

# SYST 611

## SYSTEM METHODOLOGY AND MODELING

Spring 2016

Department of Systems Engineering and Operations Research  
George Mason University

The approaches presented in this course are primarily concerned with capturing a system's behavior and changes over time. Due to the inherent interdisciplinary nature of the field of dynamic modeling, an effort is made to present a variety of modeling methodologies from different disciplines, e.g., engineering, computer science, economics, etc., together with their applications to non-trivial, real-world systems. Different model types (or languages) are characterized by way of representations, i.e., graphical or text-based grammars.

The course starts with a general introduction to dynamic models. The state machines are presented as the simplest and general method for modeling dynamic systems. The issues of composition, abstraction, and execution of models, are illustrated with the help of state machines. The same issues are revisited with each of the modeling formalism covered in the course.

Continuous and discrete time systems are presented as special classes of state machines. Different representational formalisms (e.g., operator equations, difference/differential equations, block diagrams) are presented by highlighting their representational and computational (dis)advantages over others. System Dynamics is presented as a computer-aided approach to modeling complex domains (e.g., social and economic.)

Discrete event systems (DES) are introduced as another class of dynamic systems. A review of concepts from Discrete Mathematics, that are relevant for DES modeling, is done to prepare students for more in-depth study of DESs. This review includes a short introduction to topics in Sets, Discrete Probability, Graph Theory, Logic, and Languages and then illustrates how these are used within dynamic systems modeling.

A number of DES modeling and simulation formalisms and techniques are introduced as extensions to Finite State Machines (FSM). These formalisms are presented as means to capture both a system's specifications and its behavior. This presentation is accompanied by several modeling examples of DES.

The course concludes with an introduction to the topics of modeling stochastic behavior and decision analysis.

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[szaidi2@gmu.edu](mailto:szaidi2@gmu.edu)

**Office Hours:** Monday and Wednesday 3:00 – 4:00 PM; Thursday 5:30 – 6:30 PM, and by appointment via phone/email

### **Class Information:**

**When:** January 19 – May 11, Spring 2016

**Where:** All course communication will be done via the Blackboard system. Students are expected to have access and be able to use the system before classes start. Blackboard is accessible via MyMason portal at <https://mymason.gmu.edu/>. Instructions for using the Blackboard system are provided on the Help button at the top right of the portal page.

## Learning Objectives & Outcomes

The ability to effectively apply the concepts of systems engineering in the modeling and analysis of real life systems by identifying the appropriate modeling formalism for the system under study, formulating the analysis questions of interest, selecting the suitable analysis method for the study, and employing the state-of-the-art software tools to carry out the tasks.

By completing this course a student should be able:

- To classify a given system in a class of systems of known characteristics
- Based on the classification above, to identify a suitable abstraction (modeling approach) for modeling the behavior of the system
- To identify the analysis questions that can be addressed by the modeled system
- To start developing a systems engineer's toolkit for modeling and analysis of dynamic systems

## Student Evaluation Criteria: Homework 50%, Midterm 25%, Final 25%

The following scale can be used by students for self-assessment. The instructor may relax the grading scheme for final grade assignment.

<b>94-100</b>	<b>A</b>
<b>88-93</b>	<b>A-</b>
<b>83-87</b>	<b>B+</b>
<b>77-82</b>	<b>B</b>
<b>70-76</b>	<b>B-</b>

## Attendance and Participation Requirements

There are no specific attendance and participation requirements, other than the following:

1. Midterm Examination on February 25, 2016, from 7:20 pm to 10:00 pm. This live session is optional and can be used by students who may like to interact with the instructor during the examination.
2. Live online Project Presentation Session on March 24, 2016 from 7:20 pm to 10:00 pm. It is compulsory for all students to participate in this session.
3. Final Examination on May 05, 2016, from 7:30 pm to 10:15 pm. This live session is optional and can be used by students who may like to interact with the instructor during the examination.

## Other Course Policies

1. There are no provisions for late submission of work and/or make-up examinations.

2. In case of an emergency that prevents a student from submitting required work before the deadlines or taking an examination, the student must inform the instructor at the earliest via email or telephone. Such situations will be addressed on a case by case basis.
3. No points will be awarded if homework is turned in after solutions have been posted.
4. Religious observances are one common example of events that might impact students' activities. Students are responsible for planning ahead. Please, refer to the GMU's [calendar of religious holidays](#).
5. All academic policies as given in the Honor System and code will be strictly followed. These are available here.
6. The GMU's student privacy policy is in place for this course. It is available [here](#).
7. All general policies defined in the University Catalog are in place for this course. These are available [here](#).
8. George Mason University is an Honor Code university. See the Office of [Academic Integrity website](#) for a full description of the honor code and the honor committee process.

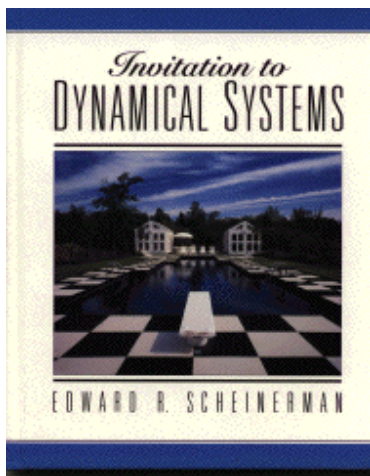
### Relevant Student Services at GMU

1. Distance Education Resources at GMU Library
2. Writing Center
3. Counseling & Psychological Services

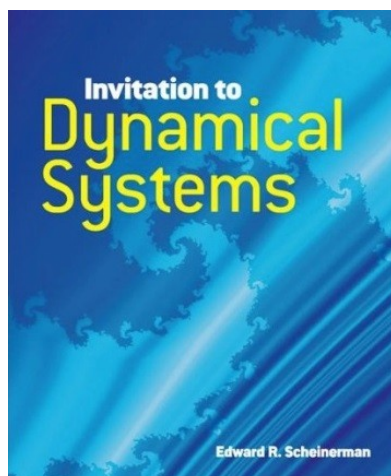
### Reading and Reference Materials

#### A. Required Text

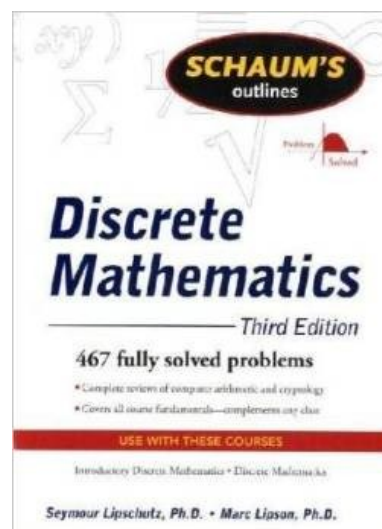
##### 1. Invitation to Dynamical Systems Edward R. Scheinerman



or



##### 2. Schaum's Series on Discrete Mathematics



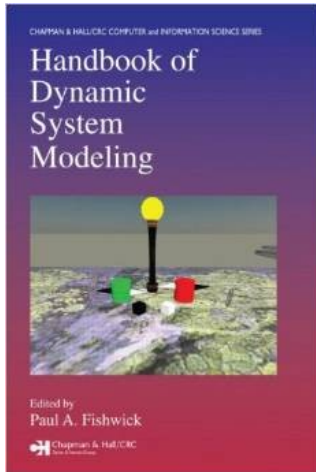
Required text for continuous and discrete time dynamical systems  
(The first half of the course)

[Available Online](#) (by the author)

Strongly recommended for review of Discrete Mathematics' concepts

## B. Recommended Text

### Handbook of Dynamic Systems Modeling Paul A. Fishwick



Recommended as a reference handbook  
Chapman & Hall/CRC Computer & Information Science  
Series  
Publication Date: June 1, 2007 | ISBN-10: 1584885653 |  
ISBN-13: 978-1584885658 | Edition: 1

## C. Additional Materials

Handouts/Lecture notes and all supplementary material are included in each weekly module.

### Technology Requirements

The technology requirements for this online course are listed below:

#### Hardware

You will need access to a Windows or Macintosh computer with at least 2 GB of RAM and to a fast, reliable broadband Internet connection (e.g., cable, DSL). For optimum visibility of course material, the recommended computer monitor and laptop screen size is 13-inches or larger. You will need computer speakers or headphones to listen to recorded content. A headset microphone is recommended for live audio sessions using course tools like Blackboard Collaborate. For the amount of computer hard disk space required to take an online course, consider and allow for the space needed to: 1) install the required and recommended software and, 2) save your course assignments.

For hardware and software purchases, visit [Patriot Computers](#).

#### Technical Help for Blackboard & Online Tools

- For Supported Web browsers (see [Blackboard Support](#))
- Log into Blackboard Courses (use <http://mymason.gmu.edu>, select the Courses Tab)
- Frequently Asked Questions (see [Blackboard Student Support](#))
- For all technical issues regarding Blackboard, see [Courses Support](#), [Blackboard Help](#), and [Blackboard Tutorials](#).
- Adobe Acrobat Reader ([free download](#))
- Flash Player ([free download](#))
- Microsoft Office ([purchase](#))
- If you still have questions, complete the Courses Support [Contact Us Form](#) for assistance with Blackboard.

- For technical questions regarding computer networking, see [IT Services for Students](#). If you still have questions, email [support@gmu.edu](mailto:support@gmu.edu) or call (703) 993-8870.



## Other Software Requirements

A part of this course requires students to implement dynamic models using some software. These software will be introduced in-class and information to download them will be provided via Blackboard. Students are required to have the software ready for use on their individual computers for the homework assignments.

**Note:** If you are using an employer-provided computer or corporate office for class attendance, please verify with your systems administrators that you will be able to install the necessary applications and that system or corporate firewalls do not block access to any sites or media types.

### Blackboard Collaborate *(for live online sessions):*

The project presentation will take place on Blackboard Collaborate, a synchronous videoconferencing platform. In addition, I will make a Collaborate Session available to each project group for their use during the semester. Login in to [mymason.gmu.edu](http://mymason.gmu.edu) with your Mason NetID and password. Select the Courses Tab. Choose the course 201610.10901 SYST-221-201 (Spring 2016). Click on Collaborate on the left menu. Under Blackboard Collaborate. Click on the

Collaborate Image to be redirect to your Collaborate  **Lecture 1**   
Suggested

Please make sure to update your computer and prepare yourself to begin using the online format BEFORE the first day of class. The IT Support Center can be found online [here](#).

Navigate to the Student Support page on your MyMason page and select the Courses Tab:



Click on the link as shown in picture.



In the menu bar to the left you will find Blackboard Collaborate; you need to become familiar with Blackboard Collaborate for this course. Make sure you run a system check a few days before videoconference day. To do this, click on Bb Collaborate and a dropdown menu will appear. Become familiar with the attributes of Collaborate and online learning.

## Overview of Course Structure

S.No.	Topics	No. of Lectures Required	Relevance to SE Concentration Tracks
1.	Definitions and Taxonomy of System Types and Models Synthesis, Analysis, and Theory of Models <ul style="list-style-type: none"> <li>State Machines</li> </ul>	1	All tracks
2.	Linear Time Invariant (LTI) Systems <ul style="list-style-type: none"> <li>Continuous Time and Discrete Time Systems</li> </ul> Nonlinear Systems <ul style="list-style-type: none"> <li>Stability</li> <li>Linearization</li> </ul>	4	C4I, FSE, ATS, and ABSI
3.	System Dynamics <ul style="list-style-type: none"> <li>Modeling Examples of Real World Systems</li> </ul>	2	ABSI, ATS, C4I and FSE
4.	Overview of Concepts from Discrete Mathematics for the Study of Discrete Event Systems (DES)	1	ABSI, C4I, SIS, SEA
5.	Discrete Event Systems (DES) Modeling and Simulation <ul style="list-style-type: none"> <li>Finite State Machines</li> <li>DEVS</li> <li>Petri Nets</li> </ul>	3	ABSI, ATS, C4I and SMG
6.	Stochastic Systems <ul style="list-style-type: none"> <li>Decision Analysis</li> <li>Markov Chains</li> </ul>	2	C4I, SEA, SMG, and FSE

## Weekly Schedule (subject to change as course progresses)

- The following table gives an overview of the entire course with important dates for examinations and presentations highlighted.
- A student needs to follow the links to the weekly modules to access all the course material including instructional videos, lecture notes, reading material, and assignments.
- The assignment submission must be done in the 'Assignment' Section before the deadline.
- Review the material in 'Examination' Section for details on making arrangements for an examination proctor.

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<b>Week</b>	<b>Lecture Topic(s)</b>
Jan 18 – Jan 24	Introduction to Systems; System Taxonomy; Review of Mathematical Concepts
Jan 25 – Jan 31	Review of Mathematical Concepts; Modeling Concepts; State Machines
Feb 01 – Feb 07	Discrete-Time Systems I
Feb 08 – Feb 14	Discrete -Time Systems II; Markov Chains
Feb 15 – Feb 21	Continuous -Time Systems
February 25	<b>Midterm Test</b>
Feb 29 – Mar 06	System Dynamics I
Mar 07 – Mar 13	<i>Recess (No Activity)</i>
Mar 14 – Mar 20	System Dynamics II
Mar 21 – Mar 27	<b>Student Presentations</b>
Mar 28 - Apr 03	Formal Languages; Finite-State Automata
Apr 04 – Apr 10	Finite-State Automata Composition
Apr 11 – Apr 17	Extended State Machines; Timed Automata; DEVS
Apr 18 – Apr 24	Discrete Event Systems with Petri Nets
Apr 25 - May 01	Decision Analysis
May 05	<b>Final Examination</b>

## **Academic Integrity**

GMU is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

## **Disabilities Statement**

If you have a documented learning disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with Office of Disability Services (SUB I, Rm. 4205; 993-2474; <http://ods.gmu.edu>) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

## **Mason Diversity Statement**

George Mason University promotes a living and learning environment for outstanding growth and productivity among its students, faculty and staff. Through its curriculum, programs, policies, procedures, services and resources, Mason strives to maintain a quality environment for work, study and personal growth.

An emphasis upon diversity and inclusion throughout the campus community is essential to achieve these goals. Diversity is broadly defined to include such characteristics as, but not limited to, race, ethnicity, gender, religion, age, disability, and sexual orientation. Diversity also entails different viewpoints, philosophies, and perspectives. Attention to these aspects of diversity will help promote a culture of inclusion and belonging, and an environment where diverse opinions, backgrounds and practices have the opportunity to be voiced, heard and respected.

The reflection of Mason's commitment to diversity and inclusion goes beyond policies and procedures to focus on behavior at the individual, group and organizational level. The implementation of this commitment to diversity and inclusion is found in all settings, including individual work units and groups, student organizations and groups, and classroom settings; it is also found with the delivery of services and activities, including, but not limited to, curriculum, teaching, events, advising, research, service, and community outreach.

Acknowledging that the attainment of diversity and inclusion are dynamic and continuous processes, and that the larger societal setting has an evolving socio-cultural understanding of diversity and inclusion, Mason seeks to continuously improve its environment. To this end, the University promotes continuous monitoring and self-assessment regarding diversity. The aim is to incorporate diversity and inclusion within the philosophies and actions of the individual, group and organization, and to make improvements as needed.

## **Student Support Resources on Campus**

Resources that you may find helpful may be found at:

<http://ctfe.gmu.edu/teaching/student-support-resources-on-campus/>