CLASS TEST S.No.: 01DLSK_ABCDEF_150426

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CONTROL SYSTEM

EC-EE

Date of Test : 15/04/2026

ANSWER KEY

1.	(c)	7.	(d)	13.	(a)	19.	(c)	25.	(d)
2.	(a)	8.	(c)	14.	(b)	20.	(a)	26.	(d)
3.	(a)	9.	(c)	15.	(b)	21.	(c)	27.	(c)
4.	(c)	10.	(a)	16.	(a)	22.	(a)	28.	(a)
5.	(b)	11.	(d)	17.	(b)	23.	(c)	29.	(a)
6.	(d)	12.	(d)	18.	(b)	24.	(b)	30.	(b)

DETAILED EXPLANATIONS

1. (c)

Using Mason's Gain formula;

$$\frac{X_6}{X_1} = \frac{G_1G_2G_3G_4 + G_1G_6G_4 + G_1G_7(1-G_5)}{1 - H_1G_2 - G_5 + G_2G_5H_1}$$

2. (a)

$$PM = 180° + \phi|_{\omega_{gc}}$$

$$\phi = \angle G(j\omega) = -90° - 2\tan^{-1}\left(\frac{\omega}{10}\right)$$

$$\phi|_{\omega_{gc}} = -90° - 2\tan^{-1}\left(\frac{40}{10}\right)$$

$$= -90° - 151.92°$$

$$= -241.92°$$

∴ $$PM = 180° - 241.92°$$

$$= -61.92°$$

3. (a)

Given; $P = 7; Z = 1$

$$\text{Final slope} = -(P - Z) \times 20$$

$$= -(7 - 1) \times 20$$

$$= -120 \text{ dB/decade}$$

4. (c)

On comparing the transfer function of the compensator with standard transfer function

$$G_c(s) = \frac{sT+1}{s\alpha T+1}$$

we get, $$\alpha = \frac{1}{3}$$

∴ $$\text{Maximum phase shift, } \phi_m = \sin^{-1}\left(\frac{1-\alpha}{1+\alpha}\right)$$

∴ $$\phi_m = \sin^{-1}\left(\frac{1-1/3}{1+1/3}\right)$$

$$= \sin^{-1}\left(\frac{2}{4}\right)$$

$$= 30°$$

5. (b)

$$\text{Resonant Peak, } M_r = \frac{1}{2\xi\sqrt{1-\xi^2}} = \frac{1}{2\times 0.5\sqrt{1-(0.5)^2}}$$

$$= 1.15$$

$$\text{Resonant frequency, } \omega_r = \omega_n\sqrt{1-2\xi^2}$$

$$= 8\sqrt{1-2(0.5)^2}$$
$$= 5.65 \text{ rad/sec}$$

6. (d)

Sketches in option (a), (b) and (c) are not symmetrical about real axis. Hence, they cannot be a root locus.

Only option (d) satisfies the conditions of a root locus.

7. (d)

The characteristic equation, $q(s) = (s + 2)(s + 4)(s + 6) + k$

$\Rightarrow$ $q(s) = s^3 + 12s^2 + 44s + 48 + k$

For system to be stable, Inner product > Outer product

$$12 \times 44 > 48 + k$$
$$k < 480$$

8. (c)

As we know that all the asymptotes intersect at centroid.

For $G(s) = \dfrac{k}{(s+2)^3}$, centroid $= \dfrac{-2-2-2}{3} = -2$

$$1 + G(s) = 0$$
$$1 + \frac{k}{(s+2)^3} = 0$$
$$k = -(s+2)^3$$
$$\frac{dk}{ds} = -3(s+2)^2 = 0$$

$\Rightarrow$ $k = -2, -2$

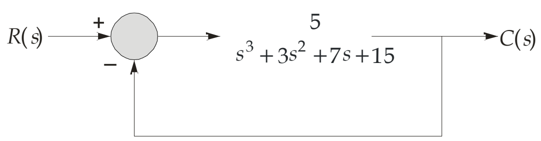
Hence, only option (c) satisfies both the conditions.

9. (c)

$$|G(j\omega)| = \frac{2}{\omega^2 + 1}$$
$$\frac{2}{1+\omega_{gc}^2} = 1$$
$$\omega_{gc} = 1 \text{ rad/sec}$$
$$\angle G(j\omega)|_{\omega_{gc}} = -2\tan^{-1}\omega_{gc}$$
$$= -90°$$
$$\text{PM} = 180° + \angle G(j\omega)|_{\omega_{gc}}$$
$$= 180° - 90°$$
$$= 90°$$

10. (a)

The block diagram can be redrawn as:



The system is of type 0.

11. (d)

The characteristic equation can be written as

$$q(s) = s^2 + 6s + 25 + k(s - 2)(s - 4)$$
$$= (1 + k)s^2 + (6 - 6k)s + 25 + 8k$$

On $j\omega$-axis, $\xi = 0$

$\therefore$ $$6 - 6k = 0$$
$$k = 1$$

12. (d)

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

$$1+\frac{k}{s(s+1)(s+2)} = 0$$

$\therefore$ Open loop transfer function, $G(s) = \dfrac{k}{s(s+1)(s+2)}$

$$\text{centroid, } \sigma = \frac{\Sigma(\text{real part of poles}) - \Sigma(\text{Real part of zeroes})}{P-Z}$$

$$= \frac{-1-2}{3}$$

$$= -1$$

13. (a)

In a root locus plot, all the asymptotes meet at a common point on the real axis known as centroid or centre of gravity which is given by,

$$\sigma_A = \frac{\sum(\text{Real parts of poles}) - \sum(\text{Real parts of zero})}{P-Z}$$

$\therefore$ $$\sigma_A = \frac{(0-1-2-3)-(-5)}{3} = -\frac{1}{3}$$

14. (b)

We know, $$X(s) = [sI - A]^{-1}\,[B]R(s)$$

$$X(s) = \begin{bmatrix} \dfrac{1}{(s+1)\,(s+2)} \\ \dfrac{1}{s+2} \end{bmatrix} R(s)$$

For step signal, $$R(s) = \frac{1}{s}$$

Now, $$Y(s) = [0 \quad 1]\ [X(s)]$$

$$Y(s) = \left[\frac{1}{s(s+2)}\right] = \frac{0.5}{s} - \frac{0.5}{s+2}$$

Therefore, $$y(t) = L^{-1}[Y(s)] = 0.5[1 - e^{-2t}]\,u(t)$$

$$y(1) = 0.43$$

15. (b)

For Type-2 system, having parabolic input $A \cdot \frac{t^2}{2} u(t)$;

The static error coefficient;

$$K_a = \lim_{s \to 0} s^2 \cdot G(s)H(s) = 0.2$$

and $$e_{ss} = \frac{A}{K_a}$$

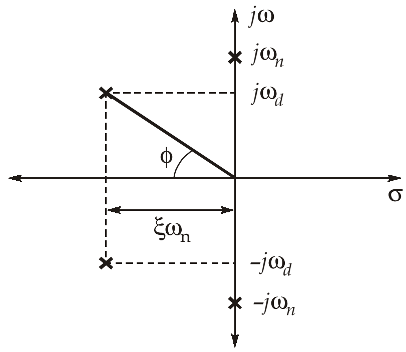
Here, A = 8, $$e_{ss} = \frac{8}{0.2} = 40$$

16. (a)

17. (b)

Concept:

The pole-zero plot for a standard second order underdamped system is as shown below,



ω_d = Damped frequency

ω_n = Natural frequency

$$\omega_d = \omega_n\sqrt{1-\xi^2}$$

$$\xi = \cos\phi$$

Calculation:

From given figure, $$\phi = 180° - 135° = 45°$$

$$\xi = \cos\phi = \frac{1}{\sqrt{2}}$$

$\because$ $$\xi\omega_n = 2$$

$$\omega_n = 2\sqrt{2}\text{ rad/sec}$$

$$\omega_d = \omega_n\sqrt{1-\xi^2} = 2\sqrt{2}\sqrt{1-\left(\frac{1}{\sqrt{2}}\right)^2} = 2\text{ rad/sec}$$

Now, Peak Time (T_p) = "Peak time is the time taken by the underdamped unit step response to reach the first peak overshoot ".

i.e. $$T_p = \frac{n\pi}{\omega_d}$$

Here, n = 1 $$T_p = \frac{\pi}{2}\text{ sec}$$

18. **(b)**

The closed loop transfer function of above system is,

$$\frac{C(s)}{T(s)} = \frac{-1}{s(3s+5)+6}$$

$$\because \quad T(s) = \frac{6}{s}$$

$$C(s) = -\frac{6}{s} \times \frac{1}{s(3s+5)+6}$$

Using final value theorem, $$C_{ss} = \lim_{s \to 0} s\left[-\frac{6}{s} \times \frac{1}{s(3s+5)+6}\right] = -1$$

19. **(c)**

Characteristic equation is

$$(s + 3)\,[s^3 + 2s^2 + 2s] + 10K = 0$$

$$s^4 + 2s^3 + 2s^2 + 3s^3 + 6s^2 + 6s + 10\text{ K} = 0$$

$$s^4 + 5s^3 + 8s^2 + 6s + 10K = 0$$

Using Routh table,

s^4	1	8	$10K$
s^3	5	6	
s^2	$\frac{40-6}{5}$	$10K$	
s^1	$\frac{\left(\frac{34}{5}\right)(6) - 50K}{\frac{34}{5}}$	0	
s^0	$10K$		

Row of 's' becomes zero for $K = \frac{34(6)}{5 \times 50}$

$$K = 0.816$$

Using Auxiliary equation,

$$\frac{34}{5}s^2 + 10K = 0$$

$$s^2 = \frac{-10(0.816) \times 5}{34}$$

$\therefore$ Natural frequency, $\omega_n = 1.095$ rad/sec

20. **(a)**

Phase cross-over frequency (ω_{pc}) : "It is system's frequency at which system's phase is 180°."

Gain cross-over frequency (ω_{gc}) : "It is system's frequency at which system's gain is unity or 0 dB."

$\Rightarrow$ From given plot, $\omega_{pc} = \omega_2$

$$\omega_{gc} = \omega_1$$

$\because \omega_{pc} > \omega_{gc}$ [i.e. $\omega_2 > \omega_1$]

The closed loop system is stable.

21. (c)

The characteristic equation of system is,

$$1 + G(s)H(s) = 0$$

$$s^4 + 6s^3 + 9s^2 + 24s + 21 = 0$$

Form *R-H* table,

s^4	1	9	21
s^3	6	24	
s^2	5	21	
s^1	−1.2		
s^0	21		

There is change of sign in first column of *R-H* table.

∴ The given system is unstable.

Remember: For unstable system, there is no steady state value present because system will NOT achieve its steady state condition.

22. (a)

$$\%M_p = \frac{c(t_p) - c(\infty)}{c(\infty)} \times 100$$

From figure,
$$= \frac{2.21-2}{2} \times 100 = 0.105 \times 100 = 10.5\%$$

We know,
$$\%M_p = e^{-\xi\pi/\sqrt{1-\xi^2}} \times 100$$

$$[\ln(0.105)]^2 = \frac{\xi^2\pi^2}{1-\xi^2}$$

$$\xi = 0.58$$

23. (c)

$$\frac{C(s)}{R(s)} = \frac{2}{s+2}$$

∵
$$r(t) = u(t)$$

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

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

∴
$$c(t) = (1 - e^{-2t})\, u(t)$$

Hence, the given system is over-damped.

Rise time: It is the time required for the response to rise from 10% to 90% of the final value for overdamped system.

$$C(\infty) = 1 \qquad \text{[Final value of response]}$$

Now,
$$0.1 = 1 - e^{-2t_1}$$

$$t_1 = 0.0526 \text{ sec}$$

$$0.9 = 1 - e^{-2t_2}$$

$$t_2 = 1.15 \text{ sec}$$

∴
$$T_r \text{ (rise time)} = t_2 - t_1 = 1.09 \text{ sec}$$

24. (b)

The closed loop response of second order system is given as,

$$\frac{C(s)}{R(s)} = \frac{K\cdot\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$$

On comparing with given transfer function,

$$K = 2,\quad \omega_n = 6,\quad \xi = \frac{1}{6}$$

Resonant peak, $$M_r = \frac{K}{2\xi\sqrt{1-\xi^2}}$$

$K \Rightarrow$ closed loop system's gain.

$\therefore$ $$M_r = \frac{2}{2\xi\sqrt{1-\xi^2}} = \frac{1}{\xi\sqrt{1-\xi^2}}$$

$$M_r = 6.085 = 20\log_{10}6.085 = 15.68 \text{ dB} \approx 16 \text{ dB}$$

25. (d)

For system to be underdamped,

Characteristic equation, $0 < \xi < 1$,

For $a = 1, K = 2$, $s^2 + 3s + 2 = 0$

$$\omega_n = \sqrt{2},\ \xi = 1.06$$

System is overdamped.

For a = 2, K = 2, $s^2 + 6s + 2 = 0$

$$\omega_n = 1.414 \text{ rad/sec}$$
$$\xi = 2.12$$

System is overdamped.

For a = 2, $K = 4$, $s^2 + 6s + 4 = 0$

$$\omega_n = 2 \text{ rad/sec}$$
$$\xi = 1.5$$

System is overdamped.

For $a = 1, K = 4$, $s^2 + 3s + 4 = 0$

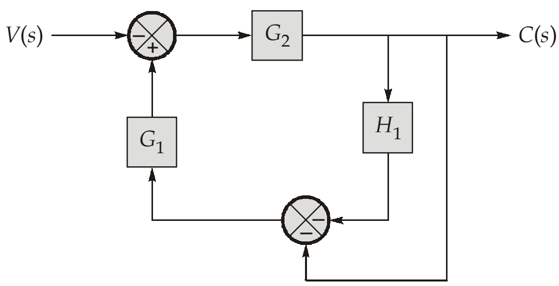
$$\omega_n = 2 \text{ rad/sec}$$
$$\xi = 0.75$$

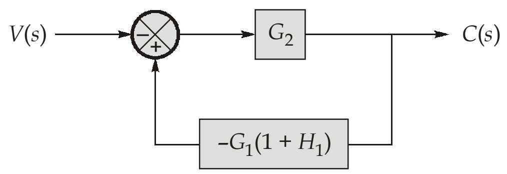
System is underdamped.

26. (d)

To obtain $\frac{C(s)}{V(s)}$, $R(s) = 0$

Using block diagram reduction





$$C(s) = G_2[-V(s) - G_1(1 + H_1)\, C(s)]$$

$$C(s) + G_1G_2(1 + H_1)\, C(s) = -G_2\, V(s)$$

$$\frac{C(s)}{V(s)} = \frac{-G_2}{1+G_1 G_2 (1+H_1)}$$

27. (c)

28. (a)

$$S_H^T = \frac{-G(s)H(s)}{1+G(s)H(s)} = \frac{-2}{s^2+2s+2}$$

$$S_H^T\Big|_{j\omega} = \frac{-2}{2-\omega^2+j2\omega}$$

$$\left|S_H^T\right| = \frac{2}{\sqrt{(2-\omega^2)^2+(2\omega)^2}} = \frac{2}{\sqrt{(2-4)^2+(4)^2}} = \frac{2}{\sqrt{4+16}} = \frac{2}{\sqrt{20}}$$

$$\left|S_H^T\right| = 0.447$$

$$S_H^T = -0.447 \approx -0.5$$

29. (a)

Comparing the closed loop transfer function to that of a standard second order system, we have

$$\omega_n^2 = 25$$

$$\omega_n = 5 \text{ rad/sec}$$

$$2\xi\omega_n = 5$$

$$\xi = \frac{5}{10} = 0.5$$

$$t_{\max} = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n\sqrt{1-\xi^2}} = \frac{\pi}{5\sqrt{1-(0.5)^2}}$$

$$t_{\max} = \frac{\pi}{5\sqrt{0.75}} = \frac{2\pi}{5\sqrt{3}} \text{ sec}$$

30. (b)

DC gain of the system is the gain of the transfer function at $s = 0$ provided all the poles and zeros at origin are removed.

DC gain, $$H(0) = \frac{3}{5(1)^2} = 0.6$$

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