

**GUJARAT TECHNOLOGICAL UNIVERSITY****BE- SEMESTER-VI (NEW) EXAMINATION – WINTER 2024****Subject Code:3161707****Date:05-12-2024****Subject Name:Control System Design****Time:02:30 PM TO 05:00 PM****Total Marks:70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Simple and non-programmable scientific calculators are allowed.

		<b>Marks</b>
<b>Q.1</b>	(a) Define the following terms: (i) Controllability (ii) Observability	<b>03</b>
	(b) Derive the state space model of series RLC circuit.	<b>04</b>
	(c) Explain Robust PID controller design in detail.	<b>07</b>
<b>Q.2</b>	(a) List the properties of state transition matrix.	<b>03</b>
	(b) Write the steps to design lag compensator in frequency domain.	<b>04</b>
	(c) Obtain the state space model of field controlled DC motor.	<b>07</b>
<b>OR</b>		
(c)	Obtain the time response of the system described by $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ -1 \end{bmatrix} u$ with the initial conditions $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ , $y = [0 \ 1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$	<b>07</b>
<b>Q.3</b>	(a) Find the dimensions of the system matrix, input matrix, output matrix and feedforward matrix for the system having three state variables, two input variables and one output variable.	<b>03</b>
	(b) Derive the equation to obtain the transfer function from the state space model.	<b>04</b>
	(c) Explain Linear Quadratic Regulator for optimal control.	<b>07</b>
<b>OR</b>		
<b>Q.3</b>	(a) Define the following terms: (i) state (ii) state vector (iii) state space	<b>03</b>
	(b) Obtain the diagonal canonical form for the system having following transfer function	<b>04</b>
	$\frac{C(s)}{R(s)} = \frac{(s + 3)}{(s + 1)^2(s + 2)}$	
(c)	Describe the procedure to design a full-state feedback controller.	<b>07</b>
<b>Q.4</b>	(a) State the procedure to check observability of a system in state space.	<b>03</b>
	(b) Explain need of compensation and types of compensation.	<b>04</b>

- (c) A unity feedback system with the forward transfer function  $G(s) = \frac{K}{s(s+7)}$  is operating with a closed-loop step response that has 15% overshoot. Evaluate the settling time and Design a lead compensator to decrease the settling time by three times. Choose the compensator's zero to be at -10. 07

**OR**

- Q.4** (a) Draw the pole- zero diagram of lead compensator and lag compensator in s-plane. 03

- (b) Consider the system given by  $\dot{x} = \begin{bmatrix} -2 & 0 \\ d & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$  and  $y = [0 \ 1]x$ . Determine the condition of controllability for this system. 04

- (c) Consider the system given by  $G(s) = \frac{1}{s(s+1)(0.5s+1)}$ . Design a lag compensator such that static velocity error constant  $K_v$  is  $5 \text{ sec}^{-1}$ , the phase margin is at least  $40^\circ$  and the gain margin is at least 10 dB. 07

- Q.5** (a) What is the goal of robust system design? When any control system is said to be a robust system? 03

- (b) Draw an electrical network realizing lead compensator. Also derive its transfer function. 04

- (c) Consider the second order system given by  $\dot{x} = \begin{bmatrix} 2 & 3 \\ -1 & 4 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$  and  $y = [1 \ 0]x$ . Design the state observer for the given system such that  $\zeta = 0.8$  and  $\omega_n = 10 \frac{\text{rad}}{\text{sec}}$ . 07

**OR**

- Q.5** (a) What are the considerations that are to be kept in mind while designing the robust control system? 03

- (b) Consider the system having  $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_0 & -a_1 & -a_2 \end{bmatrix}$  and  $C = [1 \ 0 \ 0]$ . Determine the observability of this system. 04

- (c) With the help of illustrative bode diagram, discuss the basic characteristics of lead compensator. 07

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