STA447H1 S LEC0101/LEC2001
Stochastic Processes (formerly STA348H1)
Winter 2023
Course Outline

Lecture Times:

Wednesday	10:00 AM-11:00 AM	Room : $SF1150$
Friday	10:00 AM-12:00 PM	Room : $SF1150$

Instructor: Omidali Aghababaei Jazi

Office Location: -

E-mail Address: omid.jazi@utoronto.ca

Office Hours: Friday 1:00-3:00 PM, **Room:** TBD

Course Website: https://q.utoronto.ca/courses/296836

Course Description: Discrete and continuous time processes with an emphasis on Markov, Gaussian and renewal processes. Martingales and further limit theorems. A variety of applications taken from some of the following areas are discussed in the context of stochastic modeling: Information Theory, Quantum Mechanics, Statistical Analyses of Stochastic Processes, Population Growth Models, Reliability, Queuing Models, Stochastic Calculus, Simulation (Monte Carlo Methods).

Prerequisite: STA347H1/ MAT377H1/ STAC62H3
Exclusion: STA348H5, STAC63H5
Distribution Requirements: Science
Breadth Requirements: The Physical and Mathematical Universes (5)
Mode of Delivery: In Class

Students who lack a pre/co-requisite can be removed at any time unless they have received an explicit waiver from the department.

Delivery Mode: This course is to be delivered **in person** as specified on the University Timetable Builder website. In case there is any change in the mode of delivery, the details will be announced on the course website.

Textbook A First Look at Stochastic Processes, by J.S. Rosenthal, 2019.

Additional Resources

- Introduction to Stochastic Processes, 2nd Edition, by Gregory F. Lawler, 2006.
- Essentials of stochastic processes, 3rd Edition, by Rick Durrette, 2016.

Assessments: Your final grade will be based on the following assessments

Type	Due Date	Weight
Assignments	Four Assignments (Crowdmark-Ongoing)	20%
Term Test	Friday, Mar. 3rd, 10:00 AM-12:00 PM (in-person)	25%
Final Exam	April (TBA)	55%

Assignments: There will be 4 assignments that must be completed individually. They are opportunities to practice and receive feedback on problems. Assignments must be submitted through Crowdmark, meaning you need to upload PDF, PNG or JPEG versions of your assignment solutions. Students are supposed to solve **ALL** questions. However, **NOT** all the questions will be marked. Submission via other methods such as email or Quercus will **NOT** be accepted. Late submissions (within 12 hours after a due date) will receive a penalty of 5% per hour. Requests for a deadline extension will be granted under extenuating circumstances. Other details about each assignment will be posted on Quercus.

Term Test: The term test will be held **in-person** on Friday, March 3rd, 10:00 AM-12:00 PM in room SF 1150. Other details such as the content will be announced on Quercus approximately a week before the test.

Final Exam: The final exam will be in-person, last 3 hours, and from the entire material. The exact date and time will be determined and scheduled by the Office of the Registrar.

Missed Term Work Policy: Missed assignments earn a mark of zero. Regarding the term test, there is no make-up test for missed term test. The weight of missed term test with legitimate reasons such as sickness will be shifted to the final exam. In order for this shift to be possible, students must declare their absence on ACORN on the day of the test or the day after at the latest. Other details are available in the **Absence Declaration** section.

Missed Final Exam Policy: If a student cannot attend the final exam, then they should submit a petition for a deferred exam.

Absence Declaration: The *Verification of Illness* (also known as a "doctor's note") is temporarily not required. Students who are absent from academic participation for any reason (e.g., COVID, cold, flu and other illness or injury, family situation) and who require consideration for missed academic work should report their absence through the online absence declaration. The declaration is available on ACORN under the Profile and Settings menu. For update check University policy for absence declaration. Students should also advise their instructor of their absence. Instructors will not be automatically alerted when a student declares an absence. It is a student's responsibility to let instructors know that they have used the Absence Declaration so that you can discuss any needed consideration, where appropriate. Some instructors may ask their department to confirm absences reported by students to ensure that they have been entered into the system on the dates indicated by a student.

Re-Marking Policy: The course re-mark policy exists to correct mistakes, and any request should clearly identify the error (for example, a question that was not marked, or a total incorrectly calculated). Requests to correct such mistakes must be sent by email to the instructor. Before you request for a re-mark, please make sure you know the correct solutions posted in Quercus. To be considered for a re-mark,

- the email should include student's full name and ID number, and give a specific, clear, and concise reason for each request, referring to a possible error or omission by the marker.
- students should make such requests as soon as reasonably possible after receiving the work back, but no later than 2 weeks after it was returned.

Note that if a student requests for a re-mark, the entire assignment may be re-marked. So, the new grade may go up or down, or remain the same.

Piazza: Piazza will be used for discussions. This is for student-led discussion. The instructor and the TAs will check Piazza posts on a regular basis and might participate in discussions. Please do not email questions about course content to the instructor/TAs. Instead, post your question on Piazza. Volume of messages increases one or two days before the test. It will not be possible for the instructor and/or the TAs to answer the questions.

Practice Problems: A list of practice problems will be posted on Quercus which will be essential to your understanding of the topics covered in class. You are encouraged to work together in groups on practice problems to solidify your knowledge of the material. You are also encouraged to ask your questions during the instructor/TA's office hours and on Piazza.

Academic Integrity: Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, U of T treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters outlines behaviours that constitute academic dishonesty and the process for addressing academic offences. Potential offences include, but are not limited to:

In papers and assignments:

1. Using someone else's ideas or words without appropriate acknowledgement.
2. Submitting your own work in more than one course, or more than once in the same course, without the permission of the instructor.
3. Making up sources or facts.
4. Obtaining or providing unauthorized assistance on any assignment.

On tests and exams:

1. Using or possessing unauthorized aids.
2. Looking at someone else's answers during an exam or test.
3. Misrepresenting your identity.

In academic work:

1. Falsifying institutional documents or grades.

2. Falsifying or altering any documentation required, including (but not limited to) doctor's notes.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources.

Plagiarism Detection

Normally, students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation website. Students may wish to opt out of using the plagiarism detection tool. In order to opt out, contact your instructor by email no later than two (2) weeks after the start of classes. If you have opted out, then specific information on an alternative method to submit your assignment can be found below.

Email Policy: Email is most appropriate for personal questions. Before you send an e-mail, make sure that you are not asking for information that is already on the course outline/ website/announcements, or questions about the course material that are more appropriately discussed during office hours. If you do not get a response, this may be why. If your question is conceptual and does not require calculations or an elaborate answer, you can ask by email. For all other matters, contact the instructor. Please email the instructor and TAs using your U of T email address. The subject line should contain the course number, lecture section number, and a relevant subject (indicating what the email is about). Be sure to include your full name and student number in the body of the message. You will not get a response if you email from other email addresses or do not follow the email policy.

Privacy and Use of Course Materials Notifications: Course materials belong to your instructor, the University, and/or other source depending on the specific facts of each situation and are protected by copyright. In this course, you are permitted to download session materials for your own academic use, but you should not copy, share, or use them for any other purpose without the explicit permission of the instructor. For questions about recording and use of videos in which you appear please contact your instructor.

Accessibility Needs: The University of Toronto is committed to accessibility. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom, or course materials, please contact Accessibility Resource Center as soon as possible.

Student Responsibilities:

- It is up to students to know all course policies and important dates. It is also up to them to know about any important announcements; these will come to their inbox. Check Quercus regularly!
- Students are responsible for their own learning. The instructor/TAs are happy to help you learn, but in the end it is up to you! Use office hours and Piazza often. Make an appointment with the instructor. Keep asking questions until you are satisfied. Ask about big concepts or small details there is no such thing as a stupid question. Always take advantage of extra help and don't wait until it is too late!

- Students must follow the U of T code of Behaviour this means that cheaters will be prosecuted. The Academic Regulations of the University are outlined in the Code of Behaviour on Academic Matters. You are expected to be familiar with, and to abide by, all components of the Code of Behaviour on Academic Matters. Full details can be found here.

Instructor/TAs Responsibilities:

- Lectures will be clearly presented, organized, and have plenty of examples.
- Office hours and Piazza can help studnets solve problems and solidify their learning.
- Extra help, remedial and acceleration are always available during office hours, by appointment, and by email.
- Students emails will be answered in a timely fashion, typically within 48 weekday (business) hours.
- Every student will be treated with fairness and respect. Students who wish to excel are encouraged to consult regularly with the instructor. Students who abuse the U of T code of behavior will be dealt with appropriately.

Course Topics: This course plans to cover the following topics from the textbook.

Chapter 1: Markov Chain Probabilities
- 1.1 - First Example: The Frog Walk
- 1.2 - Markov Chain Definitions
- 1.3 - Examples of Markov Chains
- 1.4 - Multi-Step Transitions
- 1.5 - Recurrence and Transience
- 1.6 - Communicating States and Irreducibility
- 1.7 - Application - Gambler's Ruin

Chapter 2: Markov Chain Convergence
- 2.1 - Stationary Distributions
- 2.2 - Searching for Stationarity
- 2.3 - Obstacles to Convergence
- 2.4 - Convergence Theorem
- 2.5 - Periodic Convergence
- 2.8 - Mean Recurrence Times

Chapter 3: Martingales
- 3.1 - Martingale Definitions
- 3.2 - Stopping Times and Optional Stopping
- 3.5 - Martingale Convergence Theorem
- 3.6 - Application - Branching Processes

Chapter 4: Continuous Processes
- 4.1 - Brownian Motion
- 4.3 - Poisson Processes
- 4.4 - Continuous-Time, Discrete-Space Processes
- 4.5 - Application - Queueing Theory

- 4.6 - Application - Renewal Theory
- 4.7 - Continuous-Space Markov Chains
- 4.8 - Application - MCMC Algorithms (continuous) (If time permits)

Lecture Schedule: This schedule is tentative and subject to change. Updates will be posted on Quercus.

Weeks	chapter	Course Topics
Week 1 (Jan. 09 - 13)	1	Finite MC: Introduction (Definitions & Examples), Multi-step Transitions
Week 2 (Jan. 16 - 20)	1	Classification of States (Transience and Recurrence), Irreducibility
Week 3 (Jan. 23 - 27)	1	Aperiodicity, Hitting Time, Gambler's Ruin
Week 4 (Jan. 30 - Feb. 03)	1	Countable MC, Recurrence (Null, Positive)
Week 5 (Feb. 06 - 10)	2	Finite MC: Convergence to Stationary Distributions
Week 6 (Feb. 13 - 17)	2	Countable MC: Convergence to Stationary Distributions, Mean Recurrence Times
Feb. 20-24		**Reading Week**
Week 7 (Feb. 27 - Mar. 03)	3	Martingales: Definitions & Examples, Stopping Times and Optional Stoppoing
Week 8 (Mar. 06 - 10)	3	Martingale Convergence Theorem, Branching Processes
Week 9 (Mar. 13 - 17)	4	Introduction, Brownian Motion
Week 10 (Mar. 20 -24)	4	Poisson Processes, Discrete-Space Processes
Week 11 (Mar. 27 - 31)	4	Queuing Theory, Renewal Theory
Week 12 (Apr. 05 & 10)	4	Continuous-space MC, MCMC Algorithm (if time permits)

Term Work Schedule: This schedule is tentative and subject to change. Updates will be posted on Quercus.

Term Work	Availability & Deadlines	Content
Assignment 1	Fri. Jan. 20th, 9:00 AM - Sun. Feb. 5th, 11:59 PM	MC Probabilities
Assignment 2	Mon. Feb. 6th, 9:00 AM - Sun. Feb. 19th, 11:59 PM	MC Convergence
Term Test	Friday March 3, 10:00 AM- 12:00 PM, Room SF1150	TBA
Assignment 3	Mon. Feb. 27th, 9:00 AM - Sun. Mar. 12th, 11:59 PM	Martingales
Assignment 4	Mon. Mar. 20th, 9:00 AM - Fri. Apr. 7th, 11:59 PM	Continuous Processes