ORI 390R.5 - Applied Stochastic Processes

- **Time & Place:** Tue & Thurs 9:30am-11:00am, ETC 5.132
- **Professor:** John J. Hasenbein
  - **Office:** ETC 5.128B
  - **Phone:** 471-3079
  - **Email:** *jhas@mail.utexas.edu* (This is the best way to contact me.)
  - **Office Hours:** Mondays, 10:30am-noon. You can also email me for an appointment.
- **Class Web Page:** All class materials will be posted on *Canvas*.
- **Required Text:** *Modeling and Analysis of Stochastic Systems*, second edition (2009) by Vidyadhar W. Kulkarni (Chapman & Hall).
- **Grading:** Problem sets will be assigned every one to two weeks. There will be one mid-term exam and one final exam. Each exam will be worth 35% of your grade. Your homework average will comprise the other 30% of your grade.

  For the problem sets, you may discuss problems with your classmates and in fact are encouraged to do so. However, you should understand and write-up your <u>own</u> solutions. A good rule of thumb is that you should be able to explain to me the solutions you have submitted.
- **Exams:** You are required to take all exams at the scheduled time. Make-up exams will not be given without a valid medical excuse.

  The mid-term exam will be given on Thursday, March 10th during class.

  The final exam will be given at the university scheduled time, which should be Friday, May 13th, 2-5pm. No early final exams will be given. You must take the final at the university scheduled time to pass the class.
- **Grading Appeals:** If you believe a mistake has been made in grading a homework or exam, you must appeal within one week of receiving the graded homework or exam. After one week, no grading changes will be made.
- **Email Communication**: For this class, email will be used as an official form of communication for notifying you of new homework assignments and other class updates. For this class, email should be checked at least every other day. The University of Texas email policy can be found at
  `http://www.utexas.edu/its/policies/emailnotify.html`.
- **Prerequisites:** Students should have taken a good introductory graduate or undergraduate course in applied probability. You need to have knowledge of such introductory topics as: conditional probability, combinatorial probability, independence, expectation and variance, distribution functions, and basic limit theorems.

- **Students with disabilities:** The University of Texas at Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TTY.

- **Course Evaluation:** Near the end of the course you will have an opportunity to anonymously evaluate the course and instructor using the standard College of Engineering evaluation form.

- **Class Web Site and Privacy:** For this class, web-based, password-protected class sites will be available via the *Canvas* system. The syllabus, handouts, assignments and other resources are types of information that may be available within this site. Site activities could include exchanging e-mail, engaging in class discussions and chats, and exchanging files. In addition, a class e-mail roster will be a component of the site. Students who do not want their names included in this electronic class roster must restrict their directory information in the Office of the Registrar, Main Building, Room 1. For information on restricting directory information see:
  `http://registrar.utexas.edu/students/records/restrictmyinfo`.

Course Topics

The goal of this course is to introduce the fundamental stochastic models which are commonly used in engineering models, analytics, and other applications. With this in mind, we will cover the basic theory of such processes, along with an introduction to some simple applications.

The primary models of interest to us are: discrete-time Markov chains, Poisson processes, continuous-time Markov chains, renewal processes, and martingales. Applications of these models include queueing theory, telecommunications, manufacturing systems, gambling models, genetics, finance, and economics. We will not have time to thoroughly investigate all the application areas. Rather, this course is intended as a springboard for those interested in further exploring these areas. In general, the problem sets will involve the modeling, computational, and theoretical aspects of the topics discussed in class.

Additional References

- *Stochastic Processes*, by Sheldon M. Ross (2nd Edition, Wiley 1996).

- *A First Course in Stochastic Processes*, by Samuel Karlin and Howard M. Taylor (2nd Edition, Academic Press 1975).

- *Adventures in Stochastic Processes*, by Sidney I. Resnick (First Edition, Birkhauser 1992).

- *Introduction to Probability Models*, by Sheldon M. Ross (9th Edition, Academic Press 2006).

Course Outline

The section information below indicates the relevant sections in the Kulkarni text.

I. Introduction to Stochastic Modeling

- Basics of stochastic processes, categorization, applications

II. Discrete-time Markov Chains

- Introduction and applications
- Transient behavior (Section 2.4)
- Computation of matrix powers (Sections 2.6.1)
- Limiting behavior - classification of states (Sections 4.1 and 4.2)
- Transience, recurrence, and null recurrence (Sections 4.4, 4.5, and 4.6)
- Markov chain models with costs and rewards (Section 4.8)
- Reversibility (Section 4.9)

III. Poisson Processes

- Introduction and applications
- Alternate definitions of a Poisson process (Section 5.2)
- Useful properties: the order statistics property, splitting, and superposition (Sections 5.3 and 5.4)
- Nonhomogeneous Poisson processes (Section 5.5)
- Compound Poisson processes (Section 5.6)

IV. An Introduction to Martingales (see class references)

- Introduction and applications
- Definition and properties of martingales
- Stopping times, the optional sampling theorem

V. Continuous-time Markov Chains

- Introductions and examples
- Limiting behavior of CTMCs - classification of states (Section 6.6)
- Recurrence and transience, ergodicity (Section 6.9 and 6.10)
- CTMCs with costs and rewards (Section 6.12)
- Reversibility (Section 6.14)

VI. Renewal Processes

- Introduction and examples
- The renewal function (Section 8.3)
- Solving renewal equations (Section 8.4)
- Blackwell's renewal theorem and the key renewal theorem (Section 8.5)
- Recurrence times (Section 8.6)
- Alternating renewal processes (Section 8.8)
- Renewal processes with costs and rewards (Section 8.10)