USN | | | | | | | | | | 17EC43

Fourth Semester B.E. Degree Examination, Jan./Feb. 2023
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. Define Control System. Distinguish between open loop and closed loop control systems. **(06 Marks)**

b. Write the differential equations of performance for the mechanical system shown in Fig.Q1(b). Draw its F – V analogous circuit.

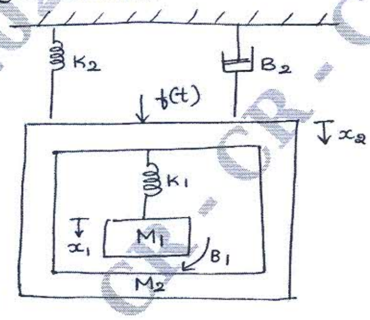

Fig.Q1(b) **(08 Marks)**

c. For the signal flow graph shown in Fig.Q1(c), determine the transfer function $\frac{C(s)}{R(s)}$ using Mason's gain formula.

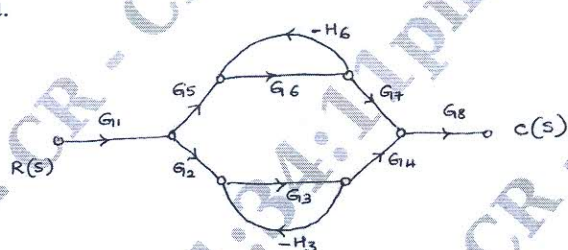

Fig.Q1(c) **(06 Marks)**

OR

2 a. Illustrate how to perform the following in connection with block diagram reduction technique.
i) Shifting – take – off point after a summing point
ii) Shifting – take – off point before a summing point
iii) Removing minor feedback loop. **(06 Marks)**

b. For the block diagram shown in Fig.Q2(b), determine the transfer function C(s)/R(s) using block diagram reduction technique.

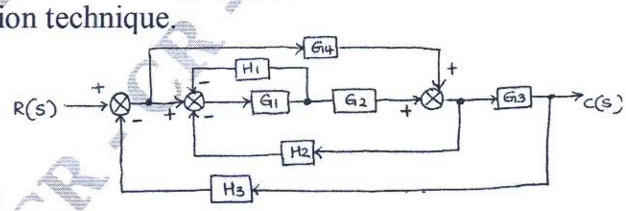

Fig.Q2(b) **(08 Marks)**

c. Obtain the transfer function $\frac{\theta_2(s)}{T(s)}$ for the system shown in Fig.Q2(c).

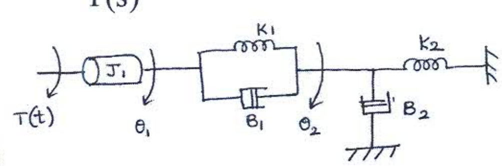

Fig.Q2(c) **(06 Marks)**

Module-2

3 a. Define the following time response specifications for an underdamped second order system :
   i) Rise time (t_r)
   ii) Peak time (t_p)
   iii) Peak overshoot (M_p)
   iv) Settling time (t_s). **(04 Marks)**

b. A system is given by differential equation :

$$\frac{d^2y(t)}{dt^2}+\frac{4dy(t)}{dt}+8y(t)=8x(t),$$

where y(t) is the output and x(t) is the input. Determine all time domain specifications for unit step input assuming 2% criterion. **(08 Marks)**

c. For a unity feedback system with $G(s)=\frac{s(s+1)}{s^2(s+3)(s+10)}$. Determine the type of the system, error co-efficient and steady state error for input $r(t)=1+3t+\frac{t^2}{2}$. **(08 Marks)**

OR

4 a. Derive an expression for c(t) of an underdamped second order system for a unit step input. **(08 Marks)**

b. The unity negative feedback system with $G(s)=\frac{K(s+\alpha)}{(s+\beta)^2}$ is to be designed to meet the following specifications. Steady state error for a unit step input = 0.1, damping ratio = 0.5, natural frequency = $\sqrt{10}$ rad/sec. Find K, α and β. **(08 Marks)**

c. Explain PID controller with the help of a block diagram. **(04 Marks)**

Module-3

5 a. State and explain Routh's stability criterion for determining the stability of the system. **(04 Marks)**

b. Determine the number of roots that are :
   i) In the right half of s-plane
   ii) On the imaginary axis
   iii) In the left half of s-plane.
   For the system with the characteristic equation : $s^6+4s^5+3s^4-16s^2-64s-48=0$. **(08 Marks)**

c. The system shown in Fig.Q5(c) oscillates with a frequency of 2 rad/sec. Find the value of 'K_{mar}' and 'P'. No poles are in RHS.

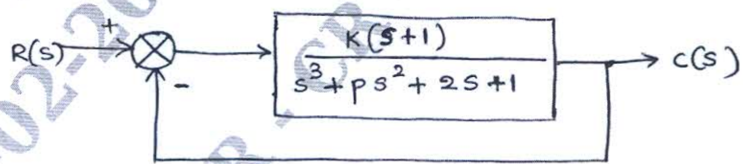

Fig.Q5(c) **(08 Marks)**

OR

6 a. Explain the following rules with respect to root locus technique :
   i) Angle of asymptotes
   ii) Point of intersection with imaginary axis
   iii) Angle of departure. **(06 Marks)**

b. The open loop transfer function of a control system is given by

$$G(s)H(s)=\frac{K}{s(s+2)(s^2+6s+25)}$$

Draw the complete root locus of the system. **(14 Marks)**

Module-4

7 a. Find the gain margin and phase margin for the negative feedback control system with an open loop transfer function :

$$G(s)H(s) = \frac{200}{s(s^2+12s+100)}.$$ **(08 Marks)**

b. Construct the Bode plot for a unity feedback control system with

$$G(s)H(s) = \frac{10(s+10)}{s(s+2)(s+5)}$$

Find its gain margin and phase margin comment on the stability. **(12 Marks)**

OR

8 a. Explain the procedure for investigating the stability using Nyquist criterion. **(06 Marks)**

b. For the system with open loop transfer function :

$$G(s)H(s) = \frac{10}{s^2(1+0.25s)(1+0.5s)}$$

Sketch the Nyquist plot and determine whether the system is stable or not? **(14 Marks)**

Module-5

9 a. Draw the block diagram of a typical system with digital controller and explain. **(06 Marks)**

b. Obtain the state model of an electrical system shown in Fig.Q9(b).

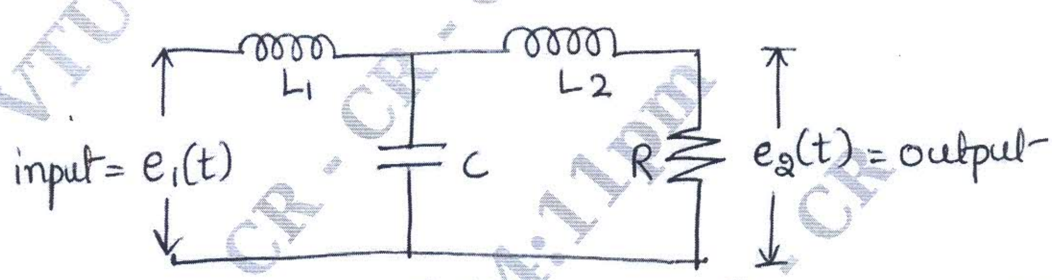

Fig.Q9(b) **(06 Marks)**

c. Find the transfer function of the system with a state model.

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} U \text{ and } y = [1\ 0]\begin{bmatrix} X_1 \\ X_2 \end{bmatrix}.$$ **(08 Marks)**

OR

10 a. State the properties of state transition matrix. **(06 Marks)**

b. Obtain the state model for the system represented by the differential equation :

$$\frac{d^3y(t)}{dt^3} + \frac{9d^2y(t)}{dt^2} + \frac{26dy(t)}{dt} + 24y(t) = 6u(t)$$ **(06 Marks)**

c. Find the state transition matrix for :

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}.$$ **(08 Marks)**

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