Department of Computer Science

Chair: Dr. Yuliang Zheng

The Department of Computer Science (CS) offers a BA degree in CS, a BS degree in CS, a BS degree in Bioinformatics (offered jointly with the School of Medicine and the Department of Biology), a BS degree in Digital Forensics (offered jointly with the Department of Criminal Justice), and a minor in CS. The BS degree in CS is accredited by the Computing Accreditation Commission of ABET, abet.org, and is designed for students desiring a more in-depth exploration of computer science, giving students a broad background in the design of software, the structure and theory of information and computation, and the hardware and software of computer and computer-based systems. The BA degree in CS is designed for students wishing to apply the tools and techniques of computer science to solving interdisciplinary problems in science, arts, humanities, business, and other areas, equipped with T-shaped knowledge and skill sets. The BS in Bioinformatics trains students in basic concepts and skills to perform computational analysis of biological data — including the human genome. Finally, the BS in Digital Forensics is an interdisciplinary degree that prepares graduates for a professional career in the field of digital forensics and cyber security. Minors are available for students who are not CS majors but who expect to use the computer in the application area of their major field. For more information, see the CS department web site at cs.uab.edu.

Requirements for students transferring to a CS major from other programs within UAB

Students admitted to an undergraduate program at UAB may transfer to CS provided they have earned a UAB GPA of 2.0 or better. The Bioinformatics degree has more stringent requirements: please see its catalog page.

Requirements for students transferring to a CS major from other institutions

Transfer students from other institutions may transfer to the CS program provided they have earned a GPA of 2.0 or better. If this requirement is not met, transfer students must transfer as a Liberal Arts major in the College of Arts and Sciences, meet the GPA requirement, and then apply to become a CS major. The Bioinformatics degree has more stringent requirements: please see its catalog page.

Minimum grade required for courses applying to the CS major.

For both the major and minor, a grade of C or better is required in each of the computer science courses. CS courses taken at another institution for which a grade of D was received may not be counted toward the CS major or the CS minor.

300 and 400-level courses

In the Bachelor of Science in Computer Science major, at least 12 semester hours of CS courses at the 300 level or above must be taken at UAB. In the Bachelor of Arts in Computer Science major, at least 12 semester hours of CS courses at the 200 level or above must be taken at UAB. Any CS course at the 300 level or above can be taken to satisfy the

12 semester hour CS elective credit. A maximum of 3 semester hours may be obtained in Directed Readings.

CS courses at the 400-level and above are normally restricted to CS Majors. Non-majors may register for such courses only with the specific permission of the specific course Instructor.

Accelerated Learning Opportunities

Computer Science offers both Accelerated Bachelors/Masters (ABM) and Fast-Track options for high-achieving undergraduate students pursuing an undergraduate degree in computer science or a BS degree in Physics at UAB. Please see the Graduate School website for details.

Graduate Programs

The Department of Computer Science offers graduate study leading to the Master of Science in Computer Science, the Master of Science in Data Science, and the Doctor of Philosophy in Computer Science. We also offer, jointly with Criminal Justice, a Master of Science degree in Cyber Security. Further information may be obtained from the department or the UAB Graduate School Catalog.

UABTeach

The CS Department participates in UABTeach. For more information, see the UABTeach website at https://www.uab.edu/uabteach/

Bachelor of Arts with a Major in Computer Science

Requirements		Hours
A grade of C or better is required in all of the following courses. At least 12 hours of CS courses at the 200-level or above must be taken at UAB		
Mathematics Requirement		
MA 125	Calculus I	4
Required CS Courses		
CS 103 & 103L	Introduction to Computer Science in Python and Introduction to Computer Science in Python Lab	4
CS 203 & 203L	Object-Oriented Programming in Java and Object-Oriented Programming Lab	4
CS 250	Discrete Structures	3
CS 300	Advanced Object-Oriented Programming in C++	3
CS 303	Algorithms and Data Structures	3
CS 330	Computer Organization and Assembly Language Programming	3
CS 420	Software Engineering	3
CSA 499	Senior BA Capstone	3
CS Electives [1]		**12**
Select four courses in Computer Science (CS), each course at the 200-level or above, and each course at least 3 hours. One of these 4 courses must be at the 400-level or above.		
A minor is required		
Since the intent of the minor is to add breadth in a non-computing area to complement the CS degree, the following minors are not allowed: Information Systems (Business), Electrical Engineering (Engineering), and Software Engineering (Engineering). If a student completes a double major, the minor requirement is waived.		
Total Hours		**42**

[1] Students may take a maximum of 3 hours combined of the following independent study courses: CS 398 CS 399, CS 496.

Bachelor of Science with a Major in Computer Science

Requirements		Hours
Blazer Core Curriculum		**41**
General Electives		**7**
Mathematics Requirements [1, 2]		
MA 125	Calculus I	4
MA 126	Calculus II	4
MA 260	Introduction to Linear Algebra	3
or MA 434	Algebra I: Linear	
Select one of the following:		3-4
MA 227	Calculus III	
MA 252	Introduction to Differential Equations	
MA 360	Scientific Programming	
MA 361	Mathematical Modeling	
MA 440	Advanced Calculus I	
MA 444	Vector Analysis	
MA 445	Complex Analysis	
MA 466	Introduction to Optimization	
MA 470	Differential Geometry	
MA 472	Geometry I	
MA 485	Probability	
EGR 265	Math Tools for Engineering Problem Solving	
Natural Sciences Requirement [1]		
A two-course sequence in a lab-based natural science is required. These 8 hours must be chosen from one of the following two-course sequences (or 4-course sequence in the case of Chemistry, since labs are treated as separate courses):		8
BY 123 & BY 124	Introductory Biology I and Introductory Biology II	
CH 115 & CH 116 & CH 117 & CH 118	General Chemistry I and General Chemistry I Laboratory and General Chemistry II and General Chemistry II Laboratory	
PH 221 & PH 222	General Physics I and General Physics II	
Required Computer Science Courses [1]		
CS 103	Introduction to Computer Science in Python	4
CS 203	Object-Oriented Programming in Java	4
CS 250	Discrete Structures	3
CS 303 & 303L	Algorithms and Data Structures and Algorithms and Data Structures Laboratory	3
CS 330	Computer Organization and Assembly Language Programming	3
CS 332	Systems Programming	3
CS 350	Automata and Formal Languages	3
CS 355	Probability and Statistics in Computer Science	3
CS 401	Programming Paradigms	3
CS 410	Database Application Development	3
CS 420	Software Engineering	3
CS 436	Fundamentals of Computer Security	3
CS 499	Senior BS Capstone	3
Electives [1]		
Complete nine hours in Computer Science courses; three of these hours must be at the 400-level and the remaining six hours must be at the 300-level or above. A maximum of 3 hours combined of the following independent courses may be taken: CS398, CS399, CS496. The following course may also be used as an elective:		9

EE 337	Introduction to Microprocessors	
If taking the Computer Networking specialization, the nine hours in electives must be chosen from the following list:		
CS 334	Networking	
CS 423	Fundamentals of Network Security	
CS 431	Distributed Systems	
CS 435	Network Programming	
CS 443	Fundamentals of Cloud Security	
Total Hours		**120-121**

[1] A grade of "C" or better must be earned in each course.
[2] Completion of MA 125 or MA 126 automatically satisfies the Area III: Mathematics Requirement.

Additional Requirements

General Electives

Students must take general electives to reach the 120 semester hour requirement. These must include CMST 101 Public Speaking and PHL 115 Contemporary Moral Issues.

<u>Bachelor of Science in Bioinformatics</u>

<u>Bachelor of Science in Digital Forensics</u>

Proposed Program of Study for a Bachelor of Science with a Major in Computer Science

Freshman

First Term	Hours	Second Term	Hours
CS 103	4	CS 203	4
MA 125	4	CS 250	3
EH 101 (Blazer Core: Writing)	3	MA 126	4
CAS 112 (Blazer Core: Local Beginnings)	3	EH 102 (Blazer Core: Writing)	3
	14		**14**

Sophomore

First Term	Hours	Second Term	Hours
CS 303	3	CS 330	3
MA 260	3	CS 355	3
Laboratory Science I	4	BlazerCore: The Creative Arts	3
BlazerCore: History and Meaning	3	General elective	3
General Elective	3	General elective	3
	16		**15**

Junior

First Term	Hours	Second Term	Hours
CS 332 (Systems Programming)	3	CS 350	3
CS 410	3	CS 436	3
CMST 101 (Blazer Core: Communicating in the Modern World)	3	PHL 115 (Blazer Core: Reasoning)	3
Laboratory Science II	3	Math elective	4
Blazer Core: Humans and their Societies	3	General elective	3
	15		**16**

Senior

First Term	Hours	Second Term	Hours
CS 420	3	CS 401	3
CS elective	3	CS 499	3
CS elective	3	CS elective	3
Blazer Core: City as Classroom	3	General elective	3
Blazer Core: Thinking Broadly	3	General elective	3
	15		**15**

Total credit hours: 120

Proposed Program of Study for a Bachelor of Arts with a Major in Computer Science

Freshman

First Term	Hours	Second Term	Hours
CS 103	4	CS 203	4
EH 101 (Blazer Core: Writing)	3	CS 250	3
CAS 112 (Blazer Core: Local Beginnings)	3	EH 102 (Blazer Core: Writing)	3
Math course	4	Blazer Core: Communicating in the Modern World	3
		Blazer Core: History and Meaning	3
	14		**16**

Sophomore

First Term	Hours	Second Term	Hours
CS 303	3	CS 330	3
Blazer Core: The Creative Arts	3	MA 125 (if not taken in Fall Freshman year)	4
Blazer Core: Scientific Inquiry	4	Blazer Core: Thinking Broadly	3
Blazer Core: Humans and Their Societies	3	Minor	3
Minor	3		
	16		**13**

Junior

First Term	Hours	Second Term	Hours
CS 300	3	CS Elective	3
Blazer Core: City as Classroom	3	CS Elective	3
Blazer Core: Scientific Inquiry	4	General Elective	3
General Elective	3	General Elective	3
Minor	3	Minor	3
	16		**15**

Senior

First Term	Hours	Second Term	Hours
CS 420	3	CSA 499	3
CS Elective	3	PHL 115	3
General Elective	3	CS Elective	3
General Elective	3	Minor	3
Minor	3	General Elective or Minor	3
	15		**15**

Total credit hours: 120

Minor in Computer Science

Requirements		Hours
Required CS courses. Must earn a grade of C or better		
CS 103	Introduction to Computer Science in Python	4
CS 203	Object-Oriented Programming	4
CS 250	Discrete Structures	3
CS 303	Algorithms and Data Structures	3
CS Electives		
Select 3 hours from 300-level or higher CS courses (CS 332 is recommended)		3
Total Hours		**17**

Note: A student who takes CS 330 as the elective will be ready to apply directly to the CS M.S. program.

GPA Requirement and Residency

A student must have at least a 2.0 average in all CS courses attempted and a 2.0 average in all CS courses taken at UAB. The current UAB course repeat policy will be used in calculating the grade point average. A minimum of six semester hours in the minor must be taken at UAB. Transfer students should be aware of the Department of Computer Science's policy regarding transfer credit.

Honors Program: Computer Science

Purpose

The Computer Science Honors Program offers outstanding, highly motivated students the opportunity to develop research skills in preparation for graduate work or a professional career.

Eligibility

In order to be accepted into the Computer Science Honors program, a student must:

- have earned a 3.5 GPA in computer science (CS) courses;
- have earned a 3.0 GPA overall;
- have completed 18 semester hours in CS courses;
- have arranged with a faculty sponsor in Computer Science to do a research project.

Requirements

Students in the Computer Science Honors Program will be required to have the following:

- during their first semester in the honors program, enroll in exactly 1 semester hour of Undergraduate Honors Research (CS 398), during which a formal research proposal will be developed and submitted, including an introduction, proposed methods, and relevant literature citation
- a total of 3 semester hours in Undergraduate Honors Research (CS 398) with each semester hour involving a minimum of three hours of laboratory work per week during the semester of enrollment;
- a formal written report in the form of a scientific paper; and
- an oral or poster presentation at a Computer Science departmental seminar.

In some instances, it will be recommended or required that Computer Science Honors students give a formal presentation of their work at a scientific meeting.

Benefits

In addition to the educational and career benefits of participating in the Computer Science Honors program, students who complete the program will graduate "With Honors in Computer Science."

Contact

For more information and/or admission to the Computer Science Honors program, contact:

Dr. John K. Johnstone
4161 University Hall, 1402 10th Ave. S.
Birmingham, AL 35294-1241
Telephone (205) 975-5633

E-mail: jkj@uab.edu

Courses

CS 102. Principles of Computer Science. 3 Hours.
This is an introductory course for non-CS majors to learn the fundamental concepts and topics of Computer Science (CS), and how CS is now impacting and changing every person's way of life. Students will explore the use of block-based and/or text-based programming languages to form computational solutions to problems. The main topics covered include program design, software development, abstract thinking, information analysis, the Internet, algorithmic methodology. The course will also discuss other topics including (but not limited to) modeling real-life phenomena, computing as a creative activity, social uses and abuses of information, and the foundations of cybersecurity. This course has a laboratory component.
Prerequisites: MA 102 [Min Grade: C] or MA 105 [Min Grade: C] or MA 106 [Min Grade: C] or MA 107 [Min Grade: C] or MA 125 [Min Grade: C] or MA 126 [Min Grade: C] or MA 225 [Min Grade: C] or MA 227 [Min Grade: C]

CS 102L. Principles of Computer Science Lab. 0 Hours.
Laboratory to accompany CS102.

CS 103. Introduction to Computer Science in Python. 4 Hours.
An introduction to computation and computational thinking, explored through programming in Python. Python is a scripting programming language that encourages exploration and quick development. This course assumes no prior programming experience and is appropriate for students in any discipline, such as linguistics, biology, business, and art. The student will leave the course with the ability to write clear and well-designed programs that solve interesting problems, and an appreciation of the power and beauty of computation. Strings, tuples, lists, dictionaries; branching, iteration, abstraction through functions, recursion, higher order programming; insertion sort, binary search, turtle graphics, binary numbers, introduction to classes. Principles of software development are emphasized, including specification, documentation, testing, debugging, exception handling. This course has a laboratory component.
Prerequisites: MA 106 [Min Grade: C] or MA 107 [Min Grade: C] or MA 125 [Min Grade: C] or MA 126 [Min Grade: C] or MA 225 [Min Grade: C] or MA 227 [Min Grade: C] or MA 226 [Min Grade: C]

CS 103L. Introduction to Computer Science in Python Lab. 0 Hours.
Laboratory to accompany CS103.

CS 104. Data Science for All. 4 Hours.
Spurred by the recent proliferation of large datasets and the maturation of techniques such as machine learning, data science is revolutionizing modern computer science in the twenty-first century. In this introductory course, students will develop an understanding of the modern use of computer science to analyze data, to make predictions from large datasets, to cluster and classify data, to analyze the reliability of conclusions drawn from data, and to communicate data visually. Empirical analysis includes datasets from areas including economics, medicine, and geography. The course introduces Python to explore and analyze data in code (no previous experience with Python is necessary). Computational tools covered include sequences, tables, data visualization, randomness, basic probability, basic statistics, hypothesis testing, estimation, prediction, inference, and linear regression. This course meets Blazer Core Curriculum Scientific Inquiry.
Prerequisites: MA 102 [Min Grade: C] or MA 105 [Min Grade: C] or MA 106 [Min Grade: C] or MA 107 [Min Grade: C] or MA 125 [Min Grade: C] or MA 225 [Min Grade: C]

CS 104L. Data Science for All Laboratory. 0 Hours.
Laboratory to accompany CS104.

CS 130. Introduction to Cyber Security. 3 Hours.
This course introduces students to the rapidly evolving and critical international arenas of privacy, information security, and critical infrastructure, and is designed to develop knowledge and skills for security of information and information systems at both individual and organizational levels. Stakeholders of information security and privacy. Framework of information security and privacy. Nature of common information hazards. Common cyber attacks and counter-measures. Operation and limitations of information and system safeguards. Ethics, privacy, policy and information decisions. Legal aspects, professional practices, and standards for information security and privacy. Security of national critical infrastructures.

CS 131. Safe and Effective Digital Life. 3 Hours.
This course introduces students to safe and effective use of digital technologies in students' academic studies and everyday lives. Students will learn various fundamental concepts and techniques that help them navigate cyberspace in a secure and productive manner. Topics include types of digital technology platforms, learning management systems, mobile technology and apps, financial applications, communication technology, security and privacy, cyber fraud and cyber crime, digital health, and effective information search and organization techniques.

CS 198. Selected Topics in Computer Science. 3 Hours.
Selected topics in computer science. This course does not have a laboratory component.

CS 199. Special Topics in Computer Science. 3 Hours.
Selected topics in computer science. This course has a laboratory component.

CS 199L. Special Topics Lab. 0 Hours.
Project oriented hands-on approach lab. Mandatory first day of attendance.

CS 203. Object-Oriented Programming in Java. 4 Hours.
A second course in computational thinking, through the lens of object oriented programming. Fundamental concepts of object oriented programming and basic data structures. Types, classes, objects, inheritance, containers, OO software design, program structure and organization, reflection, generic programming. Lists, trees, stacks, queues, heaps, search trees, hash tables, graphs, complexity analysis. This course has a laboratory component.
Prerequisites: CS 103 [Min Grade: C]

CS 203L. Object-Oriented Programming Lab. 0 Hours.
Laboratory to accompany CS203.

CS 221. Web Development. 3 Hours.
Fundamental concepts of web development. Client side application development using web languages and technologies. Client-server communication. Responsive design. User interaction models. Server-side development. This course has a laboratory component.

CS 221L. Web Development Laboratory. 0 Hours.
Laboratory to accompany CS 221.

CS 250. Discrete Structures. 3 Hours.
Discrete mathematics for computer science, including elementary propositional and predicate logic, sets, relations, functions, counting, elementary graph theory, proof techniques including proof by induction, proof by contradiction, and proof by construction.
Prerequisites: CS 103 [Min Grade: C] and (MA 106 [Min Grade: C] or MA 107 [Min Grade: C] or MA 125 [Min Grade: C] or MA 225 [Min Grade: C] or MA 226 [Min Grade: C] or MA 126 [Min Grade: C] or MA 227 [Min Grade: C])

CS 300. Advanced Object-Oriented Programming in C++. 3 Hours.
Object-oriented programming concepts in C++ including templates, multiple inheritance, const correctness. Types, streams, containers, references, pointers, iterators, operator overloading, evolution of C++ in C++11/14/17/20, using the Standard Template Library (STL). Current techniques and tools for software development in C++: unit testing, compilation, version control using git, linters.
Prerequisites: CS 203 [Min Grade: C]

CS 300L. Advanced Object-Oriented Programming in C++ Lab. 0 Hours.
Laboratory to accompany CS300.

CS 303. Algorithms and Data Structures. 3 Hours.
Techniques for design and analysis of algorithms; efficient algorithms for sorting, searching, graphs, and string matching; and design techniques such as divide-and-conquer, recursive backtracking, dynamic programming, and greedy algorithms.
Prerequisites: CS 250 [Min Grade: C] and CS 203 [Min Grade: C]

CS 303L. Algorithms and Data Structures Laboratory. 0 Hours.
Project oriented hands-on approach to accompany CS 303.

CS 330. Computer Organization and Assembly Language Programming. 3 Hours.
Register-level architecture of modern digital computer systems, digital logic, machine-level representation of data, assembly-level machine organization, and alternative architectures. Laboratory emphasizes machine instruction execution, addressing techniques, program segmentation and linkage, macro definition and generation, and computer solution of problems in assembly language.
Prerequisites: CS 250 [Min Grade: C] and CS 203 [Min Grade: C]

CS 330L. Computer Organization and Assembly Language Programming Lab. 0 Hours.
Laboratory to accompany CS330.

CS 332. Systems Programming. 3 Hours.
Unix architecture and internals with an emphasis on Linux, shell scripting, distributions of Linux for various computing platforms including large and desktop computers, and embedded computing devices, introduction to the C programming language, systems programming in C covering signals and process control, networking, I/O, concurrency and synchronization, memory allocation, threads, debugging, library development and usage.
Prerequisites: CS 203 [Min Grade: C] and CS 250 [Min Grade: C]

CS 332L. Systems Programming Laboratory. 0 Hours.
Laboratory to accompany CS332.

CS 334. Networking. 3 Hours.
Underlying network technology, including IEEE 802.11. Interconnecting networks using bridges and routers. IP addresses and datagram formats. Static and dynamic routing algorithms. Control messages. Subnet and supernet extensions. UDP and TCP. File transfer protocols. E-mail and the World Wide Web. Network address translation and firewalls. Mandatory weekly Linux-based lab.
Prerequisites: CS 250 [Min Grade: C] and CS 203 [Min Grade: C]

CS 334L. Networking Lab. 0 Hours.
Project oriented hands-on approach to accompany CS 334. Mandatory first day of class.

CS 350. Automata and Formal Languages. 3 Hours.
Finite-state automata and regular expressions, context-free grammars and pushdown automata, Turing machines, NP-completeness, Halting Problem.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 355. Probability and Statistics in Computer Science. 3 Hours.
Introduction to probability and statistics with applications in computer science. Counting, permutations and combinations. Probability, conditional probability, Bayes theorem. Standard probability distributions. Measures of central tendency and dispersion. Central Limit Theorem. Hypothesis testing. Random number generation. Random algorithms. Estimating probabilities by simulation.
Prerequisites: CS 250 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C]) and CS 203 [Min Grade: C]

CS 380. Matrix Computation. 3 Hours.
Matrix computation is the foundation of data science, of many key areas of computer science (machine learning, computer graphics, computer vision, high performance computing), and of companies like Google. The main object of study in this course is the matrix, including matrix computation (matrix multiplication, null space, solution of linear systems, least squares) and applications (e.g., image filtering, face detection, compression).
Prerequisites: CS 203 [Min Grade: C] and CS 250 [Min Grade: C]

CS 391. Special Topics. 3 Hours.
Selected Topics in Computer Science.

CS 392. Special Topics. 3 Hours.
Selected Topics in Computer Science.

CS 398. Undergraduate Honors Research. 1-3 Hour.
Research project under supervision of faculty sponsor. Prerequisite: 18 semester hours in Computer Science with grade point average of 3.5 in Computer Science and permission of instructor.

CS 399. Directed Readings. 1-3 Hour.
Selected readings, research and project development under the direction of a faculty member. Permission of instructor.
Prerequisites: CS 203 [Min Grade: D] and CS 250 [Min Grade: D]

CS 401. Programming Paradigms. 3 Hours.
The course will introduce students to major programming paradigms, such as functional programming and logic programming, and their realization in programming languages. Students will solve problems using different paradigms and study the impact on program design and implementation. The course enables students to assess strengths and weaknesses of different languages for problem solving. Other topics to be covered include lexing, parsing, type systems, and ways to formalize a language's semantics.
Prerequisites: CS 303 [Min Grade: C]

CS 401L. Programming Paradigms Laboratory. 0 Hours.
Laboratory to accompany CS401.

CS 402. Compiler Design. 3 Hours.
Study the design and implementation of compilers, including front-end (lexer, parser, type checking), to mid-end (intermediate representations, control-flow analysis, dataflow analysis, and optimizations) to back-end (code generation). Students will get hands-on experience by implementing several compiler components.
Prerequisites: CS 303 [Min Grade: C] and CS 332 [Min Grade: C] and CS 350 [Min Grade: C]

CS 403. Cloud Computing. 3 Hours.
Introduction to cloud computing architectures and programming paradigms. Theoretical and practical aspects of cloud programming and problem-solving involving compute, storage and network virtualization. Design, development, analysis, and evaluation of solutions in cloud computing space including machine and container virtualization technologies.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 403L. Cloud Computing Lab. 0 Hours.
Laboratory to accompany CS403.

CS 410. Database Application Development. 3 Hours.
Relational model of databases, structured query language, relational database design and application development, database normal forms, and security and integrity of databases.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 415. Multimedia Databases. 3 Hours.
Multimedia information processing, multimedia database architecture, multimedia database retrieval, semantic models for multimedia databases.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 416. Big Data Programming. 3 Hours.
Introduction to Big Data, Properties of Big Data, platforms, programming models, applications, business analytics programming, big data processing with Python, R, and SAS, MapReduce programming with Hadoop.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 417. Database Security. 3 Hours.
Database fundamentals, introduction to database security, overview of security models, access control models, covert channels and inference channels, MySQL security, Oracle security, Oracle label security, developing a database security plan, SQL server security, security of statistical databases, security and privacy issues of data mining, database applications security, SQL injection, defensive programming, database intrusion prevention, audit, fault tolerance and recovery, Hippocratic databases, XML security, network security, biometrics, cloud database security, big database security.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 419. Investigating Online Crimes. 3 Hours.
Introduction to cyber-investigative techniques involving network forensics. Students will develop and learn to apply new programs and techniques to automatically evaluate digital evidence from network packet captures, emails, server logs, social media, darknets and online forums related to cyber crime cases from both a law enforcement and incident response perspective.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 420. Software Engineering. 3 Hours.
Design and implementation of large-scale software systems, software development life cycle, software requirements and specifications, software design and implementation, verification and validation, project management and team-oriented software development. Lecture and laboratory.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 420L. Software Engineering Laboratory. 0 Hours.
Laboratory to accompany CS 420.

CS 421. Advanced Web Application Development. 3 Hours.
Introduction to web application design and development. Includes traditional web applications utilizing server-side scripting as well as client/server platforms. Covers responsive design for both mobile and desktop users, as well as hands on server provisioning and configuration. Other topics include web security problems and practices, authentication, database access, application deployment and Web API design, such as REpresentational State Transfer (REST).
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 421L. Advanced Web Application Development Laboratory. 0 Hours.
Laboratory to accompany CS 421.

CS 422. Mobile Application Development. 3 Hours.
Fundamental concepts of mobile application development. Focused on native application development for Android and iOS. Understand application architecture and lifecycle best practices. UX considerations for mobile devices. Interact with device sensors. Compare native vs hybrid frameworks. This course has a laboratory component.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 422L. Mobile Application Development Laboratory. 0 Hours.
Laboratory to accompany CS422.

CS 423. Fundamentals of Network Security. 3 Hours.
Conventional network security (symmetric and public-key cryptography). Message encryption and authentication. Secure communication between computers in a hostile environment, including E-mail (PGP), virtual private networks (IPSec), remote access (SSH), and E-commerce (SSL), firewalls, intrusion detection and prevention, security of IEEE 802.11 wireless networks (WEP, WPA). Mandatory weekly Linux-based lab.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 423L. Network Security Laboratory. 0 Hours.
Laboratory to accompany CS423.

CS 425. Metrics and Performance. 3 Hours.
Theory and practice of metrics for performance and scalability of software systems. The course will introduce students to the principles of queuing theory and statistical analysis relevant to analyzing the performance of software products. Students will use profiling frameworks to identify a range of performance problems in existing software. The course will enable students to improve the design of software and eliminate many common design oversights that hamper a system's performance and scalability.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 426. Secure Software Development. 3 Hours.
Why and how software fails, characteristics of secure and resilient software, life cycle of secure software development, metrics and models for secure software maturity, design methodology, best practices for secure programming, secure software for mobile computing, cloud computing and embedded systems, methodology for testing and validation.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 427. Software Design and Integration. 3 Hours.
This course provides hands-on experience in the design and integration of software systems. Component-based technology, model-driven technology, service-oriented technology, and cloud technology are all explored. Software design basics, including the decomposition of systems into recognizable patterns, the role of patterns in designing software and design refactoring, and attributes of good design. Agile culture, CASE tools, tools for continuous integration, build, testing, and version control.
Prerequisites: CS 420 [Min Grade: C]

CS 429. Software Engineering Research Project. 3 Hours.
This is a project-based research course in software engineering, involving significant implementation and experimentation under the supervision of a faculty member. A project proposal must be accepted before registering for this course.
Prerequisites: CS 420 [Min Grade: C]

CS 430. Computer Architecture. 3 Hours.
Introduction to computer architecture, including memory subsystems, direct-mapped and set-associative cache and multi-level cache subsystems, direct- access devices including RAID and SCSI disk drives, processor pipelining including super-scalar and vector machines, parallel architectures including SMP, NUMA and distributed memory systems, Interrupt mechanisms, and future microprocessor design issues.
Prerequisites: CS 330 [Min Grade: C] and CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 431. Distributed Systems. 3 Hours.
Introduction to distributed systems, distributed hardware and software concepts, communication, processes, naming, synchronization, consistency and replication, fault tolerance, security, client/server computing, web technologies, enterprise technologies.
Prerequisites: CS 303 [Min Grade: C] and CS 332 [Min Grade: C](Can be taken Concurrently) and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 432. Parallel Computing. 3 Hours.
Introduction to parallel computing architectures and programming paradigms. Theoretical and practical aspects of parallel programming and problem solving. Design, development, analysis, and evaluation of parallel algorithms.
Prerequisites: (CS 303 [Min Grade: C] and CS 330 [Min Grade: C]) and CS 332 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 433. Operating Systems. 3 Hours.
Introduction to operating systems. This course looks at the internal design and operation of a modern operating system. Topics include interrupt handling, process scheduling, memory management, virtual memory, demand paging, file space allocation, file and directory management, file/user security and file access methods. Several comparisons among current operating systems are used, with attention to Windows and Unix in particular.
Prerequisites: CS 330 [Min Grade: C] and CS 332 [Min Grade: C] and CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 433L. Operating Systems Laboratory. 0 Hours.
Laboratory to accompany CS 433.

CS 434. Virtualization. 3 Hours.
Theory and practice of virtualization. Origins, history, technical and economic motivations. Relationship to network operating systems and operating system architecture. Simulation, Emulation, Virtualization of CPUs, networks, storage, desktops, memory, devices, and combinations thereof. Different approaches to virtualization, including hardware assists and software-only techniques. Techniques, approaches, and methodologies for scale-out and scale-up computing, including security, performance and economic concerns.
Prerequisites: CS 433 [Min Grade: C] and CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 435. Network Programming. 3 Hours.
Remote procedure call and client-server mechanisms. Protocol definition and compilation; client and server stubs and application code; transport independence; multiple client and server systems. Applications, e.g., remote database query and update and image filtering and archiving; systems programming and file systems contexts.
Prerequisites: CS 334 [Min Grade: C] and CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 436. Fundamentals of Computer Security. 3 Hours.
Study of the breadth of major computer security topics including cyber threats, malware, information assurance, authorization, applied cryptography, web security, mobile and wireless security, network security, systems/software security, database and storage security, user-centered security, and best security practices and countermeasures.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 437. Digital Media Forensics. 3 Hours.
Digital media forensics addresses all stored digital evidence types faced by cyber security professionals and computer forensics examiners. Students will learn to analyze character encoding, file formats, and digital media, including hard drives, smartphones and other portable devices, and cloud-hosted evidence, as well as disk acquisition, duplication and evidence preservation techniques and how to apply these techniques in typical criminal investigation scenarios.
Prerequisites: CS 303 [Min Grade: C] and CS 330 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 437L. Digital Media Forensics Lab. 0 Hours.
Laboratory to accompany CS 437.

CS 442. Mobile and Wireless Security. 3 Hours.
Mobile/wireless devices are ubiquitous, raising the potential for many cyber threats. This course examines security vulnerabilities inherent in many existing and emerging mobile and wireless systems, ranging from smartphones to wearables and RFID tags. In addition to exposing security vulnerabilities, defensive mechanisms to address these vulnerabilities drawn from existing deployments and research literature will be studied.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 443. Fundamentals of Cloud Security. 3 Hours.
Definition of cloud computing, cloud computing models, privacy, authenticity and integrity of outsourced data, proof of data possession / retrievability, cloud forensics, malware analysis as a service, remote verification of capability and reliability, proof of availability, economic attacks on clouds and outsourced computing, virtual machine security, trusted computing technology and clouds, verifiable resource accounting, cloud-centric regulatory compliance issues and mechanisms, business and security risk models, secure MapReduce, applications of secure cloud computing, private information retrieval and cloud cartography.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 444. Network Forensics. 3 Hours.
This course covers concepts and methods involved in unraveling network intrusions, DDOS, and other untoward network behavior.
Prerequisites: CS 303 [Min Grade: C] and CS 334 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 445. Modern Cryptography. 3 Hours.
Theory and practices of modern cryptographic techniques, algorithms and protocols, including formal analysis. Secret key encryption algorithms, public key encryption algorithms, stream ciphers, one-way hashing algorithms, authentication and identification, digital signatures, signcryption, key establishment and management, secret sharing and data recovery, zero-knowledge proofs, public key infrastructures, efficient implementation, cryptanalytic attacks and countermeasures, security models, assumptions and proofs.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 446. Blockchain and Cryptocurrency. 3 Hours.
Fundamental principles of blockchains and their applications in digital cash systems including Bitcoin, Ethereum and other notable cryptocurrencies. Topics to be covered include how a cryptocurrency works, blockchain and other decentralized consensus protocols, proof of work, proof of stake, smart contracts, security and privacy of cryptocurrencies, cryptographic techniques for digital currency, and applications of blockchain in peer-to-peer trust establishment, digital asset management, financial exchanges and distributed autonomous organization.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 447. Biomedical Modeling. 3 Hours.
Modeling and analysis of biomedical datasets. Aspects of image processing and shape modeling related to biomedical datasets, morphometry, alignment, surgical planning, case studies.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 452. Design and Analysis of Algorithms. 3 Hours.
This courses introduce students to the design and analysis of fundamental algorithms that underpin many fields of importance ranging from data science, business intelligence, finance and cyber security to bioinformatics. Algorithms to be covered include dynamic programming, greedy technique, linear programming, network flow, sequence matching, search and alignment, randomized algorithms, page ranking, data compression, and quantum algorithms. Both time and space complexity of the algorithms are analyzed.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 454. Malware Analysis. 3 Hours.
Hands-on course teaching static, dynamic and contextual analysis of malware. Malware analysis, and investigation is taught through interaction with both "classroom" and "wild" malware samples. Defensive and counter-measure techniques for both corporate and law enforcement environments are explored.
Prerequisites: CS 303 [Min Grade: C] and CS 330 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 454L. Malware Analysis Lab. 0 Hours.
Laboratory to accompany CS 454.

CS 456. Web Security. 3 Hours.
The web uses advanced applications that run on a large variety of browsers that may be built using programming languages such as JavaScript, AJAX, Google Web Toolkit and Apache Struts, to name a few. This course studies how core web technologies work, the common security vulnerabilities associated with them, and how to build secure web applications that are free from these vulnerabilities.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 457. Fundamentals of Penetration Testing. 3 Hours.
This course focuses on penetration testing and vulnerability analysis. It introduces methodologies, techniques and tools to analyze and identify vulnerabilities in stand-alone and networked applications. It also covers methodologies for legal and standards compliance.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 457 [Min Grade: C])

CS 458. Fundamentals of Quantum Computing. 3 Hours.
Mathematical foundations, architecture of quantum computer, quantum algorithms, quantum programming, quantum software application development environments and methodologies, and integration of quantum and classical computers.
Prerequisites: CS 303 [Min Grade: C] and (MA 260 [Min Grade: C] or MA 434 [Min Grade: C])

CS 460. Fundamentals of Artificial Intelligence. 3 Hours.
This course will provide an introduction to fundamental concepts in the field of artificial intelligence. Topics typically covered include agents, search, logic and knowledge representation, probabilistic models, machine learning, natural language processing and perception.
Prerequisites: CS 303 [Min Grade: C] and CS 350 [Min Grade: C]

CS 462. Fundamentals of Natural Language Processing. 3 Hours.
This course provides a broad introduction to Natural Language Processing (Computational Linguistics). Topics typically covered in this course include part-of-speech tagging, syntactic parsing, semantic analysis, speech recognition, machine translation, sequence labeling algorithms, n-gram language models, statistical parsing, grammar formalisms and treebanks.
Prerequisites: (CS 303 [Min Grade: C] and CS 350 [Min Grade: C] and CS 355 [Min Grade: C]) or CS 460 [Min Grade: C]

CS 463. Fundamentals of Data Mining. 3 Hours.
Techniques used in data mining (such as frequent sets and association rules, decision trees, Bayesian networks, classification, clustering), algorithms underlying these techniques, and applications.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 467. Fundamentals of Machine Learning. 3 Hours.
Introduction to machine learning, the design of algorithms that can make predictions about the future based on past experience. Emphasizes practical considerations for developing efficient and accurate machine learning models, and theoretical underpinnings of different learning algorithms.
Prerequisites: CS 303 [Min Grade: C] and CS 355 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 468. AI Assisted Software Development. 3 Hours.
Techniques for the accelerated development of better and more robust software using emerging artificial intelligence (AI) tools such as OpenAI Codex, IntelliCode and others. Covers AI assisted key software development stages from requirements gathering, designing, coding, code review, debugging, testing and deployment to maintenance.
Prerequisites: CS 303 [Min Grade: C]

CS 469. Introduction to the Internet of Things. 3 Hours.
Definition of the Internet of Things (IoT), history, IoT components, device specifications and examples, architectures, protocols, applications, security and privacy issues, programming and development environments for IoT, interoperability, interfacing IoT devices via web and mobile applications.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 470. Fundamentals of Computer Graphics. 3 Hours.
Computer graphics is the study of the creation, manipulation, and rendering of shape models and images, for visualization, modeling, shape analysis, and animation. Topics include matrix transforms for motion and viewing, shading, viewing and camera modeling, shape modeling including meshes and smooth parametric curves and surfaces, visibility analysis, sampling, nonphotorealistic rendering, shape analysis, and texture mapping.. Topics are explored through code, including OpenGL and GLSL.
Prerequisites: CS 303 [Min Grade: C] and CS 332 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 473. Fundamentals of Computer Vision. 3 Hours.
Computer vision, the study of the interpretation of images, is central to many areas of computer science, including data science and machine learning, biomedical computing, social media, and security. Recent algorithms for vision also leverage deep learning, such as for object recognition. Topics in this course include linear filters, calculus on the image, convolution, edge and corner detection, segmentation, projective geometry, structure from motion, rectification, two-view geometry, reconstruction in 3D, Hough transform, object recognition.
Prerequisites: CS 332 [Min Grade: C] and (MA 260 [Min Grade: C] or MA 434 [Min Grade: C])

CS 475. Fundamentals of Data Visualization. 3 Hours.
The amount and complexity of data produced everyday is increasing at a staggering rate. Visualization presents an intuitive way to explore and interpret data. This course will be an introduction to the principles, and methods for effective visual analysis of data. Techniques to facilitate information visualization for non-spatial data (eg. graphs, text, high-dimensional data) and scientific visualization for spatial data (eg. gridded data from simulations and scanners and sensors) will be covered. Emphasis will be given to interactive approaches, especially while dealing with massive volumes of data. Topics in the domain of data analytics tightly coupled with visualization will also be covered. Students will learn fundamentals of perception, visualization techniques and methods for a broad range of data types, good practices for visualization, and will ultimately be able to develop their own visualization system.
Prerequisites: CS 303 [Min Grade: C] and CS 332 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 476. Introduction to Game Development. 3 Hours.
A course in game development and game design that considers the theory and practice of developing computer games from both a technical and aesthetic perspective. Technical components include shaders and materials, meshes, procedural generation, game physics, collision detection, game AI, pathfinding, animation, and lighting. Aesthetic components include game loop design, level design, gameplay, and sound.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 226 [Min Grade: C])

CS 478. Fundamentals of Digital Image Processing. 3 Hours.
Human visual system, image acquisition, binary image processing, image transformation, Fourier Transform, segmentation, edge detection, medical imaging modalities, and image reconstruction from projections.
Prerequisites: CS 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 483. Open Source Security Systems. 3 Hours.
An introduction to the design, implementation, evaluation and maintenance of secure software systems and applications using open source technologies, with an emphasis on hands-on experience. Topics include: open source ecosystems, open source security methodologies and models, notable open source software systems and projects, quality and security assurance through open source, open source supply chain security, major open source cryptographic packages; designing, implementing and maintaining security systems using open source technologies; assessment and regulatory compliance using open source tools, and open source hardware.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 484. Robot Motion. 3 Hours.
Path planning algorithms. Configuration space, potential functions, roadmaps, cell decomposition, probabilistic motion planning, compliant motion.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 485. Foundations of Data Science. 3 Hours.
This introductory course in data science teaches fundamental concepts and techniques in statistical inference and big data analytics. Topics include high-dimensional space, singular value decomposition, random graphs, random walks and Markov chains, data streaming and sketching, and basics of data mining and machine learning.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 486. Software-Defined Networking. 3 Hours.
Software defined networking (SDN) allows a logically centralized software component to manage and control the behavior of an entire network. Topics to be covered include abstractions and layered architecture of SDN, data, control and management planes, network virtualization, programming SDN, network functions (e.g. routing, load balancing and security), comparison of OpenFlow and proprietary SDN technologies, and network optimization with SDN.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 487. Complex Networks. 3 Hours.
Introduction to complex network theory and real-world applications in biology, physics, sociology, national security and cyber enabled technology systems such as social networks. Essential network models including small world networks, scale free networks, spatial and hierarchical networks together with methods to generate them with a computer will be discussed. In addition, various techniques for the analysis of networks including network modeling and evolution, community structure, dynamic network analysis, and network visualization will be explored.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 489. Fundamentals of Cyber Risk Management. 3 Hours.
This course develops knowledge and skills in risk based information security management geared toward preventive management and assurance of security of information and information systems in technology-enabled environments. It focuses on risk assessments, risk mitigation strategies, risk profiling and sensitivity, quantitative and qualitative models of calculating risk exposures, security controls and services, threat and vulnerability management, financing the cost of security risks, and return on investment for information security initiatives. The course presents several risk assessment models with an ultimate goal of identifying and realizing the unique and acceptable level of information risk for an organization.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 491. Special Topics. 3 Hours.
Special Topics in Computer Science.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 492. Special Topics. 3 Hours.
Special Topics in Computer Science.
Prerequisites: CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 496. Research Seminar. 1 Hour.
Participation in research seminar directed by a faculty member.

CS 497. Competitive Programming Techniques. 1 Hour.
This course will help students become more competitive in a programming competition such as the ACM programming contest by exploring numerous problem solving techniques and algorithms not covered in the traditional curriculum.

CS 498. Research Methods in Computer Science. 3 Hours.
This course is designed to provide future computer science teachers with the tools that computer science uses to develop new knowledge. Students will design, implement, and document independent research inquiry. Students will learn how scientists communicate through peer-reviewed publications and evaluate conflicting scientific claims. Work is closely coordinated with the work of students from other content disciplines so that students see the similarity and differences of research methods in their own field as compared with those of other science disciplines.
Prerequisites: EHS 126 [Min Grade: D]

CS 499. Senior BS Capstone. 3 Hours.
This capstone course consolidates key concepts in the undergraduate BS curriculum and prepares students for their professional careers. Teamwork and writing are key themes of the course. Students discuss and write about topics in ethics, professional practice, entrepreneurship, intellectual property, licensing (e.g., GPL, MIT), privacy, continuing professional development, professional networking tools, compliance, tolerance, inclusion, appreciation of diversity, and contemporary issues. In a software engineering project, students work in a team to put to practice principles and techniques that they have acquired throughout the undergraduate curriculum. Students take the Major Field Test in Computer Science as a requirement for completing this course. Students should be CS BS majors in their last year of undergraduate study.
Prerequisites: (CMST 101 [Min Grade: C] or CM 101 [Min Grade: C]) and PHL 115 [Min Grade: C] and CS 303 [Min Grade: C] and (MA 125 [Min Grade: C] or MA 225 [Min Grade: C])

CS 499L. Senior Capstone Laboratory. 0 Hours.
Laboratory to accompany CS 499.