Applied Stochastic Processes

ORIE 6500: Syllabus

Fall 2019

...la théorie des probabilités n'est, au fond, que le bon sens réduit au calcul.

("Probability theory is nothing but common sense reduced to calculation.")

— Pierre-Simon Laplace
" Théorie Analytique des Probabilités".

Essential Course information:

Lectures, Recitations, Website
Class time/location: MWF 12:20-1:10pm, Phillips 213
Recitation time: Monday, 2:30-4:25pm
Recitation location: Upson 222
Website: `https://people.orie.cornell.edu/sbanerjee/ORIE6500/orie6500f19.html`
Piazza page: `https://piazza.com/cornell/fall2019/orie6500`
Please ensure you are signed up on the Piazza site for all course announcements and material. In addition, for submitting assignments (and also grading), we will CMSX (you will be added once class starts).

Instructor: Sid Banerjee <`sbanerjee@cornell.edu`>
229 Rhodes Hall, Office hours: Wednesday, 2-4pm

Teaching Assistant: Andrew Lu <`xl562@cornell.edu`>
Office hours: Friday 2-4pm

Course description:

This is a graduate course which aims to provide a non measure-theoretic introduction to stochastic processes, presenting the basic theory together with a variety of applications. Students are assumed to have taken at least a one-semester undergraduate course in probability, and ideally, have some background in real analysis. We will focus on the following primary topics

1. **Fundamental tools and methods**: Basic concepts (integration, transforms, inequalities, convergence) and more advanced probabilistic tools (coupling and stochastic ordering, martingales, renewal theory, spectral methods).
2. **Markovian models**: Discrete-time Markov chains, recurrence and transience, invariant distributions, the ergodic theorem, reversibility, Lyapunov functions, Markov chain mixing, Poisson processes and continuous-time Markov chains.

In addition, we will illustrate these tools with applications in a variety of settings, depending on time and student interest:

1. **Fundamental Probabilistic Models**: Balls and bins, the Galton Watson branching process, the Erdős-Rényi graph, queueing networks, epidemics and percolation.
2. **Algorithmic Applications:** Basics of randomized algorithms, the probabilistic method, Monte Carlo simulation and sampling, applications in distributed algorithms, data sketching, optimization and machine learning.

References:

- The course will primarily be based on the following two textbooks (both by Pierre Brémaud):
  - Discrete Probability Models and Methods (for majority of topics)
  - Markov chains: Gibbs fields, Monte Carlo simulation, and Queues (for CTMC)

  An e-copy of the book is available on the Cornell library website, which also gives you access to a low-price MyCopy edition from the Springer website.
- A few other excellent references, with significant overlap in terms of topics and technical level:
  - Probability and Random Processes by Geoffrey Grimmett and David Stirzaker
  - Adventures in Stochastic Processes by (our very own!) Sid Resnick
  - Random Processes for Engineers by Bruce Hajek
- Excellent references for topics in randomized algorithms and combinatorics
  - Randomized Algorithms by Rajeev Motwani and Prabhakar Raghavan
  - Probability and Computing by Michael Mitzenmacher and Eli Upfal
  - The Probabilistic Method by Noga Alon and Joel Spencer

Homeworks:

The course will have 10 homeworks – these will be weekly until the prelim, and biweekly after that. Homeworks will be due on Monday 12pm (before class).

Typesetting and submission: *All assignment solutions must be submitted online* – we will use CMS for submissions (instructions in first homework). Homework solutions must be **written up in LaTeX**, and submitted as a pdf file using the template provided.

Late submissions and drops: You have **three late days** which you can use across assignments; these will be automatically recorded by CMS. Late submission will be graded only if you are within your late days – once you exhaust them, your late assignments will not be graded. You can use at most two late days per homework (i.e., till Wednesday 12pm).

You do not need to inform the instructor or TA if you are using late days – this is automatically recorded by CMS. It is your responsibility, to make sure you do not miss deadlines or run out of late days. We will not entertain any request to change the CMS records.

Grading: Homeworks will be graded and returned through CMS. You may request a regrade on any work within one week of the graded work being returned, along with a note that explains your request for a regrade. The entire homework/exam will be regraded.

At the end of the semester, the lowest homework grade will be dropped, conditional on the you having filled the course evaluation form.

Exams:

The course has one prelim (tentatively on October 21, during recitation) and one final exam (as announced by registrar).

Course Logistics:

Your grade will be based on assignments (40%) and exam scores (60%). The exam scores will be weighted as 25%-35%, or 0%-60%, whichever works in your favor.

Academic integrity:

Every student is expected to abide by the Cornell University Code of Academic Integrity. All work you hand in should be your own, with the following exceptions: you may discuss the homework assignments with other students, but when you type your solutions, please make sure you do so by yourself. You cannot get help in any way from students that have completed this course in the past. We believe that homework is a learning experience, and will grade as easily as possible, as long as you put in an honest effort.

If you violate this policy, you risk having your entire homework/project grade set to 0 or even failing the course. If you have any questions about this policy, then please contact the instructor beforehand. Please see `http://cuinfo.cornell.edu/Academic/AIC.html` for more information on the university code of academic integrity.