Total number of printed pages– 5

53 (IE 506) CNTH

2018

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.*

1. *(a)* Define the following : 5×2=10

   (i) Plants

   (ii) Processes

   (iii) Disturbances

   (iv) Open-Loop Control Systems

   (v) Closed-Loop Control Systems.

   (b) Find the Laplace transfroms of the following functions : 2×5=10

   (i) $f_1(t) = 0$ for $t < 0$

   $= e^{-0.4t} \cos 12t$ for $t \geq 0$

   (ii) $f_2(t) = 0$ for $t < 0$

   $= \sin wt . \cos wt$ for $t \geq 0$

Contd.

2. *(a)* Find the inverse Laplace transforms of the following functions : 2×5=10

(i) $F_1(s) = \frac{1}{s^2(s^2 + w^2)}$

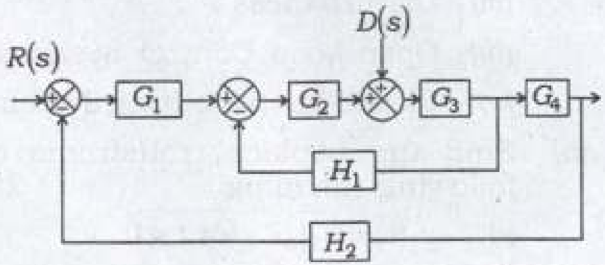
(ii) $F_2(s) = \frac{w_n^{\ 2}}{s(s^2 + 2\xi w_{ns} + w_n^{\ 2})}$

(b) By applying the final-value theorem, find the final value of $f(t)$ whose Laplace transform is given by

$F(s) = \frac{10}{s(s+1)}$.

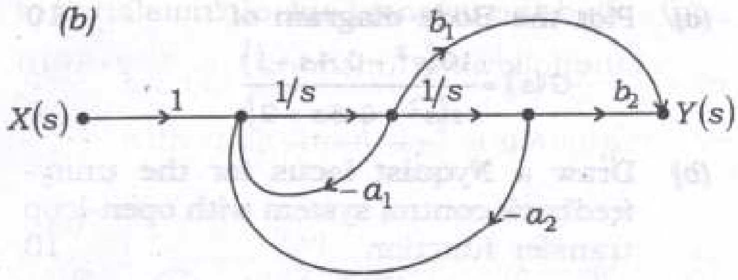
Verify this result by taking the inverse Laplace transform of $F(s)$ and letting $t \to \infty$ 10

3. *(a)*



Obtain the transfer function $C(s)/R(s)$ and $C(s)/D(s)$ of the system shown in the above figure. 10

(b)



Obtain the transfer function $Y(s)/X(s)$ of the system shown in the above signal flow graph. 10

4. *(a)* Consider the unit-step response of a unity-feedback control system whose open-loop transfer function is 10

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

Obtain the rise time, peak time, maximum overshoot and settling time.

(b) Consider a unity-feed back control system with the following feed forward transfer function : 10

$$G(s) = \frac{K}{s(s^2 + 4s + 8)}$$

Plot the root loci for the system. If the value of gain K is set equal to 2, where are the closed-loop poles located ?

5. *(a)* Plot the Bode diagram of 10

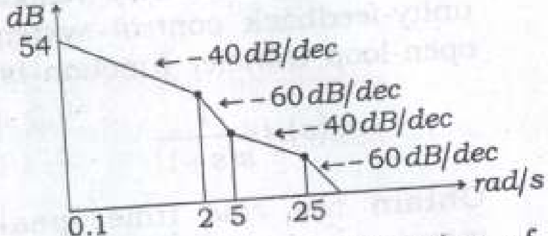
$$G(s)=\frac{10(s^2+0.4s+1)}{s(s^2+0.8s+9)}$$

(b) Draw a Nyquist locus for the unity-feedback control system with open-loop transfer function 10

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

Using Nyquist stability criterion, determine the stability of the closed-loop system.

6. *(a)*



The asymptotic approximation of the log-magnitude versus frequency plot of a minimum phase system with real poles and one zero is shown in the above figure. Derive its transfer function. 10

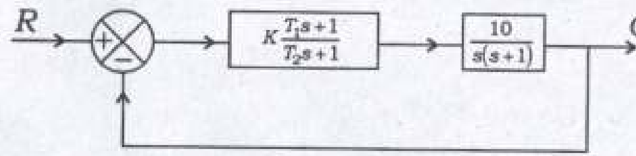
(b) The characteristic equation of a feedback control system is : 5

$$2s^4+s^3+3s^2+5s+10=0$$

Determine the number of roots in the right half of *s*-plane.

(c) Calculate the transfer function of the system described by $\frac{d^2y}{dt^2}+\frac{dy}{dt}=\frac{du}{dt}+2u$ with *u* as input and *y* as output. 5

7. *(a)*



Determine the values of *K*, T_1 and T_2 of the system shown in the above figure so that the dominant closed-loop poles have the damping ratio $\xi=0.5$ and the undamped natural frequency $\omega_n=3 rad/sec$. 10

(b) Consider a unity-feedback control system with the open-loop transfer function. 10

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

Determine the value of the gain *K* such that the phase margin is 50°. What is the gain margin with this gain *K*?