# General Course Requirement in the MS Program

| Curriculum Component | Hours Required |
|---|---|
| Major Field Core | 9 |
| Concentration | 9 |
| Electives | 9 |
| Design Project Course | 6 (For non-thesis option) |
| Thesis | 6 (For thesis option) |
| TOTAL: | 33 |

## High-Performance Computing and Bioinformatics Concentration

This concentration requires completion of the following courses

| MAJOR FIELD CORE (9 Credits) | | |
|---|---|---|
| **Course Number** | **Course Title** | **Credit Hours** |
| COMP 5100 | Software Engineering | 3 |
| COMP 5200 | Advanced Algorithms  Design and Analysis | 3 |
| COMP 5300 | Advanced Computer Architectures | 3 |
| **CONCENTRATION (12 Credits)** | | |
| COMP 5520 | Introduction to High Performance Computing | 3 |
| COMP 5800 | Introduction to Bioinformatics | 3 |
| COMP 6100 | Bioinformatics and Computational Biology | 3 |
| CISE 6360 | Distributed Computing and Design | 3 |
| **ELECTIVES  (6 Credits From List Below)** | | |
| COMP 5400 | Hybrid and Relational Databases | 3 |
| COMP 5700 | Fundamentals of Computer Networks | 3 |
| COMP 5720 | Cryptography and Computer Security | 3 |
| COMP 5750 | Computer Network Management and Security | 3 |
| COMP 5440 | Mobile Robotics | 3 |
| COMP 5600 | Mobile Applications Development | 3 |
| COMP 5900 | Special Topics | 3 |
| COMP 6200 | Machine Learning | 3 |
| COMP 6280 | Advanced Web Applications Development | 3 |
| COMP 6300 | Advanced Software Engineering | 3 |
| COMP 6800 | Introduction to Computer Vision | 3 |
| COMP 6900 | Embedded Systems Programming | 3 |
| ENGR 6150 | Advanced Software Architectures | 3 |
| ENGR 5070 | Object-Oriented Programming for Engineering | 3 |
| CISE 5110 | Introduction to Artificial Intelligence | 3 |
| CISE 5220 | Computer Aided Systems Design | 3 |
| CISE 6000 | Database Management Systems | 3 |
| CISE 7300 | Network Programming | 3 |
| **NON-THESIS OPTION DESIGN COURSES  (6 Credits From List Below)** | | |
| COMP 5400 | Hybrid and Relational Databases | 3 |
| COMP 5440 | Mobile Robotics | 3 |

| | | |
|---|---|---|
| COMP 5600 | Mobile Applications Development | 3 |
| COMP 6200 | Machine Learning | 3 |
| COMP 6280 | Advanced Web Applications Development | 3 |
| COMP 6300 | Advanced Software Engineering | 3 |
| COMP 6900 | Embedded Systems Programming | 3 |
| ENGR 6150 | Advanced Software Architectures | 3 |
| CISE 5110 | Introduction to Artificial Intelligence | 3 |
| CISE 5220 | Computer Aided Systems Design | 3 |
| CISE 6000 | Database Management Systems | 3 |
| **THESIS OPTION (6 Credits)** | | |
| COMP 5910 | Master of Science Thesis I | 3 |
| COMP 5920 | Master of Science Thesis II | 3 |
| Requires completion of a 2-semester long thesis work in high-performance computing and bioinformatics. | | |
| **TOTAL (33 Credits)** | | |

## Thesis and Design-Based Courses

The program requires completion of a 6 credit hour thesis (for the thesis option) or 6 credit hours of design-based courses (for the non-thesis option).

**For the thesis option**, a thesis manuscript and an oral presentation are required to document the student's research activity. A thesis committee supervises the student's thesis work. The committee consists of 3 faculty members, including the thesis chair.

**For the non-thesis option**, 6 credit hours of design-based courses are required. These courses will be selected from an approved list with advisement of the student's advisor. These courses have a strong project/design component.

Also, there are there study plans:
Full-time (2 Years), Part-time (3 Years), and Part-time (4 Year) plans.

**Full-Time (2 Years) Plan for High-Performance Computing and Bioinformatics Concentration**

| **SEMESTER-1 (9 Credit Hours)** | | |
|---|---|---|
| **Course Number** | **Course Title** | **Credit Hours** |
| COMP 5100 | Software Engineering | 3 |
| COMP 5200 | Advanced Algorithms Design and Analysis | 3 |
| COMP 5300 | Advanced Computer Architectures | 3 |
| **SEMESTER-2 (9 Credit Hours)** | | |
| COMP 5520 | Introduction to High Performance Computing | 3 |
| COMP 5800 | Introduction to Bioinformatics | 3 |
| Elective 1 | From List in Table E.5 | |
| **SEMESTER-3 (9 Credit Hours)** | | |
| COMP 6100 | Bioinformatics and Computational Biology | 3 |
| CISE 6360 | Distributed Computing and Design | 3 |
| Design-Based 1 | From List in Table E.5 *(Non-Thesis Option Students)* | 3 |
| COMP 5910 | Master of Science Thesis I *(Thesis Option Students)* | 3 |

| SEMESTER-4 (Non-Thesis Option – 6 Credit Hours) | | |
|---|---|---|
| Elective 2 | From List in Table E.5 | 3 |
| Design-Based 2 | From List in Table E.5 *(Non-Thesis Option Students)* | 3 |
| COMP 5920 | Master of Science Thesis II *(Thesis Option Students)* | 3 |

**Part-Time (3 Years) Plan for High-Performance Computing and Bioinformatics Concentration**

| Semester-1 | Semester-2 | Semester-3 | Semester-4 |
|---|---|---|---|
| COMP 5100<br>COMP 5200 | COMP 5520<br>COMP 5800 | COMP 5300<br>COMP 6360 | COMP 6100<br>Elective 1 |
| **Semester-5** | **Semester-6** | | |
| Elective 2<br>Design-Based 1<br>(or COMP 5910) | Design-Based 2<br>(or COMP 5920) | | |

**Part-Time (4 Years) for High-Performance Computing and Bioinformatics Concentration**

| Semester-1 | Semester-2 | Semester-3 | Semester-4 |
|---|---|---|---|
| COMP 5100<br>COMP 5200 | COMP 5520<br>COMP 5800 | COMP 5300<br>COMP 6360 | COMP 6100 |
| **Semester-5** | **Semester-6** | **Semester-7** | **Semester-8** |
| Elective 1 | Elective 2 | Design-Based 1<br>(or COMP 5910) | Design-Based 2<br>(or COMP 5920) |

## Admission Requirements

To be admitted to the program, students should demonstrate readiness to succeed in the graduate program. To do this, students should meet the following criteria:

1. Applicants must have an academic background that covers certain prerequisite knowledge in mathematics, software systems and computer programming, data structures, computer architectures, and computer networks. The student transcript should present evidence of the following courses with a grade of "C" or better:

    a. Mathematical background: 8 credit hours of calculus and 3 credit hours of linear algebra.

    b. Completion of undergraduate computer science prerequisites courses (or their equivalents): COMP 2240 (Computer Programming II), COMP 2400 (Computer Organization), COMP 3040 (Data Structures), COMP 3310 (Data Communications and Computer Networks), and COMP 4100 (Operating Systems).

2. The applicant must have a Bachelor's degree in Computer Science or a related area with a minimum cumulative grade point average (GPA) of 2.75 on a 4.0 scale.

3. The applicant must submit two letters of recommendation.

The application materials of each applicant will be evaluated by a committee, which may recommend some prerequisite undergraduate courses for the applicants under conditional admission. The applicant will have conditional classification until the completion of the recommend course or courses. If admitted the applicant must correct the deficiency within the first two semesters.

An applicant whose Bachelor's degree is not in Computer Science or a related area and who has exceptional experience in Computer Science also may be considered for conditional admission on an individual basis. Such applicants must have a minimum GPA of 2.75 and provide a written technical summary for evaluation of their technical experience. This summary should emphasize the student's experience with software systems and methodology, computer organization and architecture, and theory and mathematical background.

*Conditional admission:* Applicants admitted in this category will not be allowed to take graduate courses in the program until successful completion of the prerequisite courses with grade C or above.

## Graduation Requirements

The proposed program will have two tracks: (a) a non-thesis program that requires 33 hours of coursework or (b) the thesis program that requires completion 27 hours of coursework and a thesis. The thesis option is strongly recommended for the students who intend to pursue a doctoral degree.

The Master of Science degree in Computer Science will require the following:

1) Admission of all degree-seeking students to candidacy for the degree after the completion of nine (9) graduate credit hours in residence at the University. The student must file an *Admission to Candidacy* form with the Graduate School prior to the semester in which graduation is desired.

2) A minimum of 33 credit hours of graduate work, including 18 credit hours of required graduate core courses, with the following conditions for the Non-Thesis Option and Thesis Option:

   Non-thesis Option:
   The student must complete 33 credit hours of graduate computer science coursework.

   Thesis Option:

The student must complete 27 credit hours of graduate computer science coursework and 6 credit hours of thesis work. A thesis is documented by a report and an oral presentation is required. A thesis committee will supervise the student's thesis work.

## COURSE CATALOG DESCRIPTIONS

COMP 5100 Software Engineering (3). This course focuses on foundational concepts of software engineering including software processes and life-cycle models, software requirements and specifications, software design methodologies, software testing, maintenance, and cost analysis. Prerequisite: None.

COMP 5200 Advanced Algorithms Design and Analysis (3). Analysis and design of advanced algorithms and data structures in many areas of computing including divide and conquer, dynamic programming, the greedy approach, graph algorithms, pattern matching, geometric algorithm, P and NP, and efficient approximation algorithms. Prerequisite: COMP 3040 and COMP 3200 or Equivalent.

COMP 5300 Advanced Computer Architectures (3). This course introduces advanced computer architectures. It focuses on selecting and interconnecting hardware components to create a computer that meets functional, performance and cost goals, and teaches the qualitative and quantitative examination of computer design tradeoffs. It covers the system architecture, processor technology, advanced memory hierarchy and I/O organization, power and energy management, and reliability, and it further covers the new development in multicore, data center design, and parallel I/O. Prerequisite: COMP 2400 or Equivalent.

COMP 5400 Hybrid and Relational Databases (3). This course presents relational, object-oriented, and hybrid database concepts. Topics include: definitions of objects and attributes, methods and messages, classes, object-oriented data models, architectural issues, the object-oriented database system manifesto, object-oriented database design, object-oriented database management systems, and object/relational database management systems. Prerequisite: None.

COMP 5440 Mobile Robotics (3). This course provides students with hands-on experience in mobile robot design, implementation, and testing. It covers mobile robot topics such as robot hardware, robot sensing, actuation, embedded system programming, and algorithms for localization, path planning, and mapping. It briefly covers multi-robot systems. Students are expected to work in laboratory in teams to build and test increasingly complex mobile robots and compete in an end-of-semester robot contest. Prerequisite: COMP 5100.

COMP 5520 Introduction to High Performance Computing (3). This course focuses on concepts of distributed systems, concurrency control, files system and resource management in shared/distributed memory and high-performance computing in parallel computers and networked distributed systems. The course include fixed-connection network computing, parallel computing, cluster computing and grid computing, computing and design in synchronous /asynchronous networks, problems of consensus, communication, resource allocation, and

synchronization, problems of link/process failures in synchronous/asynchronous networks. Prerequisite: COMP 5200.

COMP 5600 Mobile Applications Development (3). This course provides comprehensive understanding of the principles of application design, implementation, and testing for mobile platforms (e.g. cell phones). Memory management, user interface design and implementation, data handling, networking, GPS and motion-based sensing are among the topics covered. Students are expected to work in teams to build and test increasingly complex mobile phone applications and compete in an end-of-semester contest. Prerequisite: COMP 5100.

COMP 5700 Fundamentals of Computer Networks (3). This course provides fundamental design principles of ATM, Internet and local area networks; protocol layers and the Internet Architecture; medium access protocols; application protocols and TCP/IP utilities; basic principles and virtual circuit switching; naming and addressing; flow and congestion control protocols; routing algorithms; Quality-of-Service in computer networks; security issues in networks. Prerequisite: COMP 5100.

COMP 5720 Cryptography and Computer Security (3). This course introduces modern cryptography, focusing on the fundamental concepts of secure computation and communication in the distrustful environments, for instance, wireless networks, internet banking, satellite radio and more. The course uses an incremental approach. It starts with the mathematics background of cryptography. Then, it will discuss attack and threaten models and security goals and review the traditional cryptography. The course will mainly investigate the techniques of modern cryptography in design of private and public key encryption schemes, digital signatures, authentication and key management. Applications in network security will be discussed. Prerequisite: ENGR 5100 and COMP 5700 or Equivalent.

COMP 5750 Computer Network Management and Security (3). This course presents various concepts of computer network management and tools. Topics include: Network interfacing, measuring failures and availability, reliability, security, maintenance, network statistics, reconfiguration and documentation. Prerequisites: COMP 5700 or Equivalent.

COMP 5800 Introduction to Bioinformatics (3). Bioinformatics is an interdisciplinary field in which biology and computer science merge. This course is designed to introduce students with basic concepts, methods and tools to analyze biological problems, prepare students with skills necessary to communicate across the fields of computer science and biology. Topics include (but not limited to) biological sequence and literature databases, strategies to search these databases to solve significant biological problems, principle and algorithms used in analysis of sequence problems.

COMP 5900 Special Topics (3). This course is for teaching important emerging computer science topics that are not covered in other computer science courses. Prerequisites: successful completion of at least 9 hours of COMP graduate courses.

COMP 5910 Master of Science Thesis I (3). Thesis topics to be selected in consultation with the chairman of thesis committee and approval of the department head. Students in specific concentration are required to work on thesis work in their corresponding concentration areas.

Other students may complete a thesis work in other state-of-the-art areas of computer science. Prerequisite: Completion of at least 18 credits of graduate coursework.

COMP 5920 Master of Science Thesis II (3). Continuation and completion of thesis and oral presentation defense. Prerequisite: COMP 5910.

COMP 6100 Bioinformatics and Computational Biology (3). This course is designed to introduce students with basic concepts, methods and tools to analyze biological information, algorithm design and programming skills for biology computing, and prepare students with knowledge and skills necessary to communicate and solve the problem across the fields of biology and computer science. Topics include fundamental knowledge of biology and bioinformatics, literature databases and tools for analysis, visualization, algorithm design, bioinformatics-oriented programming, and HPC of bioinformatics. Prerequisite: COMP 5800.

COMP 6200 Machine Learning (3). This course provides a broad introduction to machine learning, data-mining, and statistical pattern recognition. Topics include: (i) Supervised learning (parametric/non-parametric algorithms, support vector machines, kernels, neural networks). (ii) Unsupervised learning (clustering, dimensionality reduction, recommender systems, deep learning). (iii) Best practices in machine learning (bias/variance theory; innovation process in machine learning and AI). The course will also draw from numerous case studies and applications, so that you'll also learn how to apply learning algorithms to building smart robots (perception, control), text understanding (web search, anti-spam), computer vision, medical informatics, audio, database mining, and other areas. Prerequisite: ENGR 5100 or Equivalent.

COMP 6280 Advanced Web Applications Development (3). This course provides a comprehensive overview of web-based software architectures (e.g. JSP, ASP, Servlets, Web Services) and their applications. Students are expected to work in teams on a medium-scale web application development. Prerequisite: COMP 5400.

COMP 6300 Advanced Software Engineering (3). This course explores software engineering topics including software reuse, component-based software engineering, distributed software engineering, service-oriented architectures, embedded software development, aspect-oriented software engineering, advanced validation and verification methods, and configuration management. Prerequisite: COMP 5100.

COMP 6800 Introduction to Computer Vision (3). This course introduces the concepts and applications in computer vision. Topics include: cameras and projection models, low-level image processing methods such as filtering and edge detection; mid-level vision topics such as segmentation and clustering; shape reconstruction from stereo, as well as high-level vision tasks such as object recognition, scene recognition, face detection and human motion categorization. Prerequisite: ENGR 5100 or Equivalent.

COMP 6900 Embedded Systems Programming (3). In this project-based course, students will design and develop an application for an embedded systems platform, and then investigate low-level performance tuning and optimization. This course incorporates topics from the domains of software engineering, compilers, operating systems, and computer architecture, and provides

students with the foundation they will need for addressing the concerns of developing real-world embedded systems. Prerequisite: C or Java Programming.

CISE 5110 Introduction to Artificial Intelligence (3). Studies of different artificial intelligent concepts and techniques including; neural network topologies and training algorithms, fuzzy logic and decision making systems, genetic algorithms and search algorithms, probabilistic reasoning and belief functions. Applications in engineering will be discussed. Prerequisite: ENGR 5200 or equivalent.

CISE 5220 Computer-Aided Systems Design (3). Advanced computer-aided analysis and design tools for analysis of system properties and performance, study of structure and theory of computer aided design software and hardware and the small scale design of such tools. Prerequisites: EECE 3100, 3101, CISE 5010 or equivalent.

CISE 6000 Database Management Systems (3). Database concepts. Database design Data models: entity-relationship and relational. Data manipulation languages including SQL. Data dictionaries. Query processing. Concurrency, software development environments use a database system. Expert, object-oriented, multimedia and distributed database systems. Database systems architecture. Use of a commercial database management system.

CISE 6360 Distributed Computing Theory and Design (3). Fundamental and systems design aspects of distributed systems, paradigms for distributed computing, client-server computing, concurrency control, distributed file systems, resource management, high-performance computing aspects.

CISE 7300 Network Programming (3). Review of TCP/IP and UDP, transport layer, elementary and advanced sockets, TCP sockets and client server examples I/O multiplexing, socket options, elementary and advanced UDP sockets, name and address conversions, daemon processes and intend supersaver, advanced I/O functions, Unix Domain protocols, non-blocking I/O, routing sockets, broadcasting, multicasting, threads, and streamers. Prerequisite: Unix Operating System, networking protocols or equivalent.

ENGR 5070 Object-Oriented Programming for Engineering (3). A course focused on design and implementation of engineering software systems using object-oriented programming approach. Object-oriented programming concepts are emphasized with applications from engineering and science. Topics include classes, interfaces, inheritance, polymorphism, packages, design patterns, and hardware-software integration. Java programming language is used as the main implementation language. Prerequisite: Basic programming skills (ENGR 2221 or ENGR 2231 or equivalent).

ENGR 6150 Advanced Software Architectures (3). A project-based course focused on analysis, design, implementation, and integration of complex object-oriented software systems. State-of-the-art software reuse and component interoperability platforms such as COM, CORBA, Enterprise JavaBeans, and Web Services are discussed in detail. Distributed software system design methods as well as software design with UML are covered with practical applications. Prerequisite: ENGR 5070 or equivalent.