CSE3171: Introduction to Simulation & Modeling

Programme: B.Tech (All Branches) Year : IIIrd Semester : Vth
Course: Elective Credits : 3 Hours : 40

Course Context and Overview):
The objective of this course is to understand the dynamics of different deterministic & stochastic dynamical systems also to learn methods to model such systems. Monte Carlo method, MCMC will be discussed to find the solution of complex problems. It will also talks about different numerical techniques to simulate single order/multi order Ordinary Differential Equation (ODE), Stochastic Differential Equation (SDE) & Stochastic Integro-Differential Equation (SIDE).

Prerequisites Courses: Probability & Differential Equation (Engineering Mathematics).

Course Outcomes (COs):

On completion of this course, the students will have the ability to:
CO1: Understand different models used to explain the dynamics of different physical and natural system.
CO2: Comfortable with the application of Monte Carlo technique to solve problems.
CO3: Understand the methods to simulate ODE, SDE, SIDE.
CO4: Understand the applications of differential equations to model the behavior of social as well as engineering problems.

Course Topics:

Contents	**Lecture Hours**	
UNIT – 1: **Introduction:** Definition of system and simulation, Merits and demerits of simulation, Areas of application, Types of systems, various types of models to represent them, Discrete and Continuous systems. Stages of a typical simulation study, Simulation Examples, Concepts of system Clocks, Event scheduling Vs Time advance algorithms.		6
UNIT –2: **Random Numbers**		
Roles of random numbers in simulation, pseudo random number generation techniques their properties, methods of testing PRN sequences. Random Varieties: Generation, Inverse transformation techniques, Direct transformations for the Normal distributions, Acceptance Rejection technique.		6

UNIT-3: **Simulation techniques**		
Monte-Carlo methods, Lag models, Distributed lag model. Discrete Event system simulation: Different Queuing models and studies. Simulation of ODE: Euler's method, Runge-Kutta method. Simulation of SDE & SIDE: Euler's Maruyama method, Milstein method		8
UNIT-4 **Analysis of Simulation Data**		
Data Collection, Identifying the Distribution with data: Histogram, Selecting family of distribution. Parameter Estimation: Sample mean, Sample Variance, mean square method, Maximum likelihood estimation (MLE). Goodness of fit: Chi-Square Test, Kolmogorov-Smirnov test. Covariance & Correlation.	5	8
Verification & Validation of Simulation Models		
Verification & Validation, Verification of simulation models, Calibration & Validation of models.	3	
UNIT-5 **Analysis of Stochastic models**		
Queuing models: {M/M/1, M/M/1/N, M/M/m, M/M/m/m systems, long-run measures of performance, steady state behavior, network of queues.	9	12
Social & Biological Models: Bass Diffusion Model, Lotka-Volterra Model, Neuronal Models etc.	3	

Textbook & References:

Text Book:

1. J Banks, J. S. Carson II, B. L. Nelson, D. M. Nicol, *"Discrete Events System Simulation*", Prentice Hall, 5th Edition, 2009, ISBN-10: 0136062121.
2. A. M. Law, W. D. Kelton, *"Simulation Modeling and Analysis*", Tata- McGraw Hill, 4th Edition, 2008, ISBN-13: 9780070667334..

Reference books:

1. R. Y. Rubinstein, *"Simulation and the Monte Carlo Method"*, D. P. Kroese, Wiley-Interscience, 2nd Edition, 2007, ISBN-10: 0470177942.
2. T. G. Robertazzi, Springer, *"Computer Network & Systems": Queueing Theory and Performance Evaluation*, 3rd Edition, 2000, ISBN-10: 0387950370.
3. A. Papoulis, *"Probability, Random variables and Stochastic Processes*", Tata McGraw Hill 4th Ed.