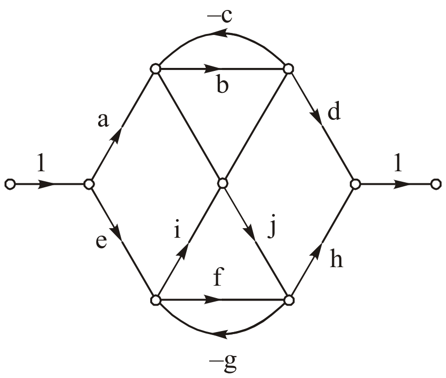
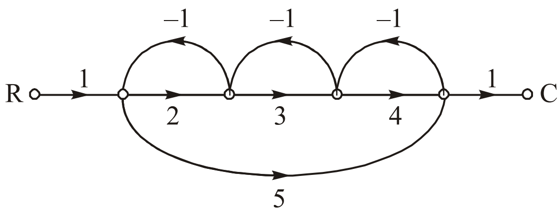
QUESTION BANK

1. For the signal flow graph shown in figure the graph determinant Δ is



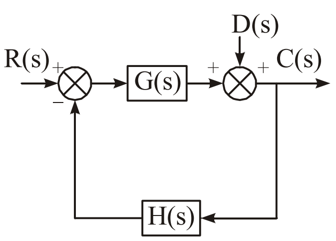
(a) 1 – bc – fg – bcfg – cjgi
(b) 1 – bc – fg – cjgi + bcfg
(c) 1 + bc + fg + cjgi + bcfg
(d) 1 + bc + fg – bcfg – cjgi

2. In the signal flow graph shown in figure the gain C/R is



(a) $\frac{44}{23}$ (b) $\frac{29}{19}$
(c) $\frac{44}{19}$ (d) $\frac{29}{11}$

3. In the feedback system C(s), R(s) and D(s) are the system output, input and disturbance, respectively



Assertion (A): For system

$$\frac{C(s)\{R(s)+D(s)\}}{R(s)D(s)} = \frac{1+G(s)}{1+G(s)H(s)}$$

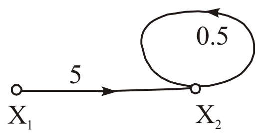
Reason (R): Transfer function of a system is defined as the ratio of output Laplace transform and input Laplace transform setting other inputs and the initial conditions to zero.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

4. Signal flow graph is used to find

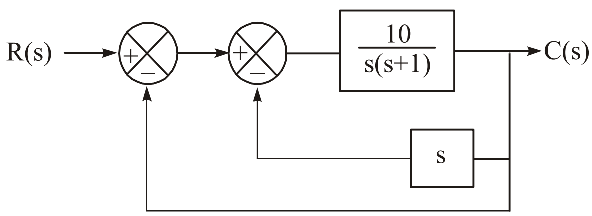
(a) Stability of the system.
(b) Controllability of the system.
(c) Transfer function of the system.
(d) Poles of the system.

5. In the signal flow graph shown in fig $X_2 = TX_1$ where T, is equal to



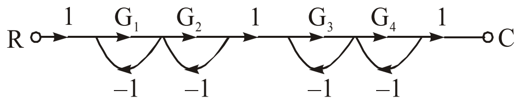
(a) 2.5 (b) 5
(c) 5.5 (d) 10

6. For the system shown in figure the transfer function $\frac{C(s)}{R(s)}$ is equal to:



(a) $\frac{10}{s^2+s+10}$ (b) $\frac{10}{s^2+11s+10}$
(c) $\frac{10}{s^2+9s+10}$ (d) $\frac{10}{s^2+2s+10}$

7. The C/R for the signal flow graph in figure is



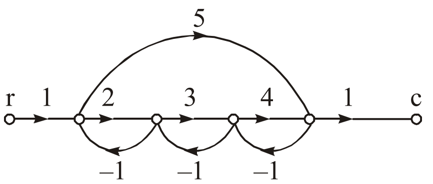
(a) $\dfrac{G_1G_2G_3G_4}{(1+G_1G_2)(1+G_3G_4)}$

(b) $\dfrac{G_1G_2G_3G_4}{(1+G_1+G_2+G_1G_2)(1+G_3+G_4+G_3G_4)}$

(c) $\dfrac{G_1G_2G_3G_4}{(1+G_1+G_2)(1+G_3+G_4)}$

(d) $\dfrac{G_1G_2G_3G_4}{(1+G_1+G_2+G_3+G_4)}$

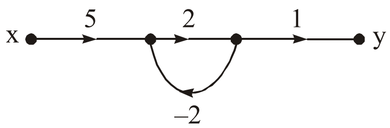
8. In the signal flow graph of figure the gain c/r will be



(a) 11/9 (b) 22/15

(c) 24/23 (d) 44/23

9. In the signal flow graph of figure y/x equals



(a) 3 (b) 5/2

(c) 2 (d) None of the above

10. The transfer function of a linear system is the

(a) ratio of the output, $V_0(t)$ and input $V_i(t)$

(b) ratio of the derivatives of the output and the input

(c) ratio of the Laplace transform of the output and that of the input with all initial conditions zeros

(d) none of these

11. In case of a second order system described by the differential equation $\dfrac{Jd^2\theta_0}{dt^2}+F\dfrac{d\theta_0}{dt}+K\theta_0=K\theta_i$ (where, θ_i and $K\theta_0$ are the input and output shaft angles), the natural frequency is given by

(a) $\sqrt{\dfrac{K}{J}}$ (b) $\sqrt{\dfrac{J}{K}}$

(c) $\sqrt{KJ}$ (d) $\sqrt{K-J}$

12. Feedback control systems are

(a) insensitive to both forward and feedback path parameter changes

(b) less sensitive to feedback path parameter changes than to forward path parameter changes

(c) less sensitive to forward path parameter changes than to feedback path parameter changes

(d) equally sensitive to forward and feedback path parameter changes

13. The principles of homogeneity and superposition are applied to

(a) Linear time variant systems

(b) Non-linear time variant systems

(c) Linear time invariant systems

(d) Non-linear time invariant systems

14. The differential equation, $\dfrac{d^2y}{dx^2}+\dfrac{dy}{dx}+\sin y=0,$ is

(a) linear (b) non-linear

(c) homogeneous (d) of degree two

15. Spring stiffness k is analogous to :

(a) Capacitance in Force-voltage analogy

(b) Reciprocal of inductance in Force-current analogy

(c) Inductance in Force-current analogy

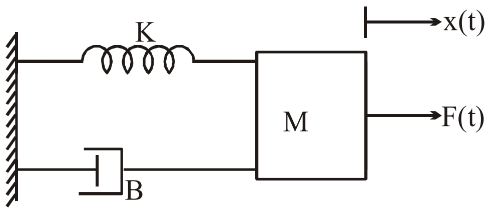
(d) Reciprocal of capacitance in Force-current analogy

16. The system described by the differential equation

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

(a) a linear time varying system
(b) a nonlinear time varying system
(c) a time varying stochastic system
(d) non of the above

17. In the figure alongside, spring constant is K, viscous friction coefficient is B, mass is M and the system output motion is x(t) corresponding to input force F(t). Which of the following parameters relate to the above system ?

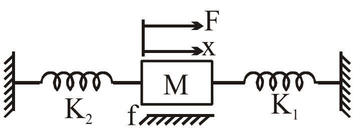


1. Time constant = $\frac{1}{M}$
2. Damping coefficient = $\frac{B}{2\sqrt{KM}}$
3. Natural frequency of oscillation = $\sqrt{\frac{K}{M}}$

Select the correct answer using the codes given below :

(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

18. Consider a simple mass-spring-friction system as given in the figure. K_1, K_2 –Spring Constants, f-Friction M-Mass, F-Force, x-Displacement
The transfer function



(a) $\frac{1}{Ms^2 + fs + K_1K_2}$

(b) $\frac{1}{Ms^2 + fs + K_1 + K_2}$

(c) $\frac{1}{Ms^2 + fs + \frac{K_1K_2}{K_1 + K_2}}$

(d) $\frac{1}{Ms^2 + fs + K_1}$

19. Which of the following quantities are analogous in a Force-Current analogy ?

1. Displacement and Inductance
2. Velocity and Voltage
3. Mass and Capacitance

Select the correct answer using the codes given below :

(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

20. The open-loop transfer function of a unity feedback control system is $G(s) = \frac{1}{(s+2)^2}$. The closed-loop transfer function will have poles at

(a) –2, – 2 (b) –2, – 1
(c) –2 ± j1 (d) –2, 2

21. The response c(t) of a system to an input r(t) is given by the following differential equation

$$\frac{d^2c(t)}{dt^2} + 3\frac{dc(t)}{dt} + 5c(t) = 5r(t)$$

The transfer function of the system is given by

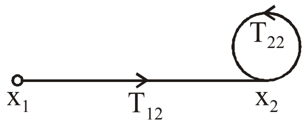
(a) $G(s) = \frac{5}{s^2 + 3s + 5}$ (b) $G(s) = \frac{1}{s^2 + 3s + 5}$

(c) $G(s) = \frac{3s}{s^2 + 3s + 5}$ (d) $G(s) = \frac{s+3}{s^2 + 3s + 5}$

22. The transfer function of a system is $\frac{2s^2 + 6s + 5}{(s+1)^2(s+2)}$, the characteristic equation of the system is

(a) $2s^2 + 6s + 5 = 0$
(b) $(s + 1)^2 (s + 2) = 0$
(c) $2s^2 + 6s + 5 + (s + 1) = 0$
(d) $2s^2 + 6s + 5 – (s + 1)^2 (s + 2) = 0$

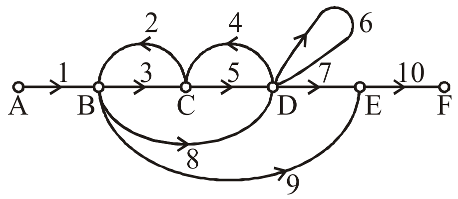
23. From the figure shown the transfer function of the signal flow graph is



(a) $\frac{T_{12}}{1-T_{22}}$ (b) $\frac{T_{22}}{1-T_{12}}$

(c) $\frac{T_{12}}{1+T_{22}}$ (d) $\frac{T_{22}}{1+T_{12}}$

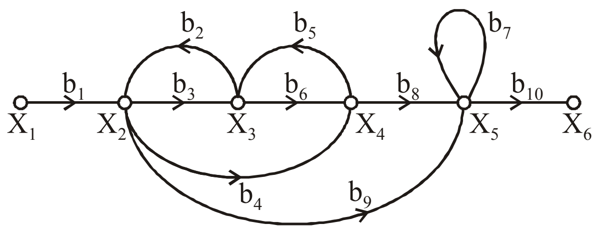
24. The signal flow diagram of a system is shown in the given figure. The number of forward paths and the number of pairs of non-touching loops are respectively



(a) 3, 1 (b) 3, 2

(c) 4, 2 (d) 2, 4

25. A signal flow graph is shown in the following figure.



Consider the following statements regarding the signal flow graph

1. There are three forward paths.
2. There are three individual loops.
3. There are two non-touching loops.

Of these statements

(a) 1, 2, and 3 are correct

(b) 1 and 2 are correct

(c) 2 and 3 are correct

(d) 1 and 3 are correct

26. ***Assertion (A):*** Stability is a major problem in closed-loop control systems.

Reason (R): Introduction of feedback affects the location of poles of open-loop system.

(a) Both A and R are true and R is the correct explanation of A

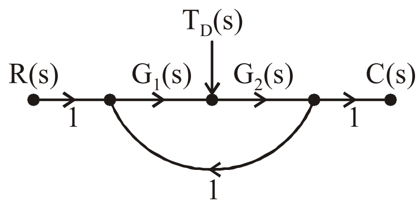
(b) Both A and R are true but R is not a correct explanation of A

(c) A is true, but R is false

(d) A is false, but R is true

27. The signal graph of a closed-loop system is shown in the figure, where T_D represent the disturbance in the forward path :

The effect of the disturbance can be reduced by



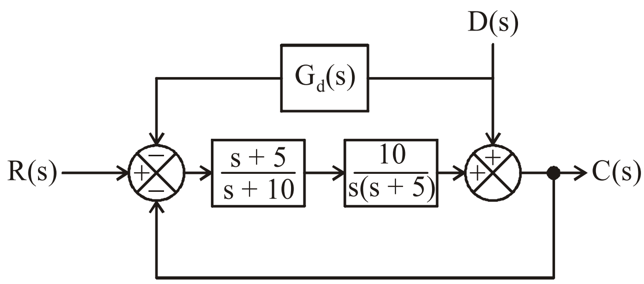
(a) Increasing G_2 (s)

(b) decreasing G_2 (s)

(c) increasing G_1 (s)

(d) decreasing G_1 (s)

28. In the system shown in the given figure, to eliminate the effect of disturbance D(s) on C(s), the transfer function G_d (s) should be



(a) $\frac{(s+10)}{10}$ (b) $\frac{10}{s+10}$

(c) $\frac{s(s+10)}{10}$ (d) $\frac{10}{s(s+10)}$

29. Consider the system shown in figure-I and figure-II. If the forward path gain is reduced by 10% in each system. The variation in C_1 and C_2 will be respectively

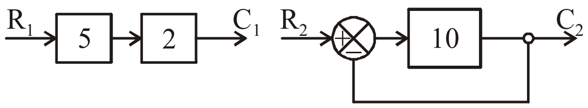
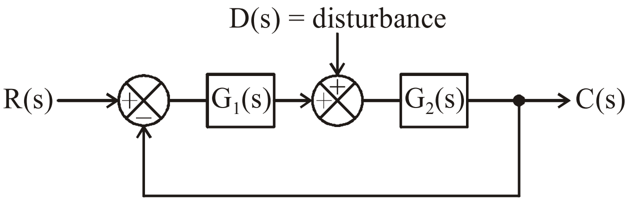


Figure-I Figure-II

(a) 10% and 10% (b) 2% and 10%

(c) 5% and 1% (d) 10% and 1%

30. For the given system, how can the steady state error produced by step disturbance be reduced ?



(a) By increasing dc gain of G_1 (s) G_2 (s)

(b) By increasing dc gain of G_2 (s)

(c) By increasing dc gain of G_1 (s)

(d) By removing the feedback

31. Consider the following statements regarding negative feedback in a closed-loop system

1. It increases sensitivity.
2. It minimizes the effect of disturbance.
3. There is a possibility of instability.
4. It improves the transient response.

Of these statements

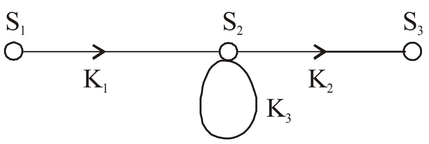
(a) 1, 3 and 4 are correct

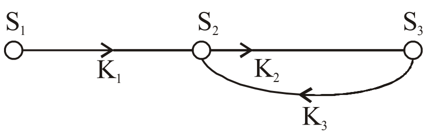
(b) 1, 2 and 4 are correct

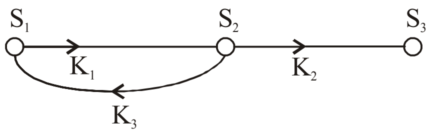
(c) 1, 2 and 3 are correct

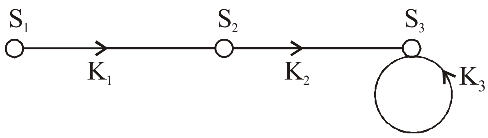
(d) 2, 3 and 4 are correct

32. Consider the following signal flow graphs

1.


2.


3.


4.


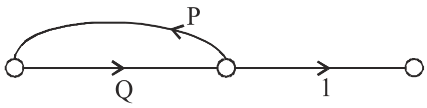
These signal flow graphs which have the same transfer function, would include -

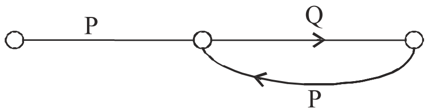
(a) 1 and 2 (b) 2 and 3

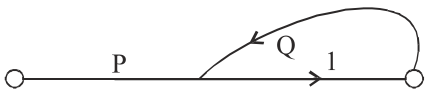
(c) 2 and 4 (d) 1 and 4

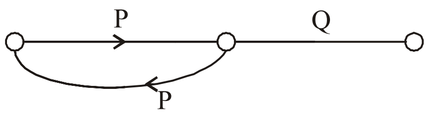
33. Match List-I (Signal flow graph) with List-II (Transfer function) and select the correct answer using the codes given below the lists -

List-I

A.


B.


C.


D.


List-II

1. $\dfrac{P}{1-Q}$ 2. $\dfrac{Q}{1-PQ}$

3. $\dfrac{PQ}{1-PQ}$ 4. $\dfrac{PQ}{1-P^2}$

(a) A-2 B-3 C-4 D-1

(b) A-2 B-3 C-1 D-4

(c) A-3 B-2 C-1 D-4

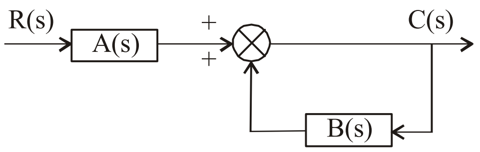
(d) A-3 B-2 C-4 D-1

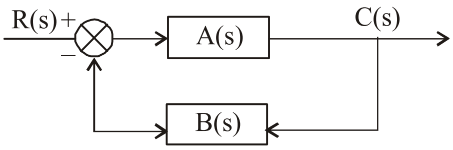
34. The closed-loop transfer of a unity feedback control system is $\frac{25}{s^2+10s+25}$, what is the loop transfer of the system?

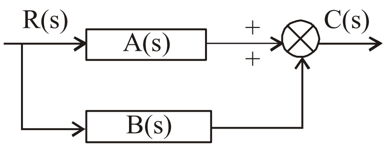
(a) $\frac{25}{s^2+10s}$ (b) $\frac{25}{s^2+25}$

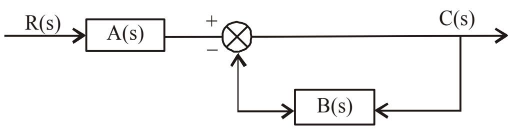
(c) $\frac{25}{s+25}$ (d) $\frac{25}{s+10}$

35. The transfer function $\frac{C(s)}{R(s)} = \frac{A(s)}{1-B(s)}$ is the simplification of which one of the following block diagrams?

(a)


(b)


(c)


(d)


36. ***Assertion (A) :*** Negative feedback in amplifiers improves performance.

Reason (R) : Gain of the amplifier is reduced by use of negative feedback.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

37. For a standard feedback control loop, the sensitivity of the closed-loop transfer function T to forward path gain G and feedback path gain H are

	S_G^T	S_H^T
(a)	1/(1 + GH)	–1(1 + GH)
(b)	–GH(1 + GH)	–H(1 + GH)
(c)	G/(1 +l GH)	1/(1 + GH)
(d)	1/(1 + GH)	–GH/(1 + GH)

38. Which one of the following is an example of an open loop system?

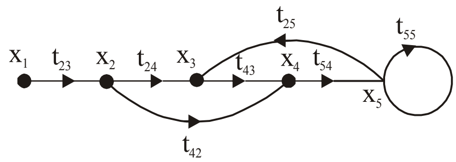
(a) Household refrigerator

(b) Respiratory system of an animal

(c) Stabilization of air pressure entering into a mask

(d) Execution of a program by a computer

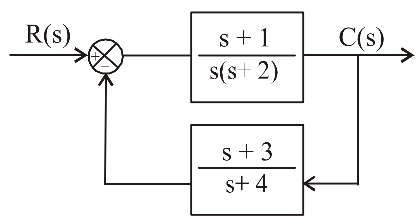
39. The gain from source node x_1 out put node x_5 for the signal flow graph given below is



(a) $\frac{t_{21}t_{32}(t_{43}t_{54}+t_{42})}{(1-t_{55}-t_{43}t_{35}t_{54})}$ (b) $\frac{t_{21}t_{54}(t_{32}t_{42}-t_{43})}{(1+t_{55}-t_{43}t_{35}t_{54})}$

(c) $\frac{t_{21}t_{54}(t_{32}t_{43}+t_{43})}{(1-t_{55}+t_{43}t_{35}t_{54})}$ (d) $\frac{t_{21}t_{54}(t_{32}t_{43}+t_{42})}{(1-t_{55}-t_{43}t_{35}t_{54})}$

40. For a negative feedback system shown in figure,

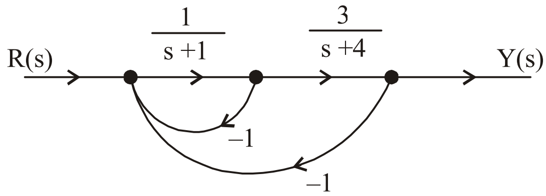


The equivalent transfer function is

(a) $\frac{s^3+5s^2+6s}{s^3+7s^2+12s+3}$ (b) $\frac{s^3+5s^2+6s}{s^3+5s^2+4s-3}$

(c) $\frac{s^2+5s+4}{s^3+7s^2+12s+3}$ (d) $\frac{s^2+5s+4}{s^3+5s^2+4s-3}$

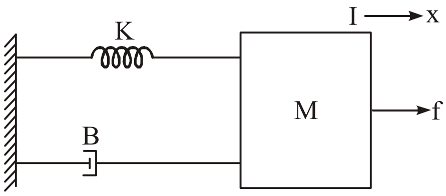
41. For the flow diagram shown in figure, the transfer function Y(S)/R(S) is

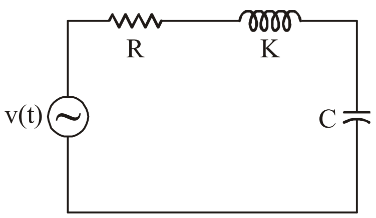


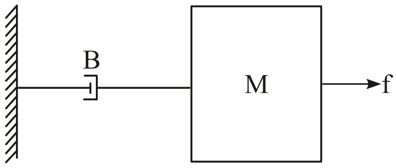
(a) $\frac{3}{s^2+6s+11}$ (b) $\frac{3}{s^2+5s+11}$

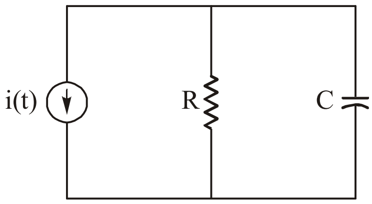
(c) $\frac{3}{s^2+6s+8}$ (d) $\frac{-3}{s^2+6s+11}$

42. Consider the following

1.


2.


3.


4.


Which of these systems can be modelled by the differential equation

$$a_2\frac{d^2y(t)}{dt^2}+a_1\frac{dy(t)}{dt}+a_0y(t)=x(t)?$$

(a) 1 and 2

(b) 1 and 3

(c) 2 and 4

(d) 1, 2 and 4

❍❍❍

ANSWERS AND EXPLANATIONS

1. ***Ans. (d)***

$L_1 = -bc, L_2 = -fg, L_3 = cjgi, L_1L_2 = bcfg$

$\Delta = 1 - (-bc - fg + cjgi) + bcfg$

$= 1 + bc + fg - cjgi + bcfg$

2. ***Ans. (a)***

$$P_1 = 1\times 2\times 3\times 4\times 1 = 24$$
$$P_2 = 1\times 5\times 1 = 5$$
$$L_1 = -2$$
$$L_2 = -3$$
$$L_3 = -4$$
$$L_4 = -5$$
$$L_1L_3 = 8$$
$$\Delta = 1-(-2-3-4-5)+8 = 23$$
$$\Delta_1 = 1, \Delta_2 = 1-(-3) = 4$$
$$\frac{C}{R} = \frac{24+5\times 4}{23} = \frac{44}{23}$$

3. ***Ans. (a)***

Transfer function is defined for linear systems, so superposition principle is applicable.

4. ***Ans. (c)***

Signal flow graph is used to find the transfer function of the system.

5. ***Ans. (d)***

$$\frac{X_2}{X_1} = \frac{5}{\Delta} = \frac{5}{1-(0.5)} = \frac{5}{0.5} = 10$$
$$\Delta = 1-(0.5) = 0.5$$

6. ***Ans. (b)***

By using Mason's gain formula

$$\frac{Y(s)}{R(s)} = \frac{\frac{10}{s(s+1)}}{1-\left(-\frac{10}{s(s+1)} - \frac{10s}{s(s+1)}\right)}$$
$$\frac{Y(s)}{R(s)} = \frac{10}{s^2+11s+10}$$

7. ***Ans. (c)***

By applying Mason's Gain formula

$$\frac{C}{R} = \frac{G_1G_2G_3G_4}{1+G_1+G_2+G_3+G_4+G_1G_3+G_1G_4+G_2G_3+G_2G_4}$$
$$\frac{C}{R} = \frac{G_1G_2G_3G_4}{(1+G_1+G_2)(1+G_3+G_4)}$$

8. ***Ans. (d)***

$$\frac{c}{r} = \frac{2\times 3\times 4+1\times 5(1+3)}{1+2+3+4+5+(2\times 4)}$$
$$= \frac{24+20}{10+8+5} = \frac{44}{23}$$

9. ***Ans. (c)***

$$\frac{y}{x} = \frac{10}{1+4} = 2$$

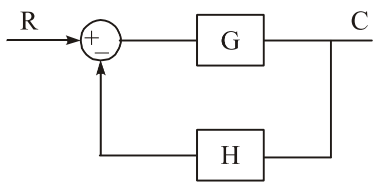
10. ***Ans. (c)***

The transfer function of a linear time invariant system is defined as ratio of Laplace transfer of output to Laplace transfer of input, with all initial conditions are zero.

$$\text{Transfer function} = \left.\frac{L[\text{Output}]}{L[\text{Input}]}\right|_{\text{initial condition}=0}$$

11. ***Ans. (a)***

12. ***Ans. (c)***



Let $\frac{C}{R} = M$

$$S_G^M = \frac{1}{1+GH} \quad ...(1)$$
$$S_H^M = \frac{-GH}{1+GH} \quad ...(2)$$
$$S_H^M \simeq -1 \quad ...(1) < (2)$$

∴ Feedback control system are less sensitive to forward path parameter changes than feedback path parameter changes.

13. ***Ans. (c)***

The principles of homogeneity and superposition are applied to Linear time invariant systems.

14. ***Ans. (b)***

15. ***Ans. (b)***

Force equation of simple second order mass damper system,

$$M\frac{d^2x}{dt^2}+B\frac{dx}{dt}+kx = f \quad ...(i)$$

Current equation for parallel RLC circuit,

$$C\frac{d^2\phi}{dt^2}+\frac{1}{R}\frac{d\phi}{dt}+\frac{\phi}{L}=i \quad ...(ii)$$

Voltage equation for series RLC circuit,

$$L\frac{d^2Q}{dt^2}+R\frac{dQ}{dt}+\frac{Q}{C}=V \quad ...(iii)$$

Comparing equations (i) and (ii), we have,

(i) Displacement (x) is analogous to flux (ϕ).

(ii) Force (f) is analogous to current (i).

(iii) Velocity (dx/dt) is analogous to voltage ($d\phi/dt$).

(iv) Mass (M) is analogous to capacitance (C).

(v) Damping coefficient (B) is analogous to inverse of resistance (1/R)

(vi) Spring constant (k) is analogous to inverse of inductance (1/L).

And comparing equations (i) & (iii), we have,

(i) Displacement (x) is analogous to charge (Q).

(ii) Force (f) is analogous to voltage (v).

(iii) Velocity (dx/dt) is analogous to current (dQ/dt).

(iv) Mass (M) is analogous to inductance (L).

(v) Damper coefficient (B) is analogous to resistance (R).

(vi) Spring constant (k) is analogous to inverse of inductance (1/C).

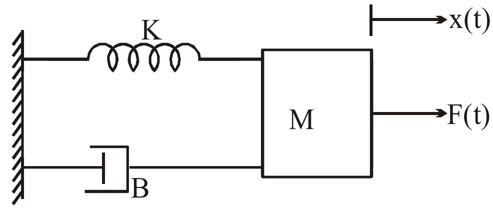
Thus option (b) is correct.

16. ***Ans. (b)***

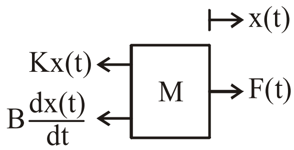
The system described by the differential equation

$\frac{d^2y(t)}{dt^2}+y^2\frac{d/y(t)}{dt}+t^2y(t)=5$ is a nonlinear time varying system.

17. ***Ans. (c)***



Free Body diagram of mass M,



Force balance equation for above feedback diagram,

$$f(t) - B\frac{dx(t)}{dt}-Kx(t) = M\frac{d^2x(t)}{dt^2}$$

Taking Laplace transform with initial conditions assumed to be zero, we have,

$F(s) - BsX(s) - KX(s) = Ms^2X(s)$

$$\Rightarrow \quad \frac{X(s)}{F(s)} = \frac{1}{Ms^2+Bs+K}$$

Characteristic equation of the system,

$Ms^2 + Bs + K = 0$

$$\Rightarrow s^2+\frac{B}{M}s+\frac{K}{M} = 0 \quad ...(i)$$

Characteristic equation of second order system in terms of damping ratio (ξ) and natural undamped frequency (ω_n) is given by,

$$s^2+2\xi\omega_n s+\omega_n^2 = 0$$

(ii) Comparing equations (i) and (ii), we have,

$$\omega_n^2 = \frac{K}{M}$$

$$\Rightarrow \quad \omega_n = \sqrt{\frac{K}{M}}$$

and $$2\xi\omega_n = \frac{B}{M}$$

$$\Rightarrow \quad \xi = \frac{1}{2\omega_n}\frac{B}{M} = \frac{1}{2\sqrt{K/M}}\frac{B}{M}$$

$$\Rightarrow \quad \xi = \frac{B}{2\sqrt{KM}}$$

Characteristic equation of second order system in terms of time constant (τ) and gain constant (k) is given by,

$$\tau s^2 + s + k = 0$$

or $$s^2 + \frac{1}{\tau}s + \frac{k}{\tau} = 0 \qquad ...(iii)$$

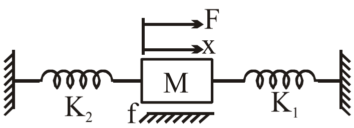
Comparing equations (i) and (iii), we have,

$$\frac{1}{\tau} = \frac{B}{M}$$

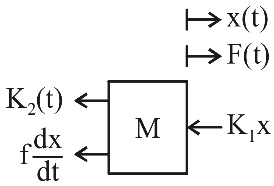
$$\Rightarrow \quad \tau = B/M$$

Thus only statement 2 and 3 are correct.

18. ***Ans. (b)***



Free Body diagram of mass M,



Force balance equation for above feedback diagram,

$$F - f\frac{dx}{dt} - K_1x - K_2x = M\frac{d^2x}{dt^2}$$

Taking Laplace transform with initial conditions assumed to be zero, we have,

$F(s) - fsX(s) - K_1X(s) - K_2X(s) = Ms^2X(s)$

$$\Rightarrow \quad \frac{X(s)}{F(s)} = \frac{1}{Ms^2 + fs + K_1 + K_2}$$

19. ***Ans. (c)***

20. ***Ans. (c)***

Given, $$G(s) = \frac{1}{(s+2)^2}, H(s) = 1$$

Closed loop transfer function,

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

$$\Rightarrow \quad T(s) = \frac{1/(s+2)^2}{1 + 1/(s+2)^2}$$

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

$$\Rightarrow \quad T(s) = \frac{1}{(s+2+j1)(s+2-j1)}$$

Poles of the close loop transfer-function are at $-2 \pm j1$

21. ***Ans. (a)***

$$\frac{d^2c(t)}{dt^2} + 3\frac{dc(t)}{dt} + 5c(t) = 5r(t)$$

For the system represented by above differential equation, c (t) is the response, r(t) is the input of the system.

Taking Laplace transform with initial conditions assumed to be zero, we have,

$s^2C(s) + 3sC(s) + 5C(s) = 5R(s)$

$$\Rightarrow \quad T(s) = \frac{C(s)}{R(s)} = \frac{5}{s^2 + 3s + 5}$$

22. ***Ans. (b)***

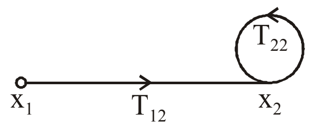
Given, $$T(s) = \frac{2s^2 + 6s + 5}{(s+1)^2(s+2)}$$

The characteristic equation is obtained by putting the denominator of the overall transfer function of the system equals to zero.

Therefore, the characteristic equation is

$$(s+1)^2(s+2) = 0$$

23. ***Ans. (a)***



Number of forward paths = 1

Forward path gain, $P_1 = T_{12} = 10$

Number of individual loops loops = 1

The loop gain, $L_1 = T_{22}$

Pairs of non-touching loops = 0

Mason's gain formula,

$$T = \frac{y}{x} = \frac{\sum_{i=1} P_i \Delta_i}{\Delta} = \frac{P_1 \Delta_1}{\Delta}$$

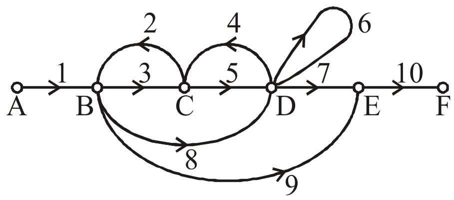
$\Rightarrow \quad \Delta = 1 - L_1 = 1 - T_{22}$

$\Rightarrow \quad \Delta_1 = 1 - 0 = 1$

Now overall transfer function or gain of the system,

$$T = \frac{P_1 \Delta_1}{\Delta} = \frac{T_{12}.1}{1 - T_{22}} = \frac{T_{12}}{1 - T_{22}}$$

24. ***Ans. (a)***



Forward paths :

P_1 = 1-3-5-7-10

P_2 = 1-8-7-10

P_3 = 1-9-10

$\therefore$ Number of forward paths = 3

Individual loops :

L_1 = 2-3-2

L_2 = 5-4-5

L_3 = 6

L_4 = 8-4-2-8

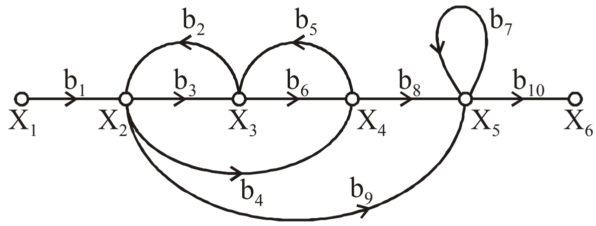
$\therefore$ Number of individual loops = 4

Pairs of 2 non-touching loops

$P_{11} = L_1$ and L_2

$\therefore$ Number of pairs of 2 non-touching loops = 1

25. ***Ans. (d)***



Forward paths :

$P_1 = b_1\text{-}b_3\text{-}b_6\text{-}b_8\text{-}b_{10}$

$P_2 = b_1\text{-}b_4\text{-}b_8\text{-}b_{10}$

$P_3 = b_1\text{-}b_9\text{-}b_{10}$

$\therefore$ Number of forward paths = 3

Individual loops :

$L_1 = b_2\text{-}b_3\text{-}b_2$

$L_2 = b_5\text{-}b_6\text{-}b_5$

$L_3 = b_7$

$L_4 = b_4\text{-}b_5\text{-}b_2\text{-}b_4$

$\therefore$ Number of individual loops = 4

Pairs of 2 non-touching loops:

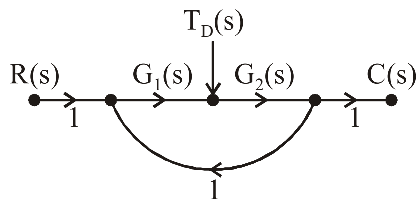
$P_{11} = L_1$ and L_3, L_2 and L_3

$\therefore$ Number of non-touching loops = 2

26. ***Ans. (a)***

Stability is a major problem in closed-loop control systems because introduction of feedback affects the location of poles of open-loop system.

27. ***Ans. (c)***



Output of the above system,

$$C(s) = C_R(s) + C_D(s)$$

where,

$$C = \frac{G_1(s)G_2(s)}{1 + G_1(s)G_2(s)} R(s)$$

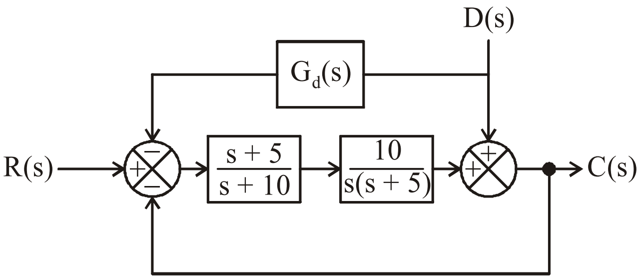
Component of output due to input only.

$$C_D(s) = \frac{G_2(s)}{1 + G_1(s)G_2(s)} D(s)$$

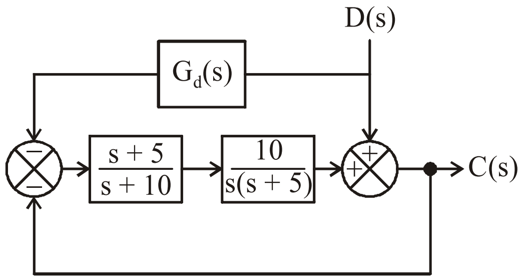
Component of output due to disturbance only.

From the above equation it is clear effect disturbance signal on output can be reduced by increasing $G_1(s)$. Change in $G_2(s)$ will have little effect because it is present in numerator and denominator both.

28. ***Ans. (c)***



Considering only disturbance signal as the input,



The transfer function of the system will be,

$$\frac{C_d(s)}{D(s)} = -\frac{G_d(s)\frac{s+5}{s+10}.\frac{10}{s(s+5)}}{1+\frac{s+5}{s+10}.\frac{10}{s(s+5)}} + \frac{1}{\frac{s+5}{s+10}.\frac{10}{s(s+5)}}$$

For eliminating effect of disturbance signal

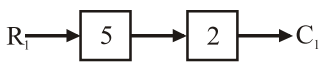
$$\frac{C_d(s)}{D(s)} = 0$$

$$\frac{G_d(s)\frac{s+5}{s+10}.\frac{10}{s(s+5)}}{1+\frac{s+5}{s+10}.\frac{10}{s(s+5)}} + \frac{1}{1+\frac{s+5}{s+10}.\frac{10}{s(s+5)}} = 0$$

$$\Rightarrow \quad G_d(s) = \frac{s+10}{s+5}\frac{s(s+5)}{10} = \frac{s(s+10)}{10}$$

29. ***Ans. (d)***

Figure-I :



Forward path Gain,

$$G = 5 \times 2 = 10$$

Output of the system,

$$C_1 = GR_1 = 10R_1$$

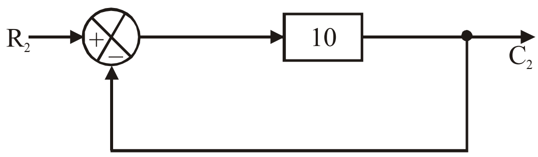
After 10% reduction in forward path gain output of system $C_1' = G'R_1 = 0.9GR_1 = 0.9C_1$

Percentage variation in output,

$$DC = \frac{C_1 - C_1'}{C_1} \times 100$$

$$DC = \frac{C_1 - 0.9C_1}{C_1} \times 100 = -10\%$$

Figure-II :



Forward path Gain, G = 10

Output of the system,

$$C_2 = \frac{G}{1+G}.R_2 = \frac{10}{1+10}.R_2 = \frac{10}{11}.R_2$$

After 10% reduction in forward path gain output of system, G' = 0.9G Output of the system,

$$C_2' = \frac{G'}{1+G'}.R_2$$

$$\Rightarrow \quad C_2' = \frac{0.9G}{1+0.9G}.R_2$$

$$= \frac{0.9 \times 10}{1+0.9 \times 10}R_2$$

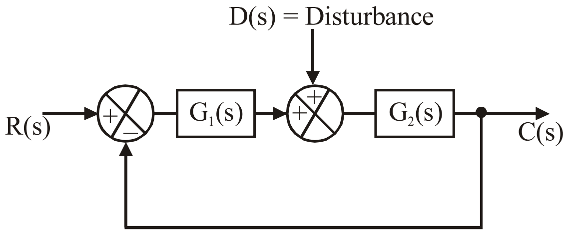
$$\Rightarrow \quad C_2' = \frac{9}{10}.R_2$$

Percentage variation in output,

$$DC = \frac{C_2 - C_2'}{C_2} \times 100$$

$$DC = \frac{10/11 - 9/10}{10/11} \times 100 = 1\%$$

30. ***Ans. (c)***



Output of the above system,

$$C(s) = C_R(s) + C_D(s)$$

where,

$$C_R(s) = \frac{G_1(s)G_2(s)}{1+G_1(s)G_2(s)}R(s)$$

Component of output due to input only.

$$C_D(s) = \frac{G_2(s)}{1+G_1(s)G_2(s)}D(s)$$

Component of output due to disturbance only.

From the above equation it is clear effect disturbance signal on output can be reduced by increasing $G_1(s)$. Change in $G_2(s)$ will have little effect because it is present in numerator and denominator both.

31. ***Ans. (d)***

32. ***Ans. (d)***

33. ***Ans. (b)***

34. ***Ans. (a)***

35. ***Ans. (a)***

36. ***Ans. (a)***

37. ***Ans. (d)***

38. ***Ans. (c)***

39. ***Ans. (d)***

40. ***Ans. (c)***

41. ***Ans. (a)***

42. ***Ans. (a)***

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