

USN

--	--	--	--	--	--	--	--	--	--

10EE55

Fifth Semester B.E. Degree Examination, Aug./Sept.2020

### Modern Control Theory

Time: 3 hrs.

Max. Marks:100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

#### PART - A

- 1 a. Compare modern control theory with conventional control theory. (05 Marks)
- b. Differential equation of dynamic system is  $\ddot{c}_1 + \dot{c}_1 + 3c_1 - 5c_2 = r_1$ ,  $\ddot{c}_2 + 2c_1 + c_2 = r_2$ . Write state and output equation. (07 Marks)
- 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 a suitable signal flow graph and obtain the state model. (08 Marks)

- 2 a. Obtain the state model in canonical form for the system described by the differential equation and write the block diagram  $\ddot{y} + 6\dot{y} + 11y = \ddot{u} + 8\dot{u} + 17u + 8u$ . (10 Marks)
- b. A system is described by the following set of equations. Develop a block diagram for the system showing the transfer functions between different inputs and outputs.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad (10 \text{ Marks})$$

- 3 a. Find the transformation matrix 'p' that transforms the matrix 'A' into diagonal or Jordan form where  $A = \begin{bmatrix} 4 & 1 & -2 \\ 1 & 0 & 2 \\ 1 & -1 & 3 \end{bmatrix}$ . (10 Marks)

- b. What is state transition matrix? For  $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$  compute the state transition matrix  $e^{At}$  using Caley-Harmilton theorem. (10 Marks)

- 4 a. Determine the complete time response of the system given by  $\dot{X}(t) = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix} X(t)$  where

$$X(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \quad \text{and} \quad Y(t) = [1 \quad -1]X(t). \quad (10 \text{ Marks})$$

- b. Define controllability and observability and also write the condition for complete controllability and observability in the S-plane. (04 Marks)
- c. Evaluate the controllability and observability of the following state model using Kalman's test.

$$A = \begin{bmatrix} -2 & 1 \\ 1 & -2 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \quad C = [1 \quad -1] \quad (06 \text{ Marks})$$

**PART - B**

- 5 a. Describe the different methods for evolution of state feedback gain matrix 'K'. (10 Marks)  
 b. It is desired to place the closed loop poles of the following system at  $s = -3$  and  $s = -4$  by a state feedback controller with the control  $u = -Kx$ . Determine the state feedback gain matrix K and the control signal. Use transformation matrix (T) method.

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u \text{ and } y = [1 \ 0]x \quad (10 \text{ Marks})$$

- 6 a. Consider the system described by the state model  $\dot{x} = Ax$ ,  $y = Cx$  where  $A = \begin{bmatrix} -1 & 1 \\ 1 & 2 \end{bmatrix}$ ,  $C = [1 \ 0]$ . Design a full order state observer. The desired eigen values for the observer matrix are  $u_1 = -5$ ,  $u_2 = -5$ . Use direct substitution method. (12 Marks)  
 b. Mention the different types of inherent nonlinearities and explain Dead zone with suitable examples. (08 Marks)
- 7 a. What is singular point? Explain the different types of singular points in a non-linear control system based on the location of eigen values of the system. (10 Marks)  
 b. What is a phase plot? Describe delta method of drawing phase plane trajectories. (10 Marks)
- 8 a. Use Krasovskii's theorem to show that the equilibrium state  $x = 0$  of the system described by  $\dot{x}_1 = -3x_1 + x_2$ ,  $\dot{x}_2 = x_1 - x_2 - x_2^3$  is asymptotically stable in the large. (08 Marks)  
 b. Explain with an example:  
 (i) Liapunov main stability theorem  
 (ii) Liapunov second method  
 (iii) Krasovskii's theorem (12 Marks)

\*\*\*\*\*