Course Code: CSE413 & CSE413L
Course Title: Simulation and Modeling & Lab

Credits: 3+1
CIE Marks: 60
SEE Marks: 40

Course Description (from syllabus)/Rational:

Simulation modeling solves real-world problems safely and efficiently. It provides an important method of analysis which is easily verified, communicated, and understood. Across industries and disciplines, simulation modeling provides valuable solutions by giving clear insights into complex systems.

The aim of this course is to introduce various system modeling and simulation techniques, and highlight their applications in different areas. It includes modeling, design, simulation, planning, verification and validation. After learning the simulation techniques, the students are expected to be able to solve real world problems which cannot be solved strictly by mathematical approaches. This course begins by demonstrating the usefulness of simulation as a tool for problem solving in business, industry, government, and society.

Course Learning Outcome: (at the end of the course, student will be able to do:)

CLO1	Able to define the different modelling terms by analysing the system or the data that is present.
CLO2	Able to learn different mathematical model and their application in simulation.
CLO3	Able to implement the model and from the results check for the validity of the model and correctness of the assumptions present in the model.
CLO4	Able to analyze the outcomes and make predictions.

Mapping of Course Learning Outcomes to Program Learning Outcomes [attainment level used for COs from 1(weak)-3(strong) correlation]

PLO's / **CLO's**	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	3	2										
CLO2		3										
CLO3		2										
CLO4				2								

Teaching and Learning Activities (TLA)

TLA1	Lectures twice a week using multimedia of different topics.
TLA2	Active discussion in class regarding efficient solving of the logical and mathematical problems.
TLA3	Group discussion and presentation regarding diverse problems and corresponding lectures.
TLA4	Evaluation of class performances to reach each student in a class for every topic.

Course Delivery Plan (Including Lab)

Week/Lessen (hour)	**Discussion Topic & Book Reference**	**Student Activities during Online and Onsite and TLA**	**Assessment and Mapping with CLO**
Week 1 Lesson 1 & 2 (1.5 each) Lab Session 1 (3.0)	**Lesson 1:** Introduction to Simulation System, Appropriate tools, advantages and disadvantages of simulation (Ref: Jerry Banks: Ch 1) **Lesson 2:** Areas of application, System and system environment (Ref: Jerry Banks: Ch 1) **Lab 1:** Introduction to Arena (Ref: W Kelton: Ch 3 / Lab Manual - 1)	Lesson 1: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1** Lesson 2: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1** Lab 1: Model design and implementation using Arena simulator, Problem solving exercise	CLO1
Week 2 Lesson 3 & 4 (1.5 each) Lab Session 2 (3.0)	**Lesson 3:** Components of a system, Discrete and continuous system, Model of a system, Types of models (Ref: Jerry Banks: Ch 1) **Lesson 4:** Discrete event system simulation concepts, Steps in simulation study, flow diagram with description (Ref: Jerry Banks: Ch 1)	Lesson 3: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1** Lesson 4: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1** Lab 2: Model design and implementation using Arena	CLO1 **Assignment 1** (will be due by Week 3) - Model design & implementation by Arena - Using LMS (BLC)

	Lab 2: A Simple Model of The Carwash System (Ref: Lab Manual - 1)	simulator, Problem solving exercise	
Week 3 Lesson 5 & 6 (1.5 each) Lab Session 3 (3.0)	**Lesson 5:** Simulation of Queuing System: Three steps of simulation, calling population, system state, flow diagrams, bar chart (Ref: Jerry Banks: Ch 2) **Lesson 6:** Single channel queuing problem with single sever (Ref: Jerry Banks: Ch 2) **Lab 3:** ATM Machine Problem (Ref: Lab Manual - 2)	Lesson 5: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lesson 6: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2, TLA4** Lab 3: Model design and implementation using Arena simulator, Problem solving exercise	CLO1, CLO2
Week 4 Lesson 7 & 8 (1.5 each) Lab Session 4 (3.0)	**Lesson 7:** The Able-Baker Carhop Problem (Ref: Jerry Banks: Ch 2) **Lesson 8:** Probability Distribution, Types of Probability Discrete Distributions (Ref: V. P. Singh: Ch 2) **Lab 4:** A two-State Manufacturing Process (Ref: Lab Manual - 3)	Lesson 7: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lesson 8: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lab 4: Model design and implementation using Arena simulator, Problem solving exercise	CLO1, CLO2 **Class Test# 1** (Either online or onsite based on Week 1-3 discussion) based on CLO1
Week 5 Lesson 9 & 10 (1.5 each) Lab Session 5 (3.0)	**Lesson 9:** Binomial Distribution, Poisson distribution, Normal Distribution (Ref: V. P. Singh: Ch 2) **Lesson 10:** Simulation of a Telephone System: Processing description with diagram (Ref: V. P. Singh:	Lesson 9: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lesson 10: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video,	CLO1, CLO2

	Ch 2) **Lab 5:** Two-station queuing system Applying animation on problems (Ref: Lab Manual - 4)	H5P; **TLA1** Lab 5: Model design and implementation using Arena simulator, Problem solving exercise	
Week 6 Lesson 11 & 12 (1.5 each) Lab Session 6 (3.0)	**Lesson 11:** Review Class-1 **Lesson 12:** Review Class-2 **Lab 6:** Applying animation on problems and working for the team Project (Ref: Lab Manual - 4)	Lesson 11: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA3** Lesson 12: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA4** Lab 6: Model design and implementation using Arena simulator, Problem solving exercise	CLO1 **PRN#1:** Project Concept Presentation by Team **Class Test# 2** (either online or onsite based on Week 4-5 discussion) based on CLO1 **Assignment 2** (will be due by Week 8) - Model design & implementation by Arena
Week 7	**MID–TERM EXAM**		
Week 8 Lesson 13 & 14 (1.5 each) Lab Session 7 (3.0)	**Lesson 13:** Simulation of Inventory Systems – basic concepts (Ref: Jerry Banks: Ch 2) **Lesson 14:** Simulation of Inventory Systems - News dealers problem, Simulation of an order-up-to level inventory system (Ref: Jerry Banks: Ch 2) **Lab 7:** Simulation Applications in Queuing Theory: Operationalizing Fundamental Waiting Line Models	Lesson 13: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1** Lesson 14: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lab 7: Model design and implementation using Arena simulator, Problem solving exercise	CLO1, CLO2

Week 9 Lesson 15 & 16 (1.5 each) Lab Session 8 (3.0)	**Lesson 15:** Simulation of Inventory Systems – M,N inventory problem Concepts in Discrete Events (Ref: Jerry Banks: Ch 2) **Lesson 16:** Reliability Problem: Bearing problem with current method (Ref: Jerry Banks: Ch 2) **Lab 8:** Drive-in fast food restaurant model- Without cook schedule Project work (Ref: Lab Manual - 5)	Lesson 15: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lesson 16: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2, TLA2** Lab 8: Model design and implementation using Arena simulator, Problem solving exercise	CLO1, CLO2
Week 10 Lesson 17 & 18 (1.5 each) Lab Session 9 (3.0)	**Lesson 17:** Reliability Problem: Bearing problem with proposed method (Ref: Jerry Banks: Ch 2) **Lesson 18:** Reliability Problem: Exercise in group (Ref: Jerry Banks: Ch 2) **Lab 9:** Drive-in fast food restaurant model with cook schedule (Ref: Lab Manual - 5)	Lesson 17: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lesson 18: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA3, TLA4** Lab 9: Model design and implementation using Arena simulator, Problem solving exercise	CLO1, CLO2, CLO3, CLO4
Week 11 Lesson 19 & 20 (1.5 each) Lab Session 10 (3.0)	**Lesson 19:** The dump truck problem: basic concepts, system states, event states (Ref: Jerry Banks: Ch 3) **Lesson 20:** Simulation table for dump truck operation (Ref: Jerry Banks: Ch 3) **Lab 10:** Project implementation	Lesson 19: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1** Lesson 20: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lab 10: Project implementation in Arena simulation environment	CLO1, CLO3 **Class Test# 3** (either online or onsite based on Week 8-10 discussion) based on CLO2
Week 12	**Lesson 21:** Petri Net:	Lesson 21: Online/Onsite	CLO1, CLO2

Lesson 21 & 22 (1.5 each) Lab Session 11 (3.0)	definition, firing of transitions, state equation (Ref: Jerry Banks: Ch 10) **Lesson 22:** Petri Net: M/M/1 Queue (Ref: Jerry Banks: Ch 10) **Lab 11:** Group Project Presentation Sharing by Team Lead on behalf of the team	discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lesson 22: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA2** Lab 11: Project presentation using PPT and animation tools	**PRN#2:** Project Implementation Presentation by Team
Week 13 Lesson 13 & 14 (1.5 each) Lab Session 12 (3.0)	**Lesson 23:** Review Class-1 **Lesson 24:** Review Class-2 **Lab 12:** Lab Performance Test and Project based assessment of course projects	Lesson 23: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA1, TLA3** Lesson 24: Online/Onsite discussion; Review Feedback online; Using Interactive content e.g. Voice over PPT, PPT, Video, H5P; **TLA2, TLA4** Lab 12: Solving real-life problems using Arena	CLO1, CLO2, CLO3
Week 14	**FINAL EXAM**		

Text Books

1. Discrete-Event System Simulation – Jerry Banks, John S. Carson II, Barry L. Nelson and David M.Nicol

Reference Books:

1. System modelling and simulation – V.P. Singh
2. Simulation with Arena – W. Kelton, Randall Sadowski, Nancy Swets

CIE – Breakup (Theory) [60 marks]

Bloom's Criteria	**Attendance (07)**	**Class Test (15)**	**Assignment (05)**	**Presentation (08)**	**Mid Exam (25)**
Remember		05			
Understand		05	02	02	05
Apply		05		03	05
Analyze			03		05
Evaluate					05
Create				03	05

CIE – Breakup (Lab) [100 marks]

Bloom's Criteria	**Attendance (10)**	**Lab Performance (25)**	**Lab Report (25)**	**Lab Final (40)**
Remember				
Understand		05	05	10
Apply		05	05	05
Analyze		05	05	10
Evaluate			10	05
Create		10		10

SEE – Semester End Examination [40 marks] {Theory}

Bloom Criteria	**Score for the Test**
Remember	05
Understand	05
Apply	15
Analyze	05
Evaluate	05
Create	05

Appendix-1: Program outcomes

POs	Category	Program Outcomes
PO1	**Engineering Knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis**	Identify, formulate, research the literature and analyze complex engineering problems and reach substantiated conclusions using first principles of mathematics, the natural sciences and the engineering sciences.
PO3	**Design/Development of Solutions**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety as well as cultural, societal and environmental concerns.
PO4	**Investigations**	Conduct investigations of complex problems, considering design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
PO5	**Modern tool usage**	Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7	**Environment and sustainability**	Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**	Apply ethical principles and commit to professional ethics, responsibilities and the norms of the engineering practice.
PO9	**Individual work and teamwork**	Function effectively as an individual and as a member or leader of diverse teams as well as in multidisciplinary settings.
PO10	**Communication**	Communicate effectively about complex engineering activities with the engineering community and with society at large. Be able to comprehend and write effective reports, design documentation, make effective presentations and give and receive clear instructions.

PO11	**Project management and finance**	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work as a member or a leader of a team to manage projects in multidisciplinary environments.
PO12	**Life Long Learning**	Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the broadest context of technological change.