USN

Fifth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Modern Control Theory

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART - A

1 a. What are the advantages of Modern Control Theory over Conventional Control theory? **(04 Marks)**

b. Obtain the two state models of the Transfer function given by

$$\frac{Y(s)}{U(s)} = \frac{2S^2+3S+4}{S^3+3S^2+4S+5}.$$ **(06 Marks)**

c. Obtain the state model of the Electrical Network shown in fig. Q1(c). **(10 Marks)**

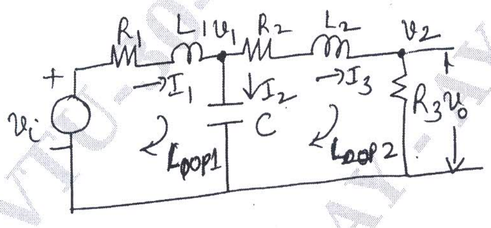
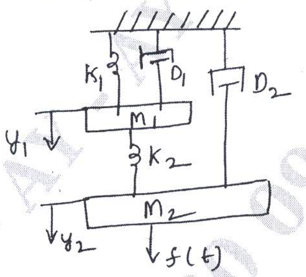


Fig.Q1(c)

2 a. For the mechanical system shown in fig. Q2(a), obtain the state model. **(06 Marks)**



Y_1 and Y_2 are outputs

Fig.Q2(a)

b. Obtain the Jordan Canonical state model of the system.

$$T(s) = \frac{Y(s)}{U(s)} = \frac{S^2+2S+4}{(S+2)^3(S+3)}.$$ **(08 Marks)**

c. Obtain the state model of the plant of the system shown in fig. Q2(c). **(06 Marks)**

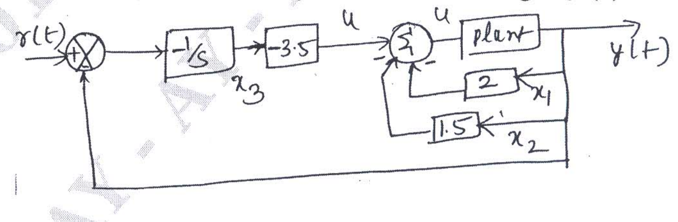


Fig.Q2(c)

3 a. Find Transfer matrix for MIMO system having state model.

$$\dot{x} = \begin{bmatrix} 2 & -1 & 0 \\ 1 & 1 & 2 \\ -1 & 0 & 1 \end{bmatrix} x + \begin{bmatrix} -1 & 0 \\ 1 & 0 \\ 0 & 2 \end{bmatrix} u \quad ; \quad y = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} x.$$ **(10 Marks)**

b. Obtain Eigen values, Eigen vector and Modal matrix for

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 0 & 2 \\ -12 & -7 & -6 \end{bmatrix}$$. Also find Diagonal Matrix. **(10 Marks)**

4 a. Obtain the solution of the system which is described by

$$\dot{x} = \begin{bmatrix} 1 & 2 \\ 0 & 2 \end{bmatrix} x \text{ and } x(0) = \begin{bmatrix} 1 \\ 2 \end{bmatrix}.$$ **(07 Marks)**

b. Findout $f(A) = 2A^4 + 3A^3 + 2I$.

Given $A = \begin{bmatrix} 0 & 2 \\ -1 & -3 \end{bmatrix}$ using Cayley Hamilton theorem. **(07 Marks)**

c. Check controllability and observability of system given by

$$\dot{x} = \begin{bmatrix} 1 & 1 \\ -2 & -1 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t) \qquad y = [1 \;\; 0]x.$$ **(06 Marks)**

PART - B

5 a. Explain the types of Controllers. **(04 Marks)**

b. Consider the system described by $\dot{x} = Ax + Bu$.

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \qquad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

By using the state feedback control u = - K x, it is desired to have closed loop poles at S = -1 ± j 1 , S = -10. Determine feedback gain matrix. **(08 Marks)**

c. An Observable system is described by

$$\dot{x} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} x + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u \quad ; \quad y = [0 \; 0 \; 1]x.$$

Design a state observer so that eigen values are at -4 , -3 ± j 1. **(08 Marks)**

6 a. Explain the properties of Nonlinear systems. **(08 Marks)**

b. Explain the following types of nonlinearities :

i) Saturation ii) Relay with dead zone iii) Back lash iv) Friction. **(12 Marks)**

7 a. What are types of singular points and explain them? **(06 Marks)**

b. Explain Isocline method of finding phase trajecteries. **(06 Marks)**

c. Using Delta method, find the phase trajectories of the following system.

$$\ddot{x} + 2\dot{x} + 4x = 0.$$ **(08 Marks)**

8 a. Explain the following terms with graphical representation :

i) Asymptotic stability ii) Asymptotic stability in the large iii) Instability. **(06 Marks)**

b. Find whether following Quadratics form is positive definite or not :

i) $V(x) = x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$.

ii) $V(x) = -5x_1^2 - 2x_2^2 - x_3^2 - 2x_1x_2 + 2x_2x_3$. **(04 Marks)**

c. A second order, linear , time – invariant system is described by

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} x.$$

Assuming the matrix Q in the equation $A^TP + PA = -Q$ to be identity matrix.

i) Solve for the matrix P ii) Obtain the Liapunov function V(x) iii) Investigate stability of the origin of the system. **(10 Marks)**