Simulation Modeling and Analysis   *

Section	IE 621	Instructor	Professor. G. Bengu
Class Hours	Monday 6:05 – 8:55 pm *Classes might delay due to projects / exams*	**Room & Software**	*GITC 2305* **64 PC** *32 Lab* *Arena software:* **16.2 (64 bit)** *(https://njit.instructure.com/courses/42201/files/6952064/download)* ↓ *(https://njit.instructure.com/courses/42201/files/6952064/download?download_frd=1)* *or* *16.2 (32bit) (https://njit.instructure.com/courses/42201/files/folder/Arena%20Software?preview=5351078)*
Email	**bengu@njit.edu (mailto:bengu@njit.edu)**	**Office Hours**	M/R @4-5:00 @ ME332 or ITC2305or appointment Zoom, GoogleMeet

Course Schedule

Lecture	Topic	Ma...
1	**INTRO TO SIMULATION MODELING** Understanding the role of simulation in systems analysis, such as manufacturing and service systems. **Assg**: *Study 2 Arena Examples,* *Report Results after reading related Articles* Examples: • *Flexible Manufacturing System, Transportation System* • *Health Care System –ER room, Bank Model System*	**Ch 01 Slides.ppt (https://njit.instructure.com/courses/42201/files/695...** **Ch 02 Slides.ppt (https://njit.instructure.com/courses/42201/files/695...**
2	**INTRO TO COMMON APPLICATIONS OF SYSTEM SIMULATION EXPERIMENTS** Presenting simulation results using a confidence level approach. Syllabus Review, Example: Airport Inspection Simulation Model **Assg: *Build Airport Inspection Analyze 3 Replication Results with 95% CI, Recommend*** ****Check the Last day to drop full semester courses with a refund***	**Arena Basics (https://njit.instructure.com/courses/42201/files/695235...** **Ch 03 Slides.ppt (https://njit.instructure.com/courses/42201/files/695...**
3	**Arena- MODELING** Arena Basic Modules: Arrive, Server, Depart, Fundamental concepts of Simulation : numerical computation *Assg: Report Basic Modules/Elements* ****Check Last day to drop full semester courses w/h a grade on record - No Refund***	**Confidence Interval (https://njit.instructure.com/courses/42201/files...** **Ch 04 Slides.ppt (https://njit.instructure.com/courses/42201/files/695...**
4	**Discrete Event Simulation** *Assg: Electronic Assembly System Model*	**Statistics Review (https://njit.instructure.com/courses/42201/files/69...** **t test (https://njit.instructure.com/courses/42201/files/6952087/preview...** **Video (HW-Electronics assembly) (https://njit.instructure.com/courses/4...**

5	**Fundamental Concepts in Simulation** Event Scheduling- Time Advance, Manual Simulation *Assg: Manual Simulation via Excel* ***Projects to choose from*** *($CANVAS_COURSE_REFERENCE$/file_ref/g746d0f437c32be2df602eaf82b044b4d/preview)* ***Project Grading Criterias*** *(https://njit.instructure.com/courses/42201/files/6952336/preview)*	**Chp. 05 Slides v1.ppt** (https://njit.instructure.com/courses/42201/files/6952050?wrap **ElectrolynandPlanting.doe example** (https://njit.instructure.com/courses/42201/file (https://njit.instructure.com/courses/42201/files/6952288/download?download_frd=1) **Manual Simulation** (https://njit.instructure.com/courses/42201/files/6952240/preview) **Man. Simulation & Mid review** (https://njit.instructure.com/courses/42201/files/6952
6	**HW to prepare for the Midterm Exam** **(https://njit.instructure.com/courses/42201/files/6952310?wrap=1)**	**HW : Call** (https://njit.instructure.com/courses/42201/assignments/492 (https://njit.instructure.com/courses/42201/assignments/492614)
7	**Simulation of Manufacturing Transportation Systems, Input Modeling** Input Distribution, Q-Q Plots, Parameter Estimation, Goodness of Fit Tests: K-S, Chi- Square *Assg: Goodness of Fit Tests*	**Goodness of Fit Tests** (https://njit.instructure.com/courses/42201/fi **Chapter 06 Slides.ppt** (https://njit.instructure.com/courses/42201/file
8	**Continuous System Simulations and System ANALYSIS** Queuing Systems. Inventory Systems, Examples (Banks, Warehouse, FMS) *Assg: Ch5 Call Center system & Inventory Model*	
9	**Simulation of Simple/Advanced Manufacturing Systems with Material Handling** *Assg: Model Sequenced Jobs on an FMS system with Transporters* **Check Last day to drop full semester courses with a grade of 'W'**	**Chapter 07 Slides-5.ppt** (https://njit.instructure.com/courses/42201/ **HW 7.1 image-1.png** (https://njit.instructure.com/courses/42201/files
10	**Statistical Models in Simulation** Discrete, Continuous Distributions - *EXAM* - ***Example Models*** ***(https://njit.instructure.com/courses/42201/files/6952328?wrap=1)*** ↓ ***(https://njit.instructure.com/courses/42201/files/6952328/download?*** ***download_frd=1)***	
11	**Simulation of Advanced Systems, Random Number Generation** *EXAM Review*	
12	**Random Variant Generation** Exponential, Uniform, Acceptance & Rejection Techniques *EXAM Review*	
13	**Verification and Validation** Calibration, Face Validity, Turing Test *Assg:* **Literature Review on Verification/Validation**	
14	**Output Analysis: Confidence Intervals, variance reduction.** Confidence Intervals, Replication, Batch Means *Project*	

15-16	**Comparison and Evaluation of Alternative Systems** Independent Sampling, CRN, Bonferroni Approach to Multiple Comparisons, Linear Regression, DOX Design of Experiments, Optimization via Simulation *Final Exam & Project*

Course Description   *

This course introduces **discrete event simulation modeling** techniques and the system simulation fundamentals and I/O data analyses such as how to **determine appropriate Input data** *(Goodness of fit Test)* **for a simulation model, and analyze the Output data of simulation experiments**. **Verification of the model and Validation of the simulation experiment results** are reviewed. Improving the system performance by integrating with **optimization** techniques such as Design of Experiments, Opt Quest, ANOVA, and Regression concepts are implemented via Course projects.
Course projects must contain complex decisions making processes which might include consideration of physical efficiency as well as economical efficiency involving multiple objectives, with uncertainty, and risk and resource failure.

Continuous system simulation and system analysis are also introduced briefly. Students are provided hands-on simulation modeling expertise using GPSL and GPPL (such as ARENA, SIMIO or FLEXSIM, and EXCEL,) and introduced to Statistical Analysis tools such as Minitab/SAS.
Interested students are also encouraged to experience in building high-level detailed simulation modeling projects as well as in presenting it at professional conferences. Simulation Competition & Award Opportunities are announced and those interested are provided help to compete.

The fundamentals of simulation modeling and analysis concepts are introduced with emphasis on problem-solving and utilizing computer tools. The class provides a comprehensive treatment of simulation using industry-standard Arena software. The class starts by having the student develop simple high-level models and then progresses to advanced modeling and analysis. Statistical design and analysis of simulation experiments are integrated with the modeling chapters, reflecting the importance of mathematical/statistical modeling of these activities. Upon Completion of the Semester project, the students must be able to administer a simulation modeling project successfully and build large-scale, non-stationary stochastic or deterministic models with medium-level complexity. ARENA simulation software is both Academic as well Industrial standard language.

Prerequisites   *

Students should have a working knowledge of basic statistics.

Textbooks   *

Simulation with Arena 6th edition ⬒ (https://www.vitalsource.com/products/simulation-with-arena-kelton-david-w-v0073545767?utm_source=google&utm_medium=cpc&utm_campaign=shopping1&gclid=EAIaIQobChMIhf6U-_yU1gIVCgeGCh3p4wHKEAYYASABEgJxSvD_BwE) (Required)

By Kelton, W. David, Sadowski, Randall, Zupick, Nancy

ISBN-10: *0073401315*

ISBN-13: *9780073401317*
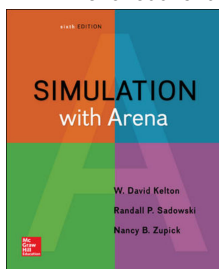
Simulation Modeling and Arena (Optional)
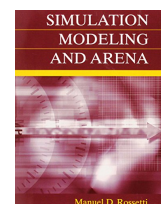
By Manuel D. Rossetti (University of Arkansas)
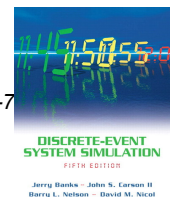
Edition: 1
ISBN-10: *0470097264*

ISBN-13: *9780470097267*

Discrete Event System Simulation

By Banks, Carson et al, Prentice Hall

Reference Books: **www.bcnn.net (https://njit.instructure.com/C:/Users/Jaybi/Doc**

ISBN: *0-13-144679-7*

Research resource guide: https://docs.google.com/document/d/1QptHpMn0ETE3rguFQgLCmKvT-ivWEbgYdPXZBBWEqSs/edit?usp=sharing
⬒ (https://docs.google.com/document/d/1QptHpMn0ETE3rguFQgLCmKvT-ivWEbgYdPXZBBWEqSs/edit?usp=sharing)

👓 **You are currently logged into Student View**

Resetting the test student will clear all history for this student, allowing you to view the course as a brand new student.

[**Reset Student**]   [**Leave Student View**]

Letter Grade	Percentage	Grade points/credit	Rating
A	93% & above	4.00	Excellent
B+	88% – 92%	3.50	Very good
B	82% – 86%	3.00	Good
B-	76% – 81%	2.50	Above average
C	70% – 75%	2.00	Average
C-	65% – 69%	1.50	Below average
D	60% - 64%	1.00	Inferior
F	59% and below	0.00	Failure

I	Incomplete; given only when a student is unable to complete a segment of the course because of circumstances beyond the student's control. A grade of incomplete may be given only when approved in writing by the department chair or school dean.
X	Conditional, with no grade points per credit; given only when the student is at fault in failing to complete a minor segment of a course, but in the judgment of the instructor does not need to repeat the course. It must be made up within the next semester in residence or the grade becomes a failure (F). An (X) grade is computed into the grade point average as an (F) grade.

1. Homeworks (8)	15%
2. Midterm 1	20%
2. Final Exam	30%
2. **Project Presentation**	25%
2. Instructor Assessment: Class attendance/participation Team Work & Integrity	10%
Total	**100%**

Late Assignments

They will not be accepted late except for special circumstances (such as jury duty or medical problems), for which you must provide documentation.

Course Policy

- **Attendance is mandatory**. A student who misses > 5 classes will be dropped, without credit. Getting to class late or leaving early counts as half an absence.

- *Homework and projects* must be submitted in hard copy or e-copy (as instructed) at the beginning of class on the due date. They will not be accepted late except for special circumstances (*such as jury duty or medical problems*), for which you must provide documentation. The semester project will consist of a written and oral presentation. All submitted work (including exams) must include your name and student ID.

- *Plagiarism* will result in zero credit for the assignment and/or an F grade in the course.

- *Cell phones or any other electronic devices* must be turned off during class and are not permitted during exams *(exceptions: approved computers use)*

Course Software *

- **ARENA** *arenasimulation.com* ⬈ **(http://www.arenasimulation.com/)**
- **SIMIO   simio.com** ⬈ **(http://www.simio.com)**
- **Flexsim** ⬈ **(http://%20www.flexsim.com%20)** (optional)
- **EXCEL** ⬈ **(http://ist.njit.edu)**
- **Minitab** *minitab.com* ⬈ *(http://minitab.com)*

  Students must install the ARENA, software from Internet by 2nd class & bring their computers to classroom.

To run ARENA on Mac:
1. Install Bootcamp (free) or Parallel, or VMWARE *(>50$)*
2. Install Win OS
3. Install ARENA

University Policy *

Academic regulations and procedures are governed by University policy. Academic dishonesty cases will be handled in accordance with the University's policies.

If you have a disability that could affect your performance in this class or that requires accommodation under the Americans with Disabilities Act, please see me as soon as possible so that we can make appropriate arrangements. The Affirmative Action Office has asked that you be made aware of the following:

New Jersey Institute of Technology complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act of 1990. If you have a disability and need a reasonable accommodation for equal access to education or services at the New Jersey Institute of Technology, please call the Dean of Students Office, at 973-596-3470.

For other concerns about discrimination, you may contact Computer Science Department Chair at 973-596-5488.

Academic Integrity

Every student should read the **University Code on Academic Integrity** ⬈ **(http://www.njit.edu/academics/integrity.php)**. All work that you represent as your own must, in fact, be your own. Work done by others must be given proper credit.
What are the ethical responsibilities of an engineer see **NSPE National Society of Professional Engineers web page.** ⬈ **(http://nspe.com)**