Total number of printed pages–7

53 (IE 506) CNTC

2016

CONTROL THEORY

Paper : IE 506

Full Marks : 100

Time : Three hours

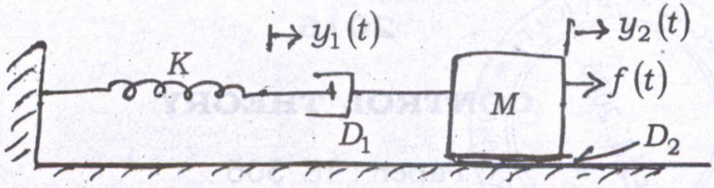
The figures in the margin indicate full marks for the questions.

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

1. *(a)* Discuss the advantages of using feedback in a water-level control system for household application. 4

   (b) Explain the working of a synchro error detector. Show how one can use it for AC servomotor based angular position control system. 6

(c) (i) Write the differential equations for the mechanical system shown below



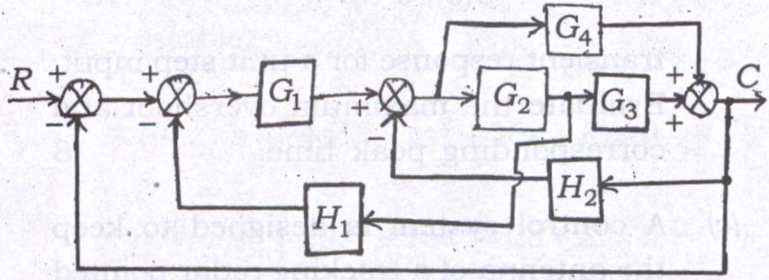
where K is the spring constant, D_1 and D_2 are damping coefficients, M is the mass, $f(t)$ is the force input, $y_1(t)$ and $y_2(t)$ are the displacement output.

(ii) Obtain the analogous electrical networks based on force-current analogy and force-voltage analogy. 4+6

2. (a) Draw the block diagram of an armature controlled DC motor. Show how one can control the angular speed

$$w(t) = \frac{d\theta(t)}{dt}$$ by varying the armature current. Discuss also the effect of varying the moment of inertia of the rotor output. 8

(b) Obtain the transfer function of the feedback control system shown below using block diagram reduction technique.



Verify the above result using Mason's gain formula and signal flow graph method. 12

3. (a) Derive the unit-ramp response of a first-order system with closed loop transfer function $M(s)=\frac{1}{Ts+1}$. From the output response determine also the steady state error. 6

(b) The open-loop transfer function of a unity feedback control system is given as $G(s)=\frac{0{\cdot}4s+1}{s(s+0{\cdot}6)}$. Determine the transient response for a unit step input. Evaluate the maximum overshoot and corresponding peak time. 8

(c) A control system is designed to keep the antenna of a tracking radar pointed at a flying target. The system must be able to follow a target travelling in a straight line with a speed of $200m/s$ with maximum permissible error of 0·01 degree. The shortest distance from the antenna to the target is $250m$. Find the value of error constant K_v in order to satisfy the requirements. 6

4. (a) Discuss how PD controller can improve the unit step transient response of a unity feedback second order control system. Determine also its effect on the steady state error in unit ramp response. 8

(b) Using Routh's stability criterion examine the condition under which the systems represented by the following characteristic equations will remain stable.

(i) $s^4 + 4s^3 + 13s^2 + 36s + K = 0$

(ii) $s^4 + 20s^3 + 15s^2 + 2s + K = 0$

Determine the value of K and the frequency of sustained oscillations if the system can be marginally stable.

6+6

5. *(a)* Draw the complete root locus of a system whose open-loop transfer function is given as

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

Write all the necessary steps involved in finding it out. 14

(b) Determine and draw the polar plot of an open loop transfer function given as

$$G(s)\,H(s)=\frac{1}{s(1+sT_1)(1+sT_2)}.$$ 6

6. (a) Explain how the following factors of $G(j\omega)\,H(j\omega)$ contribute to the Bode plot of frequency response.

(i) Multiple poles at the origin $1/(j\omega)^n$

(ii) First order pole on the real axis $1/(1+j\omega T)$

(iii) Quadratic pole,

$$\frac{1}{\left[1+2\zeta\left(\frac{j\omega}{\omega_n}\right)+\left(\frac{j\omega}{\omega_n}\right)^2\right]}$$

Explain the contribution on both the amplitude and phase of the Bode plot. 10

(b) Sketch the Bode plot for the following transfer function and determine the system gain crossover frequency, phase crossover frequency, gain margin and phase margin

$$G(s)\,H(s) = \frac{80(s+5)}{s^2\,(s+50)}. \qquad 10$$

7. (a) Sketch the Nyquist plot and therefrom determine the stability of the closed-loop system whose open-loop transfer function is given by

$$G(s)\,H(s) = \frac{K}{s(s^2+s+2)}. \qquad 12$$

(b) List the design procedure for a lead compensator. 8
