MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

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.

Graph sheet will be supplied by the Institute, if required.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) A system has a single pole of origin. Its impulse response will be

   a) constant b) ramp

   c) decaying in nature d) oscillatory.

   ii) Without affecting the steady state error, maximum overshoot can be decreased by

   a) derivative control b) integral control

   c) gain adjustment d) proportional control.

iii) The centre of the constant M-circles are defined by

a) $\left[\frac{M^2}{1+M^2}, 0\right]$ b) $\left[\frac{M^2}{1-M^2}, 0\right]$

c) $\left[0, \frac{M^2}{1+M^2}\right]$ d) $\left[0, \frac{M^2}{1-M^2}\right]$.

iv) The initial slope of Bode plot for a transfer function having single poles at origin is

a) 20 db/decade b) – 40 db/decade

c) 40 db/decade d) – 20 db/decade.

v) The capacitance, in force-current analogy is analogous to

a) velocity b) momentum

c) displacement d) mass.

vi) The 'type' of a transfer function denotes the number of

a) zeros at origin b) poles at infinity

c) poles at origin d) finite poles.

vii) The root locus diagram is

a) always symmetric about the real axis

b) always symmetric about the imaginary axis

c) never symmetric about the real axis

d) always symmetric about both the real & imaginary axes.

viii) The characteristic equation of a system is $s^2 + 2s + 4 = 0$. The system is

a) critically damped b) overdamped

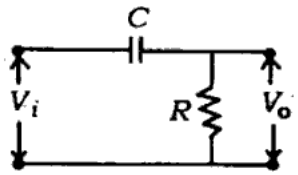
c) undamped d) underdamped.

ix) If the gain margin of a certain feedback system is given as 20 db, the Nyquist plot will cross the negative real axis at the point

a) $S = -0{\cdot}05$ b) $S = -0{\cdot}2$

c) $S = 0{\cdot}5$ d) $S = -0{\cdot}1$.

x) The transfer function of the network given below as



a) $\frac{1}{1+SRC}$ b) $\frac{SRC}{1+SRC}$

c) $\frac{RC}{1+SRC}$ d) $\frac{1+SRC}{1+RC}$.

xi) For eliminating the 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 control.

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xii) The transfer function of a network is $\frac{1+0\cdot3s}{2+s}$. It represents a

a) lag network

b) lead network

c) lag-lead network

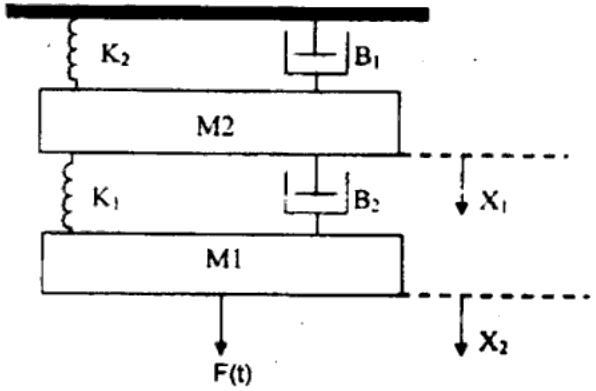
d) proportional controller.

GROUP – B

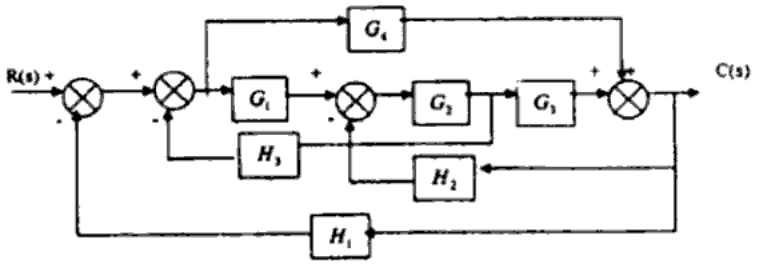
(Short Answer Type Questions)

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

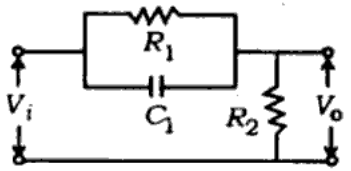
2. Determine the differential equation describing the complete dynamics of the mechanical system. Also develop the electrical analog circuit based on force – voltage analogy.



3. Find the overall transfer function of the system whose block diagram is given in figure below using Mason's gain formula.



4. Derive the transfer function $\frac{V_o(s)}{V_i(s)}$, for the electrical network shown below.



5. The open loop transfer function of a unity feedback control system is given by

$$G(s) = \frac{k}{(s+2)(s+4)(s^2+6s+25)}.$$

By applying Routh's criterion determine the range of k for which the closed loop system will be stable and find the frequency of oscillation.

6. Consider the unit step response of a unity feedback system whose open loop transfer function $G(s) = \frac{1}{s(s+1)}$. Obtain the rise time, peak time, maximum overshoot & settling time.

GROUP – C

(Long Answer Type Questions)

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

7. a) Sketch the root loci of a system for the following open loop control system on a graph paper $G(s) = \frac{k}{s(s+3)(s^2+2s+2)}$ and comment on following factors : (i) number of root loci, (ii) number of asymptotes, (iii) angle of asymptotes and real axis intercept, (iv) angle of departure, (v) imaginary axis intercept.

   b) Open loop transfer function of a system is given by $G(s)H(s) = \frac{k}{s(s+4)}$, check whether $s = -2 + j2$ lies on root locus. If so, find system gain, k at given point. $10 + 5$

8. a) The open loop transfer function of a unity feedback system is given by $G(s) = \frac{10}{s(1+s)(10+s)}$. Draw the Bode plot. Find phase crossover frequency, gain crossover frequency, gain margin & phase margin.

b) What is minimum phase system & non-minimum phase system ? Give examples. 10 + 5

9. a) State the 'Principle of argument' & its extension to Nyquist criterion.

b) Draw the Nyquist plot & determine the stability condition for the open loop transfer function of the system $G(s)H(s) = \frac{(s+2)}{(s+1)(s-1)}$. 5 + 10

10. a) Briefly discuss the necessity of PID controller in minimizing errors of a dynamical system response under step input. Show relevant graphical & mathematical expression.

b) Derive the transfer function for lead & lead-lag compensators with necessary passive equivalent circuits. 7 + 8

11. a) Consider the transfer function $G(j\omega) = \frac{1}{j\omega(1+j\omega T)}$.

Draw the polar plot of the function. Find the gain crossover frequency & phase margin of the transfer function.

b) A second order control system, having $\xi = 0 \cdot 4$ & $W_n = 5$ rad/sec, is subject to a step input. Determine (i) transfer function, (ii) t_r, (iii) t_p, (iv) t_s for 2% tolerance, (v) M_p. 7 + 8

12. Write short notes on the following : 3 × 5

a) Liquid level control

b) Speed control of DC motor

c) DC tacho generator.