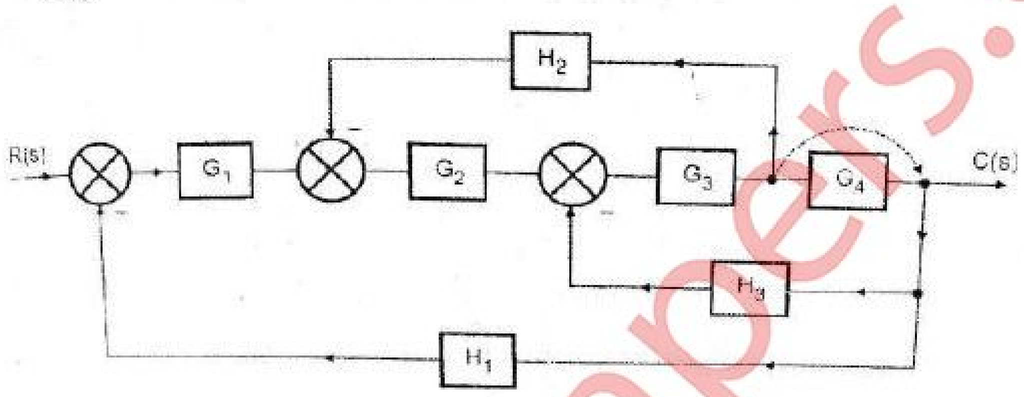
ME / sem II / Mechanical / CBCS - Choice Based / May 17
SMA

Q.P.Code: 013987

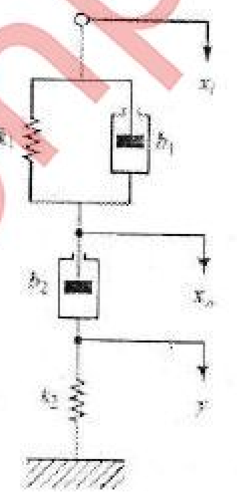
(3 HOURS) **TOTAL MARKS : 80**

Note: **1. Attempt any four Questions**
2. Figures to the right indicate full marks
3. Assumptions made should be clearly stated.

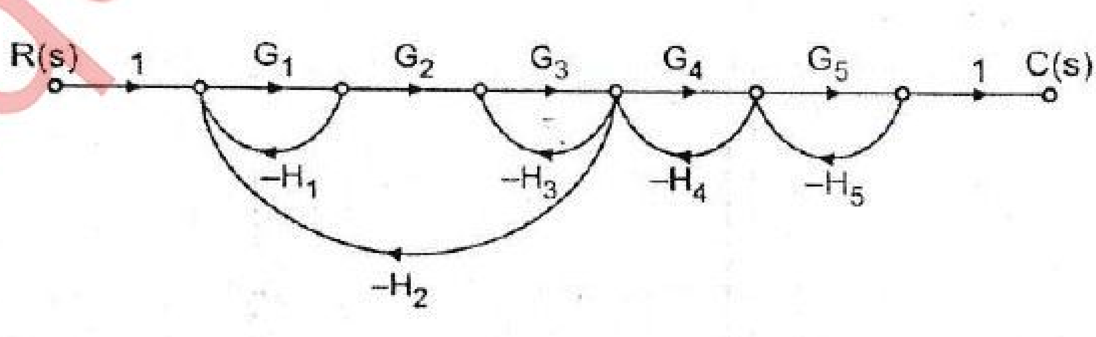
Q.1) A. Reduce the given block diagram to its simple form and hence obtain the transfer function $\frac{C(s)}{R(s)}$. (10)



B. Obtain the transfer function Xo(s)/Xi(s) of the mechanical system shown in the following figure. (10)



Q.2) A. Find $\frac{C(s)}{R(s)}$ for the signal flow graph shown in the following figure. (10)



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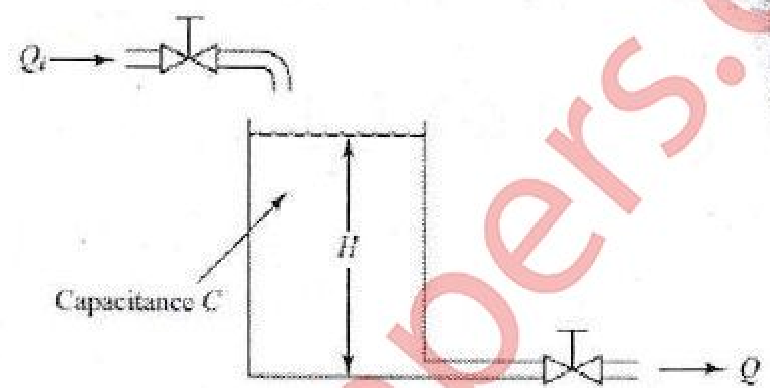
B. Write a note on Lyapunov Stability and modeling via Lyapunov. (10)

Q.3) A. In the liquid-level system of following figure, assume that the outflow rate Q m^3/sec through the outflow valve is related to the head H m by (10)

$$Q = K\sqrt{H} = 0.01\sqrt{H}$$

Assume also that when the inflow rate Qi is 0.015 m^3/sec the head stays constant. For t <0 the system is at steady state (Q_i = 0.015 m^3/sec). At t=0 the inflow valve is closed and so there is no inflow for t ≥ 0. Find the time necessary to empty the tank to half the original head. The capacitance C of the tank is 2 m^2.



B. Obtain the transfer function of the system defined by (10)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Q.4) A. A unity feedback control system has, (10)

$$G(s) = \frac{80}{s(s+2)(s+20)}$$

Draw the Bode Plot. Determine gain margin, phase margin, gain cross over frequency and phase cross over frequency.

B. The open loop transfer function of a unity feedback system is given by (10)

$$G(s) = \frac{100}{s^2(s+4)(s^2+5s+25)}$$

Find static error coefficients and the steady state error of the system when it is subjected to an input of $r(t) = 2 + 4t + 2t^2$.

TURN OVER

Q.5) A. A second order control system having damping ratio 0.4 and natural frequency 5 rad/s, is subjected to a step input. Determine: (10)

(a) closed loop transfer function
(b) rise time
(c) peak time
(d) settling time
(e) maximum overshoot

B. Consider the unity feedback system, (10)

$$G(s) = \frac{K}{s(s+4)(s+2)} .$$

Sketch the rough nature of the root locus showing all details on it. Comment on the stability of the system.

Q.6) A. A unity feedback system has an open loop transfer function (10)

$$G(s)H(s) = \frac{Ke^{-s}}{s(s^2+5s+9)}$$

Determine, by using the Hurwitz-Routh stability criteria, the range of K for which the closed loop system will be stable.

B. Show that for the differential equation system (10)

$$\dddot{y} + a_1\ddot{y} + a_2\dot{y} + a_3y = b_0\dddot{u} + b_1\ddot{u} + b_2\dot{u} + b_3u$$

state and output equations can be given, respectively, by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_3 & -a_2 & -a_1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} u$$

and

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \beta_0 u$$

where state variables are defined by

$$x_1 = y - \beta_0 u$$
$$x_2 = \dot{y} - \beta_0\dot{u} - \beta_1 u = \dot{x}_1 - \beta_1 u$$
$$x_3 = \ddot{y} - \beta_0\ddot{u} - \beta_1\dot{u} - \beta_2 u = \dot{x}_2 - \beta_2 u$$
