Simulation and Modelling

Course Title: Simulation and Modelling
Course No: CSC317
Nature of the Course: Theory + Lab
Semester: V

Full Marks: 60 + 20 + 20
Pass Marks: 24 + 8 + 8
Credit Hrs: 3

Course Description: The syllabus consists of introduction to system, modelling and simulation of different types of systems. It includes the modelling of systems, its validation, verification and analysis of simulation output. It comprises the concept of queuing theory, random number generation as well as study of some simulation languages.

Course Objective: To make students understand the concept of simulation and modelling of real time systems.

Detailed Syllabus:

Unit 1	**Introduction to Simulation**	**6 Hours**
System and System Environment	Concept of system and system environment	1 hour
Components of System	System, entities, attributes, events, state variables and other terms related to system	
Discrete and Continuous System	Introduction and examples	
System Simulation, Model of a System, Types of Model	Introduction to system simulation and system model, different types of models and examples (physical/ mathematical, static/dynamic, discrete/continuous, deterministic/stochastic)	2 hours
Use of Differential and Partial differential equations in Modelling	Brief review of how differential and partial differential equations can be used in system-modelling	1 hour
Advantages, Disadvantages and Limitations of Simulation, Application Areas	Advantages, Disadvantages, Limitations and Applications of system simulation	1 hour
Phases in Simulation Study	Study of different phases during simulation	1 hour
Unit 2	**Simulation of Continuous and Discrete System**	**7 Hours**
Continuous System Models Analog Computer, Analog Methods, Hybrid Simulation, Digital-Analog Simulators, Feedback Systems	Concept, examples, use of differential equations for modelling continuous system	2 hours

Discrete Event Simulation, Representation of time, Simulation Clock and Time Management	Concept of discrete event simulation, time representation and management	1 hour
Arrival Processes - Poisson Processes, Non-stationary Poisson Processes, Batch Arrivals	Concept of arrival pattern, generation of arrival pattern using Poisson and Non-stationary Poisson with example, Introduction to batch arrival processes	2 hours
Models of Gathering statistics	Different statistics (like counts, summary measures, utilization, occupancy, distributions etc) that are needed to generate report and methods to gather such statistics	1 hour
Probability and Monte Carlo Simulation	Concept with an example	1 hour
Unit 3	**Queuing System**	**6 Hours**
Characteristics and Structure of Basic Queuing System, Models of Queuing System	Concept of Basic Queuing System, Its Characteristics, Discipline, Models and related terms	2 hours
Queuing notation	Kendall's notation for queuing system	
Single server and Multiple server Queuing Systems	Concept and examples of single server and multiple server queue	1 hour
Measurement of Queuing System Performance, Elementary idea about networks of Queuing with particular emphasis to computer system, Elementary idea about network of queuing with particular emphasis to computer system Applications of queuing system	Performance evaluation of queuing system (M/M/1) in terms of parameters like average number of customers, average time spent in system and in queue per customer, server utilization, cost of waiting time and idle time, with numerical examples Introduction of network of queues Examples of computer system related queuing systems and other applications of queuing system	3 hours
Unit 4	**Markov Chains**	**2 Hours**
Features, Process Examples, Applications	Concept, Features, Examples, Applications of Markov Chains	2 hours
Unit 5	**Random Numbers**	**7 Hours**
Random Numbers and its properties, Pseudo Random Numbers	Concept, properties and types of random numbers	1 hour
Methods of generation of	Linear Congruential Method (mixed and	2 hours

Random Number	multiplicative), Mid square method	
Tests for Randomness - Uniformity and independence	- Uniformity testing – K-S Test and Chi – square test - Independent testing – Gap test, Auto correlation test, Poker test upto 4 digits	2 hours
Random Variate Generation	Random variate generation via inverse transform technique and acceptance-rejection technique	2 hours
Unit 6	**Verification and Validation**	**4 Hours**
Design of Simulation Models Verification of Simulation Models, Calibration and Validation of the models, Three-Step Approach for Validation of Simulation Models, Accreditation of Models	Concept of Model Building; verification; validation and calibration; three step approach, Introduction to accreditation of models	4 hours
Unit 7	**Analysis of Simulation Output**	**4 Hours**
Confidence Intervals and Hypothesis Testing, Estimation Methods (Point Estimation and confidence interval with examples), Simulation run statistics, Replication of runs, Elimination of initial bias		4 hours
Unit 8	**Simulation of Computer Systems**	**9 Hours**
Simulation Tools		1 hour
Simulation Languages - GPSS - study and use of language with related problem - study of different blocks of GPSS blocks - concept of queue, storage, facility, multi-server queue, decision making		5 hours
Case Studies of different types of Simulation Models, Construction of sample mathematical models		3 hours

Laboratory Work:

After completing this course, students should have practical knowledge regarding simulation of some real time systems (continuous and discrete event systems), Queuing Systems, Random Number generations as well as study of Simulation Tools and Language. Verification and validation of models can be done, the analysis of outputs produced in the laboratory exercise can also be performed. The laboratory work should include:

- Implement different methods of random number generation

- Simulating games of dice that generate discrete random variate, using random number generation
- Testing of random numbers (K-S and Chi Square Test)
- Implementing applications of Monte Carlo methods
- Implement applications of Markov's chain
- Simulation of single queue server system
- GPSS models - queue, storage, facility, multi-server queue, decision making problems

Text Book:

1. Jerry Banks, John S. Carson, Barry L. Nelson, David M. Nicole, "Discrete Event system simulation", 5th Edition, Pearson Education

Reference Books:

1. Geoffrey Gordon: System Simulation
2. Law, "Simulation Modeling and Analysis", 5th Edition, McGraw-Hill

Model Question

Course Title: Simulation and Modelling **Full Marks:** 60
Course No: CSC317 **Pass Marks:** 24
Semester: V **Credit Hrs:** 3

Section A

Attempt **ANY TWO** questions. (2 × 10 = 20)

1. What are the characteristics of Queuing System? What are the various performance measures in single server (M/M/1) queuing system simulation? (5 +5)
2. a) Differentiate between true and pseudo random numbers. What are the basic properties of random numbers? The sequence of numbers 0.37, 0.29, 0.19, 0.88 0.44, 0.63, 0.77, 0.70 0.21, and 0.58 has been generated. Use K-S test to determine if the numbers are uniformly distributed ($D_\alpha = 0.41$ for $\alpha = 0.05$ a) (2 + 2 + 6)
3. Explain the analogy between Mechanical system and electrical system using Dynamic Physical Model. Explain Dynamic mathematical model and static mathematical model.

Section B

Attempt **ANY EIGHT** questions. (8 × 5 = 40)

4. Explain about system, its environment and its components.
5. What is analog computer? Design a basic analog computer that represents a simple dynamic system.
6. What is non-stationary Poisson process? How can we convert it into a stationary Poisson process?
7. Explain Monte Carlo simulation method with an example.
8. Explain the three step approach of validation of models in simulation.
9. Use Multiplicative congruential method to generate a sequence of 10 three-digit random integers and corresponding random variables. Let $X_0 = 5$, a = 3 and c=2.
10. Why Confidence interval is needed in the analysis of simulation output. How can we can we establish a confidence interval?
11. Create a GPSS model and program to simulate a barber shop for a day (9am to 4pm), where a costumer enters the Shop every 10 ± 2 minutes and a barber takes 13 ± 2 for a haircut.

12. Write short notes on: (2 × 2.5 = 5)
    a. Differential equation
    b. Markov Chain