Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– VI (NEW) EXAMINATION – WINTER 2021

Subject Code:3161707 Date:04/12/2021

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 comparision of lead compensation and lag compensation.	**03**
	(b)	Realize the lead-lag compensation with RC network and also derive its transfer function.	**04**
	(c)	Write the steps to design lag compensator in frequency domain.	**07**
Q.2	**(a)**	Compare state space method and conventional method.	**03**
	(b)	Explain Ricatti equation	**04**
	(c)	Obtain the time response of the following system $\begin{bmatrix}\dot{x_1}\\ \dot{x_2}\end{bmatrix} = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ 1\end{bmatrix}u$ where u(t) is a unit step occurring at t = 0 and $x^T(0)$ = [1 0].	**07**
		OR	
	(c)	With suitable example, discuss about the robust PID controller	**07**
Q.3	**(a)**	Check the observability of the given system using Kalman's test. $\begin{bmatrix}\dot{x_1}\\ \dot{x_2}\\ \dot{x_3}\end{bmatrix} = \begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u$ $y = \begin{bmatrix}3 & 4 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$	**03**
	(b)	Obtain state model of field controlled DC servomotor. Choose θ, $\dot{\theta}$ and i_f as state variables.	**04**
	(c)	Design a phase lead compensation network in frequency domain for a system having open-loop transfer function $G(s)H(s) = \frac{K}{s^2(1 + 0.05s)}$ The system have acceleration error co-efficient=100 sec^{-2} for the phase margin of 20^o	**07**
		OR	
Q.3	**(a)**	List the properties of state transition matrix.	**03**
	(b)	Consider the system $\frac{Y(s)}{U(s)} = \frac{s+3}{s^2+3s+2}$ Obtain controllable canonical form, observable canonical form and diagonal canonical form.	**04**
	(c)	For a certain system	**07**

$$G(s) = \frac{0.025}{s\,(1 + 0.5s)(1 + 0.05s)}$$

design a suitable lag compensator to give velocity error constant = 20 sec^{-1} , phase margin = 40^o

Q.4 **(a)** What is the goal of robust system design? When any control system is said to be a robust system? **03**

(b) What are the parameters that are used to analyze the robustness of control systems? Describe in brief. **04**

(c) Design a suitable lead compensator for a system with unity feedback and having a open loop transfer function **07**

$$G(s) = \frac{K}{s\,(s + 2)}$$

to meet the specification: Damping ratio ζ = 0.5, undamped natural frequency ω_n = 4 rad/sec.

OR

Q.4 **(a)** Find f(A) = A^{10} using Cayley Hamiltom technique for **03**

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$$

(b) Write a short note on full state observer design. **04**

(c) Design a lag compensator using root locus for a system with open loop transfer function **07**

$$G(s) = \frac{k}{s(s + 2)(s + 8)}$$

to meet the following specifications

(i) Damping ratio = 0.5 (ii) = Settling time = 5 (iii) velocity error > 5

Q.5 **(a)** Explain in brief Linear Quadratic Regulator. **03**

(b) What are the considerations that are to be kept in mind while designing the robust control system? **04**

(c) Discuss about the various uncertainties in parameter variation and method to evaluate it with example for robust control system design. **07**

OR

Q.5 **(a)** Obtain the state space model of series RLC circuit. **03**

(b) Determine the transfer function for the system whose state model is given by **04**

$$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

and

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

(c) Write a short note on optimal control. **07**

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