Computer Science

Chair and Professor: Chiu
Professors: Beard
Associate Professors: Kerby, Zibran
Assistant Professors: Bodily, Eishita, Griffith
Clinical Professor: Leibrock

Master of Science in Computer Science

Admission Requirements

The student must meet all criteria for admission and then apply to the Graduate School. In unusual circumstances, students may be admitted with scores lower than those listed below. In addition to the University Requirements, the CS department also requires GRE scores (quantitative, verbal, and analytical). ISU graduates with a 3.5 GPA or higher and a letter of recommendation from an ISU CS faculty member are not required to take the GRE. Criteria are:

- GPA (4 point scale): 2.50 or better
- GRE Quantitative: 60th percentile
- GRE Verbal: 40th percentile
- GRE Analytical: 3.0
- TOEFL*: 620 PBT, 260 CBT or 105 iBT
  *for international students who do not speak English as their native language.

Although admission does not require a baccalaureate degree in computer science, applicants with a bachelor's in other fields should demonstrate in their application the skills needed to succeed in computer science coursework and research. This might include successful completion of university-level CS classes, CS-related work experience, etc. Applicants are expected to have completed or to demonstrate experience equivalent to the following courses:

- Math 1175 (Calculus II)
- CS 2235 (Data Structures and Algorithms)
- CS 2263 (Advanced Object-Oriented Programming)
- CS 4412 (Advanced Algorithms)

Applicants without these prerequisites may be required to complete prerequisite coursework prior to full admission (note: CS 5512 can be taken in place of CS 4412). All prerequisite coursework must be completed with a grade of at least a B-.

For students wishing to apply who have not completed the essential prerequisite coursework there are two options:

1. They can enroll as a non-degree seeking (or degree-seeking) undergraduate student to complete the prerequisites. Following successful completion of the prerequisites, they can apply to the graduate program.
2. The student can apply directly to the MS program and be admitted with performance requirements requiring that students complete the prerequisite coursework within 1 year of being admitted and prior to enrolling in graduate-level courses.

Graduate students must complete all prerequisite coursework prior to being considered for graduate assistantships.

General Requirements

With the assistance of the Computer Science faculty, the student shall select an initial advisor during the first semester of residence to help in planning a program of studies and research. With the help of the advisor, the student must also complete a Plan of Study and form a complete advisory committee by the time six credits of course work have been completed.

30 credit hours are required to complete the M.S. degree (at least 15 of the credits must be at the 6600 level). The Thesis or Computer Science Project should consist of study and research that complements the coursework selected.

A maximum of 6 credits of CS 6692, Special Problems in Computer Science, may count towards degree requirements.

Thesis Option (30 credits)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CS 6605</td>
<td>Computational Theory</td>
<td>3</td>
</tr>
<tr>
<td>Approved CS 66XX Electives</td>
<td>6-9</td>
<td></td>
</tr>
<tr>
<td>Approved 55XX or 66XX Electives - At least 3 credits must be CS electives</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>CS 6650</td>
<td>Thesis</td>
<td>6-9</td>
</tr>
<tr>
<td><strong>Total Credits</strong></td>
<td><strong>30</strong></td>
<td></td>
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Course-Only Option (30 credits)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 6605</td>
<td>Computational Theory</td>
<td>3</td>
</tr>
<tr>
<td>Approved CS 66XX Electives - A maximum of 6 credits of CS 6660, Computer Science Project, may count toward this requirement</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Approved 55XX or 66XX Electives - At least 3 credits must be CS electives</td>
<td>15</td>
<td></td>
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<tr>
<td><strong>Total Credits</strong></td>
<td><strong>30</strong></td>
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Graduate Certificate in Secure Cyber Operations

Admission Requirements

The student must have a baccalaureate degree and meet all criteria for admission, and then apply to the Graduate School. In unusual circumstances, students may have a GPA lower than listed below. Criteria are:

- GPA (4 point scale): 2.50 or better
- TOEFL: 620 PBT, 260 CBT or 105 iBT - for international students who do not speak English as their native language.

Applicants are expected to have completed the following courses prior to full admission:
• Math 1143 College Algebra
• CS 1181 Introduction to Computer Science Programming I
• CS 2235 Data Structures and Algorithms

All undergraduate prerequisite coursework must be completed with a grade of at least a C-. All graduate prerequisite coursework must be completed with a grade of at least a B-. If students have completed CS 1337 and 3337 they may waive the CS 5108 requirement. If students have completed CS 4416 or 4417 or 4465 they will substitute other CS 55xx or higher courses for the corresponding course(s) as selected by their CS graduate advisor.

Graduate students must complete all prerequisite undergraduate coursework prior to being considered for graduate assistantships.

General Requirements

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 5108</td>
<td>Computer Organization, Networks, and Systems</td>
<td>3</td>
</tr>
<tr>
<td>CS 5516</td>
<td>Foundations in Cybersecurity and Resilience</td>
<td>3</td>
</tr>
<tr>
<td>CS 5517</td>
<td>Cybersecurity Threat Intelligence</td>
<td>3</td>
</tr>
<tr>
<td>CS 5565</td>
<td>Special Problems in Cyber Physical Security</td>
<td>3</td>
</tr>
<tr>
<td>Total Credits</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Department Links

- CS Department home page (https://www.isu.edu/cs/
- CS Faculty (https://www.isu.edu/cs/faculty--staff/)

Courses

**CS 5101 Computer Science Principles: 3 semester hours.**
Introduction to central ideas, practices and impact of computer science, and computational thinking. Covers the big ideas in computer science: creativity, abstraction, data and information, algorithms, programming, the Internet, and global impact. Computational thinking practices: connecting computing, creating computational artifacts, abstracting, analyzing problems and artifacts, communicating, and collaborating. In-depth projects using at least one visual aid and one text-based programming language. Adapting content to high school courses.

**CS 5102 Teaching and Learning Computer Science I: 3 semester hours.**
Problem solving and object-oriented programming. Software development process. Data and expressions, conditionals and loops, arrays and lists, and classes and interfaces. Introduction to graphical user interfaces and UML diagrams. Approaches and techniques to teach CS I material in 6-12 grades.

**CS 5103 Teaching and Learning Computer Science II: 3 semester hours.**
Program correctness, testing and analysis of time and space complexity. Graphical user interfaces. Object-oriented programming and design, including hierarchy and inheritance. Basic data structures: lists, collections, stacks and queues. Basic searching and sorting. Approaches and techniques to teach CS II material in 6-12 grades.

**CS 5108 Computer Organization, Networks, and Systems: 3 semester hours.**

**CS 5122 Data Science and Applied Machine Learning: 3 semester hours.**
Covers intermediate subjects in data science and machine learning. Data analytics and visualization. Supervised and unsupervised methods, utilizing production-ready frameworks. Multiple linear regression, logistic regression, affinity analysis, k-nearest-neighbors, naive Bayes, support vector machines, decision trees and random forests, principal component analysis, and k-means clustering. Exploratory data analysis, preprocessing techniques, feature engineering, dimensionality reduction, ensemble methods. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 1181 and MATH 1143. D

**CS 5133 Applied Neural Networks: 3 semester hours.**
This course teaches applied methods in machine learning and neural networks utilizing production-ready frameworks. Students will model datasets with artificial neural networks, convolutional neural networks, and recurrent neural networks. The creation of deep learning networks will be covered. Applications include computer vision, processing sequences, and natural language processing. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 1181 and MATH 1143. D

**CS 5134 Advanced Methods In Artificial Intelligence: 3 semester hours.**
This course teaches building artificial intelligence applications using production-ready frameworks. Topics include advanced neural networks architectures, representation learning, generative adversarial networks, reinforcement learning, and creating intelligent agents. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 5113. D

**CS 5135 Data Science at Scale: 3 semester hours.**
Current practices in big data analytics and modeling utilizing cloud computing platforms. Includes usage of the most popular platforms. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 5132 and CS 5133. D

**CS 5512 Advanced Algorithms: 3 semester hours.**
Further exploration of advanced topics in algorithms and data structures. Application of time complexity and mathematical analysis of algorithms, including best, worst, and average case analysis. Discussion and application of several algorithm design techniques including brute force, Greedy, Divide-and-conquer, decrease-and-conquer, Dynamic programming, Transform-and-conquer, Backtracking and branch-and-bound, Probabilistic and Approximation Algorithms approaches. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 1337, CS 2263, CS 3305, MATH 1175 and 2240. D

**CS 5516 Foundations in Cybersecurity and Resilience: 3 semester hours.**
Confidentiality, availability, integrity of computer systems; resistance, recognition and response categories of assurance. Cyber physical. Computer security survivability, including cryptography, network security, general purpose operating system security code, and special purpose systems for high assurance security and dependability. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 2235 and ((CS 1337 and CS 3337) or CS 5108). D

**CS 5517 Cybersecurity Threat Intelligence: 3 semester hours.**
Intelligence analysis, production, evaluation, evidence assessment and executive reporting. Use prevailing US government and open source intelligence paradigms and non-attribute techniques to collect process and evaluate a range of cyber threats, malicious actors, mechanisms, and disruptive activities. Combines analytical techniques for both network and platform vulnerabilities including cyber-physical and information technologies in critical infrastructures and enterprises. Open source platforms, Python script development, Raspberry Pi ARM architectures. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 2235 and ((CS 1337 and CS 3337) or CS 5108). PRE-OR-COREQ: CS 4416 or CS 5516. D
CS 5520 Computer Security and Cryptography: 3 semester hours.
Public key and private key cryptography, key distribution, cryptographic protocols, requisite mathematics and selected topics in the development of security and cryptography. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 4412 or CS 5512. D

CS 5521 Software Architecture: 3 semester hours.
An introduction to the design and implementation of large software systems. Includes the application of software architecture patterns, architectural tactics, analysis of software architectures, selection of architectural patterns to meet functional and non-functional requirements, and the use of architecture to meet quality standards. The course will also include methods of documenting and recovering existing architectures. Students, working

CS 5522 Software Testing: 3 semester hours.
An introduction to the theory and techniques used in software testing and formal design method. Includes topics related to code coverage, program analysis, test design, and advanced concepts such as mutation testing, metamorphic testing, and test automation. The second half of the course focuses on formal modelling techniques for the specification, verification and validation of software designs. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 3321. D

CS 5523 Software Evolution: 3 semester hours.
An exploration of the theory and issues surrounding the maintenance and improvement of existing software systems. Topics will include the identification and triage of software bugs, patching and deploying fixes to existing software systems, refactoring software in large code bases, and the processes for managing change and maintenance of software systems. The second half of this course will focus on the identification of issues in software using program analysis. Specifically, focusing on current techniques used in static and dynamic analysis of software to identify maintainability, security, and performance issues. Specific, evaluated graduate-level activities and/or performance issues are identified in the course syllabus. Restricted to graduate students who have the consent of the instructor.

CS 5524 Secure Software Engineering: 3 semester hours.
Introduction to the Secure Software Development Lifecycle and the tools and techniques used in practice to design and develop software from a security standpoint. This course will also discuss methods of analyzing software for security vulnerabilities, detecting threats through current testing techniques, and the management and mitigation of risk in the software development process. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. Restricted to graduate students who have the consent of the instructor.

CS 5531 Scientific Computing: 3 semester hours.
The course reviews and engages students in current usage of advanced programming language(s) and libraries used in science and engineering modeling and simulation. Restricted to graduate students who have the consent of the instructor.

CS 5535 Cloud Computing: 3 semester hours.
The course reviews and engages students in current practices in cloud computing, including usage of the most popular platforms. Restricted to graduate students who have the consent of the instructor.

CS 5542 GUI Development: 3 semester hours.
Planning and construction of Graphical User Interfaces and essential software engineering concepts. Includes the use of a modern toolkit language. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 3321

CS 5551 Database Theory Design and Programming: 3 semester hours.
Data models, relational algebra and calculus, SQL and stored procedures, database design, ER diagrams, normalization theory, data storage, index structures, performance analysis, concurrency control. Database programming language access. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 4412 or 5512. D

CS 5558 Computer Graphics: 3 semester hours.
Graphics, transformation matrices, lighting models, object hierarchies, visible surface determination, ray tracing. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 4412 or 5512. D

CS 5561 Secure Operating Systems: 3 semester hours.
Operating systems structure and design. Process management, concurrency and synchronization, inter-process communication, scheduling, device management, memory management, I/O and files, distributed systems, security, networking. Kali. Implementation of a significant portion of an operating system. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: (CS 2263 or CS 4412 or CS 5512) and (CS 1337 or CS 5108). D

CS 5565 Special Problems in Cyber Physical Security: 3 semester hours.
Analysis and implementation of computer science cyber physical security problems. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 2235 and ((CS 1337 and CS3337) or CS 5108).PREREQ-COREQ: CS 4416 or CS 5516. D

CS 5570 High-Performance Computing: 3 semester hours.
Topics in high performance computing: parallel architectures, SIMD, MIMD, SMP, NUMA models, message passing, cache coherency issues, MPI, PVM, parallel programming languages, cluster and grid approaches, applications and experience programming on a cluster. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 3337 or CS 4461 or 5561. D

CS 5573 Computational Creativity: 3 semester hours.
Introduction to the art, science, philosophy and engineering of computational systems which, by taking on particular responsibilities, exhibit behaviors that unbiased observers would deem to be creative. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 4412 or 5512. D

CS 5578 Machine Learning: 3 semester hours.
Introduction to the philosophy, utility, and models of machine learning, such that students are able to understand the basic concepts and issues of machine learning. Students will be prepared to use machine learning approaches in real world applications and/or to continue in a graduate research program. Topics covered include neural networks, decision trees, nearest neighbor learning, data mining, feature selection, clustering, ensembles, reinforcement learning, genetic algorithms, and deep learning. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: (CS 4412 or CS 5512) and MATH 2240. D

CS 5579 Natural Language Processing: 3 semester hours.
The course reviews and engages students in Natural Language Processing (NLP) for solving problems involving natural (human) language. NLP and language technologies have become an important part of the programmer’s toolbox when working with text, speech, and other language data. Restricted to graduate students who have the consent of the instructor. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus.
CS 5581 Compilers and Lexical Analysis: 3 semester hours.
Covers lexical analysis, syntax analysis, top-down, bottom-up, and LR parsing, syntax directed translation, type checking, code generation and optimization, and writing a compiler. Specific, evaluated graduate-level activities and/or performances are identified in the course syllabus. PREREQ: CS 4412 or 5512. D

CS 5587 Topics in Computer Science: 3 semester hours.
Selected topics in Computer Science will be chosen depending on the instructor's interests. Restricted to senior and graduate students who have the consent of the instructor.

CS 5599 Experimental Course: 1-6 semester hours.
The content of this course is not described in the catalog. Title and number of credits are announced in the Class Schedule. Experimental courses may be offered no more than three times with the same title and content. May be repeated.

CS 6101 Inclusive Strategies for Teaching Computer Science: 3 semester hours.
Readings and discussion on methodologies of teaching computer science.

CS 6605 Computational Theory: 3 semester hours.
Proofs (deductive and inductive reasoning), computability (models of computability and computability issues), and complexity (time and space bounds, nondeterminism, and complexity classification). PREREQ: CS 4412 or 5512. D

CS 6612 Algorithms: 3 semester hours.
Concrete time and space complexity; combinatorial algorithms; greedy algorithms; dynamic programming; probabilistic and randomized algorithms; branch-and-bound algorithms. PREREQ: CS 4412 or 5512. D

CS 6618 Advanced Bioinformatics: 3 semester hours.
The course reviews and engages students in fundamental research on computational methods for analyzing biological systems. Restricted to graduate students who have the consent of the instructor.

CS 6620 Empirical Software Engineering: 3 semester hours.
Empirical software engineering focuses on improving software quality through the use of metrics. The course will provide guidance on designing, analyzing and reporting empirical studies, provide information on techniques and metrics needed to measure desired qualities, and the use of practical approaches to study software evolution. Restricted to graduate students who have the consent of the instructor.

CS 6622 Advanced Topics in Software Testing: 3 semester hours.
An exploration of current research associated with the theory and techniques used in software testing. Includes topics related to code coverage, program analysis, test design, and advanced concepts such as mutation testing, metamorphic testing, and test automation. PREREQ: CS 4422 or CS 5522.

CS 6625 Software Language Engineering: 3 semester hours.
An exploration of the current trends and research associated with various aspects of software language engineering. This includes the design and representation of grammars, parsers, interpreters, and compilers and the engineering processes in use to develop such tools.

CS 6631 Advanced Scientific Computing: 3 semester hours.
The course reviews and engages students in advanced topics concerning current software practices in science and engineering modeling and simulation. PREREQ: CS 5531. D

CS 6650 Thesis: 1-9 semester hours.
Thesis class for MSCS students. May be repeated for up to 9 credits.

CS 6660 Computer Science Project: 1-6 semester hours.
A significant project involving computer science toward the completion of the M.S. program with non-thesis option. Includes a report and oral examination. May be repeated for up to 9 credits.

CS 6672 Human Computer Interaction: 3 semester hours.
Science-based theories and models of user interface design and development. Graphical user interfaces for desktop, web, and mobile devices. Usability assessment by quantitative and qualitative methods. Task analysis, usability tests, expert reviews, and continuing assessments of working products by interviews, surveys, and logging. Building of low-fidelity paper mock-ups, and a high-fidelity prototype using contemporary tools and programming environments.

CS 6673 Advanced Computational Creativity: 3 semester hours.
The course reviews and engages students in fundamental research on the art, science, philosophy and engineering of computational systems which, by taking on particular responsibilities, exhibit behaviors that unbiased observers would deem to be creative. PREREQ: CS 4473 or CS 5573. D

CS 6678 Advanced Machine Learning: 3 semester hours.
The course reviews and engages students in research on advanced concepts and models in machine learning and neural networks. PREREQ: CS 4478 or CS 5578. D

CS 6692 Special Problems in Computer Science: 1-3 semester hours.
Research and reports on problems or topics in computer science. May be repeated for up to 9 credits with different content.

CS 6699 Experimental Course: 1-6 semester hours.
This is an experimental course. The course title and number of credits are announced in the class schedule by the scheduling department. Experimental courses may be offered no more than three times with the same title and content.

CS 8850 Doctoral Dissertation: 1-24 semester hours.