CONTROL SYSTEMS
(AEIE 3104)

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) Transfer function of a system is used to calculate which of the following?
(a) The order of the system (b) The time constant
(c) The output for any given input (d) The steady state gain

(ii) When the number of poles is equal to the number of zeroes, how many branches of root locus tends towards infinity?
(a) 1 (b) 2 (c) 0 (d) Equal to number of zeroes.

(iii) If number of poles are greater than number of zeroes then the system is known as _____
(a) Stable system (b) Unstable system
(c) Minimum phase system (d) Non-minimum phase system.

(iv) The transient response, with feedback system,
(a) Rises slowly (b) Rises quickly
(c) Decays slowly (d) Decays quickly.

(v) Roots with higher multiplicity on the imaginary axis makes the system
(a) Absolutely stable (b) Unstable (c) Linear (d) Stable.

(vi) Steady state refers to
(a) Error at the steady state (b) Error at the transient state
(c) Error at both state (d) Precision.

(vii) Consider a system with transfer function $G(s) = (s+6)/(Ks^2+s+6)$. Its damping ratio will be 0.5 when the values of k is
(a) 2/6 (b) 3 (c) 1/6 (d) 6.

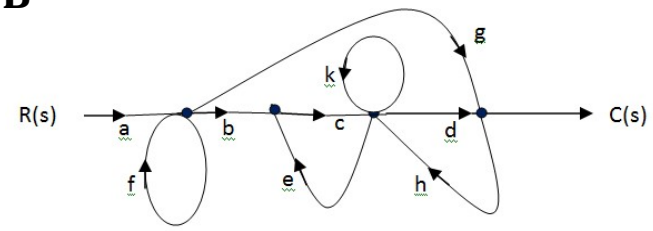
(viii) The output of the feedback control system must be a function of
(a) Reference input (b) Reference output
(c) Output and feedback signal (d) Input and feedback signal.

(ix) A linear system at rest is subject to an input signal $r(t)=1-e^{-t}$. The response of the system for $t>0$ is given by $c(t)=1-e^{-2t}$. The transfer function of the system is
(a) (s+2)/(s+1) (b) (s+1)/(s+2)
(c) 2(s+1)/(s+2) (d) (s+1)/2(s+2).

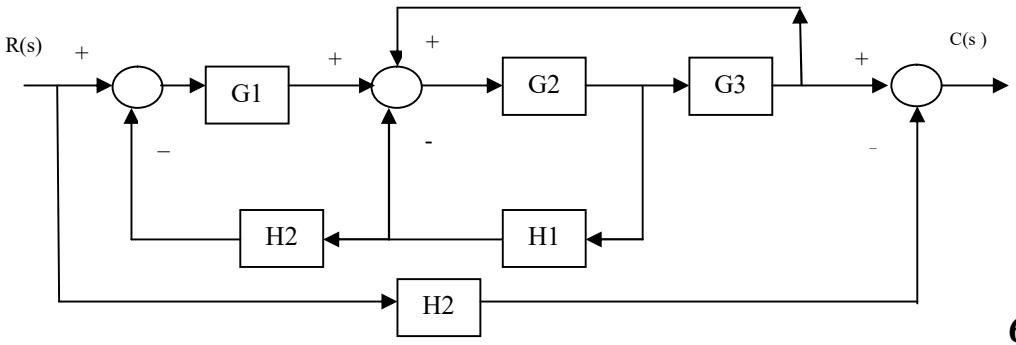
(x) A transfer function has two zeroes at infinity. Then the relation between the numerator(N) and the denominator degree(M) of the transfer function is
(a) N = M + 2 (b) N = M - 2 (c) N = M + 1 (d) N = M - 1.

Group – B

2. (a) Find the transfer function of the above signal flow graph using Mason's gain formula.

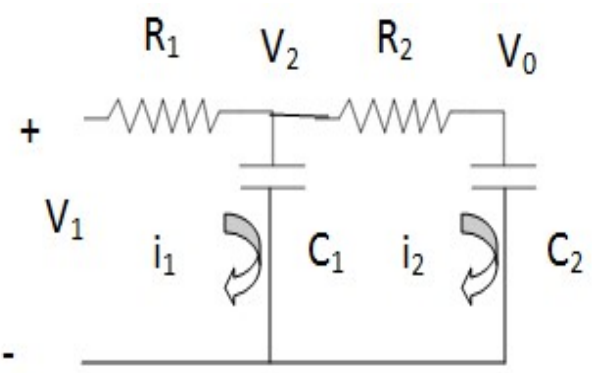


(b) Find the overall transfer function of the system using block reduction technique.



6 + 6 = 12

3. (i) Draw the block diagram of the above circuit diagram.
(ii) From the block diagram, find the transfer function.
(iii) Draw the SFG using the block diagram of the above circuit diagram.
(iv) Hence find the transfer function using MASON'S gain formula.
(v) Verify the transfer function using electrical circuit analysis.



(3 + 2 + 2 + 2 + 3) = 12

Group – C

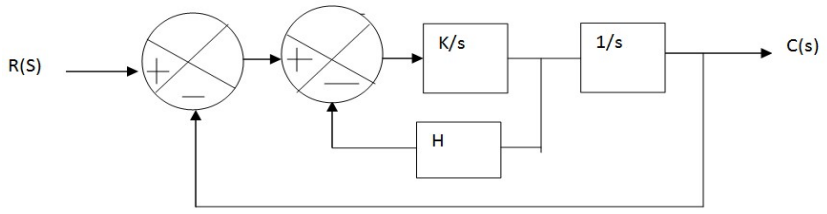
4. (a) The closed loop transfer function of a unity negative feedback control system is given by $C(s)/R(S) = \frac{Ks+b}{s(s+a)+b}$. Determine the open loop transfer function of the system. Show that the steady state error (e_{ss}) with unit ramp input will be $e_{ss}=\frac{a-k}{b}$.

(b) For the unit step response of a unity feedback control system whose open loop transfer function is G(s)= 1/[s(s+1)], (i) find the rise time(t_r), peak time (t_p), percentage peak overshoot(%Mp) and settling time (t_s) on 2% basis. (ii) Also find the steady state errors (e_{ss}) when unit step and unit parabolic inputs are applied to it.

(2 + 2) + (6 + 2) = 12

5. (a) The output response c(t) of a system when subjected to a unit step input is given by, $c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}$.
(i) Obtain the closed loop transfer function of the system.
(ii) Determine the natural frequency and damping ratio of the system.

(b) Determine the value of 'k' and 'H' of the given closed loop system so that the maximum peak overshoot in unit step response is 25% and peak time is 2 sec.



(3 + 3) + 6 = 12

Group – D

6. (a) The characteristic equation of a feedback control system is given by $S^4 + 25s^3 + 20s^2 + 2s + K = 0$. Determine the range of K for the system to be stable. Also find the frequency of sustained oscillations for the system to be marginally stable.

(b) Determine the stability of a unity feedback control system whose open loop transfer function is given by, $G(s) = e^{-sT}/[s(s+1)]$.

(4 + 3) + 5 = 12

7. (a) For a unity feedback system having open loop transfer function is $G(s) = k/[s(s+2)(s^2 + 2s +10)]$,

(b) Sketch the root locus plot by finding the required parameters, such as branches, centroid, breakaway point, asymptomatic angles.

(c) From the root locus plot comment of the stability of the given system.

5 + 4 + 3 = 12

Group – E

8. (a) Draw the Bode plot for a unity feedback control system having open loop transfer function $G(s) = 10^7 / [S(S + 10)(S + 1000)]$.

(b) From the plot calculate the gain margin, phase margin, gain cross-over frequency and phase cross-over frequency. From the plot parameters make remark on the stability of the system.

6 + (4 + 2) = 12

9. (a) Sketch the Nyquist plot for a unity feedback system having open loop transfer function $G(s) = 2 / [s(1 - 2s)]$.

(b) Hence investigate the closed loop stability of the system with proper reason.

7 + 5 = 12

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