

## 21-366 : Topics in Applied Mathematics - Monte Carlo Simulation

Fall 2014

**Instructor:** Scott Robertson

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**Course Website:** On Blackboard *www.cmu.edu/blackboard*

**Lectures:** Monday, Wednesday, Friday: 10 : 30 AM - 11 : 20 AM in Wean Hall 4709.

**Prerequisites :** 21-325 (Probability) or 21-420 (Continuous Time Finance) or 36-410 (Probability Models).

### Primary Textbook:

*Simulation*, 5<sup>th</sup> edition

Sheldon Ross

Academic Press

ISBN-13: 978-0124158252

### Additional Textbook:

*Monte Carlo Methods in Financial Engineering*

Paul Glasserman

Springer

ISBN-13: 978-0387004518

**Office Hours:** Monday 9:00 AM - 10:00 AM, Thursday 12:00 PM - 1:00 PM and/or by appointment.

**Grading:** The course grade is determined as follows:

Midterm Exam : 30%      Final Exam/Project : 30%      Homework : 40%

**Homework:** There will be 6-8 homework assignments (roughly one assignment every two weeks). Homework is due at the beginning of class on the assigned due date. This includes electronic homework submissions (e.g. computer programs) which must be uploaded to Blackboard prior to the beginning of class on the due date. Collaboration is allowed when completing homework assignments, however any submitted work must be essentially your own. Homework submissions which appear suspiciously similar will not be accepted. Late homework will also not be accepted.

**Exams** The mid-term exam will take place in class on Wednesday, October 15th. The final exam will take place during finals week at the end of the semester. In addition to the final exam, there will be a final project which is essentially an additional homework assignment, with the main difference being that you will not be able to collaborate with other students when completing the assignment. Exams are closed notes, closed text-book, etc.

**Makeup Classes** I will be unable to lecture on Friday October 31 and Friday November 7. Since we cannot afford to miss these two lectures, makeup lectures will be given. Tentatively, these lectures are to take place on Saturday November 1 and Saturday November 8 respectively. Further details, including lecture times and locations, will be given in class as we approach the dates.

**Course Objectives :** In this class, students will learn:

- The basics of Monte Carlo simulation : sampling random variables, taking averages, estimating confidence intervals, etc.
- How to simulate sample paths of stochastic processes: in particular Brownian motion and the Poisson process. Sample path simulation will be used to solve problems in financial engineering and queuing theory.
- To develop variance reduction techniques in order to improve simulation performance.
- The basics of Markov chain Monte Carlo methods : Hastings/Metropolis algorithms, Gibbs sampling and more.
- To run simulations using Matlab.

### **Course Outline**

- Generating random variables : inverse transform method, acceptance-rejection method, Box-Muller, etc.
- Simulating sample paths of stochastic processes : Brownian motion, homogeneous and non-homogeneous Poisson processes.
- Applications of Monte Carlo methods to Financial Engineering : modeling asset price dynamics and derivatives pricing.
- Applications of Monte Carlo methods to discrete event systems : basic models of queuing networks.
- Statistical analysis of data : sample mean, sample variance, bootstrapping techniques.
- Variance reduction techniques : antithetic variables, control variates, conditioning, importance sampling, etc.
- Statistical validation of data : goodness of fit tests.
- Markov chain Monte Carlo methods : Hastings/Metropolis sampler, Gibbs sampling, simulated annealing.
- (Tentatively) Simulation for Large Data Sets with Applications to Finance : Statistical Arbitrage, High Frequency Trading.