

CSCI 688 * ANALYSIS OF STOCHASTIC NETWORKS

Spring 2022

Welcome to Analysis of Stochastic Networks! I hope we all have a great time together, and that we all learn from each other this semester. Below you will find all the relevant information about this class and the assessment. While going through the rest of this document, note that everything written in [blue](#) contains a link.

1 General Information

- Schedule: Tuesday and Thursday, 5.00 – 6.20 pm
- Modality: In person
- Classroom: ~~James Blair Hall 219~~ Jones 302
- Instructor: Daniela Hurtado-Lange
- Office hours: Monday, Tuesday and Thursday 10-11 am or by appointment

2 Description

Analytical properties of the Poisson process and Markov chains, focusing on performance guarantees and applications, are studied. The goal is to answer questions such as how many cashiers are necessary to guarantee that 95% of the customer wait less than 10 minutes? Or, how many parking spaces do we need to create at a store to ensure that at most 5 customers per month have to wait to park? And many more.

We will spend an important part of the semester reviewing Markov chains and Poisson processes, so that we can speak the same language when we get to analyzing stochastic networks. Also, if you haven't completed any course that covers these topics, you will get an opportunity to get up to speed in class. After we review these topics, we will focus on analyzing performance measures of a variety of stochastic networks and we will compare theoretical results with simulations.

Prerequisites: A calculus-based class in probability. I expect you to know the definition of pdf, pmf, cdf, expectation and conditional probability along with some of the most popular distributions, such as uniform, exponential, normal, Bernoulli, binomial and Poisson.

3 Textbook

Introduction to Probability Models, Sheldon M. Ross, Academic Press (2014)

* The textbook is available in hard and soft copies. Both can be obtained at this [link](#).

We will also use the following book for some topics (I will let you know when exactly):
Random Processes for Engineers, Bruce Hajek, Cambridge (2015).

* You can purchase a hard copy in this [link](#), or you can obtain a free soft copy in this [link](#).

4 Learning Objectives

By the end of the semester you will be able to:

1. Analyze stochastic networks that arise in real-life situations using tools from Markov chains
2. Solve and use the equations that describe the steady-state of a Markov chain
3. Identify which model is more appropriate for different real-life situations
4. Create simulation models and analyze their output
5. Compare theoretical analysis versus simulation in different scenarios

5 Assessment and Grading Structure

This a letter-grade course, under the grading scale presented below:

Letter grade	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Total score	> 94	> 90	> 87	> 83	> 80	> 77	> 73	> 70	> 67	> 63	> 60	≤ 60

I might curve the grades in your favor at the end of the semester.

There will be multiple opportunities for lower-stake assessment, with the goal of preparing you for the exams and the final. Some of these will be graded, and some will not. I encourage you to use all these opportunities to learn what you know well and what needs practice before the exam.

Below you will find a brief description of each graded assignment:

- **Homework (average 20%):** Weekly sets of problems to be solved individually or in pairs. Collaboration is encouraged subject to the “empty hands policy”, described in Section 6. Each homework will be graded from 0 to 100 points, and the two lowest scores will be dropped.
* Submission rules: The students should submit their homework to Gradescope, in a **single pdf** file by 11.59 pm of the due date and they should **mark in which pages they answered each question** using the Gradescope feature. Following these simple rules saves a lot of time in grading. Let’s be empathetic! If the students fail to follow these rules, they automatically lose 5 points on the corresponding homework.
- **Midterm I and II (25% each):** In-class exam that must be solved individually in, at most, 75 minutes. The dates and (tentative) contents are provided in Section 9. Each midterm will be graded from 0 to 100 points. You are allowed to bring 1 cheat sheet for Midterm I and 2 for Midterm II, following the rules described in Section 6.

After each Midterm, you will have 1 week to fill a survey with the following questions:

1. What was easy in the Midterm?
2. What was hard in the Midterm?
3. What has the instructor done well so far?
4. How can the instructor improve?
5. What have I (as a student) done well so far?
6. How can I improve for the next assessment?

I deeply care about the feedback you can provide, so I will give you 1 bonus point in the corresponding midterm for each question that you answer (Yes, you can end the semester with 106 points in each midterm if you answer these questions!). Please be as concrete as possible with your answers.

- **Final exam (30%):** Let’s discuss about this item. I have three options for you and I want to get your feedback. At the end of the first class, I will release a survey where you can vote. Here are the options:
 - (1) **In-class exam** at the end of the semester that must be solved individually in 3 hours or less. Topics may include every chapter covered in class. You are allowed to bring 3 letter-size cheat sheets (you can use both sides). Observe the date and time of the final in the last section of the syllabus.
 - (2) **Take-home exam** to be submitted on the date established by the school (see last section of the syllabus). I will give you a set of problems 3 days in advance, and you have to submit a pdf with your answers. I may include a short simulation in the set of problems.
 - (3) **Presentation of a relevant paper** in groups of 2-3 people. Choose a published article or part of a chapter of a book, read it carefully, and present it to the class in no more than 20 minutes. I am happy to help on the search and the preparation of the presentation. If this option wins, we will discuss the date and time of the presentations.

In any case, the final exam will be graded from 0 to 100 points.

Hence, your grade will be computed as follows:

$$\text{Grade} = 0.2 \times \text{Homework} + 0.25 \times \text{Midterm I} + 0.25 \times \text{Midterm II} + 0.3 \times \text{Final}$$

6 Some Ground Rules

- **Attendance to class and participation:** I highly encourage you to attend the lectures and participate to create an active learning environment. I am not giving any % of the grade to participation, but my goal is that you learn and understand the contents in class, so that you only need revise the material at home.
- **Collaboration:** Collaboration in solving the homework and preparing for the exams is encouraged, under the “empty hands policy” described below. The exams are individual, and no collaboration in solving it is allowed. I understand that you may use similar methods to solve the problems, but you must submit your own answers.
- **Empty hands policy¹:** Two or more students may enter a room (for example, a room with a whiteboard) and may together solve some or all of the problems on a homework assignment on the board. Each student must leave the room without any written or electronic materials describing these solutions. Students are to leave such a problem-solving session with only the solutions to the problems in their heads. Each student must perform their own individual write-up of the homework solutions sometime after the problem-solving session and submit their solutions individually.
- **Cheat sheets for exams:** Each cheat sheet should not be larger than a letter-size paper, and you may use both sides. I find the process of preparing a cheat sheet incredibly useful to study and organize ideas, so I will request your cheat sheets to be handwritten by yourself. Similarly to the homework, I encourage you to study in groups, but the cheat sheet must follow the “empty hands policy”.
- **Late work:** You will have 5 days of ‘lateness’ to use at your convenience and to be spent in integer numbers. This means that you can submit your homework late by at most five days in the entire semester and your grade will not be affected. For any additional day of ‘lateness’ you will lose 5 points of the corresponding homework. For example, you may submit homework 1 two days late, homework 2 eight hours (hence, one day) late and homework 3 two days late and you qualify to the maximum grade. However, if you submit all three homeworks two days late, your third homework will have a maximum of 95 points.
- **Student-faculty expectations:** I expect you to participate in class and ask questions during the lectures, via emails or in office hours. My job is to do my best to keep you interested in the class, transmit the content in the lectures and answer your questions. I know we all may work on weekends, but I will not reply to any email and I do not expect you to submit any work during weekends.
- **Accommodations for students with disabilities:** If you need any type of accommodation, please make an appointment with the Office of Disability Services. I am happy to provide any accommodation, but you need to let me know as soon as possible (hopefully by the end of the second week of classes).

7 Absence to Class

This semester, the world will enter its third year with COVID. As we experience a fifth surge of pandemic with the highly transmissible omicron variant, it is reasonable to expect significant levels of infection at W&M. As an academic community based on faculty and students convening, spring 2022 courses will largely consist of in-person instruction. All of us will follow W&M requirements - vaccinations and boosters, indoor masking, as well as quarantine and isolation when ill. That last is really important: for those who have tested positive, W&M’s requirements must be fulfilled before class can be attended in person, and, out of an abundance of caution, anyone with symptoms consistent with COVID- even if they don’t have a positive test- should not come to class.

Please note that testing positive for COVID or any other temporary illness is not considered a disability as defined by ADA guidelines and is not under the purview of W&M’s Student Accessibility Services (SAS). Thus, any questions should be addressed via email to me.

This semester, we will handle extended absences in the following way:

- **Students missing a class:** The classes will be recorded and posted on Blackboard, so the students can access them at their convenience.
- **Instructor missing classes:** If the instructor needs to miss a class, another faculty member from the Math department will cover for her. If the absence lasts more than one week, we will switch to remote classes until the instructor can return to campus.

¹Based on policy created by Prof. Steve Park

8 Software

An important part of this class is to be able to simulate some stochastic networks. You may use your favorite language to code your simulations, but if you think you will need my help with your codes, I encourage you to use Python. Other languages that I find useful (though I am not an expert), are R, Arena and SIMIO.

9 Tentative Schedule

Date	Topics	Tasks
1. Thu, Jan 27th	Introduction	
2. Tue, Feb 1st	Ch. 1, 2 and 3: Review of probability	HW 1 posted
3. Thu, Feb 3rd		
Feb. 4th: Last day of add/drop		
4. Tue, Feb 8th	Ch. 1, 2 and 3: Review of probability (cont.)	HW 1 due, HW 2 posted on Wednesday
5. Thu, Feb 10th	Ch. 4: Discrete Time Markov Chains (DTMC)	
6. Tue, Feb 15th		HW 2 due, HW 3 posted on Wednesday
7. Thu, Feb 17th		
8. Tue, Feb 22nd		HW 3 due, HW 4 posted on Wednesday
9. Thu, Feb 24th		
10. Tue, Mar 1st		HW 4 due
11. Thu, Mar 3rd	Ch. 5: The Exponential Distribution and the Poisson Process	
12. Tue, Mar 8th	Midterm I, in class	
13. Thu, Mar 10th	Ch. 5: The Exponential Distribution and the Poisson Process (cont.)	
March 12-20: Spring break		
14. Tue, Mar 22nd	Ch. 5: The Exponential Distribution and the Poisson Process (cont.)	HW 5 posted
15. Thu, Mar 24th	Ch. 6: Continuous Time Markov Chains (CTMC)	
March 28th: Last day to withdraw from a full term course.		
16. Tue, Mar 29th	Ch. 6: CTMC (cont.)	HW 5 due, HW 6 posted on Wednesday
17. Thu, Mar 31st		
18. Tue, Apr 5th	Discrete-Event Simulation	HW 6 due, HW 7 posted on Wednesday
19. Thu, Apr 7th	Ch. 8: Queueing Theory	
20. Tue, Apr 12th		HW 7 due
21. Thu, Apr 14th		
22. Tue, Apr 19th		Midterm II, in class
23. Thu, Apr 21st	Introduction to asymptotic analysis	
24. Tue, Apr 26th	* I will provide references later in the semester, depending on our decision for the final exam and how well we adhere to the temptartive schedule.	HW 8 posted
25. Thu, Apr 28th		
26. Tue, May 3rd		HW 8 due
27. Thu, May 5th	Review session	
28. Thu, May 12th	Final exam, 7-10 pm	Let's talk about it

10 Mental and Physical Well-Being

William & Mary recognizes that students juggle different responsibilities and can face challenges that make learning difficult. There are many resources available at W&M to help students navigate emotional/psychological, physical/medical, material/accessibility concerns. **Asking for help is a sign of courage and strength.** If you or someone you know is experiencing any of these challenges, we encourage you to reach out to the following offices:

- For psychological/emotional stress, please consider reaching out to the W&M Counseling Center at <https://www.wm.edu/offices/wellness/counselingcenter/>; or (757) 221-3620, 240 Gooch Dr., 2nd floor. Services are free and confidential.

- For physical/medical concerns, please consider reaching out to the W&M Health Center at <https://www.wm.edu/offices/wellness/healthcenter/>; or (757) 221-4386, 240 Gooch Drive.
- For additional support or resources, please contact the Dean of Students by submitting a Care Report at <https://www.wm.edu/offices/deanofstudents/services/caresupportservices/index.php>; or by calling 757-221-2510, or by emailing deanofstudents@wm.edu.
- For a list of many other resources available to students, see [Health and Wellness Resources for Students](#).

As your instructor this semester, I also ask you to reach out to me if you are facing challenges inside or outside the classroom. I am happy to grab a cup of coffee together and I can guide you to appropriate resources on campus.