

# COMPUTER SCIENCE (CSCI)

## CSCI 1010 - Introduction to Computer Science: Principles

### Credit(s): 3 Credits

A broad survey of the computer science discipline, focusing on the computer's role in representing, storing, manipulating, organizing and communicating information. Topics include hardware, software, algorithms, operating systems, networks.

**Attributes:** CSCI Intro to Computer Science

## CSCI 1020 - Introduction to Computer Science: Bioinformatics

### Credit(s): 3 Credits

An introduction to computer programming motivated by the analysis of biological data sets and the modeling of biological systems. Computing concepts to include data representation, control structures, text processing, input and output. Applications to include the representation and analysis of protein and genetic sequences, and the use of available biological data sets.

**Attributes:** Bio-Chemical Biology Elective, CSCI Intro to Computer Science, UUC:Natural & Applied Science

## CSCI 1025 - Introduction to Computer Science: Cybersecurity

### Credit(s): 3 Credits

An introduction to the fundamental principles of computer and network security, privacy-preserving communication techniques, and an overview of prominent attacks on computer systems, networks, and the Web. Students will gain an understanding of security and privacy, including vulnerabilities and requirements of a secure system, and will conduct a series of lab exercises to explore these topics.

**Attributes:** CSCI Intro to Computer Science

## CSCI 1030 - Introduction to Computer Science: Game Design

### Credit(s): 3 Credits

Introduces the design of computer and video games. Students learn the practical aspects of game implementation using computer game engines and 3D graphics tools, while simultaneously studying game concepts like history, genres, storylines, gameplay elements and challenges, and the design process.

## CSCI 1040 - Introduction to Computer Science: Mobile Computing

### Credit(s): 3 Credits

An introduction to programming based on the development of apps for mobile devices such as phones and tablets. Students will learn to design an effective user interface, to interact with device hardware and sensors, to store data locally and access Internet resources.

**Attributes:** CSCI Intro to Computer Science

## CSCI 1050 - Introduction to Computer Science: Multimedia

### Credit(s): 3 Credits

An introduction to computer programming, motivated by the creation and manipulation of images, animations, and audio. Traditional software development concepts, such as data representation and control flow, are introduced for the purpose of image processing, data visualization, and the synthesis and editing of audio.

**Attributes:** CSCI Intro to Computer Science, UUC:Creative Expression

## CSCI 1060 - Introduction to Computer Science: Scientific Programming

### Credit(s): 3 Credits

Elementary computer programming concepts with an emphasis on problem solving and applications to scientific and engineering applications. Topics include data acquisition and analysis, simulation and scientific visualization.

**Prerequisite(s):** (MATH 1510\*, MATH 1320, MATH 1520, MATH 2530, or SLU Math Placement with a minimum score of 1520)

\* Concurrent enrollment allowed.

**Attributes:** CSCI Intro to Computer Science, Foreign Language BA Req (CAS), UUC:Quantitative Reasoning

## CSCI 1070 - Introduction to Computer Science: Taming Big Data

### Credit(s): 3 Credits

An introduction to data science and machine learning. Fundamentals of data representation and analysis will be covered, with a focus on real-world applications to business intelligence, natural language processing, and social network analysis.

**Attributes:** CSCI Intro to Computer Science, UUC:Quantitative Reasoning

## CSCI 1080 - Introduction to Computer Science: World Wide Web

### Credit(s): 3 Credits

An introduction to the technology of the web, from the structure of the Internet (web science) to the design of dynamic web pages (web development). The web science component of the class introduces notions of the web as an example of a network and use the tools of graph theory to better understand the web. The web development component introduces some of the fundamental languages and tools for web programming.

**Attributes:** CSCI Intro to Computer Science

## CSCI 1090 - Introduction to Computer Science: Special Topics

### Credit(s): 3 Credits (Repeatable for credit)

Special topics offerings that qualify for CSCI 10XX: Introduction to Computer Science credit.

**Attributes:** CSCI Intro to Computer Science

## CSCI 1300 - Introduction to Object-Oriented Programming

### Credit(s): 4 Credits

A rigorous introduction to programming using an object-oriented language, including use of variables, control structures, existing classes and functions and recursion, as well as user-defined functions and classes. Good software development practices will also be established, including issues of design, documentation, and testing.

**Prerequisite(s):** ((0 Course from CSCI 1010-1090 with a grade of C- or higher, BME 2000 with a grade of C- or higher, CVNG 1500 with a grade of C- or higher, MATH 3850 with a grade of C- or higher, STAT 3850 with a grade of C- or higher, ECE 1001 with a grade of C- or higher, or GIS 4090 with a grade of C- or higher); (MATH 1200 or 0 Course from MATH 1320-4999))

**Attributes:** Foreign Language BA Req (CAS)

## CSCI 1930 - Special Topics

### Credit(s): 1-4 Credits (Repeatable for credit)

## CSCI 1980 - Independent Study

### Credit(s): 1-3 Credits (Repeatable for credit)

**CSCI 2050 - Computer Ethics****Credit(s): 3 Credits**

This course examines the moral, legal, and social issues raised by computers and electronic information technologies for different stakeholder groups (professionals, users, business, etc.). Students are expected to integrate moral theories and social analysis for addressing such issues as intellectual property, security, privacy, discrimination, globalization, and community.

**Prerequisite(s):** PHIL 2050

**Attributes:** UUC:Dignity, Ethics & Just Soc

**CSCI 2100 - Data Structures****Credit(s): 4 Credits**

The design, implementation and use of data structures. Principles of abstraction, encapsulation and modularity to guide in the creation of robust, adaptable, reusable and efficient structures. Specific data types to include stacks, queues, dictionaries, trees and graphs.

**Prerequisite(s):** (CSCI 1300 with a grade of C- or higher and MATH 1660<sup>\*</sup>)

<sup>\*</sup> Concurrent enrollment allowed.

**CSCI 2190 - Computational Problem Solving****Credit(s): 1 Credit**

Intended primarily to train students for the International Collegiate Programming Contest (ICPC), this course covers data structures, algorithms, and programming techniques that apply to typical programming challenges.

**Prerequisite(s):** CSCI 2100

**CSCI 2300 - Object-Oriented Software Design****Credit(s): 3 Credits**

An implementation-based study of object-oriented software development. Teams will design and create medium-scale applications. Additional focus on the design and use of large object-oriented libraries, as well as social and professional issues.

**Prerequisite(s):** CSCI 2100 with a grade of C- or higher

**CSCI 2500 - Computer Organization and Systems****Credit(s): 3 Credits**

An introduction to computer systems, from hardware to operating systems. Topics include computer architecture, instruction sets, data representation, memory systems, and how the operating system manages processes and user applications. (Offered in Fall)

**Prerequisite(s):** CSCI 2100<sup>\*</sup>

<sup>\*</sup> Concurrent enrollment allowed.

**CSCI 2510 - Principles of Computing Systems****Credit(s): 3 Credits**

An exploration of computing systems with a strong emphasis on how systems interact with each other. Topics will include concurrent and parallel programming, network communication, and computer security. In addition to foundational knowledge, the course includes simulating, benchmarking, and testing such systems. (Offered in Spring)

**Prerequisite(s):** ((CSCI 2500 with a grade of C- or higher or (ECE 2205, ECE 3217, and ECE 3225)))

**CSCI 2930 - Special Topics**

**Credit(s): 1-4 Credits** (Repeatable for credit)

**CSCI 2980 - Independent Study**

**Credit(s): 1-3 Credits** (Repeatable for credit)

Prior approval of sponsoring professor and chair required.

**Attributes:** Special Approval Required

**CSCI 3050 - Computer Ethics****Credit(s): 3 Credits**

This course examines the moral, legal, and social issues raised by computers and electronic information technologies for different stakeholder groups (professionals, users, businesses, etc.). Students are expected to integrate moral theories and social analysis to address such issues as intellectual property, security, privacy, discrimination, globalization, and community.

**Prerequisite(s):** PHIL 2050

**Attributes:** UUC:Dignity, Ethics & Just Soc

**CSCI 3100 - Algorithms****Credit(s): 3 Credits**

Introduction to analysis and complexity of algorithms. Big-O notation. Running time analysis of algorithms for traversing graphs and trees, searching and sorting. Recursive versus iterative algorithms. Complexity, completeness, computability.

**Prerequisite(s):** CSCI 2100 and MATH 1660; (MATH 1510, MATH 1520, MATH 2530, and SLU Math Placement with a minimum score of 1520)

**CSCI 3200 - Programming Languages****Credit(s): 3 Credits**

Overview of programming languages: procedural and functional languages. Exposure to functional languages. Analysis of solution strategies to variable binding and function calls. Problem solving paradigms and linguistic issues.

**Prerequisite(s):** CSCI 2300

**CSCI 3250 - Compilers****Credit(s): 3 Credits**

Introduction to the theory and techniques of compiler design, lexical analysis, finite state automata, context-free grammars, top-down and bottom-up parsing, syntax analysis, code generation. Other important issues such as optimization, type-checking, and garbage collection will be discussed.

**Prerequisite(s):** (CSCI 2400 or ECE 3217); CSCI 2100

**CSCI 3300 - Software Engineering****Credit(s): 3 Credits**

Theory and practice of software engineering. Design and implementation of software systems. Levels of abstraction as a technique in program design. Organized around major group programming projects.

**Prerequisite(s):** CSCI 2300

**CSCI 3450X - Microprocessors****Credit(s): 3 Credits**

Review of number systems. Microprocessors/microcomputer structure, input/output. Signals and devices. Computer arithmetic, programming, interfacing and data acquisition. Fall semester.

**CSCI 3451X - Microprocessors Laboratory****Credit(s): 1 Credit**

Concurrent registration with ECE 3225. Laboratory experiments to emphasize materials covered in ECE 3225. Fall semester.

**CSCI 3500 - Operating Systems****Credit(s): 3 Credits**

Theory and practice of operating systems as managers of shared computer hardware: processors, memory, mass storage, and peripherals. Includes also an introduction to computer networking. Hands-on experience with general systems programming, concurrent and parallel programming, and network programming.

**Prerequisite(s):** (CSCI 2100; (CSCI 2400 or ECE 3217))

**CSCI 3710 - Databases****Credit(s): 3 Credits**

Fundamentals of database systems. Topics include relational and NoSQL data models, structured query language, the entity-relationship model, normalization, transactions, file organization and indexes, and data security issues. The knowledge of the listed topics is applied to design and implementation of a database application.

**Prerequisite(s):** CSCI 2100

**CSCI 3910 - Internship with Industry****Credit(s): 1-6 Credits** (Repeatable for credit)

A work experience with an agency, firm, or organization that employs persons in this degree field. Learning plan and follow-up evaluation required.

**Attributes:** UUC:Reflection-in-Action

**CSCI 3930 - Special Topics****Credit(s): 1-4 Credits** (Repeatable for credit)**CSCI 3980 - Independent Study****Credit(s): 1-3 Credits** (Repeatable for credit)

Prior approval of sponsoring professor and chairperson required.

**Attributes:** Special Approval Required

**CSCI 4120 - Advanced Data Structures****Credit(s): 3 Credits**

A comprehensive treatment of the design, analysis and implementation of advanced data structures, and their role in algorithmic design. Topics include data structures that are dynamic, persistent and/or cache-oblivious, an examination of performance including both amortized and probabilistic analyses, and domain-specific applications of data structures. (Offered occasionally)

**Prerequisite(s):** CSCI 3100

**CSCI 4310 - Software Architecture****Credit(s): 3 Credits**

The theory and practice of software architecture and global design of software systems, with focus on recurring architectural patterns via in-depth case studies of various large-scale systems. (Offered occasionally)

**Prerequisite(s):** CSCI 3300

**CSCI 4360 - Web Technologies****Credit(s): 3 Credits**

An overview of the client-side and server-side technologies that power the modern web. Hands-on experience with interactive web site and web application development for desktop and mobile. (Offered occasionally)

**Prerequisite(s):** CSCI 2300

**CSCI 4500 - Advanced Operating Systems****Credit(s): 3 Credits**

Parallel processes; processor problems; linear address space and tree structured spaces of objects; resource allocation, queuing and network control policies; system balancing and thrashing; job allocation and process scheduling; multiprogramming systems; protection mechanisms for accessing jobs; pipelining and parallelism; distributed systems.

**Prerequisite(s):** CSCI 2510

**CSCI 4530 - Computer Security****Credit(s): 3 Credits**

Fundamental introduction to the broad area of computer security. Topics include access control, security policy design, network security, cryptography, ethics, securing systems, and common vulnerabilities in computer systems.

**Prerequisite(s):** (CSCI 2510 or CSCI 3500)

**CSCI 4550 - Computer Networks****Credit(s): 3 Credits**

An exploration of the underlying concepts and principles of computer networks. Topics include communication protocols such as TCP/IP, design of network architectures, and the management and security of networks. Examples of real networks will be used to reinforce and demonstrate concepts.

**Prerequisite(s):** (CSCI 2510 or CSCI 3500)

**CSCI 4610 - Concurrent and Parallel Programming****Credit(s): 3 Credits**

The design and implementation of software that fully leverages a single computer's resources. Topics include profiling and optimization of codes, multi-threaded programming, parallelism using a graphical processor unit (GPU), and efficient use of memory cache. (Offered occasionally)

**Prerequisite(s):** (CSCI 2510 or CSCI 3500)

**CSCI 4620 - Distributed Computing****Credit(s): 3 Credits**

The design and implementation of software solutions that rely upon the cooperation of multiple computing systems. Topics will include parallelization of computation and data storage across small clusters of computers, and the deployment of systems in large-scale grid and cloud computing environments. (Offered occasionally)

**Prerequisite(s):** CSCI 2510

**CSCI 4710 - Databases****Credit(s): 3 Credits**

Fundamentals of database systems. Topics include relational and NoSQL data models, structured query language, the entity-relationship model, normalization, transactions, file organization and indexes, and data security issues. The knowledge of the listed topics is applied to design and implementation of a database application.

**Prerequisite(s):** CSCI 2100

**CSCI 4740 - Artificial Intelligence****Credit(s): 3 Credits**

Fundamental introduction to the broad area of artificial intelligence and its applications. Topics include knowledge representation, logic, search spaces, reasoning with uncertainty, and machine learning.

**Prerequisite(s):** CSCI 2100

**CSCI 4750 - Machine Learning****Credit(s): 3 Credits**

This course introduces students to the field of machine learning with emphasis on the probabilistic models that dominate contemporary applications. Students will discover how computers can learn from examples and extract salient patterns hidden in large data sets. The course will introduce classification algorithms that predict discrete states for variables as well as regression algorithms that predict continuous values for variables. Attention will be given to both supervised and unsupervised settings in which (respectively) labeled training data is or is not available.

**Prerequisite(s):** STAT 3850; CSCI 2100; MATH 2530

**Attributes:** Geospatial Elective

**CSCI 4760 - Deep Learning****Credit(s): 3 Credits**

An exploration of multi-layered machine learning architectures as applied to problems in a variety of domains. The course will study various network architectures including deep feed-forward, convolutional and recurrent networks, and uses in both supervised and unsupervised learning. Students will implement solutions in different problem domains, and learn to effectively manage practical and domain-specific issues that affect model performance. (Offered in Spring)

**Prerequisite(s):** CSCI 4750

**CSCI 4820 - Computer Graphics****Credit(s): 3 Credits**

Applications and implementation of computer graphics. Algorithms and mathematics for creating two and three dimensional figures. Animation and two and three dimensional transformations. Interaction, windowing, and perspective techniques. Coding using the graphics library OpenGL.

**Prerequisite(s):** (CSCI 2100; MATH 2530; (MATH 3110 or MATH 3120))

**CSCI 4830 - Computer Vision****Credit(s): 3 Credits**

This course will introduce the fundamentals of image processing and computer vision, including image models and representation, image analysis methods such as feature extraction (color, texture, edges, shape, skeletons, etc.), image transformations, image segmentation, image understanding, motion and video analysis, and application-specific methods such as medical imaging, facial recognition, and content-based image retrieval. (Offered occasionally)

**Prerequisite(s):** CSCI 2100

**CSCI 4845 - Natural Language Processing****Credit(s): 3 Credits**

Introduction to the development of computer systems that attempt to manage the complexity and diversity of human language. Application of artificial intelligence and machine learning techniques to address problems such as machine translation and speech recognition. Emphasis to be placed on working with real data sets in the form of text corpora and sound recordings. (Offered occasionally)

**Prerequisite(s):** CSCI 4750

**CSCI 4910 - Internship with Industry****Credit(s): 1-6 Credits (Repeatable for credit)**

A work experience with an agency, firm, or organization that employs persons in this degree field. Learning plan and follow-up evaluation required.

**Attributes:** UUC:Reflection-in-Action

**CSCI 4930 - Special Topics****Credit(s): 1-4 Credits (Repeatable for credit)****CSCI 4961 - Capstone Project I****Credit(s): 2 Credits**

The first part of a two-course sequence serving as a concluding achievement for graduating students. In this course, students develop a proposal, collect and formalize specifications, become acquainted with necessary technologies, and create and present a detailed design for completing the project.

**Prerequisite(s):** (CSCI 2510 or ECE 3127)

**Restrictions:**

Enrollment limited to students with a classification of Junior or Senior.

Enrollment limited to students in the Computer Science department.

**CSCI 4962 - Capstone Project II****Credit(s): 2 Credits**

The continuation of CSCI 4961. In the second part of the sequence, students complete their project based upon the design that was developed during the first part of the sequence. Students must demonstrate continued progress throughout the semester and make a preliminary and final presentation of their results.

**Prerequisite(s):** CSCI 4961

**CSCI 4980 - Advanced Independent Study****Credit(s): 1-6 Credits (Repeatable for credit)**

Prior permission of sponsoring professor and chairperson required.

**Attributes:** Special Approval Required

**CSCI 5001 - Object-Oriented Programming****Credit(s): 3 Credits**

An accelerated introduction to object-oriented computer programming including coverage of classes, methods, inheritance and polymorphism. Good software development practices will also be established, including issues of design, documentation, and testing. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**CSCI 5002 - Data Structures****Credit(s): 3 Credits**

An accelerated study of the design, implementation, and use of data structures. Principles of abstraction, encapsulation, and modularity to guide in the creation of robust, adaptable, reusable and efficient structures. Specific data types to include stacks, queues, dictionaries, trees, and graphs. Students not able to register due to the restrictions may contact the department for permission.

**Prerequisite(s):** CSCI 5001 with a grade of C- or higher

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**CSCI 5003 - Object-Oriented Software Design****Credit(s): 3 Credits**

An implementation-based study of object-oriented software development. Teams will design and create medium-scale applications. Additional focus on the design and use of large object-oriented libraries, as well as social and professional issues. (Offered annually)

**Prerequisite(s):** CSCI 5002 with a grade of C or higher

**CSCI 5004 - Introduction to Algorithms****Credit(s): 3 Credits**

Introduction to analysis and complexity of algorithms. Big-O notation. Running time analysis of algorithms for traversing graphs and trees, searching and sorting. Recursive versus iterative algorithms. Complexity, completeness, computability. (Offered annually)

**Prerequisite(s):** CSCI 5002 with a grade of C or higher

**CSCI 5005 - Intro to Operating Systems****Credit(s): 3 Credits**

Theory and practice of operating systems as managers of shared computer hardware: processors, memory, mass storage, and peripherals. Includes also an introduction to computer networking. Hands-on experience with general systems programming, concurrent and parallel programming, and network programming. (Offered annually)

**Prerequisite(s):** CSCI 5002 with a grade of C or higher

**CSCI 5030 - Principles of Software Development****Credit(s): 3 Credits**

An overview of software development at a graduate level, including software engineering processes, software design and architecture, testing and quality assurance, and selected other topics of interest to software practitioners. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Bioinformatics & Comp Bio Elec

**CSCI 5050 - Computing and Society****Credit(s): 3 Credits**

A study of legal and ethical issues that arise with the use of computing technologies, and how new technologies alter the society that we live in. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**CSCI 5070 - Algorithmic Fairness****Credit(s): 3 Credits**

Machine learning algorithms are being used more and more to make decisions that affect everyone. This course addresses the major moral concerns that these algorithms do not treat people fairly. Students will learn how to detect bias in machine learning models and construct models and training sets that minimize bias. (Offered occasionally)

**Prerequisite(s):** CSCI 5750 with a grade of C or higher

**Restrictions:**

Enrollment limited to students in the MS Bioinformatics Comp Biol program.

**CSCI 5090 - Computer Science Colloquium****Credit(s): 0-1 Credits (Repeatable for credit)**

A series of presentations, given by faculty members and invited speakers, to provide students with exposure to current research and developments in the field of computer science. Students will be required to produce written summaries of the presentations.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**CSCI 5100 - Algorithms****Credit(s): 3 Credits**

An overview of algorithm design and analysis. Topics include analysis of algorithms for traversing graphs and trees, searching and sorting, recursion, dynamic programming, and approximation, as well as the concepts of complexity, completeness, and computability. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Theory Elective

**CSCI 5120 - Advanced Data Structures****Credit(s): 3 Credits**

A comprehensive treatment of the design, analysis and implementation of advanced data structures, and their role in algorithmic design. Topics include data structures that are dynamic, persistent and/or cache-oblivious, an examination of performance including both amortized and probabilistic analyses, and domain-specific applications of data structures. (Offered occasionally)

**Attributes:** CS Grad-Theory Elective

**CSCI 5150 - Computational Geometry****Credit(s): 3 Credits**

The goal of computational geometry is to find efficient algorithms for solving geometric problems. Topics include convex hulls, Voronoi diagrams, Delaunay triangulations, geometric search and geometric data structures. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Theory Elective

**CSCI 5200 - Programming Languages****Credit(s): 3 Credits**

Overview of programming languages: procedural and functional languages. Exposure to functional languages. Analysis of solution strategies to variable binding and function calls. Problem solving paradigms and linguistic issues. Students not able to register due to the restrictions may contact the department for permission.

**Prerequisite(s):** CSCI 5030 with a grade of C- or higher

**Restrictions:**

Enrollment limited to students in the following programs:

- MS Bioinformatics Comp Biol
- Computer Science Accl Pathway

**Attributes:** CS Grad-Language/Compilers

**CSCI 5250 - Compilers****Credit(s): 3 Credits**

Theory and practice of compiler design, including lexical analysis, finite state automata, context-free grammars, parsing algorithms, and code generation. Other important issues such as optimization, type-checking, and garbage collection will be discussed. Students not able to register due to the restrictions may contact the department for permission.

**Prerequisite(s):** CSCI 5030 with a grade of C- or higher

**Restrictions:**

Enrollment limited to students in the following programs:

- MS Bioinformatics Comp Biol
- Computer Science Accl Pathway

**Attributes:** CS Grad-Language/Compilers

**CSCI 5300 - Software Engineering****Credit(s): 3 Credits**

Key aspects of the software engineering discipline, including software process models, software project initiation, software analysis and design, software project planning and management, and software process and product metrics. Students not able to register due to the restrictions may contact the department for permission.

**Prerequisite(s):** CSCI 5030 with a grade of C- or higher

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Software Engineering

**CSCI 5310 - Software Architecture****Credit(s): 3 Credits**

The theory and practice of software architecture and global design of software systems, with focus on recurring architectural patterns via in-depth case studies of various large-scale systems. Students not able to register due to the restrictions may contact the department for permission.

**Prerequisite(s):** CSCI 5300 with a grade of C- or higher

**Restrictions:**

Enrollment limited to students in the following programs:

- MS Bioinformatics Comp Biol
- Computer Science Accl Pathway

**Attributes:** CS Grad-Software Engineering

**CSCI 5330 - Software Quality Assurance****Credit(s): 3 Credits**

Best practices for the process of quality assurance for complex software systems. Topics include prevention of errors, testing, verification, and validation of software systems, inspection and review processes, and the distinction between process assurance and product assurance. Students not able to register due to the restrictions may contact the department for permission.

**Prerequisite(s):** CSCI 5300 with a grade of C- or higher

**Restrictions:**

Enrollment limited to students in the following programs:

- MS Bioinformatics Comp Biol
- Computer Science Accl Pathway

**Attributes:** CS Grad-Software Engineering

**CSCI 5360 - Web Technologies****Credit(s): 3 Credits**

An overview of the client-side and server-side technologies that power the modern web. Hands-on experience with interactive web site and web application development for desktop and mobile. Students not able to register due to the restrictions may contact the department for permission.

**Prerequisite(s):** CSCI 5030 with a grade of C- or higher

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Bioinformatics & Comp Bio Elec, CS Grad-Software Engineering

**CSCI 5500 - Operating Systems****Credit(s): 3 Credits**

Theory and practice of operating systems, with hands-on emphasis on one of the UNIX family of operating systems. Processes, processor scheduling, virtual memory, parallelism and concurrency, race conditions, file systems, networking models, sockets programming, as well as a general focus on operating systems mechanisms and abstractions. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the following programs:

- MS Bioinformatics Comp Biol
- Computer Science Accl Pathway

**Attributes:** CS Grad-Systems Elective

**CSCI 5530 - Computer Security****Credit(s): 3 Credits**

Fundamental introduction to the broad area of computer security. Topics will include access control, security policy design, network security, cryptography, ethics, securing systems, and common vulnerabilities in computer systems. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Systems Elective

**CSCI 5550 - Computer Networks****Credit(s): 3 Credits**

A graduate-level introduction to the concepts and principles of computer networks, including the basic technologies of a network and how these systems interact. Focus includes the design and implementation of network software that transforms raw hardware into a richly functional communication system. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Systems Elective

**CSCI 5570 - Machine Learning for Networks****Credit(s): 3 Credits**

An introduction to the underlying concepts and principles of data aspects of computer networks. The course covers machine learning techniques used by networked systems, for both wireless and wired networks.

Topics in network analytics and management including traffic analysis and prediction, service differentiation, detection of anomalous network conditions, and enhancement of end-to-end network management and operation. The course includes hands-on assignments using networking tools and large-scale virtual network testbeds that can be used to collect data from network protocols or analyze large data sets for networking problems. (Offered occasionally)

**Prerequisite(s):** CSCI 5550 with a grade of C or higher

**Restrictions:**

Enrollment limited to students in the programs.

**Attributes:** CS Grad-Systems Elective

**CSCI 5610 - Concurrent and Parallel Programming****Credit(s): 3 Credits**

The design and implementation of software that fully leverages a single computer's resources. Topics include profiling and optimization of codes, multi-threaded programming, parallelism using a graphical processor unit (GPU), and efficient use of memory cache. (Offered occasionally)

**Attributes:** CS Grad-Large Scale Systems

**CSCI 5620 - Distributed Computing****Credit(s): 3 Credits**

The design and implementation of software solutions that rely upon the cooperation of multiple computing systems. Topics will include parallelization of computation and data storage across small clusters of computers, and the deployment of systems in large-scale grid and cloud computing environments.

**Attributes:** CS Grad-Large Scale Systems

**CSCI 5710 - Databases****Credit(s): 3 Credits**

Fundamentals of database systems. Topics include relational and NoSQL data models, structured query language, the entity-relationship model, normalization, transactions, file organization and indexes, and data security issues. The knowledge of the listed topics is applied to design and implementation of a database application.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Knowledge Systems

**CSCI 5730 - Evolutionary Computation****Credit(s): 3 Credits**

A survey of the major types of evolutionary algorithms (EAs), a class of stochastic, population-based algorithms inspired by natural evolution theory, genetics, and population dynamics, which are capable of solving complex optimization and modeling problems. This is a rigorous and programming-intensive course in which students will gain hands-on experience in solving complex problems with EAs. (Offered occasionally)

**Restrictions:**

Enrollment limited to students in the MS Bioinformatics Comp Biol program.

**Attributes:** Bioinformatics & Comp Bio Elec, CS Grad-Knowledge Systems

**CSCI 5740 - Introduction to Artificial Intelligence****Credit(s): 3 Credits**

Fundamental introduction to the broad area of artificial intelligence and its applications. Topics include knowledge representation, logic, search spaces, reasoning with uncertainty, and machine learning.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Bioinformatics & Comp Bio Elec, CS Grad-Knowledge Systems

**CSCI 5745 - Advanced Techniques in Artificial Intelligence****Credit(s): 3 Credits**

Intelligent agents in complex environments must deal with uncertainty and how to represent varied knowledge. This course focuses on the design and implementation of agents that can function in such complex environments. Topics include knowledge representation, environments with hidden information, and probabilistic reasoning. (Offered occasionally)

**Prerequisite(s):** CSCI 5740 with a grade of C or higher

**Restrictions:**

Enrollment limited to students in the MS Bioinformatics Comp Biol program.

**Attributes:** CS Grad-Knowledge Systems

**CSCI 5750 - Introduction to Machine Learning****Credit(s): 3 Credits**

This course introduces students to the field of machine learning with emphasis on the probabilistic models that dominate contemporary applications. Students will discover how computers can learn from examples and extract salient patterns hidden in large data sets. The course will introduce classification algorithms that predict discrete states for variables as well as regression algorithms that predict continuous values for variables. Attention will be given to both supervised and unsupervised settings in which (respectively) labeled training data is or is not available. Emphasis is placed on both the conceptual relationships between these different learning problems as well as the statistical models and computational methods used to employ those models. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Knowledge Systems

**CSCI 5760 - Deep Learning****Credit(s): 3 Credits**

An exploration of multi-layered machine learning architectures as applied to problems in a variety of domains. The course will study various network architectures including deep feed-forward, convolutional and recurrent networks, and uses in both supervised and unsupervised learning. Students will implement solutions in different problem domains, and learn to effectively manage practical and domain-specific issues that affect model performance. (Offered occasionally)

**Prerequisite(s):** CSCI 5750 with a grade of C or higher

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Bioinformatics & Comp Bio Elec, CS Grad-Knowledge Systems

**CSCI 5830 - Computer Vision****Credit(s): 3 Credits**

This course will introduce the fundamentals of image processing and computer vision, including image models and representation, image analysis methods such as feature extraction (color, texture, edges, shape, skeletons, etc.), image transformations, image segmentation, image understanding, motion and video analysis, and application-specific methods such as medical imaging, facial recognition, and content-based image retrieval. Students not able to register due to the restrictions may contact the department for permission.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Bioinformatics & Comp Bio Elec, CS Grad-Advanced Applications

**CSCI 5845 - Natural Language Processing****Credit(s): 3 Credits**

Introduction to the development of computer systems that attempt to manage the complexity and diversity of human language. Application of artificial intelligence and machine learning techniques to address problems such as machine translation and speech recognition. Emphasis to be placed on working with real data sets in the form of text corpora and sound recordings. (Offered occasionally)

**Prerequisite(s):** CSCI 5750 with a grade of C or higher

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** CS Grad-Advanced Applications

**CSCI 5910 - Internship with Industry****Credit(s): 1-3 Credits (Repeatable for credit)**

A work experience with an agency, firm, or organization that employs persons in this degree field. Learning plan and follow-up reflection and evaluation are required. Permission of department required.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**CSCI 5930 - Special Topics****Credit(s): 1-3 Credits (Repeatable up to 12 credits)****Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**CSCI 5960 - Software Engineering Capstone Project****Credit(s): 3 Credits**

A culminating experience in which teams of students complete a full software development life-cycle resulting in the creating of a software system.

**Prerequisite(s):** CSCI 5300 with a grade of C- or higher

**Restrictions:**

Enrollment is limited to students with a program in Software Engineering.

**CSCI 5961 - Artificial Intelligence Capstone Project****Credit(s): 3 Credits**

A culminating experience in which teams of students solve complex problems using techniques from artificial intelligence.

**Prerequisite(s):** CSCI 5740 with a grade of C or higher; CSCI 5750 with a grade of C or higher

**Restrictions:**

Enrollment is limited to students with a program in Artificial Intelligence.

**CSCI 5970 - Research Topics****Credit(s): 1-3 Credits (Repeatable for credit)**

A research experience in computer science guided by faculty. Permission of instructor required.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Special Approval Required

**CSCI 5980 - Graduate Reading Course****Credit(s): 1-3 Credits (Repeatable up to 9 credits)****Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Special Approval Required

**CSCI 5990 - Thesis Research****Credit(s): 0-6 Credits (Repeatable for credit)**

Work towards a Master's thesis.

**Restrictions:**

Enrollment limited to students in the Computer Science or Math Stats/Computer Science departments.

**Attributes:** Special Approval Required

**CSCI 6990 - Dissertation Research****Credit(s): 0-6 Credits (Repeatable for credit)**

**Attributes:** Special Approval Required