Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

ME - SEMESTER– II(New course) • EXAMINATION (Remedial) – WINTER- 2015

Subject Code: 2720714 **Date: 08/12/2015**

Subject Name: MODERN CONTROL SYSTEMS

Time:2:30 pm to 5:00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Define and discuss the concept of state, state variables, state vector, state space and state equations. **07**

(b) Discuss the following nonlinearities 1. Saturation 2. Relay 3. Dead Zone **07**

Q.2 **(a)** Obtain the transfer function of the system defined by **07**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

(b) Consider the following transfer function system: **07**

$$\frac{Y(s)}{U(s)} = \frac{s+6}{s^2+5s+6}$$

Obtain the state space representation of this system in (a) Controllable canonical form and (b) Observable canonical form (c) Jordan canonical form

OR

(b) Compute $\emptyset(t)$ of the following matrix. Obtain also the inverse of the stat-transition matrix $\emptyset^{-1}(t)$, $\begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ **07**

Q.3 **(a)** Show that the following system is not completely observable: **07**

$\dot{x} = Ax + Bu$

$y = Cx$

Where,

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}, \quad A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, \quad C = \begin{bmatrix} 4 & 5 & 1 \end{bmatrix}$$

(b) Derive the condition for checking the Controllability for a given system. **07**

OR

Q.3 **(a)** Prove that the Eigen values are invariant under a linear transformation. **07**

(b) Is the following system completely state controllable? **07**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Q.4 **(a)** Explain the variable gradient method for the determination of Liapunov function. **07**

(b) Obtain the time response of the following system : **07**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

Where u(t) is the unit step function occuring at t=0 or, $u(t) = 1(t)$

OR

Q.4	**(a)**	Define the Sylvesterôs criterion for checking the definiteness and also check the definiteness of the following functions $V(x) = x_1^2 + 2x_2^2$ $V(x) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$	**07**
	(b)	Consider the system $\dot{x} = Ax + Bu$ $y = Cx$ where, $A = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix},$ design a full order state observer, assume that the desired eigenvalues of the observer matrix are $\lambda_1 = -10, \lambda_2 = -10$	**07**
Q.5	**(a)**	Design a state feedback controller gain using pole placement technique for the system given by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u$ The desired pole locations of the closed loop system are s = -3 and s = -5	**07**
	(b)	What is the pole placement? Derive the equation for Matrix K using Ackermannôs formula.	**07**

OR

Q.5	**(a)**	Explain design of control system with observers. Briefly discuss both Configurations i.e. observer controller in feed forward path and in feedback path.	**07**
	(b)	The plant is given by $\dot{x} = Ax + Bu$ where, $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$. The system uses the state feedback control u=-kx, the closed loop poles at s=-2+j4, s=-2-j4, s=-10. Determine the state feedback gain matrix K.	**07**

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