ORI 390R.5 – Applied Stochastic Processes
Spring 2018

General Information

Time and Location: Tuesdays and Thursdays, 11:00-12:30 PM, ETC 5.132

Instructor: Grani A. Hanasusanto

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- Office Hours: Mondays, 1:00-3:00 PM

Prerequisites: Students should have taken a good introductory graduate or undergraduate course in applied probability, and are expected to be comfortable with advanced mathematical formality and reasoning. The students should be familiar with the following concepts: conditional probability, combinatorial probability, independence, expectation and variance, distribution functions, and basic limit theorems.

Required Text:

1. V. W. Kulkarni, *Modeling and Analysis of Stochastic Systems*, 2nd Edition, Chapman & Hall, 2009.

Course Description: 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.

Didactic Approach: The course will be taught in the classical formal teaching fashion. The material will be presented at a modern research level and the main results will be proved rigorously.

Grading Policy: 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.

Homework assignments are due at the beginning of class on designated days. On these assignments, you are allowed and in fact encouraged to discuss the problems with your classmates. However, you *must* write your own solution. Late assignments will not be accepted.

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.

Exam Policy: You are required to take the exam 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 8th during class.

The final exam will be given at the university scheduled time, which should be Wednesday, May 9th, 9:00 AM-12:00 PM. No early final exams will be given. You must take the final at the university scheduled time to pass the class.

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. The University of Texas email policy can be found at: `http://www.utexas.edu/cio/policies/university-electronic-mail-student-notification-policy`.

Additional Information

• **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`.

• **Honor Code:** The core values of the University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community.

• **Plagiarism:** Plagiarism is a serious offense and is cause for dismissal from the University. Please see `http://deanofstudents.utexas.edu/sjs/scholdis_plagiarism.php` and `http://www.lib.utexas.edu/services/instruction/learningmodules/plagiarism/index.html`

• **Behavior Concerns Advice Line (BCAL):** If you are worried about someone who is acting differently, you may use the Behavior Concerns Advice Line to discuss by phone your concerns about another individuals behavior. This service is provided through a partnership among the Office of the Dean of Students, the Counseling and Mental Health Center (CMHC), the Employee Assistance Program (EAP), and The University of Texas Police Department (UTPD). Call 512-232-5050 or visit `http://www.utexas.edu/safety/bcal`.

• **Religious Holy Days:** By UT Austin policy, you must notify me of your pending absence at least fourteen days prior to the date of observance of a religious holy day. If you must miss a class, an examination, a work assignment, or a project in order to observe a religious holy day, you will be given an opportunity to complete the missed work within a reasonable time after the absence.

Additional References:

1. S. M. Ross, *Stochastic Processes*, 2nd Edition, Wiley, 1996.
2. S. Karlin and H. M. Taylor, *A First Course in Stochastic Processes*, 2nd Edition, Academic Press, 1975.
3. S. I. Resnick, *A First Course in Stochastic Processes*, Birkhauser, 1992.
4. S. M. Ross, *A Introduction to Probability Models*, 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 (CTMCs)

- 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) 3

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)