IMPORTANT QUESTIONS

Control Systems, Feedback and Modeling of Systems

1. Derive the transfer function $\frac{E_o(s)}{E_i(s)}$ of the network shown below.

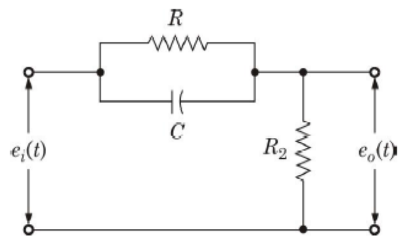


Fig. 1

2. Derive the closed loop transfer function $\frac{C(s)}{R(s)}$ = M(s) for the system shown below and find its sensitivity w.r.t. G and H

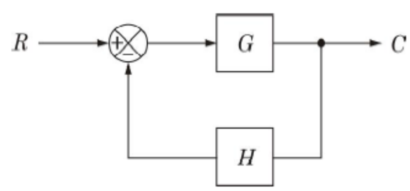


Fig. 2

3. Write the differential equation and obtain the $(f - v)$ force voltage analogous networks for the system shown in fig.

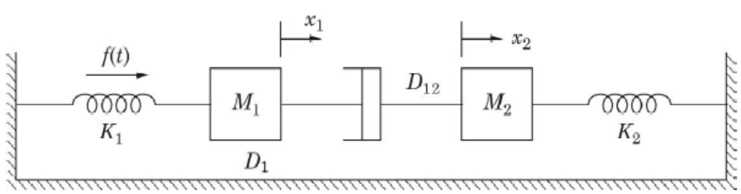


Fig. 3

4. Draw the block diagram of a closed loop control system and indicate the following on it. (i) plant (ii) command input (iii) controlled input (iv) actuating signal (v) feedback element and control element.

5. Explain difference between positive feedback and negative feedback.

6. What is need of a control system? Explain the different performance specifications, which the control system have to meet.

7. Distinguish with suitable example, between the open and closed loop control systems.

8. Define force-voltage analogy and force-current analogy translational mechanical system.

9. Compare open loop control system with closed loop control system.

10. Find the transfer function for the system whose block diagram representation is shown in Fig. 4.

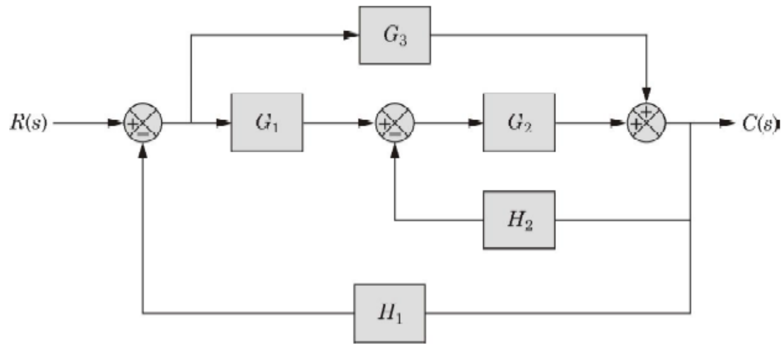


Fig. 4

11. What do you mean by feedback control system? Distinguish between an open loop system and closed loop system.

12. Find the transfer function for the system whose block diagram representation is shown in Fig. 5.

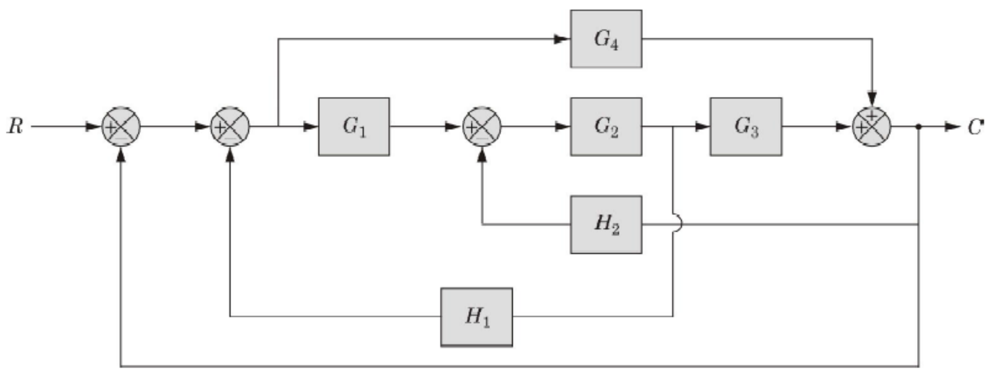


Fig. 5

13. Discuss the effect of feedback on stability, noise and overall gain of system.

14. Draw the electrical analogy, using force current analogy of the mechanical system given in Fig. 6.

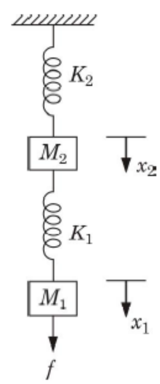


Fig. 6

Signal Flow Graphs and Components in Control System

1. What is Mason's gain formula? Define each term therein.
2. From the signal flow graph given in Fig. 1, find the transfer fuction C/R using Mason's Gain Rule.

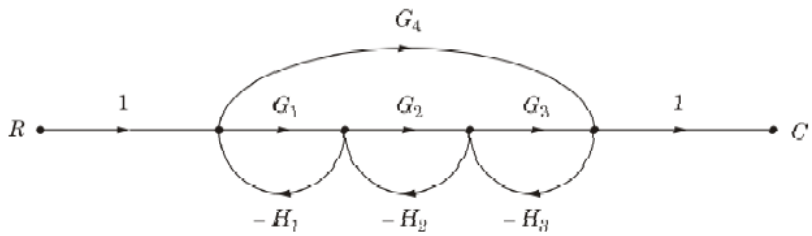


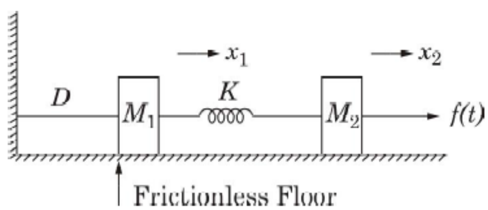
Fig. 1

3. Define the following:
   (I) Path **(II)** Forward path **(III)** Path Gain **(IV)** Loop **(V)** Non-touching loop.

4. Write notes on **(I)** Control valves **(II)** RTD **(III)** DC Tachometer generator.

State Variable Analysis

1. Derive the state variable model for the system shown below:



For the state matrix $A = \begin{bmatrix} 0 & 1 \\ -8 & -6 \end{bmatrix}$, find e^{At} by any two methods.

2. Write a note on solving state equation.

3. What is meant by state transition matrix? List the three properties of state transition matrix.

4. Obtain the state model of the system whose transfer function is given by

$$T(s) = \frac{s^2 + 3s + 3}{s^3 + 2s^2 + 3s + 1}$$

and hence, find its state transition matrix.

5. Consider the system

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u, \; x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$y = [1\ 0]x$$

(i) Determine the stability of the system.

(ii) Find the output response of the system to unit-step input.

Write the state equation for the non-homogeneous system and derive the equation for finding its solution.

6. Closed loop transfer function of a system is given as $T(s) = \frac{10(s+4)}{s(s+1)(s+3)}$ from a state variable model of the system. Is there a name for this form of state transition matrix?

7. (i) Define and state the physical significance of following terms:

Phase variables, state-space, eigen-value, conical variables, companion variables.

(ii) Define and explain the controllability and observability with a suitable example.

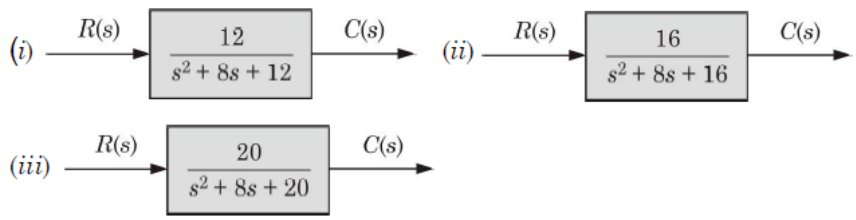
8. Consider a single-input-single output control system having an overall transfer function $T(S)$ given by

$$T(S) = \frac{s^2 + 4s + 4}{s^3 + 5s^2 + 4s}$$

Represents the system state model in terms of the canonical variables and determine a set of coefficients matrix A, B, C.

Time Domain Analysis of Control Systems

1. Define natural frequency of oscillation wn and damping ratio ξ of a second order system. find the nature for the following system:



2. Find the damping factor ξ, natural frequency wn, peak time T_p and percentage overstrict for the system with

$$G(s) = \frac{1}{9s^2 + 2s + 58}$$

Draw its pole, zero locations.

3. A closed loop servo is represented by the differential equation.

$$\frac{d^2c}{dt^2} + \frac{8dc}{dt} = 64\, e$$

where c is the displacement of the output shaft, r is the displcaement of the input shaft and $e = r - c$ determine.

(*i*) damping ratio

(*ii*) damped natural frequency

(*iii*) % M_p for unit step input.

4. (*i*) Define the following terms time delay, rise time, settling time, peak overshoot.

(*ii*) Find the response as '*t*' approaching infinity of a system having transfer function $\frac{C(s)}{R(s)} = \frac{8}{s(s+4)}$ to unit step input.

5. A servomechanism is characterized by the differential equation $\frac{d^2c}{dt^2} + 6.4\frac{dc}{dt} + 160\,(0.4c - r)$ find the value of damping ratio. What information does this convey about the transient performance.

6. Define the following:

(I) Peak overshoot (II) Settling time (III) Rise time.

7. Derive expressions for peak overshoot for the second order control system.

8. Measurement conducted on a servomechanism show the system response to be

$$C(t) = 1 + 0.2e^{-60}t - 1.2e^{-10}t$$

when subjected to a unit step input. Obtain the expression for the closed loop transfer function.

Stability of Linear Control Systems

1. The characteristic polynomial of a system is $s^7 + 9s^6 + 24s^5 + 24s^3 + 24s^2 + 23s + 15 = 0$. Determine the location of roots on s-plane and hence the stability of the system.

2. A feedback system has open-loop transfer function of $G(s) = \dfrac{K\,e^{-s}}{s(s^2 + 5s + 9)}$. Determine the maximum value of k for stability of closed loop system.

3. Determine the range of k for stability of unity feedback system whose open loop transfer function is $G(s) = \dfrac{K}{s(s+1)(s+2)}$.

4. Determine whether the largest time constant of the characteristic equation given below is greater than less than or equal to 1.0 sec:

$$s^2 + 4s^2 + 6s + 4 = 0.$$

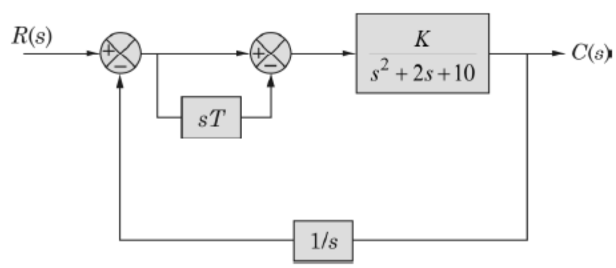
5. Determine the range of values of K such that the characteristic equation:

$$s^3 + 3\,(K + 1)\,s^2 + (7K + 5)\,s + (4K + 7) = 0.$$

6. State the Routh stability criterion. Discuss its advantages over Hurwithz stability criterion. Also discuss relative stability concept.

7. Examine the stability of the system having characteristic equation $s^5 + s^4 + 3s^3 + 2s^2 + 4s + 8 = 0$.

8. Find the characteristic equation of the system shown in Fig.



Basics of Frequency Domain Analysis

1. Define and explain various frequency domain specifications with relevant expression.

2. Establish correlation between frequency domain response and time domain response.

3. Discuss the concept of stability for bounded input bounded output continous data systems. Also explain the concept of relative stability.

4. Determine the frequency domain specifications for a second order system with unity feedback and $G(s) = \frac{225}{s(s+6)}$.

Stability Analysis Using Bode Plots

1. Discuss the general procedure of determination of transfer function from Bode plot.

2. State the Bode plot magnitude Curve characteristics of a type 1 system.

$$G(jw) = \frac{K_1}{j\omega((1 + j\omega T_1)}$$

3. Define Gain margin, phase margin, gain cross-over frequency, phase Gross-over

4. The open loop transfer function of a control system is

$$G(s)H(s) = \frac{1}{s(1 + 0.5s)(1 + 2s)}$$

1. Plot a Bode diagram for the given open loop transfer function.
2. Determine the appropriate value of gain and phase margin.

5. Write a note on Bode pole. How does it help in system design?

6. Discuss the effect of adding a zero to a system.

7. Define the following:

(I) Resonant peak (II) Gain margin (III) Phase margin.

8. Sketch the Bode plot for the system having

$$G(s)\,H(s) = \frac{20}{s\,(0.1s+1)}$$

9. Discuss the concept of stability for bounded input bounded output continuous data systems. Also explain the concept of relative

10. Determine the frequency domain specifications for a second order system with unity feedback and

$$G(s) = \frac{225}{s\,(s+6)}$$

11. A unity feedback control system has

$$G(s) = \frac{400(s+2)}{s^2\,(s+5)(s+10)}$$

Draw the Bode plot.

12. A unity feedback control system has

$$G(s) = \frac{k}{s(s+4)(s+10)}$$

Draw the Bode plot. Find k when P.M. = 30°