COURSE INFORMATION

Course title:	Simulation Modeling II: Queuing and Discrete Event Simulation		
Course code:	BAMS 504	Credits:	1.5
Session, term, period:	2021 W2, Period 5	Class location:	HA 337
Section(s):	BA1	Class times:	Tues/Thurs 2 pm – 4 pm
Course duration:	April 18 to May 21, 2021	Pre-requisites:	BAMS 503
Division:	Operations and Logistics	Co-requisites:	N/A
Program:	MBAN		
Course website:	https://canvas.ubc.ca/courses/82537		

INSTRUCTOR INFORMATION

Instructor:	Steven Shechter		
Phone:	604-822-8340	Office location:	HA 477 or by Zoom
Email:	steven.shechter@sauder.ubc.ca	Office hours:	By appointment

Teaching assistant:	TBD
Office hours:	TBD
Email:	TBD

COURSE DESCRIPTION

Simulation is a widely used methodology in both industry and academia because it is a vital tool for decision making under uncertainty. A simulation model allows the user to test a variety of "what-if" scenarios on a computer and evaluate a variety of outcomes from complex processes before considering implementing any changes to the real system. Areas of application include health care, finance, risk analysis, manufacturing g, logistics, call centers, and military.

This course introduces students to discrete-event simulation for modeling complex, dynamic processes. Because queueing often plays a big role in these processes, we will begin with an introduction to key queueing concepts. We will then learn how to model complex processes with a widely-used discrete-event simulation software package.

COURSE FORMAT

The course will consist of lectures, exposing the relevant material, in-class discussions, in-class hands-on work, out-of-class discussions on Piazza, and out-of-class practice problems.

The lectures will be self-contained and no textbook is required for this course. Copies of the slides used in class will be available on the course website after the lecture. You should supplement the slides with your own notes taken during the lectures.

LEARNING OBJECTIVES

Purpose / rationale for the course:

- To learn the benefits of Discrete Event Simulation (DES)
- To learn about queueing processes and when to use queueing theory vs. DES

- To develop a student's ability to make data-driven decisions using simulation models

By the end of the course, students will be able to:

- Understand when and why DES is useful
- Understand when and why queueing theory is useful
- Learn how to use a DES software (Arena)
- Understand the principles for developing a DES in any programming language (e.g., R, Python, C, Java, etc.)
- Know how to properly analyze DES simulation outcomes, make comparisons, and report the results to a managerial audience.

ASSESSMENTS

Summary

Component	Weight
Two group assignments (15% each)	30%
Group final project:	60%
Project report (30%)	
Project simulation models(s) (30%)	
Participation/Professionalism	10%
Total	100%

Details of Assessments

<u>Assignments</u>

Assignments should be done in groups of 3-5 people. You may choose your own groups; if you have trouble finding a group, please let me know. Students not in the same group may discuss assignments at a high level, but are not to share code, solution details, or any part of an assignment write-up with each other.

Solutions to assignments are not purely quantitative; they also involve discussion, interpretation, insights, justification, etc. (see more below). They will be marked on a "CheckPlus/Check/CheckMinus" scale. These will then be converted into a number. Usually, a "Check" means an "average" solution and will receive approximately 80%. CheckPlus will receive more than this (typically 85%) and CheckMinus will receive less (typically 75%). The category assigned will depend on the quality of the solutions, where quality involves a combination of good modeling and derivation of results, as well as good presentation and discussion of the solution. The modal mark will generally be a "Check." CheckPlus/Check/CheckMinus marks need not always map exactly to 85%/80%/75% marks. Some differences in quality may be accommodated by assigning different percentage marks. For example, while most CheckMinus solutions may receive 75%, a really bad solution may receive a much lower mark. Also, while most CheckPlus solutions may receive 85%, a really outstanding solution may receive a higher mark.

In general, a "CheckPlus" means that the solution was thorough and thoughtful, the model development was entirely (or nearly entirely) correct, and that recommendations were clearly justified. "Check" means that the solution was satisfactory but with room for improvement, due to modeling or analysis mistakes and/or due to recommendations that were not as compelling as they could be. Finally, "CheckMinus" means that the solution was unsatisfactory with significant room for improvement. For example, model development contained several errors and/or recommendations and explanations were unclear or unsupported by the evidence.

When working on assignments, consider two perspectives: 1) a student showing me you know the technical details of what is going on, and 2) a consultant explaining to management what is going on. The first component involves things like correct modeling development, experimental design, and statistical analysis. Regarding the second item, be sure you don't just provide numerical results, but explain things clearly and concisely. Provide insight. Do the results make sense? Why or why not? Are there any other data that may be needed? Do you recommend any policy changes based on the results? Not all of these questions will apply to every problem, but the idea remains the same: clearly explain your results and don't just present numbers.

Also, make sure any programs you turn in are well-documented (i.e., put comments in the program where it would be helpful, make sensible labels for objects, etc.) so that someone else (like me) can easily understand what's going on.

<u>Final Project</u>
The purpose of the course project is to gain simulation modeling, analysis, and professional writing experience. Groups of 3-5 students each can choose among several examples that have been used in past Arena/IISE[1] annual simulation competitions. Alternatively, you may find a different case that interests you or propose your own independent project. This may include extending your project from BAMS 503, if it is reasonable to do so (check with me if you are thinking about this route). You may form your own groups, or let me know if you need help finding a group. At most two groups can select the same topic or case study (these will be posted to Canvas, and a Google sheet will be created to sign up for projects and form groups).

As you can see from the assessment breakdown, the course project makes up a significant portion of your grade (60%), so you should plan on putting a considerable amount of effort into it. My default policy is that each person in a group gets the same project grade. If there are any issues with group dynamics, try your best to work it out among yourselves. If problems persist, then speak to me about them.

Project deliverables will be due in Week 6, at a date/time to be determined by the RHL office.

- Details about the Final Report

Your project report should be a very clear, well-written Word document that includes the following sections:

1. A one-page Executive Summary
2. Introduction
3. Model description
4. Discussion of data sources and assumptions
5. Discussion of validation and verification
6. Discussion and analysis of "what if" scenarios that were tested

[1] Institute of Industrial and Systems Engineers

7. Recommendations and Conclusions

The average length of the document (before any appendices) should be approximately 15-20 pages single-spaced. Also, see the section on Assignments for the same approach to marking and principles for good submissions.

- Details about the Final Simulation model(s)

Simulation models can be created using Arena, R, Python, or C. Besides being logically correct and clean (i.e., if there are many ways to go about the same thing, you chose a simpler approach), your program should be well documented. This may include adding comments within your program and/or creating a separate Word document (e.g., a "README" document). A good question to ask yourself is "can someone else reading my program and related documentation understand what it is doing and how it works, without me being there to explain it and answer any questions?"

If using Arena, your model should also include animation as appropriate (i.e., display things that you think a client would be interested in seeing on the screen during the actual run and/or things that might help with verification). If you go the coding language-based route, animation is not expected.

Submit all relevant files (your baseline model, as well as alternative models for scenario analysis).

Participation/Professionalism

There are a number of ways to actively participate in the course. These include: asking and answering questions during lecture by voice and/or chat, sharing thoughts/ideas/news stories/etc. that promote peer-to-peer learning via the Piazza discussion forum, participating in office hours, contributing to practice problems (e.g., by solving them and/or proposing new ones), and others.
The professionalism component includes being on time to class, appearing on video, avoiding distractions (e.g., cell phone usage), and treating others with respect. More aspects of professionalism are covered below in the "Robert H. Lee Graduate School" and "University" policies section

LEARNING MATERIALS

Technology requirements:

Everyone will need the Arena software up and running on their computers. The academic version of Arena is available for free. You can go to https://www.arenasimulation.com/simulation-software-download to register and receive a copy of the software. Once you receive the link and download the software, go into MediaImage and click the "autorun" Installation Wizard. For the "customer information" screen, you can just enter STUDENT, and then go with the "standard" installation option. The academic version is fully functional; it just limits the size of your models. For example, at most 150 entities can be flowing through your model at any one time.

Arena is only compatible with Microsoft Windows-based computer systems. For students with Apple-based computers, you have two options for running Windows on your Mac, depending on your specific computer hardware:

1) For **Intel-based Macs**, Apple has instructions on how to install Microsoft Windows 10 using Apple Boot Camp here: https://support.apple.com/en-ca/HT201468 While Apple Boot Camp is free to use, it will not allow installation of Windows 10 on an Apple M1-based laptop.

or

2) For **Apple M1-based Macs, or Intel-based Macs**, you may purchase Parallels Desktop (https://www.parallels.com) virtualization software, and then install Windows 10 inside of a Parallels virtual machine

In either case, active UBC students may obtain access to the Microsoft Windows 10 Education operating system for no-charge here: https://it.ubc.ca/services/desktop-print-services/software-licensing/windows-10-education

A minimum of 8GB of RAM (memory) is recommended, with more RAM resulting in a better experience. Please also ensure you have sufficient free storage space on your Apple computer to accommodate both the Apple macOS and Microsoft Windows operating systems (usually between 25GB-30GB free). If you have any problems during installation, you may contact help@sauder.ubc.ca. While Sauder IT cannot perform the installation for you, IT staff can schedule an orientation session to help guide you through the process.

The executable of the Arena software will be installed in: C:\Program Files\Rockwell Software\Arena. The installation also places very helpful materials in a different path: C:\Users\Public\Public Documents\Rockwell Software\Arena. There you can find two the subfolders:

1. \Examples\General: This contains DES examples across a variety of application areas (e.g., emergency department, airport security, assembly line, etc.).
2. \Smarts: This contains small chunks of code that you may want to adapt for models you work on (e.g., nonstationary arrival processes, search and remove an item from a queue, conveyor logic, etc.)

Suggested Reading Materials:
An excellent simulation textbook used for graduate courses at many universities is: "Simulation Modeling and Analysis" by Law and Kelton (there are several updated editions of this, and I think the most recent editions just have the single author "Law"). This book is a good reference for both BAMS 503 and BAMS 504. The book is by no means required for the course, just a good textbook to have on your bookshelf if you see yourself doing simulation modeling in the future. Other good references include: Discrete-Event System Simulation, by Banks et al. and "Simulation with Arena", by Kelton et al. (this is especially useful for learning more about the Arena software for building DES models).

Some of these resources are available through the library course reserves, at:
https://courses.library.ubc.ca/instructorhome/id/174200

COURSE-SPECIFIC POLICIES AND RESOURCES

Prerequisites
Simulation modeling requires a solid understanding of other analytics methodologies; namely statistics and probability. It also requires comfort with coding (the coding you did already in the program with Python and R will be enough coding background for this course).

Missed or late assignments
Late submissions will not be accepted and will receive a grade of zero.

Academic Concessions
If extenuating circumstances arise, please contact the RHL Graduate School program office as early as reasonably possible, and submit an Academic Concession Request & Declaration Form https://webforms.sauder.ubc.ca/academic-concession-rhlee. If an academic concession is granted during the course, the student will be provided options by RHL, or by the instructor in consultation with RHL, per UBC's policy on Academic Concession.

Other Course Policies and Resources

Code Plagiarism

Code plagiarism falls under the UBC policy for [Academic Misconduct.](#) Students must correctly cite any code that has been authored by someone else or by the student themselves for other assignments. Cases of "reuse" may include, but are not limited to:

- the reproduction (copying and pasting) of code with none or minimal reformatting (e.g., changing the name of the variables)
- the translation of an algorithm or a script from a language to another
- the generation of code by automatic code-generations software

An “adequate acknowledgement” requires a detailed identification of the (parts of the) code reused and a full citation of the original source code that has been reused.

Students are responsible for ensuring that any work submitted does not constitute plagiarism. Students who are in any doubt as to what constitutes plagiarism should consult their instructor before handing in any assignments.

POLICIES APPLICABLE TO COURSES IN THE ROBERT H. LEE GRADUATE SCHOOL

Attendance

Excepting extenuating circumstances, students are expected to attend 100% of their scheduled class hours. Absent students limit their own academic potential, and that of their classmates, and cause unnecessary disruption to the learning environment. Students missing more than 20% of the total scheduled class hours for a course (including classes held during the add/drop period) without having received an academic concession will be withdrawn from that course. Withdrawals, depending on timing, could result in a “W” or an “F” standing on the transcript.

Punctuality

Students are expected to arrive for classes and activities on time and fully prepared to engage. Late arrivals may be refused entry at the discretion of the instructor or activity lead. Students arriving later than halfway through a scheduled class will be treated as absent for that class.

Electronic Devices

During online lectures, students are not permitted to use any electronic devices other than the primary one used for attending the online lecture (e.g. laptop or desktop). Only Zoom should be open during the online lecture unless an instructor advises the use of another program/website for an in-class activity. Feedback from students indicates that personal devices are the number one distraction from effective learning and participation in the online learning environment.

Citation Style

Please use the American Psychological Association (APA) reference style to cite your sources.

Details of the above policies and other RHL Policies are available at:
http://www.calendar.ubc.ca/vancouver/index.cfm?tree=12,199,506,1625

UNIVERSITY POLICIES AND RESOURCES

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available on the UBC Senate website at https://senate.ubc.ca/policies-resources-support-student-success.

Respect for Equity, Diversity, and Inclusion

The UBC Sauder School of Business strives to promote an intellectual community that is enhanced by diversity along various dimensions including status as a First Nation, Metis, Inuit, or Indigenous person, race, ethnicity, gender identity, sexual orientation, religion, political beliefs, social class, and/or disability. It is critical that students from diverse backgrounds and perspectives be valued in and well-served by their courses. Furthermore, the diversity that students bring to the classroom should be viewed as a resource, benefit, and source of strength for your learning experience. It is expected that all students and members of our community conduct themselves with empathy and respect for others.

Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

COPYRIGHT

All materials of this course (course handouts, lecture slides, assessments, course readings, etc.) are the intellectual property of the instructor or licensed to be used in this course by the copyright owner. Redistribution of these materials by any means without permission of the copyright holder(s) constitutes a breach of copyright and may lead to academic discipline and could be subject to legal action. Any lecture recordings are for the sole use of the instructor and students enrolled in the class. In no case may the lecture recording or part of the recording be used by students for any other purpose, either personal or commercial. Further, audio or video recording of classes are not permitted without the prior consent of the instructor. Students may not share class Zoom links or invite others who are not registered to view sessions.

ACKNOWLEDGEMENT

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the xwməθkwəy̓əm (Musqueam) people, who for millennia have passed on their culture, history, and traditions from one generation to the next on this site.

ONLINE TEACHING TOOL & REQUIREMENTS

This course will be taught using Zoom for synchronous classes and office hours.

For this course, you are required to use a Zoom account during synchronous classes and office hours. If you do not have a Zoom account, you can create one here: https://zoom.us/signup. Note: creating a Zoom account requires that you provide a first name, last name, and email address to Zoom. For privacy purposes, you may consent to using your existing email address and your real name. Alternatively, if you prefer, you may sign up using an alternative email address and an anonymized name that does not identify you (i.e. Jane Doe, jane.doe@email.com). If you have trouble creating an account, or accessing a

Zoom session, please contact CLCHelp@sauder.ubc.ca. You will be required to provide the email address associated with your Zoom account in a Canvas quiz for identification purposes.

To help replicate the classroom experience, make sessions more dynamic and hold each person accountable, both students and instructors are required to have their cameras on during Zoom sessions. Students who require an accommodation with regard to the “camera on” requirement must contact their instructors in advance of the first class to discuss options. As professional graduate students, students are expected to conduct themselves professionally by joining sessions on time, muting mics when not speaking, refraining from using any other technology when in-session, attending in business casual dress (at a minimum), and participating from a quiet environment. Content from synchronous sessions will be selectively recorded per instructor discretion and made available to students on Canvas for a maximum duration of the course length. This is done to allow students the opportunity to return to lecture content to solidify learnings.

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COURSE SCHEDULE

(Subject to change)

Week	CLASS TOPICS	ASSIGNMENTS / DELIVERABLES
1	Introduction to queueing theory Simulation of queues	April 21: HW 1 assigned
2	DES modeling concepts Model of a health care facility	May 1: HW 1 due, by midnight
3	Verification and Validation Model of a call center	May 5: HW 2 assigned
4	Guest speakers (tbd and may take place a different week)	May 15: HW 2 due, by midnight
5	Discrete-event simulation optimization	
6	No class (exam week)	Project deliverables due, date/time TBD