# IE 371 – Simulation Modeling with Applications for Industrial Engineering

## Section A, Spring 2025

### 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:** **WF 11:00 am–noon**
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: | 847 9885 1723 |
| Password: | 330675 |

### 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 371]. This helps with class organization and will ensure a faster reply.

### 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).
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 and a series of simulation code files. 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.

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

| **Activity** | **Before or on** |
|---|---|
| Form group | 02/28 |
| Meet with Dr. Vogiatzis | 03/14 |
| Preliminary analysis | 04/11 |
| Meet with Dr. Vogiatzis | 04/25 |
| Submit all project files | 05/07 |
| Submit peer evaluation forms | 05/09 |

## 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.

## 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 | 30% |
| Midterm exam 2 | 30% |
| Term project | 20% |
| **Total** | **100%** |

## General class policies

**Behavior in the classroom**

- Be courteous and kind to others (including me, please!).
- We will always build together a supportive and encouraging environment, approaching the problems we face from a point of mutual curiosity.
- "Take Space, Make Space": in many of our group activities, you may observe that you talk/offer too much. If that is you, make space for others to share, too. If you do not talk as often, I encourage you and invite you to share your thoughts with me and others!
- We all make mistakes and that is OK. Leaning into the discomfort of not knowing what went wrong, but being curious to find out more about it is central to our growth.

**Class recording and other recorded materials**

- I will try to record a big part of the lectures going forward. If you have an issue with having your questions or participation recorded, please let me know and I will do my best to address this.
  - The recordings will only be made available to you through Canvas.
  - No one other than your class cohort and myself will get access to these recordings.
  - When impossible to record (or the quality of the recording is poor), I will share previous year recordings for our convenience and learning.

- If online, please mute your microphone, when not asking a question or actively participating in a discussion.

**Supporting your learning**

- I will prioritize supporting you, sharing all resources with you early and often, and communicating expectations and opportunities clearly.
- I will remain flexible throughout the semester. Simply ask for an appointment with me to discuss what I can do to contribute to your well-being in the class. If you need any accommodation, please do not hesitate to ask me.
- Please stay kind, flexible, and supportive to the people around you, too.

## 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.

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See next page for a tentative **course schedule**.

## Course schedule

In blue, we have the lab sessions that will take place. In red, the exam dates.

| 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** | |
| | 13 | Input modeling | |
| Week 8 | 13 | Input modeling | |
| | 14 | Input modeling | Lab 5 |
| | - | **No class** | |
| 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 | Application: a small manufacturing facility | Lab 7 |
| Week 12 | 19 | Advanced transfer operations: transporters | |
| | 20 | Advanced transfer operations: conveyor belts | |
| 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 | Course review: where do we go from here? | |
| | - | **Term project is due** | |

## 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.

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| **Prepared by:** | Chrysafis Vogiatzis |
| **Last updated:** | January 20, 2025 |
| **Major changes:** | None |