BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: M. Tech. **SEMESTER : I**
BRANCH: EE **SESSION : MO/2023**

SUBJECT: EE503 MODERN CONTROL THEORY

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Establish the superiority of Modern control theory over Classical control theory.	[5]	1	3
Q.1(b)	Consider the following transfer function: $$\frac{Y(s)}{R(s)} = \frac{s+6}{s^2+5s+6}$$ Obtain the state-space representation of this system in (i) controllable canonical form (CCF) (ii) Observable canonical form (OCF) and (iii) Diagonal canonical form (DCF).	[5]	1	3
Q.2(a)	The state equation of a linear system is described by $$\frac{dx(t)}{dx} = Ax(t) + Bu(t)$$ Where, $A = \begin{bmatrix} -2 & 1 & 0 \\ 0 & -2 & 0 \\ -1 & -2 & -3 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, C = [1 \quad 0 \quad 0]$ Find the transformation $x(t) = P\bar{x}(t)$ that transforms the state equations into controllable canonical form, if possible.	[5]	1,2	4
Q.2(b)	Draw the state diagram for the system given below by using direct decomposition. Assign the state variables in ascending order from right to left. Write the state equations from state diagram. $$G(s) = \frac{5(s+1)}{s(s+2)(s+10)}$$	[5]	1,2	2
Q.3(a)	Consider the system described by $$\dot{x} = Ax$$ where, $A = \begin{bmatrix} 0 & 1 \\ -3 & -2 \end{bmatrix}$, where the initial conditions are x(0)=[1 -1]^T i. compute the state transition matrix ii. Evaluate $x_1(t)$ and $x_2(t)$	[5]	2,3	3,4
Q.3(b)	Explain Liapunov stability criteria. Consider the system described by $$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$ Determine the stability of the equilibrium state X=0 using Liapunov stability criteria.	[5]	3	3
Q.4(a)	Compare and summarize the unique features of Kalman's and Gilbert's tests for controllability and observability.	[5]	1,4	3,4

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Q.4(b)	Determine the controllability and observability of the following systems: (i) $A = \begin{bmatrix} -1 & -2 & -2 \\ 0 & -1 & 1 \\ 0 & 0 & -1 \end{bmatrix}, B = \begin{bmatrix} 2 \\ 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}$ (ii) $A = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 3 & 1 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$	[5]	1,4	4
Q.5(a)	Define a regulator system. Draw and explain the block diagram of a regulator system. Discuss one method to design the state feedback gain matrix.	[5]	1,4,5	1,2,3
Q.5(b)	Consider a system given by $\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$, $y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x$. Design a full order state observer to determine the gain matrix K_e. The desired eigenvalues of the observer are located at μ1=-2+j2√3, μ2=-2-j2√3, μ3=-5. Also draw the block diagram of the system.	[5]	1,4,5	1,5,6

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