Department of Mathematics & Statistics
Concordia University

STAT 461
Statistical Simulation
Summer 2022

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Office Hours: Thursdays, 11:00-13:00.

Text: *Simulation*, 5th Edition, by Sheldon M. Ross (Academic Press).

Objectives: This course is an introduction to the methods of *simulation* and the *Monte Carlo* techniques. Simulation consists of formulating a suitable statistical model for a given system (in economy, industry, insurance, etc.) in terms of appropriate random variables and their (joint) distributions, and generating values of those variables on a computer to see how the system works. Monte Carlo techniques are statistical methods for estimating various quantities of interest for the system, based on repeated simulations, which are difficult to compute theoretically based on the model. In Part I of the course we shall review basic probability theory and study methods for generating (pseudo) 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 3 or 4 assignments. Most of the assignments will involve use of the software–*R* that will be demonstrated during one class. R is installed on the PCs in the Department's Computer Lab, and a freely downloadable student version can be found at http://www.r-project.org. 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 lectures 1-6, which will contribute up to 25% to your final grade (see the **Grading Scheme** below). Midterm test will be held on **Monday, July 18, 2022, in class.** This exam, as well as the final, will be closed book exams.

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 three hours long and will cover all the material in the course. In order to obtain a good grade, the student **MUST** show that she/he has a THOROUGH understanding of the subject.

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 (25%)
c) Final examination (60%)

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.**

Lectures	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]*

Use of Zoom

Zoom is included as an institutionally-approved technology. This means we have been assured of the privacy protections needed to use freely within the classroom)

Zoom may be used in this course to facilitate learning at a distance. It may be used to record some or all of the lectures and/or other activities in this course. If you wish to ensure that your image is not recorded, speak to your instructor as soon as possible.

Also, please note that you may not share recordings of your classes and that the instructor will only share class recordings for the purpose of course delivery and development. Any other sharing may be in violation of the law and applicable University policies, and may be subject to penalties.

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.