**MATH 611: Stochastic Simulation (Fall 2016)**

**Course Information and Syllabus**

**Instructor:** Elena Rantou, Ph.D.

St. Mary’s Hall, 3rd floor

**Lecture:** Thursdays, 6:30 – 9:00 pm (St. Mary’s 107)

**Office hours:** Thursdays, 5:30 – 6:30 pm and by appointment

(Email is the best way to reach the instructor)

**Main Text:** Introducing Monte Carlo Methods with R,

By Christian P. Robert and George Casella, Springer

**Other Texts / Resources:** Computational Statistics   
by Geoff H. Givens, Jennifer A. Hoeting   
Wiley; 2 edition

Essential of Stochastic processes by Richard Durrett,

Springer; Second Edition

**Prerequisites:** Math-501, Math-503, Math-510

**Course Overview and Goals:**

This course is an introduction to Monte Carlo methods and computer modeling of stochastic systems. Monte Carlo topics that we will cover include random variable generation, expectation estimation with confidence interval formation, importance sampling, stochastic optimization, MCMC algorithms and sampling of Brownian motion. In developing these topics we will emphasize their role both in statistical inference and modeling. This course will also introduce the students to some fundamental stochastic processes such as discrete state Markov chains, Poisson processes, and Brownian motion; as well as an array of important stochastic models. Computer programming will be a central part of this course.

Tentatively, the following topics will be discussed during the semester:

Stochastic Processes:

* Queues
* Definition of a stochastic process
* Introduction to Markov Chains

(Absorbing states, random walk, birth and death model)

* Irreducible Markov Chains
* Stationary distributions
* Recurrent Markov Chains
* Poisson processes

(Renewal processes, martingales, Brownian motion)

Statistical Computing / Monte Carlo Simulation:

* LLN and CLT
* Monte Carlo integration estimate and confidence interval
* Random variable generation (Logistic, Beta, Gamma, t, Box-Muller, Accept-Reject methods)
* Intro to inference (Review of Math-503)
* Newton’s methods
* K-means
* EM algorithm
* MCMC (Metropolis-Hastings, Gibbs sampling)
* Bootstrap and randomization tests
* Nonparametric density estimation and smoothing (???)

**Course Organization:**

1. **Lecture:** Class time will be divided into two parts; one will be about theory of stochastic processes and models and the other one will be about statistical computing and Monte Carlo simulation. Concepts will be introduced in an interactive lecture format with discussion of *R*, where appropriate. You will be expected to learn the concepts found in both the lectures *and* assigned/associated readings. Lecture time includes *R* exercises that are conducted with follow-up discussion. Completed lecture content will be available online.

1. **Homework:** Homework assignments will be both mathematical and data analytic in nature. The assignments will be found on the web and due (typed) by the beginning of lecture on the associated due date (Thursdays) listed on Blackboard. Be sure to include your name (and section number, if applicable) on all assignments! **NO LATE HOMEWORKS WILL BE ACCEPTED**.

You are allowed and even encouraged to discuss the assignments with each other, but the work that you hand in MUST BE YOUR OWN. This means that each student must perform all analyses on his/her own computer, and must independently write up the analysis. Plagiarism will be swiftly dealt with to the full extent allowed under Georgetown policies on cheating and plagiarism (see <http://gervaseprograms.georgetown.edu/hc/standards_of_conduct.html>).

3.  **Exams**: There is one midterm exam, and one final exam. A student who misses an exam due to medical reasons must provide documented evidence of medical incapacitation to the professor in order to take a makeup exam. Other reasons for missing an exam must be discussed with the professor as soon as possible prior to the exam date and each case will be considered on an individual basis. **A student who misses an exam without a valid excuse or without prior discussion with the professor will receive a grade of zero on that exam!**

5. **Web page:** The course outline, lecture notes, necessary data, homework assignments and solutions, information for the final project, and supplementary material for this course can be found on Blackboard (located at *http://campus.georgetown.edu*). Homework assignments will be posted one week prior to their due date. Any additional announcements that are made over the course of the semester will also be found / updated on blackboard.

# 6. R software: The R software is free and downloadable from The Comprehensive R Archive Network (<http://cran.us.r-project.org/>). The software is available for Windows or Mac operating systems.

7. **Grading:** Homework: 60%

Midterm exam: 20%

Final project: 20%

Total: 100%

8. **Important Dates**:

Thursday, 10/20: Midterm Exam

Thursday, 11/24: No class (Thanksgiving break)

Thursday, 12/8: Non class (Beginning of study days)

Monday 12/12 7:00 PM-9:00 PM: Final Exam (Rm TBA)