(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 2121 Roll No.

B. Tech

(SEMESTER-V) THEORY EXAMINATION, 2012-13

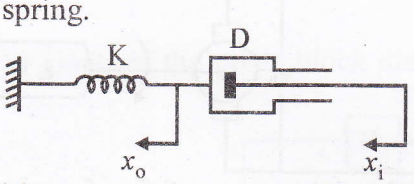
CONTROL SYSTEMS – I

Time : 3 Hours] *[Total Marks : 100*

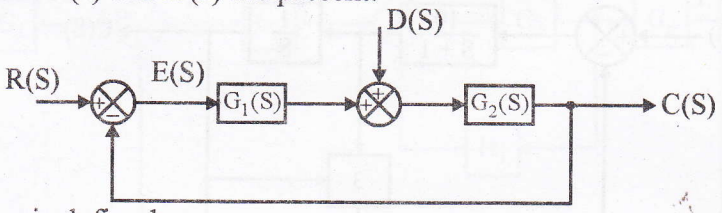
Section – A

1. Attempt **all** question parts : **10 × 2 = 20**

(a) Draw the electrical analogue of the mechanical system of fig. 1. x_i is the input displacement, x_0 is the output displacement, D is viscous damping coefficient and K is compliance of spring.



(b) Consider the closed loop control system of fig. 2. Obtain the expression for C(s) when both R(s) and D(s) are present.



(c) A system is defined as

$\dot{X}(t) = Ax(t) + Bu(t)$

$Y(t) = Cx(t) + Du(t)$

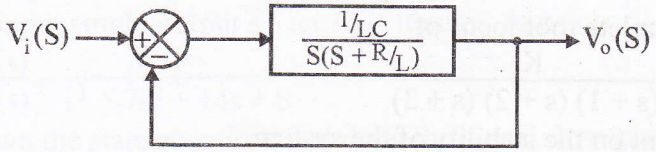
Find the expression for the transfer function $G(s) = \frac{Y(s)}{U(s)}$.

(d) The matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$ has characteristic equation

$|SI - A| = S^2 + 3S + 2 = 0$

Show that the matrix satisfies its characteristic equation.

(e) For the system of fig. 3, determine the value of E & W_n.



(f) What is the difference between the steady-state response and transient response of a control system ?

(g) Sketch the root locus of the open loop transfer function

$$G(s)\,H(s) = \frac{K}{s(s+1)(s+2)}$$

(h) What happens to the stability of the system if a zero is added to the system G(s) $H(s) = \frac{K}{s(s+2)}$?

(i) Draw polar plot of $G(s) = \frac{1}{s(Ts+1)}$

(f) Define gain margin and phase margin.

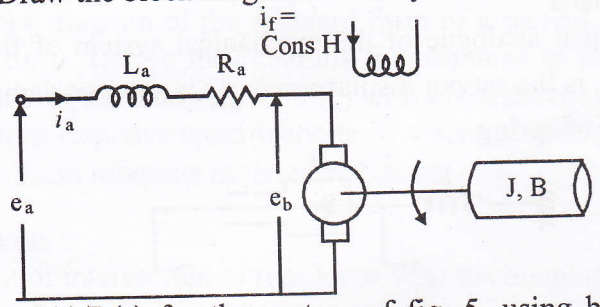
Section – B

2. Attempt any **three** question parts : **10 × 3 = 30**

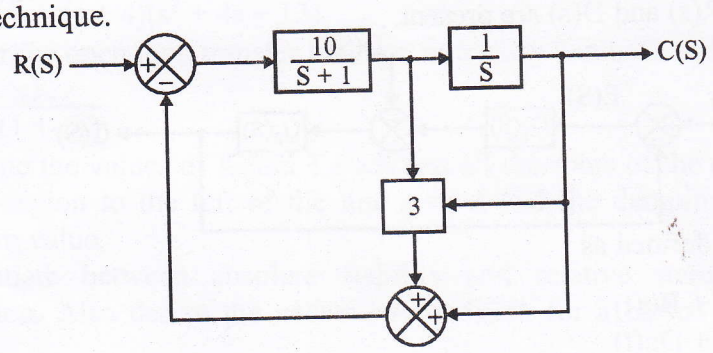
(a) (I) A separately excited dc motor with armature voltage control is shown in fig. 4.

(i) Determine the transfer function of the system.

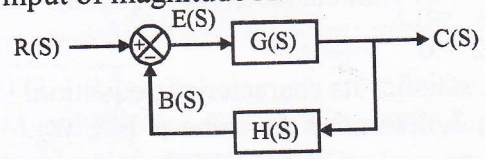
(ii) Draw the block diagram of the system.



(II) Obtain C(s)/R(s) for the system of fig. 5, using block diagram reduction technique.



(b) Derive the relation for steady state error for the system of fig. 6. Also derive the value of steady state error for step input of magnitude A, ramp input of magnitude A and parabolic input of magnitude A.

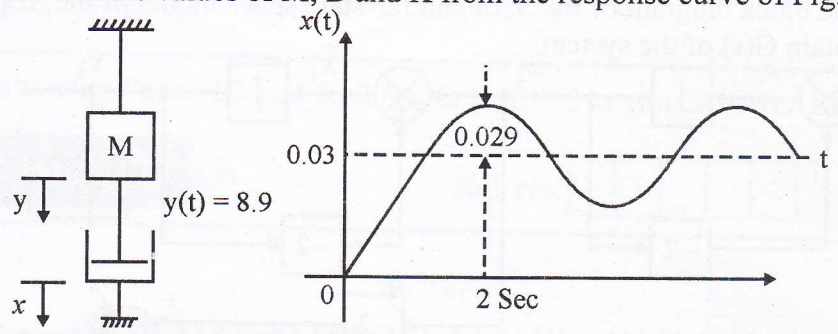


(c) Draw the complete root locus of

$$G(s)\,H(s) = \frac{K}{s(s+1)(s+2)(s+3)}$$

Also, comment on the stability of the system.

(d) Determine the values of M, B and K from the response curve of Fig. 7.



(e) A system dynamics is given by

$$\dot{\bar{x}} = \begin{bmatrix} -1 & 1 \\ 0 & -2 \end{bmatrix} \bar{x} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

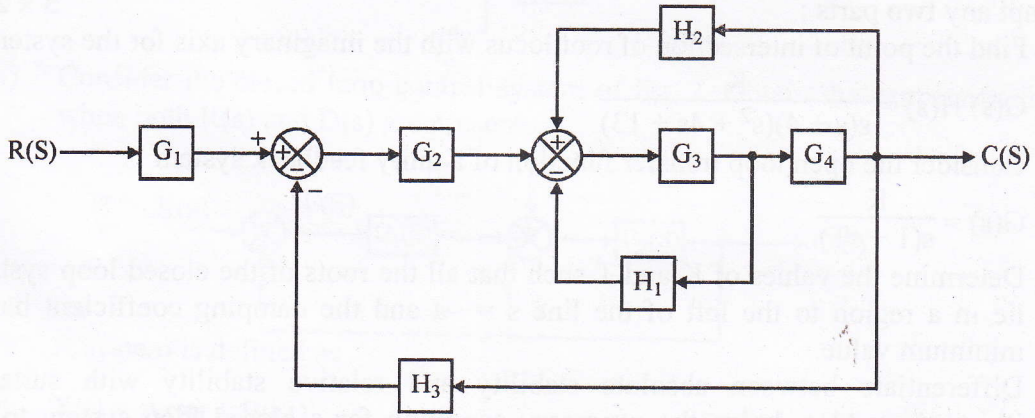
Given initial vector $\bar{x}(0) = \begin{bmatrix} -1 \\ 0 \end{bmatrix}$ and u(t) is the unit step function for all time $t \geq 0$. Find the time domain solution of the system and give the values of the state variables.

Section – C

Note : Attempt **all** questions : **10 × 5 = 50**

3. Attempt any **two** parts : **5 × 2 = 10**

(a) Draw the signal flow graph of the given block diagram of fig. 8 and its transfer function.



(b) A system is described by a differential equation $\frac{d^2y(t)}{dt^2} + \frac{3\,dy(t)}{dt} + 11y(t) = 5x(t)$ where y(t) is the output, and x(t) is the input. Obtain the transfer function of the system.

(c) What are the physical quantities (i) force (ii) mass (iii) damper, (iv) displacement and (v) velocity analogous to in the force current analogy and force voltage analogy ?

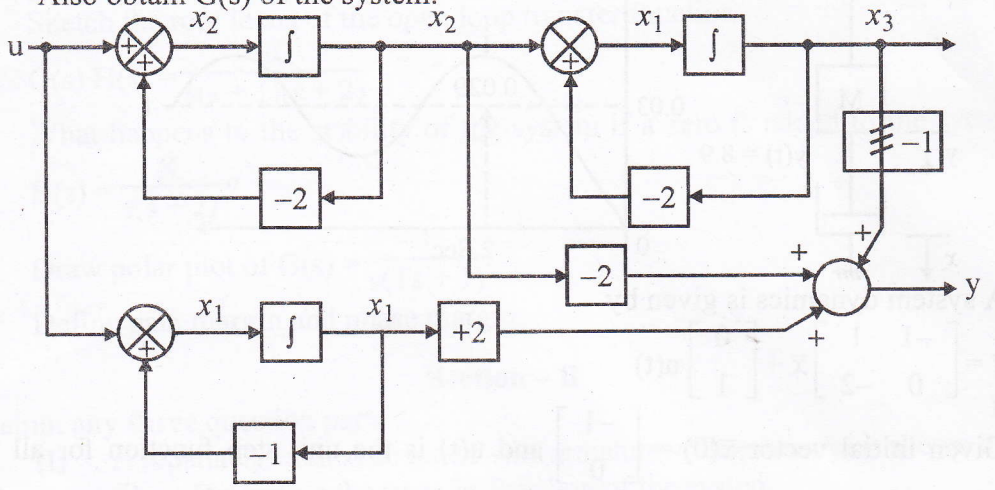
4. Attempt any **one** part : **10 × 1 = 10**

(a) A single input single-output system has transfer function

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{s^3 + 7s^2 + 14s + 8}$$

Write down the state equations and draw the signal flow graph.

(b) From the block diagram of fig. 9, obtain the state space model of the SISO system. Also obtain G(s) of the system.



5. Attempt any **one** part : **10 × 1 = 10**

(a) Draw the block diagram of the standard form of a second order control system in closed loop form. Derive the relations for response to step input (u(t) = 1) for different values of the damping ratio (ξ) with illustrations.

(b) Define the time response specifications of a second order system for a unit step input. Derive these relations in terms of ξ & ω_n.

6. Attempt any **two** parts : **5 × 2 = 10**

(a) Find the point of intersection of root locus with the imaginary axis for the system

$$G(s)\,H(s) = \frac{K}{s(s+4)(s^2+4s+13)}$$

(b) Consider the open loop transfer function of a unity feedback system

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

Determine the values of K and T such that all the roots of the closed loop system lie in a region to the left of the line s = –a and the damping coefficient has a minimum value.

(c) Differentiate between absolute stability and relative stability with suitable illustration. Also derive the necessary condition for a closed loop system to be stable.

7. Attempt any **one** part : **10 × 1 = 10**

(a) Draw the Bode plot of the unity feedback control system having open loop transfer function

$$G(s) = \frac{10}{s(1+0.02s)(1+0.2s)}$$

Also determine GM and PM and discuss the stability of the closed loop system.

(b) Draw the complete Nyquist plot of the open loop transfer function $G(s)\,H(s) = \frac{(s+2)}{(s+1)(s-1)}$ and determine the stability of the closed loop system.