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

Autonomous Institute Affiliated to VTU

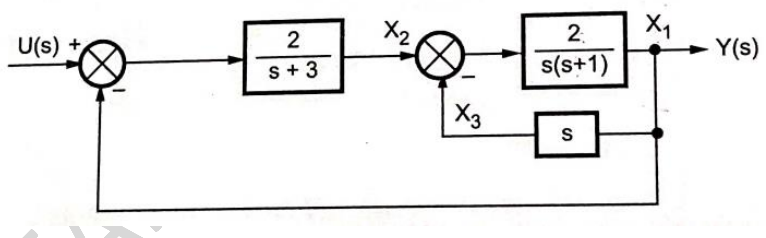
June 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Electrical and Electronics Engineering **Duration: 3 hrs.**
Course Code: 22EE5PCMCT **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.

		UNIT - I	CO	PO	Marks
1	a)	Justify with suitable equations that the state model of a system is not unique.	CO1	PO1	**05**
	b)	Construct the state model using phase variables if the system is described by the differential equation. Draw the state diagram. $\frac{d^3Y(t)}{dt^3} + 8\frac{d^2Y(t)}{dt^2} + 4\frac{dY(t)}{dt} + 2Y(t) = 7U(t)$	CO2	PO1	**08**
	c)	Obtain the state model in Jordan's canonical form of a system whose transfer function is $T(s) = \frac{1}{s^3 + 4s^2 + 5s + 2}$	CO2	PO1	**07**
		OR			
2	a)	Define: (a) State (b) State Variable (c) State Vector (d) State Space (e) state trajectory	CO1	PO1	**05**
	b)	List the drawbacks of classical control system analysis and state how these are overcome in state space analysis.	CO1	PO1	**05**
	c)	Obtain the canonical state model for the given transfer function $\frac{Y(s)}{U(s)} = \frac{10}{s^3 + 4s^2 + 2s + 1}$	CO2	PO1	**10**
		UNIT - II			
3	a)	Prove that the eigen values of matrix A are invariant under a linear transformation	CO2	PO1	**04**
	b)	For a system with given state model matrices $A = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & 3 \end{bmatrix}; B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}; C = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}^T$ Obtain the system transfer function.	CO2	PO1	**08**

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.

	c)	Consider the given matrix $$A = \begin{bmatrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{bmatrix}$$ i)Determine the eigen values and eigen vectors of A ii) Show that the modal matrix indeed diagonalizes A	*CO2*	*PO1*	**08**
		OR			
4	a)	State the various properties of State transition matrix.	*CO1*	-	**07**
	b)	Determine e^{AT} of $A = \begin{bmatrix} 0 & -1 \\ 2 & -3 \end{bmatrix}$ using power series method	*CO2*	*PO1*	**05**
	c)	Determine the state transition matrix of $A = \begin{bmatrix} 0 & 0 & -2 \\ 0 & 1 & 0 \\ 1 & 0 & 3 \end{bmatrix}$ by Cayley Hamilton method	*CO2*	*PO1*	**08**
		UNIT - III			
5	a)	Define and explain the concept of controllability	*CO3*	*PO1*	**04**
	b)	Determine the controllability and observability of the following state model $$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u$$ $$Y = \begin{bmatrix} 10 & 5 & 1 \end{bmatrix} X$$	*CO3*	*PO2*	**08**
	c)	Arrive at the state equations of the system shown in Fig 4c and determine its state controllability and observability.  Fig.4c	*CO3*	*PO2*	**08**
		OR			
6	a)	Explain how to determine controllability of a system using Kalman's method and Gilberts method.	*CO3*	*PO1*	**10**
	b)	Find whether the system given below is Observable or not using Kalman's and Gilberts test for the system given below: $$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \text{ and } C = [3 \;\; 4 \;\; 1]$$	*CO3*	*PO1*	**10**

			UNIT - IV			
	7	a)	Consider the system described by the state model, $\dot{x}=Ax$, $y = Cx$ where $$\boldsymbol{A} = \begin{bmatrix} -1 & 1 \\ 1 & 2 \end{bmatrix}, \boldsymbol{C} = [1 \;\; 0]$$ Design a full order state observer. The desired eigen values for the observer matrix are u1 = -5, u2 = -5.	*CO4*	*PO3*	**10**
		b)	Consider the system defined by $$\dot{x} = Ax + Bu$$ Where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ By using the state feedback control $u = -Kx$, it is desired to have the closed loop poles at $s = -1 \pm j2$, $s = -10$. Determine the state feedback gain matrix K	*CO4*	*PO3*	**10**
			OR			
	8	a)	What is pole placement by state feedback? Explain. Also define the necessary and sufficient condition for arbitrary pole placement.	*CO4*	*PO3*	**06**
		b)	Define state observer and mention its advantages.	*CO4*	*PO3*	**06**
		c)	Design a full order state observer using direct substitution method: $$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$ $$y = [0 \quad 1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$	*CO4*	*PO3*	**08**
			UNIT - V			
	9	a)	Enumerate the common physical non-linearities of a system.	*CO1*	-	**10**
		b)	What are singular points? Explain different types of singular points based on the location of eigen values of the system.	*CO1*	-	**10**
			OR			
	10	a)	Mention any four properties of non-linear systems.	*CO1*	-	**04**
		b)	With reference to non-linear system explain the following with suitable examples 1. Jump Resonance 2. Limit cycle	*CO1*	-	**08**
		c)	Determine the kind of singularity for the given differential equation $$\ddot{y} - 8\dot{y} + 17y = 34$$	*CO2*	*PO1*	**08**

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