University of Toronto Department of Statistical Sciences
ACT460 – Stochastic Methods for Actuarial Science and Finance
Fall 2023

Instructors:
Anthony Coache (anthony.coache@mail.utoronto.ca) and
Emma Kroell (emma.kroell@mail.utoronto.ca)

TA: Hassan Abdelrahman (hassan.abdelrahman@mail.utoronto.ca)

Lectures: Tuesdays, 2 to 5 pm, in-person

Office hours
Office hours will be held on Zoom. Details and the schedule will be provided once the course begins.

Course description
This course covers the mathematical theory, probabilistic tools and computational approaches for estimation and modeling in actuarial sciences and financial engineering. Topics include financial derivatives, continuous-time stochastic processes, Itô's Lemma and stochastic calculus, Monte-Carlo methods, variance reduction techniques, sensitivity estimation, and applications related to actuarial sciences and financial engineering. About half of the course focuses on the theory behind continuous-time models, and the other half focuses on Monte-Carlo methods and simulation techniques. Prerequisites to this course are ACT350 or STA347 (or their equivalent). ACT370 is strongly recommended. In addition, you should be comfortable with probability theory and Python.

Course details
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 Quercus.

Course communication
Students are expected to check Quercus regularly to stay up to date with the course. Having Quercus announcements delivered immediately to you via email is recommended.

Questions about the course material and assessments may be posted to Piazza. Before you post a question, please, make sure that you are not asking for information that is already on the course outline/Quercus/Piazza, nor asking questions about the course material that are more appropriately discussed during office hours. You should expect a response to your question in 1-2 business days.

For personal matters only, such as a missed quiz or test due to illness, please email the instructors directly using your U of T email address. The email subject line should contain the course number "ACT460" and a relevant subject (indicating what the email is about). Be sure to include your full name in the body of the message.

Textbooks
An Introduction to the Mathematics of Financial Derivatives, Hirsa and Neftci, 3rd edition. Available for UofT students here.
Monte Carlo Methods in Financial Engineering, Glasserman. Available for UofT students here.

Additional resources:
Options, Futures, and Other Derivatives, John C. Hull, 10th edition (background on financial markets).
Arbitrage Theory in Continuous Time, Thomas Björk, 4th edition (more mathematical details).

Course evaluation
Your final grade will be based on the following assessments:

Assessment	Weight	Details
5 quizzes	20%	Quercus quizzes approximately bi-weekly, 4% each
Test 1	20%	Start of class Oct. 3
Test 2	30%	Start of class Nov. 14
Final Project	30%	Due on Dec. 12

Quizzes
There will be 5 multiple choice quizzes of 30-60 minutes each, done online on Quercus. Each quiz, which can be completed at any time over the course of 4 days, is worth 4% of the final grade. The tentative quiz schedule is during the weeks 1, 2, 5, 7, and 10.

Term Tests
There will also be 2 in-person tests. The first test will be 60 minutes in length and worth 20% of your final grade. The second test will be 90 minutes in length and worth 30% of your final grade. Tests will take place during the classes of weeks 4 and 9. Quizzes and tests are individual and will be based on the content taught in the previous few lectures. The specific content being assessed will be announced ahead of time.

Final Project
Finally, there will be one take-home final project, worth 30% of the final grade. The final project, done in groups of 3-4 students, will require you to formulate an approach to the problem, implement it in Python, interpret the results, and write up a short report. Reports should be written in proper academic English and contain an introduction, description of the methodology/theory, and interpretation of the results. Your final project will be evaluated based on the executability of your code, the correctness of the approach, and the presentation of your report. The final project will require assimilation of multiple concepts throughout the term.

Missed Assessments
Quizzes
Because you can complete quizzes any time over the course of 5 days, adjustments will only be made for missed quizzes in very exceptional circumstances.

Term Tests
If you miss a term test for a valid reason, you must **notify the instructors via email within 48 hours of the missed examination**. In addition, you must declare your absence to the University using the Absence Declaration area in ACORN. A single make-up test will be offered for students who miss either term test. The make-up test will cover material from both term tests and will be held in late November.

Final Project
Late projects will be penalized 10% of the maximum grade for every part of a 24-hour period that it is late.

Grading questions and regrade requests

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 instructors. To be considered for a re-mark:

- the email should include the 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(s).
- 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, go down or remain the same.

Tentative Course Schedule

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

Week	Date	Content	Readings
1	Sep. 11 – 15	Review of financial derivatives, arbitrage pricing	H&N, ch 1, 2, 4
2	Sep. 18 – 22	Review of probability theory; martingales	H&N, ch 5, 6
3	Sep. 25 – 29	Stochastic processes	H&N ch 7, 8
4	Oct. 2 – 6	**Test 1**; the Itô integral	H&N ch 9
5	Oct. 9 – 13	Itô's Lemma; SDEs	H&N ch 10, 11
6	Oct. 16 – 20	Black-Scholes pricing formula; dynamic hedging	H&N ch 12, 13
7	Oct. 23 – 27	Review of Python; Monte-Carlo estimation; inverse transform method; acceptance-rejection method.	Glasserman, ch 2
8	Oct. 30 – Nov. 3	Review of stochastic processes; Brownian bridge; jump-diffusion models; discretization schemes	Glasserman, ch 3, 6
Reading week	Nov. 6 – 10	No class this week	
9	Nov. 13 – 17	**Test 2**; finite-difference approximation; pathwise derivative estimates; likelihood ratio method	Glasserman, ch 7
10	Nov. 20 – 24	Control variates; stratified sampling; importance sampling	Glasserman, ch 4
11	Nov. 27 – Dec. 1	Applications in risk management: e.g. loss probability with variance reduction; default times in credit risk; pricing of American options; neural nets and GARCH models	Glasserman, ch 8, 9
12	Dec. 4 – 8	Applications (cont'd)	

Academic Integrity

Academic integrity is fundamental to learning and scholarship at the University of Toronto. As a result, U of T treats cases of cheating and plagiarism very seriously. Please read the University of Toronto's Code of Behaviour on Academic Matters available at http://www.governingcouncil.utoronto.ca/policies/behaveac.htm.

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, please reach out to us. Note that you are expected to seek out additional information on academic integrity from other institutional resources (for example, the University of Toronto website on Academic Integrity).

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 the Accessibility Resource Center as soon as possible.

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