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Paper Code : EC-503

PUID : 05054 (To be mentioned in the main answer script)

CONTROL SYSTEM

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 : $10 \times 1 = 10$

   i) If the root locus lies only on the negative real axis then the time response is

      a) overdamped

      b) underdamped

      c) oscillatory

      d) sustained oscillations.

ii) The steady state error is determined as the difference between the reference input and the system output at

a) $t = t_p$

b) t = infinity

c) t = Time constant

d) $t = 0$.

iii) The transfer function is $\frac{k}{(s+1)(s+2)(s+3)}$. The break point will lie between

a) 0 & –1 b) –1 & –2

c) –2 & –3 d) beyond –3.

iv) The terms in the first column of Routh's array of a characteristic equation are 6, 9, 2, 4, –3. Then number of roots of characteristic equation in the right half of s-plane is equal to

a) 0 b) 3

c) 4 d) 1.

v) Given that the transfer function G(s) is $\frac{K}{s^2(1+sT)}$. The type and order of the system are

a) 2 & 3 b) 3 & 2

c) 3 & 3 d) 2 & 2.

vi) The characteristic equation of a second order system is $s^2 + 6s + 25 = 0$. The system is

a) underdamped b) overdamped

c) undamped d) critically damped.

vii) A second order control system with $\xi = 0$ is always

a) marginally stable b) stable

c) unstable d) cannot be said.

viii) A system has 4 poles and one zero. Its high frequency asymptote in its magnitude plot has a slope of

a) – 100 dB/decade b) 100 dB/decade

c) – 60 dB/decade d) 60 dB/decade.

ix) The origin for the investigation of closed-loop stability in relation to Nyquist criterion is

a) $-1 + j0$ b) $1 - j0$

c) $0 + j1$ d) $0 - j1$.

x) The frequency at which the phase curve of a Bode plot crosses –180° line is called

a) natural frequency

b) phase crossover frequency

c) gain crossover frequency

d) corner frequency.

xi) –20 dB/decade is equivalent with

a) – 40 dB/octave b) – 8 dB/octave

c) – 18 dB/octave d) – 6 dB/octave.

xii) The slope of asymptotic Bode plot at low frequencies for a type 3 transfer function is

a) – 30 dB/decade b) – 60 dB/decade

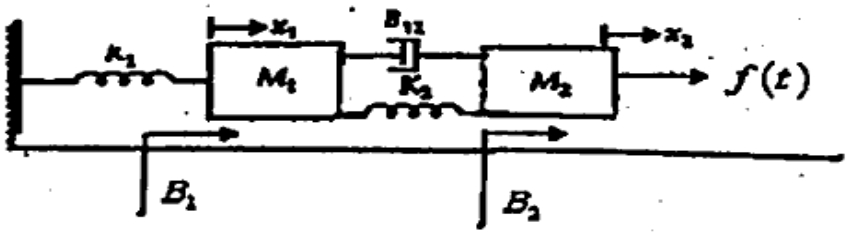
c) – 20 dB/decade d) – 40 dB/decade.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Find the equivalent force-voltage analogy circuit of the following mechanical translational system. 5



3. A unity feedback control system $G(S) = \dfrac{K(S+\alpha)}{(S+\beta)^2}$ is to be designed to meet the following specifications. Steady state error for a unit step input is 0.1. Damping ratio $\xi = 0.5$, natural frequency of oscillation $\omega_n = \sqrt{10}$. Find the values of K, α and β. 5

4. The characteristic equation of a feedback system is $s^4 + 4s^3 + 16s^2 + 16s + 48 = 0$. Check whether the system is oscillatory. If so, determine the frequency of oscillation using Routh-Hurwitz criteria. 5

5. The open loop transfer function of a feedback system is $G(s)H(s) = \frac{k(1+s)}{1-s}$. Comment on stability using Nyquist plot. 5

6. What are the properties of state transition matrix ? 5

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) The open loop transfer function of a unity feedback control system is given by $G(s) = \frac{K}{s(s^2 + s + 1)(s + 4)}$.

Applying Routh-Hurwitz criterion, discuss the stability of close loop system as a function of K. Determine the value of K which will cause sustained oscillation in the closed loop system. What is the corresponding oscillation frequency ?

b) The close loop (*-ve* feedback) system with forward path transfer function $G(s) = \frac{91.8}{S(S+6)}$, and feedback path transfer function $H(s) = 0.2$ with given unit step input. Determine the damping ratio (ξ), Maximum over shoot (M_p), Rise time (t_r). 8 + 7

8. a) Sketch the Root locus for the open loop transfer function of a unity feedback control system given below :

$$G(s)H(s)=\frac{K}{s(s+4)(s^2+4s+20)}.$$

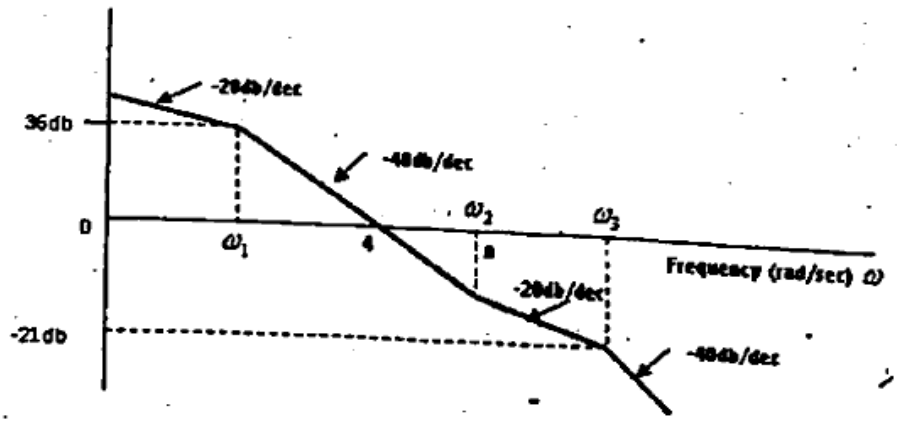
Show all relevant steps.

b) What is the 'Analogous system' ? Explain the 'Force-current analogy'. 12 + 1 + 2

9. Sketch the asymptotic Bode plot for the transfer function given $G(s)H(s)=\frac{2(s+0.25}{s^2(s+1)(s+0.5)}$. From the Bode plots determine i) P.C.F ii) G.C.F iii) PM iv) GM (All have usual meaning) for above transfer functions and mention about the stability condition.

10. a) Given the open loop transfer function $G(s)=\frac{K(S+2)}{(S+1)(S-1)}$ where K = 1. Draw the complete Nyquist plot and determine the stability of close loop system.

b) For the Bode plot shown in the figure below, find the transfer function. 10 + 5



11. a) Consider characteristic equations of the system given below. How many roots of characteristic equation are in the right half, left half and on $j\omega$ axis ? Find the stability condition using R-H criteria.

$$s^6 + s^5 + 8s^4 + 6s^3 + 20s^2 + 8s + 16 = 0$$

b) The open loop transfer function of a unity feedback control system is given by $G(s) = \frac{K}{s(1+s)(1+0.1s)}$

i) State the corner frequencies ii) Determine the gain K for gain crossover frequency of 5 red/second.

c) How can you determine the stability condition from Bode plot using gain margin (GM) and phase margin (PM). Show the different conditions of stability. 5 + 5 + 5