

# *Stochastic Modeling*

*Formulation and analysis of discrete and continuous Markov chains, Poisson processes, and birth-death processes. Applications in queuing, inventory, and reliability. Required project in modeling and solving applications.*

22 QA 760-901, 4 Graduate Credit Hours  
Winter Quarter, **2008 – 2009**  
Saturdays, 9:00 A.M. – 11:40 A.M.  
216 Carl H. Lindner Hall

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College of Business  
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**Office Hours:** 12:30 P.M. – 1:45 P.M. Mondays and Wednesdays or by  
appointment.

**Course Prerequisites** 15 Math 264 “Calculus & Analytic Geometry IV” and  
22 QA 731 “Probability”

## **Course Objectives**

1. Develop skill in recognizing situations for which stochastic processes are a valuable modeling tool.
2. Develop a solid background in the basic theory of stochastic processes, especially discrete and continuous Markov processes, queuing analyses, and inventory analyses.
3. Develop skill in formulating, analyzing, and interpreting commonly-encountered stochastic models such as Markov processes, queuing models, and inventory models.

**Text:** Ross, Sheldon M., *Introduction to Probability Models*, Ninth Edition, Academic Press, Burlington, MA, ISBN-13: 978-0-12-598062-3, ISBN-10: 0-12-598062-0, **2007**.

**References:** Anderson, David R., Sweeney, Dennis J., Williams, Thomas A., and Martin, Kipp, *An Introduction to Management Science: Quantitative Approaches to Decision Making*, Twelfth Edition, Thomson South-Western, ISBN-10: 0324399804, ISBN-13: 9780324399806, Mason, OH, **2008**.

- Buzacot, John A. and Shanthikuman, J. George, *Stochastic Models of Manufacturing Systems*, Prentice-Hall, Inc., Englewood Cliffs, NJ, **1993**.
- Goodman, Roe, *Introduction to Stochastic Models*, The Benjamin/Cummings Publishing Company, Inc., MenloPark, CA, **1988**.
- Hall, Randolph W., *Queueing Methods For Services and Manufacturing*, Prentice-Hall, Inc., Englewood Cliffs, NJ, **1991**.
- Hillier, Frederick S. and Lieberman, Gerald J., *Introduction to Operations Research*, 8<sup>th</sup> Edition, McGraw-Hill Publishing Company, New York, **2005**.
- Kao, Edward P.C., *An Introduction to Stochastic Processes*, Duxbury Press, Belmont, CA, **1997**.
- Kemeny, John G. and Snell, J. Laurie, *Finite Markov Chains*, D. Van Nostrand Co., Inc., Princeton, NJ, **1960**.
- Kulkarni, V.G., *Modeling, Analysis, Design, and Control of Stochastic Systems*, Springer-Verlag, New York, **1999**.
- Taha, Hamdy A., *Operations Research: An Introduction*, Fifth Edition, Macmillan Publishing Co., New York, **1992**.
- Wagner, Harvey M., *Principles of Operations Research*, Second Edition, Prentice-Hall, Inc., Englewood Cliffs, NJ, **1975**.
- Winston, Wayne L., *Operations Research: Applications and Algorithms*, Fourth Edition, Brooks/Cole division of Thomson Learning, Inc., Belmont, CA, ISBN# 0-534-38058-1, **2004**.
- Wolff, Ronald W., *Stochastic Modeling and the Theory Queues*, Prentice-Hall, Inc., Englewood Cliffs, NJ, **1989**.

### ***Information Resources***

Extensive use of ***Blackboard Learning and Community Portal System TM Version 8*** will be employed for students to access documents such as PowerPoint slides, the syllabus, or assignments, and for communication such as announcements and postings for office hours. Email communication will be maintained through Blackboard and this requires that you keep a functioning email address registered, a setting you control. You may access Blackboard at <http://blackboard.uc.edu/> and the ***Contact Support Team*** for Blackboard may be accessed at the Blackboard Technology Resources Center, 410 Zimmer Hall, [Blackboard@UC.edu](mailto:Blackboard@UC.edu), (513)556-1602.

### ***Grading Policy***

Midterm Examination	<b>25%</b>
Final Examination	<b>35%</b>
Homework, Presentations, Quizzes, & Participation	<b>15%</b>
Individual Project (.25 of the Course – 1 Credit Hour)	<b>25%</b>

### ***Examinations***

The Midterm Examination is a unit examination covering material from that portion of the course. The Final Examination will consist of two portions: 1) A unit examination over the material covered since the Midterm Examination and 2) A comprehensive portion that may include problems and questions from any portion of the class. You may pick up your graded final examination after final grades have been submitted.

**Notes:** 1) It is the student's responsibility to keep any graded work. This is important if for any reason your grade is at question.

2) Without mutually agreeable prior arrangements, late work will not be accepted.

### ***Make-Up Examinations***

Make-up examinations will not be given under normal circumstances. If you miss the first examination with an ***excused*** absence the percentage missed may be added to the final examination percentage. An ***excused*** absence is one that meets all of the following conditions: **1)** the professor is notified ***in advance***; **2)** the professor ***approves*** the absence; **3)** written verification is provided (and may be followed-up). A make-up examination may be given at the discretion of the instructor for an excused absence only. If the examination is a take-home examination, advanced notification must be made prior to the time that the examination is handed out or it will be considered as an absence from the examination. If the examination is a take-home examination, failure to turn in the examination at the appointed time will be considered as an absence from the examination. Unexcused absences from examinations will be recorded with a grade of ***zero*** percent.

### ***Project***

Each student is required to submit an individual project on a stochastic modeling topic rated as .25 of the 4-hour credit course (1 credit hour). Project topics must be approved in advance by the instructor by submitting a ***Project Proposal*** (no more than two pages double-spaced). Approval of your general project topic idea is not a guarantee that your development of the project will be deemed as being sufficient and is not a contract that your report will be rewarded with any particular grade. It is up to you to thoroughly, competently, and completely develop your project. A written report is due to be submitted on or before the last day of final examinations for the quarter. Late project submissions will not be accepted without mutually agreeable prior arrangements with the instructor.

### ***Withdrawal Policy***

The university policy will be followed regarding the awarding of a W grade, i.e., the W grade will be given only if a student withdraws before the officially stated university deadline. According to UC policy you may withdraw until ***5:00 P.M., Tuesday, March 3, 2009***. After this date, the W grade is no longer an option.

### ***Auditing and Pass/Fail Options***

Should you wish to audit the course, the only requirement is that you register for the course through the university system as an auditor or pass/fail student and attend and participate in classes. You may have copies of the examinations and the solutions to them, and you may perform a project,

but the staff will not evaluate or grade the work. Auditors who fail to attend class will be assigned a grade of F. Taking the course with a Pass/Fail option will not be an option.

### ***Grade Improvement***

Grades will be earned for the required work only. No additional work will be accepted for "extra credit" or "grade improvement".

### ***Incomplete Policy***

The university policy will be followed regarding the awarding of an I grade, i.e., the I grade will be given only if a student is unable to complete the course and has an excused absence from the final. Students receiving an I grade must contact Dr. Rogers during the first week of the immediately following quarter to arrange a method for completing the course. If you will not be able to schedule a meeting during the first week of the immediately following quarter then prior arrangements should be made regarding when you will be able to meet at the time an I grade is requested. Unless an acceptable reason exists to postpone completing the course during the next academic quarter, all work necessary to change an I grade must be finished during the immediately following quarter or your grade will be converted to an F.

### ***Special Needs Policy and Disability Services***

If you have any special needs related to your participation in this course, including identified visual impairment, hearing impairment, physical impairment, communication disorder, and/or specific learning disability that may influence your performance in this course, you should meet with the instructor to arrange for reasonable provisions to ensure an equitable opportunity to meet all the requirements of this course. At the discretion of the instructor, some accommodations may require prior approval by Disability Services.

If utilizing Disability Services results in any changes of usual procedures for any examination, project, or homework, please notify the professor and process the required paperwork immediately with the professor in his office. A photocopy of the paperwork must be given to the professor. For all such cases, the end of the second week of the quarter is the deadline for processing paperwork from Disability Services. If paperwork from Disability Services is pending, please discuss the situation with the professor before the end of the second week of the quarter. Failure to follow these guidelines will result in the usual procedures for any examination, project, or homework being retained.

### ***Electronics***

Please turn off all electronic equipment including cell phones and computers. If we are using the computer for problem solving it is quite appropriate to use it to follow along and check out the software. If you are using electronics for note-taking assistance during class that is acceptable. However, any other usage of electronics such as web surfing, instant messaging, or working on other projects is not allowed.

### ***Absences***

While absences from class are extremely discouraged, sometimes exceptional circumstances arise that require missing a class. In the event that you do miss a class, it is the student's responsibility to obtain missed handouts. Please work with fellow students to acquire any additional course policies and procedures, obtain homework assignments, and determine the material that was covered. Please note that the teaching assistants or professor will be pleased to assist you in identifying any material that you have missed or to answer specific questions regarding missed materials. However, a repeat or detailed synopsis of the missed lecture will not be performed.

### ***Academic Integrity Policy***

The University Rules, including the *Student Code of Conduct*, and other documented policies of the department, college, and university related to academic integrity will be enforced. Any violation of these regulations, including acts of plagiarism or cheating, will be dealt with on an individual basis according to the severity of the misconduct. Please refer to the *Student Code of Conduct* at <http://www.uc.edu/studentlife/conduct/conduct.html>.

It is expected and encouraged that students should discuss readings, homework assignments, and case reports with each other unless otherwise specified. When doing homework and cases, try on your own, ask for help from anyone, and get the work completed. However, getting an exercise or case worked through to a solution is not necessarily learning. Make sure you know what the problem is, what the solution is, and what the solution implies. Merely copying someone's work will not guarantee this.

Classroom examinations will be "closed-book" and, along with any take-home examinations, are to be the sole work of individual students. A grade of D– or F for the course will be assigned to anyone receiving assistance or assisting another during any in-class or take-home examinations. Furthermore, any other academic misconduct during an in-class or take-home examination will result in immediate dismissal and a course grade of D– or F. Academic misconduct for an in-class examination includes, but is not limited to, inappropriate behaviors such as: talking; passing any physical thing(s) such as notes, calculators, or writing devices; scanning the room and your classmates and potentially their work; peering at another individual and/or their work; communication of any type with a classmate; and behavior disruptive to the examination. Further disciplinary action for any academic misconduct may be taken that could result in dismissal from the university.

A grade of D– or F for the course will be given to anyone receiving assistance from or assisting another individual or group for assignments for which the work is to be that of each individual student or group. Integrity of take-home assignments is of paramount importance. Should there be an indication that any take-home assignment or examination is to be performed by an individual or limited number of participants, violating this policy will be determined as academic misconduct and a grade of D– or F will be assigned for the course. Plagiarism or representing someone else's work as your own will result in a course grade of D– or F. Further disciplinary action for any academic misconduct mentioned in this section may be taken that could result in dismissal from the university.

### ***Notification of Grades***

Final grades will be available through UC OneStop and will not be posted nor will they be provided over email, telephone, or personally. The Teaching Assistants and administrative staff are not authorized to release any grades.

## ***Tentative Course Outline***

<b><u>Day/Session</u></b>	<b><u>Topic</u></b>	<b><u>Text Reading</u></b>
1/10-1	Course Introduction	Syllabus
	Introduction to Stochastic Processes	4.1
	Discrete Time Markov Chains	4.1
1/17-2	Modeling Stochastic Processes	4.1, 4.5
	Chapman-Kolmogorov Equations	4.2
	First-Passage & First-Return Probabilities & Times, Occupancy Times	
	Classification Terminology	4.3
1/24-3	Ergodic Markov Chains (Steady States)	4.4
	<b><i>Project Proposals Due</i></b>	
1/31-4	Absorbing Markov Chains (Transience)	4.6
2/7-5	Continuous Time Processes: Kolmogorov Equations & Limiting Probabilities	6.1, 6.2 6.4, 6.5
	Birth-Death Processes	6.3
	Exponential RV's, Poisson Processes	5.1, 5.2, 5.3
<b><i>2/14-6</i></b>	<b><i>Examination #1 (25%)</i></b>	
2/21-7	Introduction to Queuing Theory	8.1, 8.2
	Single Server Queues (M/M/1)	8.3
	Multiple Servers (M/M/S)	8.9
2/28-8	Finite Sources	8.8
	Limited Queue Capacities	8.3
	Non-Markovian & Special Queuing Models	8.3
	Networks of Queues	8.4
3/7-9	Introduction to Deterministic Inventory	Handouts
	ABC Classification	
	Economic Order Quantity	
	Quantity Discounts	
	Finite Rate Production, Backorders	
	Probabilistic Inventory	
	The Newsboy Problem	
	Lot Size, Reorder Point Model	
3/14-10TBA		
	<b><i>3/21-11 Final Examination (35%), Case Projects (25%) Due</i></b>	