USN

Fifth Semester B.E. Degree Examination, June/July 2016
Modern Control Theory

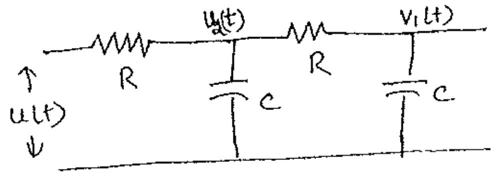
Time: 3 hrs. Max. Marks:100

Note: *Answer FIVE full questions, selecting at least TWO questions from each part.*

PART – A

1 a. What are the advantages of modern control theory over conventional control theory? (05 Marks)

b. For the system shown, write the state equations satisfied by them. Bring these equations in vector matrix form, (07 Marks)



Take R = 1 MΩ and C = 1 μF

Fig. Q1 (b)

c. A Feedback system is characterized by the closed loop transfer function,

$$T(s) = \frac{s^2 + 3s + 3}{s^3 + 2s^2 + 3s + 1}$$

Draw the signal flow graph and obtain the state model in second companion form. (08 Marks)

2 a. Obtain the state space representation of the given system in Jordan canonical form.

$$\frac{y(s)}{U(s)} = \frac{2s^2 + 6s + 7}{(s+1)^2 (s+2)}$$ (12 Marks)

b. Obtain the transfer function for the state model represented by, $\dot{x} = Ax + Bu$, $y = Cx + DU$,

where $A = \begin{bmatrix} -1 & 1 \\ -1 & -10 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 10 \end{bmatrix}$, $C = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $D = [0]$ (08 Marks)

3 a. Prove that the modal matrix M diagonalizes the system matrix A. (04 Marks)

b. For the matrix, $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & -4 & -3 \end{bmatrix}$, find i) Eigen values ii) Eigen vectors iii) Modal matrix (08 Marks)

c. Compute the state transition matrix for, $A = \begin{bmatrix} 0 & -3 \\ 1 & -4 \end{bmatrix}$ using i) Laplace – transformation method. ii) Cayley-Hamilton method. (08 Marks)

4 a. Define state transition matrix and list its properties. (04 Marks)

b. A linear time invariant system is characterized by,

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} -1 \\ 2 \end{bmatrix} [u]; \quad y = [1 \quad -1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Compute the response y(t) to a unit step input assuming $X(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$. (12 Marks)

c. Evaluate the controllability of the system with $\dot{x} = Ax + BU$ where $A = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$. **(04 Marks)**

PART – B

5 a. A system is described by following state model:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

Compute the state feedback gain matrix "K" so that the control law to $u = -Kx$ places the closed loop poles at $-2 \pm j4$, -5, using direct substitution method. **(10 Marks)**

b. Consider the system, $\dot{X} = AX + Bu$ and $y = CX$

where $A = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $C = \begin{bmatrix} 0 & 1 \end{bmatrix}$

Design a full order state observer using Ackermann's formula. **(10 Marks)**

6 a. What is PI and PD controller? What are its effect on system performance? **(06 Marks)**

b. Discuss pole placement by state feedback. What is the necessary condition for design using state feedback? **(06 Marks)**

c. Explain Backlash and Jump resonance with respect to non-linear systems. **(08 Marks)**

7 a. What are singular points? Explain different singular points based on the location of Q point. **(08 Marks)**

b. A linear second order servo system is described by the state equation,

$$\ddot{e} + 2\xi\omega_n \dot{e} + \omega_n^2 e = 0$$

where $\xi = 0.15$ and $\omega_n = 1$ rad/sec, $e(0) = 1.5$ and $\dot{e}(0) = 0$. Construct the phase trajectory using the method of isocline. **(12 Marks)**

8 a. Define : i) Positive definiteness ii) Negative definiteness iii) Positive semidefiniteness iv) Negative semidefiniteness v) Indefiniteness. **(05 Marks)**

b. Explain Kravoski's theorem with example. **(07 Marks)**

c. Examine the stability of a non-linear system governed by the equations,

$\dot{x}_1 = -x_1 + 2x_1^2 x_2$; $\dot{x}_2 = -x_2$. Assume $2x_1x_2 < 1$. **(08 Marks)**

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