Modelos Probabilísticos
IIND-2104
Universidad de Los Andes
2015-I

Universidad de los Andes
Facultad de Ingeniería

1. Staff

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2. Objectives

1. The students will learn to apply knowledge of mathematics and probability in the design, modeling and analysis of stochastic systems. Such systems include Continuous-Time Markov Chains, queueing theory, Discrete-Time Markov Chains and stochastic dynamic programming. Through the completion of three individual written exams, we evaluate this ability (ABET Outcome A).

2. The students will learn to work in teams on a project in which a system which resembles reality will be studied, using the topics covered in the course. During the first phase of the project they will need to work in groups in order to understand the system, describe it, and measure its relevant aspects. (ABET Outcome D).

3. Through the completion of the second phase of the project, the students will learn to identify and analyze stochastic models in order to measure the performance of a system resembling reality in which randomness is involved. Moreover, they will be able to provide the best answer to a decision problem over a planning horizon among a set of different modification alternatives aimed at improving the system. (ABET Outcome E).

4. By presenting the outcomes of the project, the students will learn to communicate the solutions to non-technical decision makers such as high-level managers and factory operators through graphical and visual techniques using common software packages like Microsoft Excel. (ABET Outcome G).

3. Contents

Week	Topic	Main Text	Complementary	Remarks	Class Topics
1 19/01- 23/01	Introduction- Motivation	Factory Physics 0, 1 Kulkarni 6.1, 6.3, 6.5	Winston 5.1 Winston 8.2 Ross 5.1, 5.2, 5.3		1. Introduction and Motivation 2. Exponential Random Variables, Introduction to Stochastic Processes, Poisson Process
2 26/01- 30/01	CTMC	Kulkarni 6.2, 6.4, 6.6	Ross 6.1,6.2	Homework 1 (Monday)	3. Introduction to CTMC 4. CTMC Examples
3 02/02- 06/02	Birth and Death Processes, Queueing Theory	Kulkarni 6.9, 6.10 Winston 8.3. Winston 8.1, 8.2, 8.4	Ross 6.3, 6.5 Ross 8.1, 8.2,8.3 Kulkarni 8.1,8.4		5. Limiting behavior, Birth and Death Process 6. Introduction to Queueing Theory and Little's Law
4 09/02- 13/02	Queueing Theory	Winston 8.5, 8.6 Winston 8.7, 8.8	Ross 8.9 Kulkarni 8.3, 8.4 Ross 8.5 Kulkarni 8.4	**Project Phase I Description (Monday)**	7. M/M/1, M/M/1/c 8. M/M/s, Infinite servers, M/G/1
5 16/02- 20/02	Queueing Theory	Winston 8.9 Winston 8.10	Ross 8.8. Kulkarni 8.3 Ross 8.4 Kulkarni 8.7		9. Finite source models 10. Open Networks
6 23/02- 27/02	Queueing Theory	Winston 8.10	Ross 8.4 Kulkarni 8.7	Submission Homework 1 (Friday)	11. Open networks and examples 12. Review class
7 02/03- 06/03	Queueing Theory	Factory Physics 8.1-8.4. Factory Physics 8.1-8.4		Homework 2 (Monday) **Exam 1** **(Monday 6:30 pm)** **Submission of Phase I (Friday)**	13. G/G/m and tandem queues 14. G/G/m, Tandem queues and examples

8 09/03- 13/03	DTMC	Winston 5.2 Winston 5.3	Ross 4.1 Kulkarni 5.2, 5.3 Ross 4.2 Kulkarni 5.4	**Friday: last day for the 30%**	15. DTMC introduction and modeling 16. DTMC transition probabilities, N-step transition probabilities, DTMC modeling and examples
9 16/03- 20/03	DTMC	Winston 5.4 Winston 5.5	Ross 4.3 Ross 4.4 Kulkarni 5.6	**Friday: last day to drop the course**	17. Classification of states 18. Steady state and mean first passage times
10 24/03- 27/03	DTMC	Winston 5.5 Winston 5.6	Ross 4.4, 4.5 Kulkarni 5.6, 5.7 Ross 4.6	**Project Phase 2 description (Monday)**	19. Absorbing chains 20. Examples
11 30/03- 03/04	Recess				
12 06/04- 10/04	DTMC/ Stochastic Dynamic Programming	Winston 5.6	Ross 4.6	Submission Homework 2 (Friday)	21. Absorbing states, workforce planning. 22. Review class
13 13/04- 17/04	SDP in finite time	Puterman 1 Winston 6.2 Puterman 2.1, 3, 4.5, 4.6 Winston 7.1, 7.3, 7.4.		Homework 3 (Monday) **Exam 2 (Monday 6:30 pm)**	23. Intro to DDP, Backwards Iteration 24. Formulation and solution of DDP
14 20/04- 24/04	SDP in finite time and infinite time	Winston 7.1, 7.3, 7.4. Puterman 4.5, 4.6 Winston 7.5			25. Formulation and solution of SDP 26. MDP
15 27/04- 30/04	MDP	Winston 7.5 Puterman 4.5, 4.6			27. Solution of MDP 28. MDP Examples
16 04/05- 08/05	Review Classes			Submission Homework 3 (Friday)	29. Review Class 30. Review Class

4. References

4.1. Primary Text:

- W Winston. *Introduction to Probability Models*, Fourth edition, Thomson, 2004.

4.2. Complementary Texts:

- S. Ross. *Introduction to Probability Models*, Ninth Edition: Academic Press, 2007.
- W. Hopp and M. Spearman. *Factory Physics*, Third Edition, McGraw Hill, 2008.
- V. Kulkarni. *Modeling, Analysis, Design and Control of Stochastic Systems*. New York: Springer, 1999.
- M. Puterman. *Markov decision processes: discrete stochastic dynamic programming*. New York: John Wiley & Sons 1994.
- L. Castañeda, V. Arunachalam, and S. Dharmaraja. Introduction to Probability and Stochastic Processes with Applications. New Jersey: Wiley, 2012.

5. Evaluation Method

Activity	Value	Date	Comment	
Exam 1	15%	Monday March 2nd	Written	
Exam 2	15%	Monday April 13th	Written	
Exam 3	20%	Assigned by Registro	Written (cumulative)	
Homework 1	7%	Pub Tuesday January 28th		
Homework 2	7%	Pub Tuesday March 4th		
Homework 3	7%	Pub Tuesday April 15th		
Project	20%	First phase: Published Feb 9th Submitted Mar 6th Second phase: Published Mar 24th. Submission date to be decided Presentations will be done on the date assigned by Registro.	Groups of 3-4 people	
			Phase 1 Report	5%
			Phase 2 Report	9%
			Presentation	6%
Complementary	9%	During the semester		
Total	100%			

Partial grades will be evaluated and published before the 30% grades deadline. A calendar with the important dates will be posted on SICUA+.

6. Rules

6.1. Final Grade

The final grade of the course will be approximated to the nearest two decimal digits, e.g. 3.925 yields a final grade of 3.93. Furthermore, the course will be considered passed with 3.0 points or more, with a **weighted average grade of 3.0 or greater** over the three exams. If the weighted average grade of the exams is lower than 3.0, then the final Banner mark can be at most 2.99.

6.2. Homework

Homeworks are to be done *individually* and submitted in a *digital format*. Problems will be posted on SICUA+ at least one week prior to the due date and solutions will be posted on SICUA+ after the homework is turned in. It is expected that every solution procedure is defined and explained in detail, as well as the description of the variables, set of states, queues, servers, and other components of the system. The solution to the homework assignments **must be uploaded to SICUA+ and printed on both sides** of a letter size paper with the cover format attached. If the homework is **missing in SICUA+ or was not printed the grade will be 0**. If the version in **SICUA+ differs from the printed one, it will be considered fraud**. Any homework solution that is not printed on both sides will be **penalized with 10 points.** Also, if the cover format is not attached **another 10 points will be deducted.**

Check **SICUA+, and your e-mail** frequently, since the news, errors in solutions and all the information regarding this course will be communicated through this platform. Everything related to the course will be posted on SICUA+. **It is your responsibility to check it frequently.**

6.3. Complementary Classes

The complementary classes are weekly sessions of 80 minutes where exercises related to the topics of the week are discussed. Exercises are posted on SICUA+ a few days prior to the class. During the complementary classes a quiz related to the exercises posted on SICUA+ will be carried out. The grade of the complementary class will be given by the performance of the student in the weekly and in the quizzes. **Make-up quizzes will never be performed regardless of the reason.**

6.4. Exams

There will be three written exams during the semester. It is expected that every solution procedure is defined and explained in detail, as well as the description of the variables, set of states, queues, servers, and other components of the system. Independent of the course final mark, a **weighted average grade of 3.0 or greater** over the three exams is necessary in order to pass the course.

During the exam each student will have the chance to call for assistance at most four (4) times. In each call, the student will be allowed to ask as many questions as he/she desires. After the 4 chances have been taken, there will be no further questions allowed for the student.

Exams 1 and 2 are scheduled on two different dates throughout the semester at 6:30 pm. Exam 1 covers topics from week 1 through 6 and Exam 2 covers topics from week 7 to week 12. Exam 3 is scheduled by Registro on the final exams period. This exam covers topics taught throughout the entire semester.

Makeup exams will be given according to the rules of the university, **and will be given only to students that are not present during the scheduled exam**. Additionally, the students that have a regular and prescheduled academic activity during the time of the exams should submit a written excuse during the first two weeks of classes.

6.5. Additional Resources

Problem Solving Clinics. During the semester, you can seek support from the teaching assistants regarding homework, exams or any other issue related with the course. The schedule and location of the clinics will be posted on SICUA+. Students must take into account that the teaching assistants are only available during the scheduled clinics. It is not possible for the assistants to answer questions in their office.

Students may always write an email to the professors or the assistants asking for an appointment in advance.

6.6. Project

The project is to be done in groups of **four** within the same complementary section. Each student is allowed to choose the people to team up with. The rules for evaluation and presentation of the project will be included in Phase 1 and Phase 2 project statements separately. Each team may choose to submit their project reports in English or Spanish (reports in English will be awarded a 5% bonus). The presentation of the project will be done during the last week of classes on the scheduled time for the final exam, which is announced during the last week of classes. The submission of the presentation slides is required and you will be instructed through SICUA+ on how and when to do so.

It is required for each project to be based on an original work of the team and the data gathered by the members of the group, or as instructed. Failure to comply with this will be considered fraud.

6.7. Claims:

Once the graded evaluations are delivered, deadlines to present your claims will be announced. The claims should be submitted according to a template that will be published for that purpose. The student will submit his/her evaluation with the respective signed claim template, declaring that the evaluation was not modified in any form.

6.8. Fraud:

Any suspicion of fraud within the activities of the course will be treated according to the University's rules. Make sure to review them at Chapter X of the following link:
http://secretariageneral.uniandes.edu.co/images/documents/ReglamentoGralEstudiantesPregrado.pdf

ABET Outcomes.

	ABET Outcome	Contribution	Description	Course Measures
A	Math, Science, Engineering	**Major**	An ability to apply knowledge of mathematics, science, and engineering	Three individual exams
B	Design and Conduct Experiments	Minor	An ability to design and conduct experiments, as well as to analyze and interpret data	
C	Design Systems, Components, Process	Minor	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	
D	Multi-disciplinary Teams	**Major**	An ability to function on multi-disciplinary teams	Project Phase I
E	Engineering Problems	**Major**	An ability to identify, formulate, and solve engineering problems	Project Phase II
F	Professional and Ethical Responsibilities	Minor	An understanding of professional and ethical responsibility	
G	Communication	**Major**	An ability to communicate effectively	Project Presentation
H	Impact of Engineering Solutions	Minor	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	
I	Life-long Learning	Minor	A recognition of the need for, and an ability to engage in life-long learning	
J	Contemporary Issues	Minor	A knowledge of contemporary issues	
K	Modern Engineering Tools	Minor	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	