American University of Beirut
Faculty of Engineering and Architecture
Industrial Engineering and Management Department

INDE 303 Operations Research II & ENMG 623 Stochastic Models and Applications
Spring 2024, CRN 21663 & 21427, TTh 2:00 PM - 3:15 PM, Bechtel 211

Instructor

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Course Description

Operations Research (OR) is a decision science concerned with optimal allocation of scarce resources. (Check out *www.informs.org* .) OR applications include production planning and scheduling in manufacturing, staffing, pricing, and capacity planning in service industries (e.g. airlines, hotels, retailing), military operations, health care management, and financial asset management, among others. Operations researchers develop mathematical models of real life systems with the objective of enhancing performance. In INDE 302 Operations Research I, the emphasis is on "deterministic" OR models, which assume certainty and linearity. Here, in INDE 303 Operations Research II, you will explore decision problems involving one or more elements of uncertainty. The assumption of uncertainty is quite realistic for most problems. However, it brings with it additional complexities. The mere evaluation of the objective function and constraints for a given set of decision variables requires creative use of *probability theory*. In this course, we will explore the art and science of "modeling under uncertainty." The course will start with an in-depth coverage of probability and random variables and then emphasis two wide areas of probabilistic OR applications: *Markov Chains*, and *Queueing*[1] *Systems*.

Course Learning Outcomes

- Understand the OR methodology of mathematical modeling.
- Develop probabilistic models for real problems.
- Enhance the understanding of probability theory through real applications.
- Understand the probability theory in Markov chains and queueing models.
- Identify and understand the applications of Markov chains and queueing theory.
- Master the fundamental techniques for analyzing basic Markov chains and queues.

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[1]Never spell this as "Queuing" in this course.

Textbook

Ross, S. M. (2019). *Introduction to Probability Models*, 12^{th} Edition. Academic Press.

Additional References

1. Harchol-Balter, M. (2023). Introduction to Probability for Computing. Cambridge University Press.

2. Harchol-Balter, M. (2013). Performance Modeling and Design of Computer Systems: Queueing Theory in Action. Cambridge University Press.

3. Feller, W. (1968). *An Introduction to Probability Theory and Its Applications*, Vol. 1, 3^{rd} Edition. Wiley.

4. Gross, D. and C. Harris (1998). *Fundamentals of Queueing Theory*, 3^{rd} Edition. Wiley.

5. Hillier, F. S. and G. J. Lieberman. *Introduction to Operations Research*, 8^{th} Edition. McGraw-Hill.

6. Ross, S. M. (2002). *Introduction to Probability Models*, 8^{th} Edition. Academic Press.

7. Taha, H. A. *Operations Research: An Introduction.* Ninth Edition. Prentice Hall, 2011.

8. Winston, W. L. (2003). *Operations Research: Applications and Algorithms*, 4^{th} Edition. Duxbury Press.

Tentative Schedule

Topics will be covered according to the following schedule. While the schedule may very slightly, *the midterm exam date will not be changed.*

- Week 1: Course introduction and the OR modeling approach
- Week 2: Basic probability theory, sets, probabilistic models, conditional probability, Bayes' rule, independence.
- Week 3: Random variables, discrete and continuous, mass and density functions, expectation, variance, independence.
- Week 4: Common discrete random variables: Bernoulli, Binomial, Geometric, Poisson. Properties and OR applications.
- Week 5: Common discrete random variables: Uniform, Exponential, Normal. Properties and OR applications. A stock price model: The Lognormal random variable.
- Week 6: Discrete time Markov chains, classification of states, OR applications.
- Week 7: Discrete time Markov chains, stationary solution, OR applications.
- Week 8: **Midterm exam on Tuesday March 12, 2024 at 2 PM.**

- Week 9: Continuous time Markov chains, Chapman-Kolmogorov equations, limiting probabilities, applications.
- Week 10: Continuous time Markov chains, Birth-death process, pure birth process, Poisson process.
- Week 11: Queueing models, application of birth-death analysis to Markovian queues
- Week 12: Detailed analysis of Markovian queues, single- and multi-server, finite waiting space
- Week 13: More queueing, finite population, queueing cost models.
- Week 14: Even more queueing, networks of queues and general service times.
- Week 15: **Final exam**

Grading

Midterm Exam	25%
Final Exam	35%
Homework	20%
Project	20%

Homework

Homework problems will be assigned frequently. All students are encouraged to solve the homework problems and discuss their solutions with the instructor and their colleagues. However, *every student must write his own homework assignments.* **Doing the homework is the best way to excel in this course.** Do not type the homework. But do stable it. No late submissions will be accepted.

Project

For INDE 303 students, the project will involve a case study on applying Markov chains or queueing modeling to a real-life problem. It is intended to give the students a taste of realistic OR applications. For ENMG 623 students, the project will involve an in-depth reading of an academic paper. More details will be provided in due time.

Attendance Policy and Class Management

Attendance will be noted utilizing random sampling.[2] A student is allowed **two** unexcused absences at most. Each additional unexcused absence will lead to losing five points from the final grade.

Course Website

`www.aub.edu.lb/∼bm05/ENMG501/`

Look for assignments and slides presented in class there.

[2] I'll call on 9 students in every session. With 33 students in the class, there is approximately 25% chance that your name is called in a given session. With around 28 sessions in the semester, there is approximately a 98.3% chance that your name will be called more than two times in the whole semester. So, the probability of missing all sessions and not getting penalized is 1.7%.