

Enrollment No./Seat No.:

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering - SEMESTER - VI EXAMINATION - WINTER 2025

Subject Code: 3161707

Date: 25-11-2025

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) Define compensation and discuss types of compensations.	03
(b) Draw and explain MIMO state space model.	04
(c) Discuss the robust control approach for systems with uncertain parameters,	07
Q.2 (a) Draw lead compensating network and derive its transfer function.	03
(b) Define state transition matrix and derive its equation.	04
(c) Derive state space model of RLC series network. Consider capacitor voltage as output voltage.	07
OR	
(c) Derive state space model of armature controlled DC motor. Consider angular position as output.	07
Q.3 (a) Formulate optimal control problem for the autonomous system.	03
(b) Define the concepts of controllability and observability in control systems. Describe the methods used to determine each property.	04
(c) Given the continuous-time system with state-space model: $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$ (Here “;” indicates a new row.) Design a state feedback control law $u = -Kx$ such that the closed-loop poles of the system are placed at $-2 \pm j$. Find the feedback gain matrix K that achieves the desired pole locations.	07

OR

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|--|-----------|
| (a) Discuss the role of the Riccati equation in solving optimal control problems. Derive the equation step by step and explain how it is used to obtain the optimal state feedback control law. | 03 |
| (b) Describe full state feedback control scheme with block diagram. | 04 |
| (c) Check the controllability and observability of the state space model matrix given as:
$A = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -6 & -11 & -6 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ $C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$
(Here “;” indicates a new row.) | 07 |

- Q.4 (a)** Draw the root locus with steps of the open loop system $G(s)=K/s^2$. **03**
- (b)** For the system in Q.4(a), design a suitable compensator such that the following performance specifications are satisfied: **04**
- Settling time $t_s \leq 4$ seconds
 - Peak overshoot $M_p \leq 20\%$
 - Acceleration error constant $K_a \geq 2$
- (c)** For the compensator selected in Q.4(b), design the locations of its poles and zeros as well as determine the compensator gain so that the system meets the specified performance criteria. **07**

OR

- (a)** Draw the magnitude plot for the transfer function $G(s)=K/s(s+2)$ with $K_v=20$. **03**
- (b)** For the system in OR Q.4(a), draw phase plot and find the phase margin. **04**
- (c)** Design phase-lag compensation for the system given OR Q.4(a) such that phase margin $=45$. **07**
- Q.5 (a)** Explain system sensitivities to parameter perturbations. **03**
- (b)** Explain steps of Lead compensation design for the frequency response. **04**
- (c)** Explain observer design approach. **07**

OR

- (a)** Describe design of robust PID controllers. **03**
- (b)** Draw the frequency response of the lag compensation design and explain it. **04**
- (c)** Describe full state feedback design approach with block diagram. **07**
