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PENS
Pathway in Enterprise Systems Engineering

Pathway in Enterprise Systems Engineering (PENS)

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System Modeling and Simulation Course Specification

Course Specification (Syllabus)

I. Course Details

Course Name	System Modeling and Simulation
Course Code	PENS_003
Number of Credit Hours	3
ECTS Credits	5.5 (140 learning hours)
Course type (core / elective)	Core
Pre-requisites	Knowledge in basics of statistics, probability, spreadsheet, Enterprise Modeling, Operations research, programming, is recommended.
Weekly Hours • Theoretical • Practical • Total	 • [2] • [1] (1 lab credit hours = 3 contact hours) • [3]
Course Description (provide 60-100 words describing the focus of the syllabus)	
This course introduces methods techniques, for complex real-word systems (enterprises) model simulation. Also, it covers approaches of computer simulation for different system models (Static vs. Dynamic, Deterministic vs. Stochastic/ probabilistic, Continuous vs. Discrete). It emphasizes on analysis of simulation results to help decision making to improve performance and efficiency of systems. This course introduces simulation process and analysis using simulation of simple process by hand then by using popular software packages/tool for computer simulation. The course introduces basic statistics and probability, queuing theory, input data modeling, output data analysis, verification and validation of system models. It will emphasize critical thinking rather than memorization.	
Course aim(s) (provide 30-50 words describing the aim of the course)	
This course aims to: 1- Explain methods and steps of modeling and simulation of complex systems. 2- Realize the steps and implementation of simulation process. 3- Implement and experiment the simulation and analysis using popular computer software packages. 4- Interpret and evaluate the simulation results for decision making.	

II. Intended Learning Outcomes of Course (ILOs)

On completing the course, students should be able to (provide 4-6 learning outcomes):

LO.1 Explain modeling and simulation types, entities, objectives and benefits.

LO.2 Recognize the simulation types and steps for variety of complex systems.

LO.3 Construct simulation models from enterprise high level models.

LO.4 Execute efficient simulation to analyze real-world systems.

LO.5 Evaluate the results of simulation and analysis to improve or optimize systems.

LO.6 Apply and experiment computer packages to implement simulation and analysis.

Course Matrix Contents

Week	Main Topics / Chapters	Learning Hours	Intended Learning Outcome (s)
1	**Course Overview/Introduction** Navigating the Syllabus	2	LO.1
2	**Unit 1: Introduction to simulation?** • Introduction • System Models • System models Classification • Computer Simulation Models • Computer Simulation • Randomness in systems • Discrete-Event Simulation • Simulation Languages and tools • Simulation Methodology **Students' coursework** - Self-reading assignments - Homework exercise	10	LO.1
3	**Unit 2: Fundamental Simulation Concepts** - Simple Processing Model - Time-Sharing Server Model - Multi-Teller Bank Model - Job Shop Model - Analysis Options **Students' Coursework (Practice)** - Self-reading assignment - Homework exercise	10	LO.1, LO. 2
4	**Unit 3: Discrete-Event Simulation I** - Pieces and Component of a Simulation Model (Entities, Attributes, Variables, Resources, Queues, Statistical accumulators, Event, Simulation Clocks, Starting and stopping). - Single Server Model **Students' coursework** - Self- reading assignment - Homework exercise - In-class exercise	10	
5	**Unit 3: Discrete-Event Simulation II** - Discrete-Event Simulation Program Component	10	LO.1, LO2

	- Discrete-Event Hand Simulation - Randomness in Simulation **Students' coursework** - Self- reading assignment - Homework exercise - In-class exercise		
6	**Unit 4: Guided tour through a Simulation Tool/Software** • Guided tour through Arena-Student edition • Browsing Through an Existing Model: Model 3-1 • Building a Project (Build it yourself) • Case Study: Specialized Serial vs. Generalized Parallel Processing • Building model • Case study (specialized serial process vs generalized parallel process) **Students' coursework (Practice)** - In-lab assignment - Reading and training assignment - Project Assignment 1	12	LO.1, LO.2, LO.3, LO.4, LO.5, LO.6
7	**Unit 5: Basic Probability and Statistics** - Basic Definition - Probability - Random Variables and Their Properties - Binomial Discrete Random Variables & Distribution - Poisson Discrete Random Variables & Distribution - Geometric Discrete Random Variables & Distribution - Discrete Probability Distribution - Expected Discrete Values - Continuous Random Variable - Continuous Distribution **Student Course Work** - Self- reading assignment - Homework exercise - In-class exercise	12	LO.1, LO.2, LO.3

8	**Unit 6: System Modeling and Simulation** • Modeling Basic Operations and Inputs (e.g., electronic assembly and test system) • Modeling Resource Schedules, Failure, and Frequencies • Input Analysis: Specifying Model Parameters and Distributions • Fitting Input Distributions via the Input Analyzer • Issues on Input Data **Students' coursework (Practice)** - In lab Exercise - Project assignment 2	12	LO.1, LO.2, LO.3, LO.4, LO.5, LO.6
9	**Unit 7: Queuing Theory (QT)** - Key Elements QT - Characteristics of QT - Notations for QT - Rules for All Queues - Utilization Law - Little's Law - Response Time Law - Forced Flow Law - Stochastic Processes - M/M/1 Queue Analysis - M/M/c Queue Analysis **Students' coursework (Practice)** - Self- reading assignment - Homework exercise - In-class exercise	12	LO.1, LO.2, LO.3, LO.6
10	**Unit 8: Input Data Modeling and Analysis I** - Input Modeling - Data Collection - Identifying the Distribution with Data-Histogram - Identifying the distribution with data-Selecting the family of distributions - Identifying the distribution with data- Quantile-Quantile Plots **Students' coursework (Practice)** - Homework Assignments	10	LO.2, LO.3, LO.4, LO.5, LO.6

	- In-class assignment - Project assignment 3		
11	**Unit 8: Input Data Modeling and Analysis II** - Identifying the distribution with data-Selecting the family of distributions - Identifying the distribution with data-Quantile-Quantile Plot - Parameter Estimation - Goodness-of-Fit Test - Model Selection Without Data **Students' coursework (Practice)** - Homework Assignments - In-class assignment - Project assignment 3	10	LO.2, LO.3, LO.4, LO.5, LO.6
12	**Unit 9: Output Data Analysis** - Summarizing Data by Single Number - Common Misuse of Mean - Summarizing Variability - Summarizing Variability - Indices dispersion Measures - Comparison of Alternative Systems using Sample Data - Comparing Two Alternatives - Determining Sample Size **Students' coursework (Practice)** - Homework Assignments - In-class assignment	12	LO.2, LO.3, LO.4, LO.5, LO.6
13	**Unit 10: Verification and Validation of Simulation Model** - Verification and Validation - Model Building - Verification of Simulation Computer Program - Overview of Validation - Statistical Procedures for Comparing Real-Word Observations and Simulation Output Data - More approaches on Validity Testing **Students' coursework**	12	LO.2, LO.3, LO.4, LO.5, LO.6

	- Written Exercise - In-class test		
14	Oral group project presentation, discussion and members peer evaluation of the projects	6	LO.4, LO.5, LO.6
Total Learning Hours		140	

III. Assessment Methods, Schedule and Grade Distribution

Assessment type	Used	Formative	Weight	Week	ILO(s)
Written exam (midterm)	Y	Y	20%	7	• 1, 2, 3
Written exam (final)	Y	Y	30%	16	• 1,2,3,4,5,6
Written coursework (individual)	Y	Y	10%	Per topic	• 2,3,4,5,6
Written coursework (group)	Y	Y	10%	15	• 2,3,4,5,6
Oral presentation (individual)	N	N		7	
Oral presentation (group)	Y	Y	10%	14	• 3,4,5,6
Test/Quiz (In-class and in-lab)	Y	Y	20%	Per topic	• 2,3,4,5,6
Others	N	N			

List of References

Essential textbook(s)	[1] A. Law and W. Kelton (2000),"Simulation Modeling and Analysis", 3rd ed, McGraw Hill, 2000. [2] W. David Kelton, Randall P. Sadowski, Nancy B. Zupick, (2015). Simulation with Arena, 6th e, McGraw-Hill, ISBN 978–0–07–340131–7, Available at: http://web.iitd.ac.in/~nomesh/MEL770/kelton.pdf [Accessed 28 Feb. 2019] [3] Averill M. Law, Simulation Modeling & Analysis, Fourth Edition, McGraw-Hill, 2007. Available at: http://fac.ksu.edu.sa/sites/default/files/manuel_d._rossetti-simulation_modeling_and_arena-wiley_2015.pdf [Accessed 5 March 2019]. [4] M. Baron, Probability and Statistics for Computer Science, 2nd ed, CRC Press, 2014. ISBN-13: 978-1-4822-1410-9 (eBook - ePub) [5] J. Banks, J. S. Carson II, B. L. Nelson, D. M. Nicol,Discrete-Event System Simulation, 5th ed , Prentice Hall, 2014.

	[6] Raj Jain, The Art of Computer Systems Performance Analysis", Wiley 1991. https://www.cse.wustl.edu/~jain/books/perf_sli.htm.
Recommended textbook (s)	[7] J. Banks (ed), Handbook of Simulation, Wiley, 1998 [8] Edward Lazowska, John Zahorjan, Scott Graham, and Kenneth Sevcik, Computer Systems Analysis Using Network Models, Prentice-Hall, 1984 https://homes.cs.washington.edu/~lazowska/qsp/ [9] Manuel D. Rossetti, (2016), Simulation Modeling and Arena, 2nd ed, John Wiley & Sons, Inc. ISBN 978-1-118-60791-6, Available at: http://fac.ksu.edu.sa/sites/default/files/manuel_d._rossetti-simulation_modeling_and_arena-wiley_2015.pdf [Accessed 5 March 2019] [10] János Sztrik, Basic Queueing Theory, University of Debrecen, Faculty of Informatics. Available at: https://pdfs.semanticscholar.org/848f/a1f48ad9d3edb24b05667f15cfc633eb8f69.pdf [3?] Hector Guerrero (2010), Excel Data Analysis: Modeling and Simulation, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-10834-1, e-ISBN 978-3-642-10835-8, Available at: https://www.pdfdrive.com/excel-data-analysis-d26617723.html [Accessed 2 March 2019] [5] John F. Barlow, (2005). Excel Models for Business and Operations Management, Second Edition, John Wiley & Sons Ltd, ISBN-13 978-0-470-01509-4, Available at: https://mahdimeskin.files.wordpress.com/2011/02/excel-models-for-business-and-operations-management.pdf [Accessed 27 Feb. 2019] [6] S. Christian Albright, Wayne Winston, (2005). Spreadsheet Modeling and Applications: Essentials of Practical Management Science. Authors: South-Western, 2005. [7] Jeffrey D. Camm et. al, (2016). Essentials of Business Analytics, 2nd edition, by South-Western College Pub, (ISBN 978-1285187273)

	[8]Albright S. A. and Winston W. (2014). Business Analytics: Data Analysis & Decision Making 5th Edition, South-Western College Pub. (ISBN: 978-1133629603). [9] Winston W. (2014). Microsoft Excel 2013 Data Analysis and Business Modeling,, Microsoft, (ISBN 978-0735669130) [10] Powell S. and Baker K. (2013). Management Science The Art of Modeling with Spreadsheets, 4th edition, Wiley, (ISBN 978-1118582695) [11] H. Taha (2007), Operations Research an Introduction, 8th ed, by Pearson Education, Inc and Prentic Hall.
Course notes	• Lecture Notes (Slides) for ref. [1]
Journal(s) / periodical(s)	https://www.informs-sim.org/
Specific article(s)	**[11] Chenggang Yin C., and McKay A. (2018), Introduction to Modeling and Simulation Techniques,** In: Proceedings of ISCIIA 2018 and ITCA 2018. The 8th International Symposium on Computational Intelligence and Industrial Applications and the 12th China-Japan International Workshop on Information Technology and Control Applications, 02-06 Nov 2018, Tengzhou, China **[12]** Ricki G. Ingalls, (2008). INTRODUCTION TO SIMULATION, *Proceedings of the 2008 Winter Simulation Conference*
Websites and other online resources	• https://www.informs-sim.org/ • https://www.arenasimulation.com/video-library • https://books.google.ps/books/about/Business_Process_Improvement_Toolbox.html?id=7umZlxydThoC&printsec=frontcover&source=kp_read_button&redir_esc=y#v=onepage&q&f=false • https://books.google.it/books?id=cSy_BAAAQBAJ&pg=PA328&lpg=PA328&dq=sprenger+enterprises+modeling+and+simulation&source=bl&ots=Hrdme8NNlG&sig=ACfU3U3d5oNOwLeR3csr6LPbZjurZUWxA&hl=en&sa=X&ved=2ahUKEwjIzPzXrafjAhUxMuwKHdJkAR0Q6AEwFXoECAkQAQ#v=onepage&q=sprenger%20enterprises%20modeling%20and%20simulation&f=false

IV. **Facilities required for teaching and learning**

- Computer Lab, PCs,
- LCD Projector,
- Whiteboard

- Software
    - MS Windows
    - Arena V15.1, (academic version).
    - MS Excel, Add-in @Risk,