U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

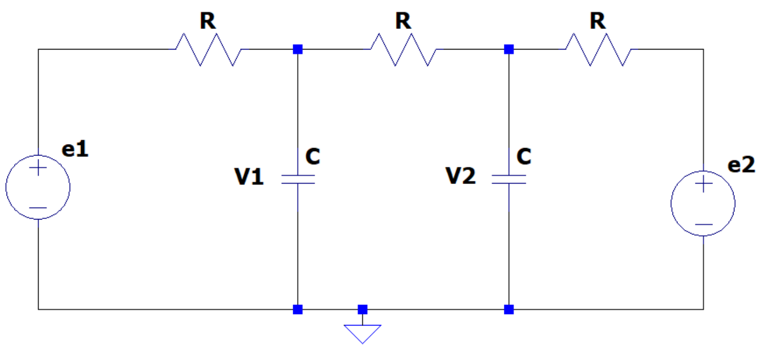
Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Electrical and Electronics Engineering **Duration: 3 hrs.**
Course Code: 23EE5PCMCT **Max Marks: 100**
Course: Modern Control Theory

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	***CO***	***PO***	**Marks**
1	a)	Explain the concept of state, state variable and state model of a linear system.	*CO1*	*PO1*	**06**
	b)	Obtain the state model of the electrical network using minimal number of state variables. select the current through e_2 as output.  Fig.1(b)	*CO2*	*PO2*	**08**
	c)	Obtain the state model by foster form of a system whose transfer function is $T(s) = \frac{(s^2+4)}{(s+1)(s+2)(s+3)}$	*CO2*	*PO2*	**06**
		OR			
2	a)	Using Taylor series, linearize the state equation $\dot{X}(t) = f(x, U)$ for small deviations about the equilibrium point (X_0, U_0). Neglect second and higher order terms.	*CO1*	*PO1*	**06**
	b)	Determine the canonical state model of the system whose transfer function is $T(s) = \frac{S^3+3s^2+2s}{S^3+12s^2+47s+60}$	*CO2*	*PO2*	**08**

		c)	For the transfer function $\frac{Y(s)}{R(s)} = \frac{S^3+5s^2+s}{s^3+6s^2+9s+4}$, obtain the state model in Jordan canonical form.	*CO2*	*PO2*	**06**
			UNIT - II			
	3	a)	What are generalized eigen vector? How are they determined?	*CO1*	*PO1*	**04**
		b)	Find state transition matrix by Caley-Hamilton theorem for the following matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$	*CO2*	*PO2*	**06**
		c)	Obtain the time response of the following vector matrix differential matrix. $\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$ $y = [1\ 0] \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$ Where u(t) is a unit step input and the initial conditions are $X_1(0)=X_2(0)=0$.	*CO2*	*PO2*	**10**
			OR			
	4	a)	What is state transition matrix? List the properties of state transition matrix.	*CO1*	*PO1*	**04**
		b)	Obtain the transfer function of the following system described by the following state equation. $\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & 3 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U$ $Y = [1\ 1\ 0] \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix}$	*CO2*	*PO2*	**06**
		c)	Find the transformation matric 'M' that transforms the matrix $A = \begin{bmatrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{bmatrix}$ into diagonal or Jordan form. Also prove that transformation $M^{-1}AM$ results in diagonal matrix.	*CO2*	*PO2*	**10**
			UNIT - III			
	5	a)	Define state controllability. Also explain and prove the Kalman's test for determining state controllability.	*CO1*	*PO1*	**05**
		b)	Explain the principle of duality between controllability and observability.	*CO1*	*PO1*	**05**
		c)	Determine the state controllability of the system by Kalman's approach and verify by Gilbert's approach.	*CO3*	*PO2*	**10**

			$\begin{bmatrix}\dot{X}_1\\ \dot{X}_2\\ \dot{X}_3\end{bmatrix} = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix}\begin{bmatrix}X_1\\ X_2\\ X_3\end{bmatrix} + \begin{bmatrix}0\\ 0\\ 1\end{bmatrix}U$			
			OR			
	6	a)	Define and explain state observability. Also Derive the Kalman's and Gilbert's test for determining state observability.	*CO1*	*PO1*	**10**
		b)	A system represented by the following state model is controllable but not observable. Show that the non-observability is due to a pole-zero cancellation in $C[SI-A]^{-1}B$ $\begin{bmatrix}\dot{X}_1\\ \dot{X}_2\\ \dot{X}_3\end{bmatrix} = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}\begin{bmatrix}X_1\\ X_2\\ X_3\end{bmatrix} + \begin{bmatrix}0\\ 0\\ 1\end{bmatrix}U$ Y= [1 1 0] X	*CO3*	*PO2*	**10**
			UNIT - IV			
	7	a)	What are the different methods of evaluating state feedback gain matrix? Explain any one method in detail	*CO4*	*PO3.4*	**08**
		b)	Consider the system defined by $\dot{X}$=AX+BU $A = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix} \quad B = \begin{bmatrix}0\\ 0\\ 1\end{bmatrix}$ By using state feedback control u=-kx, it is desired to have the closed loop poles at s=-2±j4, s=-10. Determine the state feedback gain matrix k by using i) Direct substitution method ii) Transformation matrix T.	*CO4*	*PO3.4*	**12**
			OR			
	8	a)	Obtain the necessary and sufficient condition for arbitrary pole placement.	*CO4*	*PO3.4*	**08**
		b)	Consider the system $\dot{X} = AX + BU$. $A = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix} \quad B = \begin{bmatrix}0\\ 0\\ 1\end{bmatrix}$ and C=[1 0 0]. Determine the observer gain matrix by the use of i) Direct substitution method ii) Ackermann's formula Assume that the desired eigen values of the observer gain matrix are -2±j3.4641 and -5.	*CO12*	*PO3.4*	**12**

			UNIT - V			
9	a)	Explain the following behavior of non-linear system i) Frequency amplitude dependance ii) Multi-valued responses and jump resonance	*CO1*	*PO1*	**10**
	b)	Determine whether or not the following quadratic form is positive definite. $Q(x_1, x_2) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$	*CO2*	*PO2*	**10**
			OR			
10	a)	Explain phase trajectory construction by using i) Analytical method ii) Isocline's method	*CO1*	*PO1*	**10**
	b)	Find out singular points for the following systems. i) $\ddot{y} + 0.5y + 2\dot{y} = 0$ ii) $\ddot{y} + 3\dot{y}$-10=0	*CO2*	*PO2*	**10**

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