Computer Science, M.S.C.S., Ph.D.

Degrees Offered

• Master of Science in Computer Science (M.S.C.S)
• Doctor of Philosophy in Computer Science (Ph.D.)

Nature of the Program

The Masters of Science in Computer Science (M.S.C.S.) degree program qualifies a student to assume a professional role in industry or government, teach in a junior or senior college, or undertake advanced training toward a doctorate in computer science. The following sections describe the general procedures to be followed in completing the M.S.C.S. degree. Note that steps are intended to be carried out in a specific order.

Program Educational Objectives & Outcomes

The objective of the Masters of Science in Computer Science (M.S.C.S.) degree program is to produce graduates who have the knowledge, skills, and attitudes that will ensure success in professional positions in business, industry, research, government service, or in further graduate or professional study.

Specific outcomes that will be achieved by graduates of the program are:

• Achieve a depth of proficiency in a specific field of Computer Science by completing major courses in one of three areas: computer systems, software and knowledge engineering, or the theory of computation.
• Achieve a breadth of understanding of Computer Science by completing minor coursework requirements in other areas, and by participation in graduate seminar requirements.
• Demonstrate professionalism and communication skills through completion of coursework, project, or thesis defense.

Admissions

All Masters and Ph.D. programs require applicants to provide the items below to be considered for admission.

• A minimum cumulative grade point average of 3.0 or equivalent, based on a 4.0 system.
• Three letters of reference.
• All graduate degree programs require the GRE general test, with an expected score of 3.5 or better in analytical writing, and either the 80th percentile or better on the quantitative part, or a combined score of 300 or better in (verbal + quantitative).
• All graduate degree programs require an appropriate bachelors or master's degree for entry. Students lacking some foundation courses appropriate to a particular degree program may be assigned some preparatory coursework as a condition of admission.
• International applicants must meet the WVU requirement of English language proficiency (https://graduateadmissions.wvu.edu/how-to-apply/apply-for-2022-2023/international-graduate-applicant/).

FOUNDATION ASSESSMENT

The minimum background expected of any student entering the M.S.C.S. program is coursework equivalent to the following:

• One year of calculus (MATH 155 (http://catalog.wvu.edu/search/?P=MATH%20155) and MATH 156 (http://catalog.wvu.edu/search/?P=MATH%20156)).
• One course in probability and statistics (STAT 215 (http://catalog.wvu.edu/search/?P=STAT%20215)).
• Knowledge of introductory programming in a high-level programming language (CS 110 (http://catalog.wvu.edu/search/?P=CS%20110)).

Students not meeting these minimum requirements will be required to take the equivalent coursework before applying to the M.S.C.S. program.

Students entering without a four-year Bachelors degree in Computer Science may have additional deficiencies in their coursework which must be addressed before beginning the regular M.S.C.S. program. These students will be initially admitted with provisional status and required to remove these deficiencies during their first eighteen hours of coursework.

Possible deficiency areas for students having a Bachelors degree in other disciplines represent the following core areas required of all undergraduate CS students:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 111</td>
<td>Introduction to Data Structures</td>
<td>4</td>
</tr>
<tr>
<td>CS 220</td>
<td>Discrete Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>CS 230</td>
<td>Introduction to Software Engineering</td>
<td>4</td>
</tr>
<tr>
<td>CS 310</td>
<td>Principles of Programming Languages</td>
<td>3</td>
</tr>
</tbody>
</table>
As demand justifies and resources permit, the department will offer accelerated courses to assist graduate students in satisfying deficiencies.

**Admission Requirements 2023-2024**

The Admission Requirements above will be the same for the 2023-2024 Academic Year.

MSCS Major Code: 3022

PhD Major Code: 3023

For specific information on the following programs, please see the links to the right:

- Computer Science, M.S.C.S.

For specific information on the following programs, please see the links to the right:

- Computer Science, Ph.D.

**COURSES**

**CS 510. Formal Specification of Language. 3 Hours.**
PR: CS 410. Specifications of language syntax and semantics by grammars and automata and by attribute grammars, denotational semantics, and action equations; algebraic, denotational, and operational semantics; application of formal specifications to construction of software tools.

**CS 520. Advanced Analysis of Algorithms. 3 Hours.**
PR: CS 320. Analysis and design techniques for efficient sequential and parallel algorithm design; NP-completeness, advanced analysis techniques, advanced algorithms, and parallel algorithms.

**CS 525. Computational Complexity. 3 Hours.**
PR: CS 422. Introduction to the theory of computational complexity. Topics include: turning machines, computability, complexity classes P, NP, and co-NP, the theory of NP-completeness, randomized complexity classes, inapproximability, and complexity classes beyond NP.

**CS 530. Formal Methods in Software Engineering. 3 Hours.**
PR: CS 430. Principles of rigorous specification, designing, implementation, and validation of sequential, concurrent, and real-time software; emphasis on reading current papers on these topics.

**CS 533. Developing Portable Software. 3 Hours.**
PR: CS 330 and CS 450 or Consent. Issues, problems, and techniques in the practical development of portable software and in the adaptation of programs to new environments; development of a simple interactive application; porting to several diverse computing platforms.

**CS 539. Computer Forensics and the Law. 3 Hours.**
PR: CPE 435. Surveys the emerging field of computer law and how it applies to businesses and law enforcement, both to aid and to circumscribe the policies and procedures to tackle computer crime.

**CS 540. Theory of Database Systems. 3 Hours.**
PR: CS 440. Abstract and newer database models; introduction to database design techniques in the context of semantic data modeling; equivalence of different relational models; object-oriented databases.

**CS 550. Theory of Operating Systems. 3 Hours.**
PR: CS 450. Theoretical analysis of selected aspects of operating system design; topics include interaction of concurrent processes; scheduling and resource allocation; virtual memory management; access control; and distributed and real-time system issues.

**CS 555. Advanced Computer Systems Architecture. 3 Hours.**
PR: CS 455 or CPE 442. High performance techniques, pipelined and parallel systems, and high-level architectures; comparative evaluation of architectures for specific applications; emphasis on software implications of hardware specifications.

**CS 556. Distributed and Pervasive Compt. 3 Hours.**
PR: CS 350 or consent. An in-depth study of distributed computing paradigms, standards, and applications that can exploit this paradigm and the emerging pervasive computing infrastructure.

**CS 558. Multimedia Systems. 3 Hours.**
PR: CS 350 or EE 465 or consent, requirements and QOS; multimedia data acquisition, object decomposition, multimedia storage servers; multimedia communications-networking, traffic characterizations, traffic scheduling, multicasting; compression of images, video and audio; multimedia information systems-indexing and retrieval of multimedia data.

**CS 560. Big Data Engineering. 3 Hours.**
PR: LCSEE graduate standing, or consent. Survey of the algorithms, methods, and technologies involved in building, organizing and analyzing massive datasets. Explores the field of data science from a computational perspective.
CS 568. Computer Network Forensics. 3 Hours.
PR: CS 450 and CS 453 or consent. Introduction to threat assessment in modern networked computer systems. Techniques, methodologies and
technologies for preventing, detecting, recovering from, and collecting evidence of intrusions, with the intent of prosecuting the offending parties.

CS 569. Cybersecurity and Big Data Analytics. 3 Hours.
PR: Consent. Scientific foundations for solving real-world security problems. Challenges and opportunities of big data. Typical big data analytic and
modeling techniques for cybersecurity.

CS 572. Advanced Artificial Intelligence Techniques. 3 Hours.
PR: CS 472. Reasoning under uncertainty; nonmonotonic reasoning, statistical reasoning, fuzzy logic; planning, parallel, and distributed AI, natural
language processing, learning, connectionist models, temporal logic, common sense knowledge and qualitative reasoning, AI techniques and robotics.

CS 573. Advanced Data Mining. 3 Hours.
PR: CS 230 and CS 350 or equivalent. We present the theory practice of industrial data mining. Combining pragmatics with theory, students will learn to
select appropriate data mining methods for individual applications. Graduate students will learn to conduct data mining experiments.

CS 576. Design of Immersive Media Systems. 3 Hours.
PR: Graduate student status in CS, or consent. Team-based development of a video game, demo reel, or other project demonstrating expertise in game
development.

CS 589. Game Seminar. 1 Hour.
(May be repeated for a maximum of 3 credit hours.) A discussion of current topics in video game development.

CS 591B-Q. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CS 592. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

CS 593. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CS 594. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.

CS 595. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

CS 623. String Algorithms. 3 Hours.
PR: CS 221 or Consent. Algorithms on strings from traditional combinatorial pattern matchup to recent problems such as suffix sorting and string
embeddings. Emphasis is on the data structures and algorithms required, their analysis, and optimal constructions.

CS 630. Empirical Methods in Software Engineering and Computer Science. 3 Hours.
An in-depth study of the scientific process and guidelines for empirical research. Particularly addressing surveys, case studies, and controlled
experiments. Covers in detail the qualitative and quantitative data analysis methods commonly used in empirical investigations.

CS 665. Computer System Security. 3 Hours.
PR: CS 465 or Consent. Course describes modern approaches to information and system security including encryption techniques, secure
communication protocols, operating system security principles, and network intrusion detection techniques.

CS 674. Computational Photography. 3 Hours.
Computational techniques used for the acquisition and processing of digital photographic data. Introduction to camera technology, image formation,
filtering, warping, morphing, compositing, rendering, enhancement, and novel camera design.

CS 676. Machine Learning. 3 Hours.
Principles and techniques used in learning theory, regression, classification, instance-based methods, kernel methods, risk minimization, ensemble-
based methods, graphical models, and deep models.

CS 677. Pattern Recognition. 3 Hours.
PR: Consent. Covers salient topics in statistical pattern recognition, including Bayesian decision theory, Bayesian learning and density estimation, linear
discriminant functions, multilayer neural networks, support vector machines, and unsupervised learning. Working knowledge of Matlab is essential.

CS 678. Computer Vision. 3 Hours.
An introduction to low-level image analysis methods, image transformations, methods for reconstructing three-dimensional scene information, algorithms
for motion and video analysis, and approaches to object recognition.

CS 689. Graduate Internship. 1-3 Hours.
PR: Completion of a minimum of 18 degree applicable graduate credit hours with an overall GPA of 3.0 or better. Employments in industry related to
degree program. (Graded P/F. May be repeated twice. Cannot be counted toward graduation requirements.).
CS 690. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of computer science. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It also provides a mechanism for students not on assistantships to gain teaching experience. (Grading will be S/U.).

CS 691X. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CS 692. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

CS 693. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CS 695. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

CS 696. Graduate Seminar. 1-3 Hours.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

CS 697. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U).

CS 699. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use the University’s facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department’s 699/799 Graduate Colloquium to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is S/U; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirement of registration in the semester in which graduation occurs.

CS 726. Algorithmic Graph Theory. 3 Hours.
PR: CS 520 or consent. Introduction to algorithmic graph theory with emphasis on special classes of graphs, graph structure, efficient combinatorial algorithms, graph compositions/ decompositions, and graph representations, current research development trends and open questions on structured families and graphs.

CS 727. Information Dissemination. 3 Hours.
PR: CS 520. Research issues in information dissemination in graphs; emphasis on broadcasting and gossiping algorithms, including identification and solution of open research questions.

CS 750. Secure and Survivable Systems. 3 Hours.
PR: CS 680 or Consent. An in-depth study of principles, standards, practices, and architectures in the area of secure and survivable systems. Case studies, simulations, and games will be used to gain deep understanding of the issues.

CS 751. Digital Enterprises. 3 Hours.
PR: CS 680 or Consent. An in-depth study of principles, standards, practices, and architectures in the area of digital enterprise. Case studies and simulations will be used to gain deep understandings of the issues.

CS 757. Distributed Systems and Algorithms. 3 Hours.
PR: CS 320 and CS 550. Distributed and networked operating systems and the algorithms necessary to achieve such goals as transparency, sharing, fault tolerance, and efficient process and task scheduling.

CS 772. Global Knowledge Networks. 3 Hours.
PR: CS 572. Representational formalisms and effective retrieval techniques to obtain information from international knowledge repositories connected via high-speed networks.

CS 790. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of computer science. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It will also present a mechanism for students not on assistantships to gain teaching experience. (Grading will be S/U.).

CS 791X. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CS 792. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

CS 793. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CS 795. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.
CS 796. Graduate Seminar. 1-3 Hours.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

CS 797. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper, or equivalent scholarly project, or a dissertation. (Grading may be S/U).

CS 900. Professional Development. 1-6 Hours.
Professional development courses provide skill renewal or enhancement in a professional field or content area (e.g., education, community health, geology). The continuing education courses are graded on a pass/fail grading scale and do not apply as graduate credit toward a degree program.

CS 930. Professional Development. 1-6 Hours.
Professional development courses provides skill renewal or enhancement in a professional field or content area (e.g., education, community health, geology). These tuition-waived, continuing education courses are graded on a pass/fail grading scale and do not apply as graduate credit toward a degree program.