Requirements for M.S., Computer Science

Required Courses  18 credits

Choose six courses (3 cr. each) from those listed below with at least two courses in each area.

- **Computation Theory**
  *Computer Science:*
  - I0600: Fundamental Algorithms
  - I0900: Graph Theory and Algorithms
  - I1200: Topics in Algorithms, including any course numbered I12XX
  - I1400: Analysis of Parallel Algorithms
  - I2000: Introduction to Theoretical Computer Science
  - I2100: Finite Automata and Models of Computation
  - I2200: Theory of Computability
  - I2400: Formal Language Theory
  - I2600: Computational Complexity
  - I2800: Topics in the Theory of Computing, including any course numbered I28XX
  - I4800: Codes, Cryptography, and Secure Communication
  - I4900: Computer Security
  - I6000: Mathematics for the Analysis of Algorithms

- **Computer Organization and Software**
  *Computer Science:*
  - I0400: Operating Systems
  - I0700: Compiler Construction
  - I0800: Topics in Software Systems, including any course numbered I08XX
  - I1000: Database Systems I
  - I1100: Database Systems II
  - I2300: Symbolic Computation
  - I4200: Computer Architecture
  - I4300: Computer Communication
  - I4330: Advanced Topics in Internet Programming
  - I4600: Topics in Computer Architecture, including any course numbered I46XX
  - I4700: Topics in Computer Communications, including any course numbered I47XX

- **Computing Methodologies and Mathematical Computing**
  *Computer Science:*
  - I0500: Computer Graphics
  - I1500: Artificial Intelligence
  - I1600: Natural Language Processing
  - I1800: Topics in Artificial Intelligence, including any course numbered I18XX
  - I1900: Pattern Recognition and Machine Learning
  - I3100: Seminar in Information Systems, including any course numbered I31XX
  - I6100: Mathematical Programming I
  - I6200: Mathematical Programming II
  - I6300: Decision Analysis
  - I6400: Topics in System Simulation, including any course numbered I64XX
  - I6600: Probabilistic Models in Computer Science
  - I6700: Topics in Scientific and Statistical Computing, including any course numbered I67XX
Additional Requirements 12 credits

Students must either:

- complete 3 graduate courses in Computer Science and one course with number I96XX and its associated zero-credit report I9700; or
- with permission of the department, complete 3 graduate courses in Computer Science and a 3 credit project (CSc I9800) under the direction of a member of the faculty; or
- with permission of the department, complete 2 graduate courses in Computer Science and a 6 credit thesis (CSc I9900) under the direction of a member of the faculty

With the approval of the student’s graduate advisor, one course in another Engineering discipline may be substituted for one of the Computer Science courses used to fulfill the Additional Requirements.

Total Credits 30
Computing Facilities

An extensive array of computing facilities is available to Computer Science students. The Department has several laboratories equipped with state-of-the-art computers and workstations which support teaching and research. These computers are connected to the Grove School of Engineering network which is linked to the Internet.
COURSE DESCRIPTIONS

I0400: Operating Systems
Underlying theoretical structure of operating systems; input-output and storage systems, data management and processing; assembly and executive systems, monitors; multiprogramming. Prereq: CSc 33200 or an equivalent undergraduate course. 3 hr./wk.; 3 cr.

I0500: Computer Graphics
An intensive introduction to computer graphics hardware, design of graphics packages, geometric transformations, 3D viewing and projections, raster scan conversion, visible surface determination, lighting and shading, 3D shape representation, and splines. Emphasis is on implementation of important graphics algorithms. Prereqs: CSc 32200 and Math 34600 or equivalent. 3 hr./wk.; 3 cr.

I0600: Fundamental Algorithms
An intensive study of advanced non-numerical programming techniques. Data representation; list, tree and string manipulation algorithms. Recursive programming. Introduction to searching and sorting. Storage management algorithms. Comparative efficiency of algorithms. Prereq: CSc 22000 or equivalent. 3 hr./wk.; 3 cr.

I0700: Compiler Construction
Techniques involved in analysis of source languages and generation of efficient object code. Parsing methods, storage allocation, programming language semantics, optimization techniques, interpreters, study of existing compilers and their special features. Prereqs: CSc 22000 and CSc 30400 or equivalent. 3 hr./wk.; 3 cr.

I0800: Topics in Software Systems
Selected topics of current interest. Recent offerings have included computer games, concurrent and distributed processing, search technologies, internet programming and information management. Prereqs: CSc 33200 or equivalent. 3 hr./wk.; 3 cr.

I0807: Image Processing
An intensive introduction to imaging intended for graduate students and advanced undergraduates. Topics include digital filtering theory, image enhancement, image reconstruction, anti-aliasing, warping, and state-of-the-art special effects. These topics form the basis of high quality rendering in computer graphics, as well as low-level processing for computer vision, remote sensing, and medical imaging. Emphasizes computational techniques for implementing useful image processing functions. Programming assignments will reinforce material covered in class. Prereq: CSc 32200 or equivalent. 3 hr./wk.; 3 cr.

I0900: Graph Theory and Algorithms

I1000: Database Systems I
An introduction to database architecture. Levels of abstraction in a database system, physical data organization, abstract data models, relational database systems, and their query language. Prereqs: CSc 22000 and CSc 33200 or equivalent. 3 hr./wk.; 3 cr.
I1100: Database Systems II
Logical models for database management systems, especially relational, hierarchical and network. Case studies illustrating their implications for applications system development. Physical implementation of advanced data and storage structures. Prereq: CSc I1000 or equivalent. 3 hr./wk.; 3 cr.

I1200: Topics in Algorithms
Current developments in the design, analysis and implementation of algorithms and their applications. Recent offerings have included packing and covering, randomized algorithms, geometric graphs, computational geometry, combinatorics, and algorithms in bioinformatics. Prereqs: CSc 22000 and CSc 30400 or equivalent. 3 hr./wk.; 3 cr.

I1400: Parallel Algorithms
Techniques of efficient program design. Analysis of parallel algorithms chosen from information storage and retrieval, graph theory, pattern matching, matrix operations, etc. as to their time, space, and other resource requirements. Lower bounds for the intrinsic computational difficulty of some of these programs. Prereqs: CSc 22000 and CSc 30400 or equivalent. 3 hr./wk.; 3 cr.

I1500: Artificial Intelligence
The study of how to make the computer behave intelligently. State-space methods of problem solving, heuristic search techniques, representation and use of knowledge, mechanical theorem proving, psychological implications. Examples of game playing, problem solving, or other systems. Prereqs: CSc 22000 and CSc 30400 or equivalent. 3 hr./wk.; 3 cr.

I1600: Natural Language Processing
Methods for processing English texts and dialogues on the computer. Parsing, transformational analysis, semantic analysis, interfacing; examples of natural language systems for carrying on dialogues and performing tests. Prereqs: CSc 44800, or CSc I1500 or equivalent. 3 hr./wk.; 3 cr.

I1800: Topics in Artificial Intelligence
Selected topics from expert systems, automated systems and robotics; automated reasoning; computer vision. Prereq: CSc 44800 or CSc I1500 or equivalent. 3 hr./wk.; 3 cr.

I1896: Computer Vision
A survey of the techniques used in computer vision, which recovers information from images. Topics include: the geometry of image formation; multiple 2D techniques for feature detection, image segmentation, object recognition, and texture; 3D shape from shading, stereo and motion. Some mathematical maturity is assumed, including familiarity with linear algebra, multidimensional calculus and simple statistics. Prereqs: CSc 22000, 22100 and Math 34600 or equivalent. 3 hr./wk.; 3 cr.

I1900: Pattern Recognition and Machine Learning
Generalization and classification; pattern recognition and perception; concept formation; remembering and forgetting; learning and hypothesis formation. Prereq: CSc 44800 or CSc I1500 or equivalent, and knowledge of Linear Algebra. 3 hr./wk.; 3 cr.

I2000: Introduction to Theoretical Computer Science
Fundamental concepts from logic, models of computation, and complexity theory. Scope and limitations of various formalisms. The Chomsky hierarchy of languages and machines. Basic ideas for recursive functions. Impact on programming systems. Prereqs: CSc 30400 or equivalent. 3 hr./wk.; 3 cr.
I2100: Finite Automata and Models of Computation
A review of the basic definitions, concepts and results concerning finite automata (e.g. Myhill-Nerode Theorem) Applications of finite state automata in the modelling of circuits for fast arithmetic computation, exploring graphs and robotic computations, pseudorandom number generators for internet protocols, recent physical and biological applications (e.g. Watson-Crick finite automata). Prereq: CSc 30400 or CSc I2000 or equivalent. 3 hr./wk.; 3 cr.

I2200: Theory of Computability
Formulations of effective computability: Post machines. Turing-type models, recursive functions, and semi-Thue systems. The equivalence of the various formulations. Church’s Thesis. Fundamental theorems of computability: universal machines, S-M-N, and recursion theorem. Unsolvable problems. Recursive and recursively enumerable sets. Prereq: CSc 30400 or CSc I2000 or equivalent. 3 hr./wk.; 3 cr.

I2300: Symbolic Computation
A comparative study of the structure and use of various functional, logical and sequential languages used in symbolic computation and artificial intelligence. Choice of appropriate programming tools for specific applications. Comparison of user/machine interfaces. Prereqs: CSc 30400 or CSc I2000, or equivalent. 3 hr./wk.; 3 cr.

I2400: Formal Language Theory
Classification of languages by grammars and automata. The Chomsky hierarchy: regular, context free, context sensitive and recursively enumerable languages and their associated grammars and automata. Closure properties for families of languages. Decision problems for grammars and automata. Prereq: CSc 30400 or CSc I2000 or equivalent. 3 hr./wk.; 3 cr.

I2600: Computational Complexity
Complexity measures for algorithmic systems, determinism vs. non-determinism, time vs. space, complexity hierarchies, aspects of the P-NP question, inherent complexity of specific algorithmic problems, recent applications to cryptography. Prereqs: CSc 30400 and CSc I2000 or CSc I0600. 3 hr./wk.; 3 cr.

I2800: Topics in the Theory of Computing
Topics of current interest, such as quantum computing, biological computing, automated reasoning, parallel computation, advanced topics in complexity, algebraic and symbolic computation, historical issues and open problems. Prereq: CSc I2000 or departmental approval. 3 hr./wk.; 3 cr.

I3100: Seminar in Information Systems
Topics of current interest in computer-based information systems. Possible topics include computer-human interaction, virtual organization, decision support systems, knowledge management, and systems analysis. Students are required to complete a project on an approved topic in the course. Prereqs: CSc I1000. 3 hr./wk.; 3 cr.

I3110: The Information Marketplace
All aspects of the market for computer-based information products and services. Course objectives are to define and characterize the information marketplace, to present concepts and methods for analyzing behavior within the marketplace, and review public and private policy implications of the information marketplace. Prereq: strong background in Economics and permission of the instructor. 3 hr./wk.; 3 cr.
I4200: Computer Architecture

I4300: Computer Communications

I4330: Advanced Topics in Internet Programming
The first part of the course will deal with platform independent software and data for Internet programming. The second part will address Web Services—messaging over standard web protocols. Students will be exposed to current technologies and standards. Topics discussed may include: distributed objects and remote invocation, messaging, name services, security. Prereqs: CSc 22100 or equivalent. 3 hr./wk.; 3 cr.

I4600: Topics in Computer Architecture
Selected topics from the current literature in computer architecture. Prereq: CSc 34200/34300 or CSc I4200 or equivalent. 3 hr./wk.; 3 cr.

I4633: Multimedia
Algorithms and software that handle and manipulate interactively digital sound, image, animation and video. Topics covered include digital sound formats and conversion factors affecting sound quality, digital image formats and conversion, image compression and factors affecting image quality, digital video formats and standards, video compression methods, videoconferencing and interactive media. Prereqs: CSc 32200 and good programming knowledge. 3 hr./wk.; 3 cr.

I4700: Topics in Computer Communications
Selected topics from the current literature in computer communications. Prereq: CSc I4300 or equivalent. 3 hr./wk.; 3 cr.

I4800: Codes, Cryptography, and Secure Communication
Concepts from probability and information theory entropy, codes for compression, error-correcting codes, secrecy codes, block ciphers and public key cryptosystems, cryptographic protocols for secure communication, introduction to quantum cryptography. Prereqs: CSc 30400 and CSc 34200 or equivalent. 3 hr./wk.; 3 cr.

I4900: Computer Security
An introduction to the principles and practices of computer security in various computing environments. Conventional encryption systems and classical cryptography. Confidentiality using conventional encryption. Public key encryption and protocols for authentication and digital signatures. Recent cryptanalytic attacks on conventional and public key systems. Intruders, viruses, and trusted systems. Firewalls and internetwork security. A survey of applications and problems arising in contemporary computer security. Prereqs: CSc 30400 and CSc 22000 or equivalent. 3 hr./wk.; 3 cr.
I6000: Mathematics for the Analysis of Algorithms
Those areas of mathematics necessary for the advanced analysis of algorithms: manipulation of sums, solving recurrences, number theory, binomial coefficients, special sequences, generating functions, and asymptotics. Prereq: CSc 22000 or CSc I0600. 3 hr./wk.; 3 cr.

I6100: Mathematical Programming I

I6200: Mathematical Programming II

I6300: Decision Analysis
An introduction to decision-making under uncertainty. Bayes and minimax criteria. Utility theory, treatment of risk, and the value of information. Two-person and n-person games, stochastic linear programming models, policy improvement algorithm. Markovian decision processes. Application to system design, management, and production. Prereqs: CSc 22000 or CSc I0600, and an undergraduate course in probability. 3 hr./wk.; 3 cr.

I6400: Topics in System Simulation
Simulation methodology, design, and analysis of simulation experiments. Generation and testing of random variates. Variance reduction techniques. Simulation languages. Analysis of queuing models on computer systems simulation. Prereqs: CSc 22000 and 21700 or equivalent. 3 hr./wk.; 3 cr.

I6600: Probabilistic Models in Computer Science
Introduction to queuing theory. Birth and death processes. Single server and multiple server queuing systems. Priority disciplines. Time sharing and multiprogramming models. Selected topics in system reliability theory. Prereq: CSc 22000 or CSc I0600. 3 hr./wk.; 3 cr.

I6700: Topics in Scientific and Statistical Computing
Selected topics from computer algebra, advanced numerical methods, advanced numerical computation, advanced operations research, combinatorial computing, graph algorithms, cryptography. Recent offerings have included computer vision, cluster computing, digital libraries, pattern recognition and satellite image processing. Prereq: CSc 22000 or CSc I0600. 3 hr./wk.; 3 cr.

I6730: Data Reduction in the Physical Sciences
A course in the reduction of data sets gathered by government agencies (NOAA and NASA). Data comes from satellite remote sensing and other atmospheric and oceanographic measuring systems. Prereq: Permission of the instructor. 3 hr./wk.; 3 cr.

I6744: Neural Computing
An introduction to neural networks and their applications. Material to be covered includes: models of a neuron, network architectures, visualization processes and artificial intelligence in neural networks, learning processes, the perceptron, multilayer perceptrons. Prereqs: Math 20300, 34600 and a working knowledge of C or Fortran. 3 hr./wk.; 3 cr.
**I9600: Special Topics in Contemporary Computer Science**

A research seminar course, focusing on a specialized and contemporary topical area of computer science. The course will present research articles and technology papers to students in the chosen topic, actively engaging them in the presented materials through their interactive discussions, writing of short summary reports, team projects, literature search and/or exams. Prereq: advanced graduate standing and permission of the instructor. 3 hr./wk.; 3 cr.

**I9700: Report**

Co-req: CSc I96XX, 0 CR.; SATISFIES NON-COURSE REQUIREMENT.

**I9800: Project**

Experimental or theoretical project under the direction of a faculty advisor. Student submits proposal, performs the required studies, submits a written final report, and gives a comprehensive oral presentation to the department or an approved forum. Prereq: departmental approval. 3 cr.; satisfies non-course requirement

**I9900: Research for Master’s Thesis**

Departmental approval required.

6 cr.; satisfies non-course requirement.
FACULTY

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