

University of Toronto
Department of Mechanical and Industrial Engineering
MIE 360: Systems Modelling and Simulation (Fall 2023)

- Instructor: Prof. Vahid Sarhangian; Office: BA8108; Email: sarhangian@mie.utoronto.ca
- Office hours: Regular office hours TBD in class; also by appointment
- Piazza homepage: <https://piazza.com/class/lm819fg5z957pk>
- Teaching Assistants:
 - Marking TA: Jared Chiu (jared.chiu@mail.utoronto.ca)
 - Tutorial TA: Tamara Kecman (tamara.kecman@mail.utoronto.ca)
 - Lab TA: Rachel Stephensen (r.stephenson@mail.utoronto.ca)
 - Project TA: Hamed Zakeri (hamed.zakeri@mail.utoronto.ca)
- Lectures: Wednesday, 3:00 PM - 4:00 PM in MP103 and Friday, 10:00 AM - 12:00 PM in WB116
- Tutorials: Tuesday, 9:00 AM - 10:00 AM in BA 1220 and Tuesday, 2:00 PM - 3:00 PM in SF2202
- Labs: Monday, 11:00 AM - 1:00 PM, Thursday, 12:00 PM - 2:00 PM, Friday, 12:00 PM - 2:00 PM in MB123

Note: In order to have access to the lab room to complete your lab assignments, you *must* have completed the [MIE Safety Training Course](#). Failure to complete the MIE Safety Training Course will lead to denied access to the lab.

Course Description

This course is an introduction to modelling and analysis of complex stochastic systems using computer simulation. Simulation finds applications in various areas including manufacturing, service, healthcare, finance, and public policy. Broadly speaking, simulation models allow decision makers to study systems that do not yet exist, and to answer what-if questions about them, e.g., How much will wait time on average be reduced if an emergency department adds another physician to the night shift? What is the expected increase in profit during the next quarter if a new investment strategy is employed? How many police patrol cars are required to ensure that the response time to a call is below 5 minutes, 90% of the time? The focus of this course will be on Stochastic Simulation and decision making under uncertainty. In particular, it covers topics termed Monte Carlo and Discrete-Event simulation.

Prerequisites

The theoretical foundation of simulation is probability and statistics. Therefore, familiarity with statistics and probability at the level of MIE 231 and MIE 236 is required. You are encouraged to review Chapter 4 of the recommended textbook (see Resources and textbook below). The course also involves some computer programming (first using Python and then a commercial simulation software). You are expected to be familiar with computer programming at the level of APS106.

Evaluation and Grading

Item	Mark (%)
Homework	10
Group Project	20
Midterm	35
Final	35

- **Homework:** There will be approximately weekly assignments. All assignment solutions must be submitted online. You are strongly encouraged to type your solutions. You may do the homework individually or in pairs. If doing it as a pair, write both names on one homework. Do not submit two solutions. You will receive the same grade. You may have a different homework partner for each homework. You will have one week to hand in each homework (the exact deadline will be announced on each assignment). The lowest homework grade will be dropped and not counted toward your final mark. There will be no extension to the homework deadlines. Late submissions will be penalized.
- **Exams:** There will be a final exam (date and time to be announced) and a midterm test (date and time to be announced). You may bring one sheet (double-sided) of notes for the midterm and final.
- **Group Project:** The project involves building a simulation model in Simio (see the Software section below) to answer a real-world decision making problem and preparing a report. Details and deadlines will be announced after the midterm exam. The project will be done in groups of 2-3 students, with no collaboration between different teams. If you attend at least 4 lab sessions and complete the in-lab assignments (submission details to be announced) you will receive a 10% bonus on your project mark.

Resources and Textbook

- Course notes: Instructor's notes will be uploaded to Quercus prior to the lectures. You are strongly encouraged to annotate the notes during lectures.
- Textbook (recommended): The textbook for the course is A. M. Law, *Simulation Modeling and Analysis*. The textbook is complementary to the lecture notes and is not required. Readings will be recommend so that you will know which section to read if you buy the book. Feel free to purchase any edition of the textbook. A copy will be held on reserve for the course in the [library](#).
- Other references:
 - Smith et al. *Simio and Simulation: Modeling, Analysis, Applications* (Similar level to this class, demonstrating simulation concepts via Simio - hardcopy and e-book can be purchased [online](#))
 - J. Joines and S. Roberts. *Simulation Modeling with SIMIO: A Workbook* (Practical reference for Simio. Hardcopy and e-book can be purchased [online](#).)
 - B. L. Nelson. *Foundations and Methods of Stochastic Simulation: A First Course* (Graduate level textbook, but very readable. Available online on the [library websites](#).)

Software

In the initial part of the course, we will develop Monte Carlo simulation models in Python. You may use Python together with Jupyter notebooks. Python and Jupyter are available on ECF labs which you can also access remotely. You can also install them on your personal computers (PC or Mac). Instructions will be uploaded to Quercus. In the second part and for the Lab sessions, we will use a commercial simulation software, namely Simio, which only operates on PCs, or on Macs running Windows. Simio is also available in all ECF labs and can be accessed remotely. In the input modelling section of the course, we will also see some examples in R.

Tentative Course Schedule

Week of	Topic	Chapter in book	Tutorial	Lab
Sep-4	Introduction to simulation	1	-	-
Sep-11	Review of probability and statistics	4	-	-
Sep-18	Monte Carlo simulation in Python	-	1	-
Sep-25	Random variable generation	7, 8	2	-
Oct-2	Input modelling and estimation	6	3	-
Oct-9	Input modelling and estimation / midterm (tentative)	-	4	-
Oct-16	Queueing networks	2	-	-
Oct-23	Discrete-event simulation	1	5	1
Oct-30	Discrete-event simulation examples	1	6	2
Nov-6	(Fall break)	-	-	-
Nov-13	Output analysis	9	7	3
Nov-20	Comparing alternative systems	10	8	4
Nov-27	Simulation optimization	12	9	5
Dec-04	Review	-	10	-

Learning Outcomes

Upon successful completion of the course, students will

- understand the probability and statistical foundations of simulation;
- be able to identify decision making problems for which simulation is the appropriate approach;
- be able to design simulation studies to answer complex decision making problems;
- be able to build valid, credible, and appropriately detailed simulation models; and
- be able to utilize available data in estimating the inputs of and validating simulation models.

Policies & Statements

Cell Phones and Laptop Usage

Technology can support student learning, but it can also become a distraction. Research indicates that multi-tasking (texting, surfing the Internet, using social networks) during class time can have a negative impact on learning (Clapp, Rubens, Sabharwal & Gazzaley, 2011; Ellis, Daniels, Jauregui, 2010; Hembrooke & Gay, 2003). Out of respect for your fellow learners in this class, please refrain from using laptops or mobile phones during lectures.

Academic Integrity

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the General Academic Regulations on Academic Integrity, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalty.

Wellness and Mental Health Support

As a university student, you may experience a range of health and/or mental health challenges that could result in significant barriers to achieving your personal and academic goals. The University of Toronto and the Faculty of Applied Science & Engineering offer a wide range of free and confidential services that could assist you during these times.

As a UofT Engineering student, you have a [Departmental Undergraduate Advisor](#) or a [Departmental Graduate Administrator](#) who can support you by advising on personal matters that impact your academics. Other resources that you may find helpful are listed on the [UofT Engineering Mental Health & Wellness webpage](#), and a small selection are also included here:

- [UofT Engineering's Mental Health Programs Officer](#)
- [Accessibility Services](#) & the [On-Location Advisor](#)
- [Health & Wellness](#) and the [On-Location Health & Wellness Engineering Counsellor](#)
- [Graduate Engineering Council of Students' Mental Wellness Commission](#)
- [SKULE Mental Wellness](#)
- [UofT Engineering's Learning Strategist](#) and [Academic Success](#)
- [Registrar's Office](#) and [Scholarships & Financial Aid Office & Advisor](#)

We encourage you to access these resources as soon as you feel you need support; no issue is too small.

If you find yourself feeling distressed and in need of more immediate support, consider reaching out to the counsellors at [UofT Telus Health Student Support](#) or visiting U of T Engineering's [Urgent Support – Talk to Someone Right Now](#).

Accommodations

The University of Toronto supports accommodations for students with diverse learning needs, which may be associated with mental health conditions, learning disabilities, autism spectrum, ADHD, mobility impairments, functional/fine motor impairments, concussion or head injury, visual impairments, chronic health conditions, addictions, D/deaf, deafened or hard of hearing, communication disorders and/or temporary disabilities, such as fractures and severe sprains, or recovery from an operation.

If you have a learning need requiring an accommodation the University of Toronto recommends that students [register with Accessibility Services](#) as soon as possible.

We know that many students may be hesitant to reach out to Accessibility Services for accommodations. The purpose of academic accommodations is to support students in accessing their academics by helping to remove unfair disadvantages. We can assess your situation, develop an accommodation plan with you, and support you in requesting accommodation for your course work. The process of accommodation is private; we will not share details of your needs or condition with any instructor.

If you feel hesitant to register with us, we encourage you to reach out for further information and resources on how we can support. It may feel difficult to ask for help, but it can make all the difference during your time here. Phone: 416-978-8060; Email: accessibility.services@utoronto.ca

Equity, Diversity and Inclusion

Looking for community? Feeling isolated? Not being understood or heard?

You are not alone. You can talk to anyone in the Faculty that you feel comfortable approaching, anytime – professors, instructors, teaching assistants, [first-year](#) or [upper years](#) academic advisors, student leaders or the Assistant Dean of Diversity, Inclusion and Professionalism.

You belong here. In this class, the participation and perspectives of everyone is invited and encouraged. The broad range of identities and the intersections of those identities are valued and create an inclusive team environment that will help you achieve academic success. You can read the evidence for this approach [here](#).

You have rights. The [University Code of Student Conduct](#) and the [Ontario Human Rights Code](#) protect you against all forms of harassment or discrimination, including but not limited to acts of racism, sexism, Islamophobia, antisemitism, homophobia, transphobia, ableism, classism and ageism. Engineering denounces unprofessionalism or intolerance in language, actions or interactions, in person or online, on- or off-campus. Engineering takes these concerns extremely seriously and you can confidentially disclose directly to the Assistant Dean for help [here](#).

Resource List:

- [Engineering Equity, Diversity & Inclusion Groups, Initiatives & Student Resources](#)
- [Engineering Positive Space Resources](#)
- Request a religious-based accommodation [here](#)
- Email Marisa Sterling, P.Eng, the Assistant Dean, Diversity, Inclusion & Professionalism [here](#)
- Make a confidential disclosure of harassment, discrimination or unprofessionalism [here](#) or email engineering@utoronto.ca or call 416.946.3986
- Email the Engineering Society Equity & Inclusivity Director [here](#)
- [UofT Equity Offices & First Nations House Resources.](#)

University Land Acknowledgement

I wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Learn more about Canada's relationship with Indigenous Peoples [here](#).

Indigenous Students' Supports If you are an Indigenous engineering student, you are invited to join a private Discord channel to meet other Indigenous students, professors, and staff, chat about scholarships, awards, work opportunities, Indigenous-related events, and receive mentorship. Email [Professor Bazylak](#) or [Darlee Gerrard](#) if you are interested.

Indigenous students at UofT are also invited to visit First Nations House's (FNH) Indigenous Student Services for culturally relevant programs and services. If you want more information on how to apply for Indigenous specific funding opportunities, cultural programs, traditional medicines, academic support, monthly social events or receive the weekly newsletter, go to the FNH [website](#), [email](#) or follow FNH on social media: [Facebook](#), [Instagram](#), or [TikTok](#). A full event calendar is on the CLNX platform. Check CLNX often to see what new events are added!