(b) Define relative stability.

10 + 2 = 12

Group – E

8. (a) A system is represented by the following state and output equation:

$$\dot{X} = \begin{bmatrix} -3 & -2 \\ -1 & -2 \end{bmatrix} X + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t)$$

$$Y = \begin{bmatrix} 1 & 2 \end{bmatrix} X$$

Find the poles of the system.

(b) Define Controllability and Observability of a system.

(c) A system is represented by the following state and output equation:

$$\dot{X} = \begin{bmatrix} -0.5 & 0 \\ 0 & -2 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$Y = \begin{bmatrix} 0 & 1 \end{bmatrix} X$$

Test for Controllability and Observability of the system.

4 + 2 + 6 = 12

9. Write a short note on any ***three*** of the following topics: **(4 × 3) = 12**
   (i) Gain margin and Phase margin
   (ii) Eigenvalue and Eigenvector
   (iii) PID controller
   (iv) Lag compensator
   (v) Evan's Condition.

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) A system has $T(s) = \frac{100}{s^2 + 2s + 100}$, for unit step input the settling time for 2% tolerance band is
   (a) 1.6s (b) 2.5s
   (c) 4s (d) 5s.

   (ii) The open loop transfer function of a unity feedback system is $G(s) = \frac{1}{(s+2)^2}$.
   The poles of the closed loop system are at
   (a) -2,-2 (b) -2,-1
   (c) -2 ± j (d) -2,2.

   (iii) The type number of a system with transfer function $G(s) = \frac{s+2}{s^2(s^3 + 2s + 3)}$, is
   (a) One (b) Two
   (c) Three (d) Four.

   (iv) Gain margin is the reciprocal of the gain at the frequency at which the phase angle is
   (a) 90° (b) 180°
   (c) 0° (d) 270°.

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

   (vi) Relative stability can be evaluated using
   (a) Bode Plot only (b) Nyquist plot only
   (c) Both Bode Plot and Nyquist Plot (d) R-H criterion.

(vii) The steady–state error co-efficients for a system are k_p= Finite constant, k_v=0, k_a=0, the type of the system is
(a) 0 (b) 1
(c) 2 (d) 8.

(viii) The initial slope of Bode plot for a type1 system is
(a) 20 db/decade (b) - 40 db/decade
(c) 40 db/decade (d) -20 db/decade.

(ix) A LTI system obeys
(a) principle of superposition (b) principle of homogeneity
(c) both (a) and (b) (d) none of these.

(x) The lead compensation network is considered to be
(a) high pass filter (b) low pass filter
(c) equaliser (d) none of these.

Group – B

2. (a) Find out the overall transfer function of the system shown in Fig. 1, using block diagram reduction technique.

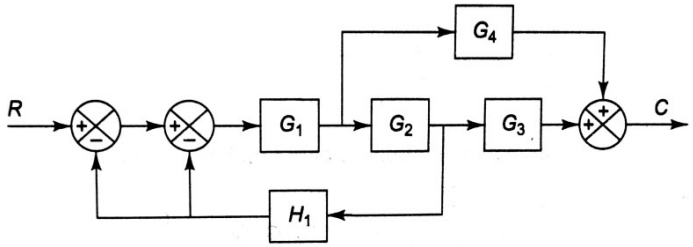

Fig. 1

(b) Find out the overall transfer function of the system indicated in Fig. 2, using Mason's gain formula.

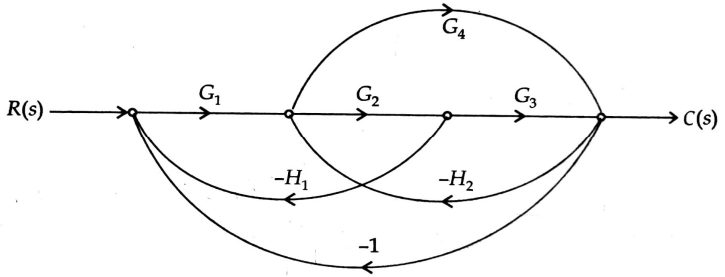

Fig. 2

6 + 6 = 12

3. (a) Show force voltage analogy by comparing an electrical RLC circuit and a mechanical translational system.

(b) Use Mason's gain formula to evaluate the overall transfer function of the block diagram shown in Fig. 3.

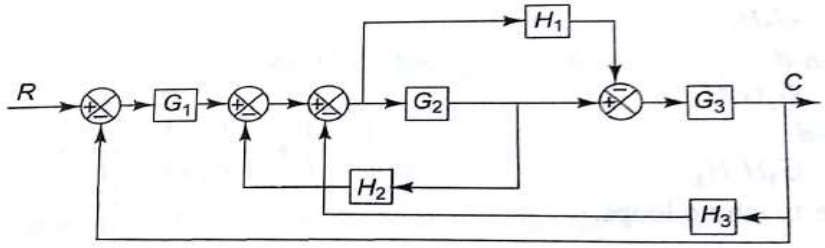

Fig. 3

4 + 8 = 12

Group – C

4. (a) Using the Routh Hurwitz stability criterion, determine the range of value of 'k' for the system to be stable if the OLTF of the unity feedback system is $G(s)=\frac{k(s+13)}{s(s+3)(s+7)}$.

(b) A unity feedback system OLTF is given by $G(s)=\frac{10}{s^2+11s+10}$. Find out the position, velocity and acceleration error for this system.

(c) A second order system had closed loop transfer function $T(s)=\frac{144}{s^2+12s+144}$. Find out the peak time and peak overshoot.

5 + 3 + 4 = 12

5. (a) Sketch the Root locus for the open-loop transfer G(s)H(s) = $\frac{K}{s(s^2+2s+2)}$ with unity gain negative feedback. Indicate the (i) angle of departure, (ii) value of K for marginal stability and (iii) imaginary axis cross over points for the plot.

(b) Define 'Break –away point' of any system.

10 + 2 = 12

Group – D

6. Sketch the Bode plot for the system having open loop transfer function $G(s)H(s)=\frac{1000}{(1+0.1s)(1+0.001s)}$.

12

7. (a) The open loop transfer function of a unity feedback system is given by $G(s)=\frac{5}{s(s+1)(s+2)}$. Draw the Nyquist plot and hence comment on its stability.