Management Science and Engineering 221
Stochastic Modeling

Mondays and Wednesdays (and a few Fridays), 11:00 AM–12:15 PM
Building 260, Room 113
3 units

Instructor:

Ramesh Johari
Assistant Professor
Management Science and Engineering
Terman Engineering Center, Room 319
E-mail: ramesh.johari@stanford.edu
Office hours: Monday, 5:30 PM - 6:30 PM; additional office hours by appointment

Course assistant:

Hongsong Yuan
E-mail: hsyuan@stanford.edu
Office hours: Location and time TBA

Note:

The course is held every Monday and Wednesday. In addition, there will be lectures on select Fridays as follows:

- Friday, January 16 (OPTIONAL Matlab review)
- Friday, January 23
- Friday, February 6 (Midterm review)
- Friday, February 20

Please make a note of these dates in your calendar.

Course webpage:

Course materials will be available at `http://eeclass.stanford.edu/msande221`.

Course description:

A more detailed title for this course might be "Stochastic Modeling of Time-Dependent Systems." We will be focusing almost entirely on dynamic models of random phenomena, and in particular, the most well-studied class of such models: *Markov chains*. The majority of the class will focus on Markov models in discrete time; with this background the development of Markov models in continuous time becomes straightforward. Time permitting, we will conclude with extensions and applications of the basic theory. The tentative list of topics (not necessarily in order of presentation):

1. Markov models in discrete time (10 lectures)
   (a) Basic definitions, calculating transition probabilities
   (b) Classification of states; recurrence and transience
   (c) Absorption probabilities and hitting times
   (d) Invariant distributions
   (e) Convergence to equilibrium
   (f) Strong Markov property
   (g) Regeneration and LLN for Markov chains
   (h) Reversibility
   (i) Markov chain Monte Carlo and the Gibbs sampler
2. Markov models in continuous time (5 lectures)
   (a) The exponential distribution and the Poisson process
   (b) Generators
   (c) Forward and backward equations
   (d) The jump chain
   (e) Analogs of discrete time results
   (f) Queueing models
3. Further directions (3 lectures)
   (a) Financial models
   (b) Algorithmic models
   (c) Branching processes and epidemics

The focus of the course will be on modeling and applications of the theory. Students seeking a more pure mathematical treatment of the subject should consider taking Statistics 217.

Grading

You are responsible for keeping up with all announcements made in class and for all changes in the schedule that are posted on the class website.

The grade will be based on the following:

- 30% problem sets
- 30% midterm (to be held February 11, 2009, in class)
- 40% final exam (to be held March 20, 2009)

Problem Sets

There will be a total of 6-7 problem sets. Problem sets will (generally) be assigned on Wednesdays and *due the following Wednesday, no later than 5:00 PM, outside my office (Terman 319).* All assignments will be posted to the course website.

Depending on their length and difficulty, the total number of points in each set might vary. You can discuss the assignments among yourselves, but everybody must turn in his/her own written solutions in his/her own words. If you are having difficulty, find help right away— *do not wait until you fall even further behind!*

Late assignments will receive no credit; no exceptions will be made.

Please familiarize yourself with the Stanford Honor Code; violations will be prosecuted to the fullest extent of the (Stanford) law.

Exam Policy

Attendance at the midterm exam on February 11, 2009, and at the final exam on March 20, 2009 (as per the registrar's schedule), are both *mandatory*, except for medical necessity.

Matlab

One of the most valuable features of Markov chain theory in practice is that it has deep connections to linear algebra and matrix analysis. To numerically explore this connection, at least one assignment in the course will make use of Matlab, a widely used software package for linear algebra (among other things). Matlab is available on the all Stanford UNIX/Linux machines, and a short Matlab tutorial is available online. More details on accessing UNIX/Linux machines can be found here:

`http://www.stanford.edu/services/unixcomputing/`

Once you login, type "matlab" at any prompt to begin.

A useful means of using X Windows programs such as Matlab remotely on Macs (Apple X11) and PCs (VNC Client) is described here:
`http://www.stanford.edu/services/unix/moreX.html`

Matlab review: A (optional) Matlab review session is scheduled for Friday, January 16, 2009.

Prerequisites

This course is intended for master's students and first year Ph.D. students, and is particularly targeted at students who wish to use Markov chains for applied work in operations and management. The main prerequisite for the course is probability at the level of **MS&E 220**; an acceptable substitute is Stat 116. *Note that this is a hard constraint;* we will not be reviewing any of the material from these courses in class. Students without this prerequisite can only enroll with permission of the instructor. The other primary prerequisite for the class is some familiarity with linear algebra and matrices, at the level of Math 51.

If you have taken probability elsewhere and would like to know if you satisfy the prerequisite, contact Prof. Johari via e-mail prior to registering for the course.

Textbook

The textbook is *Introduction to Probability Models* (Ninth Edition), by Sheldon Ross. The book can be found at the Stanford Bookstore. A few other books to consider, for an alternate perspective (presented in increasing order of difficulty):

- Bertsekas and Tsitsiklis, *Introduction to Probability*. This is an excellent introduction to basic probability, at the advanced undergraduate level. It contains two chapters on random processes and (finite state) Markov chains.

- Norris, *Markov Chains*. This is a slightly more mathematical treatment of the subject, but one of the most clearly presented versions of the material available.

- Durrett, *Essentials of Stochastic Processes*. This book is also more mathematical than Ross' book; it is a good place for an introduction to *martingales* that is not very technical.

- Grimmett and Stirzaker, *Probability and Random Processes*. This book is a comprehensive treatment of basic probability and Markov chains, at a more rigorous pace than the books above.