USN | | | | | | | | | | 10EE55

# 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.***

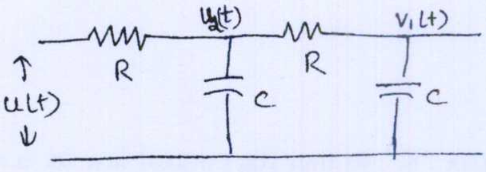




### PART – A

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,

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

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

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 $2x_1 x_2 < 1$. **(08 Marks)**

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