Group - D

6. Obtain the Bode plot for G(s)H(s)=$\frac{10(s+1)}{s(s+2)(s+10)}$. Determine the phase crossover frequency and gain margin for the system.

8 + 4 = 12

7. (a) The open loop transfer function of a system is given by $G(s)H(s)=\frac{1}{s(1+s)(1+2s)}$. Draw the Nyquist plot and hence comment on its stability.

   (b) Define (i) Gain margin (ii) Phase margin.

10 + 2 = 12

Group - E

8. (a) A single input single output system is given by

$$\dot{x}(t)=\begin{bmatrix}-1 & 0 & 0\\ 0 & -2 & 0\\ 0 & 0 & -3\end{bmatrix}x(t)+\begin{bmatrix}1\\1\\0\end{bmatrix}u;\ y=[\,1 \quad 0 \quad 2\,]\,x(t)$$

Comment on controllability and observability of the system.

   (b) A system is described by the following matrices:

$$A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ 0 & -2 & -3\end{bmatrix},\ B=\begin{bmatrix}0\\0\\1\end{bmatrix},\ C=[1 \quad 2 \quad 0].$$

Determine the transfer function.

6 + 6 = 12

9. Write a short note on any ***three*** of the following topics: **3 × 4= 12**

   i. Relative Stability Analysis
   ii. Eigenvalue & Eigenvector
   iii. PD controller
   iv. Lead compensator
   v. Polar plot

CONTROL SYSTEMS
(ECEN 3102)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

   (i) If the gain of an open loop system is doubled, the gain margin
   (a) is not affected (b) gets doubled
   (c) becomes half (d) becomes $1/4^{th}$.

   (ii) The 'type' of a transfer function denotes the no of
   (a) zeros at origin (b) poles at origin
   (c) poles on the imaginary axis (d) poles at infinity.

   (iii) The characteristic equation of a system is $s^2 + 2s + 1 = 0$. The system is
   (a) critically damped (b) under damped
   (c) undamped (d) over damped.

   (iv) Addition of a pole to a closed loop transfer function
   (a) increases rise time (b) decreases rise time
   (c) increases over shoot (d) both (a) and (c).

   (v) The characteristic equation of a unity feedback system is given by $s^3+s^2+4s+4=0$. The system has
   (a) One pole in the RHS of the s plane
   (b) No poles in the RHS of the s plane
   (c) Exhibits oscillatory nature
   (d) Both (b) and (c).

   (vi) In force–voltage analogy, displacement is analogous to
   (a) current (b) voltage
   (c) charge (d) None of these.

(vii) When the phase cross over frequency is equal to the gain cross over frequency, the system exhibits
(a) sustained oscillation
(b) damped oscillatory response
(c) oscillations of increased amplitude
(d) over damped response.

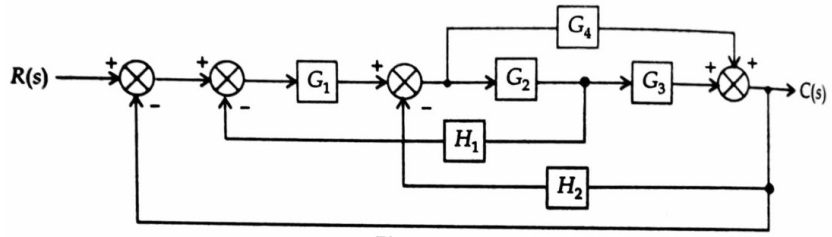
(viii) A second order system exhibits 100% overshoot. The damping ratio is
(a) zero (b) one
(c) less than one (d) more than one.

(ix) For the factor $\frac{1}{1+2j\omega}$ the corner frequency is
(a) 0.5 rad/s (b) 1 rad/s
(c) 2 rad/s (d) 4 rad/s.

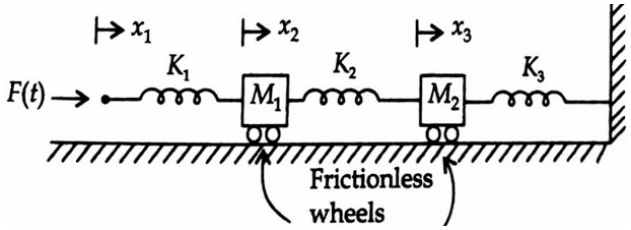
(x) If a system has repeated roots of the characteristic equation on the imaginary axis, the system is
(a) Stable (b) Unstable
(c) Marginally stable (d) Cannot comment.

Group - B

2. (a) Obtain the transfer function $\frac{C(s)}{R(s)}$ for the following figure using block diagram reduction technique.



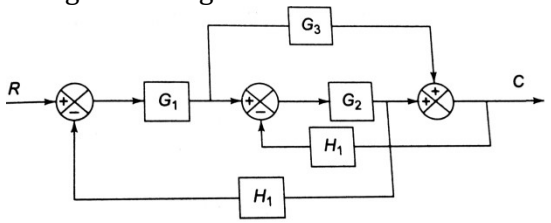
(b) Draw the mechanical equivalent network of the given figure and also draw the analogous electrical circuit using force –voltage analogy.



7 + 5 = 12

3. (a) Show the force voltage analogy of an electrical and mechanical translational system.

(b) Use Mason's gain formula to evaluate the overall transfer function of the following block diagram.



4 + 8 = 12

Group - C

4. (a) A unity feedback system has $G(s)=\frac{5(s^2+2s+100)}{s^2(s+5)(s^2+3s+10)}$,

i. What is the type of the system?
ii. Determine the step, ramp and parabolic error co-efficients.

(b) The characteristic equation of a system is given by $s^4+5s^3+9s^2+20s+k=0$. Find the range of k for which the system is stable.

(c) A second order system has forward path transfer function $G(s)=\frac{12}{s^2+4s+16}$ and feedback path transfer function $H(s)=ks$. The damping factor of the system is 0.8. Find out the peak overshoot of the system.

(1+3) + 4 + 4 = 12

5. (a) Sketch the Root locus for the system which has the open-loop transfer G(s)H(s)= $\frac{k}{s(s+5)(s+6)}$. Indicate the (i) Break-away point, (ii) value of k for marginal stability and (iii) imaginary axis cross over points for the plot.

(b) Using Routh- Hurwitz Criterion, comment on the stability of a system having the characteristic equation $s^5+6s^4+3s^3+2s^2+s+1=0$. Identify how many poles are lying on the right hand side if the system is unstable.

8 + 4 = 12