IE 398 – Simulation Modeling with Applications for Industrial Engineering

Section CV, Spring 2022

Course information

Credit hours: 3
Instructor: Chrysafis Vogiatzis
Email: **chrys@illinois.edu**
Course website: **canvas.illinois.edu**
Office: 211 Transportation Building

Online office hours link: **https://tinyurl.com/yxqdm847**
Office hours: **TR 4.00pm–5.15pm**
and by appointment

If the link to my office hours is not working as intended, please use the following details:

Meeting ID:	450 021 1406
Password:	069901

Meeting times

Component	Section	Meeting time	Meeting place	Online
Lectures	CV	TR, 2.00pm–3.20pm	2100 Sidney Lu Mechanical Engineering Building	Link

If the link to the class online is not working correctly, please use the following details:

Meeting ID:	814 3435 9259
Password:	346527

Course communication

All communication of announcements, assignments, and other materials will be done through the course website on **Canvas**. You can also email the instructor and teaching assistants; when doing so, please begin your email subject line with [IE 398]. This helps with class organization and will ensure a faster reply. Finally, please use the Piazza website for IE 398 - Simulation to ask questions and participate in discussions. The link to Piazza for the Spring 2022 semester is here: **https://piazza.com/illinois/spring2022/ie398**.

Teaching assistant

The teaching assistant will be announced shortly.

- Office hours: TBA.

Textbook

Simulation with ARENA by W. David Kelton, Randall Sadowski, and Nancy Zupick, 6th ed., ISBN-13: 978-0073401317 , ISBN-10: 0073401315. While not required, it is highly recommended.

Software

ARENA by Rockwell Automation. **Please note that the software *only* runs on Windows operation systems**. That said, you can also access Arena through **Citrix Workspace**.

Course description

Use of discrete-event simulation in the modeling and analysis of complex systems subject to uncertainty. At the end of the course, the students should be able to develop simulation models of complex, real-life systems; design simulation experiments; analyze and interpret the results of the simulation; and effectively organize and present simulation-based projects. The topics of the course include input modeling, selecting probability distributions, generating random variables, sensitivity analysis, simulation optimization, and reporting and analyzing simulation outputs.

Target audience

Undergraduate engineering students at their junior year with an interest in decision-making under uncertainty and the analysis of complex systems through simulation techniques.

Learning outcomes

Upon completion of the course and all of its topics, students should have the abilities and tools to:

- develop simple and complex simulation models of real-life systems [1,2];
- design simulation experiments, analyze the results, and interpret their findings [1,2,6];
- use ARENA proficiently [1,2,6];
- formulate and conduct simulation experiments and perform sensitivity analysis in order to reach statistically sound conclusions [1,2,6];
- work in a team to design simulation experiments, and report and communicate simulation results to general audiences [3,4,5].

Note: ABET outcomes $1--6$ that are covered with the course are (for more information, please visit https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020 and check Criterion 3):

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. 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.

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Exams

There are three exams in the class: two midterm exams and a final exam. Due to the structure of the class, all exams are cumulative with the material up to that point (for example, material from the first exam are naturally included in the second exam, and so on). The final exam will be cumulative and will be given (as designated by the University of Illinois) on the date shown here: https://registrar.illinois.edu/faculty-staff/final-exam-scheduling/final-exam-schedule/. The final exam accounts for 30% of the grade of a student in the class. Each midterm exam will count towards 20% of the grade of a student for a total of 40% of the grade in the class.

The two midterm exams will be announced in class at least one week before they are scheduled to take place. Tentatively, you may consider them to take place on or near March 1 (midterm #1) and on or near April 12 (midterm #2). The final exam will take place during finals week.

Make-up exams will be provided if notified at least three days prior to the exam date. In the case of an emergency, a make-up exam will be provided with the proper and appropriate documentation justifying your absence no later than three days after the date of the exam.

Lab assignments

There will be 8-10 lab assignments throughout the course of the semester. Lab assignments will be announced during the previous class. An announcement before every assignment will also be posted on the class website. No make-up or late assignments are going to be allowed; that said, students will be able to drop their lowest score. The average grade of a student in the assignments will count towards 20% of the grade of the student in the class.

The deadline for assignment submission will be end of day (11.59pm) unless otherwise posted. You are encouraged to work with other students on an assignment either inside or outside the classroom, however copying violates the honor code and is not allowed under any circumstances.

Term project

A project is to be submitted as part of the class. Students are encouraged to work in groups of four. The final output of the term project will be a 5-6 page report, a series of simulation code files, and a small (approximately 8-10 slides) presentation. The important milestones are summarized in Table 1. As a disclaimer, milestone dates may shift depending on the class progress. The project will count for 10% of the grade of a student in the class.

Re-grade policy

If you believe that an exam or a lab assignment was graded incorrectly, please reach out to me at the latest one week after the announcement of the result. In your email requesting the re-grade, please add an explanation of where and why a re-grade is desired.

Table 1: The important term project milestones and approximate deadlines.

Activity	**Before or on**
Form group	02/25
Meet with Dr. Vogiatzis	03/11
Submit one page project proposal	03/25
Collect data/preliminary analysis	04/08
Meet with Dr. Vogiatzis	04/18
Submit all project files	05/11
Submit peer evaluation forms	05/11

Attendance

Lectures. While attendance in lectures is not mandatory, it is highly recommended. Students will be responsible for all of the material taught in the classroom. Important discussions and in-class activities will take place during class.

Lab assignments. Whenever a lab assignment is to take place, attendance is highly encouraged. Lab assignment solutions will need to be submitted before the deadline for full credit. Labs may take place online when convenient.

Grading policy

A: $[93, 100]$, A-: $[90, 93)$, B+: $[87, 90)$, B: $[83, 87)$, B-: $[80, 83)$, C+: $[77, 80)$, C: $[73, 77)$, C-: $[70, 73)$, D+: $[67, 70)$, D: $[63, 67)$, D-: $[60, 63)$, F: $[0, 60)$.

Lab assignments	20%
Midterm exam 1	20%
Midterm exam 2	20%
Final exam	30%
Term project	10%
Total	**100%**

General class policies

- Be courteous and kind to others (including me!). Please stay kind, flexible, and supportive to the people around you.
- I will prioritize supporting you, sharing all resources with you early and often, and communicating expectations and opportunities clearly. We did not sign up for COVID-19 and the way it has upended our lives, so I will make sure to stay flexible and allow you the space and time to grow.
- If participating online, please mute your microphone, if not asking a question or actively participating in a discussion.
- Some lectures will be recorded: my goal is to also record all lab sessions. If you have an issue with having your questions or participation recorded, please contact me and we will address this.
  - The recordings will only be made available to you through Canvas.

Course topics and tentative schedule

In blue, we have the lab sessions that will take place. In red, the exam dates. The final exam will take place at the time scheduled by the registrar during finals week.

Week	Lecture	Topic	Lab
Week 1	1	Class introduction	
	2	Discrete event simulation introduction	
Week 2	3	Software for discrete event simulation	
	4	Application: simple queuing systems	Lab 1
Week 3	5	Basic modeling and animation in Arena	
	6	Conditional modeling	Lab 2
Week 4	7	Variables and attributes	
	8	Application: modeling a call center	Lab 3
Week 5	9	Modeling priorities and cross-training	
	10	Defining sets, arrays, and logical entities	
Week 6	11	Time-persistent statistics and frequencies	
	12	Exam 1 Review	Lab 4
Week 7	-	**Exam 1**	
	-	**No class**	
Week 8	13	Input modeling	
	14	Input modeling	Lab 5
Week 9	-	**SPRING BREAK**	
	-	**SPRING BREAK**	
Week 10	15	Modeling transfers and material handling operations	
	16	Application: a recycling facility	Lab 6
Week 11	17	Advanced transfer operations: sequences	
	18	Advanced transfer operations: transporters	
Week 12	19	Advanced transfer operations: conveyor belts	
	20	Application: a small manufacturing facility	Lab 7
Week 13	-	**Exam 2**	
	21	Simulation and optimization	
Week 14	22	Optimization using ARENA	Lab 8
	23	Advanced simulation modeling: searching and removing	
Week 15	24	Advanced simulation modeling: hold and signal	
	25	Application: a public transit system	Lab 9
Week 16	26	Final exam review	
Final exam week	-	**Final exam**	

See next page for a **course progression** map.

Course progression

During Weeks 1–3, students will install the necessary software and learn **how to model and animate simple queuing systems**. During Weeks 4–6, students will learn how to establish **local and global variables** (as well as sets/arrays), and use them to conditionally route entities through the system. Week 7 will be devoted to Exam 1, where students are expected to demonstrate excellence in setting up and analyzing small, simple models.

After Exam 1, students will begin with **input modeling**, i.e., identifying suitable distributions to use for their process times, entity arrival times, etc. Then, we will move into **entity transfer and material handling**. In Weeks 9–11, students will learn how to model stations and routes, transporters, conveyor belts, and sequences. Week 12 is devoted to Exam 2, where students will need to demonstrate a mastery of modeling real-life engineering systems and properly use transfer logic to analyze their performance.

The last part of the class is devoted to two advanced topics. First, students will learn how to use **simulation-optimization** to make decisions. Secondly, we will focus on advanced simulation techniques, such as searching and conditionally removing entities from the system, creating and using hold and signal modules to conditionally route entities through the system, and entity batching operations. This part will be followed by the final exam during finals week.

Academic integrity

We will follow articles 1-401 through 1-406 of the Student Code (you can find the articles beginning at http://studentcode.illinois.edu/article1/part4/1-401/). This rule defines infractions of academic integrity, which include but are not limited to cheating, fabrication, and plagiarism. You are responsible for following these guidelines. If you have any questions about whether something would be an infraction, consult with the instructor before proceeding.

Request for special accommodations

To obtain disability-related adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 217.333.4603, email disability@illinois.edu, or go to the DRES website (at http://disability.illinois.edu).

Run > Hide > Fight

Emergencies can happen anywhere and at any time. It is important that we take a minute to prepare for a situation in which our safety or even our lives could depend on our ability to react quickly. When we're faced with almost any kind of emergency – like severe weather or if someone is trying to hurt you – we have three options: Run, hide or fight. Please consult the provided attachment to the syllabus for more information.

Updates to the syllabus

The contents of the syllabus and the policies described are subject to change. If that happens, all the changes will be announced and described on the course website. A summary of the changes will be offered in this page, too.

Prepared by:	Chrysafis Vogiatzis
Last updated:	January 14, 2022
Major changes:	None