The Department of Computer Science offers undergraduate and graduate programs. The Bachelor of Science in Computer Science is a rigorous, highly concentrated curriculum of computer science courses. It includes advanced study in several important areas of computer science and provides a strong foundation in this discipline. Every course is taught by full-time faculty members who also serve as advisers to both undergraduate and graduate students.

The master's degree program emphasizes continuing self-development of individuals currently engaged in science-, technology- and engineering-related fields. It prepares persons who have completed undergraduate majors in these fields for entry into careers in areas that use computing technology. Both the theoretical and applied aspects of computer science are emphasized in this program. The program offers courses in a wide range of areas in computer science, including machine learning, artificial intelligence, cybersecurity and cloud computing, data mining, bioinformatics, and medical informatics.

- Computer Science, Bachelor of Science (B.S.) (http://bulletin.vcu.edu/undergraduate/engineering/computer-science/computer-science-bs/)
- Computer Science, Bachelor of Science (B.S.) with a concentration in cybersecurity (http://bulletin.vcu.edu/undergraduate/engineering/computer-science/computer-science-bs-concentration-cybersecurity/)
- Computer Science, Bachelor of Science (B.S.) with a concentration in data science (http://bulletin.vcu.edu/undergraduate/engineering/computer-science/computer-science-bs-concentration-data-science/)
- Computer Science, Bachelor of Science (B.S.) with a concentration in software engineering (http://bulletin.vcu.edu/undergraduate/engineering/computer-science/computer-science-bs-concentration-software-engineering/)
- Computer science, minor in (http://bulletin.vcu.edu/undergraduate/engineering/computer-science/computer-science-minor/)
- Computer Science, Certificate in (Post-baccalaureate undergraduate certificate) (http://bulletin.vcu.edu/undergraduate/engineering/computer-science/computer-science-certificate/)
- Fundamentals of Computing (Baccalaureate certificate) (http://bulletin.vcu.edu/undergraduate/engineering/computer-science/fundamentals-computing-certificate/)

CMSC 101. Introduction to Computer Science. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 141 or the equivalent with a minimum grade of C. An introduction to the work of computer scientists, including an overview of current research and application areas as well as career opportunities. Topics include problem-solving, the basics of computer organization, the software engineering life cycle, research resources and social and ethical aspects of technology. Additional topics also include binary, hexadecimal, two's complement, floating point representation, ASCII and Unicode.
CMSC 257. Computer Systems. 4 Hours.
Semester course; 3 lecture and 2 laboratory hours. 4 credits. Prerequisite: CMSC 256 with a minimum grade of C. Topics include UNIX essentials; system programming in C; machine-level representation and organization of programs/data, arrays and pointers; types, structs and unions; strings; bit/byte operations; memory management; shell programming; input/output, including file handling; debugging; signals; network programming using sockets; program concurrency using forks and threads; experiments on program performance and optimization techniques.

CMSC 302. Introduction to Discrete Structures. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 255 with minimum grade of C. Logic and proofs, sets, functions, sequences and sums, relations, graphs, trees, induction and recursion, advanced counting technique (recurrences).

CMSC 303. Introduction to the Theory of Computation. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 302 or the equivalent with a grade of C or better. Complexity classes, grammars, automata, formal languages, Turing machines, computability.

CMSC 311. Computer Organization. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 302 with minimum grade of C; corequisite: CMSC 257. Introduction to the basic organization of computers including elementary digital logic design, processor and arithmetic/logic unit design, data paths, memory hierarchy, I/O devices, instruction set architecture and addressing modes.

CMSC 312. Introduction to Operating Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 311 or EGRE 364. Computer systems design, I/O processing, secondary memory organization, command languages, memory management and job scheduling. Students will work in teams to design and implement an operating system simulation.

CMSC 320. Software Engineering and Web Development. 3 Hours.
Semester course; 3 lecture hours (delivered online). 3 credits. Prerequisite: CMSC 210. Introduction to software engineering and web development. The course introduces students to the software development process, including design, development and testing principles. Students will apply these principles in the development of a web application. This course is not applicable for credit toward any College of Engineering degrees.

CMSC 330. Data Science Skills. 3 Hours.
Semester course; 3 lecture hours (delivered online). 3 credits. Prerequisite: CMSC 210. Introduction to data science skills. The course introduces students to the foundations of data science and the tools used to collect, analyze and represent data. Students will apply these principles in both analysis and visualization projects. This course is not applicable for credit toward any College of Engineering degrees.

CMSC 340. Cybersecurity Skills. 3 Hours.
Semester course; 3 lecture hours (delivered online). 3 credits. Prerequisite: CMSC 210. Introduction to cybersecurity skills. The course introduces students to cybersecurity terminology, standards and best practices. Students will apply these practices as part of a cybersecurity-focused project. This course is not applicable for credit toward any College of Engineering degrees.

CMSC 355. Fundamentals of Software Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 256 or EGRE 246, either with a minimum grade of C. Provides an overview of how to engineer software systems, including all stages of the software development process based on agile principles. Familiarizes students with modern software tools and the principles of software quality and testing. Students will work in teams to gain experience in software development methodology, write specification and design documents, and develop a prototype.

CMSC 391. Topics in Computer Science. 3 Hours.
Semester course; 3 lecture hours. 3 credits. May be repeated for credit. Prerequisite: permission of the instructor. This course will teach selected topics in computer science. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

CMSC 401. Algorithm Analysis with Advanced Data Structures. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 256 with a grade of C or better and CMSC 302 with a grade of C or better. Introduction to algorithm analysis and complexity classes. Advanced data structures topics including multiple linked lists, height-balanced trees, B-trees, hashing and graph representation; incorporating data structures into object-oriented design. Analysis of various searching and sorting algorithms. Algorithm design topics include divide-and-conquer, dynamic programming and greedy methods.

CMSC 403. Programming Languages. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 256 and CMSC 303, both with a minimum grade of C. Survey of representative modern programming languages. Formal definition of programming languages including specifications of syntax and semantics. Precedence, infix, prefix and postfix notation. Global properties of algorithmic languages. Sub-routines, co-routines and tasks. List processing, string manipulation, data description and simulation languages. Run-time representation of program and data structures.

CMSC 404. Compiler Construction. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 401 and 403. A first course in compiler theory and construction. Formal description of languages, underlying theory and design techniques for compilers, lexical analysis, syntax analysis, syntax-directed translation, intermediate languages, run-time system management, code generation, code optimization, compiler-building tools.

CMSC 409. Artificial Intelligence. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 401 with a minimum grade of C and MATH 310. Covers problem spaces, problem-solving methods, game playing, knowledge representatives, expert systems, natural language understanding.

CMSC 410. Introduction to Quantum Computing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 401 and MATH 310, both with a minimum grade of B. Introduction to quantum information processing: state vectors and density operators, tensor product space, unitary evolution, no-go theorems, measurement, qubit, gate model of quantum computing, quantum complexity theory, quantum error correction, quantum algorithms, and quantum machine learning.

CMSC 411. Computer Graphics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 355 and MATH 310. Presents mathematical techniques for graphic development and transformation, curve and surface approximation and projections, graphical languages and data structures and their implementation, graphic modeling.
CMSC 412. Social Network Analysis and Cybersecurity Risks. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 401 with a minimum grade of C. Covers network models, link prediction and analysis, centrality measures, random networks, power-laws and preferential attachment, small-world phenomenon and decentralized search, community structure, information propagation in networks, and security and privacy issues in OSNs.

CMSC 413. Introduction to Cybersecurity. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 401 with a minimum grade of C. This course provides introduction and basic concepts of computer security, cyber attacks, cyber defense, cyber forensics and cyber ethics.

CMSC 414. Computer and Network Security. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 401 with a minimum grade of C. Corequisite: CMSC 312. This course covers the best practices of computer systems and network security. Key topics include security architecture, cryptographic systems and security management tools.

CMSC 415. Introduction to Cryptography. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 401 with a minimum grade of C. This course provides a rigorous and theoretical introduction to modern cryptography. Key topics include symmetric key encryption and authentication, public key encryption, and digital signatures.

CMSC 416. Introduction to Natural Language Processing. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 401 with a minimum grade of C. Covers rule-based and statistical methods for creating computer programs that analyze, generate and understand human language. Topics include regular expressions and automata, context-free grammars, probabilistic classifiers, and machine learning. Word-level, syntactic and semantic processing are all considered. Application to real-world problems such as spell-checking, Web search, automatic question answering, authorship identification and developing conversational interfaces.

CMSC 420. Software Project Management. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 355 with a minimum grade of C. Study of the logistics of team software development. Students work in teams to gain experience in software management and develop the components of a larger software product. Topics include risk management, project planning, quality management, configuration management and software testing.

CMSC 425. Introduction to Software Analysis and Testing. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 355 with a minimum grade of C. Enrollment is restricted to majors in the computer science program. A practical introduction to testing complex software applications. An introduction to concepts and techniques used in the analysis of software, including basic and advanced control flow and data flow analyses. Using analytic results to derive test data and validate the correct implementation of programs. Advanced testing strategies including random, structural, mutation and fuzzing.

CMSC 428. Mobile Programming: iOS. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 355, with a minimum grade of C. This course covers the fundamentals of Swift, Xcode and iOS for programming and design of iOS applications. Background in object-oriented programming and access to a computer with Xcode platform is required.

CMSC 435. Introduction to Data Science. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 401 with a minimum grade of C. This course covers understanding, representation, storage, retrieval, preprocessing and analysis of data. Specific topics include data quality and preprocessing, database management systems, data warehouses, selected methods for scalable unsupervised and supervised data analysis, and assessment of results generated by these methods. Students will be engaged in analysis of real-life data from data preprocessing, through data analysis, to the assessment of a knowledge product.

CMSC 440. Data Communication and Networking. 3 Hours. Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 257 with a minimum grade of C. Enrollment is restricted to majors in the College of Engineering. This course explores computer networking, focusing on the applications and protocols that run on the Internet. Students will take a top-down approach to the layered network architecture, studying applications first and then proceeding down the network "stack" toward the physical link. Students will examine the operation of applications such as the web, FTP, e-mail and DNS. At the transport layer, students will study both connectionless UDP and connection-oriented TCP, with an in-depth study of TCP operation, specifically flow control and congestion control. Data communications are explored through various data routing protocols. Additional topics include network security and wireless/mobile networking.

CMSC 451. Senior Project I. 3 Hours. Semester course; 3 laboratory hours. 3 credits. Prerequisites: CMSC 355 with minimum grade of C; and UNIV 200 or HONR 200 or equivalent. Enrollment is restricted to computer science majors with senior standing who have 24 credits in computer science courses. Capstone project or experience for the computer science major; research and presentation methods in computer science. Each student will participate, either individually or as part of a team, in a project or other experience approved by the course coordinator or sponsored by another computer science faculty member. Each student will write and revise a research paper on a technical topic associated with his or her project or experience. Students will submit a detailed written description of their proposed project or experience and will present orally some aspect of what they have learned and/or done during the semester. (This course cannot be counted as upper-level CMSC electives for students graduating under bulletins prior to 2008-09.)

CMSC 452. Senior Project II. 3 Hours. Semester course; 1 lecture and 2 laboratory hours. 3 credits. Prerequisites: CMSC 451 and CMSC 508, both with a minimum grade of C. Enrollment is restricted to students with senior standing in the computer science department. Capstone project or experience for the computer science major; research and presentation methods in computer science; ethical, legal and social issues in computing; and professional responsibilities of computer scientists. Each student will participate, either individually or as part of a team, in a project or other experience approved by the course coordinator or sponsored by another computer science faculty member. Each student will write and revise a research paper on a technical topic associated with his or her project or experience. Students must continue on the same project that was started in CMSC 451. A final project report and presentation, which will include a discussion of associated legal, social and/or ethical issues, are due at the conclusion of the two-semester project or experience. (This course cannot be counted as upper-level CMSC electives for students graduating under bulletins prior to 2008-09.)
CMSC 455. Software as a Service. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 355 with a minimum grade of C. Enrollment is restricted to majors in the computer science program. Students will examine the challenges, opportunities and open problems of software-as-a-service deployed on commodity cloud computing platforms. Covers relevant software architectures and API design principles. Includes concepts of modern software frameworks for software development, cloud computing for software deployment and software operations. Students participate in projects that use modern tooling to develop, deploy and monitor a software application.

CMSC 475. Design and Implementation of User Interfaces. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CMSC 355 with a minimum grade of C. Enrollment is restricted to majors in the computer science program. This course investigates the design and implementation of user interfaces and the evaluation of user experiences. Particular emphasis is placed on creating professional-quality designs and implementations and on evaluating these implementations with end-users. Students will create their own UIs as well as critique others to develop a deep understanding of what works in practice.

CMSC 491. Topics in Computer Science. 1-3 Hours.
Semester course; variable hours. 1-3 credits. May be repeated for credit with different content. Prerequisite: permission of instructor. This course will cover selected topics in computer science. See the Schedule of Classes for specific topics to be offered each semester.

CMSC 492. Independent Study. 2-4 Hours.
Semester course; variable hours. 2, 3 or 4 credits per semester. Maximum 4 credits per semester; maximum total of 6 credits. Generally open only to students of junior or senior standing who have acquired at least 12 credits in the departmental discipline. Determination of the amount of credit and permission of instructor and department chair must be procured prior to registration of the course. The student must submit a proposal for investigating some area or problem not contained in the regular curriculum. The results of the student's study will be presented in a report.