MIE1613H: Stochastic Simulation (Winter 2026)

- **Instructor:** Prof. Vahid Sarhangian, Office: BA8108, Email: sarhangian@mie.utoronto.ca
- **Office hours:** TBD in class
- **Teaching assistant:** Jangwon Park, Email: jangwon.park@mail.utoronto.ca
- **Lectures:** Wedensday, 9AM-12, Room: AB 107

Course description and prerequisites

This course is a graduate level introduction to modelling and analysis of stochastic dynamical systems using computer simulation. The course provides a rigorous yet accessible treatment of the probability and statistical foundations of simulation, and covers programming simulation models in a lower-level language. Throughout the course, concepts and methods are illustrated using various examples from different application areas. In particular, applications to service and financial engineering are emphasized.

More specifically, the following topics are covered:

- **Probability and Statistical Foundations of Simulation**: Law of Large Numbers; Central Limit Theorem; Large Deviation; Statistical estimation of expected value, probability, and quantiles; Quantifying estimation error using confidence intervals; Maximum Likelihood Estimation; Method of Moments; Bootstrap; Bias-Variance tradeoff.
- **Simulation Programming**: Programming discrete-event simulation models using object oriented programming in Python.
- **Simulation Methodology**: Input modelling; Random variate and random number generation; Input uncertainty; Output analysis; Design of experiments; Comparing alternative scenarios; Importance Sampling; Variance Reduction.
- **Simulation Optimization**: Common Random Numbers (CRN); Sample Average Approximation (SAA); Ranking and selection; gradient estimation for continuous simulation optimization.

Students are expected to have a strong background in undergraduate-level probability and statistics, and be familiar with a general purpose programming language. Familiarity with stochastic processes would be helpful but not required. Students are required to use Python for the homework and project.

Textbook and other resources

- Textbook (required):
  - Nelson, Barry, and Pei Linda. *Foundations and methods of stochastic simulation: A first course*. Second edition. Springer Science & Business Media, 2021. (Available online at https://link.springer.com/book/10.1007/978-3-030-86194-0). See also the textbook's website including slides and code: http://users.iems.northwestern.edu/ nelsonb/IEMS435/
- Masterclass: Ranking & Selection for Simulation Optimization by Barry L. Nelson.
  - Available here: http://users.iems.northwestern.edu/ nelsonb/RSMasterclass.html
- Supplementary references:
  - Botev, Z., Keller, A., Lemieux, C., & Tuffin, B. (Eds.). Advances in Modeling and Simulation: Festschrift for Pierre L'Ecuyer, 2022. Springer Nature. (Available online at: https://link.springer.com/book/10.1007/978-3-031-10193-9)
  - Asmussen, Soren, and Peter W. Glynn. *Stochastic simulation: algorithms and analysis*. Springer Science & Business Media, 2007. (Available online at https://link.springer.com)
  - Glasserman, Paul. *Monte Carlo methods in financial engineering*. Springer Science & Business Media, 2003. (Available online at http://library.utoronto.ca)

Evaluation

- 20% Homework (two homework assignments; see table on next page for tentative due dates)
- 30% Project (Assigned by February 1st; Proposal due by March 11; final report deadline to be announced; Presentations on April 1st and if needed April 8th) The project is intended to give you the opportunity to apply the methods and ideas from the course to your own research or application area of interest, or explore other advanced topics in simulation modelling or simulation optimization and/or their integration with other methodologies.
- 10% Quiz (In-class, details to be announced, tentatively on March 18)
- 35% Test (In-class, closed book; tentatively on March 28th)
- 5% Class and Piazza participation

Tentative course schedule

Date	Topic	Homework / Project
Jan 7	Intro. to stochastic simulation	
Jan 14	Simulation examples (1)	
Jan 21	Simulation examples (2)	
Jan 28	Programming in Python Sim	
Feb 04	A framework for simulation modelling and analysis Simulation input - input modelling and estimation	Homework 1 Due
Feb 11	Simulation input - random variate generation	
Feb 18	Reading week (no class)	
Feb 25	Simulation output, Design of simulation experiments	
March 04	Simulation optimization - Intro., CRN, SAA	Homework 2 Due
March 11	Simulation optimization - ranking and selection	Proposals due
March 18	Simulation optimization - gradient estimation	
March 25	Test	
April 1	Student presentations	

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). Please refrain from using laptops or mobile phones during lectures, unless you have prior permission from the instructor.

Generative AI

Students may use artificial intelligence tools, including generative AI, in this course. However, students are ultimately accountable for the work they submit.

- Students may not use artificial intelligence tools for taking tests and quizzes.

- Any content produced by an artificial intelligence tool must be cited appropriately. Many organizations that publish standard citation formats are now providing information on citing generative AI (view the U of T Libraries Citation Guide for Artificial Intelligence Generative Tools).
- Course instructor and the TAs reserve the right to ask students to explain their process for creating their submissions. You will not receive credit for code / content you cannot fully explain.

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.

Accomodations

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 Acknowledgment

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!