Computational Modeling and Simulation Engineering

Web Site: http://www.odu.edu/cmse (http://www.odu.edu/cmse/)

Yuzhong Shen, Chair

The Department of Computational Modeling and Simulation Engineering (CMSE) offers an undergraduate four-year degree program leading to the Bachelor of Science in Modeling and Simulation Engineering (M&SE). The program is accredited by the Engineering Accreditation Commission (EAC) of ABET, http://www.abet.org (http://www.abet.org/). Program graduates are prepared to enter the workforce as entry-level modeling and simulation engineers. In addition, graduates are prepared to enter graduate study in modeling and simulation and, with appropriate use of elective freedom, other disciplines where modeling and simulation has application. Program graduates also are prepared to seek certification as a Certified Modeling and Simulation Professional (CMSP) and, with proper selection of electives, licensure as an Engineer in Training (EIT).

The department also offers programs of graduate study leading to the degrees of Master of Engineering, Master of Science, Doctor of Engineering, and Doctor of Philosophy with a major in modeling and simulation. The department's academic programs are coupled with a strong departmental research program conducted jointly with researchers from the Virginia Modeling, Analysis and Simulation Center (VMASC). Research activities range from investigation of fundamental modeling and simulation methodologies and technologies to applications of modeling and simulation in medicine and health care, transportation, education, science and engineering, and business.

Vision Statement

CMSE will promote fundamental knowledge and skills in the discipline of modeling and simulation and will provide world leadership in modeling and simulation education and research.

Mission Statement

CMSE serves the public globally with education and research in modeling and simulation through the following:

- Provide high quality undergraduate and graduate modeling and simulation engineering curricula via on-campus and distance learning.
- Conduct cutting edge research in modeling, simulation, and visualization engineering.
- Promote the discipline of modeling and simulation and its use in real-world practical applications.

Bachelor of Science in Modeling and Simulation Engineering*

James Leathrum Jr., Chief Departmental Advisor

*The Bachelor of Science in Modeling and Simulation Engineering will be discontinued. Continuing students may select the program as their major until August 27, 2021, but they must earn their degree by the end of spring semester 2025. This program is not available for students entering Old Dominion University in spring 2021 and subsequent semesters.

The modeling and simulation engineering curriculum is based on a solid foundation in mathematics and basic science. Core program content includes a thorough introduction to key concepts from computer science, the major modeling and simulation paradigms, computer visualization, analysis methods, and simulation software design. Laboratory courses provide hands-on experience in the engineering of modeling and simulation systems. A capstone course sequence taken during the senior year provides an opportunity to exercise this cumulative preparation to solve a real engineering problem in a team setting. An important component of the program is the requirement that students complete courses in another academic program where modeling and simulation is used as a support tool. These courses can be combined with MSIM technical elective courses to complete a concentration providing depth in one of the following fields:

- Gaming
- Transportation
- Cybersecurity
- Digital Manufacturing
- Advanced Simulation Techniques

Students should consult the department for specific course options within each concentration. In addition, course work in General Education skills and Ways of Knowing is required to assure a well-rounded program of study.

Program Educational Objectives

The program educational objectives describe the expected accomplishments of graduates during the first few years after graduation. The educational objectives of the modeling and simulation engineering program, established with participation of all program constituencies, are consistent with the mission of Old Dominion University and the Department of Computational Modeling and Simulation Engineering.

The program educational objectives of the modeling and simulation engineering program are as follows.

Within a few years after graduation, modeling and simulation engineering alumni will have:

- Established themselves as practicing professionals in modeling and simulation engineering or related areas or have engaged in graduate study;
- Demonstrated their ability to work successfully as members of a professional team and to function effectively as responsible professionals; and,
- Demonstrated their ability to adapt to changing situations, evolving technologies, and new career challenges.

Student Outcomes

The modeling and simulation engineering program utilizes an educational process to produce a set of outcomes that foster attainment of the program objectives and an assessment process that measures the degree to which the objectives and outcomes are achieved. The results of this assessment inform the continuous improvement of the program.

The modeling and simulation engineering program outcomes are as follows. Modeling and simulation engineering students who qualify for graduation have the following general education characteristics:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

2. An ability to apply the engineering design process to produce solutions that meet specified needs with consideration for public health and safety, and global, cultural, social, environmental, economic, and other factors as appropriate to the discipline.

3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

4. An ability to communicate effectively with a range of audiences.

5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

6. An ability to recognize the ongoing need to acquire new knowledge, to choose appropriate learning strategies, and to apply this knowledge.

7. An ability to function effectively as a member or leader of a team that establishes goals, plans tasks, meets deadlines, and creates a collaborative and inclusive environment.

In addition, students have the following characteristics specific to the modeling and simulation engineering discipline, which expand on the above engineering program outcomes:

8. An ability to model a variety of systems from different domains;

9. An ability to select and apply appropriate simulation techniques and tools; and

10. An ability to apply visualization techniques to support the simulation process.

Accreditation

The Bachelor of Science in Modeling and Simulation Engineering is accredited by the Engineering Accreditation Commission of ABET www.abet.org. (http://www.abet.org)

Four-Year Plan - Modeling and Simulation Engineering - BSMSE

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Modeling and Simulation Engineering Four-Year Plan*

Freshman

First Term	Hours	Second Term	Hours
MATH 211	4	MATH 212	4
ENGL 110C	3	CHEM 123N**	3
CHEM 121N**	3	PHYS 231N	4
CHEM 122N**	1	ENGN 150	4
ENGN 110	2	MSIM 111	2
COMM 101R	3		
	16		17

Sophomore

First Term	Hours	Second Term	Hours
MSIM 201	3	MSIM 205	3
STAT 330	3	MSIM 281	1
PHYS 232N	4	MATH 307	3
CS 250	4	ENGL 231C	3
CS 252	1	Human Creativity	3
		Literature	3
	15		16

Junior

First Term	Hours	Second Term	Hours
CS 330	3	MSIM 331	3
CS 381	3	MSIM 383	1
MSIM 320	3	MSIM 410	3
MSIM 382	1	MSIM 451	3
Human Behavior	3	Interpreting the Past	3
Approved Program Elective	3	Upper-Division General Education course/Option D Course I	3
	16		16

Senior

First Term	Hours	Second Term	Hours
MSIM 441	3	ENMA 480***	3
MSIM 487W	4	MSIM 488	3
Upper-Division General Education course/Option D Course II	3	Approved MSIM Technical Elective II	3
ENMA 401	3	Approved Program Elective	3
Approved MSIM Technical Elective I	3	Impact of Technology****	3
	16		15

Total credit hours: 127

* Does not include the University's General Education language and culture requirement. Additional hours may be required.

** Students in the Modeling and Simulation Engineering program may substitute BIOL 121N, BIOL 122N, and BIOL 123N in place of the CHEM 121N, CHEM 122N, and CHEM 123N requirement.

*** Meets philosophy and ethics general education requirement.

**** Not necessarily met by the associate degree. Coursework may be taken either at Old Dominion University or the community college.

The General Education requirements in information literacy and research and philosophy and ethics are met through the major.

Program Continuance Regulations

It is the policy of the Department of Computational Modeling and Simulation Engineering to deny a student eligibility to enroll in program courses after it becomes evident that he or she is either unable or unwilling to maintain reasonable standards of academic achievement. Courses in the modeling and simulation engineering major are defined as courses with an MSIM prefix.

1. A student will be placed on departmental academic probation whenever his or her major grade point average falls below 2.00 (after six or more hours have been attempted in the major).
2. Students on departmental academic probation are expected to improve their major GPA by achieving a semester GPA of 2.0 or better during the next semester of attendance. A student on departmental academic probation will have two consecutive semesters to improve their major GPA to 2.0 before termination from the program.
3. A student on departmental academic probation is subject to termination from the program if the semester GPA is below 2.0 in the major at the end of either the Fall or Spring semesters.

Appeals of termination from the program are in order if extenuating circumstances warrant. Appeals are to be made in writing to the chair of the department. Once the appeal is submitted, it is considered by the faculty of the department.

Minor in Modeling and Simulation

An undergraduate minor in modeling and simulation may be obtained by successful completion of 12 or more credit hours of approved modeling and simulation engineering coursework at the 200-, 300-, and 400- level. In addition, a student seeking a minor in modeling and simulation must satisfy all pre- or corequisite requirements for the courses selected.

There are two tracks available in the minor in modeling and simulation: simulation application and simulation development. The chief departmental

advisor for the Department of Computational Modeling and Simulation Engineering must approve the precise course of study in the minor.

The basic course requirements for the two tracks are as follows:

Simulation Application Track

STAT 330	An Introduction to Probability and Statistics (or equivalent)	3
MSIM 205	Discrete Event Simulation	3
MSIM 320	Continuous Simulation	3
and three hours selected from either		3
MSIM 410	Model Engineering	
MSIM 451	Analysis for Modeling and Simulation	
Total Hours		12

Simulation Development Track

STAT 330	An Introduction to Probability and Statistics (or equivalent)	3
MSIM 205	Discrete Event Simulation	3
MSIM 331	Simulation Software Design	3
and three hours selected from either		3
MSIM 406	Introduction to Distributed Simulation	
MSIM 408	Introduction to Game Development	
MSIM 441	Computer Graphics and Visualization	
Total Hours		12

When appropriate, other course work can be developed in consultation with the chief departmental advisor.

For completion of the minor, a student must pass each course required for the minor, achieve a cumulative grade point average of 2.00 in all courses specified as a requirement for the minor exclusive of lower-level courses, prerequisites and corequisites, complete a minimum of twelve credit hours of approved coursework for the minor, and complete at least six hours of upper-level courses in the minor requirement through courses offered by Old Dominion University. To enter the program, students must have completed calculus and one college-level computer-programming course (CS 150, ENGN 150, or equivalent). For further information contact the Department of Computational Modeling and Simulation Engineering (http://catalog.odu.edu/undergraduate/frankbattencollegeofengineeringandtechnology/modelingsimulationvisualizationengineering/).

MODELING AND SIMULATION Courses

MSIM 111. Information Literacy and Research for Modeling and Simulation Engineers. 2 Credits.
An introduction to methods and standards for locating and using information in the discipline of modeling and simulation engineering. Topics include: assessing information requirements; searching for, locating and evaluating information sources related to modeling and simulation; tools for managing, sharing, and presenting information; and ethical issues in the use of information. Students will complete exercises and research on topics involving information of interest to modeling and simulation engineers. Prerequisites: ENGN 110.

MSIM 201. Introduction to Modeling and Simulation Engineering. 3 Credits.
This is the first course for Modeling and Simulation Engineering (M&SE) students. M&SE discipline is surveyed at an overview level of detail. Topics include basic definitions, M&S paradigms and methodologies, applications, design processes, and human factors. Information literacy and research methods are addressed. Papers and oral presentations are required and allow the student to investigate different aspects of the discipline. The course provides a general conceptual framework for further M&SE studies. Prerequisites: MATH 211 with a C or better and PHYS 231N with a C or better. Pre- or corequisite: CS 150 or ENGN 150.

MSIM 205. Discrete Event Simulation. 3 Credits.
An introduction to the modeling and simulation of discrete-state, event-driven systems. Topics include: basic properties and terminology for discrete event systems (DES); models for DES including queuing models, Petri nets, and state automata; and methodologies for simulating DES models. Investigation of the steps of a DES simulation study including problem formulation, conceptual model design, simulation model development, input data modeling, output data analysis, verification and validation, and design of simulation experiments. Corequisite: MSIM 281. Prerequisites: MSIM 201. Pre- or corequisite: STAT 330.

MSIM 281. Discrete Event Simulation Laboratory. 1 Credit.
A laboratory course designed to provide a hands-on introduction to the development and application of discrete event simulation. Topics include an introduction to one or more discrete event simulation tools, common modeling constructs, data gathering and input data modeling, design of simulation experiments, output data analysis, and verification and validation. The design and implementation of a series of increasingly complex simulations of various discrete event systems are conducted. The laboratory is designed to accompany MSIM 205. Student written reports are required.

MSIM 320. Continuous Simulation. 3 Credits.
An introduction to the fundamentals of modeling and simulating continuous-state, time-driven systems. Topics include differential equation representation of systems, formulation of state variable equations, and numerical integration techniques including Taylor series, families of Runge-Kutta and Adams methods. Application domains considered include physical, biological, electrical systems, and real-time simulations. Corequisite: MSIM 382. Prerequisite: MSIM 201. Pre- or corequisite: MATH 307 (or MATH 280) and PHYS 227N or PHYS 232N.

MSIM 331. Simulation Software Design. 3 Credits.
Introduction to data structures, algorithms, programming methodologies, and software architectures in support of computer simulation. Topics include lists, queues, sets, trees, searching, sorting, reusable code, and order of complexity. Simulation structures developed include event lists, time management, and queuing models. Software models are implemented and tested. Corequisite: MSIM 383. Prerequisites: MSIM 205, CS 330 and CS 381.

MSIM 367. Cooperative Education. 1-3 Credits.
Student participation for credit based on the academic relevance of work experience, criteria, and evaluative procedures as formally determined by the department and Career Development Services prior to the semester in which the work is to take place. Prerequisites: approval by department and Career Development Services.

MSIM 368. Internship. 1-3 Credits.
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students to gain short duration career-related experience. Prerequisites: approval by department and Career Development Services.

MSIM 369. Practicum. 1-3 Credits.
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students to gain short duration career-related experience. Prerequisites: approval by the department and Career Development Services.

MSIM 382. Continuous Simulation Laboratory. 1 Credit.
A laboratory course designed to provide a hands-on introduction to the development and application of continuous simulation. Topics include an introduction to one or more continuous simulation tools, modeling of various physics-based systems, and numerical solution of differential equations. The design and implementation of a series of increasingly complex simulations of various continuous systems are conducted. The laboratory is designed to accompany MSIM 320. Student written reports are required. Prerequisite: MSIM 201. Corequisite: MSIM 320.

MSIM 383. Simulation Software Design Laboratory. 1 Credit.
A laboratory course designed to provide a hands-on introduction to the development of simulation software. Topics include data structures, algorithms, and simulation executives. The students will conclude with the development of a basic simulation executive capable of managing discrete event simulations. The laboratory is designed to accompany MSIM 331. Student written reports are required. Prerequisites: MSIM 205, CS 330 and CS 381. Corequisite: MSIM 331.

MSIM 395. Topics in Modeling and Simulation Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on the recent developments in modeling and simulation engineering. Prerequisites: permission of the instructor.

MSIM 396. Topics in Modeling and Simulation Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on the recent developments in modeling and simulation engineering. Prerequisites: permission of the instructor.

MSIM 406/506. Introduction to Distributed Simulation. 3 Credits.
An introduction to distributed simulation. Topics include motivation for using distributed simulation, distributed simulation architectures, time management issues, and distributed simulation approaches. Current standards for distributed simulation are presented. Prerequisites: MSIM 331.

MSIM 408/508. Introduction to Game Development. 3 Credits.
An introductory course focused on game development theory and modern practices with emphasis on educational game development. Topics include game architecture, computer graphics theory, user interaction, audio, high level shading language, animation, physics, and artificial intelligence. The developed games can run on a variety of computer, mobile, and gaming platforms. Prerequisites: CS 361 or MSIM 331.

MSIM 410/510. Model Engineering. 3 Credits.
The goal of this course is to develop understanding of the various modeling paradigms appropriate for capturing system behavior and conducting digital computer simulation of many types of systems. The techniques and concepts discussed typically include UML, concept graphs, Bayesian nets, Markov models, Petri nets, system dynamics, Bond graphs, etc. Students will report on a particular technique and team to implement a chosen system model. (cross-listed with ECE 410) Prerequisites: MSIM 205. Pre- or corequisite: MSIM 320.

MSIM 411/511. Networked System Security. 3 Credits.
Course presents an overview of theory, techniques and protocols that are used to ensure that networks are able to defend themselves and the end-systems that use networks for data and information communication. Course will also discuss industry-standard network security protocols at application, socket, transport, network, VPN, and link layers, popular network security tools, security, performance modeling and quantification and network penetration testing. Discussion will be based on development of system level models and simulations of networked systems. Cross-listed with ECE 411. Prerequisites: CS 150 or ENGN 150 and junior standing or permission of the instructor.

MSIM 416/516. Cyber Defense Fundamentals. 3 Credits.
This course focuses on cybersecurity theory, information protection and assurance, and computer systems and networks security. The objectives are to understand the basic security models and concepts, learn fundamental knowledge and tools for building, analyzing, and attacking modern security systems, and gain hands-on experience in cryptographic algorithms, security fundamental principles, and Internet security protocol and standards. Prerequisites: ECE 355 or MSIM 470.

MSIM 419/519. Cyber Physical Systems Security. 3 Credits.
Cyber Physical Systems (CPS) integrate computing, networking, and physical processes. The objectives of this course are to learn the basic concepts, technologies and applications of CPS, understand the fundamental CPS security challenges and national security impact, and gain hands-on experience in CPS infrastructures, critical vulnerabilities, and practical countermeasures. Cross-listed with ECE 419/CYSE 419. Prerequisites: CS 150 or ENGN 150.

MSIM 440/540. Game Physics Modeling and Simulation. 3 Credits.
This introductory class will provide the student with a basic understanding of the mathematical foundations and algorithmic concepts needed to become competent at implementing game physics engines. We will emphasize the mathematical foundations that apply to many areas of simulation, which subsumes the mathematics of game physics, such as linear algebra emphasizing vectors and matrices, as well as introductory vector calculus. This class will also exploit open-source C++ software implemented by the author of the textbook. Prerequisites: CS 250.

MSIM 441/541. Computer Graphics and Visualization. 3 Credits.
The course provides a practical treatment of computer graphics and visualization with emphasis on modeling and simulation applications. It covers computer graphics fundamentals, visualization principles, and software architecture for visualization in modeling and simulation. Prerequisites: CS 250.

MSIM 451/551. Analysis for Modeling and Simulation. 3 Credits.
An introduction to analysis techniques appropriate to the conduct of modeling and simulation studies. Topics include input modeling, random number generation, output analysis, variance reduction techniques, and experimental design. In addition, techniques for verification & validation are introduced. Course concepts are applied to real systems and data. Prerequisites: MSIM 205 and STAT 330.

MSIM 462/562. Introduction to Medical Image Analysis. 3 Credits.
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. Cross-listed with ECE 462/ECE 562. Prerequisites: Junior standing.

MSIM 463/563. Design and Modeling of Autonomous Robotic Systems. 3 Credits.
This course focuses on autonomous robotics systems with emphasis on using modeling and simulation (M&S) for system level design and testing. Fundamental concepts associated with autonomous robotic systems are discussed. Course topics include: robotic control, architectures, and sensors as well as more advanced concepts such as error propagation, localization, mapping and autonomy. Design strategies that leverage M&S to accelerate the development and testing of sophisticated autonomous robotic algorithms for individual or teams of robots are covered. Prerequisites: CS 150 or ENGN 150.

MSIM 470/570. Foundations of Cyber Security. 3 Credits.
Course provides an overview of theory, tools and practice of cyber security and information assurance through prevention, detection and modeling of cyber attacks and recovery from such attacks. Techniques for security modeling, attack modeling, risk analysis and cost-benefit analysis are described to manage the security of cyber systems. Fundamental principles of cyber security and their applications for protecting software and information assets of individual computers and large networked systems are explored. Anatomy of some sample attacks designed to compromise confidentiality, integrity and availability of cyber systems are discussed. Prerequisites: Junior standing. Pre- or corequisite: MSIM 410 or permission of the instructor.

MSIM 474/574. Transportation Data Analytics. 3 Credits.
This course presents the basic techniques for transportation data analytics. It will discuss statistical modeling, prominent algorithms, and visualization approaches to analyze both small- and large-scale data sets generated from transportation systems. Practices of using different data for various real-world traffic/transportation applications and decision making will also be discussed. Prerequisites: Basic probability and statistics (e.g., STAT 330); any programming language such as C, Python or Java is beneficial but not required.

MSIM 480/580. Introduction to Artificial Intelligence. 3 Credits.
Introduction to concepts, principles, challenges, and research in major areas of artificial intelligence. Areas of discussion include: natural language and vision processing, machine learning, machine logic and reasoning, robotics, expert and mundane systems. Laboratory work required. Prerequisite: Instructor approval.

MSIM 487W. Capstone Design I. 4 Credits.
Part one of the senior capstone design experience for modeling and simulation engineering majors. Lectures focus on providing professional orientation and exploration of the M&S design process. Written communication, oral communication and information literary skills are stressed. Individual and group design projects focus on the conduct of a complete M&S project. Industry-sponsored projects are an option. Individual and team reports and oral presentations are required. This is a writing intensive course. Prerequisites: A grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C; MSIM 410, MSIM 331, and MSIM 451.

MSIM 488. Capstone Design II. 3 Credits.
Part two of the senior capstone design experience for modeling and simulation engineering majors. Lectures focus on providing professional orientation and exploration of the M&S design process. Written communication, oral communication and information literacy skills are stressed. Individual and group design projects focus on the conduct of a complete M&S project. Industry-sponsored projects are an option. Individual and team reports and oral presentations are required. Prerequisites: MSIM 441 and MSIM 487W.

MSIM 495/595. Topics in Modeling and Simulation Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in modeling and simulation engineering. Prerequisites: permission of the instructor.

MSIM 496/596. Topics in Modeling and Simulation Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on the recent developments in modeling and simulation engineering. Prerequisites: permission of the instructor.

MSIM 497/597. Independent Study in Modeling and Simulation Engineering. 3 Credits.
Individual analytical, computational, and/or experimental study in an area seleted by the student. Supervised and approved by the advisor. Prerequisites: Instructor approval.