Computing (COMP)

Chairperson: Sheikh Ahamed Iqbal Ph.D.
Program Director: Thomas Kaczmarek, Ph.D.
Computing website (https://www.marquette.edu/grad/programs-computing.php)

Degree Offered

Master of Science, students are admitted under Plan B (non-thesis option) but may request Plan A (thesis option) and may designate a specialization. Students are not required to select a specialization. There are two specializations that focus study on cyber security and data analytics (predictive analytics). A third specialization is offered for students with no formal background in computer science wishing to do a career change into computing.

Program Description

Computing is a broad-based family of disciplines that includes computer science, computer engineering, software engineering, information systems and information technology. By design, the computing program allows the student to pursue studies in any combination of these disciplines.

This program strives to meet the educational needs of present and future computing professionals interested in starting a career or updating their skills. Careers are in areas such as cyber security, data analytics, business and systems analysis, software engineering, project management, enterprise architecture, business process modeling and management, database design and administration, technology management and service management.

Students may select courses from a large number of approved courses offered by the Department of Computer Science, the Department of Electrical and Computer Engineering, the Graduate School of Management, the Department of Mathematical and Statistical Sciences and other units on campus. Students selecting a specialization have required coursework that constitutes about one-half of the credit requirements for the degree.

Students may pursue the degree on a full-time or part-time basis. Courses are offered in the evenings and distance learning classes are available. Distance learning options for most courses offered in the department add flexibility to the program.

Prerequisites for Admission

Applicants must have completed or be in the process of completing a bachelor's degree from an accredited college or university. Applicants who are not in the career change specialization must have studied computer programming in a modern computer programming language with have knowledge of algorithms and data structures (or have equivalent work experience). Applicants entering the career change specialization do not need the prerequisites in programming and data structures and algorithms. However, they must enroll in a Foundations of Computing course, that is a summer-long boot camp-like experience, designed to satisfy the prerequisites and provide the proper introduction to a career in computing.

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. An essay outlining relevant work experience or education, career goals, possible areas of interest and reasons for seeking admission to this program.
4. Three letters of reference from professors or professionals familiar with the applicant's abilities, academic work and/or professional background.
5. (For students applying for merit-based financial aid) GRE scores (General Test only).
6. (For international applicants who have not attended an English-speaking university only) a minimum TOEFL score of 80 on the Internet-based version or other acceptable proof of English proficiency.

[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 is placed on the student record.

Application Deadline

The master of science program in computing follows the Graduate School deadlines for the submission of applications: Decisions about acceptance into the program are made when all required documents for the application are received. Admission decisions are made independently of decisions to offer financial aid.

General Information

Students interested in applying to the program should consult the program website for additional information, including a description of specializations and a list of currently suggested courses for the degree.

A complete list and short description of the courses offered by the Department of Computer Science is available on the Department of Computer Science section of the bulletin.

Computing Master's Requirements

Students are admitted to the program under the non-thesis option (Plan B). Students may apply for the thesis option (Plan A) on approval of a thesis outline by their adviser and the computing program's graduate committee.

The course of study is very flexible. Students complete a breadth requirement and additional courses suited to their backgrounds and career goals. The program director and faculty advisers work very closely with students to ensure that they achieve their educational goals through appropriate course selection.

Computing students gain both breadth and an in-depth knowledge of their field.

Breadth Requirement

Computing students experience the breadth of the field by completing (or having completed before entering the program) at least three credits in four of the following five areas, for a total of 12 credits:

1. Information Management
2. Hardware and Software Architecture and Organization
3. Operating Systems
4. Programming Concepts and Skills
5. Software Engineering.

Classes at the 5000 level and the 6000 level have been designated by the program in each area, but satisfaction of the breadth requirement does not rely on any specific course selection. An individual plan is developed by the student and approved by the computing program's director of graduate studies.

Career Focus

Students choose a primary career focus and a secondary career focus. The career focus aids in selecting courses that provide in-depth knowledge aligned with career objectives. The courses chosen in the primary career focus area and the secondary career focus area are driven by students' interests working with an adviser. Each student must have at least 12 credit hours related to their primary career focus, and at least six credit hours in a different secondary career focus for a total of 18 credit hours.

Courses taken to satisfy the breadth requirement also count toward career focus requirements. No course may be counted toward satisfying both a primary and a secondary focus. The breadth requirements and the career focus requirements may be satisfied with any combination of approved 5000- and 6000-level classes.

Examples of a career focus include, but are not limited to, the following:

- Business Intelligence and Analytics
- Database Analysis/Administration/Architecture
- Information Security
- Mobile Computing
- System/Enterprise Architecture
- Software Development/Software Engineering.

Specific courses related to a career focus are designated by the computing program. The final course selections are determined on an individual basis with approval by an adviser. Consult the program website (http://www.marquette.edu/mscs/grad-computing.shtml) for a list of the currently approved courses.

Additional Course Work

Courses beyond the breadth and career focus requirements are taken from a list of computer science, information technology and computer engineering courses approved by the computing program. Six out-of-program elective credits may be selected from other Marquette graduate courses germane to computing or its applications.

Plan B Option (36 or 42 Credits)

Students admitted to the computing career change specialization must complete a total of 42 credit hours, which must include COSC 6500 Foundations of Computing and 35 additional credit hours. The program of study includes individualized combinations of 12 credit hours for a primary career focus and 6 credit hours for a secondary career focus. At least 25 credit hours must be taken at the 6000 level.

All other students in Plan B must complete a total of 36 credit hours of course work. The program of study includes individualized combinations of 12 credit hours for a primary career focus and 6 credit hours for a secondary career focus. At least 18 credit hours must be taken at the 6000 level.

For all students, courses beyond the career focus and breadth requirements are taken from a list of computer science, information technology and computer engineering courses approved by the computing program.

Integrated Practicum

Within Plan B, the integrated practicum provides a unique opportunity for professional development. Students must indicate a desire to participate in the integrated practicum on their application to the program. Students must satisfy the requirements for a primary career focus as well as the breadth requirement. The primary career focus must be related to their work assignments. The practicum can serve as the 6 credit secondary career focus.

In the integrated practicum, practical assignments in a working enterprise enhance the “learn from doing” opportunity beyond the typical assigned exercises, case studies, and student projects. The student adviser works with a participating employer and the student to ensure a tight integration between course work and work assignments. Together they pair work assignments and courses to provide the simultaneous acquisition of foundational knowledge, professional skills, and professional experience. The integration of course work and experience begins in the first semester of the program and must continue through graduation.

The integrated practicum curriculum path meets the 36 credit requirement of Plan B through a minimum of 24 credits of course work (of which at least 12 credits must be at the 6000-level), students may choose 6 credits in the COSC 6390 Professional Seminar in Computing, and 6 credits in COSC 6965 Curriculum Integrated Practicum in Computing. Each 300-350 hours of integrated work experience earn one practicum credit. During the final practicum session, students will earn an additional practicum credit for a comprehensive paper demonstrating their competency in their primary career focus through accomplishments in their work assignments.

Additional considerations include:

- The student must maintain full-time graduate student status every term with the exception of the final term.
- Participation in this option is subject to the availability of open positions and the qualifications of the student.
- The student must apply to the master of science program in computing and inform the director of the program or their adviser of the intention to participate in the integrated practicum.
- The student must apply to the participating employer and meet all of the requirements for an academically qualified position.
- If for any reason continuing work assignments are not available, the student can complete the degree program under Plan B's non-thesis course work option.

Plan A Option (30 credits)

Students must supply an approved thesis outline to enter Plan A, the thesis option, which requires a total of 30 credits.

In Plan A, students must complete 24 credit hours of course work, of which at least 12 hours must be earned in graduate-level courses (6000-level and above). Students must also complete a master's thesis (COSC 6999 Master's Thesis) for 6 credit hours and pass the oral examination concentrated on the thesis. The student must select a primary career focus, which is typically related to their thesis topic and meets the breadth requirement of the program. The six thesis credits are considered the secondary career focus.

Courses beyond the career focus, thesis and breadth requirements are taken from a list of computer science, information technology and computer engineering courses approved by the computing program. Six out-of-program elective credits may be selected from other Marquette graduate courses germane to computing or its applications.

Specializations

The master of science program in computing offers three specializations: information assurance and cyber defense, big data and data analytics and the computing career change opportunity. The 18 credit hours in the first two of these specializations fulfill the requirements for both the primary and the secondary career focus. In the computing career change opportunity specialization, students must work with their adviser to select a primary and secondary career focus.

Information Assurance and Cyber Defense

In addition to required course work, this specialization requires practical experience. The practicum options in the master of science program in computing provide 6 credit hours for the practical application of course work. With permission from the director of the graduate studies for the program, the student may substitute a professional project.

COSC 6550	Introduction to Cybersecurity	3
COSC 6560	Principles of Service Management and System Administration	3
COSC 5300	Networks and Internets	3
COSC 6964	Practicum for Research and Development in Computing [1]	6
or COSC 6965	Curriculum Integrated Practicum in Computing	
Elective (Choose one)		3
COSC 5360	Computer Security	
COSC 5800	Principles of Database Systems	
COSC 6355	Mobile Computing	
COSC 6380	Advanced Database Systems	
Total Credit Hours		18

[1] With consent, COSC 6998 Professional Project may be substituted.

Big Data and Data Analytics

This specialization features course work related to trends in data management, parallelism, and data analysis techniques used for business applications.

COSC 6510	Business Intelligence	3
COSC 6540	Data Analytics	3
or COSC 6520	Business Analytics	
COSC 6060	Parallel and Distributed Systems	3
COSC 6380	Advanced Database Systems (or 6000-level class with a focus on databases or data warehouses such as COSC 6530)	3
Elective-Graduate course emphasizing the application of data collection and analysis in a discipline outside of computing (requires consent of adviser)		3
COSC 5610	Data Mining (or 6000-level graduate statistics course)	3
Total Credit Hours		18

Computing Career Change Opportunity

The computing career change opportunity specialization is a workforce development initiative designed to move students from an underemployed status into a STEM career in computing. It supports a career change for students who do not have the prerequisite knowledge and skills in programming, data structures and algorithms. The specialization requires successful completion of foundations course COSC 6500 Foundations of Computing, supplying the computing program prerequisites in a 40 hour/week boot-camp-like environment. Students must then work with their adviser to select a primary and secondary career focus. Courses beyond the career focus, thesis and breadth requirements are taken from a list of computer science, information technology and computer engineering courses approved by the computing program.

Accelerated Bachelor's–Master's Degree Program

The Department of Computer Science offers an accelerated degree program where eligible students may obtain both a bachelor's degree and the professional master of science degree in computing in five years. Students are eligible to apply to this program as early as the final term of their sophomore year. Students wishing to participate in the five-year program must apply and be admitted to the program before their senior year.

Minimal criteria for application to the ADP include a GPA of at least 3.000 and the following course work: two terms of courses in programming; one course on data structures and algorithms.

Upon completion of the undergraduate degree, the ADP student must satisfy all of the requirements for the master of science degree in computing and complete additional required graduate courses. The summer term may be taken immediately after the senior year or the following summer.

Within the undergraduate degree program, the student enrolls in the required programming and data structures courses and 12 graduate credits related to a computing career. After completing the undergraduate program, there are three terms of graduate study. In these three terms, the student receives an additional 24 graduate credits, resulting in a total of 36 graduate credits.

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.