IEOR E703: Monte-Carlo Simulation (Spring 2017)
Syllabus and Course Logistics

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Course Website: All material will be posted on Columbia CourseWorks.

Class Time: Tuesdays and Thursdays 11.40am - 12.55pm.

Students should **arrive on time** and the use of cell-phones and laptops **will not be permitted** except for running specific course-related applications. Students may be **cold-called** regularly to answer questions in class.

Prerequisites This is a core MS course for MS students in Financial Engineering and so the pre-requisites for the course are the core courses from the first fall semester in the MSFE program.

Textbooks: There is no required textbook for the course as the lecture notes will be sufficient. For those who wish to consult textbooks excellent references include:

1. *Simulation* (Academic Press) by Sheldon M. Ross.
2. *Introducing Monte Carlo Methods with* `R` (Springer) by Christian Robert and George Casella. This is free to download from the Columbia network at `http://link.springer.com/book/10.1007/978-1-4419-1576-4`.

More advanced / Ph.D level textbooks include

1. *Monte Carlo Methods in Financial Engineering* (Springer) by Paul Glasserman. This is free to download from the Columbia network at `http://link.springer.com/book/10.1007/978-0-387-21617-1`.
2. *Monte Carlo Statistical Methods* (Springer) by Christian Robert and George Casella. This is also free to download from the Columbia network at `http://link.springer.com/book/10.1007/978-1-4757-4145-2`.
3. *Handbook in Monte Carlo Simulation: Applications in Financial Engineering, Risk Management, and Economics* (Wiley) by Paolo Brandimarte.

Assignments
There will be $n = 8$ or $n = 9$ assignments and students will be asked to complete $n-1$ of

them. Of these n assignments, approximately $m = 6$ of them will be compulsory. Students will then need to complete an additional $n-m-1$ assignments from the remaining $n-m$. Students are welcome to work together on the assignments but each student **must** write up his or her own solution and write their own code. Any student that submits a copy (or partial copy) of another student's solution will receive zero for that assignment and may receive an F grade for the entire course. Late assignments will **not** be accepted!

Exams
The course will have both a mid-term and final exam. Any student who is unable to take an exam must have a very good reason for doing so, e.g., a medical emergency. Such students will take a makeup exam that will be **more difficult** than the regular exam. They will also need to obtain approval from the Dean's office to take such an exam. Exam regrades may be requested by:

1. Explaining in a written statement why you think you should obtain additional points.

2. Submitting this statement and the exam to either the TA or one of the course instructors no later than one week after the exam was returned to the class. (This means that if you failed to collect your exam within a week of it being returned to the class, then you cannot request a regrade!)

It should be kept in mind that when a regrade is requested the entire exam will be regraded and it is possible that your overall score could go down as well as up. **We will also photocopy a subset of the exams before returning them to the class.** This is intended to deter the very few people (hopefully there are no such people in this class!) who might be tempted to rewrite parts of their exams before requesting a regrade.

Grading
A *tentative* grading scheme is: Assignments 20%, Midterm 35%, Final 45% but I do reserve the right to deviate from this scheme if necessary.

Tentative Syllabus

1. Generating random variables and stochastic processes. (1.5 weeks)

2. Output analysis. (0.5 weeks)

3. Basic variance reduction methods including common random variables, antithetic variates, control variates and conditional Monte-Carlo. (2 weeks)

4. Further variance reduction methods including importance sampling and stratified sampling. (2 weeks)

5. Simulating stochastic differential equations (SDEs) and multilevel sampling. (1 week)

6. Estimating the Greeks via Monte-Carlo. (1 week)

7. Markov Chain Monte-Carlo methods including Metropolis-Hastings and Gibbs sampling. (2.5 weeks)

8. A brief introduction to other Monte-Carlo topics including (possibly)

   (a) Information-relaxation based duality for optimal control problems

   (b) Quasi Monte-Carlo and low discrepancy sequences (LDS)

   (c) Optimization via Monte-Carlo

   (d) Coupling from the past

   (e) Particle filtering.

   (2 weeks)

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