

COMPUTER SCIENCE IN ARTS AND SCIENCES

<https://www.uvm.edu/cems/cs> (<https://www.uvm.edu/cems/cs/>)

The Department of Computer Science resides in the College of Engineering and Mathematics Sciences (CEMS). The College of Arts and Sciences (CAS) offers a B.A. with a major in Computer Science. CEMS offers two B.S. programs in the discipline of computer science.

Edsger Dijkstra (a renowned computer scientist, 1930-2002) is reputed to have said “Computer Science is no more about computers, than astronomy is about telescopes.” Rather, Computer Science (CS) is aptly defined as the Science of Problem Solving. CS thus requires a combination of logical thinking, creativity, problem decomposition, implementation, verification and validation, and teamwork.

CS is a vibrant subject with academic depth, enormous growth, and universal economic impact. Computers are now ubiquitous in society and influence the way we learn, the way we do business, and the way we understand our world. Whether your passion is to help fight global warming, uncover the secrets of the human genome, evolve intelligent robots, bring history to life through mobile apps, prevent terrorism, study human social phenomena, understand financial markets, create digital art, improve healthcare, find useful patterns in Big Data, or invent the technologies of the future, computing is central to these and virtually all modern endeavors. Because of this, computing-related careers are among the most versatile, creative, satisfying, lucrative, and in-demand. The demand for computer scientists continues to grow at an incredible pace and shows no sign of slowing down.

At the undergraduate level, UVM Computer Science offers 3 bachelor’s degrees, an accelerated M.S. degree, and a minor:

- **B.S.CS.:** The Bachelor of Science in Computer Science provides the most depth in computer science, complemented by breadth in math, science, humanities, and social sciences. The B.S.CS. is offered through the College of Engineering and Mathematical Sciences.
- **B.S.:** The Bachelor of Science in Computer Science and Information Systems is an interdisciplinary degree that combines computer science with business, offering a competitive combination of skills and knowledge. The B.S. is offered through the College of Engineering and Mathematical Sciences, in cooperation with the School of Business Administration.
- **B.A.:** The Bachelor of Arts in Computer Science provides a computer science major in the context of a liberal education, and has sufficient flexibility to facilitate a double major in another field such a mathematics, biology, music, etc. The B.A. is offered through the College of Arts and Sciences.
- **Accelerated M.S.:** CS juniors who are academically strong may enter our accelerated M.S. program. This allows them to apply two of their upper division courses towards both a bachelor’s and

master’s degree, enabling completion of the M.S. in as little as one additional year beyond their bachelor’s degree.

- **CS minor:** We offer a flexible 6-course minor in Computer Science, which is a great complement to virtually any other major and adds marketable skills.

UVM CS courses provide a mixture of lecture-based and hands-on experiential learning exercises. Our curricula provide a solid foundation in both applied and theoretical aspects of computing, preparing students for future careers and/or graduate study in computing. Many of our students complete paid internships during their summers, and UVM CS alumni survey respondents typically report 100% employment or graduate student status one year after graduation.

MAJORS

COMPUTER SCIENCE MAJOR

Computer Science B.A. (http://catalogue.uvm.edu/undergraduate/artsandsciences/computerscience/computer_science_major/)

MINORS

COMPUTER SCIENCE MINOR

This minor is administered by the College of Engineering and Mathematical Sciences.

Computer Science (<http://catalogue.uvm.edu/undergraduate/engineeringandmathematicalsciences/computerscience/computerscienceminor/>)

GRADUATE

Computer Science AMP

Computer Science M.S.

Computer Science Ph.D.

See the online Graduate Catalogue (<http://catalogue.uvm.edu/graduate/>) for more information.

Computer Information Systems Courses

CIS 001. SU: Cybersecurity Law & Policy. 3 Credits.

U.S. statutes, regulations, and judicial decisions dealing with cybersecurity; politics and policies that are relevant to cyberspace governance; ways to create digitally resilient organizations; the relationship between cybersecurity and sustainability.

CIS 090. Internship. 1-3 Credits.

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CIS 092. Independent Study. 1-18 Credits.

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CIS 096. Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

CIS 146. Digital Fabrication. 3 Credits.

Through hands-on experience students will practice with digital fabrication technologies (both hardware and software) that are popular with contemporary artists. Students will practice design iteration and rapid prototyping and experiment with art-making practices such as tessellation, 3D imaging, generative design, artificial life and interaction design. Prerequisites: ARTS 001 or ARTS 012; Minimum junior standing. Cross-listed with: ARTS 146.

CIS 190. Internship. 1-18 Credits.

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CIS 192. Independent Study. 1-18 Credits.

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CIS 196. Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

CIS 197. Teaching Assistantship. 1-3 Credits.

Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

CIS 198. Undergraduate Research. 1-18 Credits.

Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CIS 290. Internship. 1-18 Credits.

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CIS 292. Independent Study. 1-18 Credits.

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CIS 296. Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles.

CIS 297. Teaching Assistantship. 1-3 Credits.

Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

CIS 298. Undergraduate Research. 1-18 Credits.

Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

Computer Science Courses**CS 005. Introductory Special Topics. 1-3 Credits.**

Prerequisite: Instructor permission. Hours variable. May not be taken for credit after any Computer Science course numbered CS 016 or higher.

CS 006. Exploring Cybersecurity. 3 Credits.

Fundamental concepts and tools utilized by cybersecurity professionals to assess and detect software and network vulnerabilities; best practices in physical and data security through the use of appropriate risk management methodologies. No credit if taken after CS 166 or 266.

CS 008. QR: Intro to Web Site Dev. 0 or 3 Credits.

Provides a strong foundation in HTML, CSS, images, beginning web programming, and web design so that the student can create a complete functional web site in a team based final project.

CS 020. QR: Programming for Engineers. 0 or 3 Credits.

Introduction to computer programming principles using MATLAB, with applications chosen from civil, electrical, environmental, and mechanical engineering. Co-requisite: MATH 021. Cross-listed with: ENGR 020.

CS 021. QR: Computer Programming I. 0 or 3 Credits.

Introduction to algorithmic problem solving and computer programming. Designed to provide a foundation for further studies in computer science.

CS 050. Seminar for New CS Majors. 1 Credit.

A fun and accessible breadth-first introduction to the CS community and curricula at UVM. CS faculty serve as guest lecturers to introduce new CS majors to selected topics covered in upper division UVM CS electives. Prerequisites: Computer Science or Computer Science & Information Systems majors who have not yet completed CS 110. Co-requisite: CS 021 or CS 110.

CS 064. QR: Discrete Structures. 3 Credits.

Introduction to analytic and formal methods of computer science with practical examples, including analysis of data structures, recursion relations, proof methods, and logic programming. Credit not given for more than one of CS 064, MATH 052 or MATH 054. Prerequisites: CS 020 or CS 021 or CS 110; MATH 021 or MATH 023.

CS 087. QR: Intro to Data Science. 3 Credits.

Basic techniques of data harvesting and cleaning; association rules, classification and clustering; analyze, manipulate, and visualize data using programming languages. Basic principles of probability and statistical modeling/inference to make meaning out of large datasets. Cross-listed with: STAT 087.

CS 090. Internship. 1-3 Credits.

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CS 091. Instructing in Computer Sci. 0.5-6 Credits.

Assist in instruction of undergraduate computer science courses under the direct supervision of a faculty member. Duties may include grading, office hours, laboratory and/or recitation instruction, or other related activities. Instructor permission required. Prerequisite: Instructor Permission.

CS 094. Independent Study. 1-18 Credits.

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CS 095. Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles. Prerequisite: Instructor permission.

CS 106. QR: Embedded Programming in C. 2-3 Credits.

Fundamental exercises in C programming for embedded systems (e.g., Arduino platform) including variable types, pointers, memory allocation, input/output, etc. and demonstration of advanced knowledge of these embedded systems concepts (second credit); with embedded systems project (third credit). Prerequisites: CS 020 or CS 021. Cross-listed with: EE 106.

CS 110. QR: Intermediate Programming. 0 or 4 Credits.

Intermediate programming concepts including common data structures, algorithms, style, design, documentation, testing and debugging techniques, and an introduction to object-oriented programming. Prerequisite: One of CS 020 or CS 021 with a grade of C- or better.

CS 120. QR: Advanced Programming. 3 Credits.

Build programming maturity and proficiency through significant projects with spiral development, including program specification, design, implementation, debugging, testing, validation, internal and external documentation. Focus on advanced topics including efficiency, profiling, modularity, extensibility, programming paradigms, design patterns, memory management, and generics. Prerequisite: CS 124.

CS 121. QR: Computer Organization. 0 or 3 Credits.

Introduction to computer system organization including performance, assembly language, machine-level data representation, arithmetic for computers, processor datapath control, memory, and input/output. Includes significant semester project. Prerequisite: CS 110.

CS 124. QR: Data Struc & Algorithms. 3 Credits.

Design and implementation of linear structures, trees and graphs. Examples of common algorithmic paradigms. Theoretical and empirical complexity analysis. Sorting, searching, and basic graph algorithms. Prerequisites: CS 110 with a grade of C- or better; minimum Sophomore standing.

CS 125. QR: Computability & Complexity. 3 Credits.

Formal languages and expressiveness. Turing completeness and Church's Thesis. Decidability and tractability. Complexity classes and theory of NP completeness. Prerequisites: CS 064 or MATH 052. Co-requisite: CS 124.

CS 142. QR: Advanced Web Design. 0-3 Credits.

Advanced web site design, including structure, architecture, compliance, CSS, usability, and other related topics, to help create a pleasing user experience. Several team based projects during the semester with a team based final project. Prerequisite: CS 008.

CS 145. QR: Web Client Programming. 3 Credits.

Covers client side programming in the web browser. Explores the JavaScript programming language to include user actions in your web site, and work with the DOM (Document Object Model). Semester project. Prerequisites: CS 008; CS 020 or CS 021.

CS 148. QR: Database Design for Web. 0 or 3 Credits.

Design and implementation of a relational database model using SQL and PHP. Open ended final team based project, examples: ecommerce site, blogging site, members only site, learning site. Prerequisites: CS 008; CS 020 or CS 021.

CS 166. QR: Cybersecurity Principles. 3 Credits.

Introduction to cybersecurity, fundamental security design principles, programming flaws, malicious code, web and database security, cryptography algorithms and hashing functions; overview of computer networks and common network threat vectors. No credit if taken after CS 266. Prerequisites: CS 008, CS 110 with a grade of C- or better.

CS 167. Cybersecurity Defense. 3 Credits.

Cyber defense policy, privacy, ethics; network threat defense, intrusion detection systems, intro to penetration testing, OS security principles, system/network admin, cloud, mobile and IoT security; overview of security planning, management and incident response. Prerequisite: CS 166 or CS 266.

CS 187. QR: Basics of Data Science. 3 Credits.

Basic data science techniques, from import to cleaning to visualizing and modeling, using the R language. Machine learning methods include regression, classification and clustering algorithms. Programming methods include user-defined functions. Prerequisite: STAT 111 or STAT 141 or STAT 143 or STAT 211. Cross-listed with: STAT 187.

CS 190. Internship. 1-18 Credits.

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CS 191. Teaching Assistantship. 1-3 Credits.

Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

CS 192. Service Learning in CS. 1-3 Credits.

Service learning experience that benefits the University or the Community under the direction of a CS faculty member. Prerequisite: Instructor permission.

CS 195. Special Topics. 1-18 Credits.

See Schedule of Courses for specific titles. Prerequisite: Instructor permission.

CS 196. Undergraduate Research. 1-18 Credits.

Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CS 198. Independent Study. 1-18 Credits.

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CS 201. QR: Operating Systems. 0 or 3 Credits.

Supervisory and control software for multiprogrammed computer systems. Processes, threads, synchronization, interprocess communication, scheduling, memory management, resource allocation, performance evaluation, secondary storage, case studies. Prerequisites: CS 120 and CS 121.

CS 202. Compiler Construction. 3 Credits.

Covers the design and construction of compilers and translation of high-level programming languages to assembly language. Topics include code representation, register allocation, optimization, static analysis, mutable data, garbage collection, and compilation of higher-order language features. Prerequisites: CS 124, CS 125.

CS 204. QR: Database Systems. 3 Credits.

Techniques for processing very large collections of data. Secondary storage. Database design and management. Query languages and optimization. Database recovery. Prerequisite: CS 124.

CS 205. QR: Software Engineering. 3 Credits.

Treatment of software engineering problems and principles, with a focus on iterative software development. A significant part of the course is devoted to two multi-week team projects. Prerequisite: CS 120.

CS 206. QR: Evolutionary Robotics. 3 Credits.

Exploration of the automated design of autonomous machines using evolutionary algorithms. Coursework involves reading of research papers, programming assignments and a final project. Prerequisites: Junior standing and programming experience, or Instructor permission.

CS 211. Data Privacy. 3 Credits.

Explores the research field of data privacy, including privacy attacks on anonymized data, and formal approaches like k-Anonymity and differential privacy. Applies the theory of data privacy to real problems in programming projects. Prerequisites: CS 124, CS 125.

CS 222. QR: Computer Architecture. 3 Credits.

Architecture of computing systems. Control unit logic, input/output processors and devices, asynchronous processing, concurrency, parallelism, and memory hierarchies. Prerequisite: CS 121.

CS 224. QR: Algorithm Design & Analysis. 3 Credits.

Comprehensive study of algorithms including greedy algorithms, divide and conquer, dynamic programming, graph algorithms and network flow. Computational intractability. Approximation, local search and randomization. Prerequisite: CS 124. Pre/co-requisites: Recommended: CS 125; STAT 143, STAT 151, or CS 128.

CS 225. QR: Programming Languages. 3 Credits.

Principles of programming language design and fundamental implementation concepts. Syntax, semantics, and static analysis of programs. Provable properties of programming languages such as type safety. Prerequisites: CS 124, CS 125.

CS 226. QR: Software Verification. 3 Credits.

Principles and practice of software specification and verification. Design of algorithms which are verified correct using interactive or automated, software-based tools. Emphasis on the design space for software specification, and the spectrum of verification goals ranging from shallow to deep verification. Includes a course project. Prerequisites: CS 124, CS 125.

CS 228. Human-Computer Interaction. 3 Credits.

Covers the foundational theories and methods in the interdisciplinary field of human-computer interaction, focuses on the human-centered design and evaluation of user interfaces for various computing systems, as well as introduces a wide range of topics in current human-computer interaction research. Prerequisites: Minimum Junior standing. Pre/Co-requisites: Programming experience; CS 008 or equivalent web development experience.

CS 237. QR: Intro to Numerical Analysis. 3 Credits.

Error analysis, root-finding, interpolation, least squares, quadrature, linear equations, numerical solution of ordinary differential equations. Prerequisites: Math 121; MATH 122 or MATH 124 or MATH 271; CS 020 or CS 021. Cross-listed with: MATH 237.

CS 243. QR: Theory of Computation. 3 Credits.

Reducibility and decidability, recursion theory, time and space complexity, P, NP, NP-completeness, PSPACE, PSPACE-completeness, L and NL, advanced topics in computability and complexity. Prerequisites: CS 124 and CS 125.

CS 253. QR: Reinforcement Learning. 3 Credits.

Students will program agents that learn to optimize a reward function using Reinforcement Learning; Markov Decision Processes with discrete states, Value Iteration, Policy Iteration, Q-learning and SARSA, methods for value function approximation in complex domains using linear and non-linear methods. Prerequisites: CS 064 or MATH 052; STAT 151 or STAT 251; CS 110. Pre/Co-requisites: MATH 122 or MATH 124; CS 125.

CS 254. QR: Machine Learning. 3 Credits.

Introduction to machine learning algorithms, theory, and implementation, including supervised and unsupervised learning; topics typically include linear and logistic regression, learning theory, support vector machines, decision trees, backpropagation artificial neural networks, and an introduction to deep learning. Includes a team-based project. Prerequisites: STAT 151 or STAT 251; MATH 122 or MATH 124.

CS 265. QR: Computer Networks. 3 Credits.

Introduction to the theoretical and pragmatic principles and practices of computer networking. Topics include: the Internet; wired and wireless communications protocols; network security protocols. Prerequisites: CS 124.

CS 266. QR: Network Security & Cryptography. 3 Credits.

Security and secrecy in a networked environment. Cryptography: public and private key. Authentication: trusted agents, tickets. Electronic mail and digital signatures. Privacy and national security. Prerequisite: CS 124.

CS 275. QR: Mobile App Development. 3 Credits.

A projects-based course focusing on software development for mobile devices, including the concepts of event-driven programming, GUI design and implementation, utilization of hardware sensors, and client/server applications. A significant part of the course is devoted to a multi-month team development project. Prerequisite: CS 120, Senior standing. Pre/co-requisites: Recommended: CS 148 or CS 204.

CS 283. Undergraduate Honors Thesis. 3 Credits.

See description of Honors Thesis Program in the College of EM section of this catalog. Prerequisite: CEMS 101.

CS 284. Undergraduate Honors Thesis. 3 Credits.

See description of Honors Thesis Program in the College of EM section of this catalog.

CS 287. QR: Data Science I. 3 Credits.

Data harvesting, cleaning, and summarizing. Working with non-traditional, non-numeric data (social network, natural language textual data, etc.). Scientific visualization using static and interactive "infographics." A practical focus on real datasets, and developing good habits for rigorous and reproducible computational science. Project-based. Prerequisites: CS 020 or CS 021; STAT 141 or STAT 143 or STAT 211; CS 110 and MATH 122/124 recommended. Pre/co-requisites: Recommended: CS 110; Math 122 or Math 124. Cross-listed with: CSYS 287, STAT 287.

CS 288. QR: Statistical Learning. 3 Credits.

Statistical learning methods and applications to modern problems in science, industry, and society. Topics include: linear model selection, cross-validation, lasso and ridge regression, tree-based methods, bagging and boosting, support vector machines, and unsupervised learning. Prerequisites: STAT 143, STAT 183 or STAT 211. Cross-listed with: STAT 288.

CS 290. Internship. 1-18 Credits.

On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

CS 291. Teaching Assistantship. 1-3 Credits.

Undergraduate student service as a teaching assistant, usually in an introductory-level course in the discipline, for which credit is awarded. Offered at department discretion.

CS 292. Senior Seminar. 1 Credit.

Oral presentations that pertain to the ethical practice of computer science in government, industry, and academia. Topics may include computer security, copyright, and patent law. Prerequisite: Senior standing in Computer Science.

CS 293. Computing Career Preparation. 1 Credit.

Seminar to help students develop necessary skills for becoming computing professionals and exposes them to different computing careers. Topics include job search strategies, preparation for technical interviews, networking, and developing soft skills. Several guest lectures by computing professionals and alumni. Prerequisite: CS 124.

CS 294. Undergraduate Research. 1-18 Credits.

Undergraduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

CS 295. Special Topic: Computer Science. 1-18 Credits.

See Schedule of Courses for specific titles. Subject will vary from year to year. May be repeated for credit with instructor permission.

CS 298. Independent Study. 1-18 Credits.

A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.