Roll No.

No. of Printed Pages—6 **EE-507**

B. TECH

FIFTH SEMESTER EXAMINATION, 2002-2003

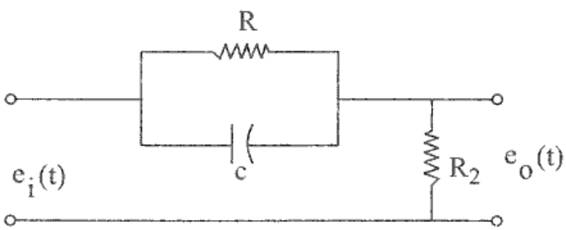
AUTOMATIC CONTROL SYSTEM

Time : 3 Hours *Total Marks : 100*

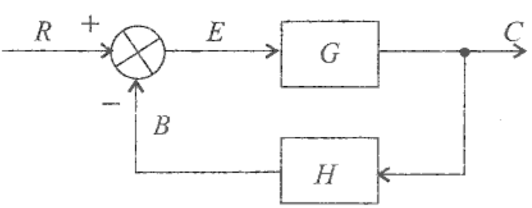
Note : Attempt **ALL** questions.

1. Answer any FOUR of the following :— (5×4)

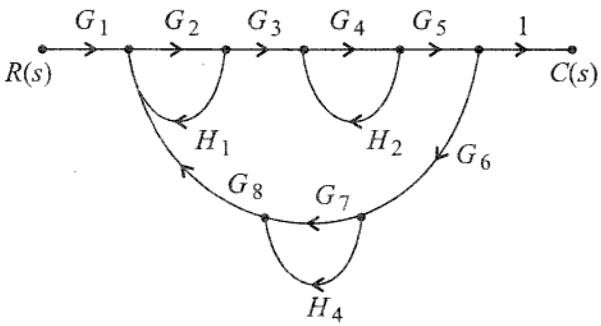
(a) Derive the transfer function $\frac{E_0(s)}{E_i(s)}$ of the network shown below :—



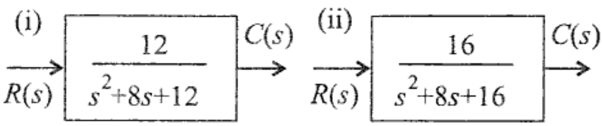
(b) Derive the closed loop transfer function $\frac{C(s)}{R(s)} = M(s)$ for the system shown below and find its sensitivity w.r.t. G and H.

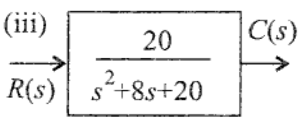


(c) Find the overall transfer function $\frac{C(s)}{R(s)}$ for the signal flow graph given below by Mason's Rule.



(d) Define natural frequency of oscillation ω_n and damping ratio ξ of a second order system. Find the nature of damping for the following systems :—





(e) Find the damping factor ξ, natural frequency ω_n, peak time T_p and percentage over shot for the system with

$$G(s) = \frac{1}{9s^2 + 2s + 58}$$

Draw its pole, zero locations.

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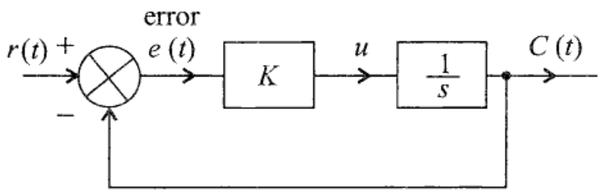


(*f*) For the above system, find the integral square error given by $J_e = \int_0^\infty e^2(t)\,dt$. and comment on the same. The input $r(t)$ is unit-step input.

2. Answer any FOUR of the following :— (5×4)

(*a*) Define static position error constant K_p. Find steady state actuating error e_{ss} to unit-step input for type 0, type 1 and type 2 systems.

(*b*) For a system with $G(s) = \frac{10}{s\,(0{\cdot}1s+1)}$, find the dynamic error coefficients.

(*c*) State the Bode Plot magnitude curve characteristics of a type 1 system.

$$G\,(j\omega) = \frac{K_1}{j\omega(1+j\omega T_1)}$$

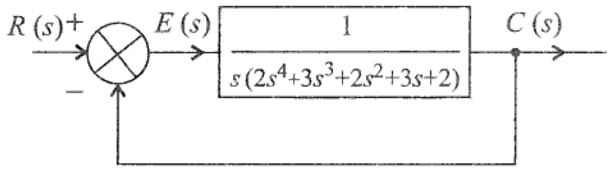
(*d*) Define gain margin, phase margin, gain crossover frequency, phase crossover frequency in a polar plot.

(*e*) Show that the polar plot of $G(s) = \frac{1}{1+Ts}$ is a semicircle.

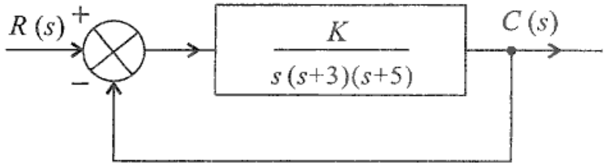
(*f*) Show that the loci of constant phase angle of a closed loop system with unity feedback is a series of circles whose centre is at $x_0 = -\frac{1}{2}, y_0 = \frac{1}{2N}$ and radius $r_0 = \frac{1}{2N}\sqrt{N^2+1}$.

3. Answer any TWO of the following :— (10×2)

(*a*) Find the number of poles in LHP, RHP and $j\omega$ axis for the system below by R-H criterion and comment on its stability :—



(*b*) For the system shown below, find the range of K for stability, instability and the value of gain for marginal stability by Nyquist criterion.

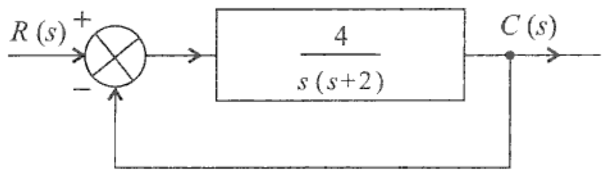


(*c*) State the rules for construction of root loci of $G(s)H(s)$. Find the breakaway points of

$$G(s)H(s) = \frac{K}{s(s+4)(s^2+4s+20)}$$

4. Answer any TWO of the following :— (10×2)

(a)



For the system shown above, design a lead compensator such that $\omega_n = 4$ rad/sec and $\xi = 0{\cdot}5$ for the compensated system.

(b) The open-loop transfer function

$$G(s) = \frac{1}{s(s+1)(0{\cdot}5s+1)}.$$

Compensate the system, such that, $K_v = 5\,\text{sec.}^{-1}$ and phase margin is at least 40° and the gain margin is at least 10 db, with a lag compensator.

(c) Derive the transfer-function of a lag-lead network. Show that at $\omega_1 = \frac{1}{\sqrt{T_1 T_2}}$, the phase angle of a lag-lead network

$$G_c(j\omega) = K_c \frac{\left(s+\frac{1}{T_1}\right)\left(s+\frac{1}{T_2}\right)}{\left(s+\frac{\beta}{T_1}\right)\left(s+\frac{1}{\beta T_2}\right)}$$

becomes zero.

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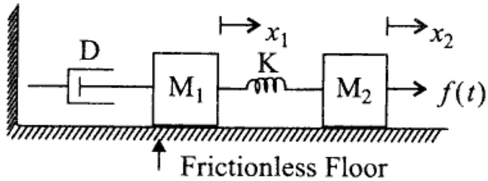
5. Answer any TWO of the following :— (10×2)

(*a*) Derive the state variable model for the system shown below :—



(*b*) For the state matrix $A = \begin{bmatrix} 0 & 1 \\ -8 & -6 \end{bmatrix}$, find e^{At} by any two methods.

(*c*) Given $\dot{X} = AX + Bu$, where

$A = \begin{bmatrix} 0 & 1 \\ -8 & -6 \end{bmatrix}$; $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$; $X(0) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$ and u =unit-step input, find $X(t)$.

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