MAJOR IN COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING CONCENTRATION

Artificial intelligence (AI) and machine learning (ML) are about creating intelligent systems – systems that perceive and respond to the world around them. AI and ML systems are everywhere, in our cars and smartphones, and businesses of all sizes are investing in these areas.

The AI/ML concentration combines a rigorous computer science degree with coursework in AI, ML, and big data. This concentration also provides students the necessary foundational coursework and skills in math, statistics, and data science.

Learning Outcomes

Upon completing this program, students will be able to:

• Develop AI and ML approaches for complex real-world problems.
• Deploy high-performance computing tools for the analysis of large datasets.

• Use a broad range of AI and ML tools, techniques, and algorithms.
• Apply AI and ML tools in an ethical and socially responsible manner, with an awareness of biases that can result from their indiscriminate use.
• Communicate results of complex analyses verbally and in writing using appropriate visualization techniques.
• Confidently pursue graduate studies or professional employment in AI/ML and computer science.

Potential Occupations

In addition to the career opportunities open to all computer science graduates, the AI/ML concentration opens career paths that include:

Machine learning engineer, data scientist, business intelligence developer, big data engineer, data mining analyst, natural language processing analyst, computer vision engineer.

Requirements

Effective Fall 2023

A minimum grade of C (2.000) is required in CO 150 and in all CS, DSCI, MATH, and STAT courses which are required for graduation.

<table>
<thead>
<tr>
<th>Course</th>
<th>Department</th>
<th>Title</th>
<th>AUCC</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 150</td>
<td>College</td>
<td>College Composition (GT-CO2)</td>
<td>1A</td>
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<tr>
<td>MATH 156 or 160¹</td>
<td>Mathematics</td>
<td>Mathematics for Computational Science I (GT-MA1)</td>
<td>1B</td>
<td>4</td>
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<td>Calculus for Physical Scientists I (GT-MA1)</td>
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<td>Group A:</td>
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<tr>
<td>CS 150A or 150B</td>
<td>College</td>
<td>Culture and Coding: Java (GT-AH3)</td>
<td>3B</td>
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</tr>
<tr>
<td>CS 162 or 164</td>
<td>College</td>
<td>Culture and Coding: Python (GT-AH3)</td>
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<td>Group B:</td>
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<td>3B</td>
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<tr>
<td>CS 152</td>
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<td>Python for STEM</td>
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<td></td>
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<tr>
<td>CS 162 or 164</td>
<td>College</td>
<td>CS1—Introduction to Java Programming</td>
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<td></td>
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<td>CS1—Computational Thinking with Java</td>
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<td>Group C:</td>
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<td>3B</td>
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<tr>
<td>CS 163</td>
<td>College</td>
<td>CS1—No Prior Programming Experience</td>
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<td></td>
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<tr>
<td>CS 201/PHIL 201</td>
<td>College</td>
<td>Ethical Computing Systems (GT-AH3)</td>
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<td>Introduction to Astronomy (GT-SC2)</td>
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<tr>
<td>&amp; AA 101</td>
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<tr>
<td>ANTH 120</td>
<td>College</td>
<td>Human Origins and Variation (GT-SC2)</td>
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<td>&amp; ANTH 121</td>
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<td>BZ 110</td>
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<td>Principles of Animal Biology (GT-SC2)</td>
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<td>BZ 120</td>
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<td>Principles of Plant Biology (GT-SC1)</td>
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<td>CHEM 107</td>
<td>Fundamentals of Chemistry (GT-SC2)</td>
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<td>GEOL 122</td>
<td>The Blue Planet - Geology of Our Environment (GT-SC2)</td>
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<tr>
<td>&amp; GEOL 121</td>
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<td>GEOL 124</td>
<td>Geology of Natural Resources (GT-SC2)</td>
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<td>&amp; GEOL 121</td>
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<td>GEOL 150</td>
<td>Physical Geology for Scientists and Engineers</td>
<td>3A</td>
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<tr>
<td>HONR 292A</td>
<td>Honors Seminar: Knowing in the Sciences</td>
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<td>LIFE 102</td>
<td>Attributes of Living Systems (GT-SC1)</td>
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<td>LIFE 103</td>
<td>Biology of Organisms-Animals and Plants (GT-SC1)</td>
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<td>LIFE 201A</td>
<td>Introductory Genetics: Applied/Population/Conservation/Ecological (GT-SC2)</td>
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<td>LIFE 201B</td>
<td>Introductory Genetics: Molecular/Immunological/Developmental (GT-SC2)</td>
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<td>LIFE 220/LAND 220</td>
<td>Fundamentals of Ecology (GT-SC2)</td>
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<td>NR 150</td>
<td>Oceanography (GT-SC2)</td>
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<td>General Physics I (GT-SC1)</td>
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<td>PH 122</td>
<td>General Physics II (GT-SC1)</td>
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<td>PH 141</td>
<td>Physics for Scientists and Engineers I (GT-SC1)</td>
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<td>PH 142</td>
<td>Physics for Scientists and Engineers II (GT-SC1)</td>
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<td>1C</td>
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<td>Electives3</td>
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**Total Credits**: 30

### Sophomore

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<tbody>
<tr>
<td>CS 165</td>
<td>CS2--Data Structures</td>
<td>4</td>
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<tr>
<td>CS 220</td>
<td>Discrete Structures and their Applications</td>
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<td></td>
<td>Select one group from the following:</td>
<td>4-5</td>
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<tr>
<td>Group A</td>
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<tr>
<td>CS 214</td>
<td>Software Development</td>
<td></td>
</tr>
<tr>
<td>CT 301</td>
<td>C++ Fundamentals</td>
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</tr>
<tr>
<td>Group B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS 253</td>
<td>Software Development with C++</td>
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<td>Select one course from the following:</td>
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<tr>
<td>CS 250</td>
<td>Computer Systems Foundations</td>
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<tr>
<td>CS 270</td>
<td>Computer Organization</td>
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<tr>
<td>MATH 256 or 161</td>
<td>Mathematics for Computational Science II</td>
<td>4</td>
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<tr>
<td></td>
<td>Calculus for Physical Scientists II (GT-MA1)</td>
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<tr>
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<td>Select one course from the following:</td>
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<tr>
<td>DSCI 369</td>
<td>Linear Algebra for Data Science</td>
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<tr>
<td>MATH 369</td>
<td>Linear Algebra I</td>
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<td>Select one course from the following:</td>
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<tr>
<td>STAT 301</td>
<td>Introduction to Applied Statistical Methods</td>
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<tr>
<td>STAT 302A</td>
<td>Statistics Supplement: General Applications</td>
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<tr>
<td>STAT 307</td>
<td>Introduction to Biostatistics</td>
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<tr>
<td>STAT 315</td>
<td>Intro to Theory and Practice of Statistics</td>
<td></td>
</tr>
<tr>
<td>Historical Perspectives (<a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives</a>)</td>
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### Junior

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CS 314</td>
<td>Software Engineering</td>
<td>3A,3B</td>
</tr>
<tr>
<td>CS 320</td>
<td>Algorithms--Theory and Practice</td>
<td>3</td>
</tr>
<tr>
<td>CS 345</td>
<td>Machine Learning Foundations and Practice</td>
<td>3</td>
</tr>
<tr>
<td>CS 370</td>
<td>Operating Systems</td>
<td>3</td>
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</tbody>
</table>

#### Technical Electives
- Select a minimum of six credits from the following:
  - DSCI 320: Optimization Methods in Data Science
  - DSCI 335: Inferential Reasoning in Data Analysis
  - DSCI 336: Data Graphics and Visualization
  - DSCI 473: Introduction to Geometric Data Analysis
  - DSCI 475: Topological Data Analysis
  - MATH 261: Calculus for Physical Scientists III
  - MATH 301: Introduction to Combinatorial Theory
  - MATH 311: Introduction to Mathematical Modeling
  - MATH 360: Mathematics of Information Security
  - MATH 430/ECE 430: Fourier and Wavelet Analysis with Apps
  - MATH 450: Introduction to Numerical Analysis I
  - STAT 341: Statistical Data Analysis I
  - STAT 342: Statistical Data Analysis II
  - STAT 400: Statistical Computing
  - STAT 420: Probability and Mathematical Statistics I

CS course numbered 300- or above, excluding 380-399 and 480-499: 3-4

#### Advanced Writing
- [Advanced Writing](http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing): 2

#### Social and Behavioral Sciences
- [Social and Behavioral Sciences](http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sciences): 3C

### Senior

#### Capstone Courses
- Select two courses from the following (one of the selected courses will fulfill AUCC 4C):
  - CS 425: Introduction to Bioinformatics Algorithms
  - CS 440: Introduction to Artificial Intelligence
  - CS 445: Introduction to Machine Learning

#### Systems Elective
- Select one course from the following:
  - CS 435: Introduction to Big Data
  - CS 455: Introduction to Distributed Systems
  - CS 475: Parallel Programming

#### Additional Computer Science Course
- Select one course from the following:
  - CS 410: Introduction to Computer Graphics
  - CS 425: Introduction to Bioinformatics Algorithms
  - CS 430: Database Systems
  - CS 435: Introduction to Big Data
  - CS 440: Introduction to Artificial Intelligence
  - CS 445: Introduction to Machine Learning
  - CS 455: Introduction to Distributed Systems
  - CS 462: Engaging in Virtual Worlds
  - CS 464: Principles of Human-Computer Interaction
  - CS 475: Parallel Programming

### Total Credits
- Junior: 30
- Senior: 30
- Electives: 0-3
1 MATH 156 is recommended for computer science majors who do not already have MATH 160 credit.

2 Recommended sequence for most incoming students is Group A: CS 150B to CS 164.

3 CS 192 or other seminar course is a recommended elective for incoming first semester students.

4 Select enough elective credits to bring the program total to a minimum of 120 credits, of which at least 42 must be upper-division (300- to 400-level).

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**Freshman**

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<th>Semester 1</th>
<th>Critical</th>
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<tr>
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<td>First course from Group A, B, or C (See options in Concentration Requirements Tab)</td>
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<tr>
<td>Department Approved Science (See list on Concentration Requirements Tab)</td>
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<td>3A</td>
<td>3</td>
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<tr>
<td>Diversity, Equity, and Inclusion (<a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion</a>)</td>
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<tr>
<td>Electives</td>
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<td>X</td>
<td>2-4</td>
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<tr>
<td>MATH 124 and MATH 126 may be necessary for some students to fulfill pre-calculus requirements.</td>
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<td><strong>Total Credits</strong></td>
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<th>Critical</th>
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<th>Credits</th>
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<tr>
<td>CS 201/PHIL 201 Ethical Computing Systems (GT-AH3)</td>
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<td>3B</td>
<td>3</td>
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<tr>
<td>MATH 156 or Mathematics for Computational Science I (GT-MA1)</td>
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<td>1B</td>
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<tr>
<td>MATH 160 Calculus for Physical Scientists I (GT-MA1)</td>
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<td>Remaining course(s) from Group A, B, or C (See options in Concentration Requirements Tab)</td>
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<tr>
<td>Department Approved Science with Lab (See list on Concentration Requirements Tab)</td>
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<td>Electives</td>
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<td>X</td>
<td>0-2</td>
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<td>CO 150 must be completed by the end of Semester 2 with a grade of C or better.</td>
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**Sophomore**

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<td>CS 165 CS2--Data Structures</td>
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<td>X</td>
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<tr>
<td>CS 220 Discrete Structures and their Applications</td>
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<td>X</td>
<td>4</td>
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<td>Select one course from the following:</td>
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<td>3-4</td>
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<tr>
<td>DSCI 369 Linear Algebra for Data Science</td>
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<tr>
<td>MATH 369 Linear Algebra I</td>
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<td><strong>Total Credits</strong></td>
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**Major Completion Map**

**Distinctive Requirements for Degree Program:**

To prepare for first semester: The curriculum for the Computer Science major assumes students enter college prepared to take calculus. Entering students who are not prepared to take calculus will need to fulfill pre-calculus requirements in the first semester. All students must maintain a C (2.000) or better in CO 150 and in all CS, DSCI, MATH, and STAT courses which are required for graduation.
Major in Computer Science, Artificial Intelligence and Machine Learning Concentration

| CS 214 | Software Development |
| CT 301 | C++ Fundamentals |

**Group B**

| CS 253 | Software Development with C++ |

Select one course from the following:

| CS 250 | Computer Systems Foundations |
| CS 270 | Computer Organization |

MATH 256 or MATH 256
161 Calculus for Physical Scientists II (GT-MA1)

Select one course from the following:

| STAT 301 | Introduction to Applied Statistical Methods |
| STAT 302A | Statistics Supplement: General Applications |
| STAT 307 | Introduction to Biostatistics |
| STAT 315 | Intro to Theory and Practice of Statistics |

Electives

CS 165 and CS 220 and CS 270 must be completed by the end of Semester 4.

MATH 156 or MATH 160 and MATH 369 or DSCI 369 must be completed by the end of Semester 4.

**Total Credits: 16**

### Junior

**Semester 5**

<table>
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<tr>
<td>CS 320</td>
<td>Algorithms–Theory and Practice</td>
<td>X</td>
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<tr>
<td>CS 370</td>
<td>Operating Systems</td>
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<td>Advanced Writing (<a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing</a>)</td>
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<td>Social and Behavioral Sciences (<a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sciences">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sciences</a>)</td>
<td>X</td>
<td>3C</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td>X</td>
<td></td>
<td>0-3</td>
</tr>
</tbody>
</table>

CS 253 must be completed by the end of Semester 5.

**Total Credits: 15**

**Semester 6**

<table>
<thead>
<tr>
<th>Critical</th>
<th>Recommended</th>
<th>AUCC</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 314</td>
<td>Software Engineering</td>
<td>X</td>
<td>3</td>
</tr>
<tr>
<td>CS 345</td>
<td>Machine Learning Foundations and Practice</td>
<td>X</td>
<td>3</td>
</tr>
<tr>
<td>One CS course numbered 300- or above, excluding 380-399 and 480-499</td>
<td>X</td>
<td></td>
<td>3-4</td>
</tr>
<tr>
<td>Technical Electives (See list on Concentration Requirements Tab)</td>
<td>X</td>
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<td>6-8</td>
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</tbody>
</table>

CS 314 and CS 320 and CS 370 must be completed by the end of Semester 6.

**Total Credits: 15**

### Senior

**Semester 7**

<table>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>Capstone Course (See list on Concentration Requirements tab)</td>
<td>X</td>
<td>4C</td>
<td>4</td>
</tr>
<tr>
<td>Systems Elective (See list on Concentration Requirements tab)</td>
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<td></td>
<td>4</td>
</tr>
<tr>
<td>Electives</td>
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<td></td>
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</tr>
</tbody>
</table>

At least 2 Upper-Division CS classes must be completed by the end of Semester 7.

**Total Credits: 15**

**Semester 8**

<table>
<thead>
<tr>
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<th>Credits</th>
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<tbody>
<tr>
<td>Capstone Course (See list on Concentration Requirements tab)</td>
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<td>4</td>
</tr>
<tr>
<td>Additional Computer Science Course (See list on Concentration Requirements tab)</td>
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<td>4</td>
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<tr>
<td>Electives</td>
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</table>
The benchmark courses for the 8th semester are the remaining courses in the entire program of study.

<table>
<thead>
<tr>
<th>Total Credits</th>
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</thead>
<tbody>
<tr>
<td>Program Total Credits:</td>
<td>120</td>
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</tbody>
</table>