Department of Computer and Information Sciences

cis.uab.edu

Chair: Yuliang Zheng

The Department of Computer and Information Sciences (CIS) offers a B.S. major and a minor in CIS. The B.S. degree in CIS is accredited by the Computing Accreditation Commission of ABET, abet.org (http://www.abet.org). The CIS major is designed to give students a broad background in the structure and theory of information, programming methodologies, and the hardware and software of computer systems. There is also a concentration that offers an opportunity for specialization in computer networking. Minors are available for students who are not CIS majors but who expect to use the computer in the application area of their major field. The Department is especially interested in students getting job-related experience and training through internships and cooperative education opportunities with local and regional high technology companies. Also, the undergraduate majors are sufficiently flexible such that majors or minors in complementary areas such as business can be accomplished within the normal degree time frame. For more information, see the CIS department web site at cis.uab.edu.

Requirements for students transferring to the CIS major from other programs within UAB

Students admitted to an undergraduate program at UAB may transfer to CIS provided they have earned a UAB GPA of 2.0 or better.

Requirements for students transferring to the CIS major from other institutions

Transfer students from other institutions may transfer to the CIS 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 CIS major.

Grade point average

For both the major and minor, a grade of C or better is required in each of the computer and information sciences courses. If a student receives a grade D or F in any CIS course, then the student will only be allowed one chance to retake that course and pass it (grade C or better).

CIS courses taken at another institution for which a grade of D was received may not be counted toward the CIS major or the CIS minor.

All CIS majors must maintain a GPA of 2.2 or better in all CIS courses taken. If the CIS GPA falls below 2.2, then the student will be put on probation and student must raise his or her CIS GPA to 2.2 or above within a year after being placed on probation. At the end of the probation term, if the CIS GPA is not at or above 2.2, then the student will be dismissed from the major, and be reclassified as an undeclared major in the College of Arts and Sciences. Note that this requirement is in addition to the minimum UAB GPA of 2.0 or better required to be in good standing. A student who is dismissed from the CIS major as described here may reapply to be CIS major provided the student has raised his or her CIS GPA to 2.2 or higher and also has a UAB GPA to 2.0 or better.

300 and 400-level courses

In the CIS major, at least 12 semester hours of CIS courses at the 300 level or above must be taken at UAB. Any CIS course at the 300 level or above can be taken to satisfy the 12 semester hour CIS elective credit. A maximum of 3 semester hours may be obtained in Directed Readings. Although not required, CIS majors have the option to structure their 12 semester hours of CIS program electives as a specialization in Computer Networking. Course substitutions may be made within this specialization with CIS advisor approval.

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

Graduate Programs

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

Advanced undergraduates with a CIS GPA of 3.0 or better may take graduate courses with the permission of the instructor.

Accelerated Master of Science Program

The Department of Computer and Information Sciences offers an opportunity to earn a B.S. and an M.S. degree in a total of five years. This program offers qualified students mentorship during undergraduate study. The student works closely with a faculty member in an area of intensive research that prepares the student for a Ph.D. degree program in computer science or a future career in computer science. Admission to the program requires a minimum 3.5 GPA, three letters of recommendation from faculty, including one from their mentor, and an interview with the admissions committee. Students should apply for entrance into the accelerated M.S. program by the end of their sophomore year. If the student does not enter with AP credits, it may be necessary to take some summer courses. For additional information, please contact Dr. Chengcui Zhang, Graduate Program Director, at (205) 934-2213 or czhang02@uab.edu.

UABTeach

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

Major Requirements for B. S. in Computer and Information Sciences

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Mathematics Requirements¹,²</td>
<td></td>
</tr>
<tr>
<td>MA 125 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MA 126 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>Select two of the following:</td>
<td>6-7</td>
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<tr>
<td>MA 227 Calculus III</td>
<td></td>
</tr>
<tr>
<td>MA 252 Introduction to Differential Equations</td>
<td></td>
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</tbody>
</table>
MA 260  Introduction to Linear Algebra
MA 360  Scientific Programming 3
MA 434  Algebra I: Linear
MA 440  Advanced Calculus I
MA 444  Vector Analysis
MA 445  Complex Analysis
MA 463  Operations Research I
MA 470  Differential Geometry I
MA 472  Geometry I
MA 485  Probability
Natural Sciences Requirement 1
12 semester hours are required in two different laboratory sciences. These 12 hours must include a two course sequence, chosen from the following:
BY 123  Introductory Biology I
& BY 124  Introductory Biology II
CH 115  General Chemistry I
& CH 116  and General Chemistry I Laboratory
CH 117  General Chemistry II
& CH 118  and General Chemistry II Laboratory
PH 221  General Physics I
& PH 222  and General Physics II
Required Computer and Information Sciences Courses 1
CS 103  Introduction to Computation 4
CS 203  Object-Oriented Programming 4
CS 250  Discrete Structures 3
CS 303  Algorithms and Data Structures 4
CS 330  Computer Organization and Assembly Language Programming 3
CS 350  Automata and Formal Languages 3
CS 355  Probability and Statistics in Computer Science 3
CS 401  Programming Languages 3
CS 420  Software Engineering 3
CS 433  Operating Systems 3
CS 499  Senior Capstone 3
Complete twelve hours in Computer and Information Sciences courses at the 300-level or above. A maximum of two of the following courses may be used:
EE 337  Introduction to Microprocessors
EE 452  VHDL Digital Systems Design
MA 360  Scientific Programming 3
PHL 372  Minds and Machines
If taking the Computer Networking specialization, the twelve hours in electives must be chosen from the following list:
CS 334  Networking
CS 336  Network Security
CS 410  Database Management Systems
CS 431  Distributed Systems
CS 435  Network Programming
CS 436  Computer Security
CS 437  Cybercrime and Forensics
CS 443  Cloud Security
3 Can be counted towards either Math requirement or CS elective not both.

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.

Proposed Program of Study for a Major in Computer and Information Sciences

<table>
<thead>
<tr>
<th>Freshman</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
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<tbody>
<tr>
<td>CS 103</td>
<td>4</td>
<td>CS 250</td>
<td>3</td>
</tr>
<tr>
<td>MA 125</td>
<td>4</td>
<td>MA 126</td>
<td>4</td>
</tr>
<tr>
<td>Laboratory Science I</td>
<td>4</td>
<td>Laboratory Science II</td>
<td>4</td>
</tr>
<tr>
<td>EH 101 (Area I)</td>
<td>3</td>
<td>EH 102 (Area I)</td>
<td>3</td>
</tr>
<tr>
<td>CAS 112</td>
<td>1</td>
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<table>
<thead>
<tr>
<th>Sophomore</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 203</td>
<td>4</td>
<td>CS 303</td>
<td>4</td>
</tr>
<tr>
<td>Math Elective</td>
<td>3</td>
<td>CS 355</td>
<td>3</td>
</tr>
<tr>
<td>Lab Science III</td>
<td>4</td>
<td>Area II Literature</td>
<td>3</td>
</tr>
<tr>
<td>Area IV course 1</td>
<td>3</td>
<td>Area IV course 2</td>
<td>3</td>
</tr>
<tr>
<td>General elective</td>
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<td>General elective</td>
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<tr>
<th>Junior</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
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<tbody>
<tr>
<td>CS 330</td>
<td>3</td>
<td>CS 401</td>
<td>3</td>
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<tr>
<td>CS 350</td>
<td>3</td>
<td>CS elective</td>
<td>3</td>
</tr>
<tr>
<td>CMST 101 (Area II)</td>
<td>3</td>
<td>PHL 115 (Area II)</td>
<td>3</td>
</tr>
<tr>
<td>Area IV</td>
<td>3</td>
<td>Math elective</td>
<td>3</td>
</tr>
<tr>
<td>General elective</td>
<td>3</td>
<td>General elective</td>
<td>3</td>
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<thead>
<tr>
<th>Senior</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>CS 420</td>
<td>3</td>
<td>CS 433</td>
<td>3</td>
</tr>
<tr>
<td>CS 499</td>
<td>3</td>
<td>CS elective</td>
<td>3</td>
</tr>
<tr>
<td>CS Elective</td>
<td>3</td>
<td>CS elective</td>
<td>3</td>
</tr>
<tr>
<td>Area IV</td>
<td>3</td>
<td>Area II: Fine Art</td>
<td>3</td>
</tr>
<tr>
<td>General elective</td>
<td>3</td>
<td>General elective</td>
<td>3</td>
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</tbody>
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<table>
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<tr>
<th>Total credit hours: 120</th>
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Minor Requirements for Computer and Information Sciences

Requirements 2

<table>
<thead>
<tr>
<th>Required CIS courses. Must earn a grade of C or better</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 103  Introduction to Computation</td>
<td>4</td>
</tr>
<tr>
<td>CS 203  Object-Oriented Programming</td>
<td>4</td>
</tr>
<tr>
<td>CS 250  Discrete Structures</td>
<td>3</td>
</tr>
<tr>
<td>CS 303  Algorithms and Data Structures</td>
<td>4</td>
</tr>
</tbody>
</table>

CIS Electives
Select 3 hours from 300-level or higher CIS courses (CS 330 is recommended) 3

Total Hours 18

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

GPA Requirement and Residency
A student must have at least a 2.0 average in all CIS courses attempted and a 2.0 average in all CIS 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 and Information Science’s policy regarding transfer credit.

Honors Program: Computer and Information Sciences

Purpose
The Computer and Information Sciences 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 and Information Sciences Honors program, a student must:

• have earned a 3.5 GPA in computer and information sciences (CS) courses;
• have earned a 3.0 GPA overall;
• have completed 18 semester hours in CS courses;
• have enrolled in Undergraduate Honors Research (CS 398) for at least 1 semester hour; and
• have arranged with a faculty sponsor in Computer and Information Sciences to do a research project.

Requirements
Students in the Computer and Information Sciences Honors Program will be required to have the following:

• a minimum 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 research proposal submitted by the end of the first term of Honors Research, including an introduction, proposed methods, and relevant literature citation;
• a formal written report in the form of a scientific paper; and
• an oral or poster presentation at a Computer and Information Sciences departmental seminar.

In some instances, it will be recommended or required that Computer and Information Sciences 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 and Information Sciences Honors program, students who complete the program will graduate “With Honors in Computer and Information Sciences.”

Contact
For more information and/or admission to the Computer and Information Sciences Honors program, contact:

Dr. John K. Johnstone
1300 University Blvd. Room 125, Campbell Hall
Birmingham, AL 35294-1170
Telephone Normal 0 false false false EN-US X-NONE X-NONE

E-mail: jjk@uab.edu (bryant@cis.uab.edu)

Courses

CS 103. Introduction to Computation. 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 small, clear programs that solve interesting problems, and an appreciation of the power and beauty of computation. Strings, tuples, lists, dictionaries, comprehensions, branching, iteration, recursion, abstraction through functions, higher order programming. Principles of software development are emphasized, including specification, documentation, testing, debugging, exception handling. This course has a laboratory component.

CS 103L. Introduction to Computation Lab. 0 Hours.
Laboratory to accompany CS103.

CS 199. Special Topics in Computer Science. 1-3 Hour.
Selected topics in Computer Science. This course may or may not have a laboratory component or be taught online.

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

CS 203. Object-Oriented Programming. 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] or CS 201 [Min Grade: C]

CS 203L. Object-Oriented Programming Lab. 0 Hours.
Laboratory to accompany CS203.
CS 330L. Computer Organization and Assembly Language Programming Lab. 0 Hours.
Laboratory to accompany CS330.

CS 333. System Programming in C. 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, system programming in C covering signals and process control, networking, I/O, concurrency and synchronization, memory allocation, threads, debugging, library development and usage.
Prerequisites: CS 250 [Min Grade: C] and (CS 203 [Min Grade: C] or CS 302 [Min Grade: C])

CS 334. Networking. 3 Hours.
Prerequisites: CS 250 [Min Grade: C] and (CS 203 [Min Grade: C] or CS 302 [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, computability.
Prerequisites: CS 250 [Min Grade: C] and MA 125 [Min Grade: C] and (CS 203 [Min Grade: C] or CS 302 [Min Grade: C])

CS 355. Probability and Statistics in Computer Science. 3 Hours.
Prerequisites: CS 250 [Min Grade: C] and (CS 203 [Min Grade: C] or CS 302 [Min Grade: C])

CS 380. Scientific Computing. 3 Hours.
Scientific computing is the foundation of many key areas of computer science (e.g., machine learning, graphics, vision, cryptography) and of companies like Google. A 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 (image filtering, face detection, compression). Other topics may include wavelets, root finding, quadrature, and Fourier transform.
Prerequisites: CS 203 [Min Grade: C] and CS 250 [Min Grade: C]

CS 391. Special Topics. 1-3 Hour.
Selected Topics in Computer Science.

CS 392. Special Topics. 1-3 Hour.
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 and information sciences with grade point average of 3.5 in computer and information sciences 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.

CS 401. Programming Languages. 3 Hours. 
Study major programming paradigms, their realization in programming languages, and their impact on application design and implementation. 
Prerequisites: CS 303 [Min Grade: C] and CS 350 [Min Grade: C]

CS 401L. Programming Languages 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 401 [Min Grade: C]

CS 410. Database Management Systems. 3 Hours. 
Relational model of databases, structured query language, normalized structure of database management systems based on relational model, and security and integrity of databases. 
Prerequisites: CS 303 [Min Grade: C] and MA 125 [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]

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]

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]

CS 419. Investigating Online Crimes. 3 Hours. 
Introduction to cyber-investigative techniques involving network forensics, using automated methods to evaluate digital evidence from network packet captures, emails, server logs, and security event logs related to cyber crime cases. This course is not available for credit to students pursuing the MS and PhD Degree in Computer and Information Sciences.

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 PHL 115 [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]

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

CS 423. 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]

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

CS 425. Metrics and Performance. 3 Hours. 
The theory and practice of metrics and performance. Querying theory and statistical analysis. 
Prerequisites: CS 303 [Min Grade: C] and MA 125 [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]

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]

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 MA 125 [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 MA 125 [Min Grade: C]
CS 330. 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 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 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 331L. Operating Systems Laboratory. 0 Hours.
Lecture to accompany CS 330.

CS 334. 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 334 [Min Grade: C] and CS 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 335. 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]

CS 336. 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 330 [Min Grade: C] and MA 125 [Min Grade: C]

CS 337. Cybercrime and Forensics. 3 Hours.
A hands-on course covering all aspects of “media forensics” faced by Computer Forensics Examiners. Students will learn to analyze character encoding, file formats, and digital media, including hard drives and smartphones, as well as disk acquisition and duplication techniques and how to apply these techniques in typical criminal investigation scenarios.
Prerequisites: CS 330 [Min Grade: C] and MA 125 [Min Grade: C]

CS 430. Bioinformatics I. 3 Hours.
Introduction to computational methodologies in bioinformatics.
Prerequisites: CS 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 443. 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.

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 330 [Min Grade: C] and CS 336 [Min Grade: C] and MA 125 [Min Grade: C]

CS 445. Modern Cryptography. 3 Hours.
Theory and practice 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 330 [Min Grade: C] and MA 125 [Min Grade: C]

CS 446. Digital Currency. 3 Hours.
Fundamental principles of digital cash systems including Bitcoin, Ripple 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, security and privacy of cryptocurrencies, cryptographic techniques for digital currency, and applications of blockchain in peer-to-peer trust establishment, smart contracts, digital asset management, financial exchanges and distributed autonomous organization.
Prerequisites: CS 330 [Min Grade: C] and MA 125 [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]

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]

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]

CS 457. Penetration Testing and Vulnerability Assessment. 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]

CS 460. 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. 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 466. Games and Puzzles Seminar. 1 Hour.
Interfaces and Engines for games and puzzles such as Chess, Checkers, Othello, Rubik’s Cube, Go, Sudoku, etc.
Prerequisites: CS 303 [Min Grade: C]

CS 467. 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 CS 460 [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]

CS 470. Computer Graphics. 3 Hours.
Graphics hardware, raster images, color, shading, ray casting, triangle meshes, coordinate frames, transformation matrices, perspective and orthographic viewing, rasterization, depth buffer, animation, quaternions, smooth curves (B-spline, Bezier) and surfaces, sampling, texture mapping, graphics programming.
Prerequisites: CS 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 473. Computer Vision. 3 Hours.
Image smoothing and filtering, feature detection, segmentation, calibration and alignment, object recognition, morphology, projective geometry, scale space.
Prerequisites: CS 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 474. 3D Printing. 3 Hours.
3D Printing: design, materials, and aesthetics. Students will do projects which result in unique artifacts created by 3D printing. Multi-disciplinary teams are encouraged. Societal and legal implications.
Prerequisites: CS 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 475. Visualization. 3 Hours.
Advanced computer graphics techniques aimed at scientific visualization applications.
Prerequisites: CS 303 [Min Grade: C] and MA 125 [Min Grade: C]

CS 482. Simulation Methodology. 3 Hours.
Foundations for computer modeling and simulation, with accent on discrete systems: random number and process generation; statistical bases with probability and frequency distribution orientation; Monte Carlo experiments and general purpose modeling.
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]

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]

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

CS 492. Special Topics. 3 Hours.
Special Topics in Computer Science.

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.
Prerequisites: CS 250 [Min Grade: C]

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 Capstone. 3 Hours.
In this course, students will discuss topics relating to ethics in Computer Science. In a software engineering project, students will work in a team to put to practice principles and techniques that they have acquired throughout the undergraduate curriculum. A series of lectures on key topics in Computer Science given by faculty members and guest lecturers will round out the course. Students take the Major Field Test in Computer Science as a requirement for completing this course. Students should be CIS majors in their last semester of undergraduate study. Lecture and laboratory.
Prerequisites: CMST 101 [Min Grade: C] and PHL 115 [Min Grade: C]

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