STAT 515: Stochastic Processes and Monte Carlo Methods
Spring 2018

Instructor: Matthew Reimherr
Department of Statistics
411 Thomas Building
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Office Hours: 9-10am Fridays and by Appointment

TA: Nathan Wikle
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Office Hours: 1-2pm Thursdays in 301 Thomas and by Appointment
The TA will hold a weekly office hour for general questions. In addition, the TA will hold more detailed RMarkdown and R sessions as needed.

Prerequisites: MATH/STAT 414 or STAT 513 (Prob/stat theory)

Class Schedule: MWF 2:30-3:20, 213 Buckhout Lab

Overview: This is a graduate level course introducing the core concepts of stochastic processes and Monte Carlo methods. It is designed for first year students pursuing a PhD in statistics, and the contents of this course make up half of the contents of one of the PhD qualifying exams. While other students are welcome, they are warned that this class is tailored towards PhD statistics students, and thus should carefully consider the difficulty and time commitment of the course.

Textbook: *Introduction to Probability Models, 11th Edition*, by Sheldon M. Ross. *Introduction to Monte Carlo Methods with R*, by Christian P. Robert and George Casella. Both books are available online through the library.

Webpage: Available through CANVAS, check regularly for updates.

Course Topics:

1. Conditional Probability (Ross Chapter 3)
2. Discrete Time/State Markov Chains (Ross Chapter 4)
3. Poisson Processes (Ross Chapter 5)
4. Continuous Time Markov Chains (Ross Chapter 6)
5. Classic Monte Carlo Methods (RC Chapters 2-3)
6. Markov Chain Monte Carlo (RC Chapters 5-6)

Learning Objectives:

Below are learning objectives organized by course topic. For each item listed, expect to gain experience working with, computing, and interpreting said item.

Stochastic Processes (8 Weeks):

1. This course will begin immediately with conditional probability and expectation, as especially as a means of understanding and modeling dependence between random variables.
2. Students will be introduced to Markov chains, starting with discrete space and time models. Students will learn about the transition probability matrix and Chapman-Kolmogorov equations. Students will learn to compute multi step probabilities, and limiting and stationary behavior of Markov chains.
3. Students will expand on the previous chapter by learning about a continuous-time/discrete space Markov chain called the Poisson point process. Students will learn about the connection between the Poisson process and exponential waiting times, and explore generalizations of the Poisson process.
4. We will then examine a more general framework for continuous time stochastic processes. We will consider different examples, define the transition probability function, the generalization of the Chapman-Kolmogorov equations, and limiting and stationary behavior.

Monte Carlo Methods (7 Weeks):

5. We will consider the basics of Monte Carlo, especially for the purposes of random variable generation (accept-reject methods) and numerical integration (importance sampling).
6. We will finish the course by covering Markov Chain Monte Carlo Methods, especially Metropolis-Hastings and Gibbs sampling. Connections and implications for Bayesian statistics will also be made.

Grading:

I anticipate the large majority of the class getting either an A or B. Grades of C or lower will be assigned more sparingly and on a case-by-case bases.
Homework: 20%
Midterm Exam: 30%
Final Exam (In Class): 30%
Final Exam (Take home): 20%

Homework:

Homework will be assigned most Fridays and will be due a week later. All homework must be turned in by **Friday**, either to me personally in class or before the end of the day through CANVAS. **No late homework will be accepted and no scores dropped.** You are encouraged to work together on homework, but each student must turn in their own write up and answers.

Exams:

Below is a list of exam dates. All students **must** take exams during these times. Conflicts should be discussed with the instructor well in advance. The final exam

date will be announced by the Registrar later in the semester. If you have three or more final exams on one day, be sure to ask the Registrar about a conflict exam.
Midterm Exam: March 23rd
Comprehensive Final Exam: TBA

R Coding and Latex:
All homework in this class must be written in either Latex or RMarkdown. The TA will conduct a tutorial in the first week for those unfamiliar with RMarkdown. Additional tutorials are possible if students find them helpful and request them.

Academic Integrity:
Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. All University policies regarding academic integrity apply to this course. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. All exam answers must be your own, and you must not provide any assistance to other students during exams.

ECOS Code of Mutual Respect:
The Eberly College of Science Code of Mutual Respect and Cooperation (http://science.psu. edu/climate/code-of-mutual-respect-and-cooperation) embodies the values that we hope our faculty, staff, and students possess and will endorse to make the Eberly College of Science a place where every individual feels respected and valued, as well as challenged and rewarded.

Disability Services:
Penn State welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course, contact the Office for Disability Services (ODS) at 814-863-1807 (V/TTY). For further information regarding ODS, please visit the Office for Disability Services Web site at http://equity.psu.edu/ods/. In order to receive consideration for course accommodations, you must contact ODS and provide documentation. If the documentation supports the need for academic adjustments, ODS will provide a letter identifying appropriate academic adjustments. Please share this letter and discuss the adjustments with your instructor as early in the course as possible.