1. Define the following terms :
   (*i*) System
   (*ii*) Control system
   (*iii*) Input
   (*iv*) Output
   (*v*) Disturbance
2. Define open-loop and closed-loop control systems. Mention their merits and demerits.
3. Draw the block diagram of a closed-loop system and indicate the following on it :
   (*i*) Plant
   (*ii*) Command input
   (*iii*) Controlled output
   (*iv*) Actuailising signal
   (*v*) Feedback element and control element.
4. What is Feedback ? Explain the effects of feedback.
5. How are feedback control systems classified ?
6. Differentiate between
   (*i*) Linear and nonlinear systems
   (*ii*) Time-invariant and time-varying systems
   (*iii*) Continuous and discrete-data systems
7. What are the limitations of open-loop systems over closed-loop systems ? List the advantages of closed-loop system over open-loop system.
8. Explain the following terms giving suitable examples :
   (*i*) Servomechanism
   (*ii*) Regulator

1. What do you mean by transfer function ?

2. Find the transfer function of the network shown in Fig. P2.1

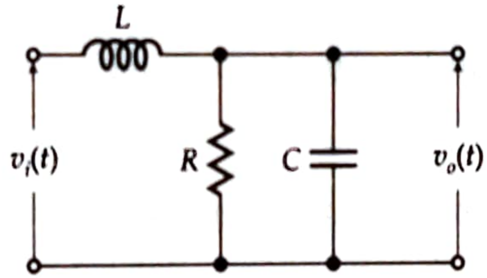

Fig. P2.1

[**Ans.** $\dfrac{V_o(s)}{V_i(s)} = \dfrac{1}{LCs^2 + \dfrac{L}{R}s + 1}$]

3. Derive the transfer function of the network shown in Fig. P2.2

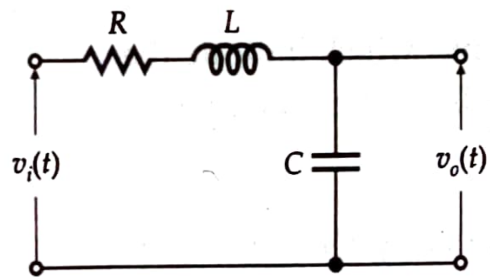

Fig. P2.1

[**Ans.** $\dfrac{V_o(s)}{V_i(s)} = \dfrac{1}{LCs^2 + RCs + 1}$

EXERCISES

1. Determine the transfer function $\dfrac{C(s)}{R(s)}$ for the block diagram as shown in Fig. P3.1.

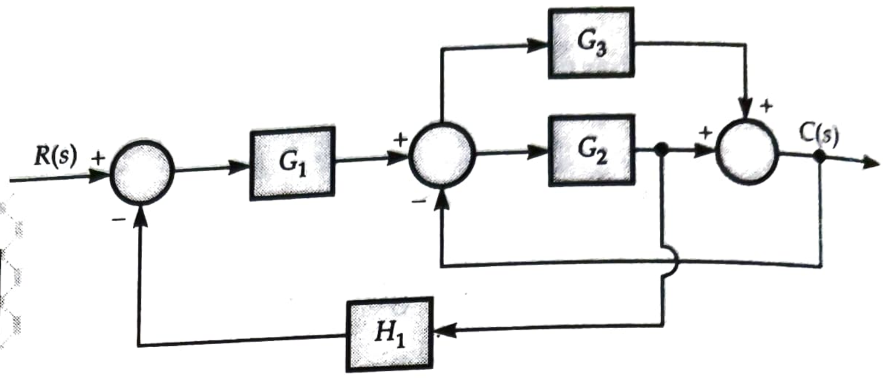

Fig. P3.1

Ans. $\left[\dfrac{C(s)}{R(s)} = \dfrac{G_1(G_2 + G_3)}{1 + G_2 + G_3 + H_1G_1G_2}\right]$

2. What do you mean by a block diagram ? What is meant by summing point and takeoff point ? State the advantages of block diagram representation.

3. Reduce the block diagram shown in Fig. P3.2 and find the input-output relationship ratio $\dfrac{C}{R}$.

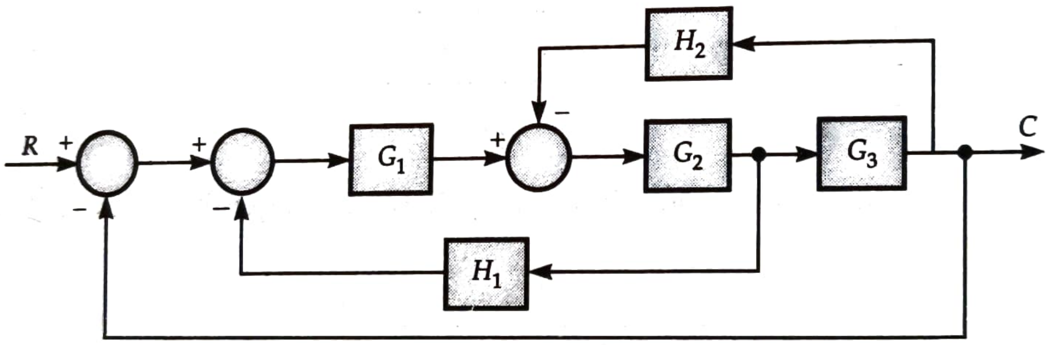

Fig. P3.2

Ans. $\left[\dfrac{C}{R} = \dfrac{G_1G_2G_3}{1 - G_1G_2H_1 + G_1G_3H_2 + G_1G_2G_3}\right]$

4. Find the equivalent transfer function $G(s) = \dfrac{C(s)}{R(s)}$ for the system shown in Fig. P3.3.

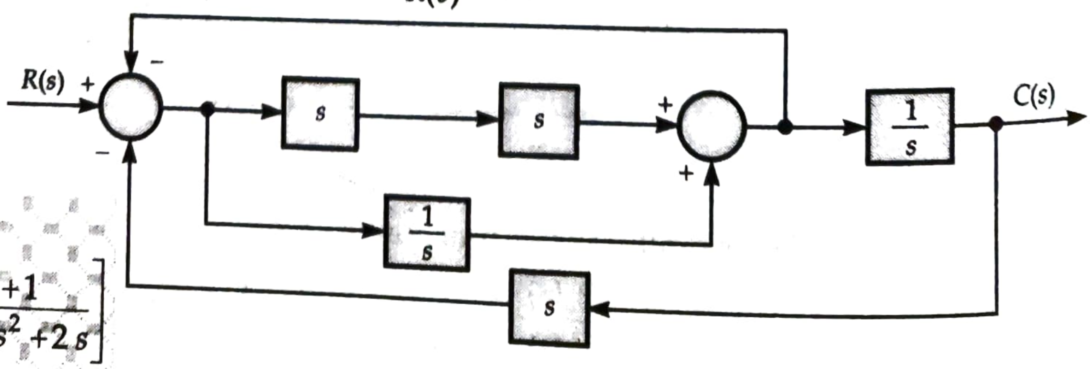

Fig. P3.3

Ans. $\left[G(s) = \dfrac{s^3 + 1}{2s^4 + s^2 + 2s}\right]$

5. A closed-loop control system is subjected to a disturbance $D(s)$ as shown in Fig. 3.4. Determine the value of $C(s)$.

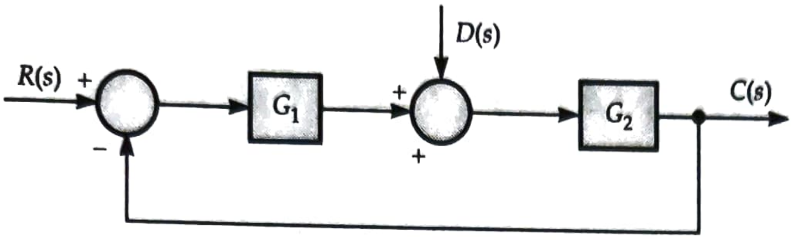

Fig. P3.4

Ans. $\left[C(s) = \left(\dfrac{G_2}{1+G_1+G_2}\right)[G_1 R(s) + D(s)]\right]$

6. A closed-loop control system is subjected to a disturbance $D(s)$ as shown in Fig. P3.5. Determine the output of the system.

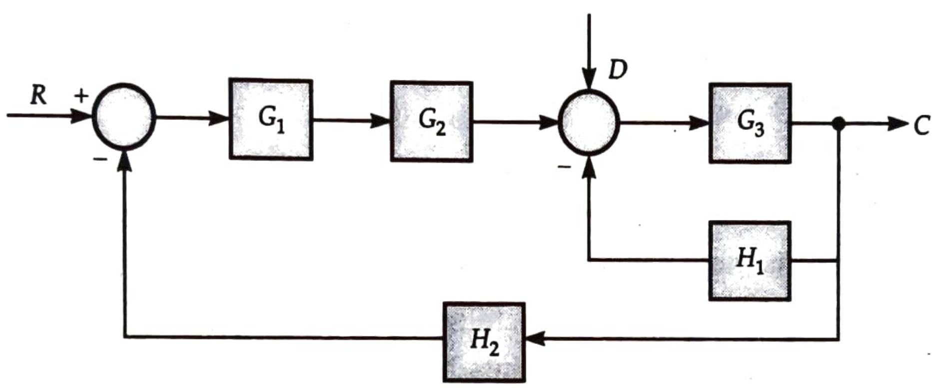

Fig. P3.5

Ans. $\left[C = \dfrac{G_1G_2G_3R}{1+G_3H_1+G_1G_2G_3H_2} + \dfrac{G_3D}{1+G_3H_1+G_1G_2G_3H_2}\right]$

7. Determine the output θ_o for the system shown in Fig. 3.6.

Ans.

$$\left[\theta_o = \left[\frac{Ks}{(s+2)-2k(s+1)}\right]\theta_i + \left[\frac{s(s+2)}{(s+2)-2K(s+1)}\right]D_1 + \left[\frac{2K}{(s+2)-2K(s+1)}\right]D_2\right]$$

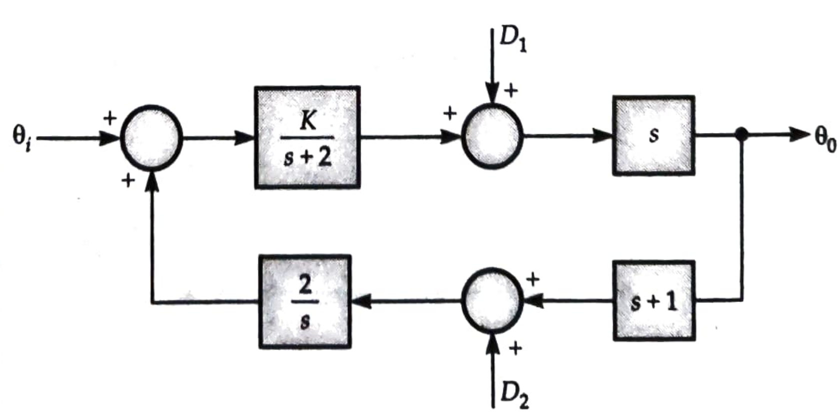

Fig. P3.61

EXERCISES

1. What is a node ? Name different types of nodes.
2. Define loop. Name different types of loops. What is meant by the term loop gain ?
3. Explain the following terms :
   (*a*) Path
   (*b*) Forward path
   (*c*) Forward path gain
   (*d*) Feedback path
   (*e*) Loop gain
4. What do you mean by a signal flow graph ? State the properties of signal flow graphs.
5. State the Mason's gain formula.
6. Compare block diagram and signal flow graph methods.
7. A system having input and output represented by u and x is described by the following equations :

$$x = x_1 + a_3 u$$

$$x_1 = b_1 x_1 + x_2 + a_2 u$$

$$x_2 = -b_2 x_1 + a_1 u$$

Draw the signal flow diagram.

Ans.

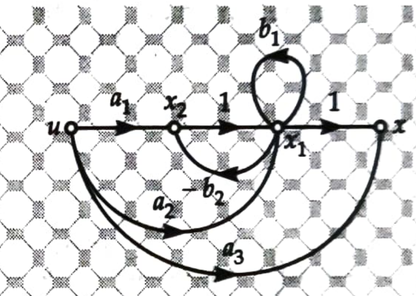

Fig. P4.1

8. Obtain the transfer function $\frac{C}{R}$ of signal flow graph shown in Fig. P4.2 using Mason's gain formula..

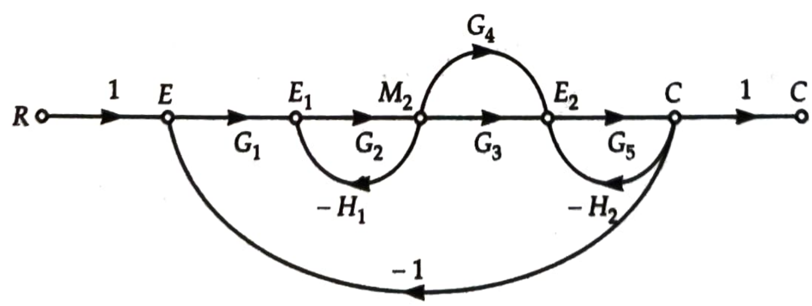

Fig. P4.2

Ans. $\left[\frac{C}{R} = \frac{G_1G_2G_3G_5 + G_1G_2G_4G_5}{1 + G_2H_1 + G_5H_2 + G_1G_2G_3G_5 + G_1G_2G_4G_5 + G_2G_5H_1H_2}\right]$

9. Obtain the transfer function $\frac{C}{R}$ of the signal flow graph shown in Fig. P4.3 using Mason's gain formula..

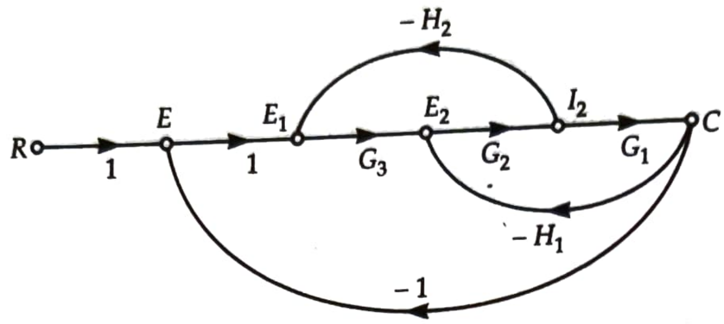

Fig. P4.3

Ans. $\left[\frac{C}{R} = \frac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H_1+G_1G_2G_3}\right]$

10. Convert the block diagram of Fig. P4.4(*a*) to a signal flow graph and determine the closed loop transfer function $\frac{C(s)}{R(s)}$ by use of Mason's gain formula.

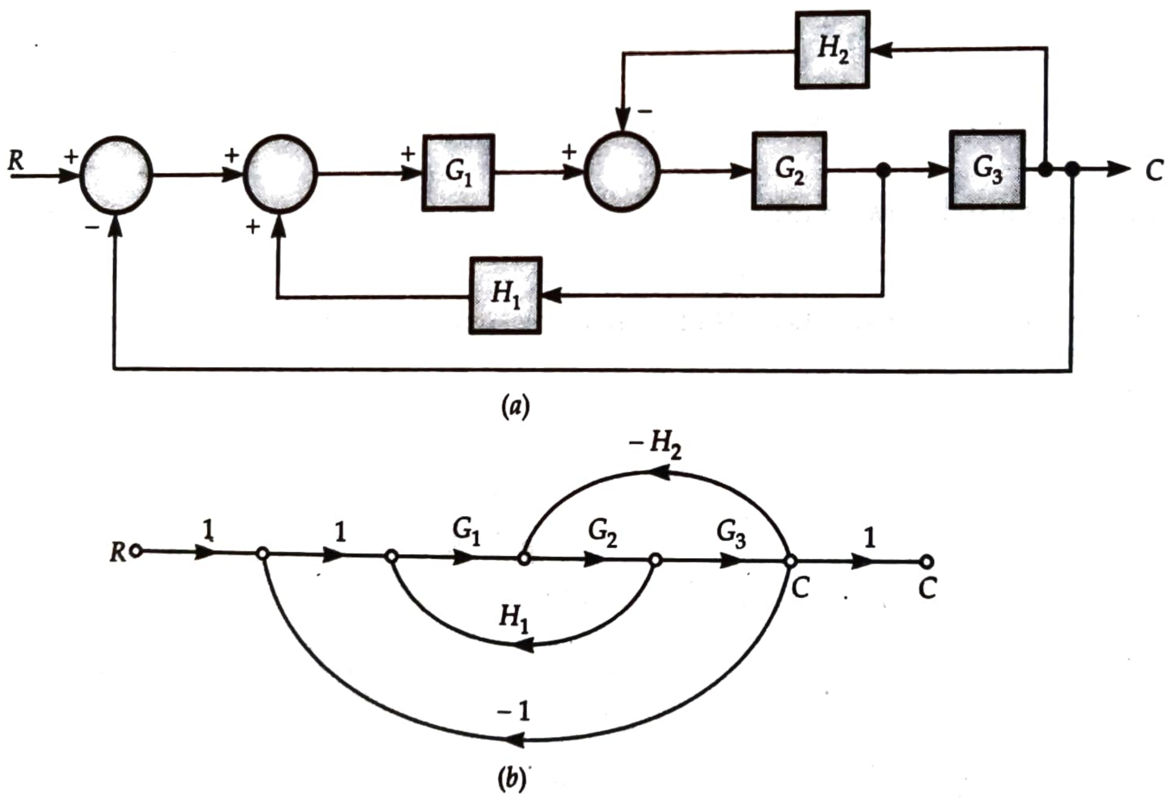

Fig. P4.4

Ans. $\left[\frac{C(s)}{R(s)} = \frac{G_1G_2G_3}{1-G_1G_2H_1+G_2G_3H_2+G_1G_2G_3}\right]$

11. Determine the closed loop transfer function $\dfrac{C(s)}{R(s)}$ in the system shown in Fig. P4.5.

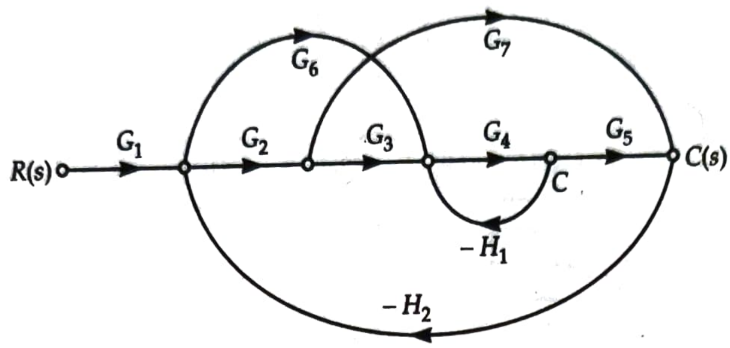

Fig. P4.5

Ans. $\left[\dfrac{C(s)}{R(s)} = \dfrac{G_1G_2G_3G_4G_5 + G_1G_6G_4G_5 + G_1G_2G_7(1+G_4H_1)}{1+G_4H_1+G_2G_7H_2+G_4G_5G_6H_2+G_2G_3G_4G_5H_2+G_4H_1G_2G_7H_2}\right]$

12. Determine the transfer function $\dfrac{Y(s)}{R(s)}$ from the signal flow graph shown in Fig. P4.6.

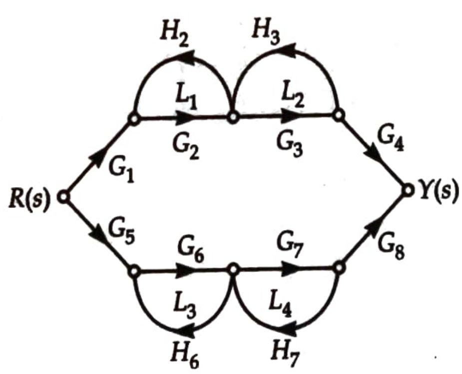

Fig. P4.6

Ans.

$$\left[\frac{Y(s)}{R(s)} = \frac{\{G_1G_2G_3G_4(1-G_6H_6-G_7H_7)+G_5G_6G_7G_8(1-G_2H_2-G_3H_3)\}}{[1-G_2H_2-H_3G_3-G_6H_6-G_7H_7+G_2H_2G_6H_6+G_2H_2G_7H_7+G_3H_3G_6H_6+G_3H_3G_7H_7]}\right]$$

13. Draw the signal flow graph and evaluate the closed-loop transfer function of a system whose block diagram is shown in Fig. P4.7(a).

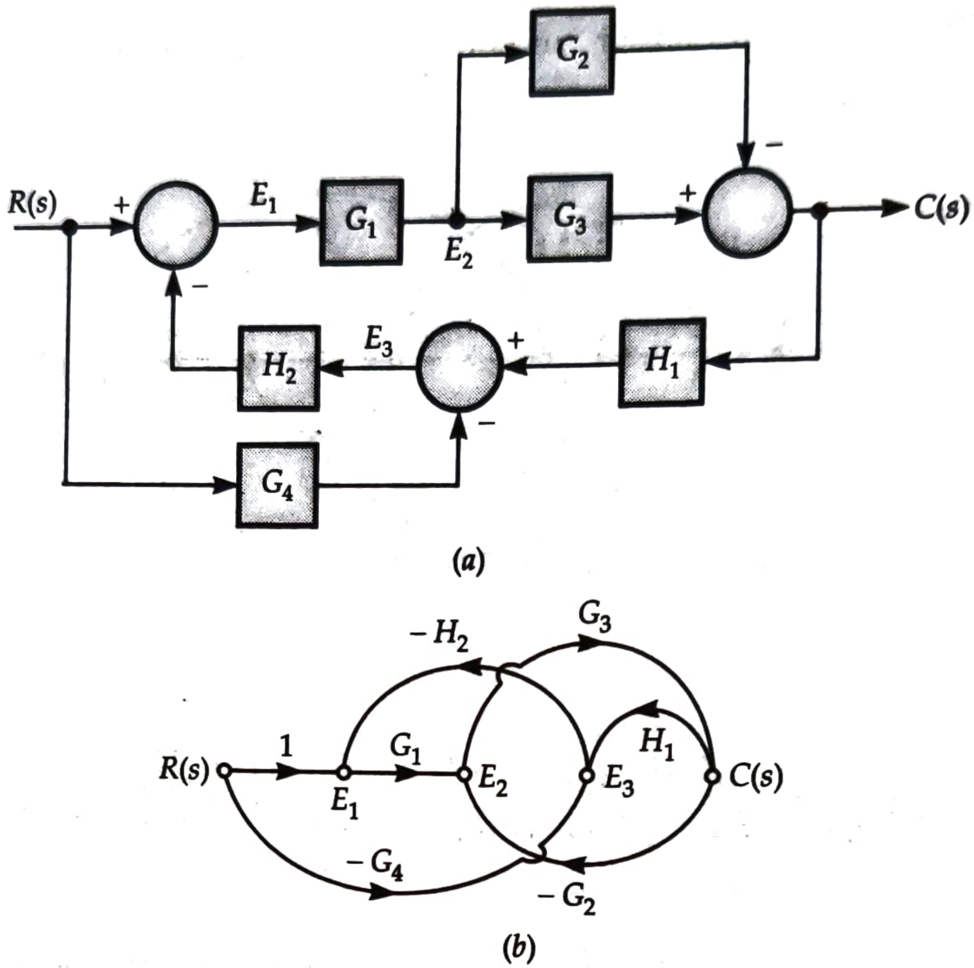

Fig. P4.7

Ans. $\left[\dfrac{C(s)}{R(s)} = \dfrac{-G_1G_2 + G_1G_3 - G_1G_2G_4H_2 + G_1G_3G_4H_2}{1 + G_1G_3H_1H_2 - G_1G_2H_1H_2} \right]$