Course Syllabus
ISE 305/404 - SIMULATION
Spring Semester 2020

Course Description

This course presents an introduction to discrete event simulation. Discrete event simulation is perhaps the most useful and widely used analytic tool for the study of complex industrial systems. It is also quite useful for simulating many other random processes that are not amenable to mathematical analysis. Examples abound in healthcare, finance, economics, communications, EE, statistics and many other fields.

Course Objectives

This course has **two main objectives**. First you will gain proficiency in the use of a special purpose simulation language in order to be able to build useful models. Specifically you will learn the ARENA system from Systems Modeling Corp / Rockwell Software. Currently, this is the best and most advanced simulation software system available. You will learn to build valid and credible simulation models in ARENA, and be able to use these models to solve industrial problems.

The second goal is to learn the important theory and methodology behind simulation modeling and the analysis of simulation results. This is necessary in order to build valid models, perform simulation experiments, analyze results properly, and avoid costly and sometimes subtle errors. Main topics include output analysis, input analysis, random number generation, random variate generation, Monte Carlo simulation, and model validation and verification. The "theory" of simulation involves probability and statistics, thus a good background in probability and statistics (e.g. ISE 111 and 121) is a ***required prerequisite***.

The specific learning objectives for this course are that students will:

- Be able to apply discrete-event simulation concepts and modeling languages to solve a variety of industrial design and decision problems. This involves designing a model based on a real world problem, and implementing the model in code. This objective will be assessed through two extensive, team based projects.
- Be able to program effectively in the simulation language ARENA. This objective will be assessed through lab assignments and the two projects.
- Understand and be able to apply simulation input analysis and output analysis. This objective will be assessed through lab assignments, projects and in class exams.
- Be able to design and carry out statistically valid and efficient simulation experiments. This objective will be assessed through lab assignments and the two projects.
- Understand the theory of random number generators. This objective will be assessed through in class exams.
- Understand the methods used in random variate generation. This objective will be assessed through in class exams.

Homework assignments are an important aspect of this class due to the heavy use of computers. You will do homework in groups of *three*, and everyone is expected to share the load.

We will have two important and extensive projects as well. In the past, the first project was based on a simulation contest sponsored by IIE and Rockwell Software. Unfortunately the registration deadline for the contest was changed making it impossible this semester.

Course Information

We will use Coursesite to distribute course notes and assignments, and for submitting assignments. The URL for Coursesite is http://coursesite.lehigh.edu/

Prerequisites

ISE 121 (Engineering Statistics) or the equivalent is ***absolutely necessary***

Course Meeting Times

Lecture: Monday, Wednesday 10:45-11:35 (roughly) PA 416
Lab: Monday 1:35-2:50 or 3:00-4:15, Tuesday, 1:35-2:50, Mohler 121
For distance students, I will record one of the Monday labs and post on course site.

Professor

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Teaching Assistants and Office Hours

Name	Email	Office Hours	Location
Tao Li (TA)	tal214@lehigh.edu	Mon 4:15-6:00	Mohler 304
Mertcan Yetkin (TA)	mey316@lehigh.edu	Thurs 10-11:15 Fri 10-11:30	Mohler 371
Ziqi Wang (Grader)	ziw718@lehigh.edu	None	
Bob Storer	rhs2@lehigh.edu	Mon, Wed 11:45-12:00 Tues 3:00 -4:00 Wed 1:30-3:00	PL lobby Mohler 477 Mohler 477

Recommended Text (completely optional)

***Simulation Modeling and Analysis* , Averill M. Law, McGraw-Hill**

The text is not required and you will probably be fine without it (historically most students do not get it). On the one hand this is a very good, and fairly advanced book on simulation. On the other hand it is expensive. If you have an earlier edition of the book it will not be a problem.

Grading

Lab Computer Homework Assignments		10%
Lab Quizzes		15%
Two Projects	2@ 12.5%	25%
Two Hour Exams	2@ 12.5%	25%
Class participation and attendance		5%
Final Exam		20%

Note: you will spend a lot of time on the computer assignments and projects. However the two hour exams and the final, which cover the lecture material, constitute 45% of your grade. It is very important that you keep up with this material.

Grading Policy: Plus and minus grading will be used. Final grades will be curved. Graduate and undergraduate students will be graded separately. *Late assignments will not be accepted. Extra credit assignments will not be given. Students that do not show up for an exam, and do not contact me* ***before*** *the exam with a valid excuse, will receive a zero for the exam.*

Academic Honesty: Here is the statement of the Lehigh Student Senate on academic integrity:

> "We, the Lehigh University Student Senate, as the standing representative body of all undergraduates, reaffirm the duty and obligation of students to meet and uphold the highest principles and values of personal, moral and ethical conduct. As partners in our educational community, both students and faculty share the responsibility for promoting and helping ensure an environment of academic integrity. As such, each student is expected to complete all academic course work in accordance to the standards set forth by the faculty and in compliance with the university's Code of Conduct. "

Lehigh University endorses The Principles of Our Equitable Community (http://www4.lehigh.edu/diversity/principles). We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

The Office of Academic Support Services in the Dean of Students office addresses requests for accommodations for learning and/or physical disabilities for undergraduate and graduate students. For more information, I encourage you to visit the web site at: http://www.lehigh.edu/%7Einacsup/disabilities/

ISE 305/404 Simulation Lab

The lab portion of ISE 305/404 will be devoted to learning to build simulation models using the modeling language ARENA. A typical day in lab might proceed roughly as follows:

- A 10 minute multiple choice type quiz on the previous week's material and homework assignment
- A roughly 20-30 minute "lecture/demonstration" introducing new ARENA concepts
- A 5 minute introduction to the next homework assignment
- A 20-30 minute period to work on the assignment in lab with help from the instructor and TA

All homework assignments will be done in groups of ***three***. Note that $2 \neq 3$ and $4 \neq 3$. Groups up to the end of the first project will be picked/organized by the students.

You should organize your groups ASAP. Here are the rules:

- Group must have 3 members
- All members must be in the same lab section
- Members must be either all undergraduates or all graduate students.

After the first project is handed in, I will rearrange groups. I usually do this based on class attendance (i.e. the 3 students with the worst attendance record will be in the same group, etc.).

ARENA programs should be submitted through Coursesite. Outputs and/or write ups, when requested, should also be turned in via Coursesite.

I would guess that there would be about 7 to 9 quizzes total. ***I will drop your 2 lowest quiz grades***. Note that the quizzes will be given at the beginning of lab. If you are late, and miss the quiz, you are out of luck. If you are sick and miss a quiz, you are out of luck. If you are away on a job interview, you are out of luck. ***That is why I drop the lowest two quiz grades.*** A significant portion of the labs will focus on the two major projects in this class. This will be especially true in the two or three weeks prior to the project due dates.

2020 Tentative Schedule for Lecture Portion of ISE 305/404: Simulation

Note that while I will try to stick to this but things may well change along the way. Thus this must be considered only as a rough guide. Typically I fall behind the schedule a bit. I will however maintain the exam dates as planned.

In the lecture portion of class, we will cover material on the "theory" of simulation (i.e. simulation methodology), and may also cover certain aspects of ARENA not covered in LAB.

Date Material and Major Assignment Due Dates

1/20 Introduction to the course; Chapter 1

1/22 Introduction to Simulation and General Principles; Sections 2.1 and 2.2.

1/27 Introduction to Simulation and General Principles; Chapter 3

1/29 Output Analysis for a Single System: Chapter 9

2/3 Output Analysis for a Single System: Chapter 9

2/5 Output Analysis for a Single System: Chapter 9

2/10 Analysis for Comparing Alternative Systems: Chapter 10

2/12 Analysis for Comparing Alternative Systems: Chapter 10

2/17 Analysis for Comparing Alternative Systems: Chapter 10

2/19 Analysis for Comparing Alternative Systems: Chapter 10

2/24 Input Analysis: Chapter 6

2/26 Input Analysis: Chapter 6

3/2 Review for exam 1

3/4 **Exam 1**

3/9 **SPRING BREAK!**

3/11 **SPRING BREAK!**

3/16 Input Analysis: Chapter 6

3/18 Input Analysis: Chapter 6

3/23 Input Analysis: Chapter 6, Random Number Generation: Chapter 7

3/25 Random Number Generation: Chapter 7.
Project 1 will be due around 3/25

3/30 Random Number Generation: Chapter 7

4/1 Random Number Generation: Chapter 7

4/6 Random Variate Generation: Chapter 7

4/8 Random Variate Generation: Chapter 7
Last day to withdraw with a "W" is 4/10

4/13 Random Variate Generation: Chapter 8

4/15 Random Variate Generation: Chapter 8

4/20 Verification and Validation of Simulation Models: Chapter 5

4/22 **Exam 2**

4/27 Variance Reduction Techniques Chapter 11

4/29 Course wrap-up and review for final

FINAL PROJECT DUE FRIDAY 5/1 5:00 pm

FINAL EXAM Saturday May 9, 8:00-11:00 AM, Neville 001