CBCS SCHEME

USN

18EC43

Fourth Semester B.E. Degree Examination, June/July 2025

Control Systems

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Differentiate between open loop and closed loop control system. Give one example for each. **(06 Marks)**

b. For the mechanical rotational system shown in Fig.Q1(b), find the transfer function $\frac{\theta(s)}{T(s)}$.

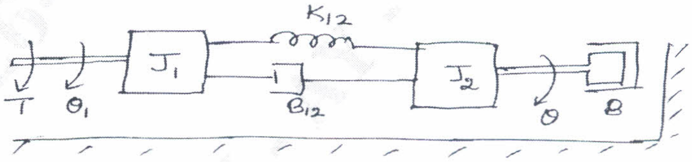

Fig.Q1(b) **(06 Marks)**

c. For the mechanical translational system shown in Fig.Q1(c), draw the F-V analogous circuit and verify by writing mesh equations.

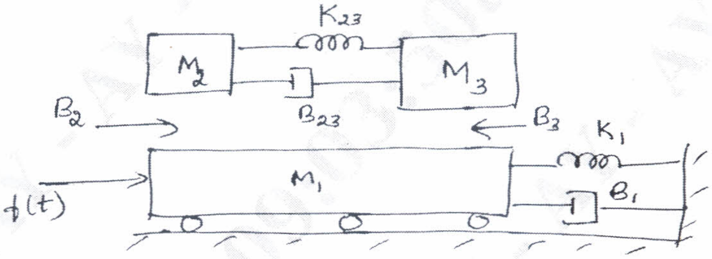

Fig.Q1(c) **(08 Marks)**

OR

2 a. For the electrical network shown in Fig.Q2(a), find the transfer function $\frac{V_0(s)}{V_i(s)}$. Assume $C_1 = 1\ \mu F$, $C_2 = 0.5\ \mu F$, $R_1 = R_2 = 1\ M\Omega$ and gain of Buffer amplifier as 1.

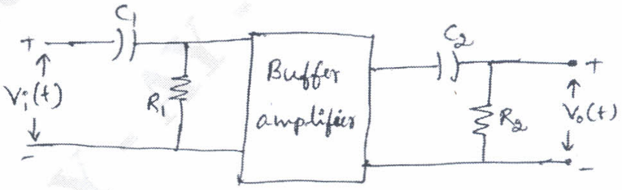

Fig.Q2(a) **(06 Marks)**

b. Write the differential equations governing the mechanical rotational system shown in Fig.Q2(b). Draw the torque-current electrical analogous circuit and verify by writing node equations.

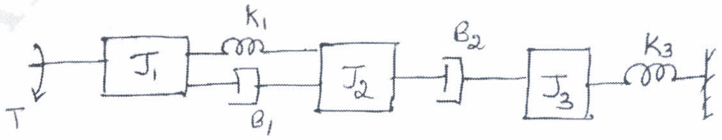

Fig.Q2(b) **(08 Marks)**

c. For the mechanical translational system shown in Fig.Q2(c), find the transfer function $\frac{X_2(s)}{F(s)}$.

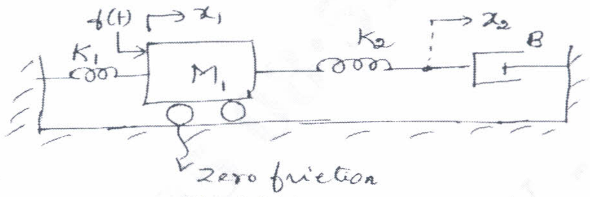

Fig.Q2(c) **(06 Marks)**

Module-2

3 a. For the block diagram shown in Fig.Q3(a), find the closed loop transfer function $\frac{C(s)}{R(s)}$ using block diagram reduction method.

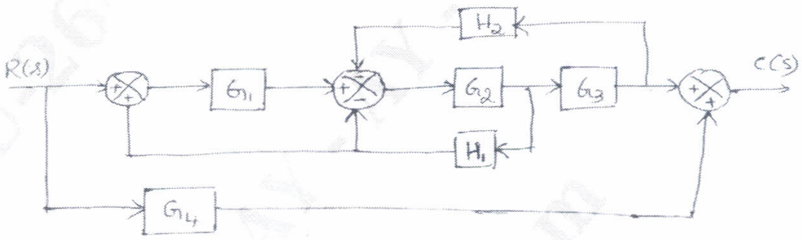

Fig.Q3(a) **(10 Marks)**

b. For the signal flow graph shown in Fig.Q3(b), find the overall gain $\frac{C(s)}{R(s)}$ using Mason's gain formula.

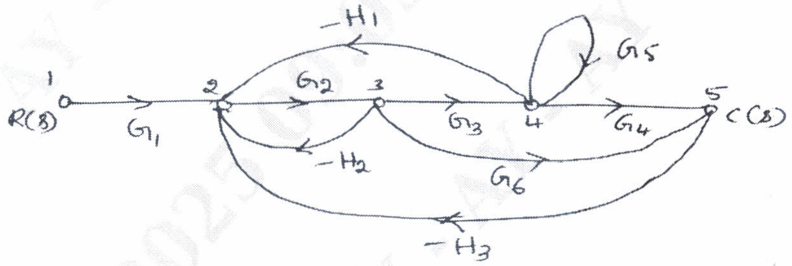

Fig.Q3(b) **(10 Marks)**

OR

4 a. Draw the block diagram for the electrical network shown in Fig.Q4(a). Also find the transfer function using block diagram reduction technique.

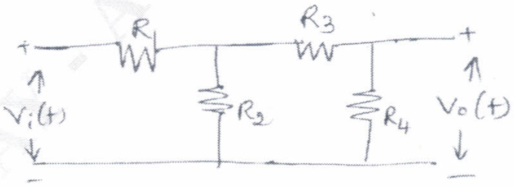

Fig.Q4(a) **(10 Marks)**

b. For the signal flow graph shown in Fig.Q4(b), find the transfer function $\frac{C(s)}{R(s)}$ using Mason's gain formula.

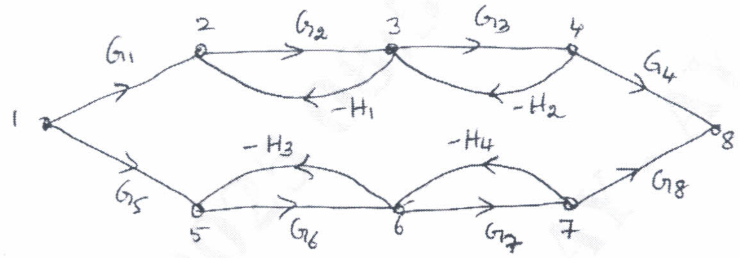

Fig.Q4(b) **(10 Marks)**

Module-3

5 a. Derive an expression for response of a critically damped system when excited by unit step input. **(06 Marks)**

b. A unity feedback system has the forward transfer function $G(s) = \frac{K(2s+1)}{s(5s+1)(1+s)^2}$ when the input is $r(t) = 1 + 6t$, determine the minimum value of K so that the steady state error is less than 0.1. **(07 Marks)**

c. The unity feedback system is characterized by an open loop transfer function $G(s) = \frac{K}{s(s+10)}$. Determine the gain K, so that the system will have a damping ratio of 0.5 for the value of K. Determine settling time, peak time and peak overshoot for a unit step input. **(07 Marks)**

OR

6 a. What is rise time? Derive the expression for rise time when excited by unit step input. **(06 Marks)**

b. For the system shown in Fig.Q6(b), determine the values of K and K_n so that the maximum overshoot is 0.2 and peak time is 1 sec for unit step response. With these values of K and K_n, find time domain specifications.

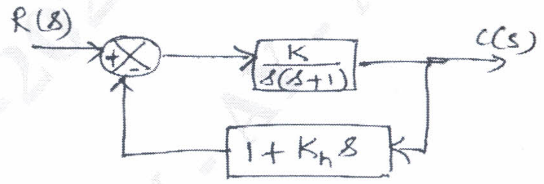

Fig.Q6(b) **(07 Marks)**

c. What are controllers? Explain PI, PID, PD controllers. **(07 Marks)**

Module-4

7 a. A unity feedback system has $G(s) = \frac{K(s+13)}{s(s+3)(s+7)}$ using Routh's criteria, calculate the range of K for which the system is (i) stable (ii) has poles located more negative than –1. **(08 Marks)**

b. A feedback control system has open loop transfer function $G(s)H(s) = \frac{K}{s(s+4)(s^2+4s+20)}$. Plot the root locus. **(12 Marks)**

OR

8 a. A feedback control system has the characteristic equation of $F(s) = s^4 + 2s^2 + 1 = 0$. Determine (i) number of roots in left half of S-plane (ii) No. of roots in right half of 8-plane (iii) No. of roots on imaginary axis. **(10 Marks)**

b. For the following transfer function, draw the Bode plot and hence find
(i) Gain margin (ii) Phase margin (iii) Gain cross over frequency
(iv) Phase crossover frequency

$$G(s) = \frac{20}{s(1+3s)(1+4s)}$$

(10 Marks)

Module-5

9 a. The open loop transfer function of a unity feedback system is given by

$$G(s) = \frac{1}{s(1+s)(1+2s)}$$

Draw the polar plot and determine the gain margin and phase margin. **(14 Marks)**

b. Explain (i) lag (ii) lead and (iii) lag-lead compensating networks. **(06 Marks)**

OR

10 a. Obtain the state model for the electrical network shown in Fig.Q10(a).

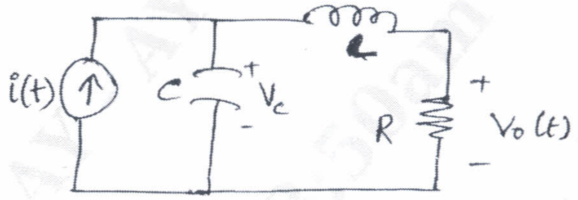

Fig.Q10(a) **(06 Marks)**

b. Consider a system having state model

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}-2 & -3\\ 4 & 2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}3\\ 5\end{bmatrix}u(t) \qquad Y = \begin{bmatrix}1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

Obtain its transfer function. **(06 Marks)**

c. Obtain the time response of the following system

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}1\\ 1\end{bmatrix}u(t)$$

Where u(t) is a unit step occurring at t = 0 and $X(0) = \begin{bmatrix}1\\ 0\end{bmatrix}$ **(08 Marks)**

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