M.E. ELECTRICAL ENGINEERING FIRST YEAR FIRST SEMESTER - 2018

MODELING & SIMULATION OF DYNAMIC SYSTEMS

Time: Three Hours; Full Marks: 100

Answer any *five* questions

1. a) State two methods for the generation of random numbers. What are pseudo random numbers? Enumerate the possible defects of pseudo random number generators. (2+2+5) +6+5

   b) Perform the Kolmogorov - Smirnov Test to check the uniformity of the following sequence of random numbers with a level of significance $\alpha = 0.01$.
   0.82, 0.43, 0.27, 0.16, 0.97, 0.64, 0.83, 0.71, 0.95, 0.58.
   Given that at $\alpha = 0.01$, critical value is 0.490.

   c) With a seed of 11, m=19, a=2, b=13, generate a sequence of 10 random numbers by using the mixed congruential random number generation method.

2. a) Write a flowchart to generate a sequence of 100 random numbers in the interval [0, 1] with two digit accuracy. 6+7+7

   b) Find the value of π by generating a sequence of 50 random numbers with your calculator.

   c) The following is a sequence of 73 random numbers:
   37, 24, 86, 52, 43, 18, 08, 90, 27, 12,
   15, 02, 52, 57, 52, 64, 91, 15, 68, 98,
   65, 48, 67, 76, 96, 18, 98, 80, 57, 76,
   22, 75, 96, 84, 47, 38, 56, 78, 17, 22,
   57, 35, 11, 43, 58, 59, 44, 32, 43, 14,
   32, 98, 60, 23, 99, 16, 49, 08, 64, 53,
   74, 23, 47, 80, 64, 77, 36, 84, 85, 66,
   63, 55, 07.
   By assuming that the number of classes is 9, perform the Chi-square test for auto-correlation to check whether the sequence is acceptable at 95% confidence level. Given that for 7 degrees of freedom, at 95% confidence level, the acceptable value of chi-square is 14.067.

3. a) Compare Sequential Systems with Queuing Discrete Event Systems. 10+4+6

   b) A fast food restaurant has a Menu Board where a person arriving at the restaurant must place his order, and an Order Pick-up Window where the customer must pay and get the food which he has ordered. Draw a flow chart for the above system.

   c) Define the terms *entity*, *activity* and *event*. Give an example of each of these terms from the system described in 3b) above.

4. a) Write the truth table for a J-K flip-flop and implement it by using ladder logic. 5+8+7

   b) With the help of a ladder logic diagram, represent a level control system which has been designed to operate a pump if the water level falls below a height h_1 and switch it off if the water level exceeds a pre-specified level h_2.

   c) A lift operates between the different floors of a multi-storeyed building. Draw the state transition diagram for the system using state machines.

contd...

5. a) (i) What is real-time simulation? (ii) When is real-time simulation mandatory? Explain with the help of examples. (iii) State three reasons why non real-time simulation would be necessary. 6+8+6

b) Given $\frac{d^2y}{dx^2}+\left(1-y^3\right)\frac{dy}{dx}+y=0;\quad y(0)=1;\quad \left.\frac{dy}{dx}\right|_{x=0}=0;\quad h=0.1.$

Obtain a solution of the above differential equation for 2 consecutive steps by using the fourth-order Runge-Kutta method.

c) What do you mean by (i) *variable step size method*, (ii) *variable order method* and (iii) *stiff ODE solver*.

6. a) Briefly state the different forms of abstract models that are used to represent dynamic systems. Discuss the advantages and limitations of each form. 6+4+10

b) With the help of a flow-chart show the steps involved in the modelling life-cycle.

c) For the nonlinear two-tank system shown in Fig 1, given that $Q_2 = C_f\sqrt{(H_1 - H_2)}$. A_1 and A_2 are the cross-sectional areas of the two cylindrical tanks as shown. (i) Obtain the nonlinear state space representation of the system. (ii) Linearize the model about $H_1 = \tilde{H}_1, H_2 = \tilde{H}_2, Q_1 = \tilde{Q}_1, Q_3 = \tilde{Q}_3$.

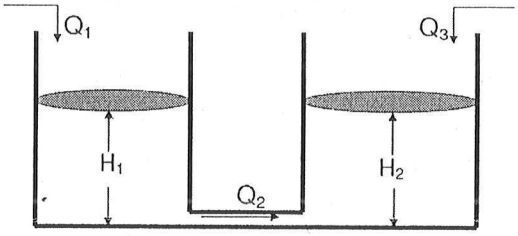

Fig. 1

7. a) A time-invariant *N*-dimensional system has a nonlinear process equation with additive process noise and a linear output equation. Linearize the system clearly showing the steps involved. 6+(8+6)

b) A coupled spring-mass system is shown in Fig. 2. The masses and springs are assumed to be identical. The displacements of the masses are denoted by x_1 and x_2 respectively, $f(t)$ is the force acting on one of the masses as shown. Unless otherwise mentioned, the symbols have their usual meanings. (i) Obtain the differential equation of the system. (ii) Hence obtain the state-space model of the system.

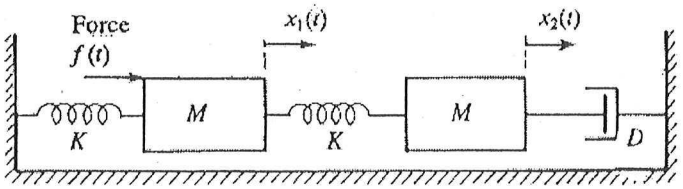

Fig. 2

8. In an inverted pendulum, the control force acting on the cart is u and the angular deviation of the pendulum from the vertical is θ. 5+5+10

a) Draw a free body diagram of (i) the cart and (ii) the pendulum. Clearly define all symbols used and state any assumptions made.

b) Write the differential equations for the above system.

c) Obtain the linearized state model for the above system.