VIT
Vellore Institute of Technology

Reg. No.: 22BPS1059

## Final Assessment Test(FAT) - Nov/Dec 2024

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|---|---|---|---|
| Programme | **B.Tech.** | Semester | **Fall Semester 2024-25** |
| Course Code | **BEEE303L** | Faculty Name | **Prof. Nithya Venkatesan** |
| Course Title | **Control Systems** | Slot | **F1+TF1** |
| | | Class Nbr | **CH2024250101910** |
| Time | **3 hours** | Max. Marks | **100** |

**General Instructions**

- Write only Register Number in the Question Paper where space is provided (right-side at the top) & do not write any other details.

**Course Outcomes**

1. Formulate mathematical models of the physical systems.
2. Analyze the system performance in time and frequency domains.
3. Determine the stability of linear time invariant system in time and frequency domains.
4. Design compensators and controllers to meet the performance specifications.
5. Perform state space analysis and design state feedback control.

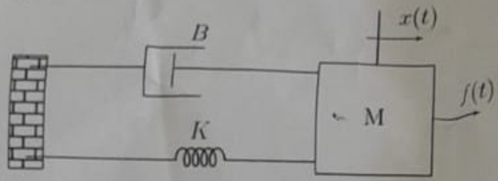
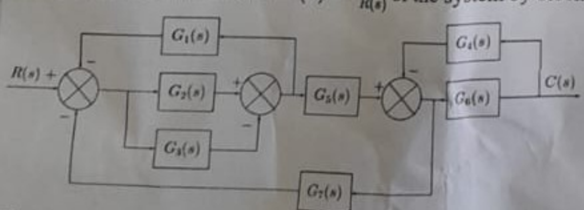
### Section - I
**Answer all Questions (2 × 15 Marks)**

*M - Marks

| Q.No | Question | *M | CO | BL |
|---|---|---|---|---|
| 01. | Consider the unity feedback control system with the open loop transfer function. $$G(s) = \frac{K}{s\,(s^2+3s+9)}$$ Determine the value of gain K such that the phase margin is $45^0$ using bode plot. What is the gain margin with this gain K? Comment on the relative stability. | 15 | 2,3 | 3 |
| 02. | Consider the unity feedback system having an open loop transfer function. $$G(s) = \frac{K(1+5\,s)}{s^2\,(1+2s)(1+4s)}$$ Sketch the Polar plot and determine the value of K so that<br>a). Gain Margin is 20 db [8]<br>b). Phase margin is $15^{\,0}$ [7] | 15 | 3,4 | 3 |

## Section - II
**Answer all Questions (5 × 10 Marks)**

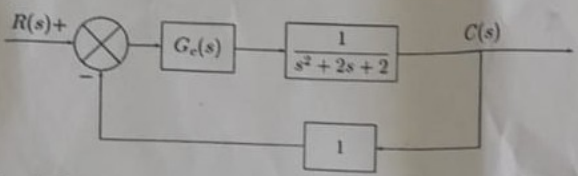
*M - Marks

| Q.No | Question | *M | CO | BL |
|---|---|---|---|---|
| 03. | A mechanical translational system is shown in Fig. 1 with input being the force $f(t)$ and output being the velocity $v(t)$ of the system.<br>(a) Obtain the transfer function and the state space representation of the system. [8]<br>(b) Draw the electrical analogy (Force-Voltage) of the system with velocity v(t) as the output. [2]<br><br>**Fig. 1.** Mechanical Translational System | 10 | 1,5 | 3 |
| 04. | A unity feedback system has the forward transfer function<br>$G(s) = \frac{1000(s+8)}{(s+7)(s+9)}$<br>(a) Find the steady state error in the response for the input $5u(t)$. [8]<br>(b) Will there be an error in the steady state for unit ramp input? Justify your answer. [2] | 10 | 2 | 4 |
| 05. | A linear time invariant system with $r(t)$ as the input and $c(t)$ as the output is represented by the differential equation<br>$\frac{d^4c(t)}{dt^4} - \frac{d^3c(t)}{dt^3} - \frac{d^2c(t)}{dt^2} - \frac{dc(t)}{dt} - 2c(t) = r(t)$<br>(a) Form the Routh table and identify the number of poles on the right half, left half and imaginary axis of the s-plane. [8]<br>(b) Comment on the stability of the system. If appropriate, find the frequency of oscillation of the system. [2] | 10 | 3 | 4 |
| 6. | An interconnected system is represented by means of a block diagram as shown in Fig. 2.<br>(a) Obtain the transfer function $T(s) = \frac{C(s)}{R(s)}$ of the system by block diagram reduction.<br><br>**Fig. 2.** Interconnected System | 10 | 1 | 3 |
| | The state space representation of a system is given below.<br>$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -3 & -6 & -9 \\ 0 & -4 & 1 \\ 1 & 0 & -8 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 2 \\ 0 \\ 3 \end{bmatrix} u$<br>$y = \begin{bmatrix} 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$<br>Comment on the stability, controllability and observability of the system. | 10 | 5 | 3 |

## Section - III

### Answer all Questions (1 × 20 Marks)

*M - Marks

| Q.No | Question | *M | CO | BL |
|---|---|---|---|---|
| 08. | A feedback control system with an ideal compensator $G_c(s)$ in cascade is shown in Fig. 3.<br>The step response of the system has a percentage overshoot of $e^{\left(\frac{-\zeta\pi}{\sqrt{(1-\zeta^2)}}\right)} \times 100$.<br>(a) Sketch the exact root locus of the system with $G_c(s) = K$. Clearly indicate the breakaway point, asymptotes and $j\omega$-axis crossing if any. [5]<br>(b) If $G_c(s) = K$, find the proportional gain K to yield 25% overshoot in the system. [5]<br>(c) Design a proportional - integral controller for the system and show that the steady state error of the system is zero. [5]<br>(d) Design a proportional - derivative controller for the system to reduce the settling time to half of the uncompensated system but maintain 25% overshoot. [5]<br><br><br>Fig. 3. Control System with Controller. | 20 | 4 | 3 |

**BL-Bloom's Taxonomy Levels - (1.Remembering, 2.Understanding, 3.Applying, 4.Analysing, 5.Evaluating, 6.Creating)**

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