Boston University, College of Engineering
ENG SE/ME 714: Advanced Stochastic Modeling and Simulation

Course Information: Spring 2023

Meeting Details:
Monday and Wednesday 2:30 pm - 4:15 pm
PHO 202

Instructor:
Professor Perkins
Office: 15 St. Mary's Street, Room 138
Phone: (617) 353–4991
Email: perkins@bu.edu

Course Website:
Blackboard Learn

Office Hours:
Monday 1:00 pm - 2:00 pm (email me to confirm) and by appointment.

Textbook:
Sheldon Ross, **Stochastic Processes** (2^{nd} edition), Wiley, 1996.

Homework:
Problem sets will be 30% of course grade. Assigned approximately every fortnight.

Exams/Projects:
Midterm worth 30% of course grade.
Final exam or project worth 30% of course grade.

Attendance and Participation:
Attendance/Participation in class will be 10% of course grade.

Reference Texts:

- **Stochastic Processes**
  1. *Stochastic Modeling and the Theory of Queues*, Ronald W. Wolff, Prentice Hall, 1989.
  2. *Stochastic Processes: Theory for Applications*, Robert G. Gallager, Cambridge University Press, 2013.
  3. *Markov Chains: Gibbs Fields, Monte Carlo Simulation, and Queues*, Pierre Bremaud, Springer-Verlag, 1999.
- **Simulation**
  1. *Simulation, 5th Edition*, Sheldon Ross, Academic Press, 2012.
  2. *Monte Carlo methods in Financial Engineering*, Paul Glasserman, Springer, 2004.

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Course Syllabus: Spring 2023

1. *Stochastic simulation I*
   (a) Simulating (generating samples of) stochastic models
2. *Poisson process (simple type of a point process model)*
   (a) Point processes: Definition and using as a modeling tool
   (b) Homogeneous Poisson Processes: Definition and properties
   (c) Generalizations: Nonhomogeneous, compound, conditional, & Markov-modulated Poisson Processes
3. *Renewal theory (a basic theoretical tool for analysis)*
   (a) Convergence of random sequences (a review)
   (b) Renewal, renewal-reward, and associated processes
   (c) Elementary renewal and renewal-reward theorems
   (d) Key renewal theorem and applications
4. *Discrete & Continuous-time Markov chains (models with short memory)*
   (a) Definition: Models with discrete state space & short memory
   (b) Stochastic dynamics (linear difference & differential equations)
   (c) Classification of states: transient, null-recurrent, positive recurrent
   (d) Long-run performance measures & limit theorems
   (e) Transient performance measures
   (f) Applications
5. *Stochastic simulation II*
   (a) Statistical analysis of simulated data
   (b) Variance reduction techniques

Course Topics

- **Simulation**: We give a general introduction to stochastic simulation and specifically talk about how to generate samples of trajectories of stochastic models, how to analyze data obtained from simulation, and (possibly) how to perform simulations in ways that reduce their computational cost, i.e., efficient simulation.
- **Stochastic Models** : The models considered are discrete time models or they evolve in a discrete state space. The assumptions of discrete time or discrete state space simplify the mathematics involved significantly. Specifically we consider two broad classes of models, point processes, and Markov chains. Point or counting processes are our stochastic models for occurrences of random events. We discuss a variety of Poisson processes that are used to model random events in a wide range of application domains. Discrete & Continuous-time Markov chains are extremely flexible models of many systems with random dynamics since there are no constraints on how the trajectories of the process can evolve in time.
- **Renewal Theory** : Renewal theory is one of our main theoretical tools for analyzing the stochastic models we consider, in particular our analysis of Markov chains will be based on renewal theory.