Seat No.: _____   Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY
BE - SEMESTER–VI (NEW) EXAMINATION – SUMMER 2022
Subject Code:3161707   **Date:10/06/2022**
Subject Name:Control System Design
Time:10:30 AM TO 01:00 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.**

			MARKS
Q.1	**(a)**	Give the comparison of lead compensation and lag compensation.	**03**
	(b)	What is state observer?	**04**
	(c)	Explain Robust PID controller design in detail.	**07**
Q.2	**(a)**	Derive the transfer function of series RLC circuit excited with DC source. Consider capacitor voltage as output	**03**
	(b)	Derive the state space model of series RLC circuit excited with DC source. Consider capacitor voltage as output	**04**
	(c)	Write the steps to design lag compensator in frequency domain.	**07**

OR

	(c)	Explain phase lead compensator design in detail for time domain.	**07**
Q.3	**(a)**	State the procedure to check controllability of a system in state space.	**03**
	(b)	State the procedure to check observability of a system in state space.	**04**
	(c)	Explain the design of state observer in detail.	**07**

OR

Q.3	**(a)**	Prove that the eigen values are the roots of the characteristic equation.	**03**
	(b)	How can we convert state space model in transfer function?	**04**
	(c)	Solve the state space equation $\dot{x} = Ax + Bu$ for x.	**07**
Q.4	**(a)**	What is state transition matrix?	**03**
	(b)	What are the parameters that are used to analyze the robustness of control systems? Describe in brief.	**04**
	(c)	Discuss design steps for pole placement using Ackerman's formula.	**07**

OR

Q.4	**(a)**	What is gain margin and phase margin?	**03**
	(b)	Explain need of linear quadratic regulator and state Riccatti equation.	**04**

	(c)	Consider the system, $\frac{y(s)}{u(s)} = \frac{K}{s^2}$. Design cascade lead compensator with root locus technique to meet the following requirements:
		   i. Settling time $<= 4$ sec
		   ii. Peak overshoot $<= 20\%$
			07

Q.5	**(a)**	Find controllable and observable canonical form for the system with transfer function $\frac{y(s)}{u(s)} = \frac{10}{s(s+2)}$.	**03**
	(b)	Find Eigen value for the state space system $\dot{x} = Ax + Bu$ with matrix $A = \begin{pmatrix} 0 & 1 \\ 2 & 4 \end{pmatrix}$	**04**
	(c)	Consider the system $G(s) = \frac{K}{s(s+2)}$. Design cascade lag compensator so that the closed loop system has	**07**

      i.   Phase margin >=60
      ii.   Velocity constant k_v >=10.

OR

Q.5 (a) Discuss how the desired closed loop poles can be found from the given specifications in time domain i.e. from given peak overshoot and settling time.   **03**

(b) Find the state feedback controller gain K for the state space system, $\dot{x} = Ax + Bu$, where   **04**

$$A = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{pmatrix}, \ B = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \text{ and the desired closed loop poles}$$

are $-2 \mp 4j, \ -10$.

(c) Find the optimal controller(LQR) gain K for the system, $\dot{x} = Ax + Bu$, where   **07**

$$A = \begin{pmatrix} 0 & 1 \\ 0 & -1 \end{pmatrix}, \ B = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \text{ and the cost function/performance index } J =$$

$\int_0^\infty (x'Qx + u'Ru)dt, \quad where \ Q = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}, \quad and \ R = 1.$

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