<table>
<thead>
<tr>
<th>FALL SEMESTER YEAR 1</th>
<th>Credits</th>
<th>SPRING SEMESTER YEAR 1</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1035 General Chemistry Co: MATH 1025 or MATH 1225</td>
<td>3</td>
<td>PHYS 2305 Found of Physics I w/lab Pre: (MATH 1205 or MATH 1205H or MATH 1225) or (MATH 1206 or MATH 1206H or MATH 1226) Co: 2325 or (MATH 1206 or MATH 1206H or MATH 1226)</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 1045 General Chemistry Lab Co: CHEM 1035</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGL 1105 First-Year Writing</td>
<td>3</td>
<td>ENGL 1106 First-Year Writing Pre: ENGL 1105</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1225 Calculus of a Single Variable (C-) Pre: Math Ready</td>
<td>4</td>
<td>MATH 1226 Calculus of a Single Variable Pre: MATH 1225 (C-)</td>
<td>4</td>
</tr>
<tr>
<td>ENGE 1215 Foundations of Engineering (C-)</td>
<td>2</td>
<td>ENGE 1216 Foundations of Engineering (C-) Pre: ENGE 1215 (C-)</td>
<td>2</td>
</tr>
<tr>
<td>Pathways</td>
<td>3</td>
<td>CS 1114[1] Intro to Software Design (C) 3[F, S, SI]</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FALL SEMESTER YEAR 2</th>
<th>Credits</th>
<th>SPRING SEMESTER YEAR 2</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2204[1] Intro Multivariable Calculus Pre: MATH 1226</td>
<td>3</td>
<td>Communications Elective</td>
<td>3</td>
</tr>
<tr>
<td>MATH 2534[1] Intro Discrete Math Pre: CS 1114 or ECE 1574 (Note: Math double majors take MATH 3034)</td>
<td>3[F, S, SI]</td>
<td>MATH 2114[1] Introduction to Linear Algebra Pre: MATH 1225 (B) or MATH 1226</td>
<td>3</td>
</tr>
<tr>
<td>Natural Science Elective</td>
<td>4</td>
<td>CS 2505[1] Intro to Computer Organization I (C) Pre: 2114 (C); Co: MATH 2534 or MATH 3034</td>
<td>3[F, S, SI]</td>
</tr>
<tr>
<td>CS 1944 Computer Science 1st Yr Sem Pre: 1114 (C)</td>
<td>1[F, S]</td>
<td>Statistics Elective</td>
<td>3</td>
</tr>
<tr>
<td>Pathways</td>
<td>3</td>
<td>Pathways</td>
<td>3</td>
</tr>
<tr>
<td>CS 2114 Software Design &amp; Data Structures (C) Pre: 1114 (C) or 1124 (C)</td>
<td>3[F, S, SI]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>17</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FALL SEMESTER YEAR 3</th>
<th>Credits</th>
<th>SPRING SEMESTER YEAR 3</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 3134 Applied Combinatorics Pre: (MATH 1206 or MATH 1226), (MATH 2534 or MATH 3034) (Note: Math double majors take MATH 3124)</td>
<td>3</td>
<td>Pathways</td>
<td>3</td>
</tr>
<tr>
<td>CS 2506[1] Intro to Computer Organization II (C) Pre: 2505 (C), 2114 (C), (MATH 2534 or MATH 3034)</td>
<td>3[F, S]</td>
<td>CS 3214[1] Computer Systems Pre: 2506 (C), 2114 (C)</td>
<td>3[F, S]</td>
</tr>
<tr>
<td>Professional Writing Elective</td>
<td>3</td>
<td>Data-Centric Computing Elective[2]</td>
<td>3</td>
</tr>
<tr>
<td>CMDA/STAT/CS 3654[2] Introductory Data Analytics &amp; Visualization Pre: 1114, (MATH 2204 or CMDA 2005), (STAT 3006 or STAT 4705 or STAT 4714 or CMDA 2006)</td>
<td>3</td>
<td>Pathways</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FALL SEMESTER YEAR 4</th>
<th>Credits</th>
<th>SPRING SEMESTER YEAR 4</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS Technical Elective</td>
<td>3</td>
<td>CS 3/4XXX Elective</td>
<td>3</td>
</tr>
<tr>
<td>Free Elective</td>
<td>3</td>
<td>Pathways</td>
<td>3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>14</strong></td>
</tr>
</tbody>
</table>
Graduation Requirements:

Most current prerequisites may change from what is indicated. Be sure to confirm course offerings in advance with their department.

Statement of Prerequisites:

Expectations for satisfactory progress for Computer Science majors are as follows:

- Maintain an in-major GPA of 2.5 is required. To take Undergraduate Research (4994), a minimum overall GPA of 2.5 and an in-major GPA of 3.0 is required. CS 4974 and 4994 also require completion of CS 3114 with a grade of C or better.

- Not repeat more than 3 CS courses required in the major, including attempts ending in course withdrawal.

- Not take any CS course required in the major more than twice, including attempts ending in course withdrawal.

Change of Major Requirements:

To qualify for a B.S. degree in CS, a student must:

- Earn a "C" (2.0) or better in CS 1114, CS 2104, CS 2114, CS 2505, CS 2506 and CS 3114.
- Complete at least 123 semester credit hours with a minimum overall GPA of 2.00 and a minimum in-major GPA of 2.00 (the in-major GPA is calculated using all classes with a CS designator).

Pathways to General Education

Consult the Pathways Course Listing (https://www.pathways.prov.vt.edu/about/table.html) for more information. Pathways must be completed prior to graduation.

<table>
<thead>
<tr>
<th>Pathways</th>
<th>Course</th>
<th>Credits</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathways 1F: Discourse (6 hrs)</td>
<td>ENGL 110S</td>
<td>(3)</td>
<td>ENGL 1106</td>
</tr>
<tr>
<td>Pathways 1A: Discourse (3 hrs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pathways 2: Critical Thinking in the Humanities (6 hrs)</td>
<td>CHEM 1035 + 1045</td>
<td>(4)</td>
<td>PHYS 2305</td>
</tr>
<tr>
<td>Pathways 3: Reasoning in the Social Sciences (6 hrs)</td>
<td>MATH 1225</td>
<td>(4)</td>
<td>MATH 1226</td>
</tr>
<tr>
<td>Pathways 4: Reasoning in the Natural Sciences (6 hrs)</td>
<td>CS 3114</td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td>Pathways 5F: Quantitative and Computational Thinking (6 hrs)</td>
<td>ENGE 1215</td>
<td>(2)</td>
<td>ENGE 1216</td>
</tr>
<tr>
<td>Pathways 6D: Critique and Practice in Design and Arts (3 hrs)</td>
<td>ENGE 1215</td>
<td>(2)</td>
<td>ENGE 1216</td>
</tr>
<tr>
<td>Pathways 6A: Critique and Practice in Design and Arts (3 hrs)</td>
<td>ENGE 1215</td>
<td>(2)</td>
<td>ENGE 1216</td>
</tr>
<tr>
<td>Pathways 7: Critical Analysis of Identity and Equity in the United States</td>
<td>ENGE 1215</td>
<td>(2)</td>
<td>ENGE 1216</td>
</tr>
</tbody>
</table>

Pathways 7 can be double-counted with another core concept. In this case, additional free elective credits must be taken to maintain a minimum of 123 credits.

Additional Requirements and notes:

1. **CS Non-Technical Course Requirement.** B.S. in CS students must complete 30 credits of non-technical courses. All courses are approved as non-technical courses except those in the departments of Biological Sciences, Chemistry, Geosciences, Physics, Mathematics, and Statistics, and all departments in the College of Engineering, except for engineering courses satisfying Pathways 7. Also excluded are courses listed as CS technical electives.

2. **Independent Study/Undergraduate Research.** No more than a total of 6 credits of CS Independent Study (4974) and/or CS Undergraduate Research (4994) may be used to fulfill CS degree requirements. To take Independent Study (2974 or 4974), a minimum overall and in-major GPA of 2.5 is required. To take Undergraduate Research (4994), a minimum overall GPA of 2.5 and an in-major GPA of 3.0 is required. CS 4974 and 4994 also require completion of CS 3114 with a grade of C or better.

3. See checksheet page 3 for definitions of each elective category and a list of approved courses for each.

Change of Major Requirements: Please see http://www.enge.vt.edu/em

Foreign Language Requirements: Students must have had 2 years of a foreign language in high school or one year at the college level (6 credit hours) of the same language. College-level credits used to meet this requirement do not count towards the degree.

Satisfactory Progress Towards Degree: University Policy 91 outlines university-wide minimum criteria to determine if students are making satisfactory progress towards the completion of their degrees. The CS Department fully supports this policy. Specific expectations for satisfactory progress for Computer Science majors are as follows:

- Each student must meet the minimum University-wide criteria as described in Policy 91 and summarized in the Undergraduate Catalog (http://www.undergradcatalog.registrar.vt.edu/1920/academic-policies.html#22).
- Be registered in at least one 3-credit course required in the major during each on-campus semester of the regular academic year.
- Maintain an in-major GPA of 2.0 or better (calculated using all classes with a CS designator).
- Not take any CS course required in the major more than twice, including attempts ending in course withdrawal.
- Not repeat more than 3 CS courses required in the major, including attempts ending in course withdrawal.

Statement of Prerequisites: Pre-requisites for each course are listed after the course title. The (letter grade) notation, such as (C), indicates the minimum grade students must earn in the pre-requisite course. There are no hidden pre-requisites in the program of study. Prerequisites may change from what is indicated. Be sure to consult the University Catalog or check with your advisor for the most current pre-requisites.

Graduation Requirements: To qualify for a B.S. degree in CS, a student must:

- Earn a "C" (2.0) or better in CS 1114, CS 2104, CS 2114, CS 2505, CS 2506 and CS 3114.
- Complete at least 123 semester credit hours with a minimum overall GPA of 2.00 and a minimum in-major GPA of 2.00 (the in-major GPA is calculated using all classes with a CS designator).
Data-Centric Computing Electives

Note: Some elective courses may include prerequisites not required by this checksheet. It is the student’s responsibility to be aware of prerequisites and to ensure that all prerequisites are completed prior to enrolling in the chosen course. Some courses may be restricted to majors other than CS in some semesters. Check the Undergraduate Course Catalog and consult with an academic advisor to confirm your eligibility for specific electives. Actual course offerings are subject to availability of sufficient resources, including faculty availability and student demand.

1. **Natural Science Elective.** A minimum of 12 hours of natural science is required. Of those hours, 8 hours must be in a sequence. In addition to the required CHEM 1035/45 and PHYS 2305, this requirement may be satisfied by taking (a) CHEM 1036/46), (b) PHYS 2306, or (c) an eight hour sequence in Biology: BIOL 1105-6 & 1115-6.

2. **Communications Elective.** Students must take one of the following:

   - COMM 2004  Public Speaking  *Pre: Completion of 30 hours*
   - COMM 2014  Speech Communication

   **Note:** COMM 2004 can be used to satisfy Pathways 1A. Students who do not take COMM 2004 as their communications elective will need to satisfy Pathways 2A through a suitable professional writing elective or free elective.

3. **Professional Writing Elective.** Students must take one of the following:

   - ENGL 3764  Technical Writing  *Pre: ENGL 1106 or ENGL 1204H or COMM 1016*
   - ENGL 3804  Technical Editing and Style  *Pre: ENGL 1106 or ENGL 1204H or COMM 1016*
   - ENGL 3814  Creating User Documentation  *Pre: ENGL 1106 or ENGL 1204H or COMM 1016*
   - ENGL 3824  Designing Documents for Print  *Pre: ENGL 1106 or ENGL 1204H or COMM 1016*
   - ENGL 3834  Intercultural Issues in Professional Writing  *Pre: ENGL 1106 or ENGL 1204H or COMM 1016*
   - ENGL 3844  Writing and Digital Media  *Pre: ENGL 1106 or ENGL 1204H or COMM 1016*
   - ENGL 4824  Science Writing  *Pre: ENGL 1106 or ENGL 1204H or COMM 1016*

   **Note:** ENGL 3764 can be used to satisfy Pathways 1A. Students who do not take ENGL 3764 as their communications elective will need to satisfy Pathways 2A through a suitable communications elective or free elective.

4. **Statistics Elective.** Students must take one of the following:

   - STAT 4705  Probability and Statistics for Engineers  *Pre: MATH 2224 or MATH 2204 or MATH 2204H or MATH 2406H*
   - STAT 4714  Probability and Statistics for Electrical Engineers  *Pre: MATH 2224 or MATH 2204 or MATH 2204H or MATH 2406H*
   - CMDA 2006  Integrated Quantitative Sciences  *Pre: CMDA 2005, (MATH 2114 or MATH 2114H)*
5. **Data-Centric Computing Elective.** Students must take three of the following:

- **BIT 4604** Data Governance, Privacy and Ethics  
  **Pre:** BIT 2405 or CMDA 2014 or CS 1114 or CS 1054 or CS 1064
- **BIT 4624** Cybersecurity Analytics  
  **Pre:** BIT 4614
- **CMDA/STAT/CS 4654** Intermediate Data Analytics and Machine Learning  
  **Pre:** (STAT 3654 or CMDA 3654 or CS 3654), (STAT 3104 or STAT 4705 or STAT 4714 or CMDA 2006)
- **CS 3414 (MATH 3414)** Numerical Methods  
  **Pre:** (1044 or 1705 or 1114 or 1124), (MATH 2214 or MATH 2214H), (MATH 2224 or MATH 224H or MATH 2204 or MATH 2204H)
- **CS 4414 (MATH 4414)** Issues in Scientific Computing  
  **Pre:** (MATH 2214 or MATH 2214H or MATH 2406H or CMDA 2006), MATH 3214, (CS 2114 or MATH 3054)
- **CS 4604** Introduction to Data Base Management Systems  
  **Pre:** 3114
- **CS 4804** Introduction to Artificial Intelligence  
  **Pre:** 3114
- **CS 4824/ECE 4424** Machine Learning  
  **Pre:** ECE 2574 or CS 2114, (STAT 4604 or STAT 4705 or STAT 4714)
- **STAT 3504** Nonparametric Statistics  
  **Pre:** STAT 3006 or STAT 3616 or STAT 4106 or STAT 4706 or CMDA 2006
- **STAT 4214** Methods of Regression Analysis  
  **Pre:** STAT 3006 or STAT 3616 or STAT 4106 or STAT 4706 or STAT 5606 or STAT 5616 or CMDA 2006
- **STAT 4444** Applied Bayesian Statistics  
  **Pre:** (MATH 2224 or MATH 2224H or MATH 2204 or MATH 2406H or CMDA 2005), (STAT 3104 or STAT 4105 or STAT 4705 or CMDA 2006), (STAT 3006 or STAT 3616 or STAT 4706 or CMDA 2006)

6. **Data-Centric Computing Capstone Requirement.** Students must complete one 4000-level CS capstone course in the data-centric computing area. Students may choose the course listed here, or other 4/5000-level CS courses that have received prior approval as fulfilling the secure computing capstone requirement.

   - **CS 4624** Multimedia, Hypertext and Information Access  
     **Pre:** 3114

7. **CS Technical Elective.** Data-Centric Computing majors must satisfy a 3 credit hour technical elective requirement by taking one of:

   1. Any 3-credit CS 3/4/5000-level course not otherwise used to fulfill a Data-Centric Computing requirement can be used as a technical elective, including both Independent Study (CS 4974) and Undergraduate Research (CS 4994).

   2. Any approved 3000- or 4000-level course in another discipline that has significant technical content relevant to the science or application of computer science can be used as a technical elective.

      a. Requests to have a non-CS course approved as a technical elective are made by submitting a course syllabus to your CS advisor for review prior to enrolling in the course. This includes non-CS Independent Study (4974) and Undergraduate Research (4994) courses.

      b. Below is a listing of non-CS courses that are approved as technical electives.
Computer Science Technical Elective Courses

ACIS/BIT 4554  Networks & Telecommunications in Business  (3H, 3C) Pre: ACIS 3504 or BIT 3424

AOE 4434  Introduction to Computational Fluid Dynamics  (3H, 3C) Pre: MATH 2214

ART 3704  Topics in Computer Animation  (3H, 3C) Pre: ART 2704

BIT 4424  Business Information Visualization & Analytics  (3H, 3C) Pre: BIT 2406

BIT 4434  Computer Simulation in Business  (3H, 3C) Pre: BIT 3414

BIT 4444  Web-based Decision Support Systems  (3H, 3C) Pre: BIT 3444

BIT 4514  Database Technology for Business  (3H, 3C) Pre: BIT 3424, BIT 4524

BIT 4544  Advanced Methods in Business Analytics  (3H, 3C) Pre: BIT 3444 or ACIS 2504

BIT 4604  Data Governance, Privacy and Ethics  (3H, 3C) Pre: BIT 2405 or CMDA 2014 or CS 1114 or CS 1054 or CS 1064

BIT 4614  Information Security  (3H, 3C) Pre: BIT 4554 or ACIS 4554

BIT 4624  Cybersecurity Analytics  (3H, 3C) Pre: BIT 4614

CMDA 3606  Mathematical Modeling: Methods and Tools II

COMM 4374  New Communications Technology  (3H, 3C) Pre: COMM 2084 or COMM 4014

ECE 3544  Digital Design I  (3H, 3C) Pre: ECE 2504

ECE 3574  Applied Software Design  (3H, 3C) Pre: ECE 2574

ECE 4524  Artificial Intelligence and Engineering Applications  (3H, 3C) Pre: ECE 2574, STAT 4714

ECE 4550  Real Time Systems  (3H, 3C) Pre: ECE 4534 or CS 3214

ECE 4560  Computer and Network Security Fundamentals  (3H, 3C) Pre: CS 3214 or ECE 2504

ECE 4564  Network Application Design  (3H, 3C) Pre: ECE 2504, ECE 2574

ECE 4580  Digital Image Processing  (3H, 3C)

ECE 4704  Principles of Robotic Systems  (3H, 3C) Pre: (ME 3514, STAT 3704) or ECE 2704

GEOG/GEOS 4084  Modeling with GIS  (3H, 3C) Pre: GEOG 2084

GEOG 4314  Analysis in GIS  (3H, 3C) Pre: GEOG 4084

GEOG 4324  Algorithms in GIS  (3H, 3C) Pre: GEOG 4084, CS 1044

MATH 4175  Cryptography I  (3H, 3C) Pre: MATH 3034 or MATH 3124 or MATH 3134 or MATH 3144 or MATH 3224 or MATH 4134

MATH 4176  Cryptography II  (3H, 3C) Pre: MATH 4175 or (MATH 3034, MATH 3124) or (MATH 3034, MATH 3134) or (MATH 3034, MATH 3144) or (MATH 3034, MATH 3224) or (MATH 3034, MATH 4134) or (MATH 3124, MATH 3134) or (MATH 3124, MATH 3144) or (MATH 3124, MATH 3224) or (MATH 3124, MATH 4134) or (MATH 3134, MATH 3144) or (MATH 3134, MATH 3224) or (MATH 3134, MATH 4134) or (MATH 3144, MATH 3224) or (MATH 3144, MATH 4134) or (MATH 3224, MATH 4134)

MATH 4445  Introduction to Numerical Analysis  (3H, 3C) Pre: MATH 2406H or (CMDA 2005, CMDA 2006) or (MATH 2214 or MATH 2214H), (MATH 2224 or MATH 2224H) or (MATH 2204 or MATH 2204H)

MATH 4454  Applied Mathematical Modeling  (3H, 3C) Pre: MATH 3214

ME 4524  Robotics and Automation  (3H, 3C) Pre: (ECE 2574, STAT 4714) or (ME 3514, STAT 3704)

MUS 3064  Digital Sound Manipulation  (3H, 3C)

MUS 3065  Computer Music & Multimedia I  (3H, 3C) Pre: MUS 2054

MUS 3066  Computer Music & Multimedia II  (3H, 3C) Pre: MUS 2054, MUS 3065

PHYS 4755  Intro to Computational Physics  (3H, 3C) Pre: PHYS 2306, CS 1044