

Computer Science (COSC)

Chairperson: *Sheikh Iqbal Ahamed, Ph.D.*

Program Director: *Praveen Madiraju, Ph.D.*

Computer Science website (<https://www.marquette.edu/grad/programs-computer-science-phd.php>)

Degree Offered

Doctor of Philosophy

Program Description

The computer science graduate program prepares students for careers in research in industry, research laboratories and institutions of higher education. The program allows students to tailor course work based on their interests and strengths. The program places particular emphasis on students contributing to applied research in computer science.

Prerequisites for Admission

Students are expected to have demonstrated academic excellence, and should have an undergraduate background in a computer science-related discipline.

Application Deadline

To be considered for fall admission, all application requirements must be completed and received in the Graduate School. The priority deadline for review of applications is **Jan. 15**. After the priority admission deadline, applications are reviewed on a rolling basis.

Application Requirements

Applicants must submit, directly to the Graduate School:

1. A completed application form and fee online (http://marquette.edu/grad/future_apply.shtml).
2. Copies of all college/university transcripts except Marquette.¹
3. A statement of professional goals and aspirations.
4. Three letters of recommendation addressing the applicant's academic qualifications for graduate study in the intended program.
5. Graduate Record Examination (GRE) general test scores.
6. (For international applicants only) Test of English as foreign language (TOEFL) scores or other acceptable proof of English proficiency.
7. English-language publications authored by the applicant, including a master's thesis or essay, if applicable (optional, but strongly recommended).

¹ Upon admission, final official transcripts from all previously attended colleges/universities, with certified English translations if original language is not English, must be submitted to the Graduate School within the first five weeks of the term of admission or a hold preventing registration for future terms are placed on the student's record.

Computer Science Doctoral Requirements

A doctoral student in computer science must first complete a plan of study on an approved Doctoral Program Planning Form, designed to see the student through completion of the qualifying examination. This plan of study should be prepared in cooperation with an adviser and approved by the Graduate Committee of the Department of Computer Science.

The total 57-credit program includes a minimum of 45 credit hours of approved course work beyond the bachelor's degree in computer science or related field plus 12 dissertation credits. Students must complete:

- 2 credit hours of COSC 6090 Research Methods/Professional Development, completed by the second year.
- 6-8 credit hours of COSC 6974 Practicum for Research and Development in Computer Science or COSC 6960 Seminar in Computer Science.
- 35-37 credit hours of electives. Elective course work must be chosen based on mutual agreement of the student and his or her adviser's mutual research interests. Each student is advised to take such courses as are properly related to academic background and research interests. No more than 18 credit hours may be taken at the 5000 level.
- 12 credit hours of COSC 8999 Doctoral Dissertation, which may only be taken after passing the qualifying examination.

Advancement to candidacy for the doctoral degree is considered following successful completion of the lecture course work specified in the Doctoral Program Planning Form and after passing the qualifying examination (written and oral). Following advancement to candidacy, students must submit a Dissertation Research Plan that is approved by their advisory committee. Their proposal (written and oral) and dissertation (written and oral) must be approved.

COSC 6090	Research Methods/Professional Development (1 credit, taken at least twice)	2
COSC 6974 or COSC 6960	Practicum for Research and Development in Computer Science Seminar in Computer Science	6-8
Approved Elective courses (no more than 18 credits at the 5000 level) ¹		37-35
COSC 5300	Networks and Internets	
COSC 5360	Computer Security	
COSC 5500	Advanced Data Science	
COSC 5610	Data Mining	
COSC 5800	Principles of Database Systems	
COSC 6050	Elements of Software Development	
COSC 6060	Parallel and Distributed Systems	
COSC 6260	Advanced Algorithms	
COSC 6270	Advanced Operating Systems	
COSC 6280	Advanced Computer Security	
COSC 6330	Advanced Machine Learning	
COSC 6360	Enterprise Architecture	
COSC 6380	Advanced Database Systems	
COSC 6390	Professional Seminar in Computing	
COSC 6510	Business Intelligence	
COSC 6530	Concepts of Data Warehousing	
COSC 6540	Data Analytics	
COSC 6550	Introduction to Cybersecurity	
COSC 6560	Principles of Service Management and System Administration	
COSC 6995	Independent Study in Computer Science	
Additional courses as approved by adviser.		
COSC 8999	Doctoral Dissertation	12
Total Credit Hours		57

¹ Students must work closely with advisers to create individualized plans of study, depending on the mutually agreed upon focus area. Not all electives in this list will be available to all students.

Courses

COSC 5290. Real-Time and Embedded Systems. 3 cr. hrs.

Focuses on event-driven programming, real-time scheduling, and synchronization; worst-case execution time analysis and deadline analysis; real-time operating systems and real-time programming languages.

COSC 5300. Networks and Internets. 3 cr. hrs.

Focuses on data communication and network protocols, including the TCP/IP protocol suite; Internet transport, packet switching and routing; network programming and network applications. May consist of a 3 hr. lec. or a 2 hr. lec. and 2 hr. lab.

COSC 5360. Computer Security. 3 cr. hrs.

Fundamentals of computer security, including cryptography, access control, security policy models, attacks, surveillance, privacy, and forensics. Draws examples of security vulnerabilities and defenses from many areas of computer science such as operating systems, databases, networks and software engineering.

COSC 5370. Internet of Things (IoT). 3 cr. hrs.

Topics include the definition of IoT, trends in the adoption of IoT, the importance of the IoT in society, the current components of typical IoT devices and trends for the future. Focuses on IoT design considerations, constraints, and interfacing between the physical world and the device. Students are presented with design trade-offs between hardware and software, technologies behind the Internet of Things – RFID, NFC, Wireless networks, WSN, RTLS, GPS, agents, multiagent systems, IoT in retail, NFC applications for the IoT, and IoT in healthcare.

COSC 5400. Compiler Construction. 3 cr. hrs.

Lexical analysis, parsing, code generation and optimization. Includes theoretical foundations and the practical concerns of implementation.

COSC 5500. Advanced Data Science. 3 cr. hrs.

Focuses on developing data products using the Javascript/D3 framework by combining concepts from human-computer interaction, visualization and design. Also focuses on model visualization, interpretation, A/B testing and design thinking.

COSC 5600. Fundamentals of Artificial Intelligence. 3 cr. hrs.

An introduction to the broad field of artificial intelligence. Topics include problem solving by searching, knowledge representation, reasoning, planning, decision making, learning, perception and language processing.

COSC 5610. Data Mining. 3 cr. hrs.

Techniques for extracting and evaluating patterns from large databases. Introduction to knowledge discovery process. Fundamental tasks including classification, prediction, clustering, association analysis, summarization and discrimination. Basic techniques including decision trees, neural networks, statistics, partitional clustering and hierarchical clustering.

COSC 5800. Principles of Database Systems. 3 cr. hrs.

Topics include database concepts and architecture, data modeling, formal query languages such as relational algebra, commercial query language SQL, database access from application programs and a brief examination of advanced concepts including transactions, distributed databases, security and XML.

COSC 5820. Ethical and Social Implications of Data. 3 cr. hrs.

An introduction to the ethical and social consequences of collecting, curating and analyzing data in academia, public and private contexts. A socio-technical stance is taken in unpacking issues of algorithmic biases, fairness, transparency and accountability.

COSC 5860. Component-Based Software Construction. 3 cr. hrs.

Introduction to software components in the context of the object-oriented paradigm. Component development, component selection and adaptation/customization, component deployment and assembly/integration, and system architecture. Industry standards such as JavaBeans, CORBA Component Model, and Microsoft COM/DOM/COM+.

COSC 5931. Topics in Computer Science. 1-3 cr. hrs.

Topics selected from one of the various branches of computer science. Specific topics to be announced in the Schedule of Classes.

COSC 6050. Elements of Software Development. 3 cr. hrs.

Students explore the software design and development processes through a term project. Concepts covered include: requirements gathering and analysis, mapping requirements to a design, sound coding and documentation practices, configuration management, testing and quality assurance, system deployment and maintenance. Prereq: Programming in a high-level language, knowledge in data structures such as stacks, recursion, queues, trees and graphs.

COSC 6051. Professional Software Engineering 1. 3 cr. hrs.

Covers software engineering topics typically including: the software development life cycle (SDLC), development methodologies, software quality overview, configuration management, designing for risks and fault tolerance, languages and design, object-oriented programming, observational research and prototyping, requirements, software architectures, operating systems design and real time systems. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

COSC 6052. Professional Software Engineering 2. 3 cr. hrs.

Covers software engineering topics typically including: systems and communication networks, security and distributed systems, interoperability and standards, design for "ility" (e.g., usability and reliability) and performance, design for parallel processing, embedded systems hardware for software developers, embedded systems software, software design patterns and algorithms. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

COSC 6053. Professional Software Engineering 3. 3 cr. hrs.

Covers software engineering topics typically including: database systems, decision science, data quality and analytics, user interface design, design for globalization, debugging and troubleshooting, approach, method, implementation and emerging software technologies. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

COSC 6054. Professional Software Engineering 4. 3 cr. hrs.

Covers design topics related to system design with embedded computing. Topics typically include: design of controls, design for low cost, design for serviceability, design for usability, design for reliability, program management, innovation, requirements management and design thinking. Offered at General Electric facilities. As this course extends beyond the Marquette term, students receive the grade of IC initially. The IC grade converts to an A-F grade at the completion of the course. Prereq: GE employee in the Software Edison program.

COSC 6055. Software Quality Assurance. 3 cr. hrs.

Provides a perspective on people, organizations, controls, processes and tools that collectively influence the success of a Software Quality Assurance (SQA) strategy. Discussion topics include quality approaches as they apply to: requirements, design, release, configuration management, testing, defect management, operations and support. Topics are discussed in the context of a traditional development approach (waterfall, CMMI) and more contemporary models driven by lean and agile practices. Covers considerations specific to implementing an SQA approach within a regulated setting. Approach emphasizes a hands-on view of SQA, thereby providing realistic takeaways to practice in a professional career.

COSC 6060. Parallel and Distributed Systems. 3 cr. hrs.

Students use and develop software for parallel and distributed computing systems. Topics include: job submission and management, tools for parallel and distributed software development, approaches for implementing parallel and distributed computation, parallel and distributed system architectures, and essential evaluation techniques. Prereq: COSC 3100 or equiv.

COSC 6090. Research Methods/Professional Development. 1 cr. hr.

Designed to introduce the process of research and communication of research in computer science, including presentation and publication of research, preparation of grant proposals, and ethical considerations. May be repeated.

COSC 6260. Advanced Algorithms. 3 cr. hrs.

Covers advanced paradigms for the design and analysis of efficient algorithms. Emphasizes fundamental algorithms and advanced methods of algorithmic design, analysis, and implementation. Domains include: string algorithms, network optimization, parallel algorithms, computational geometry, external memory and streaming algorithms, and advanced data structures.

COSC 6270. Advanced Operating Systems. 3 cr. hrs.

Fundamental concepts of operating systems including kernel data structures; process control and scheduling; interprocess communication and synchronization; virtual memory and memory management; mass storage systems and device control; protection and security; and protection and virtualization; evaluation and prediction of performance. Students are expected to spend at least three hours per week gaining hands-on experience in using and modifying a small operating system.

COSC 6280. Advanced Computer Security. 3 cr. hrs.

Symmetric key and public key cryptography, hash functions, random numbers and cryptanalysis; authentication and authorization, password-based security, ACLs and capabilities, covert channels, security models, firewalls and intrusion detection systems; authentication protocols, session keys, SSH, SSL, IPSec, Kerberos, WEP, and GSM; flaws and malware, buffer overflows, viruses and worms, malware detection, software reverse engineering, digital rights management, secure software development and operating systems security; fundamentals about bitcoin and cryptocurrency technologies. Students write programs for assignments using the C programming language.

COSC 6330. Advanced Machine Learning. 3 cr. hrs.

Provides a graduate-level introduction to machine learning and statistical pattern recognition and in-depth coverage of new and advanced methods in machine learning, as well as their underlying theory. Emphasizes approaches with practical relevance and discusses a number of recent applications of machine learning, such as data mining, computer vision, robotics, text and web data processing. An open research project is a major part of the course.

COSC 6340. Component Architecture. 3 cr. hrs.

Focuses on designing and implementing software components, and streamlining the translation from business intent into realized application behavior in a practical hands-on, business-based environment. Introduces service-oriented architecture (SOA) and principles such as loose coupling, abstraction, reusability, autonomy, statelessness, discoverability, interoperability and composability.

COSC 6345. Mobile Health (mHealth). 3 cr. hrs.

Offers a multidisciplinary overview of the emerging technologies used in mobile health (mHealth). Research and innovations in this area promise solutions to the need for broader access to affordable and effective healthcare by enabling consumers and their caregivers to take charge of their health and well-being. mHealth is the provision of health information and services using sensor data via mobile phones and tablets. Students develop foundational knowledge of understanding the behaviors, different data models, security and privacy issues.

COSC 6350. Distributed Computing. 3 cr. hrs.

Introduces a broad spectrum of topics encompassing system architecture, software abstractions, distributed algorithms and issues pertaining to distributed environments such as replication, consistency, fault tolerance, transactions and security.

COSC 6355. Mobile Computing. 3 cr. hrs.

Focuses on the fundamentals of mobile computing, challenges in mobile computing, mobility management and mobile data management. Also focuses on context awareness and wireless communications, ubiquity of wireless communication technologies and standards, seamless access network services and resources from anywhere, at anytime, middleware for mobile computing, operation systems, programming languages, network protocols and security aspects of mobile computing. Explores concepts in sensor networks, including operating systems, programming languages, network protocols and programming models. Prereq: COSC 2100 or equiv.

COSC 6360. Enterprise Architecture. 3 cr. hrs.

Focuses on key topics and concepts that represent enterprise architecture (EA). Addresses the people, process and technology elements of EA from both a business and technical perspective. Explores the background, history, planning, governing, maintaining and common methodologies associated with EA. Prototypes some of the technology used in enterprises today to gain a better understanding of how information is represented, systems are integrated and standards are put into practice.

COSC 6375. Web Technologies. 3 cr. hrs.

Exposes students to design and architectural principles in developing web applications. Focuses on the client side, middleware and service layer of web applications. Topics range from HTML, JavaScript, JQuery, Java Servlets, MVC Design Pattern, Java Spring MVC, SQL, JDBC, Hibernate, AngularJS and Cloud Computing.

COSC 6380. Advanced Database Systems. 3 cr. hrs.

Focuses on newer, advanced database techniques in the areas of Big Data, NoSQL, Hadoop and Apache Spark. Covers main NoSQL data management topics such as document databases, key-value stores and graph databases. Prereq: Database Systems or equiv.

COSC 6390. Professional Seminar in Computing. 1 cr. hr.

Topic to be chosen each term from among issues important to all professionals in computing. All students specifically in the computing program are expected to participate for the fall and spring terms, and one of the two summer terms. S/U grade assessment.

COSC 6500. Foundations of Computing. 7 cr. hrs.

Presents the breadth and current status of computer science in our computerized society and the fundamentals of professional knowledge, skills and abilities. Foundational topics are intermixed with study of software development which include an introduction to abstraction, algorithmic thinking, simulation and testing for computer-based problem solving using higher-level programming languages. Algorithm analysis and computational complexity are presented in the context of considering data structures, algorithms and alternatives. Students program exercises using graphical user interfaces, data base connections, parallel computing and interfaces to the World Wide Web (WWW). Experience includes using an interactive development environment, studying software development methodology, and testing code, basic system administration, computer networking and operating system configuration.

COSC 6510. Business Intelligence. 3 cr. hrs.

Foundational topics in business intelligence. Includes properties and benefits for business intelligence and methodology for the development of business intelligence solutions. Examines technology employed for managing data and creating visualizations and dashboards. Topics include developing a business case, evaluating performance and managing data. Presents overview of data architectures commonly used in business intelligence solutions and includes exercises using common techniques for prediction and time series analysis.

COSC 6520. Business Analytics. 3 cr. hrs.

Foundational topics in the analysis of data from a business perspective. Includes methodology for the development of business analytics systems. Examines technology employed for business analytics in a variety of industry segments and the benefits derived from business analytics. Foundations of text and data mining techniques commonly used for classification, clustering and prediction. Students are presented techniques for developing a business case, evaluating predictive performance and managing data. Includes exercises using analytic technology and a project to apply analytics to a customer application.

COSC 6530. Concepts of Data Warehousing. 3 cr. hrs.

Provides an introduction to data warehouse design. Reviews topics in data modeling, database design and database access. Data warehouse planning, design, implementation and administration. The role of data warehouse in supporting decision support systems (DSS), business intelligence and business analytics.

COSC 6540. Data Analytics. 3 cr. hrs.

Introduces the most important information technologies used in manipulating, storing, and analyzing big data. Examines the basic tools for statistical analysis, R, Python, and several machine learning algorithms. Emphasis is on designing, implementing and developing machine learning algorithms. Particular focus is placed on interpretation and visualization of results. Prereq: Familiarity with Intermediate Python or R is recommended.

COSC 6550. Introduction to Cybersecurity. 3 cr. hrs.

Provides an introduction to cybersecurity threats, methods and security techniques. Foundations of various cybersecurity frameworks and methods for applying them to different types of organizations. Includes cyber threat environment, along with methods, tools and techniques that can help mitigate vulnerabilities and reduce risks to an organization.

COSC 6560. Principles of Service Management and System Administration. 3 cr. hrs.

Introduction to the concepts, principles and practices involved in the operations of secure computing systems. Presents principles of service management and explores how the principles of system administration are derived from concepts of delivering quality services. Lab exercises performing rudimentary tasks of a system administrator using virtual machine environments. Foundation topics include: cryptography, popular operating systems for servers, network configuration, system components, networked systems, host management, user management, configuration of servers and services, incident management, change management, security, monitoring and analysis of operations. Prereq: Basic knowledge of scripting, operating systems and services.

COSC 6570. Data at Scale. 3 cr. hrs.

Combines ideas from parallel databases, distributed systems and programming languages to analyze data at scale. Relevant technologies are introduced and taught in an accessible and inclusive way. Some examples include cloud computing, SQL and NoSQL databases, MapReduce ecosystem, Spark and its contemporaries and graph databases.

COSC 6931. Topics in Computer Science. 3 cr. hrs.

Topics vary. Students may enroll more than once as the subject matter changes.

COSC 6960. Seminar in Computer Science. 1-3 cr. hrs.

Seminar topics selected from one of the various branches of computer science. Specific topics to be announced in the Schedule of Classes.

COSC 6964. Practicum for Research and Development in Computing. 3-6 cr. hrs.

S/U grade assessment. Prereq: 3.00 MU GPA; must be enrolled in Plan B option of the M.S. in computing program and have completed at least 15 credit hours earned in graduate (6000-level) courses. Available only to full-time students. Cons. of the computing dir. of graduate studies or cons. of dept. ch.

COSC 6965. Curriculum Integrated Practicum in Computing. 1-2 cr. hrs.

Involves practical application of the knowledge and skills being studied concurrently, and previously studied, in other course work for computing professionals. Prereq: Admission to the COMP program's integrated practicum option; cons. of the computing dir. of graduate studies or cons. of dept. ch.

COSC 6974. Practicum for Research and Development in Computer Science. 1-6 cr. hrs.

S/U grade assessment. Prereq: Cons. of dept. ch.

COSC 6995. Independent Study in Computer Science. 1-6 cr. hrs.

An in-depth study on a topic or subject matter usually not offered in the established curriculum with faculty and independent of the classroom setting. Prereq: Cons. of instr. and cons. of dept. ch.

COSC 6998. Professional Project in Computer Science. 0 cr. hrs.

SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 6999. Master's Thesis. 1-6 cr. hrs.

S/U grade assessment. Prereq: Cons. of dept. ch.

COSC 8995. Independent Study in Computer Science. 1-3 cr. hrs.

A doctorate level in-depth research on a topic or subject matter usually not offered in the established curriculum with faculty and independent of the classroom setting. Prereq: Cons. of instr. and cons. of dept. ch.

COSC 8999. Doctoral Dissertation. 1-12 cr. hrs.

S/U grade assessment. Prereq: Cons. of dept. ch.

COSC 9970. Graduate Standing Continuation: Less than Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9974. Graduate Fellowship: Full-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9975. Graduate Assistant Teaching: Full-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9976. Graduate Assistant Research: Full-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9987. Doctoral Comprehensive Examination Preparation: Less than Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9988. Doctoral Comprehensive Examination Preparation: Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9989. Doctoral Comprehensive Examination Preparation: Full-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9991. Professional Project Continuation: Less than Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9992. Professional Project Continuation: Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9993. Professional Project Continuation: Full-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9994. Master's Thesis Continuation: Less than Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9995. Master's Thesis Continuation: Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9996. Master's Thesis Continuation: Full-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9997. Doctoral Dissertation Continuation: Less than Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9998. Doctoral Dissertation Continuation: Half-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.

COSC 9999. Doctoral Dissertation Continuation: Full-Time. 0 cr. hrs.

Fee. SNC/UNC grade assessment. Prereq: Cons. of dept. ch.