

University of Cincinnati College of Business
Department of Quantitative Analysis and Operations Management
QA 571/771: Simulation Modeling – Fall Quarter 2009

Syllabus

Undergraduate students should register for QA 571, and graduate students should register for QA 771 (the content and requirements are identical).

Instructor:

- Dr. W. David Kelton, Professor of Quantitative Analysis and MSQA Program Director (www.business.uc.edu/msgq)
- david.kelton@uc.edu, 525 Lindner Hall, 513-556-6834, www.cba.uc.edu/faculty/keltonwd/
- Office hours: Mondays 4:00-6:00pm, after each class, by appointment, and ongoing by e-mail (please set your e-mail account/client to copy back prior messages when replying or forwarding)

Website: <http://blackboard.uc.edu/>. Use your UC login and password to access, then select the “meta”-course on Simulation Modeling under My Courses in the upper right (you will not find anything for either QA 571 or QA 771 separately). Check frequently for announcements, material, and updates.

Catalog description: 4 undergraduate/graduate credits. Building simulation models of complex dynamic, stochastic, discrete-event systems using high-level simulation software. Topics include modeling, input, and output analysis, and managing simulation projects. Prereq.: QA 242 or QA 711 or MSQA student or QAOM PhD student.

Objectives: Techniques and application of computer simulation of existing or proposed real-world facilities and processes. Models of such facilities or processes are often complex, precluding traditional analytical techniques. Students will learn to build simulation models and do simulations with full-strength commercial simulation software (Arena), analyze and interpret the results, as well as to plan simulation studies. Additional topics include selecting input probability distributions and statistical analysis of simulation output.

Class meetings: Tuesdays, 6:00pm-9:30pm, 216 Lindner Hall.

- Class attendance is essential for you to learn this material; let me know in advance if you must miss a class, and why, so I can help make sure you stay on track.
 - You *must* be in attendance on **Nov. 3** (mid-term exam) and **Dec. 8** (final exam).
 - We *will* have class as usual on Tues. Nov. 24 (Thanksgiving week).
- Laptop use will be allowed in class, but *only* for taking notes and following along in the class notes and software – *please, no* web surfing, e-mailing, instant-messaging, social-networking, etc., as such is very distracting to those around you, to me (believe me, I *know* when you’re doing it), and (obviously) to you. *If I receive information or complaints that this policy is being violated I regret that I will be forced to ban laptops from class.*
- Obviously, turn *off* all cell phones, Blackberries, etc. ... just putting on vibrate is not enough (search YouTube for “cell phone in class”).

Materials:

- Kelton/Sadowski/Swets, *Simulation with Arena*, 5th edition, McGraw-Hill, copyright 2010 (ISBN-10 = 0073376280, ISBN-13 = 9780073376288). *Be sure you get the 5th edition, which is very different from the first four editions.* International versions are OK as long as it's the 5th edition.
- The website for the book is <http://www.mhhe.com/kelton> and you should visit it to check the Errata Sheet and update your copy of the book accordingly.
- Lecture slides as PDF files are on the website under Course Documents. Hardcopy will be handed out for the first class only; after that it's up to you to download and print if you wish.
- Additional material will be handed out in class or posted on the website as we progress.

Prerequisites required:

1. Calculus, both differential and integral.
2. Basic probability and statistics course(s), like QA 241-242, QA 281-282, QA 711, or QA 701-702.
3. Basic operations-research overview course(s), like QA 375, QA 380, QA 711-712, or QA 702-703.
4. Experience using the Windows operating system.
5. Experience using Excel, including formulas, functions, and absolute/relative cell references.

The above five prerequisites are not just "suggested" or "maturity" prerequisites ... you really will have to know the above material quite well and be comfortable working with it routinely; otherwise, you should not take this course.

Grading:

- 20%: Approximately seven ***Individual*** Assignments. Possible solutions will be posted on Blackboard immediately after the due date/time, so late assignments cannot be accepted (the upload site will be closed at the due date/time). To reiterate, these are ***individual*** assignments to be done by yourself, ***not*** in groups, and you cannot consult with anyone other than the instructor (see "Academic Integrity" below).
- 30%: Mid-term exam (***Tues. Nov. 3***, 6:00-9:30pm, 216 Lindner). Open-book, but closed everything else. Calculators required, but no computers allowed. No sharing books or calculators.
- 20%: ***Individual*** project and paper. This will be a complete simulation study of a system of your choosing (more information on the project is below). Like the Individual Assignments, the Individual Project is indeed to be ***individual***.
- 30%: Final exam (***Tues. Dec. 8***, 6:00-9:30pm, 216 Lindner). Open-book, but closed everything else. Calculators required, but no computers allowed. No sharing books or calculators.

Computing:

- We'll use the Arena 12 software throughout the course; earlier versions of Arena won't do.
- The academic version (all functionality of the commercial version, but limits model size) is downloadable at no cost. Follow the instruction in Appendix D of the book. Be sure to enter "STUDENT" (without the quotes) when prompted for the serial number during installation ... do not default this field to blank (if you do, Arena will indeed install, but in a smaller "demo" version which is not adequate for the class, and does not include the Book Examples folder that you'll need).
- Arena 12 is also available in the Lindner Hall labs on the second floor, in its full, unlimited commercial version (this license cannot be used for any commercial purpose). As far as I know, it is not available elsewhere on campus. If you are in a College of Business program, you should already have an account. If your program is outside the College of Business, you should have an account by virtue of being in this course. In either case, log in to these machines with your usual UC credentials that you use for everything else. Consultants in the 211a Lindner lab (556-7159) can help with login problems.

List of topics by chapter in the book:

- What is Simulation? (Chapter 1)
- Fundamental Simulation Concepts (Chapter 2)
- A Guided Tour Through Arena (Chapter 3)
- A Refresher on Probability and Statistics (Appendix B)
- Modeling Basic Operations and Inputs (Chapter 4)
- Modeling Detailed Operations (Chapter 5)
- Statistical Analysis of Output from Terminating Simulations (Chapter 6)
- Intermediate Modeling and Steady-State Statistical Analysis (Chapter 7)
- Entity Transfer (Chapter 8)
- Continuous and Combined Discrete/Continuous Models (Chapter 11), if time permits
- Further Statistical Issues (Chapter 12), if time permits

Individual-project information: The **Individual** Project is to be a complete simulation study of a real system of your choosing. Typically, the steps in your project will include:

- Defining the system to be simulated and stating the purpose of the study.
- Collecting data on the system (primary or secondary) and use to determine input probability distributions and other parameters. Experience indicates that data collection can be a very difficult and time-consuming part of a study; for the purposes of this project, don't be concerned about getting a large sample size, etc., but just collect a small amount of data to get a model defined, with the knowledge that if you were being paid to do this (rather than paying to do it) you would collect more data.
- Coding and verifying the model.
- Exercising the model to evaluate the system as it is, and at least one alternate configuration or operating policy, with an eye toward improvement. Pay attention to concerns about the statistical validity of your results, i.e., do an appropriate statistical analysis of the simulation output, including the comparison or selection or optimum-seeking (see Chapter 6).
- Writing a brief final report describing what you did and what your results and recommendations are. Include output as an appendix, and submit your model(s) electronically as you'll do for the Individual Assignments. Write the report for someone who is familiar with the system, and who knows basic probability and statistics, but who does not know (or care) anything about how simulations are done. In other words, you must summarize and interpret your results, rather than present page after page of output data. There are no minimum or maximum page limits or format; say everything you need to say and don't say anything more.
- Milestones:
 - *Tues. Oct. 27, 6:00pm:* Submit a brief proposal (via e-mail to me) of what you plan to simulate, how you'll observe the systems and get data, and what questions you'll address with your model. Be sure to get permission from whomever is responsible for operating the real system.
 - *Tues. Nov. 17, 6:00pm:* Submit a brief progress report (via e-mail to me).
 - *Thurs. Dec. 10:* File(s) and written report due by 6:00pm (all files via upload through the Individual Project item under Assignments in the Blackboard metacourse). You must submit a written report, with appendices/supplements as you see fit with your results, and also your Arena files, plus any other files (e.g., Excel) that you used in your project.

Academic integrity: I take this very seriously, and you should too as it affects the value of your program and degree. On each project and exam you will be required to state and sign, in writing, "*On my honor, I have neither given nor received unauthorized aid in completing this academic work.*" Academic dishonesty in any form will not be tolerated, and will be dealt with harshly.

Simulation links:

- INFORMS Simulation Society (<http://www.informs-sim.org/> ... not linked from here due to problems with hyphen)
- Winter Simulation Conference (<http://www.wintersim.org>)
- EUROSIM, the Federation of European Simulation Societies (<http://www.eurosim.info/>)
- Rockwell Software, the vendor of Arena (<http://www.arenasimulation.com>)
- DoD Modeling and Simulation Coordination Office (M&S CO) (<http://www.msco.mil/>)
- Simio, another vendor of competing software (<http://www.simio.biz/>)
- ExtendSimulation, another competing software product (<http://www.extendsim.com/>)
- ProModel, yet another simulation product (<http://www.promodel.com/>)