Course Name : Modeling and Simulation
Course Number : ME 620
Credit : 2-0-2-3
Prerequisites : Engineering Mathematics (IC110), Linear Algebra (IC111)
Students intended for: UG/MS/PHD
Elective or Core : Elective
Semester : Even

Preamble:
Modeling and Simulation, or M & S as it is commonly referred, is becoming an important tool of industrial design and development and so, it is necessary to train the students in the techniques of M & S and this course is introduced with that aim to all the students across the disciplines. M & S has matured over the years with its own body of knowledge, theory, and research methodology. At the core of the discipline is the realization that every system need not be studied in all its complexity to reflect reality and depending on the objective, simplified models may be constructed incorporating only the relevant aspects for the purpose.

The first step to be learnt is to create a model approximating a system and the approach to be adopted could be based on differential equations, artificial neural network or fuzzy logic depending on available knowledge about the system. The behavior of the model is then studied by simulation tools, which allows for time evolution of outcome and may inspire changes in the design of the system and the model in order to arrive at the desired outcome through further simulation. An existing system may also be modeled in order to optimize its performance at the desired level of inputs. Thus, the present course offers a segment with special emphasis on nontraditional techniques like genetic algorithm and simulated annealing.

The course will begin with a segment on physical modeling based on dimensionless parameters so that students may learn the science of scaling up from laboratory to pilot plant and finally to full scale. It will be followed by modeling through different approaches, optimization and simulation. The students will receive hands on training in using software widely used in industries for different techniques. The present course is a first course giving an overview of the capabilities and techniques of M & S and it may be followed by developing higher level courses in each of the approaches to M & S.

This course is proposed as an elective course to UG/MS/PhD students across the disciplines with the aim of imparting basic understanding of Modeling and Simulation so that the students will find it easy to use this knowledge in profession for applying to various engineering systems and design.
Learning outcomes of this course are anticipated as follows:

- Students will understand the techniques of modeling in the context of hierarchy of

knowledge about a system and develop the capability to apply the same to study systems through available software.

- Students will learn different types of simulation techniques.
- Students will learn to simulate the models for the purpose of optimum control by using software.

Course Outline:

Modeling and Simulation has become an essential tool for engineers for optimum design and the course aims to impart an overview of the modeling and simulation approaches with emphasis on applications using MATLAB.

Course Modules:

1. Introduction: System, environment, input and output variables, State variables; Static and Dynamic systems; Hierarchy of knowledge about a system and Modeling Strategy. (2 L)
2. Physical Modeling: Dimensions analysis, Dimensionless grouping of input and output variables of find empirical relations, similarity criteria and their application to physical models. (2 L)
3. Modeling of System with Known Structure: Review of conservation laws and the governing equation for heat, mass and momentum transfer, Deterministic model-(a) distributed parameter models in terms of partial identification and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modeling for control (7 L)
4. Optimizations and Design of Systems: Summary of gradient based techniques : Nontraditional Optimizations techniques (1) genetic Algorithm (GA)- coding, GA operations elitism, Application using MATLAB:(ii) Simulated Annealing (4 L)
5. Neural Network Modeling of Systems only with Input-output Database: Neurons, architecture of neural networks, knowledge representation, learning algorithm. Multilayer feed forward network and its back propagation learning algorithm, Application to complex engineering systems and strategy for optimum output. (4 L)
6. Modeling Based on Expert Knowledge: Fuzzy sets, Membership functions, Fuzzy Inference systems, Expert Knowledge and Fuzzy Models, Design of Fuzzy Controllers (4 L)
7. Simulation of Engineering Systems: Monte-Carlo simulation, Simulation of continuous and discrete processes with suitable examples from engineering problems. (5 L)

List of practical's:

Exp. 1&2 Introductions to programming with MATLAB

Exp. 3&4 Find the response of a lumped variable model expressed in terms of transfer function using MATLAB for input of (i) unit step function (ii) unit impact function and (iii) unit ramp function

Exp. 5, 6 & 7 Use of Simulink in MATLAB for engineering problems
Exp. 8, 9 & 10 Use of Neural Network in MATLAB for engineering problems
Exp. 10, 11 &12 Use of FIS and ANFIS in MATLAB for engineering problems
Exp. 13 & 14 Monte Carlo simulation

Textbooks:

1 Zeigler B.P. Praehofer. H. and Kim I.G. "Theory of modeling and simulation", 2 nd Edition. Academic press 2000
2 Ogata K " Modern control Engineering" 3 rd edition. Prentice hall of India 2001
3 Jang J.S.R. sun C.T and Mizutani E,, "Neuro-Fuzzy and soft Computing ", 3 rd edition, Prentice hall of India 2002
4 Shannon, R. E., "System Simulation: the Art and Science", Prentice Hall Inc. 1990
5 Pratab.R " Getting started with MATLAB" Oxford university Press 2009