53 (IE 503) CNSY-I

2014

CONTROL SYSTEM-I

Paper : IE 503

Full Marks : 100

Time : Three hours

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

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

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

   (i) fource - current analogy

   (ii) fource - voltage analogy 2+2+2

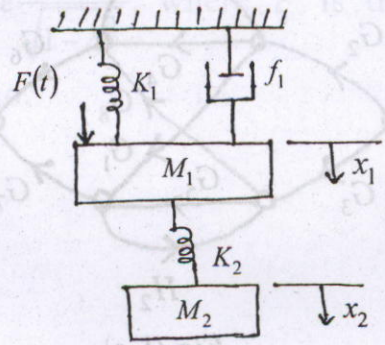

Fig.(1.a)

Contd.

(b) Simplify the block diagram shown in *Fig.(1.b)*. Obtain the closed-loop transfer function $C(S)/R(S)$ using block diagram algebra. 7

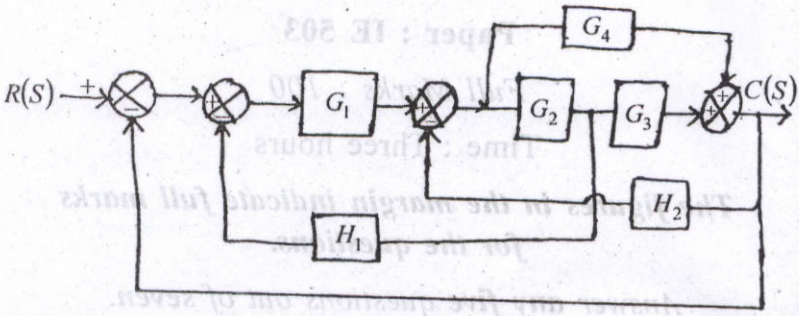

Fig.(1.b)

(c) Obtain the overall transfer function C/R from the signal flow graph shown in *Fig. (1.c)*. 7

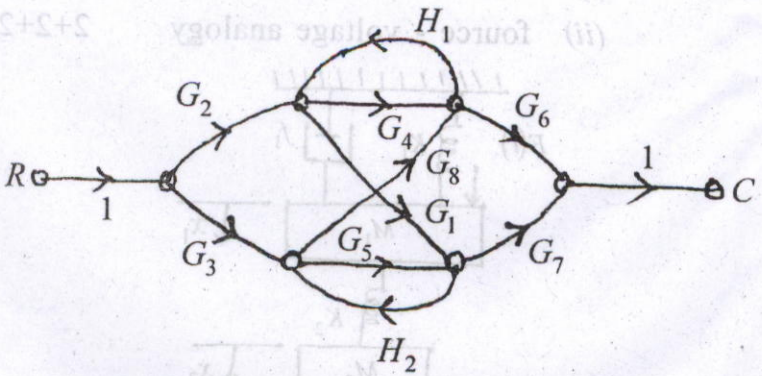

Fig.(1.c)

2. *(a)* A unity feedback system is characterised by an open loop transfer function

$$G(S)=\frac{40}{S(0{\cdot}5S+1)}$$

Determine the error constants for the system. Also obtain the steady-state error when the input is $r(t)=1+5t+10t^2$. 5

(b) Derive the unit step response to a typical second order feedback control system. 5

(c) Prove the maximum over shoot for the unit step response for the second order system is $e^{\frac{-\xi\pi}{\sqrt{1-\xi^2}}}$, where ξ is the damping ratio. 5

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

$$\frac{K}{S(S+3)\left(S^2+S+1\right)}$$

By applying Routh criterion, discuss the stability of the closed loop system as a function of K. Determine the value of K which will cause sustained oscillations in the closed loop system. What are the corresponding oscillation frequency ? 5

3. (a) 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 constant. By what factor should the amplifier gain be reduced so that the peak overshoot of unit-step response of the system is reduced from 75% to 25% ? 5

(b) A unity feedback control system has an open-loop transfer function

$$G(S)=\frac{K}{S\left(S^2+4S+13\right)}$$

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

(i) Centroid, number and angle of asymptotes.

(ii) Angle of departure of root loci from the poles.

(iii) Break away point if any.

(iv) The value of K and the frequency at which the root loci cross the jw-axis. 15

4. Sketch the Bode plot showing the magnitude *(dB)* and phase angle (degree) as a function of log frequency for the transfer function

$$G(S)=\frac{10}{S(1+0{\cdot}5S)(1+0{\cdot}01S)}$$

Determine the gain crossover frequency, phase crossover frequency, gain margin and phase margin. 20

5. Sketch the Nyquist plot having the open loop transfer function of a unity feedback control system as

$$G(S)=\frac{K}{S(S+1)^2}$$ and determine 20

(i) The limiting value of K for closed loop stability.

(ii) The gain and phase margin for $K=0{\cdot}5$.

6. *(a)* What is the difference between the polar plot and Nyquist plot ?

With an example explain which technique is best for stability checking. 5

(b) Sketch the polar plot of the system

$$G(S)=\frac{1}{S(1+S)(1+2S)}$$ 10

(c) State and prove the Nyquist stability criterion. 5

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

(a) The P-I-D control effect

(b) Armature control PMDC motor

(c) Synchro error detector

(d) Brushless DC motor

(e) BIBO stability.
