



**ISE 580 Performance Analysis with Simulation**  
Units: 3  
Spring 2022- W 6:40 p.m.  
**Location:** OHE 136

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## **Course Description**

Simulation is a widely used statistical method for decision making. It consists of building a probability model representing a system. The model contains relationships that describe how to compute the outputs given the values of the inputs. Some of these inputs are controllable by the decision maker and others are probabilistic in nature. The system outputs depend on the decisions made by the analyst, who may experiment with the model to find the best set of decisions. Those that lead to optimal results. The inputs are modeled by random variables whose distribution may be estimated by the data available. Simulation models are tools to predict how a system operates given some choices. It can be very powerful to designing a new system or to improve an existing one.

Monte Carlo simulation models are useful to represent a system at a fixed time instant while system simulation models represent systems that evolve in time (with changes occurring at separated time instants). Both can be used to improve operations and to identify what decisions lead to optimal results.

In this course we review the fundamentals of simulation models and use state-of-the-art tools to implement these models on a variety of applications.

**Prerequisite(s):** None.

**Recommended Preparation** Expected to have knowledge of Engineering Statistics at the level of ISE 225 and working knowledge of a programming language.

## Learning Objectives and Outcomes

At the end of this course students are able to

- Identify the different types of simulation models
- Build Simulation Models with ARENA
- Perform goodness of fit tests
- Analyze the output of a simulation model
- Construct Confidence Intervals to compare the performance of two or more system configurations
- Optimize a system configuration with ARENA

## Course Notes

The course material is available on Blackboard.

## Technological Proficiency and Hardware/Software Required

The student version of ARENA, is the main computational tool. It is a MS Windows based Software. Students using MacOS should follow the VDI Tutorial pdf file on Blackboard to have access to ARENA. The R language and the RStudio IDE will be used for more general statistical analysis.

## Required Textbook

- Kelton, Sadowski, *Simulation with ARENA*, 6ed., McGraw-Hill, 2014

## Supplementary Materials (References)

- Law A., *Simulation Modeling & Analysis*, 5<sup>th</sup> Edition, McGraw-Hill, ISBN 9780073401324

## Description and Assessment of Assignments

- **Midterm** in-class based on the schedule and 2 hours length.
- **Final Examination** a comprehensive exam scheduled by USC.
- **Homework** are assigned every other week. Homework is based on the material of the previous and current week. It may be graded by an in-class quiz.

## Grading Policy

Assignment	Points	% of Grade
Homework	100 each	30
Midterm	100	30
Final	100	40
TOTAL		100

Grading Scale (Course final grades will be determined using the following scale)

A	95-100	B-	80-82	D+	67-69
A-	90-94	C+	77-79	D	63-66
B+	87-89	C	73-76	D-	60-62
B	83-86	C-	70-72	F	59 and below

## Assignment Submission Policy

Assignments should be typewritten and clean. They should be submitted as pdf files by the due date. Email submissions and late submissions are not allowed. No make-up exams are considered.

## Timeline and Rules for submission

Assignments are to be returned the week after submission. Solutions will be released soon after the homework submission date.

## Course Schedule: A Weekly Breakdown

	Date	Topics/Daily Activities	Chapter
1	Jan 12	<b>Introduction to Simulation.</b> Types of Simulation Models. The Flaw of Averages. <b>Introduction to R</b> , RStudio, and rmarkdown. Introductory example with R	
2	Jan 19	<b>Monte Carlo simulation.</b> Random variables Triangular, Gamma, Weibull, Lognormal. Examples on Marketing, Manufacturing, and Finance.	Notes
3	Jan 26	<b>Simulation with ARENA.</b> Category Overview Report. Statistics on Queues, Resources, Time in System. Case Study: Serial and parallel Service. Exercises 5.2, 5.7.	K 6.4 p288  K 3.5
4	Feb 2	<b>Simulation with ARENA.</b> Model 4-1 Assembly and Test System.	K 4.1
5	Feb 9	<b>Simulation with ARENA.</b> Model 4-2. Resource Schedules and States (failures) Exercise 4.18 Fast Food Restaurant. Arrival Schedules.	K 4.2  K 4.6.6 p193
6	Feb 16	<b>Comparing Two Systems with ARENA.</b> Two-Sample $t$ test, Paired $t$ test. Exercise 4.10	K 6.4 p288
7	Feb 23	<b>MIDTERM EXAM</b> (Exercises 4.15, 4.16, 4.18)	
8	Mar 2	<b>Input Probability Distributions.</b> Fitting data with the ARENA Input Analyzer. Goodness of Fit test. Empirical cdf. Examples.	K 4.6
9	Mar 9	<b>Applications on Discrete Systems Simulation</b> Queues (Capacity and Entity Priority). Example. Car Wash Service.	
10	Mar 16	<b>Spring Break</b>	
11	Mar 23	<b>Applications on Discrete Event Simulation</b> Sets (Counters). Exercise 4.13, Emergency Room. Sets (Resources). Exercises 5.5, 6.6	K 4, 6
12	Mar 30	<b>Statistical Concepts on Simulation Models</b> Confidence Interval, half-width and precision. Arrival Processes. The Poisson Process.	K 4.2, 12.3
13	Apr 6	<b>Systems Optimization.</b> ARENA OptQuest Toolbox. Exercise 6.5	K 6.6
14	Apr 13	<b>Generating Random Observations</b> The Inverse Transform Method. Mixtures and the Composition Method.	K 12.2
15	Apr 20	<b>Modeling Detailed Operations</b> Model 5-2. Call Center Simulation	K 5
16	Apr 27	REVIEW	
	May 4	<b>Final Exam</b>	

## Statement on Academic Conduct and Support Systems

### Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” [policy.usc.edu/scampus-part-b](http://policy.usc.edu/scampus-part-b). Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, [policy.usc.edu/scientific-misconduct](http://policy.usc.edu/scientific-misconduct).

### Support Systems:

*Counseling and Mental Health - (213) 740-9355 – 24/7 on call*  
[studenthealth.usc.edu/counseling](http://studenthealth.usc.edu/counseling)

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

*National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call*  
[suicidepreventionlifeline.org](http://suicidepreventionlifeline.org)

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

*Relationship and Sexual Violence Prevention and Services (RSVP) - (213) 740-9355(WELL), press “0” after hours – 24/7 on call*  
[studenthealth.usc.edu/sexual-assault](http://studenthealth.usc.edu/sexual-assault)

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

*Office of Equity and Diversity (OED)- (213) 740-5086 | Title IX – (213) 821-8298*  
[equity.usc.edu](http://equity.usc.edu), [titleix.usc.edu](http://titleix.usc.edu)

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

*Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298*  
[usc-advocate.symplicity.com/care\\_report](http://usc-advocate.symplicity.com/care_report)

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity | Title IX for appropriate investigation, supportive measures, and response.

*The Office of Disability Services and Programs - (213) 740-0776*  
[dsp.usc.edu](http://dsp.usc.edu)

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

*USC Support and Advocacy - (213) 821-4710*

[uscса.usc.edu](http://uscса.usc.edu)

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

*Diversity at USC - (213) 740-2101*

[diversity.usc.edu](http://diversity.usc.edu)

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

*USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call*

[dps.usc.edu](http://dps.usc.edu), [emergency.usc.edu](http://emergency.usc.edu)

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

*USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call*

[dps.usc.edu](http://dps.usc.edu)

Non-emergency assistance or information.