ISE/OR 560: Stochastic Models in Industrial Engineering
Fall 2022
M/W: 1:30 pm – 2:45 pm
Location: 2207 Engineering Building 3

Hong Wan,
hwan4@ncsu.edu, 4325 Fitts-Woolard Hall.

Office hour: **MW** 11:00-12:00 or by appointment.

Textbook:

Introduction to Stochastic Models in Operations Research, Ninth Edition, Hillier and Lieberman, 1990.Publisher: McGraw-Hill. (Selected Chapter in Library Course Reservation)

Introduction to modeling and analysis of stochastic systems V.G. Kulkarni. Kulkarni, Vidyadhar G. New York : Springer, c2011. 2nd ed. Accessible online for free at NC State University library.

The little book of probability (Related material will be on slides)
https://www.amazon.com/Little-Book-Probability-Essentials-Stochastic/dp/1452882924

Course Website: http://moodle.wolfware.ncsu.edu/

Course Description:

An introduction to mathematical modeling, analysis, solution, and simulation procedures applicable to uncertain (stochastic) service and production systems. Methodologies covered include probability theory and stochastic processes. Applications relate to the design and analysis of problems, capacity planning, inventory control, bottleneck and waiting time, and system reliability and maintainability. The course will be more methodology oriented than theory-oriented, and there will be a significant computation/simulation part.

Course Objectives:
This course has four components:
I. Probability Tools: characterizing uncertainty using probabilities and random variables.
II. Decision Modeling under Uncertainty: models for decision making under uncertainty: decision trees, utility theory, the value of information, Bayes rule.
III. Stochastic Modeling: characterizing uncertainty over time and space using:
- A. Discrete Time Markov Processes: Markov Chains & Markov decision processes
- B. Continuous Time Markov Processes: Birth & Death Processes, Poisson Processes, and Queueing Theory
- C. Probabilistic Inventory Models

IV. Computational Analysis and Simulation of stochastic processes.

Upon the completion of this course, students will be able to use the tools of probability and stochastic processes to develop analytical and computational/simulation models to improve decision-making in an uncertain environment.

Probability Objectives: Students will be able to:

Identify and Apply probability distributions appropriately to various applications

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Understand probability distributions (unconditional and conditional) for single and multivariate random variables

Decision Modeling Objectives: Students will be able to:

Formulate/Structure decision problems using tables, and decision trees
Use various criteria to evaluate decision problems
Estimate the value of perfect and sample information
Demonstrate understanding of utility theory and calculate a utility
Formulate dynamic decision problems using a Markov decision process

Stochastic Modeling Objectives: Students will be able to:

Define and characterize a stochastic process
Identify, Define and Apply stochastic models particularly, Markov chains (discrete and continuous), queueing models and inventory models
Develop Stochastic Models for various real-world applications
Apply stochastic modeling theory to a real-world problem.

Computational Objectives: Students will be able to:

Generate data based on various distributions
Conduct computation to characterize stochastic models, particularly, Markov chains (discrete and continuous) and queueing models
Conduct simulations of stochastic systems and decision models.

General Description:

Homework: assignments are due on ***Fridays at 11:59 pm***; the assignment will be posted at least one week ahead. **You will work in groups of two** and ***turn in one assignment for your group*** *with the names of the group members clearly indicated*. Homework groups *must remain the same* throughout the semester (see below)

Assignment Groups: You will complete your homework assignments and projects in groups of two students. Once you select your assignment group, it should remain fixed for the entire semester, i.e., your homework group will be your project group. Please notify me using the google doc by ***Sept 9th***. If you are looking for a homework group, please indicate this on the google doc by ***Sept 2nd***.

Homework 0 is an individual assignment for everyone*; each person should turn in their own assignment.*

Software: there will be no software restriction. The instructor will demonstrate with Python or Matlab. *You should select the one you are most familiar with to conduct the calculation and simulation.*

Project: Working in your homework groups, you will develop a stochastic model for a real-world-mimicking problem and prepare a written project report and a short presentation. More details on the project will follow.

Grading

Homework and Exercises	25%
Project	25%
Midterm	20%
Final Exam (Take home)	30%
Total	100%
Extra credit	

ISE/OR 560 "Living" Course Outline (Note that the reading materials may be updated along the course):

Week	Class	Topic	Reading
1	Aug. 22	Course Introduction & What is a stochastic system & Probability Review I: Conditional Probability, Independence, Bayes Formula, Random Variables, Expectation, Variance, Distributions	Hillier & Lieberman (Online Reserve): Ch. 3: 3.1 – 3.9
	Aug. 24	Probability Review I, Decision Analysis: Decision Criteria, Decision Trees, Perfect Information	H&L: Ch. 14: 14.1 – 11.2, 14.4, 14.6
2	Aug. 29	Decision Trees: Sample Information and Bayes Rule	H&L: Ch.14: 14.3 – 14.4, 14. 6
	Aug. 31	Probability I: Joint Distributions, Conditional Probability & Conditional Expectation	H&L: Ch. 3: 3.10 – 3.16
	Sept 2	**HOMEWORK 0: Probability Review DUE**	
3	Sept 5	No Class	
	Sept 7	Probability II: Conditional Expectation & Moment Generating Functions	H&L: Ch. 3: 3.10 – 3.16
4	Sept 12	Introduction to Stochastic Processes	H&L: Ch. 5: 5.1 – 5.2
	Sept 14	Markov Chains I	H&L: Ch. 5: 5.3
	Sept 16	**HOMEWORK I: Decision Analysis & Conditional Probability DUE**	
5	Sept 19	Markov Chains II	H&L: Ch. 5: 5.4 – 5.5
	Sept. 21	Markov Chains III	H&L: Ch. 5: 5.6 – 5.7
	Sept 22	**HOMEWORK II: Conditional Expectation & Markov Chains I DUE**	
6	Sept. 26	Markov Chains IV	H&L: Ch. 5: 5.7 – 5.8
	Sept. 28	Markov Chains V	H&L: Ch. 5: 5.8
	Sept. 30	**HOMEWORK III: Markov Chains II DUE**	
7	Oct 3	Markov Decision Processes I	H&L: Ch. 11: 11.1 – 11.2, 11.4
	Oct 5	Markov Decision Processes II	H&L: Ch. 11: 11.3, 11.5
	Oct. 7	**PROJECT Deliverable 1 Due**	
8	Oct 10	No class	
	Oct 12	Markov Decision Processes III	H&L: Ch. 11: 11.5
	Oct. 14	**HOMEWORK IV: Markov Chains III DUE**	

ISE/OR 560 "Living" Course Outline (cont.):

Week	Class	Topic	Reading
9	Oct.17	Midterm Review	
	Oct 19	Midterm	
10	Oct. 24	Review: Exponential and Poisson Distributions	H&L: Ch. 3: 3.7, Ch. 6: 6.4
	Oct. 26	Review: Exponential and Poisson Distributions	H&L: Ch. 3: 3.6, Ch. 6: 6.4
	Oct. 28	**HOMEWORK V: MDPs DUE**	
11	Oct. 31	Counting Processes - Poisson Processes	H&L: Ch. 5: 5.9, Ch. 6: 6.4
	Nov. 2	CTMC: Continuous-time Markov Chain I: Birth and Death Processes - Poisson Processes	H&L: Ch. 6: 6.5
	Nov. 4	**HOMEWORK VI: Exponential & Poisson Distributions & Poisson Processes DUE**	
12	Nov. 7	CTMC: Continuous-time Markov Chain II: Birth and Death Processes - Poisson Processes	H&L: Ch. 6: 6.5
	Nov. 9	Queueing Theory I: Intro Queueing Systems	H&L: Ch. 6: 6.1 – 6.3, 6.6
	Nov. 11	**HOMEWORK VII: Poisson Processes & CTMC DUE**	
13	Nov. 14	Queueing Theory II: Queueing Systems	H&L: Ch. 6: 6.6 – 6.8
	Nov. 16	Queueing Theory III: Queueing Decision Problems	H&L: Ch. 7: 7.1 – 7.3
	Nov. 18	**HOMEWORK VIII Queueing Homework Due**	
14	Nov. 21	Project Q&A	
	Nov. 23	No class	
15	**Nov. 28**	***Project Presentations***	
	Nov. 30	***Project Presentations***	
	Dec 2		
16	Dec. 5	No Class, office hour	
	Dec. 8	**Project Report Due by 5:00pm** Final exam will be posted on moodle at 5:00pm	
	Dec. 12	Final exam due to moodle.	

Academic Integrity
Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php

Academic Honesty
See http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php for a detailed explanation of academic honesty.

Honor Pledge
Your signature on any test or assignment indicates "I have neither given nor received unauthorized aid on this test or assignment."

Attendance Policy
Absences will be excused if approved in advance. Please refer to the university attendance regulation for a list of excused absences: http://policies.ncsu.edu/regulation/reg-02-20-03. Students will be allowed to make-up work missed due to an excused absence within a reasonable amount of time as determined by the instructor.

Late Assignments
No late assignments will be accepted.

Accommodations for Disabilities
Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, student must register with the Disability Services Office (http://www.ncsu.edu/dso) located at 1900 Student Health Center, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation at http://www.ncsu.edu/policies/academic_affairs/courses_undergrad/REG02.20.1.php.

NC State University Policies, Regulations and Rules (PRR):
Students are responsible for reviewing the PRRs which pertain to their course rights and responsibilities. These include: http://policies.ncsu.edu/policy/pol-04-25-05 (Equal Opportunity and Non-Discrimination Policy Statement), http://oied.ncsu.edu/oied/policies.php (Office for Institutional Equity and Diversity), http://policies.ncsu.edu/policy/pol-11- 35-01 (Code of Student Conduct), and http://policies.ncsu.edu/regulation/reg-02-50-03 (Grades and Grade Point Average).

Transportation
NA

Safety & Risk Assumptions
None

DIVERSITY AND INCLUSION STATEMENT

In an ideal world, science would be objective. However, much of science is subjective and is historically built on a small subset of privileged voices. In this class, we will make an effort to read papers from a diverse group of scientists, but limits still exist on this diversity. I acknowledge that it is possible that there may be both overt and covert biases in the material due to the lens with which it was written, even though the material is primarily of a scientific nature. Integrating a diverse set of experiences is important for a more comprehensive understanding of science. I would like to discuss issues of diversity in stochastic modeling as part of the course from time to time.

Please contact me (electronically) or submit anonymous feedback if you have any suggestions to improve the quality of the course materials.

Furthermore, I would like to create a learning environment for my students that supports a diversity of thoughts, perspectives and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, etc.) To help accomplish this:

If you have a name and/or set of pronouns that differ from those that appear in your official NCSU records, please let me know.

If you feel like your performance in the class is being impacted by your experiences outside of class, please do not hesitate to come and talk with me. I want to be a resource for you. Remember that you can also submit anonymous feedback (which will lead to me making a general announcement to the class, if necessary to address your concerns).

I (like many people) am still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, please talk to me about it. (Again, anonymous feedback is always an option.)

As a participant in course discussions, you should also strive to honor the diversity of your classmates.