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Paper Code : EE-503

CONTROL SYSTEM-I

Time Allotted: 3 Hours | *Full Marks*: 70

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for *any ten* of the following: http://www.makaut.com 1×10=10

(i) The characteristic equation of the system is $s^2 + 2s + 2 = 0$. The system is

(a) critically damped (b) under damped
(c) over damped (d) undamped

(ii) The transfer function G(s) of a PID controller is

(a) $k\left[1 + \frac{1}{T_i S} + T_d S\right]$ (b) $k[1 + T_i S + T_d S]$
(c) $k\left[1 + \frac{1}{T_i S} + \frac{1}{T_d S}\right]$ (d) $k\left[1 + T_i S + \frac{1}{T_d S}\right]$

(iii) The B[illegible] of $(1 + JWT)$ has

(a) Slope of [illegible] decade and phase angle $+ \tan^{-1}(WT)$
(b) Slope of – 20 dB/decade & phase angle $+ \tan^{-1}(WT)$
(c) Slope of 20 dB/decade & phase angle $- \tan^{-1}(WT)$
(d) Slope of – 40 dB/decade & phase angle $- \tan^{-1}(WT)$

Turn Over

(iv) The frequency of which Nyquist diagram crosses the negative real axis is known as

(a) gain crossover frequency
(b) phase crossover frequency
(c) Natural frequency
(d) break away point

(v) Addition of zero to the closed loop transfer function

(a) increase rise time
(b) decrease rise time
(c) increase overshoot
(d) has no effect

(vi) The value of ξ for a second order system is zero. The step response will be

(a) over damped
(b) critically damped
(c) under damped
(d) sustained oscillatory

(vii) The root loci of a system have three asymptotes. The system can have

(a) five poles & two zeros
(b) three poles & one zero
(c) four poles & two zeros
(d) six poles & two zeros

(viii) The transfer function of a network is $\frac{1+0.3s}{2+s}$. It represents a

(a) lag network
(b) lead network
(c) lead – lag network
(d) proportional controller

(ix) For eliminating steady state error, the control action required is

(a) Proportional control
(b) Proportional plus derivative control
(c) Proportional plus integral control
(d) Proportional, derivative & integral co

(x) The characteristic equation $1 + G(s)H(s) = 0$ of a system is given by

$$s^4 + 6s^3 + 11s^2 + 6s + K = 0$$

For the system to remain stable, the value of gain K should be

(a) zero

(b) greater than zero but less than 10

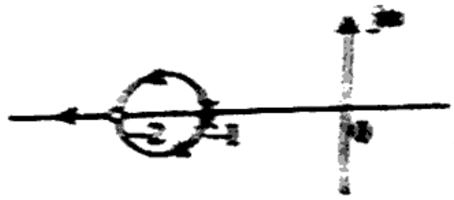
(c) greater than 10 but less than 20

(d) greater than 20 but less than 30

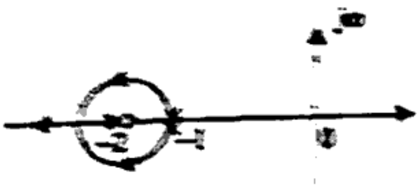
(xi) Given a unity feedback system with open-loop transfer function $G(s) = \frac{K(s+2)}{(s+1)^2}$. The correct root-locus plot of the system is

(a)

(b)

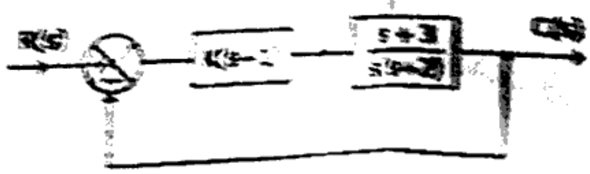


(c)



(d)

(xii) For the system in the given figure the characteristic equation is



(a) $1 + \frac{K(s+1)(s+3)}{s(s+2)} = 0$

(b) $1 - \frac{K(s+1)(s+3)}{s(s+2)} = 0$

(c) $K(s+1)(s+3) = 0$

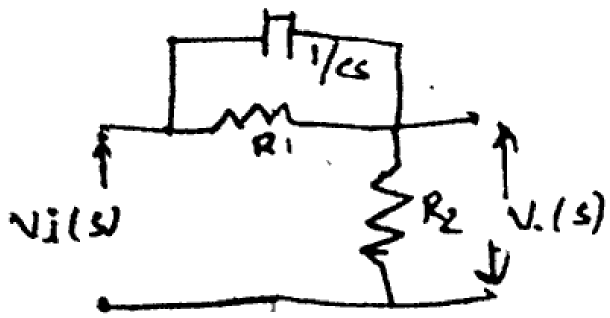
(d) $s(s+2) = 0$

Group – B

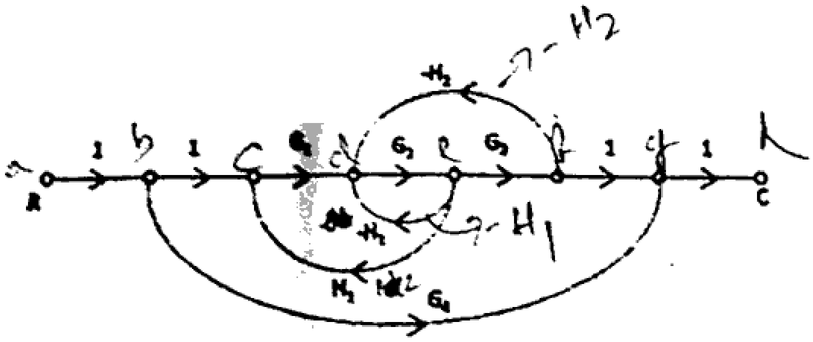
(Short Answer Type Questions)

Answer *any three* of the following. 5×3=15

2. Find the transfer function of the system shown in the figure:

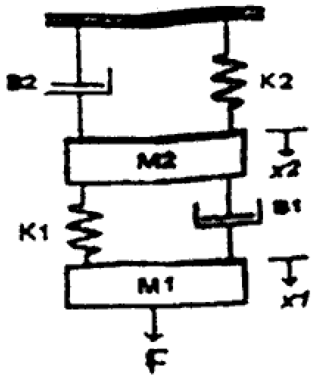


3. Determine the overall transfer function of the signal flow graph given below using Mason's gain formula



4. A unity feedback system has an open loop transfer function $G(s) = \frac{25}{s(s+8)}$. Find its damping ratio, natural frequency, rise time, over shoot & time required to reach the peak output.

5. Consider the following mechanical translational system. F denotes force, x denotes displacement, M denotes mass, B denotes friction coefficient and K denotes spring constant.



(a) Write down the differential equations governing the above system.

(b) Draw the corresponding electrical equivalent circuit using force-voltage analogy scheme.

6. A unity feedback system has $G(s) = \frac{180}{S(s+6)}$ & $r(t) = 4t$.

Determine: (a) Steady state error

(b) The value of K to reduce error by 6%

Group – C

(Long Answer Type Questions)

Answer *any three* of the following. 15×3=45

7. (a) The open loop transfer function of a unity feedback control system is given by

$$G(s) = \frac{K}{S(S+1)(S+3)(S+5)}$$

Sketch the root locus plot of the system by finding the following:

(i) angle of asymptotes, centroid and breakaway points

(ii) angle of departure

(iii) the value of K and frequency at which the root loci cross the imaginary axis

(b) Explain what is meant by stability of the system. How root locus plot of a system is useful to find stability? 10+5=15

8. (a) What are the advantages of Bode diagram? http://www.makaut.com

(b) Sketch the asymptotic Bode plot for the following open loop transfer function with unit feedback

$$G(s)H(s) = \frac{20(s+10)}{s(s+20)(s+s+1)}$$

Calculate the gain and phase cross-over frequency, gain margin and phase margin of the Bode plot. Also, determine the closed loop stability of the system. 3+12=15

9. (a) State and explain Nyquist criterion for studying stability of a control system.

(b) For a unity feedback system having open loop transfer function

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

Determine using Nyquist criterion the range of gain 'K' for which the closed loop system will be stable. http://www.makaut.com 5+10=15

10. (a) Obtain the equations for the armature controlled DC servomotor and find the transfer function of the DC servomotor.

(b) Show that the transfer function of a two-phase induction motor can be written in form

$$\frac{\theta_m(S)}{V_z(S)} = \frac{K_m}{s(1+s\tau_m)}$$

What are the expressions for K_m and τ_m and what are they called? 7+8=15

11. (a) Drive the expression for the time response of a first order system subjected to unit step input.

(b) The open loop transfer function of a unity feedback system is given by

$$G(s) = \frac{K}{s(Ts + 1)}$$

Where K and T are positive constants. By how much should the amplifier gain be reduced so that the peak overshoot of unit step response of the system is reduced from 75% to 25%?

(c) Define position, velocity and acceleration error constants. 5+7+3=15