Total Pages—7

B.Tech-6
CSE-II

Set-2

CONTROL SYSTEM ENGINEERING - II

Full Marks : 70

Time : 3 hours

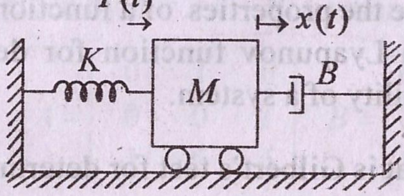
Answer **Q. No. 1**, which is compulsory and any **five** from the rest

The figures in the right-hand margin indicate marks

1. Answer the following : 2×10

(*a*) What do you mean by a modal matrix ? Given any system matrix, how can you construct a modal matrix ?

(*b*) Obtain the state model of the mechanical system shown in figure.



(*Turn Over*)

(c) Obtain the phase variable state model for the system described by the differential equation

$$4\frac{d^3y}{dt^3}+3\frac{d^2y}{dt^2}+\frac{dy}{dt}+2y(t)=5u(t)$$

(d) What is meant by 'Pole placement through state feedback control' ? How does it differ from the design approach by root locus method ?

(e) What do you mean by a 1st order hold device ? How does it differ from a zero order hold ?

(f) Show that the mapping $z=e^{sT}$ between the S-plane and the Z-plane is not a one-to-one mapping.

(g) State the properties of a function to quality as a Lyapunov function for determining stability of a system.

(h) What is Gilbert's test for determining state controllability ?

(Continued)

(i) Write any three differences between a lag and a lead compensator.

(j) What do you understand by the terms 'phase plane' and 'phase trajectory' ?

2. The state equation of a linear time-invariant system is given as

$$\dot{X}=\begin{bmatrix}0 & 5\\ -1 & -2\end{bmatrix}X+\begin{bmatrix}1\\ 1\end{bmatrix}r \quad \text{and} \quad Y=\begin{bmatrix}1 & 1\end{bmatrix}X$$

Determine 4 + 4 + 2

(a) The characteristic equation and eigenvalues

(b) The state transition matrix

(c) The transfer function

Also, draw the state diagram.

3. (a) Consider a regulator system in which the plant is given by $\dot{X}=AX+BU$, where

$$A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix},\ B=\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}.$$

(Turn Over)

The system uses state feedback control $u = -kx$ to locate the desired closed loop poles at

$$S_1 = -2 + j4,\ S_2 = -2 - j4,\ S_3 = -10$$

Determine the state feedback gain matrix K using any one method. 5

(*b*) Draw the block diagram of an observed state feedback control system and show that the controller poles and the observer poles can be placed independent of each other. 5

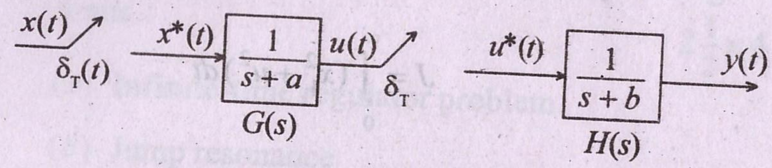
4. (*a*) Obtain the inverse *z*-transform of

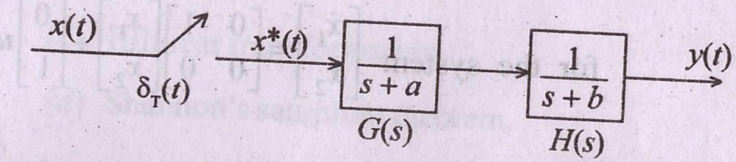
$$X(z) = \frac{z^2}{(z-1)^2(z-e^{-at})}$$

by using (*i*) inversion integral method

(*ii*) partial fraction expansion method. 6

(*b*) Consider the systems shown below





Show that the two systems have different pulse transfer functions. 4

5. (*a*) Obtain the Z-transform of K^3. 3

(*b*) Derive the formula to determine the Z-transform of a sequence $X(k)$, advanced by *n* sampling instants. 3

(*c*) A continuous time system has state equation given by

$$\dot{X} = AX, \text{ where } A = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$$

Find $F(A) = e^{AT}$ using Cayley-Hamilton theorem. 4

6. (*a*) Obtain the control law which minimizes the performance index

$$J = \int_0^{\infty} (x_1^2 + u^2)\,dt$$

for the system $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$ 5

(*b*) Explain in brief about the various non-linearities. Draw the input-output characteristic in each case. 5

7. (*a*) What do you understand by the term 'describing function'? Determine the describing function for the saturation non-linearity. 6

(*b*) What is a lead compensator? Show its pole-zero location in the *s*-plane. Derive an expression for the maximum phase lead and the frequency at maximum phase lead. 4

8. Give brief description about the following terms : $2\frac{1}{2} \times 4$

(*a*) Infinite-time regulator problem

(*b*) Jump resonance

(*c*) Bilinear transformation

(*d*) Shannon's sampling theorem.
