21st century and their impact on public policy in cities through a survey of best practices, model policies, and lessons learned from cities across the United States and globe. Cross-listed with ENVS 5660, PUAD 5627, and URPL 6299. Max hours: 3 Credits.
Grading Basis: Letter Grade

ENGR 7150 - Seminar: Special Topics in Engineering (0.5 Credits)
A flexible seminar format dealing with topics of special interest in engineering on an advanced graduate level. Topics vary from semester to semester. Prereq: Graduate standing. Cross-listed with ENGR 4150 and 5150. Repeatable. Max hours: 1 Credit.
Grading Basis: Letter Grade
Repeatable. Max Credits: 1.
Restriction: Restricted to graduate students
Typically Offered: Fall, Spring.