53 (IE 503) CNSY-I

2013

(December)

CONTROL SYSTEM-I

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer five questions out of ***seven.***

1. *(a)* Write the differential equations governing the behaviour of the mechanical system shown in *Fig. (1.a)*. Also obtain the analogous electrical circuits based on 8

   (i) force-current analogy

   (ii) force-voltage analogy

   Also find the transfer function $\dfrac{X_1(S)}{F(S)}$

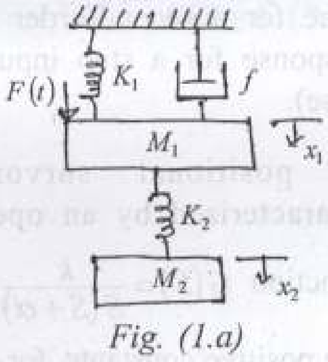

Fig. (1.a)

(b) Reduce the block shown in *Fig (1.b)* and obtain the overall transfer function 8

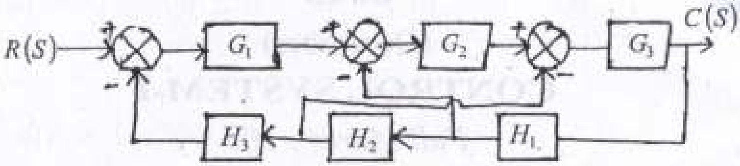

Fig. (1.b)

(c) For the system represented by the following equations, find the transfer function $X(S)/F(S)$ by signal flowgraph technique.

$$x = x_1 + \beta_3 u$$

$$\dot{x}_1 = -\alpha_1 x_1 + x_2 + \beta_2 u$$

$$\dot{x}_2 = -\alpha_2 x_1 + \beta_1 u$$ 4

2. (a) Obtain expressions for rise time and peak time for a second-order feedback system response for a step input (under-damped case). 5

(b) A positional survomechanism is characterised by an open loop transfer function $G(S) = \dfrac{k}{S(S+\alpha)}$, where k and α are positive constants, for a unity feedback.

Find the values of k and α for a damping co-efficient value of 0.6 and damped frequency of $8 rad/sec$. Also find the peak value of the response when the system is excited by a step of 2 volts. 10

(c) A unity feedback control system has $G(S)=\frac{k(S+13)}{S(S+3)(S+7)}$. Using the Routh's criterion, calculate the range of 'k' for which the system is stable. 5

3. (a) What is the effect on polar plot if a pole at origin is added to the transfer function? 2

(b) Sketch the polar plot of the system given by

$$G(S)=\frac{500}{S(S+6)(S+9)}$$ 10

(c) The open loop transfer function of a servo system with unity feedback is

$$G(S) = \frac{10}{S\,(0.1S+1)}$$

Evaluate the static error co-efficient (k_p, k_v, k_a) for the system. Obtain the steady-state error of the system when subjected to an input given by the polynomial

$$r(t) = a_0 + a_1 t + \frac{a_2}{2} t^2$$ 8

4. (a) Plot the root-locus for a closed-loop control system with $G(S) = \frac{k(S+q)}{S(S^2+4S+11)}$ and $H(S) = 1$.

Locate the closed-loop poles on the root-locus such that the dominant closed-loop poles have a damping ratio equal to 0.5. Determine the corresponding value of gain K. 15

(b) Why root locus technique is needed in control system? What are the basic conditions to sketch the root locus? 5

5. *(a)* Sketch the Bode plot for the transfer function given below and hence find Gain cross over frequency, phase cross over frequency, Gain margin and phase margin.

$$G(S)=\frac{10}{S(1+0.5S)(1+0.01S)} \qquad 20$$

6. *(a)* State Nyquist stability criterion. 5

(b) Draw the Nyquist plot for the system whose open loop transfer function is 5

$$G(S)\,H(S)=\frac{k}{S(S+2)(S+10)}.$$

Determine the range of k for which closed loop system is stable. 15

7. Write short notes on the following : ***(any four)*** 4×5

(a) Phase margin and Gain margin

(b) Masson's Gain formula

(c) Proportional and Derivative action

(d) Tachometer

(e) DC Servomotor

(f) Synchro error detector.
