COURSE SYLLABUS

COURSE TITLE:	Queueing Systems and Simulation
ALPHA-NUMERIC CODIFICATION:	ININ 5025
NUMBER OF CREDITS-CONTACT HOURS:	Four credits / 4 hours
PREREQUISITES, COREQUISITES AND OTHER REQUIREMENTS:	• ININ 4020 – Applied Industrial Statistics AND • ININ 4150 – Introduction to Models in Operations Research OR ININ 4021 – Deterministic Models in Operations Research

COURSE DESCRIPTION:

Spanish: Análisis de sistemas estocásticos utilizando los fundamentos de teoría de colas y simulación de eventos discretos. Modelar la interrelación entre los componentes del sistema a través de la generación de variables aleatorias, análisis de entrada / salida, diseño de experimentos y optimización. Se enfatiza el modelaje de sistemas industriales utilizando paquetes de simulación por computadora.

English: Analysis of stochastic systems using the theoretical foundation of basic queuing networks and discrete-event simulation. Modeling the interrelationship between system's components through the generation of random variables, input/output analysis, and experimental design and optimization. Emphasis is placed on modeling industrial systems using computer simulation packages.

COURSE OBJECTIVES:

At the completion of the course the students should be able to:
Develop technical communication skills.
Related to Queuing Theory:
- Model waiting line systems with the rate transition diagram applicable to the steady-state of the system.
- Recognize the significance of the Markovian property in the mathematical solution of queuing systems.
- Derive steady-state probabilities by the stochastic flow balance procedure and the performance measures of interest: L, L_q, W, W_q.
- Develop cost functions for the comparison of system performance under various scenarios.

Related to Simulation modeling:
- Understand the advantages and limitations of simulation.
- Apply techniques for the generation of random numbers.
- Verify randomness using tests for random numbers.
- Apply techniques for the generation of random variables.

- Analyze input data to allow the model to mimic reality using goodness-of-fit tests to identify the correct probability models.
- Design, develop, 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.

TEXT BOOK:

Banks, J., Carson II, J. S., Nelson, B. L. and Nicol, D. M., 2009, **Discrete-event System Simulation**, 9th Ed., Prentice Hall, Inc.*

* This book is a classic with no up-to-date editions and remains as the top book in the subject.

Course time frame and thematic outline:

Theme	TIME DISTRIBUTION Face-to-Face
Part I: Queuing Models	
Basic concepts in queuing	2
The birth and death process. Long-run measures of performance of queuing systems	3
Queuing Models. Infinite calling populations	2
Queuing Models. Finite calling populations	2
Queuing models in the evaluation of alternatives	3
Queuing Networks	2
Part II: Discrete-Event Simulation	
Introduction to Modeling, System Analysis, and Simulation	3
Random number generators, testing of random number generators	3
Generating random variables including Binomial, Negative Binomial, Poisson, Gamma, Normal	3
Selecting input probability distributions - discrete and continuous. Goodness of fit tests: χ^2 and Kolmogorov Smirnov.	3
Basic modeling with a simulation software	3
Intermediate with a simulation software	6
Animating the simulation with a simulation software	1
Model verification and validation	2
Terminating statistical analysis	3
Steady-state statistical analysis	3
Comparing alternative system configuration	3
Advanced modeling with a simulation software	3
Variance reduction techniques	2
Experimental design and optimization	3
Case Studies: Simulation of Manufacturing, Advanced Material Handling, and Service Systems	1
Exams	4
Total contact hours	**60 hours**

INSTRUCTIONAL STRATEGIES:

Face-to-Face

- Conferences/Lectures
- Workshop
- Discussion
- Teamwork
- Practice activities
- Individual tasks
- Oral presentations

MINIMUM OR REQUIRED RESOURCES AVAILABLE:

RESOURCE	FACE-TO-FACE
Students and faculty need access to a discrete-event simulation software - currently available in the computer center and ININ server.	Institution
Institutional email account	Institution
Computer with high-speed internet access or mobile device with data service	Student
Programs or applications: word processor, spreadsheets, presentation editor	Student
Built-in or external speakers	Not applicable
Webcam or mobile with camera and microphone	Not applicable

EVALUATION STRATEGIES:

FACE to FACE

	Quantity	Percent
Exams	1-4	20-60%
Final Exam	1	20-30%
Short Quizzes	0-5	0-20%
Projects	1-2	10-20%
Homeworks	3-10	10-20%
TOTAL:		100%

REASONABLE ACCOMMODATIONS:

The University of Puerto Rico at Mayagüez (RUM) recognizes that each student has an inherited right to request reasonable accommodation according to Law 51: Law for Integral Educational Services for People with Disabilities. Every student has the right to receive reasonable accommodation if he/she presents the necessary evidence to be evaluated by the Office of Services to Students with Disabilities (OSEI-RUM), and the related information can be found at the following link: https://www.uprm.edu/cms/index.php/page/85. If your case is approved by OSEI-RUM, you will receive reasonable accommodation in your courses and evaluation, and you must contact each professor for course registered. For additional information contact OSEI-RUM at Sánchez Hidalgo 410 or via telephone 787-832-4040 extension 3107.

ACADEMIC INTEGRITY:

The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Student General Bylaws (Board of Trustees Certification 13, 2009-2010) states

that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person's answers to the questions of an oral or written exam by taking or having someone else take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure established by the UPR Student General Bylaws.─.

To ensure the integrity and security of user data, all hybrid, distance and online courses must be offered through the institutional learning management platform, which uses secure connection and authentication protocols. The system authenticates the identity of the user (student and professor) using the username and password assigned by the institution. The users are responsible for keeping their password safe, protected, and not to share it with other people.

POLICY AGAINST DISCRIMINATION BASED ON SEX, SEXUAL ORIENTATION, AND GENDER IDENTITY:

«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 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, or the Coordinator of the Office of Compliance with Title IX for an orientation or formal complaint».

GRADING SYSTEM

☒ Quantifiable (letters, A, B, C, D, F) ☐ Not Quantifiable

CONTINGENCY PLAN IN CASE OF AN EMERGENCY

In case of an emergency or class interruption, the professor can apply Bylaw 19-85 of the UPRM. This bylaw states that up to 25% of a class can be offered online.

BIBLIOGRAPHY

R1- Winston, W. L., 2004, Operations Research: Applications and Algorithms, 4th Ed., PWS-Kent.*

R2- Hillier and Liberman, 2001, Introduction to Operations Research, Seventh Edition. McGraw Hill.*

R3- Kelton, W. D., Smith, J.S. and Sturrock, D. T., 2013, Simio & Simulation - Modeling, Analysis, and Applications, 2nd Ed., CreateSpace Independent Publishing Platform.*

R4- Law, A.M., and Kelton, W. D., 2015, Simulation Modeling and Analysis, 5th Ed., McGraw-Hill Corp.*

R5- Sturrock, D.T., Smith, J.S., Kelton, D., 2018, Simio and Simulation: Modeling, Analysis, Applications, 5th Ed., Simio LLC and Amazon's CreateSpace.

* These books are key classic references and remain as the top books for the subjects covered in the course and there are no up-to-date textbooks to substitute these books.