POSTAL Study Package 2019

Electronics Engineering

Objective Practice Sets

Control Systems

Contents

MADE EASY Publications

1 CHAPTER Introduction

Q.1 A control system is represented by $y(t) = x(t + T)$ with $T > 0$. Is the system causal?
(a) Yes (b) No
(c) Not necessarily (d) None of these

Q.2 $s(t)$ is step response and $h(t)$ is impulse response of a system. Its response $y(t)$ for any input $u(t)$ is given by

(a) $\frac{d}{dt}\int_0^t s(t-\tau)\,u(\tau)\,d\tau$

(b) $\int_0^t s(t-\tau)\,u(\tau)\,d\tau$

(c) $\int_0^t \int_0^t s(t-\tau_1)\,u(\tau_1)d\tau_1\,d\tau$

(d) $\int_0^t h(t-\tau)u(\tau)d\tau$

Q.3 The response of a system to a unit ramp input is $\frac{1}{2}tu(t)-\frac{1}{8}u(t)+\frac{1}{8}e^{-4t}u(t)$. Which one of the following is the unit impulse response of the system?
(a) $1 - e^{-4t}$ (b) $2(1 - e^{-4t})$
(c) e^{-4t} (d) $2e^{-4t}$

Q.4 The unit step response of a particular control system is given by $c(t) = 1 - 10e^{-t}$. Then its transfer function is

(a) $\frac{10}{s+1}$ (b) $\frac{s-9}{s+1}$

(c) $\frac{1-9s}{s+1}$ (d) $\frac{1-9s}{s(s+1)}$

Q.5 In a linear system, an input of 5 $\sin\omega t$ produces an output of 10 $\cos\omega t$. The output corresponding to input 10 $\cos\omega t$ will be equal to
(a) $+5\,\omega t$ (b) $-5\sin\omega t$
(c) $-20\sin\omega t$ (d) $20\sin\omega t$

Q.6 Let $F(s)$ be the Laplace transform of a signal $f(t)$.

If $F(s)=\frac{K}{(s+1)(s^2+4)}$, then $\lim_{t\to\infty} f(t)$ is given by

(a) $K/4$ (b) zero
(c) infinite (d) undefined

Q.7 The final value of function $F(s)=\frac{5}{s(s^2+s+2)}$ is equal to

(a) 0 (b) $\frac{2}{5}$

(c) $\frac{5}{2}$ (d) 5

Q.8 The step response of a system is $y(t) = te^{-t}$ $(t > 0)$ Its transfer fuction will be

(a) $\frac{1}{(s+1)^2}$ (b) $\frac{1}{s+1}$

(c) $\frac{s}{s+1}$ (d) $\frac{s}{(s+1)^2}$

Q.9 The impulse response of system is

$$c(t) = -te^{-t} + 2e^{-t}\ (t > 0)$$

The open loop transfer function is

(a) $\frac{2s+1}{(s+1)^2}$ (b) $\frac{2s+1}{s+1}$

(c) $\frac{2s+1}{s^2}$ (d) $\frac{2s+1}{s}$

Explanations   Introduction

1. (b)

$$y(t) = x(t+T)$$

Taking Laplace transform,

$$Y(s) = X(s)e^{sT}$$

$$H(s) = \frac{Y(s)}{X(s)} = e^{sT}$$

Taking inverse Laplace transform

$$h(t) = \delta(t+T),\ T > 0$$

Thus, $h(t) \neq 0,\ t < 0$, its an impulse at $t = -T$.

System is causal if $h(t) = 0,\ t < 0$.

2. (d)

$$y(t) = x(t) \otimes h(t)$$

$$y(t) = u(t) \otimes h(t)$$

$$y(t) = \int_{-\infty}^{\infty} h(t-\tau)\, u(\tau) dt$$

$$y(t) = \int_{0}^{t} h(t-T)u(t)dT$$

3. (d)

$$c(t) = \frac{t}{2} - \frac{u(t)}{8} + \frac{1}{8}e^{-4t}$$

Taking Laplace transform,

$$r(t) = tu(t)$$

$$C(s) = \frac{1}{2s^2} - \frac{1}{8s} + \frac{1}{8}\frac{1}{s+4},\ R(s) = \frac{1}{s^2}$$

$$\therefore \quad \frac{C(s)}{R(s)} = \frac{1}{2} - \frac{s}{8} + \frac{s^2}{8(s+4)}$$

$$= \frac{1}{2} - \frac{s}{2(s+4)} = \frac{2}{s+4}$$

$$= \frac{1}{2} - \frac{s}{2(s+4)} = \frac{1}{2}\left(\frac{s+4-s}{s+4}\right)$$

For impulse response $R(s) = 1$

$$\therefore \quad C(s) = \frac{2}{s+4}$$

$$c(t) = 2e^{-4t}$$

4. (c)

$$c(t) = 1 - 10e^{-t}$$

$$r(t) = u(t)$$

Taking Laplace transform,

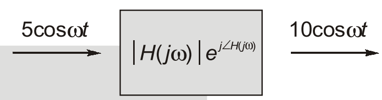
$$C(s) = \frac{1}{s} - \frac{10}{s+1}$$

$$= \frac{s+1-10s}{s(s+1)} = \frac{-9s+1}{s(s+1)}$$

$$R(s) = \frac{1}{s}$$

$$\therefore \quad \frac{C(s)}{R(s)} = \frac{-9s+1}{s(s+1)} \cdot \frac{s}{1} = \frac{1-9s}{s+1}$$

5. (c)



$$y(t) = 5\sin\omega t \cdot |H(j\omega)|\, e^{j\angle H(j\omega_o)}$$

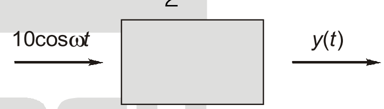
$$10\cos\omega t = 10\sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= 5|H(j\omega)| \cdot \sin(\omega t + \angle H(j\omega_o))$$

$$5|H(j\omega)| = 10$$

$$H(j\omega) = \frac{10}{5} = 2$$

$$\angle H(j\omega_o) = -\frac{\pi}{2}$$



$$y(t) = 10|H(j\omega)|\cos[\omega t + \angle H(j\omega)]$$

$$= 10.2\cos\left(\omega t - \frac{\pi}{2}\right) = -20\sin\omega t$$

6. (b)

$$F(s) = \frac{K}{(s+1)(s^2+4)}$$

$$\lim_{t\to\infty} f(t) = \lim_{s\to 0} sF(s)$$

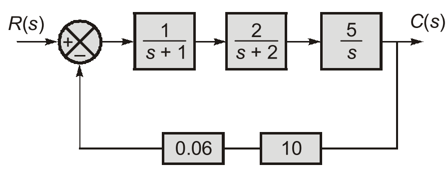
$$= \lim_{s\to 0} \frac{sK}{(s+1)(s^2+4)} = 0$$

7. (c)

$$F(s) = \frac{5}{s(s^2+s+2)}$$

2 CHAPTER
Block Diagram and Transfer Function

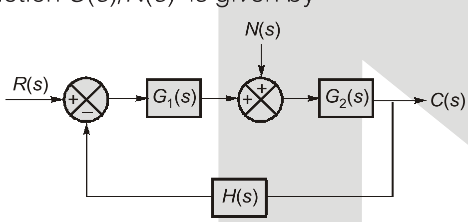
Q.1 The transfer function of the control system shown in the given figure is



(a) $\dfrac{10}{s(s+1)(s+2)}$ (b) 0.6

(c) $\dfrac{6}{s(s+1)(s+2)}$ (d) $\dfrac{10}{s^3+3s^2+2s+6}$

Q.2 The closed-loop system shown in the figure is subjected to a disturbance $N(s)$. The transfer function $C(s)/N(s)$ is given by



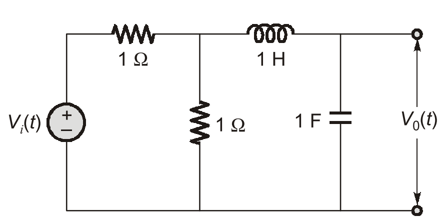
(a) $\dfrac{G_1(s)\,G_2(s)}{1+G_1(s)G_2(s)\,H(s)}$

(b) $\dfrac{G_1(s)}{1+G_1(s)\,H(s)}$

(c) $\dfrac{G_2(s)}{1+G_2(s)\,H(s)}$

(d) $\dfrac{G_2(s)}{1+G_1(s)\,G_2(s)\,H(s)}$

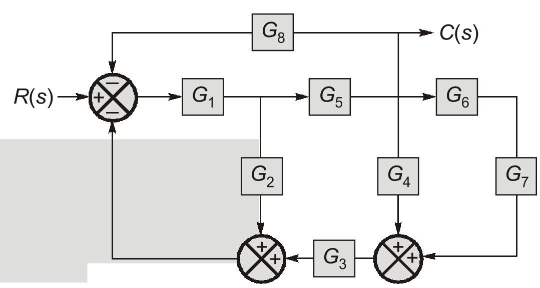
Q.3 Find the transfer function $\dfrac{V_0(s)}{V_i(s)}$ for the network shown in figure.



(a) $\dfrac{1}{s^2+s+2}$ (b) $\dfrac{1}{2s^2+s+2}$

(c) $\dfrac{1}{s^2+2s+2}$ (d) $\dfrac{1}{2s^2+2s+2}$

Q.4 Determine $C(s)/R(s)$ for the block diagram shown below.



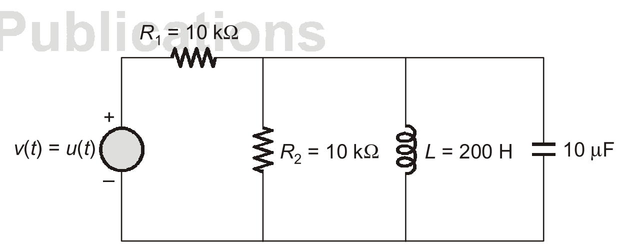
(a) $\dfrac{G_1G_5}{1+G_1(G_5G_8+G_3G_4G_5+G_2)}$

(b) $\dfrac{G_1G_5(1+G_2)}{1+G_1(G_5G_8+G_3G_4G_5+G_2)}$

(c) $\dfrac{G_1G_5(1+G_2)}{1+G_1(G_5G_8+G_3G_4G_5+G_2+G_3G_5G_6G_7)}$

(d) $\dfrac{G_1G_5}{1+G_1(G_5G_8+G_3G_4G_5+G_2+G_3G_5G_6G_7)}$

Q.5 The general form of the capacitor voltage for the electrical network shown in figure is



(a) $0.5\,u(t)$

(b) $Ae^{-10t}\cos(10t)\,u(t)$

(c) $0.02 + Ae^{-20t}\cos(10t+\phi)\,u(t)$

(d) $0.02 + Ae^{-10t}\cos(20t+\phi)\,u(t)$

Q.6 The unit step response of a linear time invariant system is $y(t) = 5e^{-10t}\, u(t)$, where $u(t)$ is the unit step function. If the output of the system corresponding to an unit impulse input $\delta(t)$ is $h(t)$, then $h(t)$ is

(a) $-50\, e^{-10t}\, u(t)$ (b) $5\, u(t) - 50\, e^{-10t}\, \delta(t)$
(c) $5\, e^{-10t}\, \delta(t)$ (d) $5\, \delta(t) - 50\, e^{-10t}\, u(t)$

Q.7 A system is represented by the following equations:

$$x_2 = x_1 - x_3$$
$$x_3 = x_2$$
$$x_4 = x_1 - 2x_5$$
$$x_5 = x_4$$
$$x_6 = x_1 - 3x_7$$
$$x_7 = x_6$$
$$x_8 = x_3 + x_5 + x_6$$

Determine the transfer function x_8/x_1.

(a) $\dfrac{11}{13}$ (b) $\dfrac{13}{12}$
(c) $\dfrac{12}{13}$ (d) None of these

Q.8 For a transfer function $H(s) = \dfrac{P(s)}{Q(s)}$, where $P(s)$ and $Q(s)$ are polynomials in s.

Then:

(a) the degree of $P(s)$ is always greater than the $Q(s)$.
(b) the degree of $P(s)$ and $Q(s)$ are same.
(c) degree of $P(s)$ is independent of degree of $Q(s)$.
(d) the maximum degree of $P(s)$ and $Q(s)$ differ at most by one.

Q.9 The impulse response of an initially relaxed linear system is $e^{-2t}\, u(t)$. To produce a response of $te^{-2t}\, u(t)$, the input must be equal to

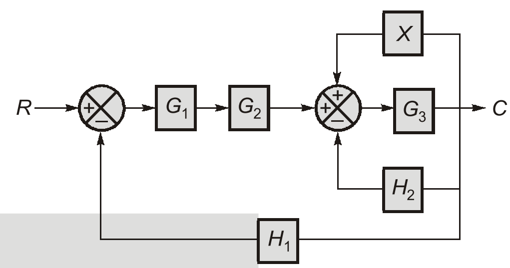
(a) $e^{-t}\, u(t)$ (b) $e^{-2t}\, u(t)$
(c) $2e^{-t}\, u(t)$ (d) $\dfrac{1}{2}\, e^{-2t}\, u(t)$

Q.10 The transfer function is applicable to

(a) linear and time variant system
(b) non-linear and time variant system
(c) linear and time invariant system
(d) non-linear and time invariant system

Q.11 A system block diagram is shown in the given figure. The overall transfer function of the system is

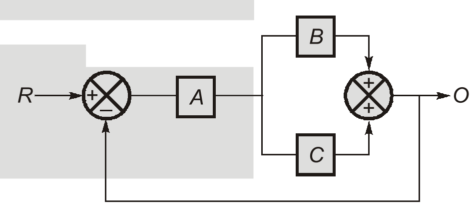
$$\frac{C}{R} = \frac{G_1 G_2 G_3}{1 + G_1 G_2 G_3 H_1 + G_3 H_2 - G_3 H_3}$$



The value 'X' would be equal to

(a) H_3 (b) $G_1 H_3$
(c) $G_2 H_3$ (d) $G_3 H_3$

Q.12 The transfer function of the system shown in the given figure is



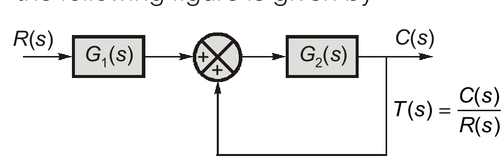
(a) $O/R = \dfrac{ABC}{1 + ABC}$

(b) $O/R = \dfrac{A + B + C}{1 + AB + AC}$

(c) $O/R = \dfrac{AB + AC}{ABC}$

(d) $O/R = \dfrac{AB + AC}{1 + AB + AC}$

Q.13 The transfer function $T(s)$ of the system shown in the following figure is given by



Answers Block Diagram and Transfer Function

1. (d)	2. (d)	3. (b)	4. (d)	5. (a)	6. (d)	7. (b)	8. (c)	9. (b)
10. (c)	11. (a)	12. (d)	13. (a)	14. (b)	15. (d)	16. (d)	17. (d)	18. (a)
19. (b)	20. (a)	21. (a)	22. (c)	23. (c)	24. (b)	25. (c)		

Explanations Block Diagram and Transfer Function

1. (d)

For negative feedback, as shown

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

$$G(s) = \frac{1}{s+1}\cdot\frac{2}{s+2}\cdot\frac{5}{s} = \frac{10}{s(s+1)\,(s+2)}$$

$$H(s) = 0.06 \times 10 = 0.6$$

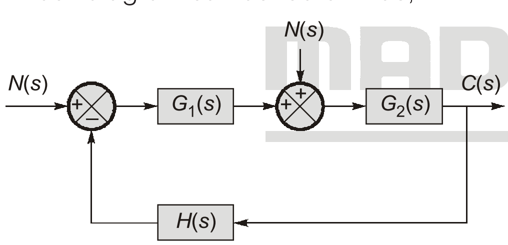
$$\frac{C(s)}{R(s)} = \frac{\dfrac{10}{s(s+1)\,(s+1)}}{1+\dfrac{10\times 0.6}{s(s+1)\,(s+2)}}$$

$$\frac{C(s)}{R(s)} = \frac{10}{s^3+3s^2+2s+6}$$

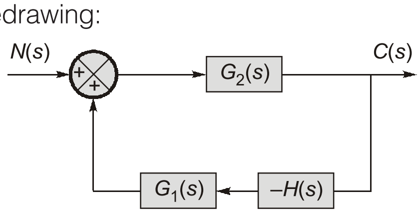
2. (d)

To calculate, $\dfrac{C(s)}{N(s)}$, input $R(s)$ is set to zero.

Block diagram can be redrawn as,



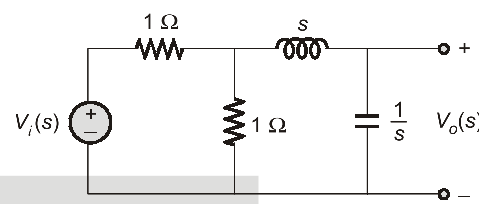
Redrawing:

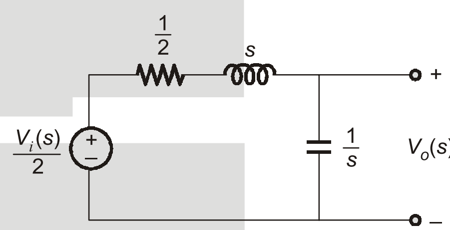


$$\frac{C(s)}{N(s)} = \frac{G_2(s)}{1-2(G_1 s)\,G_2(s)\,(-H)(s))}$$

$$\frac{C(s)}{N(s)} = \frac{G_2(s)}{1+G_1(s)\,G_2(s)\,H(s)}$$

3. (b)





Applying voltage division

$$\frac{V_o(s)}{\dfrac{V_i(s)}{2}} = \frac{\dfrac{1}{s}}{\dfrac{1}{2}+s+\dfrac{1}{s}} = \frac{2}{2s^2+2+2s}$$

$$2\frac{V_o(s)}{V_i(s)} = \frac{2}{2s^2+s+2}$$

$$\frac{V_o(s)}{V_i(s)} = \frac{1}{2s^2+s+2} = \frac{1}{2s^2+s+2}$$

4. (d)

Forward path:

$P_1 = G_1\,G_5$

Loops:
$L_1 : -G_1\,G_5\,G_8$
$L_2 : -G_1\,G_3\,G_4\,G_5$
$L_3 : -G_1\,G_5\,G_3\,G_6\,G_7$
$L_4 : -G_1\,G_2$

Note: No loops touch each other, no loops touch forward paths.

$\Rightarrow$ As per mason gain formula,

$$\frac{C}{R} = \sum_K \frac{P_k\cdot\Delta_k}{\Delta}$$

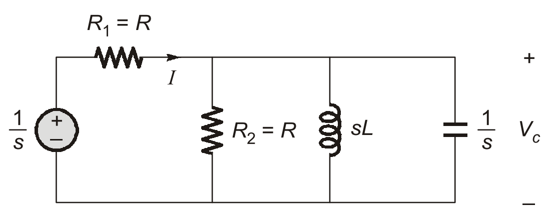
$$\Delta = 1-(L_1+L_2+L_3+L_4)$$

$$\Delta_k = 1 - 0$$

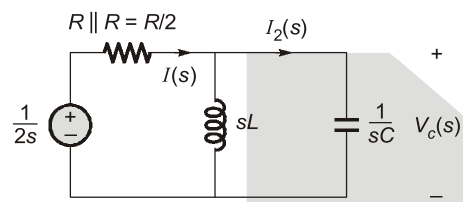
$$\frac{C}{R} = \frac{G_1 G_5}{1 + G_1(G_5 G_8 + G_3 G_4 G_5 + G_2 + G_3 G_5 G_6 G_7)}$$

5. (a)

Circuit in Laplace domain



Circuit can be redrawn as



$$I(s) = \frac{\frac{1}{2s}}{sL \| \frac{1}{sC}}$$

$$I_2(s) = \frac{sL}{sL + \frac{1}{sC}} \cdot I(s)$$

$$V_c(s) = \frac{1}{sC} \cdot I_2(s)$$

$$V_c(s) = \frac{1}{sC} \cdot \frac{sL}{\left(sL + \frac{1}{sC}\right)} \cdot \frac{\frac{1}{2s}}{sL \cdot \frac{1}{sC}} \cdot \left(sL + \frac{1}{sC}\right)$$

$$V_c(s) = \frac{1}{sC} \cdot \frac{sL}{2s} \cdot \frac{C}{L} = \frac{sLC}{2s^2 LC}$$

$$V_c(s) = \frac{1}{2s}$$

$$v_c(t) = \frac{1}{2} u(t)$$

6. (d)

$$h(t) = \frac{d}{dt}(s(t))$$

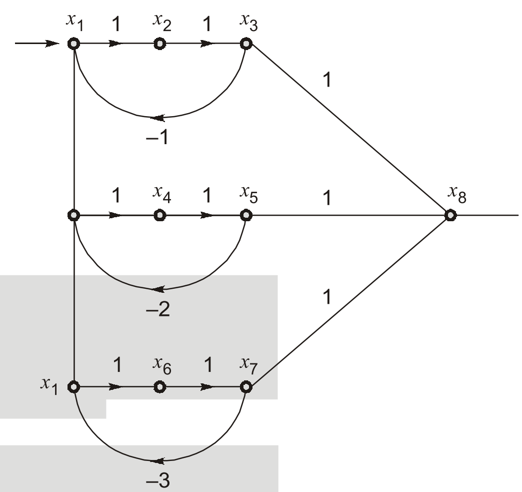
$$= \frac{d}{dt}(5e^{-10t} u(t))$$

$$h(t) = 5\left[e^{-10t}\delta(t) - 10e^{-10t}u(t)\right]$$

$$h(t) = 5e^{-0} \cdot \delta(t) - 50e^{-10t}u(t)$$
$$= 5\delta(t) - 50\, e^{-10t}u(t)$$

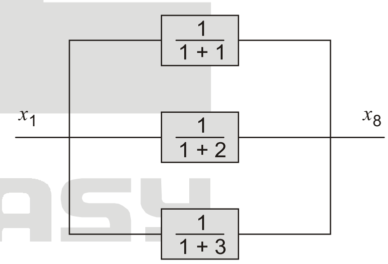
7. (b)

Drawing the signal flow graph,



Mason gain formula

$$\frac{C}{R} = \sum_K \frac{P_K \Delta_K}{\Delta}$$



$$\frac{x_8}{x_1} = \frac{1}{2} + \frac{1}{3} + \frac{1}{4} = \frac{13}{12}$$

8. (c)

Transfer function = $H(s) = \frac{P(s)}{Q(s)}$

For positive real function, the degree of $P(s)$ and $Q(s)$ must differ by one, but here nothing is mentioned, for transfer function to exist, only initial conditions must be mode zero, degree of $P(s)$ and $Q(s)$ are not of importance.

9. (b)

$$h(t) = e^{-2t}u(t)$$
$$y(t) = te^{-2t}u(t)$$