7. For a unity feedback system the open loop transfer function is given by

$$G(s) = \frac{60}{(s+1)(s+2)(s+5)}$$

(i) Draw the Nyquist plot.
(ii) Is the closed loop system stable?
(iii) What are phase and gain margins of the system?

4 + 4 + 4 =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) Find the transfer function of the system that is represented as

$$\dot{X} = \begin{bmatrix} -5 & -1 \\ 3 & -1 \end{bmatrix} X + \begin{bmatrix} 2 \\ 5 \end{bmatrix} u(t)$$

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

(c) Define 'controllability' and 'observability' of a system.

4 + 4 + 4 = 12

9. Write short notes on any three: **(3 × 4) = 12**

(i) PI and PD controller
(ii) Gain margin and Phase margin
(iii) Polar plot
(iv) Time domain specifications
(v) Eigenvalue.

CONTROL SYSTEMS
(ECEN 4182)

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) 1.6 (b) 2.5 (c) 4 (d) 5.

(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 viscous friction co-efficient, in force-voltage analogy, is analogous to
(a) charge (b) resistance
(c) reciprocal of inductance (d) reciprocal of conductance.

(iv) The entries in the first column of Routh array of a fourth order system are 5, 2, - 0.1, 2, 1. The number of poles in the right half s-plane are
(a) 1 (b) 2
(c) 3 (d) 4.

(v) In case of type-1 system steady state acceleration error is
(a) unity (b) infinity
(c) zero (d) 10.

(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) A lag network for compensation normally consists of
(a) R, L and C elements (b) R and L elements
(c) R and C elements (d) R elements only.

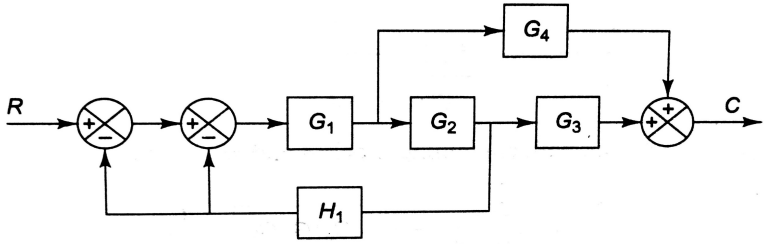
(viii) The initial slope of Bode plot for a type-1 system is
(a) 20 db/decade (b) - 40 db/decade
(c) 40 db/decade (d) -20 db/decade.

(ix) If a system has non-repeated roots of the characteristic equation on the imaginary axis and all other roots are on the left hand side of the s-plane, the system is
(a) stable (b) unstable
(c) marginally stable (d) cannot comment.

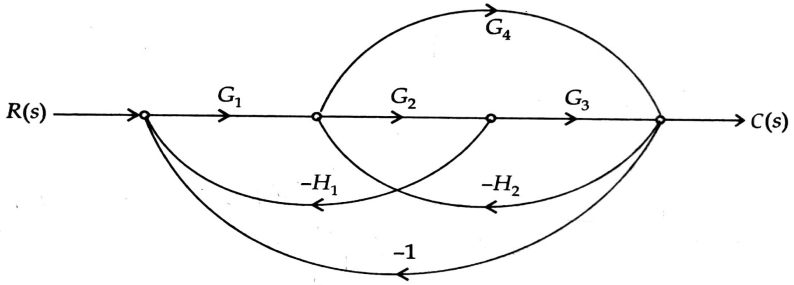
(x) If the poles of a second order system lie in the second quadrant, the system is
(a) undamped (b) underdamped
(c) overdamped (d) critically damped.

Group – B

2. (a) Find out the overall transfer function of the system using block diagram reduction technique.



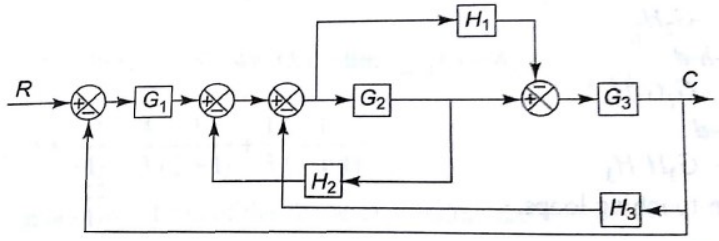
(b) Find out the overall transfer function using Mason's gain formula.



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 following block diagram.



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 settling time for 2% tolerance.

6 + 3 + 3 = 12

5. The forward path transfer function of a unity feedback system is given by G(s) = $\frac{K}{s(s+4)(s+5)}$. Sketch the root locus as K varies from zero to infinity.

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