

# Computer Science

---

300 Technology Hall  
 Telephone: 256.824.6088  
 Email: info@cs.uah.edu

**Chair:** Heggere S. Ranganath, Professor

---

The Computer Science department offers the following graduate degree programs:

- Master of Science in Computer Science
- Master of Science in Software Engineering
- Doctor of Philosophy in Computer Science

The Computer Science department offers the following certificate programs:

- Software Engineering

---

## Admission Requirements

Requirements for admission to the computer science graduate degree program are in addition to those of the School of Graduate Studies. Scores from the GRE basic test are required for admission to the program. Transcripts will be reviewed and deficiencies in computer science background may result in the need to take one or more broadening courses. The MAT or GMAT is not an acceptable substitute for the GRE.

Requirements for admission to a graduate certificate program are the same as requirements for admission to the Computer Science M.S. program. Students must also satisfy the breadth requirements described below. Students in a certificate program are required to maintain a 3.0 GPA.

Students applying for the master's program are expected to have an undergraduate background in Computer Science. Those students who do not have such a background must satisfy the breadth requirements described below. In particular, students who have not had an undergraduate course in programming languages must take CS 424 (<http://catalog.uah.edu/search/?P=CS%20424>) or CS 524 (<http://catalog.uah.edu/search/?P=CS%20524>) as a prerequisite to the MSSE program.

The admission policies for the Ph.D. program in computer science follow the general policies of the School of Graduate Studies and Computer Science Department as described above. An applicant's admission request will be reviewed in light of preparatory coursework, GRE scores, any supporting information, and general expectation of completing the degree. Students requiring a large amount of prerequisite coursework will not normally be admitted to the program until the courses have been completed. Graduate admission requests for the Ph.D. program will be reviewed once per semester by a departmental admissions committee. Applicants are required to submit supporting recommendation letters and an indication of research interests and study plans. Specific requirements are available from the Computer Science Department office. Requests for admission will be evaluated according to the following guidelines.

## Unconditional Admission

Students applying to the M.S. program will be given unconditional admission if they meet all the requirements of the School of Graduate Studies and of the Computer Science Department including the breadth requirements listed below.

Unconditional admission to the Ph.D. program will be given to applicants who meet all of the requirements of the School of Graduate Studies and Computer Science Department. Students showing exceptional promise who desire to pursue the Ph.D. full-time may be admitted to the program after completing a bachelor's degree in Computer Science.

## Conditional Admission

Conditional admission will be recommended for applicants who do not meet all of the requirements of the School of Graduate Studies and the Computer Science Department, but show high potential for completing the degree requirements.

## Breadth Requirements

Applicants to graduate programs in Computer Science must satisfy the following breadth requirements before admission to the program.

### Mathematics

MA 171	CALCULUS A	4
MA 172	CALCULUS B	4
MA 244	INTRO TO LINEAR ALGEBRA	3

MA 385	INTRO TO PROBABILITY & STATIST	3
<b>Computer Science</b>		
CS 121	COMPUTER SCIENCE I <sup>1</sup>	3
CS 221	COMP SCI II: DATA STRUCTURES <sup>1</sup>	3
CS 321	INTRO OBJECT-ORIENTED PROG JAV <sup>1</sup>	3
CS 214	INTRO DISCRETE STRUCTURE	3
CS 317	INTRO DESIGN/ANALYSIS OF ALG	3
CS 490	INTRO TO OPERATING SYSTEMS	3
CS 309	COMPUTER ORG & SWTCHNG THRY	3
CS 413	INTRO DIGITAL COMP ARCHITECTUR	3
<b>Total Semester Hours</b>		<b>38</b>

<sup>1</sup> An introductory sequence covering Object-Oriented Programming and Data Structures in C/C++/Java.

The breadth requirements can be satisfied in one of the following ways:

1. Completion of the course at UAH with a grade of B or better;
2. Completion of an equivalent course at another institution with a grade of B or better;
3. Testing out of the course, where permitted by departmental policy.

Consult a departmental advisor for additional information.

---

## Program Objective

The objective of the Computer Science program is to prepare students to become contributors to the computer science profession, whether they find themselves in industrial, government, research, or university environments. Our second objective is to enable students to demonstrate leadership capabilities and work effectively with others of varying backgrounds in team environments.

## Learning Outcomes

Students will demonstrate:

- Advanced knowledge of computer systems
- Proficient development and usage of software systems and development tools
- Ability to develop solutions based on advanced algorithmic principles

## Master's Programs in Computer Science

---

### Degree Requirements and Restrictions

The Master of Science degree or Master of Science in Software Engineering is conferred under Plan I or Plan II.

### Transfer to Computer Science from Other UAH Graduate Programs

Students enrolled in other graduate programs at UAH who wish to obtain a degree in Computer Science should see a Computer Science advisor for evaluation. Such a student must fulfill the Computer Science breadth requirements. Taking CS graduate courses without first checking with a departmental advisor will not eliminate the need for completing the breadth requirements.

### The Program of Study

A program of study should be completed as soon as the course content of the program has been selected. The plan must be made in consultation with an advisor from the Computer Science faculty. The student's Faculty Advisor, Department Chair, and the Dean of the School of Graduate Studies approve the program of study. After approval, student requested changes must be agreed to by the student's advisor and submitted for approval.

### Cybersecurity

The MSCBS degree is a unique, interdisciplinary program involving three colleges: Business Administration, Engineering, and Science. The program prepares graduates with the skills to secure and defend networks, recover from security failures, use computer forensics, and manage data security -- leading to careers in the fast growing field of information security. The Computer Science track involves developing, documenting, and maintaining secure coding practices for scripts and applications. The design aspects of networks ensuring a risk mitigated network in relation to confidentiality,

integrity, and the availability of data and devices are also included. A student must complete five core courses (IS 660, IS 663, CPE 549, CS 585 and CPE/CS/IS 692 (capstone course)), two courses from (CS 565, CS 570, and CS 685) and 9 hours of elective courses approved by the department to earn the MSCBS degree in the Computer Science track. The elective courses in this area include the following:

CS 553	CLIENT/SERVER ARCHITECTURES	3
CS 565	NETWORK SECURITY	3
CS 570	INTRO TO COMPUTER NETWORKS	3
CS 580	MOBILE DIGITAL FORENSICS	3
CS 585	INTRO TO COMPUTER SECURITY	3
CS 670	COMPUTER NETWORKS	3
CS 685	COMPUTER SECURITY	3

**Other Elective Courses may be taken with Departmental Approval**

**Computer Architecture and Networking**

The courses offered in the area of computer architecture cover the organization, architecture, and design of digital computer systems from high-level conceptual design to gate level implementation. The main concentration areas are: logic design and digital computer hardware design; parallel computer architectures; distributed processing; and networks. Courses in this area include:

CS 570	INTRO TO COMPUTER NETWORKS	3
CS 553	CLIENT/SERVER ARCHITECTURES	3
CS 670	COMPUTER NETWORKS	3
CS 613	COMPUTER ARCHITECTURES	3

**Plan I – Master of Science with Thesis**

A minimum of 24 semester hours of coursework and the writing of an acceptable thesis is required. At least six semester hours of thesis credit (CS 699 (<http://catalog.uah.edu/search/?P=CS%20699>)) must be earned. A student must present his/her thesis and pass an oral examination based on the thesis and related coursework. Plan I students must register for CS 699 (<http://catalog.uah.edu/search/?P=CS%20699>) each term they receive supervision from their advisor.

**Plan II – Master of Science without Thesis**

A minimum of 33 semester hours of coursework is required. A student must pass a written comprehensive examination over three core courses as described below. Plan II students must complete at least 18 semester hours of coursework before taking the written comprehensive examination. The examination may only be taken twice.

The following requirements and restriction apply to a student in either plan.

**Course Requirements**

All M.S. students must take three core courses from the options below:

CS 617	DES & ANALY OF ALGORITHM	3
CS 613	COMPUTER ARCHITECTURES	3
or CS 690	ADVANCED OPERATING SYSTEMS	
CS 650	SOFT'W ENGINEERING PROC	3
or CS 687	DATA BASE SYSTEMS	

**Total Semester Hours** **9**

CS 545	INTRO COMPUTER GRAPHICS	3
CS 546	ADVANCED COMPUTER GRAPHICS	3
CS 548	HUMAN-COMPUTER INTERACTION	3
CS 640	MACHINE LEARNING	3
CS 642	COMP PROC/DIGITAL IMAGES	3

**Master of Science in Software Engineering**

**Overview Non-thesis Option:**

1. Complete 12 hours of core courses including one course in systems architecture
2. Complete 3 hours in cyber security (CS or CPE)

3. Complete 6 hours in one concentration
4. Complete 3 hours capstone
5. Complete 6 hours of electives (must include CS 524 if no prior course in program languages have been taken)
6. Total of 30 hours

**Overview Thesis Option:**

1. Complete 12 hours of core courses including one course in systems architecture
2. Complete 3 hours in cyber security (CS or CPE)
3. Complete 6 hours in one concentration
4. Complete 6 hours CS 699 or CPE 699
5. Complete 3 hours of electives (must include CS 524 if no prior course in program languages have been taken)
6. Total of 30 hours

**Course Requirements****Core Courses**

CS 617	DES & ANALY OF ALGORITHM	3
CS 650	SOFT'W ENGINEERING PROC	3
CS 652	OBJECT-ORIENTED DESIGN	3

**Required Courses**

CS 613	COMPUTER ARCHITECTURES	3
or CS 690	ADVANCED OPERATING SYSTEMS	
or CPE 536	INTERNALS OF MODERN OPER SYS	
or CPE 631	ADV COMP SYSTEMS ARCHITECTURE	
CPE 549	INTRO TO CYBERSECURITY ENGINRG	3
or CS 585	INTRO TO COMPUTER SECURITY	
or CS 685	COMPUTER SECURITY	

**Concentration Area - Pick two courses within any one concentration** 6**Big Data and Data Mining**

CS 554	INTRO TO CLOUD COMPUTING	
CS 696	SELECTED TOPICS IN CS (ST: BIG DATA ANALYTICS)	
CS 696	SELECTED TOPICS IN CS (ST: MACHINE LEARNING)	
CS 696	SELECTED TOPICS IN CS (ST: DATA VISUALIZATION)	
CS 641	DATA MINING	

**Project Management (ISE 690 Required)**

EM 660	ENGR MGMT THEORY	
MGT 601	TECH & INNOVATION MGMT	
MKT 604	NEW PRODUCT DEVELOPMENT	
ISE 690	STATISTICAL METHODS FOR ENGR	

**Parallel Programming**

CPE 512	INTRO PARALLEL PROGRAMMING	
CPE 612	PARALLEL ALGORITHMS	
CPE 613	GEN PURPOSE GPU COMPUTING	

**Embedded Systems**

CPE 538	REAL TIME & EMBEDDED SYSTEMS	
CPE 523	HARDWARE/SOFTWARE CO-DESIGN	
CPE 621	ADVANCED EMBEDDED SYSTEMS	

**Advanced Cybersecurity**

CPE 649	ADV CYBERSECURITY ENGINEERING	
CPE 645	COMPUTER NETWORK SECURITY	
IS 663	COMPUTER FORENSICS	

**Non-Thesis and Thesis Options:** 9**Non-Thesis Option****Capstone (3 hours)**

CPE 656	SOFTWARE ENGRG STUDIO I	
<b>Electives (6 hours)</b>		
CS 524	PROGRAMMING LANGUAGES (If no prior course in Programming Languages has been completed)	
<b>Thesis Option</b>		
CS 699	MASTER'S THESIS (6 hours)	
or CPE 699	MASTER'S THESIS	
<b>Elective (3 hours)</b>		
CS 524	PROGRAMMING LANGUAGES (If no prior course in Programming Languages has been completed)	
<b>Total Semester Hours</b>		<b>30</b>

Note: There will be NO comprehensive examination for either CS or CPE students

## Additional Information

If a student has not had an undergraduate course in programming languages, CS 524 (<http://catalog.uah.edu/search/?P=CS%20524>) must be included in the program of study. No more than 50% of the semester hours in the program of study may be 500-level courses. No more than three semester hours of selected topics or independent study courses may be included in a program of study. Exceptions must be recommended by the student's advisor and approved by the department chair.

## Grade Requirements

A grade of B or better must be earned in each of the core courses. No grade lower than C can be counted toward a graduate degree. A 3.0 average must be maintained in all graduate work at UAH and in all work to be counted toward the degree.

## Time Limit

The degree must be completed within six years. Courses older than six years may be validated according to Graduate School policy. Courses older than ten years may not be applied to the degree.

## Transfer Credit

Graduate work may be transferred from another institution according to Graduate School policy.

## Doctoral Program in Computer Science

### Degree Requirements

The general requirements for the Ph.D. degree comply with those of the School of Graduate Studies. The requirements include a preliminary examination, completion of coursework, a Qualifying Examination, completion of significant research documented in a dissertation, and the dissertation defense.

### Major/Minor Subjects

A minimum of 54 semester hours of graduate course credit plus a minimum of 18 dissertation semester hours is required for the Ph.D. in Computer Science. The program of study will be approved by the student's Supervisory Committee. Coursework grade requirements are the same as for the M.S. degree. Coursework taken as part of a graduate degree program at another institution may be applied to the degree with permission of the student's Supervisory Committee. At least 9 semester hours of graduate level mathematics or statistics must also be included in the program.

The program must include:

CS 524	PROGRAMMING LANGUAGES	3
CS 603	FORMAL LANG/AUTOMAT THRY	3
CS 613	COMPUTER ARCHITECTURES	3
CS 617	DES & ANALY OF ALGORITHM	3
CS 650	SOFT'W ENGINEERING PROC	3
CS 690	ADVANCED OPERATING SYSTEMS	3
<b>Total Semester Hours</b>		<b>18</b>

It also must have a coherent area of emphasis, of which at least 6 semester hours must be at the 700 level.

## Additional Information

### Preliminary Examination

Ph.D. students will be required to take a preliminary examination, consisting of:

1. a written test covering fundamental concepts in Computer Science, and
2. an evaluation by the graduate faculty of the student's overall academic potential.

The examination must be taken within a year after admission to the Ph.D. program, or at the earliest opportunity upon completion of the core coursework. Successful completion of the examination will provide evidence of the student's ability to continue in pursuit of the Ph.D. degree. The examination can be taken no more than twice.

### Admission to Candidacy

To be admitted to candidacy for the Ph.D. degree, students must first pass the Qualifying Examination. The Qualifying Examination can cover any aspect of the student's program and is taken after completion of the student's coursework and upon recommendation of the student's Supervisory Committee. It is designed to test students' fitness for pursuing research projects in their chosen areas and to test their general knowledge of Computer Science. As part of the Qualifying Examination, each student will present a research proposal to the Supervisory Committee.

### Ph.D. Residency Requirements

According to graduate school policy, residence may be established through either:

1. being enrolled as a full-time student (at least 9 graduate semester hours) either for one continuous academic year, or for Spring and Fall semesters in the same calendar year, or
2. being enrolled in at least 6 semester hours of graduate course work in at least three of four consecutive semesters.

### Other Requirements for the Ph.D. Degree

- The program must be completed within five years after admission to candidacy.
- The Qualifying Examination may be taken no more than twice.
- CS 799 (<http://catalog.uah.edu/search/?P=CS%20799>) is required each semester a student is receiving direction on the doctoral dissertation.

For additional requirements, consult the Academic Information (<http://catalog.uah.edu/grad/academic-info>) Section of this Graduate Catalog.

### Dissertation

The research described in the dissertation must be accepted for publication in an approved journal or three conference proceedings prior to defense of the dissertation. A public defense of the dissertation is required.

## Certificates in Computer Science

### Software Engineering Certificate

The Software Engineering Program is designed for those students who want to broaden their knowledge in this area, but do not necessarily desire to pursue a graduate degree in Computer Science.

CS 650	SOFT'W ENGINEERING PROC	3
CS 585	INTRO TO COMPUTER SECURITY	3
ISE 690	STATISTICAL METHODS FOR ENGR	3
Select 2 courses from the following:		6
CS 553	CLIENT/SERVER ARCHITECTURES	
CS 652	OBJECT-ORIENTED DESIGN	
CS 655	FORMAL METHODS IN SOFTWARE ENG	
CS 656	SOFTWARE TESTING	
Select 1 course from the following:		3
MGT 601	TECH & INNOVATION MGMT	
MGT 622	MGT TECHNI PROFESSIONALS	

**Total Semester Hours**

**18**

Students desiring to complete the certificate program should have either industrial experience in software development or have undergraduate courses in software development. Students pursuing an MSSE degree are not eligible for the Software Engineering Certificate.

**CS 503 - UNIX & C PROGRAMMING/A&M**

Semester Hours: 3

**CS 513 - INTRO TO COMP ARCHITECT**

Semester Hours: 3

Review of combinational and sequential logic design, register transfer concept, logic design of memory, arithmetic unit, control unit, and I/O system of simple computer. Review of Machine and Assembler language programming. Architectural trade-offs.

**CS 517 - DATA ORG ANALYSIS OF ALGORIT**

Semester Hours: 3

Review of basic data structures such as stacks, queues, lists, B-Trees, and binary trees. Overview of file structures and access methods. Introduction to complexity analysis of algorithms. Basic algorithm design techniques such as divide & conquer, dynamic programming, and backtracking. Introduction to the classification of problems by class; i.e., tractable, NP, intractable, and unsolvable.

**CS 524 - PROGRAMMING LANGUAGES**

Semester Hours: 3

Principles of modern programming language features and design. Comparative study of language paradigms. Overview of language implementation, including lexical, syntax, and semantic analysis. Formal grammars, BNF notation. Brief history of programming languages.

**CS 526 - PROG TRANS & COMPILER CONSTR**

Semester Hours: 3

Language representation; grammar classification; lexical analysis technique and tools; parsing technique and tools; compile-time and run-time symbol table design; code generation and optimization; error diagnostics. Compiler writing tools.

**CS 530 - EXP SYS/HEURISTIC PROGRAMMING**

Semester Hours: 3

Expert systems concepts and architectures. Languages and tools for knowledge engineering. Heuristic versus algorithmic methods, heuristics as used in expert systems, and heuristic programming techniques. Class and individual projects. Background in algorithms and programming languages assumed.

**CS 537 - INTRO TO NEURAL NETWORKS**

Semester Hours: 3

Introduction to artificial neural networks, covering the most prominent models. Neural networks solutions to classification, clustering, data compression, and constrained optimization applications. Experience with neural networks through projects.

**CS 543 - INTRO TO MULTIMEDIA SYSTEMS**

Semester Hours: 3

Multimedia authoring, color models for image and video, introduction to image and video compression, digital audio, multimedia networks, multimedia synchronization, multimedia retrieval. Students may not receive credit for both CS 443 and CS 543. Courses numbered at the 500-level may be taken for undergraduate credit with prior approval, except as otherwise noted. Courses at 600-level or above are reserved for graduate students. They may be taken by other students only by approval. Consult Seniors Taking Graduate Courses in the Graduate Admissions section of this catalog for specific policies and approval procedures. Taught as CS 443/543. Course completion and/or grade requirements for graduate credit will differ from those for undergraduate credit. Prerequisite: CS 617.

**CS 545 - INTRO COMPUTER GRAPHICS**

Semester Hours: 3

Introduces underlying theory and mechanics of interactive computer graphics. Basic modeling, rasterization, 2D/3D transformations, and viewing. 3D graphics rudiments. Some hardware and historical perspectives. Many programs.

**CS 546 - ADVANCED COMPUTER GRAPHICS**

Semester Hours: 3

High resolution 3D graphics, including advanced topics in viewing, vertex processing, fragment processing, local and global illumination and shading, 3D modeling (including curve and surface representation), texture mapping, and some coverage of solid modeling and color theory. Game production pipeline. Hierarchical issues, visibility, and 3D processing algorithms may also be covered. A significant number of programming projects are involved, with some different program requirements and additional theoretical expectations for CS 546 students. (Same as CS 456; no credit for both).

Prerequisite: CS 545.

**CS 547 - GAME ENGINES & LEVEL DEV**

Semester Hours: 3

(Same as CS 447) This course provides the opportunity for students to produce fully functional games from beginning to end with team members. Along the way, students work on homework/projects involving design document creation, prototyping and gameplay/implementation. Also, game software as artistic content has led to collaborations between engineers and artists. In this course, students focus on not only game engineering development but also art asset generation and management. Considers a 3D game design and development using game engines focusing on the fundamental components for developing cross-platform games. The course focus includes design, development, and distribution of computer games. Emphasis also is on user interface and menus, scripting for game programming, game physics, terrain generation, asset management, animation management, special effects, and cross platform game development. Students may not receive credit for both CS 447 and CS 547.

**CS 548 - HUMAN-COMPUTER INTERACTION**

Semester Hours: 3

Introduces underlying theory and mechanics of interactive computer graphics. Basic modeling, rasterization, 2D/3D transformations, and viewing. 3D graphics rudiments. Some hardware and historical perspectives. Many programs. Introduction to human-computer interaction and principles of graphical user interface design. Includes examination of interactive environments including windowing systems development tools, multimedia, and visual programming interfaces. Prerequisite: CS 545.

**CS 553 - CLIENT/SERVER ARCHITECTURES**

Semester Hours: 3

Aspects of client/server distributed computing, a paradigm that includes technologies addressing web services (such as AJAX using Javascript/PHP, ASP.NET) as well as distributed object (such as .NET remoting, CORBA). Students will apply the concepts in practical distributed programs.

**CS 554 - INTRO TO CLOUD COMPUTING**

Semester Hours: 3

Different cloud computing paradigms: IaaS, SaaS, PaaS. Open Source cloud software (for ex., OpenStack, CloudStack). RESTful interfaces, AWS interface. Cloud security. Students may not receive credit for both CS 454 and CS 554.

**CS 565 - NETWORK SECURITY**

Semester Hours: 3

Fundamentals of network security and cryptography. Examines security at different network layers. Wireless security. Firewalls. Intrusion detection and penetration analysis. Students may not receive credit for both 465 and 565.

**CS 570 - INTRO TO COMPUTER NETWORKS**

Semester Hours: 3

Organization and operation of computer networks. Physical, Data Link, Network, Transport, and Application-layer protocols and algorithms; LAN and WAN systems; TCP/IP; Wired and wireless organizations; security approaches. Prerequisite: CS 513.

**CS 571 - MOBILE COMPUTING SFTWR ARC&DEV**

Semester Hours: 3

Considers application design for the mobile space, focusing on the fundamental requirements for mobile applications that target mobile devices. The course focus includes development, testing, distribution of mobile applications in a cross-platform environment. Emphasis also is on multimedia and entertainment computing and games. This course will also cover various issues in mobile computing from the readings from research literature such as software engineering practices, analysis of social media and general mobile analytics.

**CS 580 - MOBILE DIGITAL FORENSICS**

Semester Hours: 3

This course examines digital forensics of mobile devices such as smart phones and tablets in a law enforcement context. Mobile device characteristics that make forensics examinations difficult are discussed. Various forensics tools are critically examined with an eye toward improved tool development.

**CS 581 - MODELING & SIMULATION I**

Semester Hours: 3

Discrete event simulation from a computer science perspective. Mathematics of probability distributions applied to simulation. Design, implementation, and application of discrete event simulation software. Application to computer and network system design.

**CS 582 - MODELING & SIMULATION II**

Semester Hours: 3

Advanced application of computer science methods to modeling and simulation software development. Design, development, and integration of software for real-time distributed simulations using standard network interoperability protocols. Team development of modeling and simulation software. Prerequisites: CS 581 or MOD 501.



**CS 585 - INTRO TO COMPUTER SECURITY**

Semester Hours: 3

This course examines the issues related to security policies, models and mechanisms applicable to providing security for computer-based systems including operating systems, database management systems, and networks.

**CS 590 - PROGRAMMING ENVIRON W/UNIX**

Semester Hours: 3

Strategies for design and development of systems and programs in the UNIX environment. Emphasis: automated tool and system development using UNIX tools. Advanced shell concepts including control flow and interrupt handling. Process and inter-process communication.

**CS 595 - INDEPENDENT STUDY**

Semester Hours: 3

Individual directed study under the supervision of an instructor. Must have approval of the instructor.

**CS 596 - SPECIAL TOPICS**

Semester Hours: 3

Individual directed study under the supervision of an instructor. Must have approval of the instructor.

**CS 597 - SPECIAL TOPICS**

Semester Hours: 3

Course offered by an instructor in a specialized area of computer science. Must have approval of instructor.

**CS 598 - SPECIAL TOPICS**

Semester Hours: 3

Course offered by an instructor in a specialized area of computer science. Must have approval of instructor.

**CS 600 - INTERNSHIP IN COMPUTER SCIENCE**

Semester Hour: 1

Work experience in Computer Science or a related field in a business or government agency; conducted under the direction of the agency supervisor and approved by a member of the CS faculty. A substantial report must be produced and approved by the supervisor and the faculty member.

**CS 603 - FORMAL LANG/AUTOMAT THRY**

Semester Hours: 3

Formal definition of programming languages. Formal grammars: regular, context-free, context sensitive, and phrase-structure. Automata: finite-state, pushdown, linear-bounded automata, Turing Machines. Relationship between formal languages and automata.

**CS 613 - COMPUTER ARCHITECTURES**

Semester Hours: 3

Organization, operation, and analysis of advanced computer architectures. Topics include advanced pipelining approaches, multi-processor architectures, instruction set architectures, memory hierarchy design, hardware and software-based performance optimization, and system performance measurement. Prerequisite: CS 513.

**CS 617 - DES & ANALY OF ALGORITHM**

Semester Hours: 3

Strategies of algorithm synthesis and analysis. Classical algorithm categories such as: divide-and-conquer, greedy method, dynamic programming, search and traversal. Computational complexity; theoretical results from lower- and upper-bound studies, NP-hard, and NP-complete problems. Prerequisite: CS 517.

**CS 630 - ARTIFICIAL INTELLIGENCE I**

Semester Hours: 3

All concepts and methods for problem solving, heuristic search, planning, hypothesis formation, modeling and knowledge representation, knowledge acquisition and learning. Applications of AI in various areas. Background in algorithms and programming languages assumed. CS 530 recommended.

**CS 635 - COMPUTAT MODEL COGNITION**

Semester Hours: 3

Computational models of human information processing covering topics of current interest to both artificial intelligence and cognitive psychology. Use of computer simulations to test psychological theories. Application of psychological research to building AI systems. Prerequisite: CS 630.

CS 640 - MACHINE LEARNING

Semester Hours: 3

Discriminant analysis, maximum likelihood decisions, deterministic and nondeterministic approaches for trainable classifiers, preprocessing and feature extraction, clustering, syntactic pattern recognition. Pattern recognition in image analysis.

CS 641 - DATA MINING

Semester Hours: 3

Data preprocessing, distance measures, classification with decision trees, Bayesian classifiers, neural networks, support vector machines, frequent item set analysis, association rule generation, clustering methods.

CS 642 - COMP PROC/DIGITAL IMAGES

Semester Hours: 3

Introduction to image processing systems; sensing, sampling and quantization; image transforms; image enhancement and restoration; image segmentation, and description; image correlation; image sequence analysis; practical applications of image processing.

CS 643 - DATA COMPRESSION

Semester Hours: 3

Lossless and lossy compression algorithms, Huffman coding, Arithmetic coding, Dictionary-based compression, quantization techniques, differential encoding, transform coding, wavelet-based coding; image compression, video compression, audio compression, applications of compression algorithms to audio, image, and video compression standards. Prerequisite: CS 617.

CS 646 - COMPUTER GEOMETRY MODELING

Semester Hours: 3

Numerical and computer rep. of curves and surfaces. Solid geometry modeling. Geometric data management. Curve and surface design, incl. cubic-B-splines, esp. Bezier curves/surfaces. Interpolation methods. Graph-based and Boolean models. Apps. to robotics, graphics, CAD.

CS 650 - SOFT'W ENGINEERING PROC

Semester Hours: 3

The process of developing complex software products. Includes software life cycles, phases of development and disciplines such as CM, QA, V&V, and T&E. Issues of professionalism and the ethical use of computers. Background in algorithms and programming languages assumed.

CS 652 - OBJECT-ORIENTED DESIGN

Semester Hours: 3

A survey of formal and informal techniques and methodologies for software analysis, requirements, architecture and design. Emphasis is on effective development processes. Comparison of different approaches, considering their advantages and disadvantages. Prerequisite: CS 650.

CS 655 - FORMAL METHODS IN SOFTWARE ENG

Semester Hours: 3

Formal mechanisms to specify, validate, and verify software systems. Propositional and predicate calculi. Program verification through Dijkstra's weakest preconditions and Hoare's method. Formal specification via algebraic specifications and abstract model specifications. Prerequisites: CS 617 and CS 650.

CS 656 - SOFTWARE TESTING

Semester Hours: 3

Advanced software testing techniques, including white box, black box, integration testing, and system testing. Other topics may include test data adequacy, test data selection, and output oracle, including functional, structural, and fault-based testing methods. Prerequisite: CS 650.

CS 658 - SOFTWARE PROC & PROD IMPROVEMT

Semester Hours: 3

Software quality assurance as an umbrella activity. Use of process, project, quality and product metrics to gain insight into the software development activity. Use of metrics to drive incremental process improvement techniques. Examination of CASE tools and how they affect the software process. Prerequisite: CS 650.

CS 666 - SOFTWARE STUDIO I

Semester Hours: 3

Students work in teams on medium-sized software projects to analyze and document software requirements, produce a project plan, design and build a prototype, and present the project for evaluation. The design-evaluation phases are repeated twice to generate a more mature design. Prerequisites: CS 650 and either CS 652, 656, or 658.

**CS 668 - SOFTWARE STUDIO II**

Semester Hours: 3

A continuation of CS 666. Students work in teams to continue the software engineering cycle with emphasis on software management, evolution, maintenance, quality analysis, testing, integration, validation, and security auditing. Prerequisite: CS 666.

**CS 670 - COMPUTER NETWORKS**

Semester Hours: 3

Detailed analysis of the organization and operation of computer networks, focusing on algorithms and organizations for the Transport Layer, Network Layer and Data Link Layer protocols of wired and wireless systems. Prerequisite: CS 570.

**CS 685 - COMPUTER SECURITY**

Semester Hours: 3

Advanced topics in security policies, models and mechanisms applicable to providing security for computer based systems, including operating systems, database management systems, and networks.

**CS 687 - DATA BASE SYSTEMS**

Semester Hours: 3

Basic concepts of database systems. Use of semantic models in database design. Data models with an major focus on the relational and object-oriented models. Relational query languages and normal forms. Database management system design issues. Security and integrity issues.

**CS 690 - ADVANCED OPERATING SYSTEMS**

Semester Hours: 3

Issues related to shared memory multiprocessors, multicore computers, clusters, grids and clouds. Concurrency and distributed process coordination. Introduction to network communication issues and systems such as client-server, peer-to-peer, transaction based. Prerequisite: CS 513.

**CS 692 - COMPUTER SECURITY**

Semester Hours: 3

**CS 695 - INDEPENDENT STUDY**

Semester Hours: 3

Individual directed study under the supervision of an instructor. Must have instructor approval.

**CS 696 - SELECTED TOPICS IN CS**

Semester Hours: 3

Course offered by an instructor in a specialized area of computer science. Must have instructor approval.

**CS 699 - MASTER'S THESIS**

Semester Hours: 3-6

Course offered by an instructor in a specialized area of computer science. Must have instructor approval. Required each semester a student is working and receiving direction on master's thesis. Prerequisite: instructor approval.

**CS 703 - THEORY OF PROG LANGUAGES**

Semester Hours: 3

Syntactic analysis and semantic interpretation of programming languages based on research and results in formal languages and associated compiler techniques. Identification of research directions and potential research projects in programming languages.

**CS 717 - ADV ALGORITHM DES/ANALYSIS**

Semester Hours: 3

Parallel algorithms, combinatorial algorithms, approximation algorithms for NP-complete problems, computational complexity. Distribution of algorithms across complex architectures. Prerequisite: CS 617.

**CS 730 - ARTIFICIAL INTELLIGENCE II**

Semester Hours: 3

Rigorous treatment of special topics in artificial intelligence. Topics may include knowledge representation, automated deduction, search control, machine learning, or meta-level architectures. Prerequisite: CS 630.

CS 742 - IMAGE PROC ALGO/ARCHITEC

Semester Hours: 3

Algorithms and data structures for image enhancement, segmentation, object recognition and image sequence analysis; real-time versus non real-time image processing; computer architectures for fast image processing; cellular logic array processors, distributed, systolic and binary array processors.

Prerequisite: CS 613 and CS 642.

CS 790 - OPERATING SYSTEMS SEMINAR

Semester Hours: 3

Advanced research topics in operating system theory and practice. Students will read and discuss classic and current papers in the literature. Each student will present reports in class and prepare a substantial research paper. Prerequisite: CS 690.

CS 795 - ADVANCED SELECTED TOPICS

Semester Hours: 3

Individual directed study under the supervision of an instructor. Must have instructor approval.

CS 796 - ADVANCED SELECTED TOPICS

Semester Hours: 3

Course offered by an instructor in a specialized area of computer science. Must have instructor approval.

CS 799 - DOCTORAL DISSERTATION

Semester Hours: 3-9

Required each semester student is enrolled and receiving direction on doctoral dissertation. Maximum of 18 hours credit toward degree.

CS ADD - COMPUTER ORG & ARCHITEC/ATHENS

Semester Hours: 3