

UNIVERSITY OF PUERTO RICO MAYAGÜEZ CAMPUS COLLEGE OF ENGINEERING INDUSTRIAL ENGINEERING DEPARTMENT



COURSE SYLLABUS

General Information

Course Number: ININ 4018 Course Title: **Discrete-Event System Simulation** Credit-Hours: Three

Course Description

Analysis of stochastic systems using discrete event simulation and basic queuing networks. Modeling the interrelationship between systems components through the generation of random variables, input/output analysis and optimization design. Emphasis is placed in solving industrial systems using modern computer simulation packages.

Prerequisite:

ININ 4020 – Applied Industrial Statistics/ININ 4022 - Probabilistic Models in Operations Research ININ 4150 – Models in Operations Research

Textbook and References

- T- Banks, J., Carson II, J. S., Nelson, B. L. and Nicol, D. M., 2009, **Discrete-event System Simulation**, 9th Ed., Prentice Hall, Inc.
- R1- Kelton, W. D., Smith, J.S. and Sturrock, D. T., 2013, Simio & Simulation Modeling, Analysis, and Applications, 2nd Ed., CreateSpace Independent Publishing Platform.
- R2- Law, A.M., and Kelton, W. D., 2015, Simulation Modeling and Analysis, 5th Ed., McGraw-Hill Corp.
- R3- Winston, W. L., 2004, Operations Research: Applications and Algorithms, 4th Ed., PWS-Kent.

Purpose

This is an undergraduate course mainly designed for Industrial Engineering students; however, it is appropriate for anyone with interest in simulating stochastic systems. The purpose of the course is to prepare students for (1) understanding the fundamentals of stochastic simulation; (2) modeling a real-world situation using a simulation language and integrating input and output data analysis phases; (3) improving a real-world problem by identifying bottlenecks, evaluating multiple scenarios and selecting the best alternative under a set of time and money restrictions; (4) formulating conclusions firmly attached to statistical analysis; and (5) submitting and enhancing recommendations using animation tools. This course is a prerequisite for ININ 4079, Design Project, and it is a requirement in the B.S.I.E. curriculum.

Course Goals

• At the completion of the course the students should be able to:

- Identify all the components necessary to construct a simulation model.
- Gather and analyze all the information needed as input data for the simulation model.
- Apply goodness of fit tests for the selection of input probability distribution.
- Apply techniques for the generation of random numbers.
- Verify randomness using tests for random numbers.
- Apply the inverse transform technique for the generation of random variables.
- Design, verify, and validate computer simulation models.
- Analyze and interpret the output of computer simulation models.
- Contrast performance under alternative system designs using the simulation model.
- Propose the best system design to IE problems.
- Understand the advantages and limitations of simulation.
- Develop skills in technical writing.

Requirements

All students are expected to come to class all the time, on time, and prepared; do all assigned readings and related homework; actively participate in class discussions; and satisfy all assessment criteria to receive credit for the course.

Department and Campus Policies

- **Class attendance:** Class attendance is compulsory. The University of Puerto Rico, Mayagüez Campus, reserves the right to deal at any time with individual cases of non-attendance. Professors are expected to record the absences of their students. Frequent absences affect the final grade, and may even result in total loss of credits. Arranging to make up work missed because of legitimate class absence is the responsibility of the student (Bulletin of Information Undergraduate Studies).
- Absence from examinations: Students are required to attend all examinations. If a student is absent from an examination for a justifiable reason acceptable to the professor, he or she will be given a special examination. Otherwise, he or she will receive a grade of zero of "F" in the examination missed (Bulletin of Information Undergraduate Studies).
- **Final examinations:** Final written examinations must be given in all courses unless, in the judgment of the Dean, the nature of the subject makes it impracticable. Final examinations scheduled by arrangements must be given during the examination period prescribed in the Academic Calendar, including Saturdays (see Bulletin of Information Undergraduate Studies).
- **Partial withdrawals:** A student may withdraw from individual courses at any time during the term, but before the deadline established in the University Academic Calendar (see Bulletin of Information Undergraduate Studies).

- **Complete withdrawals:** A student may completely withdraw from the University of Puerto Rico, Mayagüez Campus, at any time up to the last day of classes (see Bulletin of Information Undergraduate Studies).
- **Disabilities:** All the reasonable accommodations according to the Americans with Disability Act (ADA) Law will be coordinated with the Dean of Students and in accordance with the particular needs of the student.
- Ethics: Any academic fraud is subject to the disciplinary sanctions described in article 14 and 16 of the revised General Student Bylaws of the University of Puerto Rico contained in Certification 018-1997-98 of the Board of Trustees. The professor will follow the norms established in articles 1-5 of the Bylaws.
- Sexual Harassment: Certification 130-2014-2015 states: Sexual harassment in the workplace and in the study environment is an illegal and discriminatory act and is against the best interests of the University of Puerto Rico. All persons who understand they have been subject to acts of sexual harassment at the University of Puerto Rico may file a complaint and request that the institution investigate, where necessary, and assume the corresponding action by the university authorities. If the complainant is a student, he or she must refer his or her complaint to the Office of the Student Ombudsperson or that of the Dean of Students.
- Hostigamiento Sexual: La Certificación 130-2014-2015, indica: El hostigamiento sexual en el empleo y en al ambiente de estudio es una práctica ilegal y discriminatoria, ajena a los mejores intereses de la Universidad de Puerto Rico. Toda persona que entienda ha sido objeto de actuaciones constitutiva de hostigamiento sexual en la Universidad de Puerto Rico podrá quejarse para que se investigue, de ser necesario, y se tome la correspondiente acción por parte de las autoridades universitarias. Si quien reclama fuera estudiante, deberá referir su queja a la Oficina de la Procuradora Estudiantil o al Decanato de Estudiantes.
- **Certification 36 (2018-2019): Discrimination by Sex and Gender on Modality of Sexual Violence:** "The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification Num. 130, 2014-2015 from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, and/or the Coordinator of the Office of Compliance with Title IX for an orientation and/or formal complaint."
- Certification 06-43 of the Academic Senate states, "The academic guidelines for offering online courses," defines: Traditional face-to-face courses are those that have less than 25% of the course's regular contact hours via the Internet. Therefore, a three-credit course will be considered "face to face" if, of the 45 hours of regular contact, 11 or less are taught via the Internet. According to certification 16-43 of the Academic Senate, a course may include up to

25% of its total contact hours via the Internet. The objective of this is so that all professors have this alternative in the case of any unscheduled eventuality.

Law 51: The Comprehensive Educational Services Act for People with disabilities states that after identifying with the instructor and the institution, the student with disabilities will receive reasonable accommodation in their courses and evaluations. For more information contact the Department of Counseling and Psychological services at the Office of the Dean of Students (Office DE 21) or call 787-265-3864 or 787-832-4040 x 3772, 2040 and 3864.

Campus Resources

General Library and University Computer Center is available to obtain professors reference materials. The University's Counseling Office has a tutorial program for students who need extra help.

Contact Hours	Торіс	References				
3	Introduction to Modeling, System Analysis and Simulation	T[Ch.1-4: 1-128] R1[Ch.1-3: 1-74] R2[Ch.1: 1-32,45-55, 66-84] R3[Ch.21:1145-1155,1180- 1190]				
3	Random number generators, Testing of random number generators,	T[Ch.7: 275-298] R2[Ch.7: 393-425] R3[Ch.21:1155-1162]				
3	Generating random variables.	T[Ch.7: 299-332] R2[Ch.8: 426-487] R3[Ch.21:1162-1180]				
3	Selecting input probability distributions - Discrete and Continuous. Goodness of fit tests: χ^2 and Kolmogorov Smirnov.	T[Ch.9: 335-379] R1[Ch.6: 185-203] R2[Ch.6: 279-392]				
3	Basic Modeling with Simio	R1[Ch.4: 75-130]				
6	Intermediate with Simio	R1[Ch.5&7: 131-182,215-246	;]			
1	Animating the simulation with Simio	R1[Ch.8:247-282]				
2	Model Verification and Validation	T[Ch.10: 388-416] R1[Ch.1: 9] R2[Ch.5: 246-278]				
3	Terminating Statistical Analysis	T[Ch.11: 427-434] R2[Ch.9: 497-510]				
3	Steady-state Statistical Analysis	T[Ch.11: 435-452] R2[Ch.9: 511-544]				

General Topics

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3	Comparing Alternative System Configuration	T[Ch.12: 463-482] R2[Ch.10: 556-586]			
3	Advanced Modeling with Simio	R1[Ch.9: 283-324]			
2	Variance Reduction Techniques	R1[Ch.6: 206] R2[Ch.11: 587-628]			
3	Experimental Design and Optimization	R1[Ch.4&9: 91,283-320] R2[Ch.12: 629-692]			
1	Case Studies: Simulation of Manufacturing, Advanced Material Handling and Service Systems	T[Ch.13: 485-507] R1[Ch.11: 348-375] R2[website-chapter]			
42	Total number of contact hours	1			

Revised by W. Torres García January 18, 2017

ABET Outcomes											
А	В	С	D	E	F	G	Н	I	J	K	
Х	Х	Х	Х	Х				Х	Х		

IE Program Outcomes										
1	2	3	4	5	6	7	8	9	10	11
Х					Х	Х	Х	Х		

ABET Outcomes:

- A: Knowledge of mathematics, science, and engineering.
- B: Design and conduct experiments and data analysis.
- C: Design a system, components, or process to meet desired needs.
- D: An ability to function on multidisciplinary teams.
- E: Identify, formulate and solve engineering problems.
- I: Engage in life-long learning.
- J: Knowledge of contemporary issues.

IE Program Outcomes:

- 1: Design a work facility or system.
- 6: Develop models to experiment, evaluate or solve problems.
- 7: Use engineering design process from IE point of view.
- 8: Use modern telecommunication and computer technology.
- 9: Present information to individuals or to an audience.