Seat No.: _____ Enrolment No._____

# GUJARAT TECHNOLOGICAL UNIVERSITY

**BE - SEMESTER–VI (NEW) EXAMINATION – WINTER 2023**

**Subject Code:3161707 Date:13-12-2023**

**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.**

| | | | MARKS |
|---|---|---|---|
| **Q.1** | **(a)** | Explain the procedure to determine the location of closed loop dominant poles from the given values of peak overshoot and settling time. | **03** |
| | **(b)** | Define state transition matrix and explain how it can be determined using Laplace transform method. | **04** |
| | **(c)** | Explain the procedural steps for designing a phase lag compensator in time domain. | **07** |
| **Q.2** | **(a)** | Draw the pole- zero diagram of lead compensator and lag compensator on s-plane. | **03** |
| | **(b)** | Draw an electrical network of lag compensator and also derive its transfer function. | **04** |
| | **(c)** | With the help of illustrative bode diagram, discuss the basic characteristics of lead compensator. | **07** |
| | | **OR** | |
| | **(c)** | The open loop transfer function of a system is given by $$G(s) = \frac{1}{s(s+1)(0.5s+1)}$$ Design a suitable compensator using frequency domain technique so that (1) $k_v >= 5sec^{-1}$ (2) PM >= 40˚ and (3) GM>=10 dB | **07** |
| **Q.3** | **(a)** | Define linear dependence and independence of vectors. | **03** |
| | **(b)** | Define controllability and observability with suitable example. | **04** |
| | **(c)** | State Caley-Hamilton theorem and explain how it can be used to determine the state transition matrix. | **07** |
| | | **OR** | |
| **Q.3** | **(a)** | Derive the equation for obtaining transfer function from a given state model. | **03** |
| | **(b)** | Determine the controllability of a state space model given by $\begin{bmatrix}\dot{x_1}\\ \dot{x_2}\end{bmatrix}=\begin{bmatrix}-3 & 1\\ -4 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}1\\ 0\end{bmatrix}u(t)$ | **04** |
| | **(c)** | Explain diagonalization method for determining state transition matrix. | **07** |
| **Q.4** | **(a)** | Briefly explain observable canonical form. | **03** |
| | **(b)** | Explain the concept of lag compensator using root locus technique. | **04** |
| | **(c)** | A system is represented by the equations given below: | **07** |

$$\begin{bmatrix}\dot{x_1}\\ \dot{x_2}\end{bmatrix}=\begin{bmatrix}0 & 1\\ -4 & -5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}u(t)$$

Given that $\boldsymbol{x}(0) = [1 \quad 1]^T$

Determine (A) zero input response (B) zero state response for unit step input and (C) total response

**OR**

| | | | |
|---|---|---|---|
| **Q.4** | **(a)** | Briefly explain controllable canonical form in state space. | **03** |
| | **(b)** | Briefly explain the steps for designing phase lead compensator in frequency domain. | **04** |
| | **(c)** | Apply parallel decomposition method and determine corresponding state model for the transfer function given below: $$G(s) = \frac{s+7}{s^3+9s^2+26s+24}$$ | **07** |
| **Q.5** | **(a)** | Briefly explain the concept of optimal control system. | **03** |
| | **(b)** | Briefly explain the concept of robust control system. | **04** |
| | **(c)** | State and derive Ackerman's formula for determining state feedback gain matrix K. | **07** |

**OR**

| | | | |
|---|---|---|---|
| **Q.5** | **(a)** | Explain the use of observer in state feedback control system. | **03** |
| | **(b)** | Briefly describe the parameters used to analyse robustness of control system. | **04** |
| | **(c)** | Explain the design of Linear Quadratic Regulator | **07** |

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