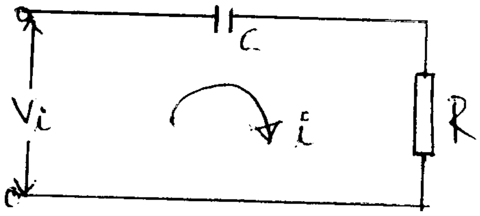
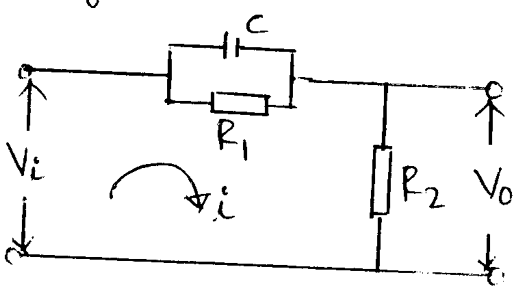
Control Systems Practice Paper - I

(1) Derive the transfer function of the circuit shown in figure



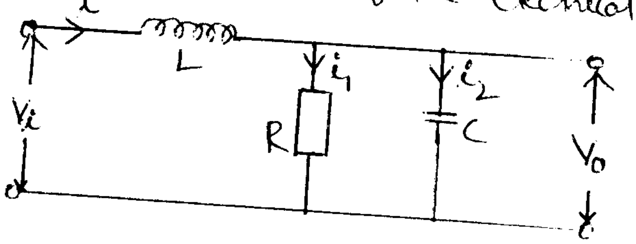
Ans : $\dfrac{SC}{1+SCR}$

(2) Find the transfer function of the electrical network shown in fig. in phase lead form



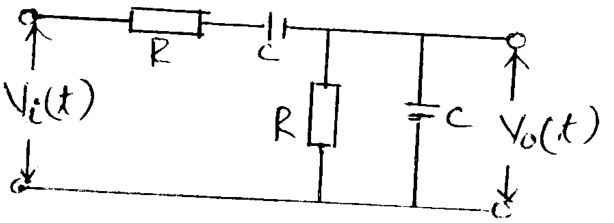
Ans : $\dfrac{a(1+ST)}{1+SaT}$

(3) Find the transfer function of the electrical network shown in figure



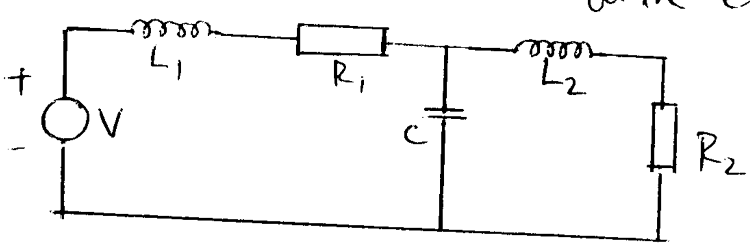
Ans : $\dfrac{1}{T_1T_2S^2+T_1S+1}$

(4) Find the transfer function of the network shown in figure. plot its poles and zeros for $R = C = 1$



Ans : $\dfrac{S}{S^2+3S+1}$

(5) write the differential equations for the electrical network shown in fig.

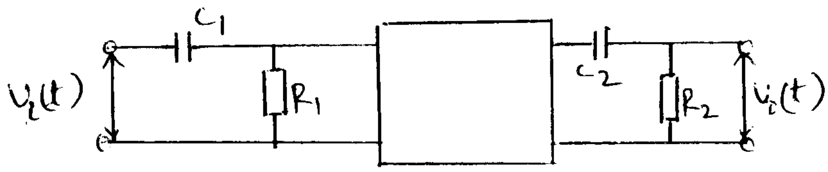


Ans :

$$V(t) = \frac{L_1 di_1(t)}{dt} + R_1 i_1(t) + \frac{1}{C}\int i_1(t)dt - \frac{1}{C}\int i_2(t)dt$$

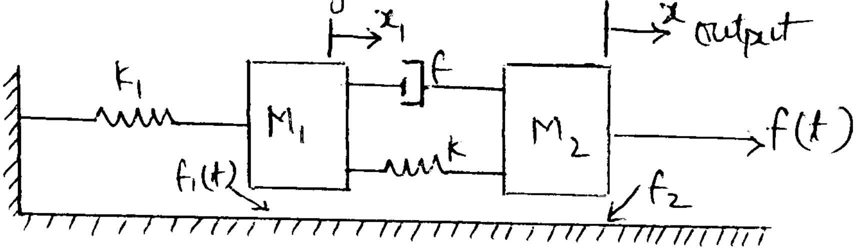
$$0 = \frac{L_2 di_2(t)}{dt} + R_2 i_2(t) + \frac{1}{C}\int i_2(t)dt - \frac{1}{C}\int i_1(t)dt$$

(6) Determine the transfer function relating $V_o(S)$ to $V_i(S)$ for network shown in figure. Calculate output voltage, $t \geq 0$ for a unit step voltage input at $t=0$ when $C_1 = 1\mu f$, $R = 1M\Omega$, $C_2 = 0.5\mu f$ and $R_2 = 1M\Omega$

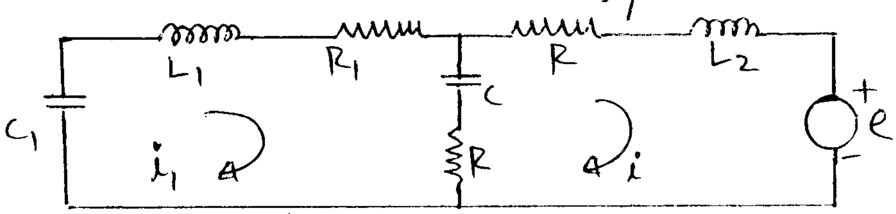


Ans : $V_o(t) = 2e^{-2t} - e^{-t}$

(7) Obtain the transfer function of the mechanical system shown in fig. and draw its analogous circuit.

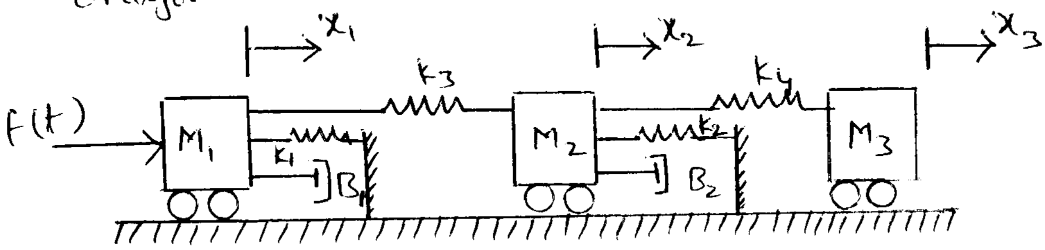


Ans : Transfer function $= \dfrac{X(S)}{F(S)} = \dfrac{M_1 s^2 + f_1 s + f s + k + K_1}{\{M_1 M_2 s^4 + (M_1 f_2 + M_2 f_1 + M_1 f + M_2 f)s^2 + [M_2 K_1 + K(M_1+M_2) + f_1 f_2 + f(f_1+f_2)]s^2 + [K_1(f_1+f_2) + k(f_1+f_2)]s + kK_1]\}}$



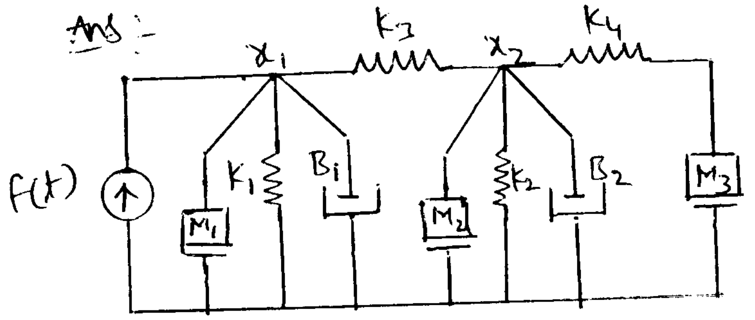
Electrical analog Circuit

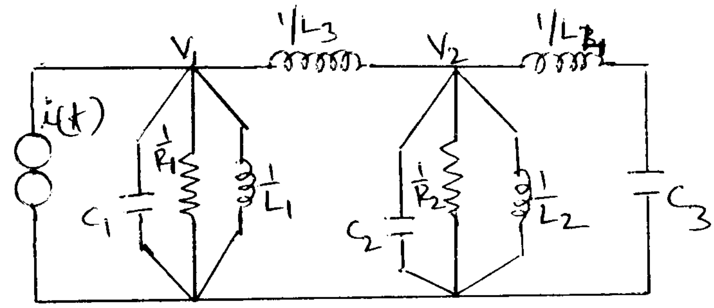
(8) Draw the mechanical network for the system in fig. and draw its analogous circuit.



Institute of Engineering Studies (IES)
56, 2nd floor, behind Namura hotel
22nd Main, Marenahalli, J.P. Nagar
2nd Phase, Bangalore-560 078
Ph: 080 32491693/9741900225

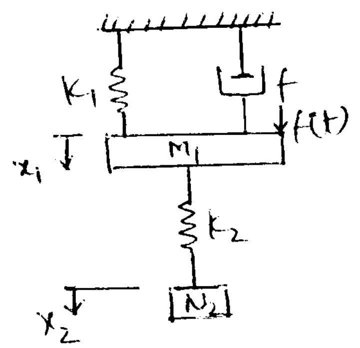
Ans :-





Based on force-current analogy

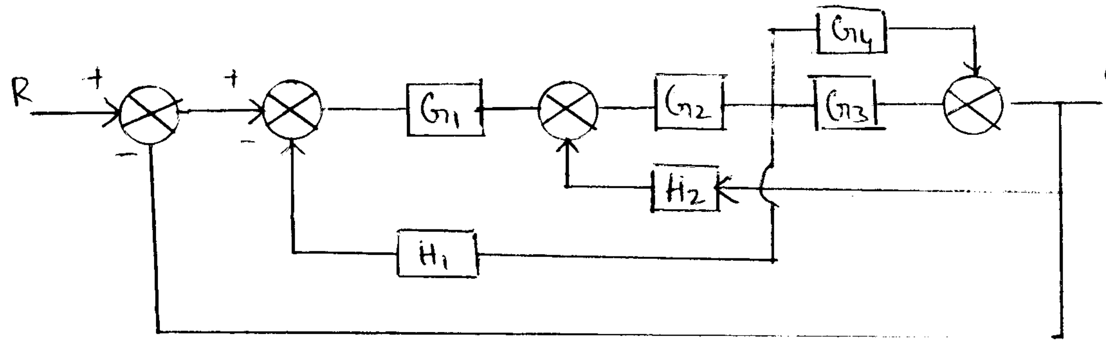
(9) Obtain the nodal equations for the system shown in fig. and draw its analogous electrical network



Ans: Node x_1 : $F(S) = (S^2M_1 + Sf + K_1 + K_2)X_1(S) - K_2X_2(S)$

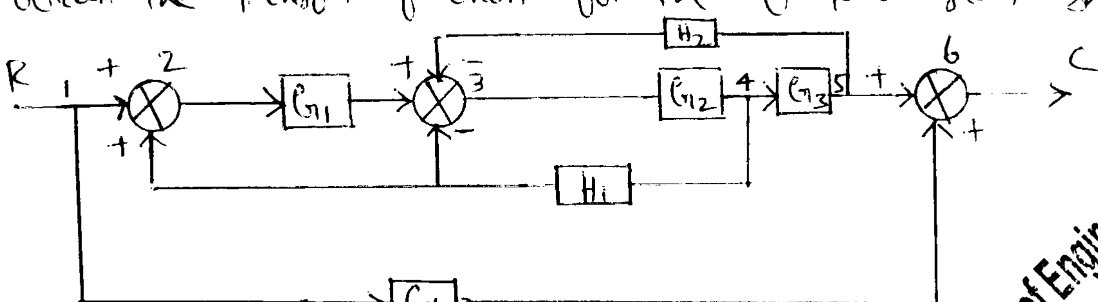
Node x_2 : $(S^2M_2 + K_2)X_2(S) - K_2X_1(S) = 0$

(10) Obtain the transfer function for the block diagram shown in fig.



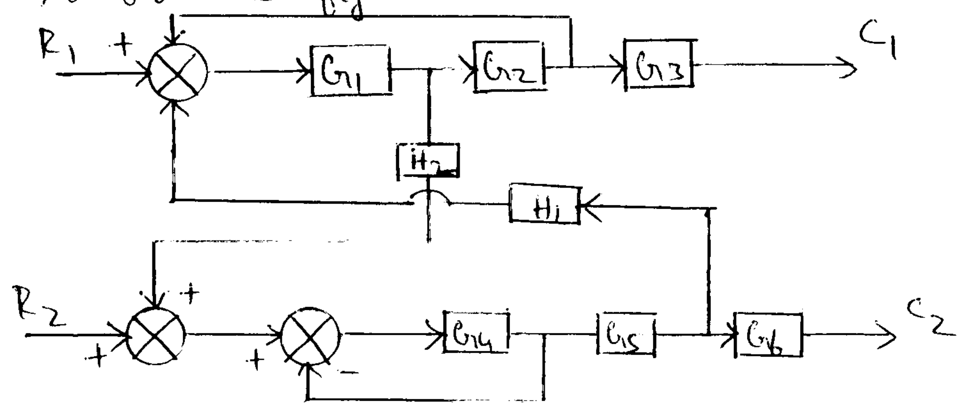
Ans : $\frac{C}{R} = \frac{G_1(G_4 + G_2G_3)}{1 + (G_4 + G_2G_3)(H_2 + G_1) + H_1G_1G_2}$

(11) Obtain the Transfer function for the block diagram shown in fig.



Ans : $\frac{C}{R} = G_4 + \frac{G_1G_2G_3}{1 + H_2G_2G_3 + G_2H_1(1 - G_1)}$

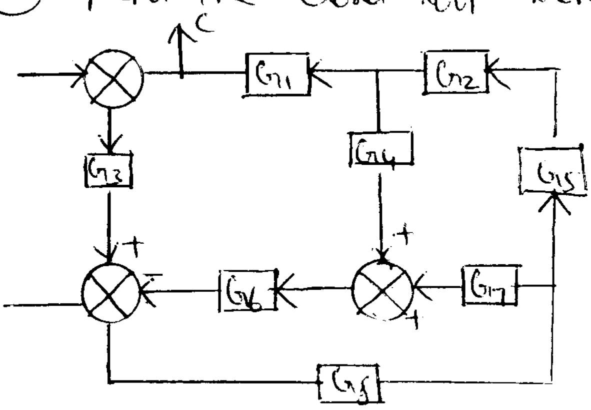
(12) Evaluate $\frac{C_1}{R_1}$ and $\frac{C_2}{R_1}$ for a system whose block diagram representation is shown in fig.



Ans : $$\frac{C_1}{R_1} = \frac{G_1G_2G_3(1+G_4)}{(1+G_1G_2)(1+G_4) - G_4G_5H_1H_2}$$

$$\frac{C_2}{R_1} = \frac{G_1G_4G_5G_6H_2}{(1+G_1G_2)(1+G_4) - (G_1G_4G_5H_1H_2)}$$

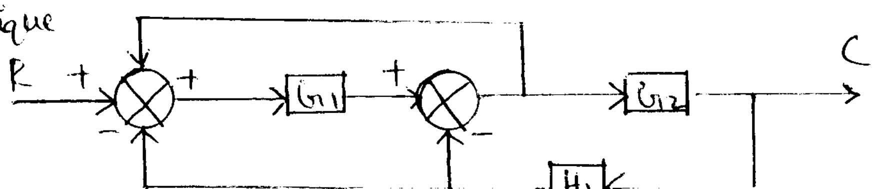
(13) Find the closed loop transfer function of the system shown in fig.



Ans :-

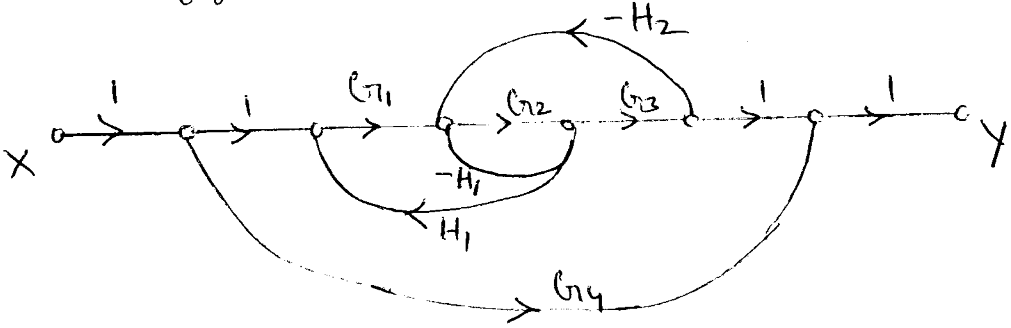
$$\frac{C}{R} = \frac{G_1G_2G_3G_5G_8}{1+G_1G_2G_3G_5G_8 + G_4G_6G_8 + G_6G_7G_8}$$

(14) Determine C/R of system shown in fig. below by block diagram reduction technique



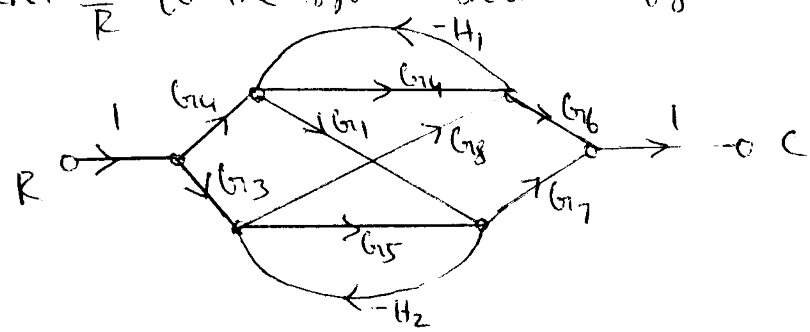
Ans :- $$\frac{C(s)}{R(s)} = \frac{G_1G_2G_3 + G_2G_3}{1+G_3 + G_2H_1 + G_2G_3H_2 + G_1G_2G_3H_2}$$

(15) Obtain the closed loop transfer function for the system shown in figure



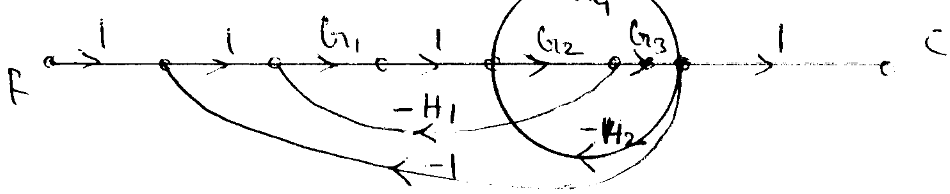
Ans: $$\frac{Y}{X} = \frac{G_1G_2G_3 + G_4(1+G_2H_1 - G_1G_2H_1 + G_2G_3H_2)}{1+G_2H_1 - G_1G_2H_1 + G_2G_3H_2}$$

(16) Find $\frac{C}{R}$ for the system shown in fig.



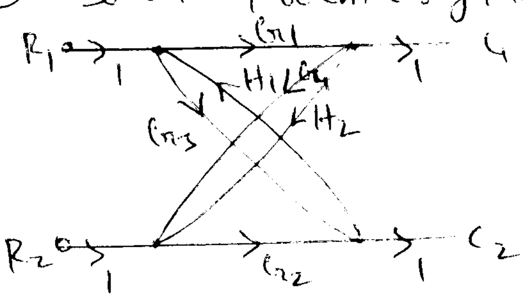
Ans: $$\frac{C}{R} = \frac{-G_2G_6G_8G_1H_2 - G_3G_7G_8G_4H_1}{1+G_4H_1+G_5H_2+G_4G_5H_1H_2 - G_6G_8H_1H_2}$$

(17) Solve the problem using Mason's Gain formula



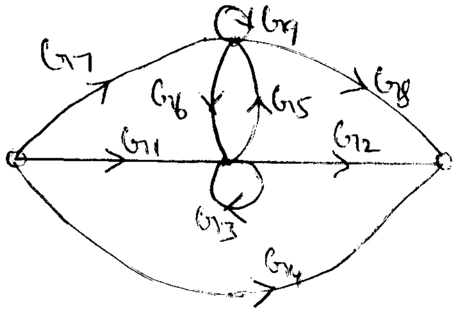
Ans: $$T = \frac{G_1G_2G_3 + G_1G_4}{1+G_1G_2H_1 + G_2G_3H_2 + G_1G_2G_3 + G_4H_2 + G_1G_4}$$

(18) Solve the problem using Mason's gain formula



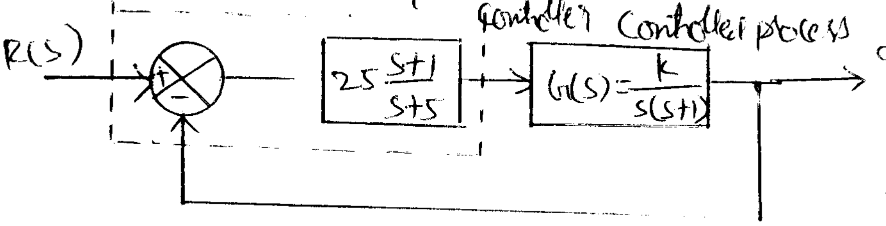
Ans: $$T = \frac{G_3(1-G_4H_2) + G_1G_2H_2}{(1-G_4H_2) + H_1[G_3(G_4H_2-1) - G_4G_2H_2]}$$

(19) Find C/R for the following system using Mason's gain Rule



Ans : $$T = \frac{G_1G_2(1-G_9)+G_4(1-G_9-G_3-G_5G_6+G_9G_3)+G_7G_8(1-G_3) + G_1G_5G_8 + G_7G_6G_2}{1-G_3-G_9-G_5 \cdot G_6+G_9G_3}$$

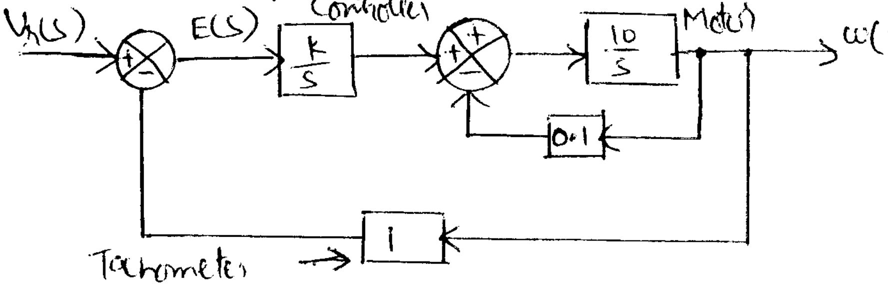
(20) Consider the feedback ~~following~~ control system shown in fig. The nominal value of process parameter k is 1. Let us evaluate the sensitivity of transfer function $T(S) = C(S)/R(S)$ to variations in k



Ans : $T(S) = \frac{25}{S^2+5S+25}$

(21) Consider the speed control system of fig. wherein the inner loop corresponds to motor back emf. The controller is an integrator with gain K. Observe that the load is inertia (a) Determine the value of K for which steady-state error to unit ramp input ($V_R(S) = 1/S^2$) is less than 0.01 rad/sec

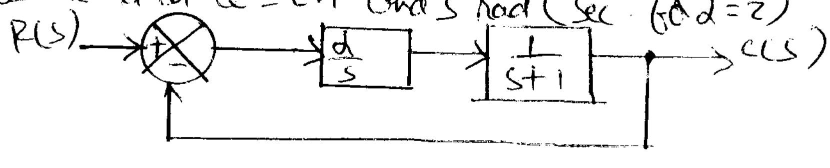
(b) For the value of K found in part (a) determine the sensitivity S_K^T, $T(S) = \omega(S)/V_R(S)$. What will be the limiting value of S_K^T at low frequencies



Ans : $K = 10$, $e_{ss} = 0.01$

(b) $S_{10}^T = 0.01$

(22) For block diagram shown in figure. Determine the sensitivity S_α^T, $T(S) = \frac{C(S)}{R(S)}$. Evaluate it at $\omega = 0.1$ and 5 rad/sec for $\alpha = 2$)



Ans : $S_\alpha^T = \frac{S(S+1)}{S(S+1)+\alpha}$