**Q. Code:755083**

**Reg. No.** | | | | | | | | | | | | | |

# B.E./B.TECH. DEGREE EXAMINATIONS, MAY 2024

Fourth Semester

## EE22402 – CONTROL SYSTEMS

*(Electrical and Electronics Engineering)*

**(Regulation 2022)**

**TIME: 3 HOURS** **MAX. MARKS: 100**

| COURSE OUTCOMES | STATEMENT | RBT LEVEL |
|---|---|---|
| **CO 1** | Derive transfer functions for electrical and mechanical systems. | **4** |
| **CO 2** | Analyze the root locus for a transfer function and interpret time response. | **4** |
| **CO 3** | Sketch Bode and Polar plots for a transfer function and verify the stability of a system by Routh-Hurwitz and Nyquist criteria. | **4** |
| **CO 4** | Implement a Controller and Design a Compensator using Bode plot. | **4** |
| **CO 5** | Solve a physical system with state variable. | **4** |

### PART- A (20 x 2 = 40 Marks)

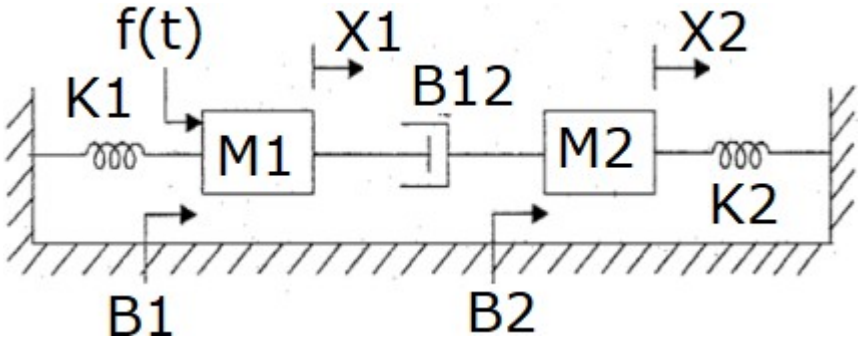
(Answer all Questions)

| | | CO | RBT LEVEL |
|---|---|---|---|
| **1.** | Write Mason's gain formula. | **1** | **2** |
| **2.** | Identify the basic components of automatic control systems? | **1** | **3** |
| **3.** | Write the analogous electrical elements in force voltage analogy for the elements of mechanical translational system. | **1** | **2** |
| **4.** | Outline the advantages of closed loop control systems. | **1** | **2** |
| **5.** | Define damping ratio. | **2** | **2** |
| **6.** | Express rise time and peak time in time domain analysis. | **2** | **2** |
| **7.** | Name the test signals used in time response analysis. | **2** | **2** |
| **8.** | Determine the type and order of the following system. $G(S) = \frac{S+4}{(3+S)(S-2)}$ . | **2** | **2** |
| **9.** | Differentiate Gain cross over frequency and Phase cross over frequency. | **3** | **4** |
| **10.** | Define Nyquist stability criterion. | **3** | **2** |
| **11.** | Write the necessary and sufficient condition for the stability in Routh Stability criterion. | **3** | **2** |
| **12.** | Compare Bode plot with Polar plot. | **3** | **4** |
| **13.** | The addition of a pole will make a system more stable. Justify your answer. | **4** | **5** |
| **14.** | What are the two situations in which compensation is required? | **4** | **3** |
| **15.** | Draw the Lag-Lead compensator network. | **4** | **2** |
| **16.** | Discuss the effect of PI controller on the system performance? | **4** | **2** |

| | | | | |
|---|---|---|---|---|
| **17.** | What are the advantages of state space representation? | **5** | **2** | |
| **18.** | Explain the sampling theorem in digital domain. | **5** | **2** | |
| **19.** | Summarize the properties of State Transition Matrix? | **5** | **2** | |
| **20.** | Write the general form of state variable matrix. | **5** | **2** | |

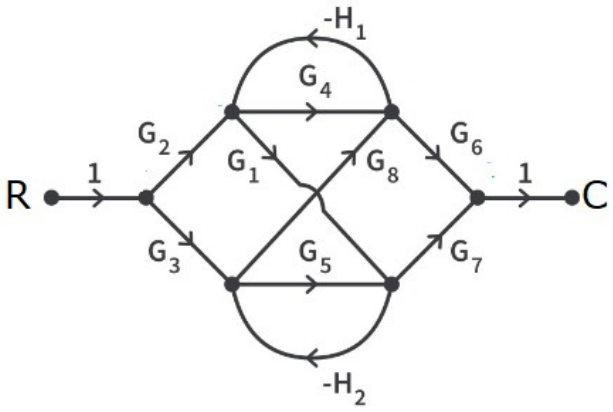
**PART- B (5 x 10 = 50 Marks)**

| | | Marks | CO | RBT LEVEL |
|---|---|---|---|---|
| **21.(a)** | Write the differential equations governing the mechanical system, and obtain the force voltage analogy network. | **(10)** | **1** | **4** |




**(OR)**

| | | | | |
|---|---|---|---|---|
| **(b)** | Using Mason's gain formula, find **C/R** of the signal flow graph shown in figure. | **(10)** | **1** | **4** |




| | | | | |
|---|---|---|---|---|
| **22.(a)** | Sketch the root locus for the open loop system given as $G(S)H(S)=\frac{K(S^2-4S+20)}{(S+2)(S+4)}$ | **(10)** | **2** | **4** |

**(OR)**

| | | | | |
|---|---|---|---|---|
| **(b)** | Derive the time response analysis of second order system for the unit step input. | **(10)** | **2** | **4** |
| **23.(a)** | Develop the bode plot for the system having the following transfer function | **(10)** | **3** | **4** |

$$G(S)H(S)=\frac{800000(S+1)}{S(S+10)(S+40)(S+100)}$$

**(OR)**

| | | | | | |
|---|---|---|---|---|---|
| **(b)** | **(i)** | Determine the range of 'K' for stability of unity feedback system using Routh stability criterion whose transfer function $\frac{C(S)}{R(S)}=\frac{K}{S(S^2+S+2)(S+2)+K}$ | **(5)** | **3** | **4** |
| | **(ii)** | Explain the various procedures for polar plot and to find the stability. | **(5)** | **3** | **4** |
| **24.(a)** | | Consider the following linear system given as below, design a state feedback controller for the desired pole locations at $S=-1, S=-2, S=-3$ $A=\begin{bmatrix}-1 & 2 & 0\\ 1 & -3 & 4\\ -1 & 1 & -9\end{bmatrix}, B=\begin{bmatrix}1\\2\\-1\end{bmatrix}, C=\begin{bmatrix}1 & 0 & 1\end{bmatrix}$ | **(10)** | **4** | **4** |

**(OR)**

| | | | | | |
|---|---|---|---|---|---|
| **(b)** | | Derive the transfer function for Lag compensator network. List the various procedures to design a Lag Compensator. | **(10)** | **4** | **4** |
| **25.(a)** | | Determine the state controllability of the system described by $\begin{bmatrix}\dot{X}_1\\ \dot{X}_2\\ \dot{X}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}\begin{bmatrix}X_1\\X_2\\X_3\end{bmatrix}+\begin{bmatrix}0\\0\\1\end{bmatrix}U$ | **(10)** | **5** | **4** |

**(OR)**

| | | | | | |
|---|---|---|---|---|---|
| **(b)** | | Obtain the transfer function of the system defined by the following state space equations. $\begin{bmatrix}\dot{X}_1\\ \dot{X}_2\\ \dot{X}_3\end{bmatrix}=\begin{bmatrix}-1 & 1 & -1\\ 0 & -2 & 1\\ 0 & 0 & -3\end{bmatrix}\begin{bmatrix}X_1\\X_2\\X_3\end{bmatrix}+\begin{bmatrix}1 & 0\\ 0 & 1\\ 1 & 0\end{bmatrix}\begin{bmatrix}U_1\\U_2\end{bmatrix}$ $\begin{bmatrix}Y_1\\Y_2\end{bmatrix}=\begin{bmatrix}1 & 1 & 1\\ 0 & 1 & 1\end{bmatrix}\begin{bmatrix}X_1\\X_2\\X_3\end{bmatrix}$ | **(10)** | **5** | **4** |

## PART- C (1 x 10 = 10 Marks)

(Q.No.26 is compulsory)

| | | Marks | CO | RBT LEVEL |
|---|---|---|---|---|
| **26.** | A discrete-time system has the transfer function $\frac{Y(Z)}{U(Z)} = \frac{4Z^3 - 12Z^2 + 13Z - 7}{(Z-1)^2(Z-2)}$ Determine the state model of the system in phase variable form. | **(10)** | **5** | **5** |

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