Department of Mathematics & Statistics
Concordia University

STAT 461 (MAST 729/MAST 881) Sec. G

Statistical Simulation

Winter 2021

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Preface: **Due to exceptional circumstances, this course will be taught, and all assessments will be done completely ONLINE. Given the subject matter and nature of this course, exams, including the class tests and/or the final exam will be given online through the Concordia Online Exams (COLE) platform. For more details read the ADDENDUM at the end of this course outline.**

Office Hours: Your professor will announce his office hours during which he will be also available to give a reasonable amount of help. The office hours will be held over Zoom and one can also send questions via email. **Note that the system does not allow one to reply to an email sent from Moodle. Thus, emails should be sent from one's own emailer, not Moodle.** Note, however, that if you missed a class it is not reasonable to expect your professor to cover the missed material for you.

Text: *Simulation*, 5th Edition, by Sheldon M. Ross (Academic Press): *available for download as e-book on Library website via Concordia Netname log in*.

Objectives: This course is an introduction to the methods of *simulation* and the *Monte Carlo* techniques. In Simulation, we consider joint distributions of random variables, and more generally, stochastic models describing systems in economy, industry, insurance etc., which essentially are specifications of complex joint distributions; we then *generate* (pseudo) values of those variables using appropriate algorithms to study the models. Monte Carlo techniques are statistical methods for estimating, based on repeated simulations, various quantities of interest related to the models, which are difficult to compute theoretically. In Part I of the course, we shall review basic probability theory and study methods for generating random variables. In Part-II we shall study simulation of a few complex systems and their estimation using Monte Carlo methods.

Assignments: There will be 4 or 5 assignments, to be posted on, and returned via, Moodle. Most of the assignments will involve use of the software **R** that will be demonstrated during one or two classes. A freely downloadable student version can be found at http://www.r-project.org. A useful reference is the book, *A first course in statistical programming with R*, 2nd Edition, by W. John Braun and Duncan J. Murdoch (Cambridge University Press).

There will be a few separate questions for undergraduate and graduate students in the assignments and exams.

Midterm Test: There will be one midterm test, based on the material of Weeks 1-6, which will contribute up to 30% to your final grade (see the Grading Scheme below). Missed tests cannot be made up. The midterm test will be held in ***week of 22–28 February 2021*** via the COLE platform (See Addendum). This test will be held during online lecture time.

NOTE: It is the Department's policy that tests missed for any reason, **including illness,** cannot be made up. If you miss the midterm test because of illness (***medical note required***) the final exam will count for 85% of your final grade, and the assignments will count for the remaining 15%.

Final Exam: The final examination will be given online via COLE. This exam will be two hours long and will cover all the material in the course.

NOTE: Students are responsible for finding out the date and time of the final exams once the schedule is posted by the Examinations Office. Conflicts or problems with the scheduling of the final exam must be reported directly to **the Examinations Office**, **not to your instructor**. It is the Department's policy and the Examination Office's policy that students must be available to take the final exam on the selected date and time. Conflicts due to travel plans will not be accommodated.

Final Grade:

a) Assignments (15%)
b) Midterm test (30%)
c) Final examination (55%)

If the grading scheme for this course includes graded assignments, a reasonable and representative subset of each assignment may be graded. Students will not be told in advance which subset of the assigned problems will be marked and should therefore attempt all assigned problems.

IMPORTANT: **PLEASE NOTE THAT THERE IS NO "100% FINAL EXAM" OPTION IN THIS COURSE.**

Weeks	Chapters
1	**Chapter 2: Elements of Probability** Sample Space and Events Axioms of Probability Conditional Probability and Independence Random Variables Expectations Variance Chebyshev's Inequality and the Laws of Large Numbers
2 & 3	**Chapter 2: Elements of Probability** Some Discrete Random Variables Continuous Random Variables Conditional Expectation and Conditional Variance **Chapter 3: Random Numbers** Introduction to R Pseudorandom Number Generation Using Random Numbers to Evaluate Integrals
4 & 5	**Chapter 4: Generating Discrete Random Variables** The Inverse Transform Method Generating a Poisson Random Variable Generating Binomial Random Variables The Acceptance-Rejection Technique The Composition Approach The Alias Method of Generating Discrete Random Variables Generating Random Vectors
6 & 7	**Chapter 5: Generating Continuous Random Variables** Introduction The inverse Transform Algorithm The Rejection Method The Polar Method for Generating Normal Random Variables Generating a Poisson Process **Mid-Term Test**
8 & 9	**Chapter 5: Generating Continuous Random Variables** Generating a Nonhomogeneous Poisson Process Simulating a Two-Dimensional Poisson Process **Chapter 7: The discrete Event Simulation Approach** Introduction Simulation via Discrete Events A Single-Server Queueing System A queueing System with Two Servers in Series A queueing System with Two Parallel Servers An Inventory Model An Insurance Risk Model

10 & 11	**Chapter 7: The discrete Event Simulation Approach** A Repair Problem Exercising a Stock Option Verification of the Simulation Model **Chapter 8: Statistical Analysis of Simulated Data** Introduction The Sample Mean and Sample Variance Interval Estimates of a Population Mean The Bootstrapping Technique for Estimating Mean Square Errors
12 & 13	**Chapter 9: Variance Reduction Techniques** Introduction The Use of Antithetic Variables The Use of Control Variates Variance Reduction by Conditioning Stratified Sampling Applications of Stratified Sampling Importance Sampling

Academic Integrity and the Academic Code of Conduct
This course is governed by Concordia University's policies on Academic Integrity and the Academic Code of Conduct as set forth in the Undergraduate Calendar and the Graduate Calendar. Students are expected to familiarize themselves with these policies and conduct themselves accordingly. "Concordia University has several resources available to students to better understand and uphold academic integrity. Concordia's website on academic integrity can be found at the following address, which also includes links to each Faculty and the School of Graduate Studies: concordia.ca/students/academic-integrity." *[Undergraduate Calendar, Sec 17.10.2]*

Behaviour
All individuals participating in courses are expected to be professional and constructive throughout the course, including in their communications.

Concordia students are subject to the Code of Rights and Responsibilities which applies both when students are physically and virtually engaged in any University activity, including classes, seminars, meetings, etc. Students engaged in University activities must respect this Code when engaging with any members of the Concordia community, including faculty, staff, and students, whether such interactions are verbal or in writing, face to face or online/virtual. Failing to comply with the Code may result in charges and sanctions, as outlined in the Code.

Intellectual Property
Content belonging to instructors shared in online courses, including, but not limited to, online lectures, course notes, and video recordings of classes remain the intellectual property of the faculty member. It may not be distributed, published or broadcast, in whole or in part, without the express permission of the faculty member. Students are also forbidden to use their own means of recording any elements of an online class or lecture without express permission of the instructor. Any unauthorized sharing of course content may constitute a breach of the Academic Code of Conduct and/or the Code of Rights and Responsibilities. As specified in the Policy on Intellectual Property, the University does not claim any ownership of or interest in any student IP. All university members retain copyright over their work.

Extraordinary circumstances
In the event of extraordinary circumstances and pursuant to the Academic Regulations the University may modify the delivery, content, structure, forum, location and/or evaluation scheme. In the event of such extraordinary circumstances, students will be informed of the change.

Addendum:

This course will be taught and all assessments will be completely online. A midterm and/or a final online exam will be provided through the Concordia Online Exams (COLE) platform More information about the COLE system may be found at the COLE website.

Please note the following with respect to online exams:

- That the exam will take place during the exam period at the designated date and time set by the professor (midterm) or the Exams office (final). All exam times will be set to Eastern Standard/Daylight Time.
- That you are very **strongly recommended** to enter the virtual test site found at the COLE website and become familiar with the software that will be used for your exam before starting the exam.
- That you will need a quiet place within which to take the exam. Earplugs or noise-cancelling headphones that are not connected to a device may also be used to allow you to focus for the duration of the exam.

Students who are unable to write an exam because they are unable to meet the above conditions and requirements are advised that they will need to drop the course. More information can be provided on the next offering of this course by consulting the Department. Students are advised that the drop deadline (DNE) for this course is **January 26, 2021**.

Students who require additional accommodations for their exams due to a documented disability should contact the Access Centre for Students with Disabilities as soon as possible (acsdinfo@concordia.ca).

If you face issues during the exam, you should inform your professor of those issues immediately. Please note that there are in-exam supports you should spend time getting to know. Visit the COLE website for more information.