COMPUTER SCIENCE, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN DATA SCIENCE

The Bachelor of Science in Computer Science is built on a rigorous, highly concentrated, accredited curriculum of computer science courses, and includes concentrations in cybersecurity, data science and software engineering. The program provides a strong foundation in the discipline and includes advanced study in several important areas of computer science.

The degree requires a minimum of 120 credit hours and includes undergraduate requirements, general education requirements and computer science major requirements.

Student learning outcomes
Upon completing this program, students will know and know how to do the following:

Computer science core outcomes
1. Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions
2. Design, implement and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program’s discipline
3. Communicate effectively in a variety of professional contexts
4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles
5. Function effectively as a member or leader of a team engaged in activities appropriate to the program’s discipline
6. Apply computer science theory and software development fundamentals to produce computing-based solutions

Data science concentration-specific outcome
1. Apply data science and artificial intelligence algorithms to meet specific data and/or model requirements and produce practical solution to a data analysis or data processing problem

Special requirements
The B.S. in Computer Science with a concentration in data science requires a minimum of 120 credits. Students must receive a minimum grade of C in all computer science courses in order to graduate.

Based on the results of the Computer Science Placement Test, students may be required to take CMSC 254, which then can count toward the degree requirements as an elective.

Degree requirements for Computer Science, Bachelor of Science (B.S.) with a concentration in data science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General education</td>
<td></td>
</tr>
</tbody>
</table>

Select 30 credits of general education courses in consultation with an adviser.

Major requirements
• Major core requirements
CMSC 235 Computing and Data Ethics 3
CMSC 255 Introduction to Programming 4
CMSC 256 Data Structures and Object Oriented Programming 4
CMSC 257 Computer Systems 4
CMSC 302 Introduction to Discrete Structures 3
CMSC 303 Introduction to the Theory of Computation 3
CMSC 311 Computer Organization 3
CMSC 312 Introduction to Operating Systems 3
CMSC 355 Fundamentals of Software Engineering 3
CMSC 401 Algorithm Analysis with Advanced Data Structures 3
CMSC 403 Programming Languages 3
CMSC 440 Data Communication and Networking 3
CMSC 441 Senior Design Studio I (Laboratory/Project Time) and Senior Project I 3
CMSC 442 Senior Design Studio II (Laboratory/Project Time) and Senior Project II 3
CMSC 508 Database Theory 3
• Concentration requirements
CMSC 409 Artificial Intelligence 3
CMSC 416 Introduction to Natural Language Processing 3
CMSC 435 Introduction to Data Science 3

Ancillary requirements
ECON 205 The Economics of Product Development and Markets (satisfies general education BOK for social/behavioral science and AOI for global perspectives) 3
ENGR 395 Professional Development 1
MATH 200 Calculus with Analytic Geometry I (satisfies general education quantitative foundations) 4
MATH 201 Calculus with Analytic Geometry II 4
STAT 212 Concepts of Statistics 3
Humanities electives (from list below) 6
MATH courses (300- to 400-level) 3
Natural science option: Select from BIOL, CHEM or PHYS sequence (3-5 credits satisfy general education BOK for natural science and AOI for scientific and logical reasoning) 8-10

Open electives
Select any course. 8-10

Total Hours 120

Select one of the following options:
• Option A: CHEM 101 and CHEZ 101 and CHEM 102 and CHEZ 102
• Option B: PHYS 207 and PHYS 208
• Option C: BIOL 151 and BIOZ 151 and BIOL 152 and BIOZ 152

The minimum number of credit hours required for this degree is 120.

Approved humanities electives

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select six credits from the following programs or subject areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American studies</td>
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<tr>
<td>American studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthropology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School of the Arts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td></td>
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<tr>
<td>Foreign language</td>
<td></td>
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<tr>
<td>History</td>
<td></td>
<td></td>
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<tr>
<td>Philosophy</td>
<td></td>
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<tr>
<td>Psychology</td>
<td></td>
<td></td>
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<tr>
<td>Religious studies</td>
<td></td>
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<tr>
<td>Social work</td>
<td></td>
<td></td>
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<tr>
<td>Sociology</td>
<td></td>
<td></td>
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<tr>
<td>Urban studies</td>
<td></td>
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</tr>
</tbody>
</table>

Some courses in other programs (including most honors modules and other courses that focus on human behavior, communication and/or social interaction) may be counted toward this requirement with departmental approval.

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

Freshman year

Fall semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>CMSC 235</td>
<td>Computing and Data Ethics</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 255</td>
<td>Introduction to Programming</td>
<td>4</td>
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<tr>
<td>UNIV 111</td>
<td>Focused Inquiry I (satisfies general education UNIV foundations)</td>
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</tr>
<tr>
<td>General education course</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Humanities elective (from list)</td>
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</table>

Term Hours: 16

Spring semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>CMSC 256</td>
<td>Data Structures and Object Oriented Programming</td>
<td>4</td>
</tr>
<tr>
<td>CMSC 302</td>
<td>Introduction to Discrete Structures</td>
<td>3</td>
</tr>
<tr>
<td>ECON 205</td>
<td>The Economics of Product Development and Markets (satisfies general education BOK for social/behavioral science and AOI for global perspectives)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I (satisfies general education quantitative foundations)</td>
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Term Hours: 16

Sophomore year

Fall semester

<table>
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<th>Hours</th>
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<tr>
<td>CMSC 257</td>
<td>Computer Systems</td>
<td>4</td>
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<td>CMSC 355</td>
<td>Fundamentals of Software Engineering</td>
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</tr>
<tr>
<td>MATH 201</td>
<td>Calculus with Analytic Geometry II</td>
<td>4</td>
</tr>
<tr>
<td>UNIV 200</td>
<td>Advanced Focused Inquiry: Literacies, Research and Communication (satisfies general education UNIV foundations)</td>
<td>3</td>
</tr>
<tr>
<td>General education course (select BOK for humanities/fine arts)</td>
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<td>3</td>
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Term Hours: 17

Spring semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSC 303</td>
<td>Introduction to the Theory of Computation</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 311</td>
<td>Computer Organization</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 395</td>
<td>Professional Development</td>
<td>1</td>
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<tr>
<td>STAT 212</td>
<td>Concepts of Statistics</td>
<td>3</td>
</tr>
<tr>
<td>General education course</td>
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<tr>
<td>Humanities elective (from list)</td>
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</table>

Term Hours: 16

Junior year

Fall semester

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<thead>
<tr>
<th>Course</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>CMSC 312</td>
<td>Introduction to Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 401</td>
<td>Algorithm Analysis with Advanced Data Structures</td>
<td>3</td>
</tr>
<tr>
<td>Natural science option (3-5 credits satisfy general education BOK for natural science and AOI for scientific and logical reasoning)(select one):</td>
<td>3-5</td>
<td></td>
</tr>
<tr>
<td>CHEM 101</td>
<td>General Chemistry I &amp; CHEZ 101</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 207</td>
<td>University Physics I</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 151</td>
<td>Introduction to Biological Sciences I &amp; BIOL 151</td>
<td>4</td>
</tr>
<tr>
<td>General education course</td>
<td></td>
<td>3</td>
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</table>

Term Hours: 13-14

Spring semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>CMSC 403</td>
<td>Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 508</td>
<td>Database Theory</td>
<td>3</td>
</tr>
<tr>
<td>MATH course (300- to 400-level)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Natural science option (select one):</td>
<td></td>
<td>4-5</td>
</tr>
<tr>
<td>CHEM 102</td>
<td>General Chemistry II &amp; CHEZ 102</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 208</td>
<td>University Physics II</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 152</td>
<td>Introduction to Biological Sciences II &amp; BIOL 152</td>
<td>4</td>
</tr>
<tr>
<td>General education course</td>
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</tbody>
</table>

Term Hours: 13-14

Senior year
Overall GPA of 3.0; and a GPA of 3.4 in the six courses identified above.

Minimum qualifications for entrance to this accelerated program include completion of 30 undergraduate credit hours including six computer science courses CMSC 255, CMSC 256, CMSC 257, CMSC 302, CMSC 303 and CMSC 311; an overall GPA of 3.0; and a GPA of 3.4 in the six courses identified above.

Successful applicants would enter the program in the fall semester of their senior year.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the “Satisfactory academic progress” section of the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students admitted to the accelerated program is provided by both the undergraduate computer science adviser and the faculty adviser to the graduate program.

Admission to the graduate program

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degrees. However, entry into an accelerated program via an approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application to the master’s program, which is submitted through Graduate Admissions no later than a semester prior to graduation with the baccalaureate degree, that is, before the end of the fall semester of the senior year. In order to continue pursuing the master’s degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin. Three reference letters (including one from the computer science undergraduate program director and at least one more from a computer science faculty member) must accompany the application. Students who do not meet the minimum GPA requirements may submit GRE scores to receive further consideration.

Degree requirements

The Bachelor of Science in Computer Science degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. At most, six of these graduate credits will substitute for open elective credits for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

The graduate computer science courses that may be taken as an undergraduate, once a student is admitted to the program, are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSC 501</td>
<td>Advanced Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 502</td>
<td>Parallel Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 510</td>
<td>Regularization Methods for Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 516</td>
<td>Advanced Natural Language Processing</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 525</td>
<td>Introduction to Software Analysis, Testing and Verification</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 591</td>
<td>Topics in Computer Science</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours 18

The minimum number of credit hours required for this degree is 120.

Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows qualified students to earn both the B.S. and M.S. in Computer Science in a minimum of five years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count up to six hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 144 credits rather than the 150 credits necessary if the two degrees are pursued separately.

The program is designed to develop skills and educate computer science students to be major contributors in the computing industry. The graduate program in computer science provides state-of-the-art education through the use of didactic courses to those students who wish to further their knowledge and careers within the computing industry. The program emphasizes continuing self-development and broadening of the knowledge of individuals currently engaged in science, technology and engineering-related fields. It also prepares persons who have completed undergraduate majors in these fields for entry into a career in the numerous areas that use computing technology. Both the theoretical and applied aspects of computer science are emphasized in this program.

Entrance to the accelerated program

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit (no later than two semesters prior to graduating with a baccalaureate degree, that is, before the end of the spring semester of their junior year) an Accelerated Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program include completion of 30 undergraduate credit hours including six computer science courses CMSC 255, CMSC 256, CMSC 257, CMSC 302, CMSC 303 and CMSC 311; an overall GPA of 3.0; and a GPA of 3.4 in the six courses identified above.
Recommended course sequence/plan of study for students pursuing a thesis master’s

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Junior year</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMSC 312</td>
<td>Introduction to Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 401</td>
<td>Algorithm Analysis with Advanced Data Structures</td>
<td>3</td>
</tr>
<tr>
<td>Approved natural science elective (BIOL, CHEM or PHYS course that counts toward the major in that science)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td></td>
<td>4-5</td>
</tr>
<tr>
<td>CHEM 101 &amp; CHEZ 101</td>
<td>General Chemistry I and General Chemistry Laboratory I</td>
<td></td>
</tr>
<tr>
<td>PHYS 207</td>
<td>University Physics I</td>
<td></td>
</tr>
<tr>
<td>BIOL 151 &amp; BIOZ 151</td>
<td>Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I</td>
<td></td>
</tr>
<tr>
<td>Contact undergraduate and graduate program directors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Term Hours:</td>
<td></td>
<td>13-14</td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMSC 403</td>
<td>Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 508</td>
<td>Database Theory</td>
<td>3</td>
</tr>
<tr>
<td>MATH upper-level (300 to 400)</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td></td>
<td>4-5</td>
</tr>
<tr>
<td>CHEM 102 &amp; CHEZ 102</td>
<td>General Chemistry II and General Chemistry Laboratory II</td>
<td></td>
</tr>
<tr>
<td>PHYS 208</td>
<td>University Physics II</td>
<td></td>
</tr>
<tr>
<td>BIOL 152 &amp; BIOZ 152</td>
<td>Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II</td>
<td></td>
</tr>
<tr>
<td>Secure approval from undergraduate program director</td>
<td></td>
<td></td>
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<tr>
<td>Apply to the M.S. program</td>
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<td></td>
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<tr>
<td>Term Hours:</td>
<td></td>
<td>13-14</td>
</tr>
<tr>
<td><strong>Senior year</strong></td>
<td></td>
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<tr>
<td>Fall semester</td>
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</tr>
<tr>
<td>CMSC 451</td>
<td>Senior Project I</td>
<td>3</td>
</tr>
<tr>
<td>MATH upper-level (300 to 400)</td>
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</tr>
<tr>
<td>Approved natural science elective (BIOL, CHEM or PHYS course that counts toward the major in that science)</td>
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<td></td>
</tr>
<tr>
<td>CMSC 501</td>
<td>Advanced Algorithms</td>
<td>3</td>
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<tr>
<td>CMSC 516</td>
<td>Advanced Natural Language Processing</td>
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<tr>
<td>Term Hours:</td>
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</tr>
<tr>
<td>Spring semester</td>
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<tr>
<td>CMSC 440</td>
<td>Data Communication and Networking</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 452</td>
<td>Senior Project II</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 525</td>
<td>Introduction to Software Analysis, Testing and Verification (counts toward B.S. and M.S.)</td>
<td>3</td>
</tr>
</tbody>
</table>

Secure approval from the undergraduate program director
Apply to the M.S. program
Term Hours: 13-14

**Choose the M.S. thesis adviser**
Term Hours: 12

**Fifth year**

Fall semester
CMSC 697 Directed Research 3
M.S. foundational area courses (theory and systems) 6
Term Hours: 9

Spring semester
CMSC 697 Directed Research 6
M.S. foundational area course (applied) 3
Term Hours: 9

See the Graduate Bulletin for the list of theory, systems and applied foundational area courses.

Recommended course sequence/plan of study for students pursuing a non-thesis master’s

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Junior year</strong></td>
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<td>Algorithm Analysis with Advanced Data Structures</td>
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<td>Approved natural science elective (BIOL, CHEM or PHYS course that counts toward the major in that science)</td>
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<tr>
<td>BIOL 151 &amp; BIOZ 151</td>
<td>Introduction to Biological Sciences I and Introduction to Biological Science Laboratory I</td>
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<tr>
<td>Contact undergraduate and graduate program directors</td>
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<td>Select one of the following:</td>
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<td>4-5</td>
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<td>CHEM 102 &amp; CHEZ 102</td>
<td>General Chemistry II and General Chemistry Laboratory II</td>
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<td>University Physics II</td>
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<tr>
<td>BIOL 151 &amp; BIOZ 151</td>
<td>Introduction to Biological Sciences II and Introduction to Biological Science Laboratory II</td>
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</tr>
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<td>Apply to the M.S. program</td>
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<td>Term Hours:</td>
<td></td>
<td>13-14</td>
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<tr>
<td><strong>Senior year</strong></td>
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<tr>
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<td>Spring semester</td>
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<tr>
<td>CMSC 440</td>
<td>Data Communication and Networking</td>
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</tr>
<tr>
<td>CMSC 452</td>
<td>Senior Project II</td>
<td>3</td>
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<tr>
<td>CMSC 525</td>
<td>Introduction to Software Analysis, Testing and Verification (counts toward B.S. and M.S.)</td>
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Fourth graduate course (counts toward B.S. and M.S.) 3
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<tr>
<th>Fall semester</th>
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<tr>
<td>CMSC 451</td>
<td>Senior Project I</td>
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<tr>
<td>MATH upper-level (300 to 400)</td>
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<tr>
<td>Approved natural science elective (BIOL, CHEM or PHYS course that count toward the major in that science)</td>
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<td>CMSC 501</td>
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<td>CMSC 516</td>
<td>Advanced Natural Language Processing</td>
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Term Hours: 15

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<td>CMSC 440</td>
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<tr>
<td>CMSC 452</td>
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<td>Introduction to Software Analysis, Testing and Verification (counts toward B.S. and M.S.)</td>
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Fourth graduate course (counts toward B.S. and M.S.) 3

Term Hours: 12

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<tr>
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<tr>
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Term Hours: 9

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<td>Graduate didactic course work</td>
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Term Hours: 9

1

See the Graduate Bulletin for the list of theory, systems and applied foundational area courses.