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

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: VI**
Branch: Electrical and Electronics Engineering **Duration: 3 hrs.**
Course Code: 19EE6PCMCT **Max Marks: 100**
Course: Modern Control Theory **Date: 21.09.2023**

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

1 a) Define and explain the following terms i) State ii) State variables and iii) State vector. **06**

b) Prove the non-uniqueness property of the state model. **06**

c) Obtain the state space representation in Diagonal (Jordon canonical) form for the following system. **08**

$$\dddot{y} + 9\ddot{y} + 23\dot{y} + 15y = \ddot{u} - 2\dot{u} + 4u$$

UNIT - II

2 a) Given the state model of a system, **10**

$$\dot{X}(t) = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix} X(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U(t) \text{ and}$$

$$Y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} X(t) \text{ and initial condition, } X(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}.$$

Determine (i) The State Transition matrix using Cayley Hamilton method
(ii) The solution X(t) and the output Y(t) for a unit step input (iii) Inverse State Transition matrix

b) Consider the homogeneous equation, **10**

$\dot{X}(t) = A\,X(t),$ where A is a 3 x 3 matrix.

$$X(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \\ 2e^{-t} \end{bmatrix} \text{ when } X(0) = \begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix} \text{ and}$$

$$X(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \\ 0 \end{bmatrix} \text{ when } X(0) = \begin{bmatrix} 1 \\ -2 \\ 0 \end{bmatrix} \text{ and}$$

$$X(t) = \begin{bmatrix} 2e^{-3t} \\ -6e^{-3t} \\ 0 \end{bmatrix} \text{ when } X(0) = \begin{bmatrix} 2 \\ -6 \\ 0 \end{bmatrix}.$$

(i) Determine the system matrix A
(ii) Find the State Transition matrix using Laplace transform method

UNIT - III

3 a) Check the controllability and observability using Gilbert's method for the following system **10**

$$A=\begin{bmatrix}0 & 0 & 0\\ 1 & 0 & -3\\ 0 & 1 & -4\end{bmatrix}\quad B=\begin{bmatrix}40\\ 10\\ 0\end{bmatrix}\quad C=\begin{bmatrix}0 & 0 & 1\end{bmatrix}$$

b) Write the state equations of the system shown in the Fig. 1 and determine is state controllability and observability. **10**

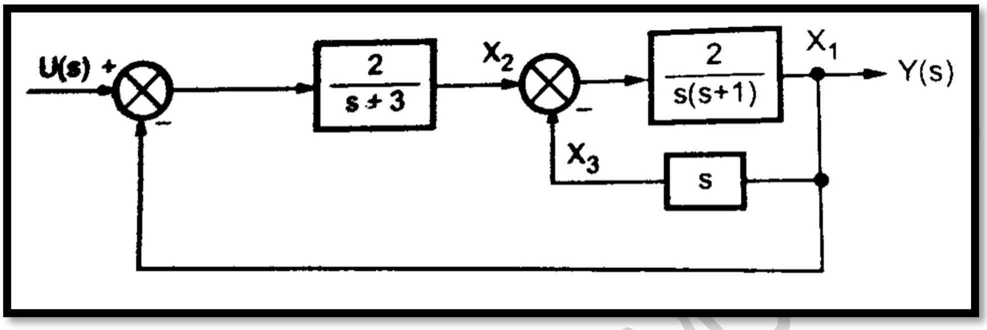

Fig. 1

OR

4 a) Check the controllability and observability using Kalman's method for the following system **10**

$$A=\begin{bmatrix}0 & 0 & 0\\ 1 & 0 & -3\\ 0 & 1 & -4\end{bmatrix}\quad B=\begin{bmatrix}40\\ 10\\ 0\end{bmatrix}\quad C=\begin{bmatrix}0 & 0 & 1\end{bmatrix}$$

b) Use controllability and observability matrices to determine whether the system represented by the signal flow graph shown in Fig. 2 is completely controllable and completely observable or not. **10**

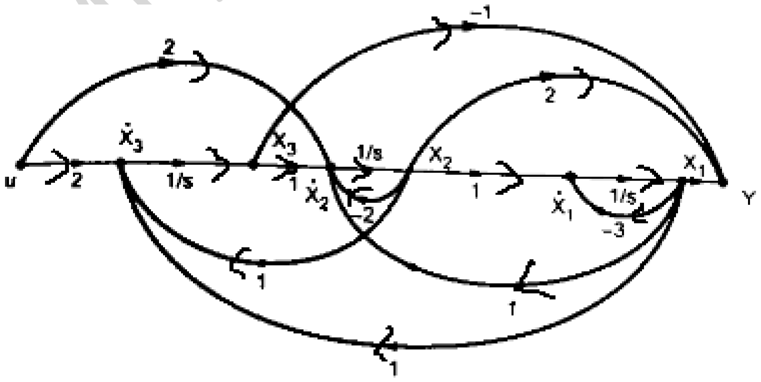

Fig. 2

UNIT - IV

5 a) Consider the system described by the state model, $\dot{x}$=Ax, y = Cx where **07**

$$A=\begin{bmatrix} 0 & 1 \\ -15 & -8 \end{bmatrix}, C = [1 \quad 0]$$

The desired eigen values for the observer matrix are s = -8, s = -9. Determine the observer gain matrix using Direct Substitution method

b) Consider the system represented by, **07**

$\dot{X}$ = A * X(t) + B* U(t)

$$A=\begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & 0 \end{bmatrix} \quad B=\begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} \text{ and } C = [0 \quad 0 \quad 1]$$

Design a full order state observer using Ackermann's formula so that the eigen values are at s = (-3 ±j1) and s = -4.

c) Discuss the dual problem concept with reference to state observers. Also, discuss the necessary and sufficient condition for state observation. **06**

UNIT - V

6 a) With reference to non-linear system explain the following **10**

i) Jump Resonance ii) Limit cycle

b) Using isoclines method, draw the phase trajectory for the system, **10**

$\frac{d^2x}{dt^2} + \frac{dx}{dt} + x = 0$ with x = 6 and $\frac{dx}{dt} = 0$ as initial condition.

OR

7 a) What is singular point? How the singular points are classified. Sketch phase portraits of systems with various types of singular points. **10**

b) Discuss the common physical non-linearities of a system. **10**

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