Department of

Computer Science

College of Science

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Degrees offered: Bachelor of Science (BS), Bachelor of Arts (BA), Master of Science (MS), and Doctor of Philosophy (PhD) in Computer Science; Master of Computer Science (MCS)

Undergraduate emphases: *BS, BA*—Science, Digital Systems, Information Systems; **Graduate specializations:** Artificial Intelligence, Parallel Systems, Software Engineering

Accreditation: The Computer Science undergraduate program is accredited by the Computing Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone (410) 347-7700.

Undergraduate Programs

Objectives

The core objective of the department is to fulfill its mission, as defined in its mission statement. A detailed description of all department objectives is given under the department's web site: **http://www.cs.usu.edu/**. The outcome objectives for undergraduates are as follows:

Undergraduate Outcomes

All students graduating with a Bachelor of Science in Computer Science from Utah State University will be expected to show mastery as follows:

1. Graduates will be proficient in programming in at least two programming languages which have significance in industry.

2. Graduates will master the core curriculum in:

   a. Data Structures and Algorithms
   b. Computer Architecture and Organization
   c. Programming Languages
   d. Operating Systems
   e. Theory of Computing
   f. Software Engineering

3. Graduates will understand the practices and dynamics required to develop software, whether it be a single program or a major software product developed in a team environment.

4. Graduates will gain proficiency in the use of mathematical tools, including calculus, elementary statistics, and probability.

5. Graduates will have sufficient mastery of fundamental knowledge to be lifelong learners in computer science.

6. Graduates will understand the social and ethical issues which face computer scientists, and thus be able to contribute in a positive and productive manner to society.

7. Graduates will be able to communicate information effectively, both in writing and orally.

The course of study offered by the Department of Computer Science is directed primarily toward developing the problem solving skills of its students. This, in conjunction with the understanding of computers and computer systems provided by coursework, will enable a graduate of the program to apply his or her knowledge to finding solutions to problems that arise in the sciences, business, industry, government, and education sectors.

Students who have the ability to think analytically and creatively will find a challenging and exciting future in computer science.

Opportunities for practical applications of computer science skills are available with members of the computer science faculty who are engaged in research and consultation work both on and off campus.

Computer Science

Computer Science deals with information structures and processes as they are represented and implemented in modern high-speed digital computers, and with information processing systems designed to implement useful applications of computing.

The program in computer science attempts to provide a solid foundation of knowledge about computers and to teach a mode of thinking which will permit continuing growth on the part of graduates. Prospective students should have an aptitude for mathematics and logic and an interest in analysis and deduction.

Computer science is one of the fastest growing fields of study in our society. Excellent employment opportunities are available to computer science graduates. All of the major corporations hire computer science graduates. Graduates in Computer Science work for such Utah-based corporations as Novell, Evans and Sutherland, TRW, and Thiokol, as well as Microsoft, IBM, Hewlett-Packard, etc.

The Computer Science bachelor's degree is a four-year degree with areas of emphasis in Science, Digital Systems, and Information Systems. In addition, by working with a departmental advisor, students may develop a plan of study tailored to their own unique career objectives.

Science Emphasis

The Science Emphasis is designed for those who plan to pursue scientific or technical careers, research, or graduate education in computer science. Students choosing the science emphasis will take courses in programming languages, advanced algorithms, and math courses in calculus, linear analysis, and multi-variable calculus. Additional courses include a variety of upper-division computer science courses, chosen in consultation with an advisor.

Digital Systems Emphasis

The Digital Systems Emphasis is available for those interested in both the hardware and software aspects of computer systems. In addition to computer science and mathematics courses, students in this emphasis will take electrical engineering courses in electronics, circuits, digital fundamentals, microcomputer systems, and digital system design. The curriculum for students in this emphasis is similar to that for students in the computer engineering major in the Electrical and Computer Engineering Department.

Information Systems Emphasis

The Information Systems program at Utah State University offers a common core of courses through two department majors: (1) **Business Information Systems** and (2) **Computer Science**. The curricula of the individual departments differ substantially in emphasis.

The Computer Science major with an Information Systems emphasis is designed for students interested in a career as a Computer Scientist with a background in Information Sciences and Systems. Majors in this emphasis are trained in all phases of the analysis, design, and implementation of information systems. As part of this emphasis, students also receive training in the theory and application of information. Students select an application area such as business, accounting, or economics. Other application areas can be developed by working closely with an advisor. This program of study, offered within the College of Science, leads to a Bachelor of Science, Bachelor of Arts, or Master of Science degree in Computer Science.

The Business Information Systems major, Management Information Systems emphasis, is offered in the Business Information Systems Department, College of Business (see page 163). The Bachelor of Science or Bachelor of Arts program is designed for students interested in business careers as information specialists, systems analysts, network managers, application programmers, and information systems managers in business and industry. BIS majors take required courses in analysis and design, Internet management, telecommunications, decision support systems, spreadsheet and database applications, and information systems projects. All graduates are required to complete a common core of business subjects. The College of Business is accredited by the American Assembly of Collegiate Schools of Business. The department also offers a Master of Science in Business Information Systems with a specialization in Management Information Systems. See page 165 for additional details.

Department and General College of Science Requirements

In addition to the University Studies requirements, all majors in computer science must complete a total of 30 semester credits in writing, languages, humanities, arts, and/or social sciences. Courses taken to meet the University Studies requirements, if applicable, may also be counted to meet this departmental requirement. Students must work closely with their advisor to meet both these requirements.

Bachelor of Science Core Requirements. Students working toward the Bachelor of Science degree in Computer Science must complete the following:

1. One year of calculus, including Math 1210 and 1220.

2. One of the following four year-long science sequences: (1) Biol 1210, 1220; (2) Chem 1210, 1220, 1230, 1240; (3) Phyx 2110, 2120; or (4) Geol 1150, 3200. The sequence chosen must be outside the student's department.

3. USU 1360 (Integrated Physical Science). This course may also be applied toward the University Studies Breadth Physical Sciences (BPS) requirement.

The science credits must total at least 13 credits. For students taking Phyx 2110, 2120, and USU 1360, the total will be 11 credits. In this case, students must take one more advisor approved science class.

Requirements

Summary of Departmental Admission and Retention Requirements

Admission requirements of the Department of Computer Science for freshmen are the same as those described for the University on pages 48-51. Transfer students with a 2.5 GPA may apply for admission to the department.

Before a student can register for a Computer Science course, he or she must earn a grade of *C-* or better in all prerequisite courses. All required classes for the major must be completed with a grade of *C-* or better. Required courses, regardless of department, may not be taken pass-fail, and a Computer Science major must have advanced standing or written permission to register for a Computer Science course at the 3000-level or above.

For a more complete statement of requirements, please contact the department directly. Requirements may change from time to time.

Bachelor of Science Degree

The department offers a degree program with emphases in science, digital systems, or information systems. The objectives are to train computer scientists who can relate to science, computer design, or information-based business disciplines. Other areas of emphasis will be considered on an individual basis.

COMPUTER SCIENCE REQUIRED COURSES

Science Emphasis

CS 1700, 1710, 1720, 2200, 2370, 3000, 3100, 4700, 5050; CS 2550 and 2560; Stat 3000; Math 1210, 1220, 2210, 2250, 3310; Math 4630 or 5610; Phil 2400 or 2500 or 3510 or 3520 or 4540 or MHR 3720; Spch 1050; at least 19 credits of upper-division advisor-approved computer science classes numbered 5000 or above.

Digital Systems Emphasis

CS 1700, 1710, 1720, 2200, 2370, 3000, 3100, 4700, 5050; Stat 3000; Math 1210, 1220, 2250, 3310; ECE 2410, 2420, 2530, 2540, 3710, 3720; Phil 2400 or 2500 or 3510 or 3520 or 4540 or MHR 3720; Spch 1050; at least 19 credits of upper-division advisor-approved computer science classes numbered 5000 and above.

Information Systems Emphasis

CS 1700, 1710, 1720, 2200, 2370, 3000, 3100, 4700, 5050; CS 2550 and 2560; Stat 2300; Math 1210, 1220, 3310; Acct 2010, 2020; Econ 1500; MHR 3110; BA 3080; Phil 2400 or 2500 or 3510 or 3520 or 4540 or MHR 3720; Spch 1050; at least 19 credits of upper-division advisor-approved computer science classes numbered 5000 and above.

Minor

Requirements for a minor in computer science are listed below. Before beginning any minor, a student must meet with a departmental advisor and file an approved minor application form with the Computer Science Department.

Computer Science Minor

CS 1700, 1710, 1720, 2200; two additional CS classes selected from the following list: CS 2370, 2550, 2560, 3100, 4700, or any CS class numbered 5000 or above.

Graduate Programs

Computer science deals with the programming, use, management, and organization of computers. Graduate students specialize in many different areas, several of which have strong ties to other disciplines such as mathematics, electrical engineering, statistics, accounting, and business administration.

Admission Requirements

Applicants for admission to the graduate program should have a bachelor's degree in computer science **or** extensive experience in computing. Normally, a score of at least 640 on the quantitative test of the general GRE is required for admission to the MS, and a score of at least 700 is required for admission to the PhD or MCS. For scores less than these, applicants must show other strengths in their backgrounds to be considered for admission. The GRE computer science subject exam is not required for admission. Those who do take the GRE computer science subject exam will have preference in consideration for the award of financial aid. Decisions on financial aid are made on or near March 15 for the following fall semester.

Course Requirements

In addition to the specific departmental admission and degree requirements described in this section, students are advised that they must also meet all Graduate School requirements as described in the Graduate School section of this catalog. Please note that departmental requirements change from time to time, so students should work closely with their advisor in designing their graduate program. Graduate-level courses outside the department *may* be acceptable for the graduate degree. In all cases, approval of the candidate's graduate committee should be obtained *before* registering for such courses.

Graduate students who have not taken or passed at the 50th percentile the computer science GRE subject exam are required to meet departmental placement requirements before completion of their first year. Students who have not met this requirement after the first year, as a minimum, will not be eligible for department-funded financial aid and cannot submit their program of study. In some circumstances, students will be terminated in the program. The department placement requirement is met in one or a combination of the following three ways:

1. Pass three of five placement exams: Computer Architecture and Organization, Algorithms, Operating Systems, Programming Languages/Compilers, and Software Engineering.

2. Complete with a grade of at least *B-* three of the following departmental placement courses: CS 2550 and 2560 or ECE 5750 (architecture and organization); CS 2200 or 5050 (algorithms); CS 3100 or 5200 (operating systems); CS 4700, 5300, or 6300 (programming languages/compilers); and CS 2370 or 5370 or 6370 (software engineering).

3. Show on an official transcript from an accredited college or university the completion of three courses deemed by the department to be equivalent to its placement courses. These must be semester-based courses of at least 3 credits, and the corresponding grade must be at least a *B-*.

Master of Science (MS). Whether Plan A or Plan B (see School of Graduate Studies general requirements), all MS/CS students must meet the following general requirements:

1. Complete four Computer Science courses numbered between 6000 and 6950. CS 6250 and 6900 are *not accepted* for these four courses. CS 6950 can count as *only one* of these four courses, and in that case must be taken for at least 3 credits in a single semester.

2. Complete 1 credit of CS 6900.

No more than 3 total credits in *both* CS 5950 and 6950 and 1 credit of CS 6900 may be used to satisfy the MS degree requirements. CS 6250 cannot be used to meet MS coursework requirements. A maximum of 15 credits of committee-approved coursework below the 6000-level may be used for the MS degree.

Students completing a Plan A MS degree must fulfill the following requirements:

1. Complete at least 24 credits of graduate coursework. The total GPA must be at least 3.0, and no more than two class grades below *B*- and none below *C* may be included.

2. Successfully meet the departmental placement requirement.

3. Successfully complete and submit a graduate thesis proposal.

4. Successfully complete and defend a graduate thesis, based on original work (CS 6970, 6 credits).

Students completing a Plan B MS degree must fulfill the following requirements:

1. Complete at least 32 credits of graduate coursework. The total GPA must be at least 3.0, and no more than two class grades below *B*- and none below *C* may be included.

2. Successfully meet the departmental placement requirement.

3. Successfully complete and submit a graduate report proposal.

4. Successfully complete and defend a graduate report (CS 6970, 2 credits).

Master of Computer Science (MCS). The Master of Computer Science (MCS) is a terminal degree with coursework requirements similar to the PhD, but lacking the PhD's requirement for original research. Students completing an MCS degree must fulfill the following requirements:

1. Complete at least 60 credits of graduate coursework beyond the BS/CS or 30 credits of graduate coursework beyond the MS/CS with a minimum class grade of *B*- and a minimum cumulative GPA of 3.2.

2. No more than 15 credits of coursework numbered below 6000 may be used for the MCS.

3. Complete at least 12 credits of 7000-level computer science coursework.

4. Successfully meet the departmental placement requirement.

5. Successfully complete and submit a research report proposal.

6. Successfully complete and defend a research report, based on original work (CS 7970, 6 credits).

Doctor of Philosophy (PhD). The Doctor of Philosophy in Computer Science is, above all else, a degree of quality. Simply completing a number of graduate courses or years of study is not sufficient to receive the degree. The successful candidate must demonstrate a breadth of understanding in computer science, as well as a depth of understanding in his or her chosen area(s) of emphasis. Also, students must show an ability to do creative research. This research should be carried out over a significant period of time (i.e., at least one year or three semesters). Thus, each successful PhD candidate will produce a significant piece of original research, presented in a written dissertation and defended in an oral examination. This work should be of such quality that one or more journal or conference articles can be derived from it.

Students completing a PhD/CS must fulfill the following requirements:

1. Complete at least 90 credits of graduate coursework (including at least 27 credits of dissertation/research) beyond a BS/CS or at least 60 credits beyond an MS/CS with a minimum class grade of *B* and a minimum cumulative GPA of 3.5.

2. If an MS/CS is completed first, then no more than 15 credits of the 60 credits required for the PhD may be taken in coursework numbered below the 6000 level. If an MS/CS is not completed first, then no more than 21 credits of the 90 credits required for the PhD may be taken in coursework numbered below the 6000 level.

3. Complete at least 12 credits of 7000-level computer science coursework.

4. Complete 2 credits of PhD Seminar (CS 7900).

5. Complete 9 credits of department-approved business administration or business management courses.

6. Pass a set of comprehensive written examinations and an oral examination showing depth and breadth of knowledge in computer science and the student's area(s) of emphasis.

7. Successfully complete and defend a research proposal.

8. Successfully complete and defend a dissertation (CS 7970, for at least 27 credits).

Financial Assistance

Applicants for admission will automatically be considered for financial aid, with no need for additional application procedures. Continuing students will be requested to apply for aid during the spring semester. Acceptance into the program does not guarantee financial assistance.

Computer Science Courses (CS)

CS 1010 (BPS). Foundations of Computer Science, and the Application of Computer Science to the Investigation of Physical Systems and Phenomena. Investigation of computers and computing in today's society, including the basic scientific and mathematical concepts that underlie computer science, computing, and computer systems. No prerequisites. (3 cr) (F,Sp,Su)

CS 1020. Campus Computing and Beyond. Hands-on laboratory for CS 1010. Introduces the campus network and the Internet. Emphasizes general problem-solving strategies and skills associated with computer and application software use. Successful completion of this class includes completion of all Computer and Information Literacy requirements. (1 cr) (F,Sp,Su)

CS 1050. Problem Solving with Computers. Investigates problem-solving using methodologies of computer science. Emphasizes techniques used by computer scientists to solve problems, as well as the scientific method. Develops problem-solving methodology for both new and traditional computer applications. (3 cr) (F,Sp)

CS 1700. Introduction to Computer Science—CS 1. Introduction to science of problem solving, programming, program development, algorithm analysis, and data structures. Students will learn to develop correct software in a current programming language environment. Computer science majors must enroll in CS 1710 concurrently with CS 1700. Prerequisite or corequisite: Math 1050 or Math ACT score of at least 23. (3 cr) (F,Sp,Su)

CS 1710. Introduction to Computer Science—CS 1 Lab. One-hour lab taught in conjunction with CS 1700. Students learn to develop correct software in a hands-on structured environment. Computer science majors are required to pass both the laboratory and the lecture, and are required to enroll in CS 1700 concurrently with CS 1710. For students not majoring in computer science, this laboratory is advised, but not required, for CS 1700. Prerequisite: Math 1050 or Math ACT score of at least 23. (1 cr) (F,Sp,Su)

CS 1720 (QI). Introduction to Computer Science—CS 2. Introduction to science of problem solving, programming, program development, algorithm analysis, and data structures. Students will learn to develop correct software in a current programming language environment. Prerequisite: CS 1700. (3 cr) (F,Sp,Su)

CS 2200 (QI). Algorithms and Data Structures—CS 3. Introduction to science of problem solving, programming, program development, algorithm analysis, and data structures. Students will learn to develop correct software in a current programming language environment. Prerequisite: CS 1720. (3 cr) (F,Sp,Su)

CS 2250. Cooperative Work Experience. Provides credit for students working at a participating firm under faculty supervision. Prerequisite: Permission of instructor. (1-9 cr) (F,Sp,Su) ®

CS 2370 (CI). Software Engineering. Science of small and large software project development, taught in team and project management format. Students complete a well-documented functional product, working in teams of four to five students. Prerequisite: CS 2200. (3 cr) (F,Sp)

CS 2550. Computer Organization. Fundamental building blocks of digital computers, and the underlying theories upon which these building blocks are assembled. Introduction to information representation, number systems, combinational logic circuits, sequential logic circuits, and instruction sets. Programming such systems at the assembly level. Prerequisites: CS 1700 and Math 1050. (3 cr) (F,Sp)

CS 2560. Computer Architecture. Architecture of a computer system, as viewed by the programmer. Topics such as memory management, RISC vs. CISC, pipelining, parallelism, interrupts, and networking discussed in detail. Includes several homework assignments, at least one of which deals with interrupts and interrupt-driven applications. Prerequisite: CS 2550. (3 cr) (F,Sp)

CS 3000. Undergraduate Seminar. Serves as a capstone course for the pre-computer science curriculum, as well as an introduction to the advanced standing curriculum. Also includes discussion of computer science as a career and discussion of the advanced standing test. Prerequisite: CS 2200. (1 cr) (F,Sp)

CS 3010 (DSC, CI, QI). Information Acquisition, Analysis, and Presentation. Introduces students to use of scientific method and computer technology in analysis of multi-faceted problem, and presentation of that analysis. Each semester, built around single topic such as global warming. Prerequisites: Completion of Computer Literacy and Quantitative Literacy requirements. (3 cr) (F,Sp,Su)

CS 3100. Operating Systems and Concurrency. Design and implementation of operating systems. UNIX will be used as one example, but all categories of operating systems will be discussed. Presentation of the concept of concurrency as it applies to operating system design and application. Prerequisite: CS 2200. (3 cr) (F,Sp)

CS 3410 (DSC, CI). Algorithm Development: JAVA/Internet. Introduces students to algorithm development and programming for JAVA-based applications, especially those dealing with the Internet. Examines computer-based representation, storage, retrieval, and transmission of information, along with the algorithms used to perform such operations. Prerequisites: CS 1700 and completion of Computer and Information Literacy and Quantitative Literacy requirements. (3 cr) (F,Sp,Su)

CS 3500 (QI, DSC). Algorithm Development: Visual BASIC/Graphical User. Introduces students to algorithm development and programming in Visual BASIC, with special emphasis on graphical user interfaces for Windows applications and environments. Prerequisites: Completion of Computer Literacy and Quantitative Literacy requirements. (3 cr) (F,Sp,Su)

CS 3510 (QI, DSC). Algorithm Development: COBOL/Business. Introduces students to algorithm development and programming in COBOL. Special emphasis given to applications and algorithms for use in business and information processing applications. Prerequisites: Completion of Computer Literacy and Quantitative Literacy requirements. (3 cr) (F)

CS 4250. Cooperative Work Experience. Provides credit for students working at a participating firm under faculty supervision. Prerequisite: Permission of instructor. (1-9 cr) (F,Sp,Su) ®

CS 4700. Programming Languages. Theories of programming design and implementation. Introduction to variety of programming languages, showing how they represent trade-offs with respect to these theories. Prerequisite: CS 2200. (3 cr) (F,Sp)

CS 4720. Computer Networking I. Focuses on client/server model, which is the dominant architectural model for today's computer systems. Explores the network underlying this model, specifically examining the topology, protocol(s), user interface(s), and hardware. Emphasizes the general theory and functionalities underlying the client/server model and computer networks in general. Prerequisite: CS 2200 or permission of instructor. (3 cr) (F)

CS 4730. Computer Networking II. Focuses on client/server model, which is the dominant architectural model for today's computer systems. Emphasizes the specifics of the products of today's dominant network companies, which are currently Novell and Microsoft. Completion of this course prepares students for certification under such products. Prerequisite: CS 4720. (3 cr) (Sp)

CS 4950. Undergraduate Research. Participation in research projects, under supervision of a computer science faculty member. Prerequisites: CS 2200 and permission of instructor. (1-4 cr) (F,Sp,Su) ®

CS 5000. Theory of Computability. Theory of computation, including presentation of computability, decidability, and complexity. Includes formal grammars, finite and pushdown automata, and turing machines. Prerequisites: CS 2200, Math 3310. (3 cr) (F)

CS 5050. Advanced Algorithms. Study of algorithms and their analysis, including: design by induction, algorithms involving sequences and sets, graph algorithms, geometric algorithms, algebraic algorithms, reductions, NP-completeness, and parallel algorithms. Prerequisites: CS 2200, Math 3310. (3 cr) (Sp)

CS 5100. Graphical User Interfaces and Windows Programming. Design principles of GUIs and philosophy, structure, and programming in Windows environments. Prerequisite: CS 2200. (4 cr) (Sp)

CS 5200. Distributed and Network Programming. Introduction to programming concepts and techniques for distributed and networked environments. Explores concurrency, process synchronization, network protocols, connectionless and connection-oriented communications, network architectures and topology, load balancing, and transmission media. Prerequisite: CS 3100. (4 cr) (F)

CS 5300. Compiler Construction. Review of programming language structures, translation, loading, execution, and storage allocation. Compilation of declarations, expressions, statements, and procedures/functions. Organization and design of a compiler. Prerequisite: CS 4700. (4 cr) (F)

CS 5370. Advanced Software Engineering. Advanced software engineering concepts, including project management, requirements acquisition, formal methods of specification and verification, object-oriented design, and software testing. Student cannot receive credit for both CS 5370 and CS 6370. Prerequisite: CS 2370. (3 cr) (F)

CS 5400. Computer Graphics I. Introduction to concepts of graphical techniques. Digital and pictorial representation of information. Prerequisites: CS 2200; Math 1220; Math 2250 or 2270. (4 cr) (F)

CS 5450. Multimedia Systems. Introduction to concepts and techniques underlying multimedia-based systems. Deals with both the hardware aspects of multimedia systems (e.g., transfer rates, capacities, resolution, etc.) and the software requirements of such systems. Each student required to develop a multimedia-based system. Prerequisite: CS 2200. (4 cr) (Sp)

CS 5500. Parallel Algorithms. Examines basic techniques for designing parallel algorithms, such as balanced trees, pointer jumping, partitioning, pipelining, accelerated cascading, list ranking, and tree contraction. Consideration of classic parallel algorithms in graphs, merging, sorting, planar geometry, string matching, and randomized techniques. Prerequisite: CS 2200. (3 cr) (Sp)

CS 5600. AI: Problem Solving and Expert Systems. Introduction to practical artificial intelligence methods for building problem solving and expert sytems. Covers search, knowledge representation, and reasoning. Students will develop projects in LISP and expert system shells. Prerequisite: CS 2200. (3 cr) (F)

CS 5650. AI: Pattern Analysis and Machine Intelligence. Introduction to theories and techniques of machine intelligence, with emphasis on pattern recognition, computer vision, fuzzy logic, and neural networks. Prerequisites: CS 2200, Math 2270, Stat 2000. (3 cr) (Sp)

CS 5700. Object-Oriented Software Development. Study of fundamental object-oriented principles, including abstraction, encapsulation, classification, and inheritance. Application of these principles in systems analysis, specification, design, implementation, and testing. Prerequisite: CS 2370. (3 cr) (F)

CS 5800. Introduction to Database Systems. Comparison of various database systems. Normal forms, protection, concurrency, security and integrity, and distributed and object-oriented systems. Prerequisite: CS 2200. (3 cr) (F)

CS 5850. Systems Analysis. Theory and practice of analysis, design, and implementation of information systems. Students will construct an information system. Prerequisite: CS 5800. (3 cr) (Sp)

CS 5890. Topics in Computer Science (Topic). Current topics in computer science as determined by advances in the field. Prerequisite: CS 2200 and permission of instructor. (1-4 cr) (F,Sp,Su) ®

CS 5950. Independent Study. Provides for independent study of selected topics. Prerequisites: CS 2200 and permission of instructor. (1-6 cr) (F,Sp,Su) ®

CS 6200. Distributed System Design. Examines advanced design concepts related to development of distributed software systems. Students learn how to model and evaluate communication protocols and study techniques for time coordination, distributed process synchronization, object replication and migration, and distributed transaction processing. Students also learn about Common Object Request Broker Architecture (CORBA). Prerequisite: CS 5200 or ECE 6600. (3 cr) (Sp)

CS 6250. Cooperative Work Experience, Graduate. Provides credit for students working at a participating firm under faculty supervision. Prerequisite: Permission of instructor. (1-9 cr) (F,Sp,Su) ®

CS 6300. Supercompilers for Sequential and Parallel Computers. Analysis and optimization for sequential and parallel computers, including loop restructuring, concurrency analysis, vector analysis, and optimizations for shared and distributed memory computers. Prerequisite: CS 5300. (3 cr) (Sp)

CS 6370. Software Engineering with a Project. Advanced software engineering concepts, including project management, requirements acquisition, formal methods of specification and verification, object-oriented design, and software testing. Students will work in teams, developing significant software products. Student cannot receive credit for both CS 5370 and CS 6370. Prerequisite: CS 2370. (3 cr) (F)

CS 6400. Computer Graphics II. Study of computer rendering of three-dimensional objects. Object representation, hidden surface removal, and shading. Ray tracing of synthetic scenes using mathematically defined surfaces. Prerequisite: CS 5400. (3 cr) (Sp)

CS 6500. Advances in Parallel Systems. Survey of current advances in parallel processing and concurrent systems. Review of current scientific literature to understand current issues, problems, and progress in advanced topics of parallel processing. Students read, summarize, report, and discuss up-to-date scientific papers in the field. Prerequisite: CS 5500. (3 cr) (F)

CS 6550. Parallel Computing Systems. Design of large-scale parallel systems. Explores machine organizations SIMD and/or MIMD modes of parallelism, emphasizing interconnection patterns among processors. Discussion of low-level parallel processing algorithms. Presents case studies of existing and proposed systems. Prerequisite: CS 5500. (3 cr) (F)

CS 6600. AI: Advanced Intelligent Systems. Investigation of advanced techniques for creating intelligent systems. Covers machine learning, reasoning under uncertainty, decision making, natural language understanding, and advanced knowledge representation. Students develop projects in LISP and expert system shells. Prerequisite: CS 5600. (3 cr) (Sp)

CS 6650. AI: Advanced Techniques in Pattern Analysis and Machine Intelligence. Advanced course in theories and techniques of machine intelligence, emphasizing pattern recognition, computer vision, robotics, fuzzy logic, and neural networks. Prerequisite: CS 5650. (3 cr) (Sp)

CS 6690. AI: Advanced Topics in Artificial Intelligence (Topic). Advanced course in selected theories and techniques of artificial intelligence. Prerequisite: Permission of instructor. (3 cr) (Sp)

CS 6700. Object-Oriented Models, Methods, and Tools. Study of object-oriented concepts, principles, techniques, development processes, and tools across all areas of software engineering, with special emphasis on current research topics. Prerequisite: CS 5700. (3 cr) (F)

CS 6800. Theory of Relational Databases. Graduate-level relational database course covering constraints and normal forms, mathematical models and provable properties, minimality, graphs, and synthesis. Prerequisite: CS 5800. (3 cr) (Sp)

CS 6890. Topics in Computer Science (Topic). Current topics in computer science as determined by advances in the field. Prerequisite: Permission of instructor. (1-4 cr) (F,Sp,Su) ®

CS 6900. Seminar. Series of one-hour seminars on current research topics presented by computer science faculty. Prerequisite: Permission of instructor. (1 cr) (F)

CS 6950. Reading and Reports. Directed reading on advanced topics in computer science. Prerequisite: Permission of instructor. (1-4 cr) (F,Sp,Su) ®

CS 6970. Thesis and Research. Graduate research in computer science. Prerequisite: Permission of instructor. (1-9 cr) (F,Sp,Su) ®

CS 6990. Continuing Graduate Advisement. Prerequisite: Permission of instructor. (1-6 cr) (F,Sp,Su) ®

CS 7350. Patterns in Computer Software Systems. Investigates common patterns in computer software systems and how they can be better cataloged, understood, and reused to improve software productivity and quality. Includes readings of current literature, writing research papers, and participation in group discussions. Prerequisite: Permission of instructor. (3 cr) (Sp)

CS 7380. Software Testing. Explores current issues, including testing, object-oriented software, test data generation and sufficiency, domain-based testing,

functional testing, and code-based testing. Prerequisite: Permission of instructor. (3 cr) (F)

CS 7500. Fault-Tolerant Systems. Advanced study of design and implementation of operating systems for fault-tolerant parallel and distributed systems. Topics chosen will provide students with knowledge of current research issues, practices, and techniques for the design and development of such systems. Prerequisite: Permission of instructor. (3 cr) (Sp)

CS 7550. Interconnection Networks for Parallel Computer Systems. Explores the design of large-scale parallel processing systems generally suited for multi-microprocessor implementation. Emphasizes interconnection patterns among the processing elements in parallel processors. Prerequisite: Permission of instructor. (3 cr) (F)

CS 7650. Advanced CVPRIP: Computer Vision, Pattern Recognition, and Image Processing. Investigates new developments in representation and processing of gray-level and color images, including thresholding, segmentation, curve detection, etc. Also examines visual perception, as well as statistical and syntactical pattern classification. Prerequisite: Permission of instructor. (3 cr) (Sp)

CS 7660. Robotics and Autonomous Systems. Surveys current advances in robotic and autonomous systems. Reviews current scientific literature in the field, with emphasis on understanding the problems solved and the approaches used. Prerequisite: Permission of instructor. (3 cr) (F)

CS 7670. Data Mining and Machine Learning. Covers cutting-edge research in machine learning, data mining, and intelligent information retrieval. Focuses on how these topics related to data mining. Prerequisite: Permission of instructor. (3 cr) (Sp)

CS 7900. Seminar. Series of lectures and presentations on current topics in computer science. Students participate by giving presentations. As part of the course, students are expected to prepare their dissertation proposal. Prerequisite: Permission of instructor. (2 cr) (Sp)

CS 7910. Special Topics in Intelligent Systems (Topic). Discussion of current topics in intelligent systems, such as parallelism and software systems. Prerequisite: Permission of instructor. Taught on demand. (3 cr) (F,Sp,Su) ®

CS 7920. Special Topics in Parallelism (Topic). Topics of current interest in the area of parallelism. Prerequisite: Permission of instructor. (3 cr) (F,Sp,Su) ®

CS 7930. Special Topics in Software Systems (Topic). Topics of current interest in the area of software systems. Prerequisite: Permission of instructor. (3 cr) (F,Sp,Su) ®

CS 7950. Reading and Reports. Directed reading on cutting-edge topics in computer science. Prerequisite: Permission of instructor. (1-4 cr) (F,Sp,Su) ®

CS 7970. Dissertation Research. PhD dissertation research. Prerequisite: Permission of instructor. (1-15 cr) (F,Sp,Su) ®

CS 7990. Continuing Graduate Advisement. Continuing PhD-level advisement. Prerequisite: Permission of instructor. (1-6 cr) (F,Sp,Su) ®

® Repeatable for credit. Check with major department for limitations on number of credits that can be counted for graduation.