COMPUTER SCIENCE (CS)

CS 1308. Computer Literacy and the Internet.
A study of the uses of computers and their effects on society. Text
processing, spreadsheets, databases, and Web programming. Does
not count for computer science credit towards a minor, a BS, or a BA in
computer science.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Lab Required
Grade Mode: Standard Letter
TCCN: COSC 1301

CS 1319. Fundamentals of Computer Science.
Provides fundamental knowledge of the six layers of computer science
as per the ACM CS0 curriculum. The information, hardware, programming,
operating system, applications, and communications layers are presented
plus appropriate open computer laboratory exercises. Does not count for
computer science credit towards a minor, BS, or BA in computer science.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
TCCN: COSC 1336

CS 1342. Programming for Scientists and Engineers.
This course is an introduction to computer science and problem
solving techniques with applications in engineering and the physical
sciences. Topics include an introduction to computer organization, data
representation, algorithm development, and computer programming in a
high-level language.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 1428. Foundations of Computer Science I.
Introductory course for computer science majors, minors and others
desiring technical introduction to computer science. Contains overview
of history and structure of the digital computer, including binary data
representation. Problem solving, algorithm development, structured
programming, good coding style, and control structures of C++ are
emphasized. Prerequisite: MATH 1315 or MATH 1317 or MATH 1319 or
MATH 1329 or MATH 2417 or MATH 2471, with a grade of "C" or better, or
ACT Mathematics score of 24 or more, SAT Mathematics score of 520 or
more, SAT Math Section score of 550 or more.
4 Credit Hours. 3 Lecture Contact Hours. 2 Lab Contact Hours.
Course Attribute(s): Lab Required
Grade Mode: Standard Letter
TCCN: COSC 1437

CS 2308. Foundations of Computer Science II.
The course is an introduction to Abstract Data Types (ADTs) including
lists, stacks, and queues. Searching and sorting, pointers and dynamic
memory allocation, and simple classes and objects also will be covered.
The course is a continuation of CS 1428. Prerequisite: CS 1428 with a
grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
TCCN: COSC 2336

CS 2315. Computer Ethics.
This course is primarily for computer science majors, focusing on the
ethical codes of the professional societies, the philosophical bases of
ethical decision-making, and the examination of several contemporary
case studies. Prerequisites: CS 1428 and ENG 1310 and COMM 1310, and
PHIL 1305 or PHIL 1320, all with a grade of "C" or better. (WI).
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Writing Intensive
Grade Mode: Standard Letter

CS 2318. Assembly Language.
A course covering assembly language programming, including instruction
sets, addressing modes, instruction formats, looping, logic, data
representation, subroutines and recursion; and the interface between
hardware and software. Prerequisites: MATH 2358 and CS 2308, all with a
grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
TCCN: COSC 2325

CS 3300. Internet Software Development.
A course providing foundations for the construction and design of static
and dynamic Web pages with database applications. This will include
server-side and client-side software development. Prerequisite: CS 2308
with a grade of "C" or better, or consent of instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

Use of fundamental hardware components. Topics include ALU's, single
and multiple cycle datapath and control, RISC vs. CISC, pipelining,
caches, I/O, virtual memory and related performance issues. Prerequisite:
CS 2318 or EE 3420 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 3354. Object-Oriented Design and Programming.
The course covers object-oriented design principles and programming
for students with prior programming experience. The topics include
inheritance and polymorphism, object-oriented design process, UML
diagrams, design patterns, exception handling and multithreading.
Students will design and implement programs in Java. Cannot receive
credit if the student has taken CS 4354. Prerequisite: CS 2308 with a
grade of "C" or better, or consent of instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 3358. Data Structures and Algorithms.
This is a course that covers classic data structures and the analysis of
algorithms. Prerequisites: CS 2308 and MATH 2358, all with a grade of C
or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
CS 3369. Embedded Computer Systems.
This course studies the architecture of embedded systems, micro-controllers, their peripherals, languages, and operating systems and the special techniques required to use them. Prerequisite: CS 2318 or EE 3420 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 3378. Theory of Automata.
An introduction to automata theory, computability, and formal languages. Prerequisite: CS 3358 with a grade of C or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 3393. Software Testing.
This course introduces basic concepts and techniques for testing software and finding bugs. Topics include test design, test process, unit, integration and system testing, manual and automatic techniques for generation of test inputs and validation of test outputs, and coverage criteria. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 3398. Software Engineering.
The study of software design, implementation, and validation techniques through team projects. Structured analysis, programming style, and project documentation are emphasized in large software projects. (WI) Prerequisite: CS 2315 or EE 2400; CS 3354 and CS 3358; all with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Writing Intensive
Grade Mode: Standard Letter

CS 4100. Computer Science Internship.
Provides on-the-job training supervised by computer scientists in industry internship programs approved by the department. Prerequisite: CS majors and minors only.
1 Credit Hour. 0 Lecture Contact Hours. 20 Lab Contact Hours.
Grade Mode: Credit/No Credit

CS 4298. Undergraduate Research I.
Supervised individual research project in a mentor-student relationship with a computer science faculty member. Cannot be given degree credit until the satisfactory completion of CS 4299. Prerequisites: Junior standing; major GPA of 3.00; departmental approval.
2 Credit Hours. 1 Lecture Contact Hour. 2 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Credit/No Credit

CS 4299. Undergraduate Research II.
Supervised individual research projects in a mentor-student relationship with a computer science faculty member. Prerequisites: CS 4298 and departmental approval.
2 Credit Hours. 1 Lecture Contact Hour. 2 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Standard Letter

CS 4301. Operating Systems.
This course covers the principles of operating systems design. The covered topics include: process management, CPU scheduling algorithms, inter-process communication and synchronization, memory management, virtual machines and I/O device management. Prerequisites: CS 3339 and CS 3358; both with grades of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4310. Computer Networks.
This course covers the fundamental concepts in the design of computer networks and networking protocols with emphasis on the Internet (TCP/IP) architecture. The covered topics include: protocol layering, media access, internet routing, transport protocols and applications. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4315. Introduction to Data Mining.
This course covers fundamental concepts and techniques in data mining and information retrieval. Data mining topics include classification, cluster analysis and pattern mining. Information retrieval topics include Boolean retrieval, vector space model, and Web search. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4318. Compiler Construction.
This course investigates theoretical and practical issues in the design and construction of modern compilers. Topics covered include lexical and syntactic analysis, syntax-directed translation, type checking, intermediate representation, code generation, and runtime systems. A major portion of the course involves implementing a compiler from scratch for a C-like programming language. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

Principles and methods in human factors and ergonomics applied to the design and use of computer systems. Prerequisite: CS 3358 with a grade of "C" or better. (WI).
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Writing Intensive
Grade Mode: Standard Letter

This course covers the principles of operating systems design. The covered topics include: process management, CPU scheduling algorithms, inter-process communication and synchronization, memory management, virtual machines and I/O device management. Prerequisites: CS 3339 and CS 3358; both with grades of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4332. Introduction to Database Systems.
Introduction to database concepts, data models, file structures, query languages, database management systems. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4346. Introduction to Artificial Intelligence.
An introduction to the basic concepts of artificial intelligence; search techniques, knowledge representation, problem solving. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
This course provides systematic introduction to machine learning, covering basic theoretical as well as practical aspects of the use of machine learning methods. Topics include learning theory, learning methods, and recent learning models. Application examples include multimedia information retrieval, text recognition, and computer vision. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4379V. Fundamentals of Algorithm Design and Analysis.
This course covers classic algorithms in computer science and their applications, with emphasis on algorithm design, algorithm analysis, and problem formulation. Topics include disjoint sets and union-find algorithms, tree and graph algorithms, sorting algorithms, greedy algorithms, dynamic programming, and string processing algorithms. Prerequisite: CS 3358 with grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Topics Grade Mode: Standard Letter

CS 4379C. Introduction to Computer Vision.
This course covers fundamental topics of computer vision. Topics include elementary image operations and transformations, template matching, object recognition, classification and tracking, camera models and stereo vision, and image retrieval from image databases. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Topics Grade Mode: Standard Letter

CS 4350. Unix Systems Programming.
Fundamentals of Unix operating systems, Unix file system and environment, C memory allocation, development tools, processes and signals, threads, device drivers, and programming for security. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4379B. Introduction to Graphical User Interfaces.
This course covers abstract and practical foundations of graphical user interface design, evaluation, and implementation. It discusses the fundamentals of computer graphics and interactive computer/human interfaces. The course includes a survey of usability measures, the major GUI standards, and GUI tools. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Topics Grade Mode: Standard Letter

CS 4379. Introduction to Recommender Systems.
This course covers the basic concepts of recommender systems, including personalization algorithms, evaluation tools, and user experiences. We will discuss how recommender systems are deployed in e-commerce sites, social networks, and many other online systems. Additionally, we will review current research in the field. Prerequisite: CS 3358 with a grade of "C" or better, or consent of instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Topics Grade Mode: Standard Letter

CS 4379. Introduction to Green Computing.
Reducing energy consumption of mobile devices, cloud computing platforms, and supercomputers is a paramount but daunting problem. This course covers fundamental concepts and techniques in green computing, including a hardware energy efficiency roadmap; energy efficient software design, resource management, and storage solutions; and green data centers and mobile computing. Prerequisites: CS 3339 and CS 3358 with grades of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Topics Grade Mode: Standard Letter

CS 4379. Parallel Programming.
This course teaches practical aspects of parallel programming. The covered topics include multi-core processors and shared-memory programming, hardware accelerator programming, and distributed-memory machines and message-passing programming. The students will gain the knowledge and skills needed for developing parallel software by writing programs for a variety of parallel computers. Prerequisite: CS 3339 and CS 3358 with a grade of "C" or higher, or instructor consent.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4368. Survey of Computer Languages.
A survey of computer languages. Criteria for choosing languages to be covered include history, important development paradigms and environments, and language implementations. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

Course covers practical aspects of computer system security including managing and producing code for secure systems. Theory, such as cryptography, is introduced as needed. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4372. Introduction to Digital Multimedia.
The course covers concepts, problems and techniques in digital multimedia. Topics include digital representation and data compression of text, speech, audio, natural and synthetic images, and video, as well as multimedia applications, transmission, and standards. In addition, the course introduces perceptual aspects of multimedia signals and sources. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4379Y. Introduction to Green Computing.
Course Attribute(s): Exclude from 3-peat Processing
Topics
CS 4381. Practical Game Development.
This course teaches practical aspects of computer game design and implementation. Topics include graphics game engines, game physics, AI methods applied to games, and software architectures for computer games. Students will gain knowledge and skills needed for game development via team projects. Prerequisite: CS 3398 with grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

A study of the hardware and software used in graphic representation and interpretation of data. Prerequisites: CS 3358 with a grade of C or higher and familiarity with trigonometric functions.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 4395. Independent Study in Computer Science.
Open to undergraduate students on an independent basis by arrangement with the faculty member concerned. Requires department chair approval.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Credit/No Credit

CS 4398. Software Engineering Project.
Students undertake a software development project. They work in teams, developing requirements and designs which they will implement and test. Prerequisite: CS 3398 with grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5100. Advanced Computer Science Internship.
This course provides advanced training supervised by computer scientists in internship programs approved by the department. Course cannot be counted toward any graduate degree, is open only to majors in the Department of Computer Science. May be repeated once and requires approval of the department chair. This course does not earn graduate degree credit.
1 Credit Hour. 0 Lecture Contact Hours. 1 Lab Contact Hour.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Leveling/Assistantships

CS 5199B. Thesis.
This course represents a student's continuing thesis enrollments. The student continues to enroll in this course until the thesis is submitted for binding.
1 Credit Hour. 1 Lecture Contact Hour. 0 Lab Contact Hours.
Grade Mode: Credit/No Credit

CS 5299B. Thesis.
This course represents a student's continuing thesis enrollments. The student continues to enroll in this course until the thesis is submitted for binding.
2 Credit Hours. 2 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Credit/No Credit

CS 5300. Professional Development of Graduate Assistants.
This course is designed to develop and enhance the professional and technical skills of graduate teaching and instructional assistants. Topics covered may include, but are not limited to, teaching skills, technical skills, ethical and legal issues, and laboratory management. This course does not earn graduate degree credit.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Graduate Assistantship
Grade Mode: Leveling/Assistantships

CS 5301. Programming Practicum.
Intensive review of programming through data structures. Includes syntax, semantics, problem solving, algorithm development, and in-class exercises. May be repeated once. This course does not earn graduate degree credit. Prerequisite: Consent of instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Leveling/Assistantships

CS 5302. Foundations of Data Structures and Algorithm Design.
This course serves as a foundation course for computer science master's degree students who need reinforcement of fundamental concepts covered by CS 3358. May be repeated once. This course does not earn graduate degree credit. Prerequisite: Instructor Approval.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Leveling/Assistantships

This foundation course for CS master's degree students who need concept reinforcement covers fundamental hardware components. Topics include ALUs, single and multiple cycle datapath and control, RISC vs. CISC, pipelining, caches, I/O, virtual memory, and related performance issues. It may be repeated once and is non-graduate degree credit. Prerequisite: Instructor Approval.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Leveling/Assistantships

This foundation course for CS master's degree students who need fundamental concept reinforcement. It covers the principles of operating systems, algorithms for CPU scheduling, memory management, cooperating sequential processes and device management. It may be repeated once. This course does not earn graduate degree credit. Prerequisite: Instructor Approval.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Leveling/Assistantships

A study of modern operating systems including network, distributed, or real-time systems. Prerequisites: CS 3358 and CS 4328 all with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
**CS 5310. Network and Communication Systems.**
A study of network and communication systems. Verification and/or implementation of protocols will be required. Prerequisite: CS 3358 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5316. Data Mining.**
This course covers fundamental concepts and techniques plus recent developments in data mining and information retrieval. It provides relevant research training and practice opportunities. May not be taken for credit if student received credit for CS 4315. Prerequisite: CS 3358 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5318. Principles of Programming Languages.**
This course focuses on the principles of programming languages. Topics covered include programming paradigms, concepts of programming languages, formal syntax and semantics, and language implementation issues. Prerequisite: CS 3358 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5326. Advanced Studies in Human Factors of Computer Science.**
Professional level presentation of techniques and research findings related to human-computer interactions. Prerequisite: CS 3358 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5329. Algorithm Design and Analysis.**
Introduction to algorithm design and analysis, computational complexity, NP completeness theory. Prerequisites: CS 3358 and MATH 2472 and MATH 3398 or MATH 5358, all with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5331. Crafting Compilers.**
Overview of the internal structure of modern compilers. Research on compilation techniques. Topics include lexical scanning, parsing techniques, static type checking, code generation, dataflow analysis, storage management, and execution environments. Prerequisite: CS 3358 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5332. Data Base Theory and Design.**
Computer system organization for the management of data; data models, data model theory; optimization and normalization; integrity constraints; query languages; intelligent database systems. Prerequisites: CS 3358 and CS 4328, all with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5334. Advanced Internet Information Processing.**
Integration of popular scripting languages (Perl, JavaScript, PHP, and other CGI capable languages) and database programming languages (embedded database programming languages, Java Servlets, and PHP) to provide advanced information processing for Internet applications that demand both database support and sophisticated, application specific information processing. Prerequisite: CS 4332 or CS 5332 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5335. Research in Object-Oriented System Development.**
The course covers the object-oriented methodologies for system analysis, design, implementation, testing, and other aspects of system development. Emphasis will be on using OO methodologies to manage the complexity of complicated software. Other topics like modeling, OODB, and OO languages will also be covered. Prerequisites: CS 3358, and either CS 4332 or CS 5332, all with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5338. Formal Languages.**
Advanced topics in automata theory, grammars, Turing machines, decidability, and algorithmic complexity. Prerequisites: CS 3358 and MATH 3398 all with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5341. Advanced Network Programming.**
Study of advanced concepts and programming skills in computer networks such as advanced TCP/IP API, multicasting and broadcasting, reliable communications, advanced I/O functions and options. Prequisite: CS 5310 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5343. Wireless Communications and Networks.**
Study of the fundamental aspects of wireless communications and wireless/mobile networks, introduction of wireless/mobile networking APIs. Prerequisites: CS 3358 with a grade of "B" or better, and CS 5310 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5346. Advanced Artificial Intelligence.**
Knowledge representation; knowledge engineering; parallel and distributed AI; heuristic searches; machine learning and intelligent databases; implementation of systems in high-level AI languages. Prerequisite: CS 3358 with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*

**CS 5351. Parallel Processing.**
Introduction to the design and analysis of parallel algorithms, parallel architectures, and computers. Prerequisites: CS 3358 and CS 4328 all with a grade of "C" or better.

*3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.*
*Grade Mode: Standard Letter*
CS 5352. Distributed Computing.
Study of advanced topics in distributed systems: concurrency control and failure recovery, management of replicated data, distributed consensus and fault tolerance, remote procedure calls, naming and security. Prerequisites: CS 3358 and CS 4328 all with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5369B. Computer Vision.
This course covers the basic and recent topics in computer vision. Topics include classic computer vision features, object tracking and recognition, detection and segmentation, camera models, and image and video retrieval. Prerequisite: CS 3358 or equivalent, with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing|Topics
Grade Mode: Standard Letter

CS 5369G. Web Service Engineering.
Advanced concepts and techniques for enabling Web application integration and interaction using Semantic Web and Web services. Concepts and techniques include service discovery ontology (RDF, DAML-S), XML-based interactions standards (ebXML, RossettaNet) and Web Services (WSDL, SOAP, UDDI, BPEL). Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5369J. Advanced Human Computer Interaction.
This course will cover state of the art human computer interaction topics such as perceptual compression, eye-gaze, and brain computer interfaces with emphasis on the human visual system, eye-tracking, and electroencephalography. Prerequisite: CS 3358 with a grade of "D" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Topics
Grade Mode: Standard Letter

CS 5369L. Machine Learning and Applications.
Provides broad introduction to machine learning, including learning theory, and recent topics like support vector machines and feature selection. Covers basic ideas, intuition, and understanding behind modern machine learning methods. Discusses applications like face recognition, text recognition, biometrics, bioinformatics, and multimedia retrieval. Prerequisite: CS 3358 grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Topics
Grade Mode: Standard Letter

CS 5369M. Software Evolution and Maintenance.
Software evolution and maintenance is one of the most important and complex activities in software engineering. Programmers rarely build software from scratch but often modify existing software to fix defects or add new features. This course studies the fundamentals of cutting-edge techniques and tools for software evolution and maintenance. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing|Topics
Grade Mode: Standard Letter

CS 5369Q. Recommender Systems.
This course covers various concepts of recommender systems, including personalization algorithms, evaluation tools, and user experiences. Discussion of how recommender systems are deployed in business applications, design of new recommender experiences, and how to conduct and evaluate research in recommender systems. Cannot take for credit if already took CS 4379Q. Prerequisite: CS 3358 with a grade of "C" or better or consent of instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing|Topics
Grade Mode: Standard Letter

CS 5369Y. Green Computing.
Reducing mobile device, cloud computing platform, and supercomputer energy consumption is a paramount, daunting problem. This course covers state-of-the-art green computing research, including energy-efficient hardware and software design, power-aware resource management and storage solutions, green data centers and mobile computing. Cannot be taken for credit if received CS 4379Y credit. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing|Topics
Grade Mode: Standard Letter

A study of the digital representation and processing of major multimedia data types: image, audio, and video. Compression techniques for the three data types, standards, and storage media. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5376. Enterprise Application Integration.
Introduction to the integration of all services available on the Web. It emphasizes component-based integration frameworks based on J2EE specification (EJB, Servlets, JMS), inter-organization workflow integration frameworks, and XML framework. Students must have knowledge of object-oriented design, object-oriented programming language, databases, and networking. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

This course covers various aspects of producing secure computer information systems that provide guaranteed controlled sharing. Emphasis is on software models and design, including discovery and prevention of computing systems security vulnerabilities. Current systems and methods are examined and critiqued. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

A study of the algorithms and data structures used in representing and processing visual data. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
CS 5389. Graphical User Interfaces.
Covers both abstract and practical treatments of using graphics to implement interactive computer/human interfaces. Includes a survey of the major GUI standards and tools. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5391. Survey of Software Engineering.
A study of the software life cycle with emphasis on system analysis and design. Methodologies based on data flows and on objects will be surveyed. A component on professional ethics is included. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

The use of design and specification languages in producing software systems. Emphasis is placed on proving correctness of designs and implementations. Prerequisites: CS 3358 and CS 5391 all with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5393. Software Quality.
The latter half of the software life cycle is discussed. Topics include testing, performance evaluation, and software metrics. Appropriate software tools are studied and used. Prerequisite: CS 5391.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5394. Advanced Software Engineering Project.
Students produce a software project of significant size in a team environment. All aspects of the software engineering course sequence are integrated and put into practice. Prerequisite: CS 5391 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

Open to graduate students on an independent basis by arrangement with the faculty member concerned. Course is not repeatable for credit. Prerequisite: CS 3358 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Credit/No Credit

The essentials of software engineering processes, methods, and tools for the evolutionary design of complex interactive software are discussed. Overviews of other topics like quality concepts, SEI CMM, information technology, and network technology are covered. Student completes a literature survey of the latest software engineering analysis and design processes, methods, and tools. Prerequisite: CS 5391 with a grade of "C" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 5399A. Thesis.
This course represents a student's initial thesis enrollment. No thesis credit is awarded until the student has completed the thesis in CS 5399B.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Credit/No Credit

CS 5399B. Thesis.
This course represents a student's continuing thesis enrollment. The student continues to enroll in this course until the thesis is submitted for binding.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Credit/No Credit

CS 5599B. Thesis.
This course represents a student's continuing thesis enrollments. The student continues to enroll in this course until the thesis is submitted for binding.
9 Credit Hours. 9 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Credit/No Credit

CS 7100. Graduate Computer Science Internship.
This course provides advanced training supervised by computer scientists in internship programs approved by the department.
1 Credit Hour. 0 Lecture Contact Hours. 1 Lab Contact Hour.
Course Attribute(s): Exclude from 3peat Processing
Grade Mode: Credit/No Credit

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Repeatable for credit.
Prerequisite: Consent of the dissertation advisor.
1 Credit Hour. 1 Lecture Contact Hour. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3peat Processing
Grade Mode: Credit/No Credit

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Repeatable for credit.
Prerequisite: Consent of the dissertation advisor.
2 Credit Hours. 2 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3peat Processing
Grade Mode: Credit/No Credit
CS 7300. Introduction to Research in Computer Science.
This credit/no credit course is designed to develop research and communication skills for Ph.D. students. Topics covered include research processes, research methods, ethics, conducting literature review, critiquing papers, preparing research proposals, faculty research presentations, and the software tools and platforms available for conducting applied computing research.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Credit/No Credit

CS 7308. Computer Science Studies.
This course provides foundations in computer science for students entering the doctoral program who may need certain background or leveling coursework. The course does not earn graduate degree credit. It is repeatable with a different emphasis.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Exclude from Graduate GPA|Leveling
Grade Mode: Leveling/Assistantships

CS 7309. Professional Development of Doctoral Assistants.
This course is designed to equip the doctoral students with skills and an understanding of the proper procedures to be effective doctoral instructional and teaching assistants. This course does not earn graduate degree credit.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Graduate Assistantship
Exclude from Graduate GPA|Leveling
Grade Mode: Leveling/Assistantships

CS 7311. Data-Driven Computational Methods and Infrastructure.
This course covers computational and statistical methods for using large-scale data sets ("big data") to answer scientific and business questions. It focuses on framing research questions, understanding how data can answer them, and using modern software tools for scalable data storage, processing, and analysis.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7312. Advanced Data Mining.
This course provides in-depth coverage of advanced data mining and information retrieval principles and techniques. It also offers extensive training and practice opportunities in frontier research directions. Prerequisite: CS 5316 or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7313. Advanced Machine Learning and Pattern Recognition.
This course provides students advanced theoretical and practical skills to learn, design, implement, and apply machine learning and pattern recognition approaches. The students will gain analytical and problem-solving skills by studying machine learning and pattern recognition techniques and applying them to solve real problems.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7314. Bioinformatics.
This course introduces advanced algorithms for data-intensive computational analysis targeting biological applications such as drug response prediction, gene network analysis, and protein/RNA structure prediction. Main techniques include greedy search, linear regression, clustering, network analysis, expectation maximization, and Hidden Markov models, which are widely applicable beyond biological data. Prerequisite: CS 5329 or CS 5369L or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

This course provides an introduction to Human Computer Interaction (HCI) research, methods, and topics, including fundamentals of user interface and experimental design, usability, evaluation methods, software toolkits for interactive applications, graphics, visualization, mobile design, collaborative and social computing, biological factors, and human computation.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7322. Human Factors and Ergonomics.
This course combines knowledge in the fields of intelligent user interfaces, human factors, ergonomics, and environmental psychology. Topics include HCI principles, human information processing, anthropometry, principles of eye tracking and their effects on human factors research, as well as operations of biometrics systems and human factors influencing those systems.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7323. Image Processing and Computer Vision.
Image Processing and Computer Vision are research areas with a variety of modern applications ranging from the analysis of images and videos to real-time processing of image streams coming from self-driving vehicles and robotic agents. This course will prepare students with advanced state of the art knowledge in those fields. Prerequisite: CS 5329 or equivalent, with a grade of "B" or better.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7324. HCI Paradigms for Animation, Visualization, and Virtual/Augmented Reality.
This course introduces advanced methods for enhancing user experience and presents effective HCI models via computer graphics, imaging, animation, simulation, visualization, augmented reality, and immersive virtual reality. Additionally, the course presents related science and engineering foundations as well as graphic design, cognitive science, and perceptual psychology theories and models. Prerequisite: CS 5329 or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter
CS 7331. High-Performance Computing.
This course covers the advanced design, analysis, and optimization of high-performance applications. Topics include high-performance computer architectures, including accelerators and systems-on-chip, performance modeling and benchmarking, data and control dependence analysis, data locality estimation, memory hierarchy management, techniques for exposing parallelism, and code transformations. Different workloads are studied. Prerequisite: CS 5329 or equivalent with a grade of B or higher, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

This course covers advanced design of parallel algorithms, performance modeling, parallel hardware, language support for parallel programming, and programming models for shared- and distributed-memory systems ranging from handheld multicore devices to large-scale clusters and accelerators. The students will gain applied knowledge and skills by developing parallel software for multiple platforms. Prerequisite: CS 5351 or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

This course covers hardware and software techniques to improve the energy-efficiency of computing systems. Topics include best practices in building energy-efficient data centers and mobile devices, current trends in reducing the energy consumption of processors and storage components, energy-aware resource management, software optimizations, and hands-on experience on power-measurable systems. Prerequisite: CS 5351 and CS 5369Y or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7334. Mobile Networks and Computing.
This course provides an in-depth study of wireless mobile communication networks, wireless network measurements and modeling, channel assignments and coverage, wireless network protocols, mobile data management, wireless security, and various wireless network applications including ad hoc, sensor networks, delay-tolerant networks, and mobile social networks. Prerequisite: CS 5310 or CS 5343 or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7335. Advanced Software Engineering.
Software engineering is the application of scientific methods to software development and maintenance. This course provides an in-depth study of advanced concepts and techniques of automatic software generation and analysis. Topics include software process programming, symbolic execution, model checking, property generation and checking, and runtime verification of complex software systems. Prerequisite: Consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Grade Mode: Standard Letter

CS 7337. Research in Computer Science.
This course covers up-to-date research topics in computer science under the direction of a supervising professor. The course can be repeated once for additional credit with a different emphasis. Prerequisite: Consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Credit/No Credit

CS 7387. Advanced Software Engineering.
This course introduces concepts and principles for enabling the development of software as a service based on Service-Oriented Architecture (SOA), methodology of SOA systems development, the main technologies used in achieving SOA, and state of the art techniques and advances in emerging cloud and edge (Internet of Things) services. Prerequisite: CS 5329 or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Standard Letter

CS 7389A. Service Computing.
This course introduces concepts and principles for enabling the development of software as a service based on Service-Oriented Architecture (SOA), methodology of SOA systems development, the main technologies used in achieving SOA, and state of the art techniques and advances in emerging cloud and edge (Internet of Things) services. Prerequisite: CS 5329 or equivalent with a grade of "B" or better, or consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Standard Letter

CS 7389B. Advanced Software Evolution.
This topics course provides an in-depth study of state-of-the-art software evolution techniques and tools based on the current research literature. Software evolution has become increasingly important in software development. Software systems often evolve to fix defects, to improve performance, or to adapt to various other requirements. Prerequisite: Consent of the instructor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Standard Letter
Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Repeatable for credit.
Prerequisite: Consent of the dissertation advisor.
3 Credit Hours. 3 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Credit/No Credit

CS 7599. Dissertation.
Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Repeatable for credit.
Prerequisite: Consent of the dissertation advisor.
5 Credit Hours. 5 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Credit/No Credit

Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Repeatable for credit.
Prerequisite: Consent of the dissertation advisor.
6 Credit Hours. 6 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Credit/No Credit

CS 7999. Dissertation.
Original research and writing in computer science is to be accomplished under the direct supervision of the Ph.D. research advisor. While conducting dissertation research and writing, the student must be continuously enrolled each long semester. Repeatable for credit.
Prerequisite: Admission to candidacy and consent of the dissertation advisor.
9 Credit Hours. 9 Lecture Contact Hours. 0 Lab Contact Hours.
Course Attribute(s): Exclude from 3-peat Processing
Grade Mode: Credit/No Credit