

American University of Beirut  
Faculty of Engineering and Architecture  
Engineering Management Program

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## ENMG 622 Simulation

Summer 2015, CRN 30494, MW 5:00 - 7:30 PM, Bechtel 209

### Instructor

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Office hours: MW 2:00 -4:00 PM.

### Course Description and Objectives

Simulation is concerned with developing computer models that mimic the behavior of real systems. This is done through the generation of “random variates” that replicate the statistical properties of a system. Simulation falls under the umbrella of Operations Research. The objective of simulation (like other OR models) is to gain insight into the real system with the ultimate goal of enhancing performance. Simulation is generally used when analytical methods are not effective (i.e., the model cannot be developed with closed-form mathematical expressions). It is also used for validating analytical models. As such, simulation is one of the most popular decision making tools used by analysts in OR and related disciplines. The objective of this course is to introduce the student to the main ingredients of a successful simulation study. Students will learn how to (i) process input data for a simulation model; (ii) develop a simulation model on a computer; and (iii) analyze the output of the simulation. Simulation models will be developed using Arena and spreadsheets. Financial, logistic, manufacturing, and service applications will be emphasized.

### Textbooks

1. Law, Averill M. *Simulation Modeling and Analysis*. 5<sup>th</sup> Edition. McGraw Hill, 2015.
2. Kelton, W. David, Randall P. Sadowski and Nancy Zupick. *Simulation with Arena*. 6<sup>th</sup> Edition. McGraw Hill, 2014.

### Additional References

1. Banks, J., J. S. Carson, B. L. Nelson, and D. M. Nicol. *Discrete-Event System Simulation*, 4<sup>th</sup> Edition. Prentice-Hall, 2005.
2. Hillier, F. S. and G. J. Lieberman. *Introduction to Operations Research*, 8<sup>th</sup> Edition. McGraw-Hill, 2004.
3. Ross, S. M. *Introduction to Probability Models*, 8<sup>th</sup> Edition. Academic Press, 2002.
4. Ross, S. M. *Simulation*, 3<sup>rd</sup> Edition. Academic Press, 2001.
5. Taha, H. A. *Operations Research: An Introduction*. 8<sup>th</sup> Edition. Prentice Hall, 2007.

## Tentative Schedule

Topics will be covered according to the following schedule.

- Week 1: Course introduction, OR modeling approach, simulation overview Review of Probability Theory and Random Variables. A primer on queuing theory.
- Week 2: Introduction to discrete event and process oriented simulation. Hand simulation of a queuing and an inventory system. Introduction to Arena.
- Week 3: Random number generators, linear congruential generators, mixed and multiplicative. Modeling basic systems with Arena. Other random number generators (more general congruential, composite), tests for random numbers. Modeling detailed operations in Arena.
- Week 4: Generating nonuniform random variates, inverse transform method, composition method, acceptance-rejection method. Generating nonuniform random variates, application to well-known continuous and discrete distributions.

### Midterm Exam.

- Weeks 5: More on generating random variates, generating from Normal, gamma and arrival processes. Modeling detailed operations with Arena.
- Weeks 6: Input Analysis, collecting input probability distributions, estimation of parameters, MLE estimators goodness of fit tests, Chi-Square, Kolmogorov-Smirnov. (Chapter 6 Law). Input Analysis in Arena. Financial application: Simulating stock prices.
- Weeks 7: Output analysis, statistical estimation, confidence intervals, termination rules. Output analysis in Arena. Variance reduction technique. Financial application: Pricing Asian options via Monte Carlo Simulation.

### Class presentation of student projects.

### Final Exam.

## Grading

Midterm Exam	27%
Final Exam	28%
Project	25 %
Homework	20%

## Homework

Homework will be assigned frequently. It will involve conceptual problems from Law book and Arena applications from KSS book. All students are encouraged to solve the homework problems, and to discuss them with each others and the instructor. However, every student must write and submit the homework assignment individually. Homework problems should not be typed unless they are the output of Arena or Excel spreadsheets. Make sure you staple the homework. Certain assignments require emailing Arena files. Doing the homework is the best way to excel in this course.

## **Project**

The project involves simulating a real system with complete input analysis, model development in Arena and output analysis with suggestions for improvement. Possible ideas include simulating traffic, parking systems, port and airport operations, computer and communications networks, call centers, banks operations, supermarket check-out lines, hospitals, diseases spread, emergency rooms, emergency response, construction operations, manufacturing systems, games, or any *interesting* system you find. You should work in groups of two. **A one-page proposal for the project is due on Mon 06/27/2016.** In this proposal, you briefly describe the system you want to simulate and the objective of the simulation study. Upon reading your proposals, I will either accept your proposal or ask you to look for another idea. In the last week of classes, you are required to do a 15-minute presentation of your project. You must also submit a written report not exceeding 15 pages, double-spaced, font 12, ample margins, and containing an abstract, an introduction and a conclusion section.

## **Attendance Policy and Class Management**

Attendance will be noted. No student will be admitted to class after 15 minutes from the beginning of the lecture. **Cell phones, laptops and other gadgets are not allowed in class.**

## **Examination Policy**

A student is not allowed to miss an exam except for a valid medical excuse. However, no make-up exam will be given for the midterm exam. Instead, for students who miss the midterm exam, with a valid excuse, the weight of the final exam will be changed to 55%. Students who miss the final exam will be given an incomplete grade and will have to take a make-up exam at the beginning of the following semester. **The make-up exam is expected to be more challenging than the regular final exam.**

## **Course Website**

[www.aub.edu.lb/~bm05/ENMG622/](http://www.aub.edu.lb/~bm05/ENMG622/)

Look for assignments and slides presented in class there.