

DATA-CENTRIC COMPUTING MAJOR

Program Curriculum

Code	Title	Credits
Degree Core Requirements		
CS 1114	Introduction to Software Design (C)	3
CS 2505	Introduction to Computer Organization (C)	3
CS 2506	Introduction to Computer Organization (C)	3
CS 3214	Computer Systems	3
CS 3604	Professionalism in Computing	3
MATH 2114	Introduction to Linear Algebra	3
MATH 2204	Introduction to Multivariable Calculus	3
or CMDA 2005	Integrated Quantitative Sciences	
MATH 2534	Introduction to Discrete Mathematics	3
or MATH 3034	Introduction to Proofs	
Subtotal		24
Major Requirements		
CS 3314	Programming Language Theory and Practice	3
CS/STAT/CMDA 3654	Introductory Data Analytics and Visualization	3
CS 4XXX	Data-Centric Computing Capstone	3
Data-Centric Computing Electives ³		12
Subtotal		21
Additional Course Requirements		
CS 1944	Computer Science First Year Seminar	1
CS 2114	Software Design and Data Structures (C)	3
CS 4944	Seminar	1
MATH 3134	Applied Combinatorics and Graph Theory	3
or MATH 3124	Modern Algebra	
Subtotal		8
Elective Courses		
CS 3/4/5XXX Elective ³		3
CS Technical Elective ³		3
Advanced Natural Science Elective		4
Communications Elective		3
Professional Writing Elective		3
Statistics Elective		3
Free Electives		4
Subtotal		23
Pathways to General Education		
<i>Pathways Concept 1 - Discourse</i>		
ENGL 1105	First-Year Writing (1F)	3
ENGL 1106	First-Year Writing (1F)	3
Select three hours in Pathway 1a (https://catalog.vt.edu/course-search/?attrs_pathways=attrs_pathways_G01A) (use Communications Elective, Professional Writing Elective, or Free Elective)		
<i>Pathways Concept 2 - Critical Thinking in the Humanities</i>		
Select six hours in Pathway 2 (https://catalog.vt.edu/course-search/?attrs_pathways=attrs_pathways_G02)		6

Pathways Concept 3 - Reasoning in the Social Sciences

Select six hours in Pathway 3 (https://catalog.vt.edu/course-search/?attrs_pathways=attrs_pathways_G03)	6
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Pathways Concept 4 - Reasoning in the Natural Sciences

Natural Science Elective	4
Natural Science Elective	4

Pathways Concept 5 - Quantitative and Computational Thinking

MATH 1225	Calculus of a Single Variable (5F ; C-)	4
MATH 1226	Calculus of a Single Variable (5F)	4
CS 3114	Data Structures and Algorithms (5A ; C)	3

Pathways Concept 6 - Critique and Practice in Design and the Arts

Select three hours in Pathway 6a (https://catalog.vt.edu/course-search/?attrs_pathways=attrs_pathways_G06A)		3
ENGE 1215	Foundations of Engineering	4
& ENGE 1216	and Foundations of Engineering (6D)	
or ENGE 1414	Foundations of Engineering Practice	

Pathways Concept 7 - Critical Analysis of Identity and Equity in the United States

Pathways Concept 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.	3
Subtotal	47

Total Credits 123

Additional Requirements and Notes

Double Major Restriction: students pursuing a Major in Data-Centric Computing may not double major in the Major in Computational Modeling and Data Analytics or one of the major concentrations/options listed under the Bachelor of Science in Computational Modeling and Data Analytics.

Data-Centric Computing Electives

Note: Some elective courses may include prerequisites not required by this checklist. 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 Electives: Choose 8 credits

Code	Title	Credits
BIOL 1105	Principles of Biology	4
& BIOL 1115	and Principles of Biology Laboratory	
CHEM 1035	General Chemistry	4
& CHEM 1045	and General Chemistry Laboratory	
PHYS 2305	Foundations of Physics	4

2. Advanced Natural Science Elective: Choose 4 credits

Code	Title	Credits
BIOL 1106	Principles of Biology	4
& BIOL 1116	and Principles of Biology Laboratory	
CHEM 1036	General Chemistry	4
& CHEM 1046	and General Chemistry Laboratory	
PHYS 2306	Foundations of Physics	4

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

Code	Title	Credits
COMM 2004	Public Speaking	3
COMM 2014	Speech Communication	3

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

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

Code	Title	Credits
ENGL 3764	Technical Writing	3
ENGL 3804	Technical Editing and Style	3
ENGL 3814	Creating User Documentation	3
ENGL 3824	Visual Rhetoric and Document Design	3
ENGL 3834	Intercultural Issues in Professional Writing	3
ENGL 3844	Writing and Digital Media	3
ENGL 4824	Science Writing	3

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

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

Code	Title	Credits
STAT 4705	Probability and Statistics for Engineers	3
STAT 4105	Theoretical Statistics	3
CMDA 2006	Integrated Quantitative Sciences	6

6. **CS 3/4/5XXX Electives³.** Other than the exceptions listed below, any 3-credit CS 3/4/5000-level course not otherwise used to fulfill a Computer Science requirement can be used as a CS 3/4/5XXX elective, including both CS 4974 Independent Study and CS 4994 Undergraduate Research. Additionally, the following cross-listed courses are allowed for CS 3/4/5XXX elective credit.

Code	Title	Credits
BIT 4164	Future of Security: Integrative Solutions for Complex Security Systems	3
CMDA 4654	Intermediate Data Analytics and Machine Learning	3
ECE 4424	Machine Learning	3
ECE 4504	Computer Organization	3
ECE 4570	Wireless Networks and Mobile Systems	3
MATH 3414	Numerical Methods	3
MATH 4414	Issues in Scientific Computing	3
PSCI 4164	Future of Security: Integrative Solutions for Complex Security Systems	3
STAT 4654	Intermediate Data Analytics and Machine Learning	3

Exceptions (not allowed to count towards CS 3/4/5XXX electives)

Code	Title	Credits
CS/CMDA 3634	Computer Science Foundations for Computational Modeling & Data Analytics	3
CS 4774	Human-Computer Interaction Design Experience	3

CS 5040	Intermediate Data Structures and Algorithm Analysis	3
CS 5044	Object-Oriented Programming with Java	3
CS 5045	Computation for the Data Sciences	3
CS 5046	Computation for the Data Sciences	3
CS 5644	Machine Learning with Big Data	3
CS 5664	Social Media Analytics	3
CS 5904	Project and Report	1-19
CS 5944	Graduate Seminar	1
CS 5974	Independent Study	1-19
CS 5994	Research and Thesis	1-19

7. **Data-Centric Computing Elective³.** Students must take four of the following:

Code	Title	Credits
BIT 4604	Data Governance, Privacy and Ethics	3
BIT 4624	Cybersecurity Analytics for Business	3
CMDA/STAT/CS 4654	Intermediate Data Analytics and Machine Learning	3
CS/MATH 3414	Numerical Methods	3
CS 3824	Introduction to Computational Biology and Bioinformatics	3
CS/MATH 4414	Issues in Scientific Computing	3
CS 4604	Introduction to Data Base Management Systems	3
CS 4804	Introduction to Artificial Intelligence	3
CS 4824/ ECE 4424	Machine Learning	3
STAT 3504	Nonparametric Statistics	3
STAT 4214	Methods of Regression Analysis	3
STAT 4444	Applied Bayesian Statistics	3
CS 5054	Programming Models for Big Data	3
CS 5124	Algorithms in Bioinformatics	3
CS 5424	Computational Cell Biology	3
CS 5465		3
CS 5466		3
CS 5474	Finite Difference Methods for Partial Differential Equations	3
CS 5484	Finite Element Methods for Partial Differential Equations	3
CS 5485	Numerical Analysis and Software	3
CS 5486	Numerical Analysis and Software	3
CS 5525	Data Analytics	3
CS 5526	Statistical Learning	3
CS 5614	Database Management Systems	3
CS 5764	Information Visualization	3
CS 5814	Introduction to Deep Learning	3
CS 5854	Computational Systems Biology	3

8. **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 data-centric computing capstone requirement.

Code	Title	Credits
CS 4624	Multimedia, Hypertext and Information Access	3
CS 4664	Data-Centric Computing Capstone	3
CS 4884	Computational Biology and Bioinformatics Capstone	3

With prior departmental approval, CS 4414 Issues in Scientific Computing or MATH 4414 Issues in Scientific Computing or ENGE 4735 Interdisciplinary Design Capstone or ENGE 4736 Interdisciplinary Design Capstone can fulfill the capstone requirement in semesters where the course includes a significant data-centric computing aspect.

9. **CS Technical Elective³.** Data-Centric Computing majors must satisfy a 3 credit hour technical elective requirement by taking one of:
- Any 3-credit CS 3/4/5000-level course meeting the CS 3/4/5XXX elective requirements under (6) above.
 - Any Data-Centric Computing Elective listed under (6) above that is not otherwise used to fulfill a Data-Centric Computing requirement.
 - 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.
 - 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.
 - Below is a listing of non-CS courses that are approved as technical electives.
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.

Code	Title	Credits
AOE 4434	Introduction to Computational Fluid Dynamics	3
ART 3704	Topics in Computer Animation	3
BIT 4424	Business Information Visualization and Analytics	3
BIT 4434	Computer Simulation in Business	3
BIT 4444	Web-Based Decision Support Systems	3
BIT 4544	Artificial Intelligence, Machine Learning, and Deep Learning in BIT	3
BIT 4604	Data Governance, Privacy and Ethics	3
BIT 4614	Cybersecurity Management II	3
BIT 4624	Cybersecurity Analytics for Business	3
CEM 4624	Construction Robotics and Automation	3
CEM 4634	Data Analysis and Visualization for Construction and Facilities Management	3
CMDA 3606	Mathematical Modeling: Methods and Tools	3
ECE 3544	Digital Design I	4
ECE 3574	Applied Software Design	3
ECE 4524	Artificial Intelligence and Engineering Applications	4

ECE 4550	Real-Time Systems	3
ECE 4560	Computer and Network Security Fundamentals	3
ECE 4564	Network Application Design	3
ECE 4580	Digital Image Processing	3
ECE 4704	Principles of Robotics Systems	3
ENGE 4735	Interdisciplinary Design Capstone	3
ENGE 4736	Interdisciplinary Design Capstone	3
ENGE 4964	INTERDISCIPLINARY DESIGN PROJECT	
GEOG/GEOS 4084	Modeling with Geographic Information Systems	3
GEOG 4314	Spatial Analysis in Geographic Information Systems	3
GEOG 4324	Algorithms in Geographic Information Systems	4
MATH 4175	Cryptography	3
MATH 4176	Cryptography	3
MATH 4445	Introduction to Numerical Analysis	3
MATH 4454	Applied Mathematical Modeling	3
ME 4524	Introduction to Robotics and Automation	3
MUS 3064	Digital Sound Manipulation	3
MUS 3065	Computer Music and Multimedia Design	3
MUS 3066	Computer Music and Multimedia Design	3
PHYS 4755	Introduction to Computational Physics	3

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 4974 Independent Study and/or CS 4994 Undergraduate Research may be used to fulfill CS degree requirements. To take Independent Study (CS 2974 Independent Study or CS 4974 Independent Study), a minimum overall and in-major GPA of 2.5 is required. To take CS 4994 Undergraduate Research, a minimum overall GPA of 2.5 and an in-major GPA of 3.0 is required. CS 4974 Independent Study and CS 4994 Undergraduate Research also require completion of CS 3114 Data Structures and Algorithms with a grade of **C** or better.

³ **Undergraduates Taking Graduate Courses.** Students within 2 semesters of graduating and with a 3.0 or better GPA may enroll in 5000-level courses satisfying undergraduate degree requirements within their department if they have been accepted into the Accelerated Undergraduate/Graduate Program, or by permission of the course instructor and the Department. For students not accepted into the Accelerated Undergraduate/Graduate Program, these courses may not be used on the Plan of Study for a graduate 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.

Graduation Requirements

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

1. Completed at least 123 credit hours
2. Earn a “C” (2.0) or better in CS 1114 Introduction to Software Design, CS 2114 Software Design and Data Structures, CS 2505 Introduction to Computer Organization, CS 2506 Introduction to Computer Organization and CS 3114 Data Structures and Algorithms.
3. Earn 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).

Acceptable Substitutions

1. MATH 2405H may be substituted for MATH 2114
2. MATH 2405H + MATH 2406H may be substituted for MATH 2114 + MATH 2204 + free elective (4 cr)
3. CS 2064 (C) may be substituted for CS 1114
4. ECE 2514 (C) may be substituted for CS 1114 (C)
5. ECE 3514 (C) may be substituted for CS 2114 (C)
6. ECE 2564 (C) may be substituted for CS 2505 (C)

Foreign Language Requirement

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.

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Roadmap

First Year		
Fall Semester		Credits
CS 1114	Introduction to Software Design (C)	3
ENGE 1215	Foundations of Engineering	2
ENGL 1105	First-Year Writing	3
MATH 1225	Calculus of a Single Variable (C-)	4
Natural Science Elective		4
		Credits 16
Spring Semester		
CS 2114	Software Design and Data Structures (C)	3
ENGE 1216	Foundations of Engineering	2
ENGL 1106	First-Year Writing	3
MATH 1226	Calculus of a Single Variable	4

Natural Science Elective		4
		Credits 16
Second Year		
Fall Semester		
CS 1944	Computer Science First Year Seminar	1
CS 2505	Introduction to Computer Organization (C)	3
MATH 2204 or CMDA 2005	Introduction to Multivariable Calculus or Integrated Quantitative Sciences	3
MATH 2534 or MATH 3034	Introduction to Discrete Mathematics or Introduction to Proofs	3
Pathways 2, 3, 6a, or 7		3
Pathways 2, 3, 6a, or 7		3
		Credits 16
Spring Semester		
CS 2506	Introduction to Computer Organization (C)	3
MATH 2114	Introduction to Linear Algebra	3
Communications Elective		3
Statistics Elective		3
Advanced Natural Science Elective		4
		Credits 16
Third Year		
Fall Semester		
CS 3114	Data Structures and Algorithms (C)	3
CS 3654 or STAT 3654 or CMDA 3654	Introductory Data Analytics and Visualization or Introductory Data Analytics and Visualization or Introductory Data Analytics and Visualization	3
MATH 3134	Applied Combinatorics and Graph Theory	3
Professional Writing Elective		3
Pathways		3
		Credits 15
Spring Semester		
CS 3214	Computer Systems	3
CS 3604	Professionalism in Computing	3
Data-Centric Computing Elective ³		3
Pathways 2, 3, 6a, or 7		3
Pathways 2, 3, 6a, or 7		3
		Credits 15
Fourth Year		
Fall Semester		
CS 3314	Programming Language Theory and Practice	3
CS Technical Elective ³		3
Data-Centric Computing Elective ³		3
Data-Centric Computing Elective ³		3
Free Elective		3
		Credits 15
Spring Semester		
CS 4944	Seminar	1
CS 3/4/5XXX	Elective ³	3
CS 4XXX	Data-Centric Computing Capstone	3
Data-Centric Computing Elective ³		3
Pathways 2, 3, 6a, or 7		3
Free Elective		1
		Credits 14
		Total Credits 123