COMPUTER SCIENCE (CSC)

CSC 200 | SURVEY OF COMPUTING | 4 quarter hours (Undergraduate)
This introductory course explores various careers in the field of information technology. A hands-on component will deal with state of the art personal computer operating systems, applications, database systems, Internet, email, and basic website construction. The structure of the course utilizes both classroom lectures and computer classroom labs. This course is geared toward the non-major and assumes no prior knowledge or experience in Computer Science.

CSC 208 | ETHICS IN TECHNOLOGY | 4 quarter hours (Undergraduate)
Information Technology and the rapid pace in which it has advanced have had a tremendous impact on our lives. Changes have been swift and the human capacity to deal with them is limited. It has been said that our technology has outpaced our humanity. This course will research the new responsibilities technology presents and our ability to deal with these changes in an ethical manner. Students will employ ethical frameworks, which integrate computer science and ethics, to develop the skills required to examine different sets of assumptions and question them. Case studies will provide a historical perspective for analysis.

CSC 211 | PROGRAMMING IN JAVA I | 4 quarter hours (Undergraduate)
Introduction to programming in Java and problem solving. Variables, data types, input/output, using objects and methods from the standard classes (such as String and Scanner), control structures, writing methods, arrays. Solving problems with algorithms and implementing algorithms in Java. (Not for CS majors)

CSC 212 | PROGRAMMING IN JAVA II | 4 quarter hours (Undergraduate)

CSC 211 is a prerequisite for this class.

CSC 223 | THE IMPACT OF COMPUTING TECHNOLOGY ON OUR LIVES | 4 quarter hours (Undergraduate)
This course will introduce students to an overview of social analysis techniques and the theories of social change. These tools will be used to explore social impact issues of computing technology. Counts for Liberal Studies SCBI credit.

CSC 233 | CODES AND CIPHERS | 4 quarter hours (Undergraduate)
This course is an introduction to the science and history of secret writing (cryptography) and how codes and ciphers can be broken (cryptanalysis). In historical settings we will encounter the main ideas and methods devised to secure communication channels. Possible topics include: substitution ciphers, transposition ciphers, the Vigenere cipher, statistical methods in cryptanalysis, public-key cryptography, and quantum cryptography. PREREQUISITE: LSP 120 or MAT 130 or CSC 241 or CSC 243.

CSC 235 | PROBLEM SOLVING | 4 quarter hours (Undergraduate)
How do you solve a problem? In this course we discuss different problem solving techniques and strategies such as modeling, establishing subgoals, and searching and pruning. The techniques will be presented as part of a theoretical framework, but there will be significant emphasis on solving problems in familiar domains such as games, newspaper articles, philosophy, and simple geometry and logic. At the end of the course, students will have built a repertoire of problem solving tools that will allow them to make an informed choice of approach towards new problems.

CSC 241 | INTRODUCTION TO COMPUTER SCIENCE I | 4 quarter hours (Undergraduate)
This course will introduce students to an overview of social analysis techniques and the theories of social change. These tools will be used to introduce different Computer Science areas (e.g. a Client/Server application for the Distributed Systems area). Classes and object oriented programming are motivated and introduced. PREREQUISITE(S): CSC241.

CSC 241 is the prerequisite for this class.

CSC 243 | PYTHON FOR PROGRAMMERS | 4 quarter hours (Undergraduate)
An intermediate course in problem solving, algorithms and structured programming using a higher-level programming language. The course will focus on skills for developing algorithms, and for writing and debugging programs. Students will learn how and when to use loops, conditionals, and functional abstractions in the context of problems motivated by real world applications. PREREQUISITE(S): MAT 130 or Mathematics Diagnostic Test placement into MAT 140. MAT 130 or above or equivalent or Mathematics Diagnostic test placement into MAT 140 is the prerequisite for this class.

CSC 250 | COMPUTERS AND HUMAN INTELLIGENCE | 4 quarter hours (Undergraduate)
Students taking this course will study human problem-solving and its simulation by computers. Artificial intelligence, pattern recognition and learning programs will be discussed. PREREQUISITE(S): Familiarity with basic computer productivity tools and the Web.

CSC 270 | FROM FIREFLIES TO FACEBOOK: THE SCIENCE OF NETWORKS | 4 quarter hours (Undergraduate)
This course explores complex systems both natural and man-made, characterized by the relationships between interacting entities. Network structures can be found in the Internet and its many applications, but also in social relationships, marketplaces, ecosystems, even cells. We will examine a wide range of networks including technological, social, and natural. Students will learn basic concepts from graph theory, algorithms and network analysis, apply tools for extracting, analyzing and visualizing network properties, using data sets drawn from a variety of areas. PREREQUISITE(S): LSP 120.

LSP 120 is a prerequisite for this class.
CSC 281 | WORKSHOP: JAVA FOR PROGRAMMERS | 2-2.25 quarter hours
(Undergraduate)
This course introduces students to the Java programming language and eclipse development environment. PREREQUISITE(S): CSC 241 or CSC 243 (2 quarter hours)
CSC 241 or CSC 243 is a prerequisite for this class.

CSC 282 | WORKSHOP: LINUX FOR PROGRAMMERS | 2-2.25 quarter hours
(Undergraduate)
This course provides an introduction to Linux, the command-line environment, C programming, and version control. PREREQUISITE(S): CSC 241 or CSC 243 (2 quarter hours)
CSC 241 or CSC 243 is a prerequisite for this class.

CSC 298 | INTERNSHIP | 4 quarter hours
(Undergraduate)
This course satisfies the junior year experiential learning requirement. In cooperation with local employers, this course offers students the opportunity to integrate their academic experience with on-the-job training in computer related work areas. Admission to the program requires consent of internship course instructor. Current work experience plus classroom time is required. Supervisor evaluation will contribute to the final grade.

CSC 299 | SOPHOMORE LAB IN APPLIED COMPUTING | 4 quarter hours
(Undergraduate)
In this course, students investigate a particular application of computing. Students learn tools, methodologies, and formalisms used in a particular computing area, and apply them to develop working systems. Courses stress student initiative in investigating the application context, learning new tools (including languages and APIs), studying algorithms and code examples, and working on projects. Topics will vary by the faculty member’s interest and perspective. PREREQUISITE(S): CSC 242 or CSC 243.
CSC 242 or CSC 243 is a prerequisite for this class.

CSC 300 | DATA STRUCTURES I | 4 quarter hours
(Undergraduate)
This is the first course in a two-course sequence on data structures using Java. The course introduces basic Java programming, reviews recursion, introduces asymptotic notations, and focuses mainly on linear data structures including arrays, linked lists and their variants, stacks and queues, and data structures supporting disjoint-set operations. The implementation of the basic operations on each data structure are discussed and analyzed in terms of their efficiency. The applications covered highlight and exploit the unique characteristics of the data structures, and emphasize problem solving and recursive thinking. Prerequisite(s): CSC 242 or CSC 243.
CSC 242 or CSC 243 is a prerequisite for this class.

CSC 301 | DATA STRUCTURES II | 4 quarter hours
(Undergraduate)
This is the second course in a two-course sequence on data structures using Java. The course focuses mainly on the following data structures, their analysis, and their applications: trees (search trees, balanced search trees), heaps, associative arrays, hash tables, and data structures for representing graphs. The implementation of the basic operations on each data structure are discussed and analyzed in terms of their efficiency. The applications discussed highlight and exploit the unique characteristics of the different data structures, and emphasize problem solving and recursive thinking. Prerequisite(s): CSC 300 and MAT 140.
CSC 300 and MAT 140 are prerequisites for this class.

CSC 308 | FRAMEWORKS FOR WEB APPLICATION DEVELOPMENT | 4 quarter hours
(Undergraduate)
This course introduces concepts, techniques, technologies and APIs for web application development. The main focus of this course is on the Model-View-Controller design pattern employed by modern full-stack web frameworks. Examples of full-stack MVC frameworks include Ruby-on-Rails (written in Ruby), Django and TurboGears (written in Python). PREREQUISITE(S): CSC 374.
CSC 374 is a prerequisite for this class.

CSC 309 | C++ FOR PROGRAMMERS | 4 quarter hours
(Undergraduate)
This course covers the essentials of C and C++ programming, focusing primarily on the topics of memory management and object-oriented programming. Topics include pointers and dynamic allocation, operator overloading, copy constructors and destructors, inheritance and polymorphism. PREREQUISITE(S): CSC 242 or CSC 243 or proficiency in another programming language. (CSC 242 or CSC 243) or proficiency in another programming language is a prerequisite for this class.

CSC 321 | DESIGN AND ANALYSIS OF ALGORITHMS | 4 quarter hours
(Undergraduate)
Techniques for designing algorithms including: analyzing algorithms (big-O, recurrence relations) and divide-and-conquer (quicksort, mergesort). Additional topics chosen from: the greedy method, dynamic programming, backtracking, branch-and-bound and string matching. PREREQUISITE(S): (CSC 301 or CSC 393) and MAT140. MAT141 Recommended.
(CSC 301 or CSC 393) and MAT140 are prerequisites for this class.

CSC 325 | TIME SERIES ANALYSIS AND FORECASTING | 4 quarter hours
(Undergraduate)
The course introduces students to statistical models for time series analysis and forecasting. The course topics include: autocorrelated data analysis, Box-Jenkins models (autoregressive, moving average, and autoregressive moving average models), analysis of seasonality, volatility models (GARCH-type, GARCH-M type, etc.), forecasting evaluation and diagnostics checking. The course will emphasize applications to financial data, volatility modeling and risk management. Real examples will be used throughout the course. PREREQUISITE(S): (CSC 212 or CSC 224 CSC 262 or CSC 309) and (CSC324 or MAT356) or consent of instructor.

CSC 327 | PROBLEM SOLVING FOR CONTESTS | 2 quarter hours
(Undergraduate)
This course prepares students to compete in programming contests. More broadly, it covers problem solving techniques in an informal, fun, and hands-on setting. This course will improve your analytical and programming skills and is thus recommended for all students and not just the competitors among us. This course can be taken for credit twice. PREREQUISITE(S): CSC 301 or CSC 383 (2 quarter hours)
CSC 301 is a prerequisite for this class.
CSC 331 | SCIENTIFIC COMPUTING | 4 quarter hours  
(Undergraduate)  
This course presents fundamental numerical algorithms for solving problems in scientific computing and computational finance. Areas covered include: error analysis, computer arithmetic, linear algebra, optimization problems, numerical integration (solvers), ordinary differential equations (ODE). The emphasis of the course is on the design of the algorithms, and their analysis. Algorithms will be implemented using mathematical software. PREREQUISITE(S): (CSC 242 or CSC 243) and MAT 152) or instructor permission.  
((CSC 242 or CSC 243) and MAT 152) or by permission of instructor

CSC 333 | CRYPTOLOGY | 4 quarter hours  
(Undergraduate)  
Introduction to the methods of cryptography and cryptanalysis. Topics include classical cryptography (codes, substitution ciphers, transposition ciphers), block and stream ciphers (Feistel networks, DES), and public key cryptography (RSA, Key agreement, signature schemes). Optional topics include zero-knowledge protocols, quantum cryptography, and history. PREREQUISITE(S): (CSC 242 or CSC 243 or IT 212) and MAT 140.  
(CSC 242 or CSC 243 or IT 212) and MAT 140 are prerequisites for this class.

CSC 343 | INTRODUCTION TO OPERATING SYSTEMS | 4 quarter hours  
(Undergraduate)  
An advanced course on operating system design and implementation. Process management and scheduling, memory management, file systems, device drivers, access control, and virtualization will be covered. The emphasis of the course will be on implementing components of a functional operating system. PREREQUISITE(S): CSC 301 and CSC 373 and CSC 374.  
CSC 301 and CSC 373 and CSC 374 are prerequisites for this class.

CSC 344 | AUTOMATA THEORY AND FORMAL GRAMMARS | 4 quarter hours  
(Undergraduate)  
An introduction to the most important abstract models of computation and their applications: finite state machines and pushdown automata. Explores the relationship between regular expressions and formal grammars and automata. PREREQUISITE(S): CSC 301 and MAT 141.  
CSC 301 and MAT 141 are prerequisites for this class.

CSC 347 | CONCEPTS OF PROGRAMMING LANGUAGES | 4 quarter hours  
(Undergraduate)  
Syntax of programming languages: regular expressions, finite automata, context-free grammars, parsing. Scoping, binding, parameter passing, exception handling. Declarative programming languages. Typing, polymorphism. Runtime systems: dynamic loading, byte-code verification, security managers, garbage collection, versioning. PREREQUISITE(S): 
(CSC 301 or CSC 393) and CSC 373.  
(CSC 301 or CSC 393) and CSC 373 are prerequisites for this class.

CSC 348 | INTRODUCTION TO COMPILER DESIGN | 4 quarter hours  
(Undergraduate)  
An overview of the design of a compiler for a general purpose programming language; tools for designing the components of the compiler; implementing the compiler; run time environments. PREREQUISITE(S): CSC 301 and CSC 373 and CSC 347.  
CSC 301 and CSC 373 and CSC 347 are prerequisites for this class.

CSC 352 | DATABASE PROGRAMMING | 4 quarter hours  
(Undergraduate)  
Programming in a large-scale relational database environment using procedural languages. Topics covered in the course include: procedural extension of query languages, runtime error handling, subprograms (procedures and functions), packages, database triggers, dynamic query language. Optional topics include transaction management, reliability, and security. PREREQUISITE(S): (IT 240 or CSC 355) and (CSC 212 or CSC 242 or CSC 243 or CSC 300 or CSC 309).  
(IT 240 or CSC 355) and (CSC 212 or CSC 242 or CSC 243 or CSC 300 or CSC 309) are prerequisites for this class.

CSC 353 | ADVANCED DATABASE CONCEPTS | 4 quarter hours  
(Undergraduate)  
An introduction to advanced selected topics in databases. Possible topics include: object-oriented databases, distributed databases, intelligent and deductive databases, temporal databases, multimedia databases, spatial and geographic databases, fuzzy databases, mobile databases, data mining and data warehousing, as well as emerging issues and concepts in database design, implementation and management. PREREQUISITE(S): IT 240.  
IT 240 is a prerequisite for this class.

CSC 355 | DATABASE SYSTEMS | 4 quarter hours  
(Undergraduate)  
An introduction to modern database systems; the course covers the traditional concepts and techniques of database systems including the relational model, SQL, indexes and normalization as well as a selection of advanced topics such as constraints and triggers, transactions, database programming, semi-structured data, and recursive SQL. PREREQUISITE(S): CSC 301 or CSC 393.  
CSC 301 or CSC 393 is a prerequisite for this class.

CSC 357 | EXPERT SYSTEMS | 4 quarter hours  
(Undergraduate)  
A study of the development of expert systems. Students will use commercial packages to develop standalone and embedded expert systems. Topics will include rule-based systems, decision trees, forward and backward chaining, inference, reasoning with uncertainty, and intelligent agents. PREREQUISITE(S): CSC 301 or CSC 393.  
CSC 301 or CSC 393 is a prerequisite for this class.

CSC 358 | SYMBOLIC PROGRAMMING | 4 quarter hours  
(Undergraduate)  
Concepts of symbolic programming as embodied in the language LISP. Basic data and control structures of LISP symbolic expressions, the interpreter, functions, recursion, iteration. Techniques for prototyping and building conceptually advanced systems in an environment that encourages procedural and data abstraction. Advanced topics may include Prolog, intelligent tutoring systems, intelligent agents, and natural language processing. Assignments will focus on basic AI techniques, but the class is intended for anyone who will need to rapidly develop large complex systems. PREREQUISITE(S): CSC 301 or CSC 393.  
CSC 301 or CSC 393 is a prerequisite for this class.

CSC 360 | WEB APPLICATIONS | 4 quarter hours  
(Undergraduate)  
This course covers the design and development of single-page web applications and their interaction with web services. Possible topics include: HTML; JavaScript/TypeScript; RxJS; Frameworks such as Angular and/or React; Node.js; programming and security models for browsers; client-side web applications with local storage; HTTP proxies, and caching. PREREQUISITE(S): CSC 347 and CSC 376.  
CSC 347 and CSC 376 are prerequisites for this course.
CSC 361 | OPTIMIZED C++ | 4 quarter hours  
(Undergraduate)  
Implementation techniques to improve the performance and resource usage of C++ programs. This class will provide low level understanding of C++’s internal behavior that can be exploited to create faster performing software. Identify existing SISD (single instruction single data) implementation and refactor into SIMD (single instruction multiple data) to improve math centric software segments. Understand a system’s dynamic memory usage to design and implement a custom high performance memory system. Topics include: performance enhancements through extended SIMD instruction set, dynamic memory usage, caching, implicit behavior, C++ language extensions, algorithms, streaming and profiling. PREREQUISITE(S): (CSC 301 or CSC 383 or CSC 393) and CSC 373.

(CSC 301 or CSC 393) and CSC 373 are prerequisites for this class.

CSC 362 | OPTIMIZED C++ MULTITHREADING | 4 quarter hours  
(Undergraduate)  
Applied C++ concurrency and multithreading fundamentals. Basic threading concepts: process model, threads, stacks, fibers, mutexes, semaphores, atomic states, and events. Understanding synchronous/asynchronous interactions and behavior of threads. Using managed thread pools and queues in applications. Understanding advanced C++ language features relating to the memory model and the threading support. PREREQUISITE(S): GAM 391 or CSC 361.

GAM 391 (or CSC 361) is a prerequisite for this class.

CSC 371 | MOBILE APPLICATION DEVELOPMENT FOR IOS | 4 quarter hours  
(Undergraduate)  
This course introduces the core issues associated with application development for mobile devices using the iOS platform. Students will learn the Swift language, the XCode IDE, UIKit and other frameworks, the elements and architecture of the user interfaces, and more. Students will be exposed to the iOS system architecture including memory management, MVC, delegates and threads. Topics will also include understanding and handling of multi-touch events, gestures, and motion events. PREREQUISITE(S): (CSC 301 or CSC 383 or CSC 393) and CSC 374.

(CSC 301 or CSC 383 or CSC 393) and CSC 374 are prerequisites for this class.

CSC 372 | MOBILE APPLICATION DEVELOPMENT FOR ANDROID | 4 quarter hours  
(Undergraduate)  
This course introduces the core issues associated with application development for mobile devices using the Android platform. Students will learn the Eclipse IDE, frameworks, the elements and architecture of user interfaces, graphics, and more. Students will be exposed to the Android system architecture, including Views, Widgets, Resources, Adapters, Intents and Activities. Topics will also include understanding and handling of threads, multi-touch events, gestures, and motion events. PREREQUISITE(S): (CSC 301 or CSC 383 or CSC 393) and CSC 374.

(CSC 301 or CSC 383 or CSC 393) and CSC 374 are prerequisites for this class.

CSC 373 | COMPUTER SYSTEMS I | 4 quarter hours  
(Undergraduate)  
A course on computer systems topics, focusing on machine-level programming and architecture and their relevance for application programming. Information representations, assembly language, C programming, and debuggers, processor architecture. PREREQUISITE: (CSC 393 or CSC 300) and MAT 140.

(CSC 393 or CSC 300) and MAT 140 are prerequisites for this class.

CSC 374 | COMPUTER SYSTEMS II | 4 quarter hours  
(Undergraduate)  
A course on computer systems topics, focusing on operating systems components and their relevance for application programming. Caching, memory hierarchy, performance optimization, linking, processes, virtual memory, dynamic memory allocation, system level I/O. PREREQUISITE: CSC 373.

CSC 373 is the prerequisite for this class.

CSC 375 | INTRODUCTION TO ROBOTICS | 4 quarter hours  
(Undergraduate)  
An introduction to the field of Robotics. Topics include history of robotics, kinematics, control theory, and sensor theory. A large portion of class time will be lab based, building and programming robots using the Lego Mindstorms NXT Robotics Kit. The programming will be using a C derivative and knowledge of C and general systems concepts is required. PREREQUISITE(S): CSC 373 and CSC 374.

CSC 373 and CSC 374 are prerequisites for this class.

CSC 376 | DISTRIBUTED SYSTEMS | 4 quarter hours  
(Undergraduate)  
An introduction to distributed systems. Topics may include: architecture of distributed systems; networking; datagram-oriented and stream-oriented protocols; network programming (for example, the sockets API); remote procedure call and remote method invocation; processes and threads; code migration; software agents; naming of non-mobile and mobile entities; cryptography and security. PREREQUISITE(S): (CSC 301 or CSC 383 or CSC 393) and CSC 374.

(CSC 301 or CSC 383 or CSC 393) and CSC 374 are prerequisites for this class.

CSC 377 | TECHNOLOGY PARTNERSHIPS IN URBAN SCHOOLS | 4 quarter hours  
(Undergraduate)  
Students in this course will have the opportunity to assess urban community needs in the technology arena and develop skills in assisting and developing methods for “bridging the digital divide” that exists. As a result, the student will be able to make a substantial difference in an underprivileged academic community group. This course is a CDMSponsored community-based service learning course. Any student enrolled in this course can also satisfy the junior year experiential learning requirement.

CSC 378 | FOUNDATIONS OF ARTIFICIAL INTELLIGENCE | 4 quarter hours  
(Undergraduate)  
An in-depth survey of important concepts, problems, and techniques in artificial intelligence, including search, knowledge representation, logical reasoning, and reasoning with uncertainty. A particular focus and a unifying theme of the course will be the concept of intelligent agents. No prior knowledge of AI is required. The course is particularly suitable for graduate and advanced undergraduate students who want to gain the technical background necessary to build intelligent systems, or who want to prepare for more advanced work in AI. The concepts and techniques learned in this course will be directly applicable to many other areas of computer science including software design, distributed systems, databases, and information management and retrieval. PREREQUISITE(S): CSC 301 or CSC 393.

CSC 301 or CSC 393 is a prerequisite for this class.
CSC 381 | INTRODUCTION TO DIGITAL IMAGE PROCESSING | 4 quarter hours
(Undergraduate)
Components of an image processing system and its applications, elements of visual perception, sampling and quantization, image enhancement by histogram equalization, color spaces and transformations, introduction to segmentation (edge detection algorithms), and morphological image processing. PREREQUISITE(S): MAT 150 or MAT 262.
MAT 150 or MAT 262 are prerequisites for this class
CSC 382 | APPLIED IMAGE ANALYSIS | 4 quarter hours
(Undergraduate)
Image analysis from classical computational imaging techniques to deep learning techniques. Fundamentals of computational image analysis in terms of image information extraction and modeling of image patterns. Specific topics include, but are not limited to: image segmentation, multi-scale representation, shape analysis, texture analysis, Fourier analysis, wavelets, Gabor and fractal analysis, and template matching. Deep learning models to extract image representations automatically. Classical and deep learning imaging techniques applied and compared in the context of different image analysis tasks such as image representation, segmentation, classification, retrieval, and object recognition. Applications of these techniques for autonomous driving, biometrics, sports analytics, smart and connected communities, and biomedical and health informatics. PREREQUISITE(S) CSC 381.
CSC 381 is a prerequisite for this class.
CSC 386 | REAL-TIME NETWORKING (FORMERLY GAM 390) | 4 quarter hours
(Undergraduate)
Applied real-time networking fundamentals. Topics include low-level TCP/UDP socket programming, serialization of data for network transportation, deterministic data flow and queuing in applications, dynamic configuration and session communications. Students will explore issues related to performance-based networking in different topologies: client/server and peer to peer. Students will create and build real-time applications using different protocols (TCP, UDP, RUDP) with active network simulation of loss, delayed, corrupted and out of order data packets. PREREQUISITE(S): GAM 372 or (SE 350 and CSC 361)
GAM 372 or (SE 350 and CSC 361) are prerequisites for this class.
CSC 388 | REAL-TIME MULTITHREADED ARCHITECTURE | 4 quarter hours
(Undergraduate)
Real-time constrained multithreaded architecture. Topics include multithreaded handle development, inter-thread communication, creating systems for user-defined callbacks, asynchronous loading and streaming of resources, non-blocking threading synchronization, design patterns and data driven messaging with time delivery constraints Exploration of multithreaded interfaces to maintain uniqueness and control for contended resources. Wrapping and intergrating a multithreaded solution into an application will be analyzed. Students will design, develop and implement a multithreaded real-time application (i.e. Audio engine) that integrates existing single and multithreaded middleware libraries. PREREQUISITE(S): GAM 372 or (CSC 361 and SE 350)
GAM 372 or (SE 350 and CSC 361) are prerequisites for this class.
CSC 389 | THEORY OF COMPUTATION | 4 quarter hours
(Undergraduate)
Advanced topics in the mathematical foundations of computation. Topics may include random access and Turing machines, recursive functions, algorithms, computability and computational complexity, intractable problems, NP-complete problems. PREREQUISITE(S): CS321 or CS344.
CSC 321 or CSC 344 is a prerequisite for this class.
CSC 399 | INDEPENDENT STUDY | 1-8 quarter hours (Undergraduate)
Independent study supervised by an instructor. Independent study form required. Can be repeated for credit. Variable Credit. PREREQUISITE(S): None. (variable credit)

CSC 400 | DISCRETE STRUCTURES FOR COMPUTER SCIENCE | 4 quarter hours (Graduate)
This course covers the basic mathematical tools essential for solving problems in computer science. The mathematical topics are presented with emphasis on their applications in computer science. The topics covered include: logic and set theory, relations, functions, graphs, and counting and probability.

CSC 401 | INTRODUCTION TO PROGRAMMING | 4 quarter hours (Graduate)
An introduction to programming with a focus on problem solving, structured programming, and algorithm design. Concepts covered include data types, expressions, variables, assignments, conditional and iterative structures, functions, file input/output, exceptions, arrays and an introduction to user-defined classes.

CSC 402 | DATA STRUCTURES I | 4 quarter hours (Graduate)
A first course on data structures in Java for graduate students. The course introduces Java programming from within the context of data structures. The course covers arrays, linked lists, stacks and queues, data structures supporting disjoint-set operations, and discusses recursion and performance analysis. The implementation of the basic operations on each data structure are discussed and analyzed in terms of their efficiency. PREREQUISITE(S): CSC 401.

CSC 403 | DATA STRUCTURES II | 4 quarter hours (Graduate)
This is the second course on data structures in Java for graduate students. The course covers trees, heaps, associative arrays, hash tables, tries, and data structures for representing graphs. The implementation of the basic operations on each data structure are discussed and analyzed in terms of their efficiency. PREREQUISITE(S): CSC 402.

CSC 404 | ACCELERATED C++ | 4 quarter hours (Graduate)
This introductory graduate course covers the essentials of C++ programming. Topics include encapsulation, inheritance, polymorphism, dynamic memory allocation, casting, pointer arithmetic, operator overloading, templates, and the Standard Template Libraries. PREREQUISITE(S): None.

CSC 406 | SYSTEMS I | 4 quarter hours (Graduate)
An introductory graduate course on computer systems topics, focusing on machine-level programming and architecture and their relevance for application programming. Information representations, assembly language and debuggers, processor architecture, program optimization, memory hierarchy and caching. Students are recommended to finish CSC 400 before enrolling in this course. PREREQUISITE(S): CSC 401.

CSC 407 | SYSTEMS II | 4 quarter hours (Graduate)
An introductory graduate course on computer systems topics, focusing on operating systems components and their relevance for application programming. Linking, processes, virtual memory, dynamic memory allocation, system level I/O, networking and network programming, concurrent servers and web services. PREREQUISITE(S): CSC 406 and CSC 402.

CSC 406 and CSC 402 are prerequisites for this class.

CSC 412 | TOOLS AND TECHNIQUES FOR COMPUTATIONAL ANALYSIS | 4 quarter hours (Graduate)
Use of mathematical software to explore basic concepts in linear algebra and calculus. Scripting for symbolic and computational processing. Emphasis is on applications in computer science, finance, data mining, and computer vision. PREREQUISITE(S): None.

CSC 421 | APPLIED ALGORITHMS AND STRUCTURES | 4 quarter hours (Graduate)
This course covers techniques for designing and analyzing algorithms and structures in the context of computer application development. Examples will come from Internet, WWW, database, and computer system applications. Fundamental topics such as running-time analysis, searching and sorting within various structures, divide-and-conquer and dynamic programming will be covered. PREREQUISITE(S): CSC 400 and CSC 403.

CSC 400 and CSC 403 are prerequisites for this class.

CSC 426 | RESEARCH METHODS AND PRACTICE IN COMPUTING | 4 quarter hours (Graduate)
The course is intended to help students understand the process of and issues related to doing scientific research in computing or related areas. Topics covered include how to develop an effective research proposal, how to critically evaluate or review a scientific research paper, how to use appropriate research methods in scientific research, key elements of a publishable paper or a dissertation, ethics and professional responsibility in scientific research. The course is intended for PhD students in Computer and Information Sciences or for students who are interested in pursuing a research career. PREREQUISITE(S): PhD status or consent of instructor.

PhD status or consent of instructor is a prerequisite for this class.

CSC 431 | SCIENTIFIC COMPUTING | 4 quarter hours (Graduate)
This course presents fundamental numerical algorithms for solving problems in scientific computing and computational finance. Areas covered include: error analysis, computer arithmetic, linear algebra, optimization problems, numerical integration (solvers), ordinary differential equations (ODE). The emphasis of the course is on the design of the algorithms, and their analysis. Algorithms will be implemented using mathematical software. PREREQUISITE(S): (CSC 401 and two quarters of calculus) or instructor permission.

CSC 401 and two quarters of calculus (or instructor permission) are prerequisites for this course.
CSC 435 | DISTRIBUTED SYSTEMS | 4 quarter hours
(Graduate)
An introduction to distributed systems. Topics may include: architecture of distributed systems; networking; datagram-oriented and stream-oriented protocols; network programming (for example, the sockets API); remote procedure call and remote method invocation; processes and threads; code migration; software agents; naming of non-mobile and mobile entities; cryptography and security. PREREQUISITE(S): CSC 403 and CSC 407.

CSC 403 and CSC 407 are prerequisites for this class.

CSC 436 | WEB APPLICATIONS | 4 quarter hours
(Graduate)
This course covers the design and development of modern web applications and their interaction with web services. The primary focus is on client-side web applications using AJAX-techniques to access web services. Possible topics include: HTML5, JavaScript/TypeScript; MVC and single-page application programming models, e.g., AngularJS; programming and security models for browsers; client-side web applications with local storage; data synchronization; HTTP proxies, and caching; Node.js; RESTful web services. PREREQUISITE(S): CSC 435 and CSC 447.

CSC 435 and CSC 447 are prerequisites for this class.

CSC 438 | FRAMEWORK FOR WEB APPLICATION DEVELOPMENT | 4 quarter hours
(Graduate)
This course introduces concepts, techniques, technologies and APIs for web application development. The main focus of the course is on the Model-View-Controller design pattern employed by modern full-stack web frameworks. Concepts and techniques covered include client/server programming, database abstraction APIs, and asynchronous javascript. Examples of full-stack MVC frameworks include Ruby-on-Rails (written in Ruby), Django and TurboGears (written in Python). PREREQUISITE: CSC 407.

CSC 407 is a prerequisite for this class.

CSC 439 | COMPUTER SECURITY | 4 quarter hours
(Graduate)
This course covers core principles of computer security. Topics include: user authentication; access control (discretionary, mandatory, role-based); security auditing; database security; software security, common vulnerabilities, and secure coding practices; malicious software; and operating system security. Prerequisite(s): CSC 407.

CSC 407 is a prerequisite for this class.

CSC 440 | CRYPTOLOGY | 4 quarter hours
(Graduate)
Introduction to the methods of cryptography and cryptanalysis. Topics include classical cryptography (codes, monoalphabetic and polyalphabetic substitution ciphers, transposition ciphers), modern block ciphers (such as DES, AES), and public key cryptography (such as RSA). Optional topics include zero-knowledge protocols, information theory, coding theory, error-correcting codes, steganography, stream ciphers, hashing algorithms, quantum cryptography, elliptic curve cryptography, and history. PREREQUISITE(S): CSC 403.

CSC 403 is a prerequisite for this class.
**CSC 454 | DATABASE ADMINISTRATION AND MANAGEMENT | 4 quarter hours**  
*(Graduate)*  
This course is designed to give students a comprehensive foundation in database administration and management. The course provides a conceptual understanding of the database architecture and how its components work and interact with one another. Topics covered in this course include: database architecture, capacity planning, installation and maintenance, network configuration, security management, utilities and tools, industry standards and guidelines, database management techniques and practices. **PREREQUISITE(S): CSC 451 or CSC 453 or CSC 455.**  
**CSC 451 or CSC 453 or CSC 455 or DSC 450 is a prerequisite for this class.**

**CSC 457 | EXPERT SYSTEMS | 4 quarter hours**  
*(Graduate)*  
A study of the development of expert systems. Students will use commercial packages to develop standalone and embedded expert systems. Topics will include rule-based systems, decision trees, forward and backward chaining, inference, reasoning with uncertainty, and intelligent agents. **PREREQUISITE(S): CSC 403.**  
**CSC 403 is a prerequisite for this class.**

**CSC 458 | SYMBOLIC PROGRAMMING | 4 quarter hours**  
*(Graduate)*  
Concepts of symbolic programming as embodied in the language LISP. Basic data and control structures of LISP symbolic expressions, the interpreter, functions, recursion, iteration. Techniques for prototyping and building conceptually advanced systems in an environment that encourages procedural and data abstraction. Advanced topics may include Prolog, intelligent tutoring systems, intelligent agents, and natural language processing. Assignments will focus on basic AI techniques, but the class is intended for anyone who will need to rapidly develop large complex systems. **PREREQUISITE(S): CSC 403.**  
**CSC 403 is a prerequisite for this class.**

**CSC 461 | OPTIMIZED C++ | 4 quarter hours**  
*(Graduate)*  
Analysis and implementation techniques to improve the performance and resource usage of C++ programs. This class will provide low level understanding of C++’s internal behavior that can be exploited to create faster performing software. Analysis of existing software to help identify and remedy execution performance issues related to data layout, processor caching, unintended compiler interactions, algorithmic considerations, data containers and supplied subsystems. Topics include: performance enhancements through SIMD instruction set, dynamic memory usage, caching, implicit behavior, C++ language extensions, algorithms, streaming and profiling. **PREREQUISITE(S): CSC 400 and CSC 403 and CSC 406.**  
**CSC 400 and CSC 403 and CSC 406 are prerequisites for this class.**

**CSC 462 | OPTIMIZED C++ MULTITHREADING | 4 quarter hours**  
*(Graduate)*  
Software architecture of applied C++ concurrency and multithreading fundamentals. Basic threading concepts: process model, threads, stacks, fibers, mutexes, semaphores, atomic events and events. Leveraging advanced C++ language features relating to the memory model and the threading support in large multithreaded architectures. Architecting lock-based and lock-free concurrent data structures in applications. Designing a threaded management system to control the access and reuse of threads in applications. Designing multithreaded architecture for real-time performance. **PREREQUISITE(S): GAM 491 or CSC 461.**  
**GAM 491 (or CSC 461) is a prerequisite for this class.**

**CSC 471 | MOBILE APPLICATION DEVELOPMENT FOR IOS | 4 quarter hours**  
*(Graduate)*  
This course introduces the core issues associated with application development for mobile devices using the iOS platform. Students will learn the Swift language, the XCode IDE, UIKit and other frameworks, the elements and architecture of the user interfaces, and more. Students will be exposed to the iOS system architecture including memory management, MVC, delegates and threads. Topics will also include understanding and handling of multi-touch events, gestures, and motion events. **PREREQUISITE(S): CSC 403 and CSC 407.**  
**CSC 403 and CSC 407 are prerequisites for this class.**

**CSC 472 | MOBILE APPLICATION DEVELOPMENT FOR ANDROID | 4 quarter hours**  
*(Graduate)*  
This course introduces the core issues associated with application development for mobile devices using the Android platform. Students will learn the Eclipse IDE, frameworks, the elements and architecture of user interfaces, graphics, and more. Students will be exposed to the Android system architecture, including Views, Widgets, Resources, Adapters, Intents and Activities. Topics will also include understanding and handling of threads, multi-touch events, gestures, and motion events. **PREREQUISITE(S): CSC 403 and CSC 407.**  
**CSC 403 and CSC 407 are prerequisites for this class.**

**CSC 475 | INTRODUCTION TO ROBOTICS | 4 quarter hours**  
*(Graduate)*  
An introduction to the field of Robotics. Topics include history of robotics, kinematics, control theory, and sensor theory. A large portion of class time will be lab based, building and programming robots using the Lego Mindstorms NXT Robotics Kit. The programming will be using a C derivative and knowledge of C and general systems concepts is required. **PREREQUISITES: CSC 407.**  
**CSC 407 is a prerequisite for this class.**

**CSC 480 | ARTIFICIAL INTELLIGENCE | 4 quarter hours**  
*(Graduate)*  
An in-depth survey of important concepts, problems, and techniques in artificial intelligence, including search, knowledge representation, logical reasoning, and reasoning with uncertainty. A particular focus and a unifying theme of the course will be the concept of intelligent agents. No prior knowledge of AI is required. The course is particularly suitable for graduate and advanced undergraduate students who want to gain the technical background necessary to build intelligent systems, or who want to prepare for more advanced work in AI. The concepts and techniques learned in this course will be directly applicable to many other areas of computer science including software design, distributed systems, databases, and information management and retrieval. **PREREQUISITE(S): CSC 403.**  
**CSC 403 is a prerequisite for this class.**

**CSC 481 | INTRODUCTION TO IMAGE PROCESSING | 4 quarter hours**  
*(Graduate)*  
The course is a prerequisite for more advanced Visual Computing (VC) courses and the students will be challenged to implement VC algorithms for real world applications. The topics covered in the course include: components of an image processing system and its applications, elements of visual perception, sampling and quantization, image enhancement by histogram equalization, color spaces and transformations, introduction to segmentation (Edge detection), and morphological image processing. **PREREQUISITE(S): CSC 412 or consent of instructor.**  
**CSC 412 or consent of instructor is a prerequisite for this class.**
CSC 482 | APPLIED IMAGE ANALYSIS | 4 quarter hours
(Graduate)
Image analysis from classical computational imaging techniques to deep learning techniques. Fundamentals of computational image analysis in terms of image information extraction and modeling of image patterns. Specific topics include, but are not limited to: image segmentation, multi-scale representation, shape analysis, texture analysis, Fourier analysis, wavelets, Gabor and fractal analysis, and template matching. Deep learning models to extract image representations automatically. Classical and deep learning imaging techniques applied and compared in the context of different image analysis tasks such as image representation, segmentation, classification, retrieval, and object recognition. Applications of these techniques for autonomous driving, biometrics, sports analytics, smart and connected communities, and biomedical and health informatics. PREREQUISITE(S) CSC 481.

CSC 481 is a prerequisite for this class.

CSC 485 | NUMERICAL ANALYSIS | 4 quarter hours
(Graduate)

CSC 486 | REAL-TIME NETWORKING (FORMERLY GAM 490) | 4 quarter hours
(Graduate)
Applied real-time networking fundamentals. Topics include low-level TCP/UDP socket programming, serialization of data for network transportation, deterministic data flow and queuing in applications, dynamic configuration and session communications. Students will explore issues related to performance-based networking in different topologies: client/server and peer to peer. Students will create and build real-time applications using different protocols (TCP, UDP, RUDP) with active network simulation of loss, delayed, corrupted and out of order data packets. Architecture of different bandwidth compression and estimation techniques will be investigated. Research of wireless ad hoc networks such as Bluetooth and ZigBee will be explored. PREREQUISITE(S): CSC 461 and (SE 456 or SE 450) CSC 461 and (SE 456 or SE 450) are prerequisites for this class.

CSC 489 | THEORY OF COMPUTATION | 4 quarter hours
(Graduate)
Advanced topics in the mathematical foundations of computation. Topics may include random access and Turing machines, recursive functions, algorithms, computability and computational complexity, intractable problems, NP-complete problems. PREREQUISITE(S): CSC 444 or CSC 421.

CSC 444 or CSC 421 is a prerequisite for this class.

CSC 491 | MOBILE APPLICATION DEVELOPMENT FOR IOS II | 4 quarter hours
(Graduate)
This course will cover advanced topics in mobile application development for iOS. The topics covered will be made explicit by the course instructor when the course is offered. PREREQUISITE(S): CSC 471.

CSC 471 is a prerequisite for this class.
CSC 528 | COMPUTER VISION | 4 quarter hours
(Graduate)
Introduction to computer vision, including fundamentals of image formation, camera imaging geometry, feature detection and matching, stereo, and motion analysis. Basic methods and modern deep learning models for applications that include camera calibration, depth recovery from video, motion estimation and tracking, image and video, image search, and new image generation. Focus on the mathematics of these methods and models. Development of modern techniques such as convolutional neural networks for optical flow estimation and object detection, and generative adversarial networks for artificial image generation. PREREQUISITE(S): CSC 481.

CSC 481 is a prerequisite for this class.

CSC 531 | INTRODUCTION TO BIOINFORMATICS | 4 quarter hours
(Graduate)
An introduction to the field of Bioinformatics, which is computational modeling of biological and biochemical processes. Some programming in Java will be involved. Little biological knowledge will be assumed. Any required will be taught in the course. Topics will include genomics, biological databases, sequence alignment (longest common subsequence), phylogenetic trees, and protein folding. Prerequisites: CSC 421 and SE 450.

CSC 421 and SE 450 are prerequisites for this class.

CSC 534 | SOFTWARE DEVELOPMENT FOR LIMITED AND EMBEDDED DEVICES | 4 quarter hours
(Graduate)
This course will focus on the unique aspects, tools, and techniques of developing software applications for limited and embedded devices, such as set-top boxes and smart cards. Formerly CSC 542. PREREQUISITE(S): SE 450.

SE 450 is a prerequisite for this class.

CSC 535 | FORMAL SEMANTICS OF PROGRAMMING LANGUAGES | 4 quarter hours
(Graduate)

CSC 447 is a prerequisite for this class.

CSC 536 | DISTRIBUTED SYSTEMS II | 4 quarter hours
(Graduate)
Advanced course that introduces the techniques required to build large-scale, highly available, fault tolerant distributed systems. Covers the distributed algorithms (e.g., vector clocks, consistent hashing, gossip protocols, Merkle trees, Paxos/Raft algorithms) that solve the fundamental problems (e.g., synchronization, replication and replica consistency, fault tolerance) in building such systems. Focus is on problems and solutions relevant to systems that store and process massive data sets and the design decisions behind current large-scale distributed database systems. PREREQUISITE(S): CSC 435.

CSC 435 is a prerequisite for this class.

CSC 538 | VISION SYSTEMS | 4 quarter hours
(Graduate)
Vision Systems will cover the geometry of computer vision as well as a survey of working vision systems to include 1) Content-based Image Retrieval Systems; 2) Object Detection and Tracking Systems; 3) Medical Visual Systems; 4) Robotic Navigation Systems. PREREQUISITE(S): CSC 528.

CSC 528 is a prerequisite for this class.

CSC 540 | MOBILE APPLICATION DEVELOPMENT II | 4 quarter hours
(Graduate)
This course will cover advanced topics in mobile and wireless application development. The topics covered will be made explicit by the course instructor when the course is offered. PREREQUISITE(S): CSC 471.

CSC 471 is a prerequisite for this class.

CSC 543 | SPATIAL DATABASES & GEOGRAPHIC INFORMATION SYSTEMS | 4 quarter hours
(Graduate)
This course considers how spatial databases work within a GIS, how data is structured, stored, indexed, retrieved, and displayed. Other topics may include fuzzy spatial databases, temporal spatial databases, and multiple criteria spatial decision making. The class will consist of hands-on work with commercial products, as well as investigating the state-of-the-art research in the field. Prerequisites: CSC 453 or CSC 455.

CSC 453 or CSC 455 or DSC 450 is a prerequisite for this class.

CSC 547 | ADVANCED TOPICS IN PROGRAM LANGUAGES | 4 quarter hours
(Graduate)
A project-based course on advanced topics related to programming languages and programming environments. The course does not have any formal exams or homework assignments, but participants are expected to read papers on current research, actively participate in discussions, and complete a significant course project. PREREQUISITE(S): Instructor consent required.

CSC 453 or CSC 455 is a prerequisite for this class.

CSC 548 | ADVANCED COMPILER DESIGN | 4 quarter hours
(Graduate)
Emphasis on practical problems in implementing compilers, data flow analysis, code optimization, error analysis. Discussion of compiler generators. As a class project, students will write a compiler. PREREQUISITE(S): CSC 448.

CSC 448 is a prerequisite for this class.

CSC 549 | DATABASE SYSTEM IMPLEMENTATION | 4 quarter hours
(Graduate)
This is an advanced database course that covers issues in DBMS implementation. Topics covered in this course include: physical data organizations, indexing and hashing, query processing and optimization, database recovery techniques, transaction management, concurrency control, and security. PREREQUISITE(S): CSC 453.

CSC 453 is a prerequisite for this class.

CSC 550 | OBJECT-ORIENTED DATABASES | 4 quarter hours
(Graduate)

CSC 453 is a prerequisite for this class.
CSC 551 | DISTRIBUTED DATABASE SYSTEMS | 4 quarter hours (Graduate)
Distributed database architecture, distributed database design, distributed query processing, query decomposition and optimization of distributed queries, distributed transaction management and concurrency control, distributed DBMS reliability, distributed database operating systems. Distributed multidatabase systems. Client/Server database systems. PREREQUISITE(S): CSC 453 and (CSC 435 or TDC 405 or TDC 463)
CSC 453 and (CSC 435 or TDC 405 or TDC 463) are prerequisites for this class.

CSC 552 | CONCURRENT SOFTWARE DEVELOPMENT | 4 quarter hours (Graduate)
Fundamentals and techniques of developing concurrent object-oriented applications, using a patterns-based approach. Concepts covered include: threads, synchronization and object locking, thread blocking and deadlock, safety and liveness, state-dependent action and concurrency control. Formerly SE 552. PREREQUISITE(S): SE 450 and CSC 407. SE 450 and CSC 407 are the prerequisites for this class.

CSC 553 | ADVANCED DATABASE CONCEPTS | 4 quarter hours (Graduate)
An introduction to advanced selected topics in databases. The topics include: intelligent and deductive databases, temporal databases, multimedia databases, spatial and geographic databases, fuzzy databases, mobile databases, data mining and data warehousing, as well as emerging issues and concepts in database design, implementation and management. PREREQUISITE(S): CSC 453. CSC 453 is a prerequisite for this class.

CSC 554 | ADVANCED DATABASE MANAGEMENT | 4 quarter hours (Graduate)
In this class, we will discuss concepts, technologies, guiding principles, processes and best practices in managing database environment to meet high availability, scalability, and compliance needs. Organizations with business critical applications must reduce their risk of downtime, manage database environment efficiently and ensure data meets compliance requirements effectively. IT now has additional responsibilities to secure and manage information in alignment with legal, records management and regulations. This class explores methods and techniques to achieve the availability needs and also focuses on how to protect the database against disasters by maintaining multiple copies of the databases in separate locations, synchronized in real-time. Students learn to design and manage key business resumption functions including disaster recovery plans and business continuity plans. Data governance challenges will be discussed along with solutions including data life cycle management, preservation, retention, and disposition. Prerequisite(s): CSC 453 or CSC 454. CSC 453 or CSC 454 is a prerequisite for this class.

CSC 555 | MINING BIG DATA | 4 quarter hours (Graduate)
Introduction to fundamentals of distributed file systems and map-reduce technology (e.g., Hadoop); tuning map-reduce performance in a distributed network. Algorithms and tools for mining massive data sets and discussion of current challenges. Applications in clustering, similarity search, classification, data warehousing (e.g., Hive), machine learning (e.g., Mahout). PREREQUISITE(S): ((CSC 401 and (CSC 453 or DSC 450) and (DSC 441 or DSC 478)) or (MAT 491 and MAT 449)) ((CSC 401 and (CSC 453 or CSC 455 or DSC 450)) and (IS 467 or DSC 441 or CSC 478)) or (MAT 491 and MAT 449)) are prerequisites for this class.

CSC 557 | FOUNDATIONS OF COMPUTER SECURITY | 4 quarter hours (Graduate)
This course provides an overview of foundational techniques in the specification and verification of computer systems in the presence of malicious attackers. Topics may include: formal models of interaction, attacker models, robust safety properties such as confidentiality and authenticity, information flow properties such as noninterference, and tools such as model checkers, type checkers and theorem provers. Formerly 557. PREREQUISITE(S): CSC 439. CSC 439 is a prerequisite for this class.

CSC 559 | SOFTWARE ENGINEERING FOR FINANCIAL MARKETS | 4 quarter hours (Graduate)
This course focuses on software engineering issues in creating a financial engine that drives automation and execution in a financial market. The course will cover different types of financial engines from back-office to front-office, exchange matching engines, data gathering engines, trading engines and straight through processing. The emphasis will be on the engines themselves rather than the financial models beneath them. Students will be required to work individually and/or in teams and create a financial engine. This is a project course and it will put students in the role of a domain architect who will need the skills required to communicate with financial traders and software engineers at the same time. PREREQUISITE(S): CSC 404 and (CSC 431 or CSC 521 or CSC 425) CSC 404 and (CSC 431 or CSC 521 or CSC 425 or DSC 425) are prerequisites for this class.

CSC 575 | INTELLIGENT INFORMATION RETRIEVAL | 4 quarter hours (Graduate)
Examination of the design, implementation, and evaluation of information retrieval systems. The focus is on the underlying retrieval models, algorithms, and system implementations. Also examined is how an effective information search and retrieval is interrelated with the organization and description of information to be retrieved. Topics include: automatic indexing; thesaurus generation; Boolean, vector-space, and probabilistic models; clustering and classification; information filtering; distributed IR on the WWW; intelligent information agents; IR system evaluation; information visualization; and natural language processing in IR. Throughout the course, current literature from the viewpoints of both research and practical retrieval technologies both on and off the World Wide Web will be examined. PREREQUISITE(S): CSC 403. CSC 403 (or Data Science MS students)

CSC 576 | COMPUTATIONAL ADVERTISING | 4 quarter hours (Graduate)
Computational advertising is the problem of finding the best advertisement for a given user in a given on-line context. It is a complex and emerging area at the intersection of quantitative marketing, web search, data mining, recommendation, optimization, and algorithmic game theory. Students will read current scientific papers and explore a range of models both mathematically and empirically. Students can choose from three types of final course projects: implementation projects, research papers, or data analysis projects. Prerequisite(s): IS 467 or CSC 478 or ECT 584. IS 467 or DSC 441 or CSC 478 or ECT 584 or DSC 484 is a prerequisite for this class.
CSC 577 | RECOMMENDER SYSTEMS | 4 quarter hours (Graduate)
Recommender systems offer personalized access to online information in product catalogs, social media networks, and document collections, among other applications. This class will introduce students to a range of approaches for building recommender systems including collaborative, content-based, knowledge-based, and hybrid methods. Students will implement recommendation algorithms using an open-sourced toolkit and conduct experimental evaluations. PREREQUISITE(S): (CSC 412 and CSC 478) or (CSC 403 and IS 467) (CSC 412 and (CSC 478 or DSC 478)) or (CSC 403 and (IS 467 or DSC 441)) are the prerequisites for this class.

CSC 578 | NEURAL NETWORKS AND DEEP LEARNING | 4 quarter hours (Graduate)
Course focuses on the algorithms, implement, and application of neural networks for learning about data. It will present how neural networks represent data and learn in supervised and unsupervised contexts with applications to language processing, classification, and regression problems. Topics include learning algorithms, and optimization methods, deep learning methods for deriving deep representations from surface features, recursive networks, Boltzmann machines and convolutional networks. PREREQUISITE(S): (CSC 412 and DSC 478) or (CSC 403 and DSC 441) (CSC 412 and (CSC 478 or DSC 478)) or (CSC 403 and (IS 467 or DSC 441)) are the prerequisites for this class.

CSC 580 | DESIGN OF OBJECT-ORIENTED LANGUAGES | 4 quarter hours (Graduate)
This course covers issues in the design and specification of object-oriented programming languages. Sample topics include the use of patterns in program representation, static and dynamic semantics, subject reduction, sub-typing, inheritance, polymorphism, genericity and concurrency. Formerly SE 580. PREREQUISITE(S): SE 450.
SE 450 is a prerequisite for this class.

CSC 583 | ARTIFICIAL INTELLIGENCE II | 4 quarter hours (Graduate)
The course provides an in-depth coverage of advanced topics in Artificial Intelligence, including planning, reasoning with uncertainty, decision theoretic agents, constraint satisfaction and optimization problems, as well as selected topics of interest in knowledge representation, machine learning, and natural language processing. These topics are discussed in the context of design and implementation of real-world intelligent agents. This course is suitable for advanced students with interest in further study in artificial intelligence and related topics, as well as those interested in the application of AI techniques in building systems with intelligent components. PREREQUISITE(S): CSC 480.
CSC 480 is a prerequisite for this class.

CSC 587 | COGNITIVE SCIENCE | 4 quarter hours (Graduate)
A study of the relationships between our knowledge of human and computer intelligence. Levels of analysis of intelligent system, examples of cognitive models, and expose to current publications, with an emphasis on those related to human computer interaction. Students will participate in the design and testing of models of human intelligence, both experimentally and using computer models. PREREQUISITE(S): CSC 403 or HCI 460.
CSC 403 or HCI 460 is a prerequisite for this class.

CSC 588 | REAL-TIME MULTITHREADED ARCHITECTURE | 4 quarter hours (Graduate)
Real-time constrained multithreaded architecture. Topics include multithreaded handle development, inter-thread communication, creating systems for user-defined callbacks, asynchronous loading and streaming of resources, non-blocking threading synchronization, design patterns and data driven messaging with time delivery constraints. Design and implementation of thread safe data management with atomic non-blocking synchronization. Exploration of real-time data driven messaging to allowing the run-time object data to control the behavior an application. Students will design, develop and implement a multithreaded real-time application (i.e. Audio engine) that integrates existing single and multithreaded middleware libraries. PREREQUISITE(S): CSC 461 and (SE 456 or SE 450) CSC 461 and (SE 456 or SE 450) are prerequisites for this class.

CSC 594 | TOPICS IN ARTIFICIAL INTELLIGENCE | 2-4 quarter hours (Graduate)
Specific topics will be selected by the instructor and may vary with each quarter. Can be repeated for credit. Variable credit. PREREQUISITE(S): CSC 482 or CSC 528.
CSC 482 or CSC 528 is a prerequisite for this class.

CSC 595 | TOPICS IN COMPUTER SCIENCE | 2-4 quarter hours (Graduate)
Specific topics will be selected by the instructor and may vary with each quarter. Can be repeated for credit. Variable credit. PREREQUISITE(S): CSC 482 or CSC 528.
CSC 482 or CSC 528 is a prerequisite for this class.

CSC 596 | TOPICS IN ARTIFICIAL INTELLIGENCE | 2-4 quarter hours (Graduate)
Specific topics will be selected by the instructor and may vary with each quarter. Can be repeated for credit. Variable credit. PREREQUISITE(S): CSC 482 or CSC 528.
CSC 482 or CSC 528 is a prerequisite for this class.

CSC 597 | TOPICS IN COMPUTER SCIENCE | 2-4 quarter hours (Graduate)
Specific topics will be selected by the instructor and may vary with each quarter. Can be repeated for credit. Variable credit. PREREQUISITE(S): CSC 482 or CSC 528.
CSC 482 or CSC 528 is a prerequisite for this class.

CSC 598 | TOPICS IN DATA ANALYSIS | 2-4 quarter hours (Graduate)
Specific topics will be selected by the instructor and may vary with each quarter. Can be repeated for credit. Variable credit. PREREQUISITE(S): CSC 482 or CSC 528.
CSC 482 or CSC 528 is a prerequisite for this class.

CSC 599 | TOPICS IN DATA SCIENCE | 2-4 quarter hours (Graduate)
Specific topics will be selected by the instructor and may vary with each quarter. Can be repeated for credit. Variable credit. PREREQUISITE(S): CSC 482 or CSC 528.
CSC 482 or CSC 528 is a prerequisite for this class.

CSC 600 | TOPICS IN SOFTWARE ENGINEERING | 2-4 quarter hours (Graduate)
Specific topics will be selected by the instructor and may vary with each quarter. Can be repeated for credit. Variable credit. PREREQUISITE(S): CSC 482 or CSC 528.
CSC 482 or CSC 528 is a prerequisite for this class.
CSC 599 | INDEPENDENT STUDY | 1-8 quarter hours  
(Graduate)  
Independent study supervised by an instructor. Independent study form required. Can be repeated for credit. Variable Credit. PREREQUISITE(S): None. (variable credit)

CSC 601 | MASTER'S RESEARCH CONTINUATION | 0 quarter hours  
(Graduate)  
Non-credit. This course is intended for master's degree students who have completed all course registration requirements and who are regularly using the facilities of the University for study and research, thesis or project completion. These students are required to be registered in this course each quarter of the academic year until all requirements have been completed. PREREQUISITE(S): Completion of required courses. Independent Study form required. (0 credit hours)

CSC 690 | RESEARCH SEMINAR | 1-4 quarter hours  
(Graduate)  
Readings and discussion on current research topics. PREREQUISITE(S): Consent of the instructor. (variable credit)

CSC 695 | MASTER'S RESEARCH | 1-4 quarter hours  
(Graduate)  
Students interested in a more in-depth study of a particular area will register for this course and work with a faculty member (not necessarily their academic advisor) on a research project. The work involved may include system development, empirical studies, or theoretical work. 4 credit hours of CSC 695 replaces one 500level elective course in student's degree program. This course can be taken for 1-4 credit hours for up 8 credit-hours. PREREQUISITE(S): Consent of research advisor. Independent study form required. Students must successfully complete the foundation courses prior to their first enrollment in CSC 695. (variable credit)

CSC 696 | MASTER'S RESEARCH | 0 quarter hours  
(Graduate)  
A student who has made a significant contribution to a research project, through work done in 8 credit-hours CSC 695, may choose to complete the Master's Research option. During the second of the two quarters, the student must submit a technical report detailing the results of the research project. This report must be approved by the student's research supervisor and the faculty advisor, at which point it will be made available to the public as a CDM Departmental Master's Research Technical Report. The transcript will show the Research project title as the course topic. PREREQUISITE(S): Successful defense of a Master's Thesis. (variable credit)

CSC 698 | MASTER'S THESIS | 0 quarter hours  
(Graduate)  
A student who has made an original contribution to the area (typically through 8 credit-hours' worth of work done in CSC 695, but not necessarily) may choose to complete a Master's Thesis. The student and the student's research advisor form a Master's Thesis Committee. The student submits to the committee a thesis detailing the original results of the research project. After a public defense, the committee will decide whether to accept the thesis. In that case, the student will be allowed to register for this course and the transcript will show the thesis title as the course topic. PREREQUISITE(S): Successful defense of a Master's Thesis. (variable credit)

CSC 699 | RESEARCH | 1-12 quarter hours  
(Graduate)  
PREREQUISITE(S): Research course supervised by an instructor. Independent Study Form required. Variable credit. Can be repeated for credit. (variable credit)

CSC 701 | FULL-TIME CANDIDACY CONTINUATION | 0 quarter hours  
(Graduate)  
Non-credit. Students in the doctoral degree who have completed their course credit requirements are required to be registered each quarter of the academic year until the exams, dissertation and final examination have been completed. Registration through independent study form requires certification that the student is actively working on exams and/or thesis under the advisor's supervision. This course carries the equivalent of full-time enrollment status.

CSC 702 | PART-TIME CANDIDACY CONTINUATION | 0 quarter hours  
(Graduate)  
Non-credit. Students in the doctoral degree who have completed their course credit requirements are required to be registered each quarter of the academic year until the exams, dissertation and final examination have been completed. Registration through independent study form requires certification that the student is actively working on exams and/or thesis under the advisor's supervision. This course carries the equivalent of part-time enrollment status.