

MIE1605H: Stochastic Processes (Fall 2023)

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- **Teaching assistant:** Yaniv Ravid, Email: y.ravid@rotman.utoronto.ca
- **Office hours:** TBD in class.
- **Lectures:** Thursday 9AM-12PM in RS208; First class: September 14th.

Course description and prerequisites

This course is an introduction to stochastic processes with an emphasis on applications to queueing theory and service Engineering. More specifically, the following topics will be covered:

- **Fundamental Methods from Probability Theory and Calculus:** Basic probability theory; Conditional probability and expectation; Bounded, finite, and infinite; Infinite series and limits; Convergence theorems.
- **Discrete-time Markov Chains:** Recurrence and transience; Communicating states and irreducibility; Stationary distributions; Markov chain convergence.
- **Martingales:** Stopping times; Optional stopping theorem; Wald's theorem; Martingale convergence theorem.
- **Brownian Motion:** Construction of Brownian Motion from a random walk; Diffusion processes.
- **Poisson Processes and Continuous-Time, Discrete-Space Markov Processes.** Definition; Construction; and examples.

The concepts and methods will be illustrated using various examples and applications, including:

- **Fundamental Probabilistic Models:** Random walks; Gambler's ruin; Ehrenfest Urn; Branching processes; Markov Chain Monte Carlo (MCMC) algorithms.
- **Financial Applications:** Geometric Brownian Motion; Option pricing in discrete and continuous time.
- **Machine Learning:** Gaussian processes.
- **Queueing Networks and Approximations:** Birth-death queues; Fluid and diffusion approximations of queueing networks.

The course is designed for graduate research students and mathematical rigour is emphasized throughout the course. MEng students require permission from the instructor to enroll in the course (details to be announced on Quercus). Students are expected to have a strong undergraduate (non-measure theoretic) level background in probability at the level of MIE231, STA347, or equivalent, and ideally have some knowledge of real analysis.

Textbook and additional references

Notes will be provided in class. The main reference for the course is:

- J. S. Rosenthal (2019) A first look at stochastic processes. World Scientific Publishing Company, Singapore,

which can be purchased from the [publisher's website](#) or [Amazon.ca](#).

Some of the topics and applications will be based on the following texts, which are also useful sources for supplementary readings.

- R. Durrett (2012) Essentials of stochastic processes. Springer, New York.
- J. S. Rosenthal (2006), A first look at rigorous probability theory. World Scientific Publishing Company, Singapore.
- C. Hong, and D. Yao (2013) Fundamentals of queueing networks: Performance, asymptotics, and optimization. Springer Science & Business Media.

Durrett (2012) is available online on the [publisher's website](#) and [here](#). Additional resources and papers will be posted on the course webpage on Quercus.

Evaluation

- 30% Homework (Three assignments to be assigned after covering each major topic)
- 30% Midterm (Date and time to be confirmed; tentatively on November 2nd)
- 40% Final exam (Date and time to be confirmed; tentatively on December 14th)

Tentative Course Plan

- Introduction and probability review (1 lecture)
- Discrete Markov Chains (4-5 lectures)
- Random walks and Martingales (2 lectures)
- Brownian Motion and diffusion processes (1-2 lectures)
- Poisson processes (1 lecture)
- Continuous-time Markov processes (2 lectures)
- Exact and approximate analysis of queueing networks (1 lecture)

Policies & Statements

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!