MASTER OF SCIENCE IN COMPUTER SCIENCE

The program for the Master of Science in Computer Science (MSCS) prepares students for more highly productive careers in industry. Graduates receive the MSCS for completing one of three options in the program as described in this section. Students may apply to the program if they possess a bachelor's degree in computer science from an accredited institution. Students without a bachelor's degree in computer science are encouraged to apply as well, with the understanding that they will be required to complete remedial coursework appropriate to their background in addition to the requirements of the MSCS degree. All applicants are evaluated according to their prior academic record, scores on the Graduate Record Examination, a personal statement, and letters of recommendation. Applicants are selected for fall semester admission only. The application deadline is February 1. However, all applicants are encouraged to apply as early as possible because the selection process may begin well before the deadline.

Students entering the program must demonstrate a core competency in computing equivalent to undergraduate-level courses in the following areas:

- systems, design and analysis of algorithms,
- formal languages and automata theory,
- databases,
- networking and communications,
- computer architecture, and
- human-computer interaction.

This requirement can be satisfied by having taken undergraduate courses as a part of an undergraduate degree, taking remedial courses in the MS CS program, or by examination. Students may specialize in areas of their choice. Every student must complete at least one specialization as a part of their degree program. The current eleven specialization areas are:

- Computer Graphics, Computing Systems
- High-Performance Computing, Human-Computer Interaction
- Interactive Intelligence
- Machine Learning
- Modeling and Simulations
- Scientific Computing
- Social Computing
- Visual Analytics.

A student who is enrolled in another graduate program of the Institute may pursue an MSCS while that student is also pursuing their degree in the other major. To be granted permission to pursue the MSCS, a student must submit to the MS program coordinator of the College of Computing the material required for admission to the MSCS program. This includes transcripts, letters of recommendation, and GRE General Test. If the student is approved by the College to pursue the MSCS, the student will be notified in writing. At no time will a student outside the College be allowed to pursue a concurrent degree without prior permission of the MS program coordinator of the College of Computing.

A student enrolled in the MS degree program in computer science who wishes to be admitted to the PhD program in computer science should apply via the same process as external students. It is expected that such a student will have at least two letters of recommendation from College of Computing faculty.

For more information about the MS CS program, visit www.cc.gatech.edu.

Program of Study

The College's master's degree requirements supplement the Institute's master's requirements listed in this catalog:

- Students must achieve a grade-point average of at least 3.0 to graduate, and no course grades below C will count toward graduation. Students must take all master's degree coursework on a letter-grade basis.
- Undergraduate courses required for the BSCS degree may not be used toward the MSCS degree. In addition, no graduate credit will be given for 3000 level courses or lower-level courses.
- No course may be used to satisfy the requirements of two degrees. In addition, no graduate credit will be given for CS courses with a number lower than 4140.
- A maximum of 6 hours may be taken at the 4000-level and/or with a subject code other than CS or CSE. See exceptions under the Project and Thesis options below.
- The maximum total credit hours of Special Problems (CS or CSE 89xx) that may be applied toward the MSCS degree is 3. These courses must be within the CoC.
- There is no maximum number of Special Topics (CS or CSE 88xx) courses that may be used towards the degree.
- Each student must complete the requirements for one specialization. Click here for specialization requirements.
- Students may choose from one of three options in pursuing the MSCS degree, including:

Course Option

This option requires the student to complete 30 hours of coursework.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Course Credit Hours (no MS project or thesis hours)</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>CS and CSE (minimum 24 credit hours)</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>CS and CSE 6000-8000 Level Courses (minimum 24 credit hours)</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>6000/8000 Level Courses (minimum 24 credit hours)</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

Project Option

This option requires the student to complete 21 credit hours of coursework and a 9 credit hour project. The project requires approval by a faculty advisor and the MS program coordinator in the semester prior to its inception.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Coursework Credit Hours</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>MSCS Project hours (CS 6999)</td>
<td>9</td>
<td></td>
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<tr>
<td>Total Credit Hours</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>CS and CSE Courses (minimum of 15 credit hours)</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

1. Any course above the required 15 credit hours is counted as elective credit.
Master of Science in Computer Science

CS and CSE 6000-8000 Level Courses (minimum of 15 credit hours) 1

1 May not include MS project or thesis hours.

**Thesis Option**
This option requires the student to complete 18 credit hours of coursework and a 12 credit hour thesis. The thesis process is defined elsewhere in this catalog.

**Specializations**

**Computational Perception and Robotics**

### Core Courses

- **Algorithms:** Pick one (1) of:
  - CS 6505 Computability, Algorithms, and Complexity
  - CS 6515 Introduction to Graduate Algorithms
  - CS 6520 Computational Complexity Theory
  - CS 6550 Design and Analysis of Algorithms
  - CS 7520 Approximation Algorithms
  - CS 7530 Randomized Algorithms
  - CSE 6140 Computational Science and Engineering Algorithms

  And, pick one (1) of:
  - CS 6601 Artificial Intelligence
  - CS 7641 Machine Learning

### Electives

Pick three (3) courses from Perception and Robotics, with at least one from each:

- Perception
  - CS 6475 Computational Photography
  - CS 6476 Introduction to Computer Vision GR
  - CS 7499 3D Reconstruction and Mapping in Computer Vision, Robotics, and Augmented Reality
  - CS 7636 Computational Perception
  - CS 7639 Cyber Physical Design and Analysis
  - CS 7644 Machine Learning for Robotics
  - CS 7650 Natural Language

- Robotics
  - CS 7630 Autonomous Robotics

### Credit Hours

- Total Coursework Credit Hours: 18
- MS Thesis Credit Hours: 12
- Total Credit Hours: 30

- CS and CSE Courses (minimum of 15 credit hours) 1

1 May not include MS project or thesis hours.

The student must obtain advance approval of the thesis proposal by the faculty advisor and MSCS coordinator. See your academic advisor for more information about the thesis process.

**Computer Graphics**

### Core Courses

- Pick one of:
  - CS 6491 Foundations of Computer Graphics
  - CS 6457 Video Game Design and Programming
  - CS 7496 Computer Animation

- Pick one of:
  - CS 6505 Computability, Algorithms, and Complexity
  - CS 6515 Introduction to Graduate Algorithms

### Electives: select three (3) of:

- CS 6457 Video Game Design and Programming
- CS 6475 Computational Photography
- CS 6476 Introduction to Computer Vision GR
- CS 6491 Foundations of Computer Graphics
- CS 6492 Shape Grammars
- CS 6730 Data Visualization: Principles and Applications
- CS 7496 Computer Animation

### Total Credit Hours

- 15

**Computing Systems**

### Core Courses

- CS 6505 Computability, Algorithms, and Complexity
- or CS 6515 Introduction to Graduate Algorithms
- And, pick two (2) of:
  - CS 6210 Advanced Operating Systems
  - CS 6241 Design and Implementation of Compilers
  - CS 6250 Computer Networks
  - CS 6290 High-Performance Computer Architecture
  - CS 6300 Software Development Process
  - CS 6390 Programming Language Design
  - CS 6400 Database Systems Concepts and Design

### Electives: pick three (3) of: 1,2

- CS 6035 Introduction to Information Security
- CS 6200 Graduate Introduction to Operating Systems
- CS 6220 Big Data Systems and Analytics
- CS 6235 Real-Time System Concepts and Implementation
- CS 6238 Secure Computer Systems
- CS 6260 Applied Cryptography
- CS 6262 Network Security
- CS 6263 Intro to Cyber-Physical Systems Security
- CS 6291 Embedded Software Optimizations

1 May not include MS project or thesis hours.

2 The student must obtain advance approval of the thesis proposal by the faculty advisor and MSCS coordinator. See your academic advisor for more information about the thesis process.
### Human-Centered Computing

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 6451</td>
<td>Introduction to Human-Centered Computing</td>
<td>3</td>
</tr>
<tr>
<td>CS 6452</td>
<td>Prototyping Interactive Systems</td>
<td>3</td>
</tr>
<tr>
<td>CS 7455</td>
<td>Issues in Human-Centered Computing</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Electives

Pick two (2) of:

1. CS 6455 User Interface Design and Evaluation
2. CS 6456 Principles of User Interface Software
3. CS 6460 Educational Technology: Conceptual Foundations
4. CS 6465 Computational Journalism
5. CS 6470 Design of Online Communities
6. CS 6471 Computational Social Science
7. CS 6474 Social Computing
8. CS 6476 Introduction to Computer Vision GR
9. CS 6601 Artificial Intelligence
10. CS 6730 Data Visualization: Principles and Applications
11. CS 6750 Human-Computer Interaction
12. CS 6795 Introduction to Cognitive Science
13. CS 7450 Information Visualization
14. CS 7451 Human-Centered Data Analysis
15. CS 7460 Collaborative Computing
16. CS 7470 Mobile and Ubiquitous Computing
17. CS 7471 Machine Learning
18. CS 7476 Advanced Computer Vision
19. CS 7610 Modeling and Design
20. CS 7632 Game Artificial Intelligence
21. CS 7633 Human-Robot Interaction
22. CS 7637 Knowledge-Based AI
23. CS 7620 Case-Based Reasoning
24. CS 7650 Natural Language
25. CS 7695 Philosophy of Cognition
26. CS 7697 Cognitive Models of Science and Technology
27. CS 7790 Cognitive Modeling
28. CS 8803 Special Topics (Computational Creativity)
29. CS 8803 Special Topics (Expressive AI)
30. CS 8803 Special Topics (Computers, Communications & International Development)

### Total Credit Hours

15

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### High-Performance Computing

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 6140</td>
<td>Computational Science and Engineering Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CSE 6220</td>
<td>High Performance Computing</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Electives

Pick three (3) of:

1. CSE 6221 Multicore Computing: Concurrency and Parallelism on the Desktop
2. CS 6230 High-Performance Parallel Computing: Tools and Applications
3. CS 6241 Design and Implementation of Compilers
4. CS 6290 High-Performance Computer Architecture
5. CS 8803 Special Topics (Parallel Numerical Algorithms) or CSE 8803 Special Topics
6. CS 6236 Parallel and Distributed Simulation
7. CS 8803 Special Topics (Hot Topics in Parallel Computing)

### Total Credit Hours

15

### Human-Computer Interaction

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 6456</td>
<td>Principles of User Interface Software</td>
<td>3</td>
</tr>
<tr>
<td>or CS 7470</td>
<td>Mobile and Ubiquitous Computing</td>
<td>3</td>
</tr>
<tr>
<td>CS 6750</td>
<td>Human-Computer Interaction</td>
<td>3</td>
</tr>
</tbody>
</table>

#### Electives

Pick three (3) from the two sub-areas below, including one from each sub-area:

1. CS 6455 User Interface Design and Evaluation
2. CS 6456 Principles of User Interface Software
3. CS 6460 Educational Technology: Conceptual Foundations
4. CS 6465 Computational Journalism
5. CS 6470 Design of Online Communities
6. CS 6471 Computational Social Science
7. CS 6474 Social Computing
8. CS 6476 Introduction to Computer Vision GR
9. CS 6601 Artificial Intelligence
10. CS 6730 Data Visualization: Principles and Applications
11. CS 6750 Human-Computer Interaction
12. CS 6795 Introduction to Cognitive Science
13. CS 7450 Information Visualization
14. CS 7451 Human-Centered Data Analysis
15. CS 7460 Collaborative Computing
16. CS 7470 Mobile and Ubiquitous Computing
17. CS 7471 Machine Learning
18. CS 7476 Advanced Computer Vision
19. CS 7610 Modeling and Design
20. CS 7632 Game Artificial Intelligence
21. CS 7633 Human-Robot Interaction
22. CS 7637 Knowledge-Based AI
23. CS 7620 Case-Based Reasoning
24. CS 7650 Natural Language
25. CS 7695 Philosophy of Cognition
26. CS 7697 Cognitive Models of Science and Technology
27. CS 7790 Cognitive Modeling
28. CS 8803 Special Topics (Computational Creativity)
29. CS 8803 Special Topics (Expressive AI)
30. CS 8803 Special Topics (Computers, Communications & International Development)
## Master of Science in Computer Science

**Sub-area: Design and evaluation concepts**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>CS 6010</td>
<td>Principles of Design</td>
</tr>
<tr>
<td>CS 6320</td>
<td>Software Requirements Analysis and Specification</td>
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<tr>
<td>CS 6435</td>
<td>Digital Health Equity</td>
</tr>
<tr>
<td>CS 6455</td>
<td>User Interface Design and Evaluation</td>
</tr>
<tr>
<td>CS 6457</td>
<td>Video Game Design and Programming</td>
</tr>
<tr>
<td>CS 6460</td>
<td>Educational Technology: Conceptual Foundations</td>
</tr>
<tr>
<td>CS 6465</td>
<td>Computational Journalism</td>
</tr>
<tr>
<td>CS 6470</td>
<td>Design of Online Communities</td>
</tr>
<tr>
<td>CS 6795</td>
<td>Introduction to Cognitive Science</td>
</tr>
<tr>
<td>CS 7465</td>
<td>Educational Technology: Design and Evaluation</td>
</tr>
<tr>
<td>CS 7467</td>
<td>Computer-Supported Collaborative Learning</td>
</tr>
<tr>
<td>CS 7790</td>
<td>Cognitive Modeling</td>
</tr>
</tbody>
</table>

**Sub-area: Interactive technology**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<tbody>
<tr>
<td>CS 6440</td>
<td>Information to Health Informatics</td>
</tr>
<tr>
<td>CS 6730</td>
<td>Data Visualization: Principles and Applications</td>
</tr>
<tr>
<td>CS 6763</td>
<td>Design of Design Environments</td>
</tr>
<tr>
<td>CS 6770</td>
<td>Mixed Reality Experience Design</td>
</tr>
<tr>
<td>CS 7450</td>
<td>Information Visualization</td>
</tr>
<tr>
<td>CS 7451</td>
<td>Human-Centered Data Analysis</td>
</tr>
<tr>
<td>CS 7460</td>
<td>Collaborative Computing</td>
</tr>
<tr>
<td>CS 7470</td>
<td>Mobile and Ubiquitous Computing</td>
</tr>
<tr>
<td>CS 7632</td>
<td>Game Artificial Intelligence</td>
</tr>
</tbody>
</table>

**Total Credit Hours** 15

### Interactive Intelligence

#### Core Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 6300</td>
<td>Software Development Process</td>
</tr>
<tr>
<td>CS 6301</td>
<td>Advanced Topics in Software Engineering</td>
</tr>
<tr>
<td>CS 6505</td>
<td>Computability, Algorithms, and Complexity</td>
</tr>
<tr>
<td>CS 6515</td>
<td>Introduction to Graduate Algorithms</td>
</tr>
<tr>
<td>CSE 6140</td>
<td>Computational Science and Engineering Algorithms</td>
</tr>
</tbody>
</table>

**Take one (1) of:** 3

- CS 6505 Computability, Algorithms, and Complexity
- CS 6515 Introduction to Graduate Algorithms
- CS 6520 Computational Complexity Theory
- CS 6550 Design and Analysis of Algorithms
- CS 7510 Graph Algorithms
- CS 7520 Approximation Algorithms
- CS 7530 Randomized Algorithms

**Take two (2) of:** 6

- CS 6601 Artificial Intelligence
- CS 7637 Knowledge-Based AI
- CS 7641 Machine Learning

#### Electives

**Pick two (2) courses from:** 6

- CS 6440 Information to Health Informatics
- CS 6460 Educational Technology: Conceptual Foundations
- CS 6465 Computational Journalism
- CS 6471 Computational Social Science
- CS 6603 AI, Ethics, and Society
- CS 6750 Human-Computer Interaction

### Machine Learning

#### Core Courses

**Algorithms**

**Pick one (1) of:** 3

- CS 6505 Computability, Algorithms, and Complexity
- CS 6515 Introduction to Graduate Algorithms
- CS 6520 Computational Complexity Theory
- CS 6550 Design and Analysis of Algorithms
- CS 7510 Graph Algorithms
- CS 7520 Approximation Algorithms
- CS 7530 Randomized Algorithms

- CSE 6140 Computational Science and Engineering Algorithms

**Pick one (1) of:** 3

- CS 7641 Machine Learning
- CSE 6740 Computational Data Analysis: Learning, Mining, and Computation

**Electives**

**Pick three (3) of:** 9

- CS 6220 Big Data Systems and Analytics
- CS 6476 Introduction to Computer Vision GR
- CS 6603 AI, Ethics, and Society
- CS 7280 Network Science: Methods and Applications
- CS 7535 Markov Chain Monte Carlo Algorithms
- CS 7540 Spectral Algorithms and Representations
- CS 7545 Theoretical Foundations of Machine Learning
- CS 7616 Pattern Recognition
- CS 7626 Introduction to Behavioral Imaging
- CS 7642 Reinforcement Learning and Decision Making
- CS 7643 Deep Learning
- CS 7644 Machine Learning for Robotics
- CS 7646 Machine Learning for Trading
- CS 7650 Natural Language
- CS 8803 Special Topics (Probabilistic Graph Models)
- CSE 6240 Web Search and Text Mining
<table>
<thead>
<tr>
<th>Core Courses</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 6242 Data and Visual Analytics</td>
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</tr>
<tr>
<td>CSE 6250 Big Data Analytics for Healthcare</td>
<td></td>
</tr>
<tr>
<td>ISYE 6416 Computational Statistics</td>
<td></td>
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<tr>
<td>ISYE 6420 Introduction to Theory and Practice of Bayesian Statistics</td>
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</tr>
<tr>
<td>ISYE 6644 Stochastic Optimization</td>
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</table>

| Total Credit Hours | 15 |

### Modeling and Simulations

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CSE 6730</td>
<td>Modeling and Simulation: Foundations and Implementation</td>
<td>3</td>
</tr>
</tbody>
</table>

Pick one (1) of:
- CSE 6220 High Performance Computing
- ISYE 6644 Simulation
- MATH 6640 Introduction to Numerical Methods for Partial Differential Equations

<table>
<thead>
<tr>
<th>Core Courses</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CSE 6220 High Performance Computing</td>
<td></td>
</tr>
<tr>
<td>ISYE 6644 Simulation</td>
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<tr>
<td>MATH 6640 Introduction to Numerical Methods for Partial Differential Equations</td>
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<table>
<thead>
<tr>
<th>Electives</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pick three (3) of:</td>
<td></td>
</tr>
</tbody>
</table>
- CSE 6220 High Performance Computing
- CSE 6236 Parallel and Distributed Simulation
- CSE/CHEM Special Topics (Quantum Information, Computation, and Simulation)
- CS 7280 Network Science: Methods and Applications
- INTA 6742 Modeling, Simulation and Military Gaming
- ISYE 6644 Simulation
- MATH 6640 Introduction to Numerical Methods for Partial Differential Equations

| Total Credit Hours | 15 |

### Scientific Computing

<table>
<thead>
<tr>
<th>Core Courses</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CSE/MATH 6643 Numerical Linear Algebra</td>
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</table>

Pick one (1) of:
- CSE/MATH Iterative Methods for Systems of Equations
- MATH 6640 Introduction to Numerical Methods for Partial Differential Equations

<table>
<thead>
<tr>
<th>Electives</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pick three (3) of:</td>
<td></td>
</tr>
</tbody>
</table>
- CS/CSE 6230 High-Performance Parallel Computing: Tools and Applications
- CS/CSE 8803 Special Topics (Parallel Numerical Algorithms)
- CSE 6140 Computational Science and Engineering Algorithms
- CSE 6220 High Performance Computing
- CSE/MATH Iterative Methods for Systems of Equations

| Total Credit Hours | 15 |

### Visual Analytics

<table>
<thead>
<tr>
<th>Core Courses</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>CSE 6242 Data and Visual Analytics</td>
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</tr>
<tr>
<td>CSE 8803 Special Topics (Algorithms for Medical Imaging and Inverse Problems)</td>
<td></td>
</tr>
<tr>
<td>CSE 8803 Special Topics (Computational Chemistry)</td>
<td></td>
</tr>
<tr>
<td>MATH 6640 Introduction to Numerical Methods for Partial Differential Equations</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electives</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pick two (2) from:</td>
<td></td>
</tr>
</tbody>
</table>
- CS 6456 Principles of User Interface Software
- CS 6465 Computational Journalism
- CS 6491 Foundations of Computer Graphics
- CS 6750 Human-Computer Interaction
- CS 6795 Introduction to Cognitive Science
- CS 7451 Human-Centered Data Analysis
- CS 7641 Machine Learning

| Total Credit Hours | 15 |
Master of Science in Computer Science

CSE 6740  Computational Data Analysis: Learning, Mining, and Computation

| Total Credit Hours | 15 |

The Master of Science in Computer Science is also offered online.

For more information, visit: Online Master of Science in Computer Science.