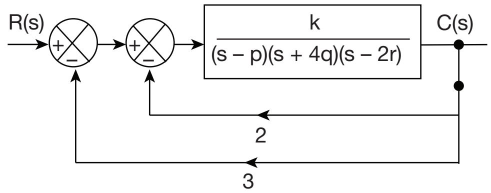
Control Systems Test 2

Number of Questions: 35 **Time: 60 min.**

Directions for questions 1 to 35: Select the correct alternative from the given choices.

1. For given block diagram, the limiting value of k for stability of inner loop is found to be $a < k < b$. The overall system will be stable if and only if



(A) $5a < k < 5b$ (B) $6a < k < 6b$

(C) $\frac{a}{6} < k < \frac{b}{6}$ (D) $\frac{a}{5} < k < \frac{b}{5}$

2. The transfer function $\frac{1+s}{1+0.5s}$ represent a

(A) lag network
(B) lag-lead network
(C) lead network
(D) proportional controller

3. The angles of asymptotes of given unity feed back transfer function are $G(s) = \frac{k(s+1)}{s(s+3)(2s+4)(s+7)}$

(A) $0, \frac{2\pi}{3}, \frac{4\pi}{3}$ (B) $\frac{\pi}{3}, \pi, \frac{5\pi}{3}$

(C) $\frac{2\pi}{3}, \pi, \frac{5\pi}{3}$ (D) $0, \frac{\pi}{3}, \frac{5\pi}{3}$

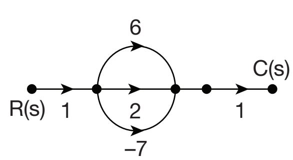
4. Characteristic equation of a feedback control system is given by $(s^2 + 8s + 15)(s^2 + 10s + 21) + ks^2 + k9 = 0$ and $k > 0$.
The point where the asymptotes meet in s – plane is

(A) (+2, –j3) (B) (–2, +j3)
(C) (10, 0) (D) (–9, 0)

5. Which one of the following must have negative real parts for a system to be stable?

(A) Gain margin
(B) the zeros of the transfer function
(C) the system eigen values
(D) all the above

6. For the given signal flow graph $\frac{C(s)}{R(s)}$ is



(A) 1 (B) zero
(C) infinite (D) not possible to find

7. The Bode plot is used to analyse

(A) minimum phase network
(B) non-minimum phase network
(C) All phase
(D) All the above

8. The break away points of root-locus occur at

(A) single root of characteristic equation
(B) imaginary axis
(C) Real axis
(D) multiple roots of characteristic equation

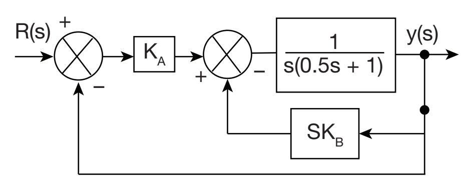
9. A unity feedback system has an open loop transfer function, $G(s) = \frac{36}{s(s+9.6)}$, the time required to reach the peak input will be

(A) 0.65 sec (B) 1 sec
(C) 0.83 sec (D) 0.87 sec

10. The step error co-efficient of a system $G(s) = \frac{1}{(s+3)(s+2)}$, with unity feed back is

(A) 6 (B) 0
(C) ∞ (D) $\frac{1}{6}$

11.



The open loop DC gain of a unity negative feed back system with closed loop transfer function $\frac{s+5}{s^2+8s+20}$ is

(A) $\frac{1}{4}$ (B) $\frac{1}{3}$

(C) 4 (D) 3

12. Non-minimum phase transfer function for a stable system is defined as the transfer function

(A) which has zeros in the right-half of s plane
(B) which has zeros only in the left-half of s plane
(C) which has poles in the left-half s plane
(D) which has poles in the right-half s plane

13. Consider the following statements
In root-locus plot, the breakaway points
(1) Need-not always lie be on the real-axis alone
(2) Must be on the root loci

which of these statements are correct

(A) only 1 (B) only 2

(C) both statements (D) None of the above

14. If the transfer function of a phase lead compensator is $(s + p) / (s + q)$ and transfer function of a lag compensator is $(s + a) / (s + b)$ then which of the following sets of conditions are required

(A) $a > b$ and $p > q$ (B) $a > b$ and $p < q$

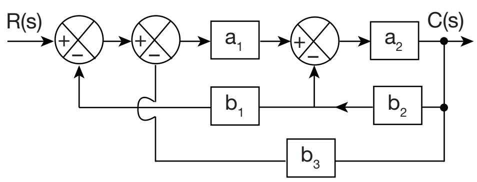
(C) $a < b$ and $p < q$ (D) $a < b$ and $p < q$

15. A system described by given differential equation $\frac{dy^2}{dt^2} + 5\frac{dy}{dt} + 4y = x(t)$ is initially at rest. For input $x(t) = 3u(t)$,the output $y(t)$ at = 0.5 sec is

(A) 0.75 (B) 0.64

(C) 1.39 (D) 0.11

16. Consider the block diagram shown below.



For given system the transfer functions is

(A) $\dfrac{a_1 \ a_2}{1 + a_2b_2 + a_1b_1 + a_2a_1b_3}$

(B) $\dfrac{a_1 \ a_2}{1 + a_2b_2 + a_1b_1 - a_1a_2b_3}$

(C) $\dfrac{a_1 \ a_2}{1 + a_2b_2 + a_1a_2b_3 + a_1a_2b_1b_2}$

(D) $\dfrac{a_1 \ a_2}{1 + (a_2b_2 + a_1a_2b_1b_2 + a_1a_2b_3)}$

17. The state-space representation of a system is given by

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

$Y(t) = \begin{bmatrix} 1 & 1 \end{bmatrix} x(t)$, The initial value of this system is

(A) 2 (B) 1

(C) 6 (D) 5

18. Given state-space representation of a transfer function as $\dot{X} = \begin{bmatrix} -2 & 0 \\ -1 & -4 \end{bmatrix} x + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u(t)$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} x \ and \ x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

Where $U(t)$ is unit step input then output is given as

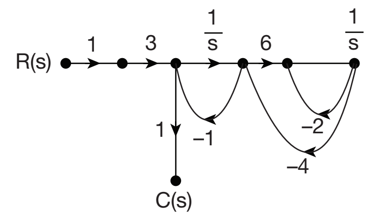
(A) $\left[\frac{1}{6} - \frac{1}{4}e^{2t} + \frac{7}{8}e^{-4t}\right]u(t)$

(B) $\left[\frac{1}{6} - \frac{7}{8}e^{-2t} + \frac{1}{4}e^{-4t}\right]u(t)$

(C) $\left[\frac{1}{2} - \frac{3}{4}e^{-2t} + \frac{7}{4}e^{-4t}\right]u(t)$

(D) $\left[\frac{3}{8} - \frac{5}{4}e^{-2t} + \frac{15}{8}e^{-4t}\right]u(t)$

19. The transfer function $\frac{C(s)}{R(s)}$ of the given signal flow is



(A) $\dfrac{3s(s+26)}{s^2+27s+2}$ (B) $\dfrac{3s^2+78s+96}{s^2+27s+2}$

(C) $\dfrac{3(s+26)}{s^2+27s+2}$ (D) $\dfrac{s(s+26)}{s^2+27s+2}$

20. When the poles of a system is on imaginary axis with out repeating, then the system is

(A) stable (B) absolutely stable

(C) marginally stable (D) unstable

21. The transfer function of a system

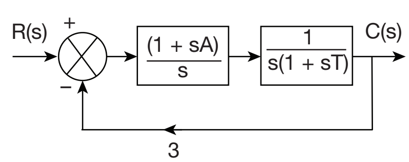
$$G(s) = \frac{200}{(s+2)(s+200)}$$

for a unit step input to the system. The approximate seltling time for 5% criterion is

(A) 1.5 sec (B) 2 sec

(C) 0.03 sec (D) 0.04 sec

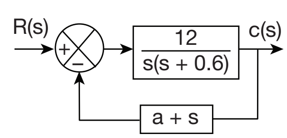
22. In order to stabilize the system given below 'A' should satisfy



(A) $A > T$ (B) $A > T$

(C) $A = T$ (D) $A \leq T$

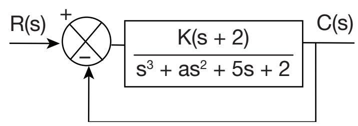
23. Find the rise time t_r, if damping ratio is 0.5



(A) 0.11 sec (B) 0.109 sec

(C) 0.19 sec (D) 0.25 sec

24. The positive values of 'K' and 'a', so that the given system oscillates at a frequency of 3 rad/sec, respectively are



(A) $\begin{matrix}K=4\\a=10/9\end{matrix}$ (B) $\begin{matrix}K=10/9\\a=4\end{matrix}$

(C) $\begin{matrix}K=7/2\\a=18/17\end{matrix}$ (D) $\begin{matrix}K=18/17\\a=7/2\end{matrix}$

25. Consider a closed – loop system shown in figure (a) below and its root locus is in figure (b). The closed loop transfer function for the system is

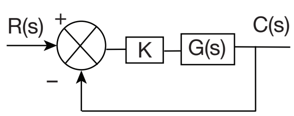


fig (a)

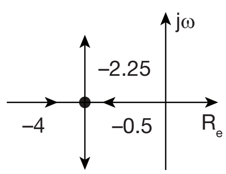


fig (b)

(A) $\dfrac{k}{1+(2s+1)(0.25s+1)}$

(B) $\dfrac{k}{(2s+1)(0.25s+1)}$

(C) $\dfrac{k}{1+k(s+0.5)(s+4)}$

(D) $\dfrac{k}{k+(2s+1)(0.25s+1)}$

26. The polar plot of $G(s)=\dfrac{15}{s(s+2)^2}$, intersects real axis at $\omega=\omega_o$, then, the real part and ω_o are respectively.

(A) $\frac{15}{16},2$ (B) $\frac{16}{15},2$

(C) $2,\frac{15}{16}$ (D) $2,\frac{16}{15}$

27. The open loop transfer function of a feedback control system is $G(s)=\dfrac{1}{s(s+1)(s+2)}$, the gain margin of the system is

(A) $\frac{1}{6}$ (B) $\sqrt{2}$

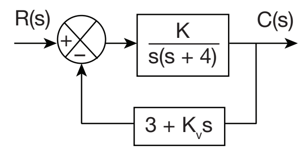
(C) $\sqrt{6}$ (D) 6

28. A unity feedback system has transfer function $G_1=\dfrac{1}{(s+2)(5s+1)}$. An integral controller with transfer function $G_c(s)=\dfrac{k}{s}$ is kept in the forward path of feedback system. The compensated system has an open – loop gain margin of 5 then the value of k is

(A) $\sqrt{\frac{2}{5}}$ (B) 22

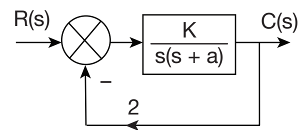
(C) $\frac{1}{22}$ (D) $\sqrt{\frac{5}{2}}$

29. Find the K_v value so that the maximum overshoot in the unit step response is 0.35 and peak time is 2 sec



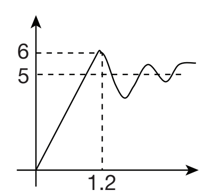
(A) 1.914 (B) 2.317
(C) –3.23 (D) –2.317

30. For the system given below, obtain the value of constant ‘a’ to satisfy, $M_r = 1.04$ and $\omega_r = 12$ rad/sec.



(A) 27 (B) 57
(C) 25 (D) 37

31. The step response of second order system is given below, for an input of 5u(t) the closed loop transfer function is



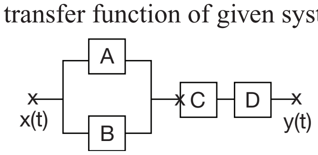
(A) $\dfrac{2.94}{s^2+2.67s+2.94}$ (B) $\dfrac{8.65}{s^2+2.67s+8.65}$

(C) $\dfrac{8.65}{s^2+2.67s+2.94}$ (D) $\dfrac{2.94}{s^2+2.67s+8.65}$

Statement for common data questions 32 and 33

Block A, B, C, D are connected as shown in the figure and their impulse responses are cos2t, sin2t, Ke^{-4t}, e^{-t} respectively.

32. The overall transfer function of given system is



(A) $\dfrac{k(s+2)}{(s^2+2)(s+4)(s+1)}$

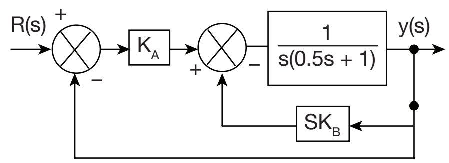
(B) $\dfrac{k}{(s^2+2)^2(s+4)(s+1)}$

(C) $\dfrac{k}{(s^2+4)(s+1)}$

(D) $\dfrac{k(s+2)}{(s^2+2)^2(s+1)(s+4)}$

33. Find the range of k for which the system become stable
(A) all values of k
(B) No value of k
(C) $-4 < k < 0$
(D) All values of k except (–4, 0) range

Statement for linked questions 34 and 35



34. Find the steady – state error to unit ramp input when $K_B = 0$ and $K_A = 10$.
(A) 10
(B) 20
(C) 0.05
(D) 0.1

35. Find suitable values of the parameters K_A and K_B so that the damping ratio is 0.7 and steady state error is as obtained in 34 question
(A) $K_A = 98$, $K_B = 8.8$
(B) $K_B = 98$, $K_A = 8.8$
(C) $K_A = K_B = 9.8$
(D) $K_A = K_B = 8.8$

Answer Keys

1. D	**2.** C	**3.** B	**4.** D	**5.** C	**6.** A	**7.** A	**8.** D	**9.** D	**10.** D
11 B	**12.** A	**13.** C	**14.** B	**15.** D	**16** C	**17.** A	**18.** D	**19.** A	**20.** C
21. A	**22.** A	**23.** C	**24.** A	**25.** D	**26.** A	**27.** D	**28.** B	**29.** C	**30.** A
31. B	**32.** C	**33.** C	**34.** D	**35.** A					

Hints and Explanations

1. The overall transfer function look like

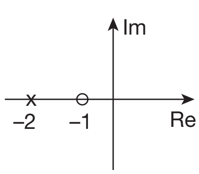
$$\frac{C(S)}{R(S)} = \frac{G(S)}{G(S)+2k+3k}$$

If stability k range is given as $a < k < b$, $a < 5k < b$

$$\frac{a}{5} < k < \frac{b}{5}$$

Choice (D)

2. Polar plot is
$s = -1$ zero
$s = -2$ pole



So it is lead network
Choice (C)

3. Angle of asymptotes $\dfrac{(2k+1)\pi}{no.of\ poles - No.of\ zeros}$

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

$$Qa = \begin{cases} \dfrac{\pi}{3} & for \quad k=0 \\ \pi & for \quad k=1 \\ \dfrac{5\pi}{3} & for \quad k=2 \end{cases}$$

Choice (B)

4. Characteristic equation

$$1+\frac{k(s^2+9)}{(s+3)^2+(s+5)(s+7)} = 0$$

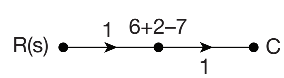
Poles are –3, –3, –5, –7, zeros are $-j3, j3$
Intersection of Asymptotes is

$$= \frac{-3-3-5-7-(-j3+j3)}{4-2} = -9$$

The point of intersection of asymptotes is (–9, 0)
Choice (D)

5. Choice (C)

6.



Choice (A)

7. Choice (A)

8. Break – away or break – in point occurs at multiple roots of characteristic equation. Choice (D)

9. $t_p = \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

Closed loop Transfer function = $\dfrac{36}{s^2+9.6s+36}$

$\omega_n = 6$

$$\xi = \frac{9.6}{2x6} = 0.8$$

$$t_p = \frac{\pi}{6\sqrt{1-(0.8)^2}} = \frac{\pi}{3.6} = 0.87s$$

Choice (D)

10. Step error co-efficient (k_p) = $\underset{s\to 0}{Lt}\dfrac{1}{(s+2)(s+3)}$ = 1/6

Choice (D)

11. $$\frac{G}{1+G}=\frac{s+5}{s^2+8s+20}$$

$$\Rightarrow G(s)=\frac{s+5}{s^2+7s+15}$$

So open loop DC gain is = $\dfrac{5}{15}=\dfrac{1}{3}$ Choice (B)

12. A system in which one or more zeros lie on the right half of s – plane and remaining all poles and zeros lie on the left half of s – plane is called Non-minimum phase. Choice (A)

13. Choice (C)

14. In phase lead compensator, zero is nearer to origin. In phase lag compensator, pole is near to origin.

Choice (B)

15. Given differential equation is

$$\frac{d^2y}{dt^2}+5\frac{dy}{dt}+4y=x(t)$$

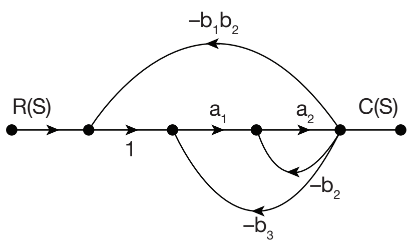
$$\Rightarrow \quad y(s)=\frac{3}{s(s+1)(s+4)}$$

$$y(s)=\frac{3}{4s}-\frac{1}{s+1}-\frac{1}{4(s+4)}$$

$$=\left(\frac{3}{4}-e^{-t}-\frac{1}{4}e^{-4t}\right)u(t)\ = 0.109$$

≈ 0.11 Choice (D)

16. Draw signal flow graph for given block diagram.



$$\frac{c(s)}{R(s)}=\frac{a_1a_2}{1+a_2b_2+a_1a_2b_3+a_1a_2b_1b_2}$$ Choice (C)

17. $T(S) = C\,(sI - A)^{-1}\,B + D$

$$=\begin{bmatrix}1 & 1\end{bmatrix}\left\{\begin{bmatrix}s & 0\\ 0 & s\end{bmatrix}-\begin{bmatrix}-2 & 0\\ 0 & -3\end{bmatrix}\right\}^{-1}\begin{bmatrix}1\\ 1\end{bmatrix}+0$$

$$=\frac{(s+3)+(s+2)}{(s+2)(s+2)}=\frac{2s+5}{(s+5)(s+2)}$$

Appling initial value theorem

$$\underset{s\to\infty}{Lt}\ sT(s)=\underset{s\to\infty}{Lt}\frac{s(2s+5)}{(s+3)(s+2)}=2$$ Choice (A)

18. $X(s) = (sI - A)^{-1}\,x(0) + B.U$

$$=\left\{\begin{bmatrix}s & 0\\ 0 & s\end{bmatrix}-\begin{bmatrix}-2 & 0\\ -1 & -4\end{bmatrix}\right\}^{-1}\left[\begin{bmatrix}1\\ 1\end{bmatrix}+\begin{bmatrix}1\\ 2\end{bmatrix}\frac{1}{s}\right]$$

$$=\frac{1}{(s+2)(s+4)}\begin{bmatrix}s+4 & 0\\ -1 & s+2\end{bmatrix}\left[\begin{bmatrix}1\\ 1\end{bmatrix}+\begin{bmatrix}1\\ 2\end{bmatrix}\frac{1}{s}\right]$$

$$=\frac{1}{(s+2)(s+4)}\begin{bmatrix}\frac{s^2+5s+1}{s}\\ \frac{s^2+s+3}{s}\end{bmatrix}$$

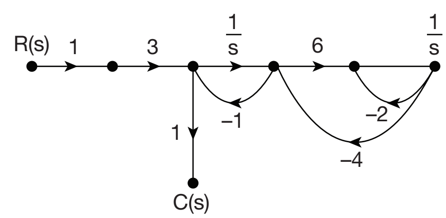
$$y(s)=\begin{bmatrix}0 & 1\end{bmatrix}\begin{bmatrix}\frac{s^2+5s+1}{s(s+2)(s+4)}\\ \frac{s^2+s+3}{s(s+2)(s+4)}\end{bmatrix}$$

$$y(s)=\frac{s^2+s+3}{s(s+2)(s+4)}$$

$$y(s)=\frac{3}{8s}-\frac{5}{4(s+2)}+\frac{15}{8(s+4)}$$

$$=\left[\frac{3}{8}-\frac{5}{4}e^{-2t}+\frac{15}{8}e^{-4t}\right]u(t)$$ Choice (D)

19.



$$\frac{C(s)}{R(s)}=\frac{3\left[1+\frac{2}{s}+\frac{24}{s}\right]}{1+\frac{1}{s}+\frac{2}{s}+\frac{24}{s}+\frac{2}{s^2}}=\frac{3s(s+26)}{s^2+27s+2}$$

Choice (A)

20. Choice (C)

21. $$G(s)=\frac{200}{(s+2)(s+200)}$$

Dominate pole is at –2 and setting time is = $3T$

$=\dfrac{3}{\xi\omega_n}$ = 1.5 sec Choice (A)

22. Transfer function $=\dfrac{(1+sA)}{s^2(1+sT)+3(1+sA)}$

$\Rightarrow$ characteristic equation is

$s^3\,T + s^2 + 3sA + 3 = 0$

$$\begin{array}{c|c|c} s^3 & T & 3A\\ s^2 & 1 & 3\\ s^1 & \dfrac{3A-3T}{1} & 0\\ s^0 & 3A & \end{array}$$

$A > 0$

$A - T > 0$

$A > T$ Choice (A)

23. $\dfrac{C(s)}{R(s)} = \dfrac{12}{s^2+0.6s+12(a+s)}$

$= \dfrac{12}{s^2+s(12.6)+12a}$

$\Rightarrow 2\times\dfrac{1}{2}\times\omega_n = 12.6\sqrt{b^2-4ac}$

$\omega_n = 12.6$

$\Rightarrow \textit{rise time} = \dfrac{\pi-\cos^{-1}\xi}{\omega_d}$

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

$= 12.6\sqrt{1-0.25} = 12.6\sqrt{0.75}$

Rise time $= \dfrac{\pi-\cos^{-1}0.5}{12.6\sqrt{0.75}} = 0.19$ sec

Choice (C)

24. Given transfer function

$\dfrac{C(s)}{R(s)} = \dfrac{k(s+2)}{s^3+as^2+5s+2+k(s+2)}$

characteristic equation is

$s^3 + as^2 + (5+k)s + 2(1+k) = 0.$

s^3	1	5 + k
s^2	a	2(1 + k)
s^1	$\dfrac{(5+k)a-2(1+k)}{a}$	0
s^0	2(1 + k)	

For oscillations $\dfrac{(5+k)a-2(1+k)}{a} = 0$

$a = \dfrac{2(1+k)}{(5+k)} \rightarrow @$

$\Rightarrow$ $as^2 + 2(1+K) = 0$ and $\omega_n = 3$

Sub $s = j\omega$

$s^2 = \omega^2 = -9$

$-9a = -2(1+K)$

$a = \dfrac{2}{9}(1+k) \rightarrow (b)$

$\Rightarrow$ equate (a) & (b)

$\dfrac{2(1+k)}{5+k} = \dfrac{2}{9}(1+k)$

$\Rightarrow$ $k = 4$ and $a = \dfrac{10}{9}$

Choice (A)

25. $G(s) = \dfrac{1}{(s+0.5)s+4} = \dfrac{8}{(2s+1)(0.25s+1)}$

$\dfrac{C(s)}{R(s)} = \dfrac{k}{k+(2s+1)(0.25s+1)}$

Choice (D)

26. $G(s) = \dfrac{15}{s(s+2)^2}$

$-180° = -90° - 2\tan^{-1}\dfrac{\omega}{2}$

$\Rightarrow$ $\omega = 2$

$|M| = \dfrac{15}{\omega\sqrt{(\omega^2+2^2)^2}} = \dfrac{15}{2(8)} = \dfrac{15}{16}$

Choice (A)

27. $\omega_{pc} = -180 - 90° - \tan^{-1}\omega - \tan^{-1}\dfrac{\omega}{2}$

$90 = \tan^{-1}\omega + \tan^{-1}\dfrac{\omega}{2}$

$1 - \dfrac{\omega^2}{\omega} = 0$

$\omega = \sqrt{2}$

$M = \left|\dfrac{1}{\omega\sqrt{1+\omega^2}\sqrt{4+\omega^2}}\right| = \left|\dfrac{1}{\sqrt{2}\sqrt{3}\sqrt{6}}\right|$

$M\big|\omega_{pc} = \dfrac{1}{6}$

$G.M = \dfrac{1}{|M|\omega_{pc}} = 6$

Choice (D)

28. $G(s) = G_1(s)G_c(s)$

$= \dfrac{k}{s(s+2)(5s+1)}$

$\Rightarrow$ $\omega_{pc} = -180° = \angle G(j\omega)$

$-180° = -90° - \tan^{-1}\dfrac{\omega}{2} - \tan^{-1}5\omega$

$\tan^{-1}\dfrac{5.5\omega}{1-\dfrac{5}{2}\omega^2} = 90°$

$\omega^2 = \dfrac{2}{5} \Rightarrow \omega = \sqrt{\dfrac{2}{5}}$

$G.M = 5 = \dfrac{K}{\left|\omega\sqrt{4+\omega^2}\sqrt{25\omega^2+1}\right|}$

$5 = \dfrac{K}{\left|\sqrt{\dfrac{2}{5}}\sqrt{4+\dfrac{2}{5}}\sqrt{25\times\dfrac{2}{5}+1}\right|} \Rightarrow K = 22$

Choice (B)

29. Characteristic equation

$s(s+4) + k(3+k_v s) = 0$

$s^2 + (4+kk_v)s + 3k = 0$

$\omega_n = \sqrt{3k}$

$2x\ \xi\ x\ \sqrt{3k} = 4 + kk_v$

$$= \frac{4+kk_v}{2\sqrt{3k}}$$

$\rightarrow$ peak overshoot $e^{-\xi\pi/\sqrt{1-\xi^2}} = 0.35$

$\Rightarrow$ $\xi = 0.317$

$\rightarrow$ Given that $t_p = 2$ sec

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

$$\omega_n = \frac{\pi}{2\sqrt{1-(0.317)^2}} = 1.65 \text{ rad/sec}$$

$\Rightarrow$ $1.65 = \sqrt{3k}$

$\Rightarrow$ $0.317 = \dfrac{4+0.914k\Omega}{2\times 1.65}$

$k_v = -3.23$ Choice (C)

30. $\dfrac{C(s)}{R(s)} = \dfrac{k}{s^2+as+2k}$

$$M_r = 1.04 = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

$\xi = 0.6$; 0.798 but M_r is valid only for $\xi < \dfrac{1}{\sqrt{2}}$

So $\xi = 0.6$

$2\xi\ x\ \sqrt{2k} = a$

$\xi = \dfrac{\xi}{2\sqrt{2k}} = 0.6$

And $\omega_r = 12$

$\omega_n\sqrt{1-2\xi^2} = 12$

$\omega_n = 22.677$

But $\omega_n = \sqrt{2k}$

$k = 257.14$

$\Rightarrow$ $a = 2\xi\omega_n$

$= 2\ x\ 0.6\ x\ 22.677 = 27$ Choice (A)

31. Maximum peak over short $M_p = \dfrac{6-5}{5} \times 100 = 20\%$

$e^{-\xi\pi/\sqrt{1-\xi^2}} = 0.2$

$\Rightarrow$ $\xi = 0.455$

$$t_p = 1.2 = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$$

$\omega_n = 2.94$

And order closed loop transfer function is

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

$$= \frac{8.65}{s^2+2.67s+8.65}$$ Choice (B)

32. $H(S) = (A + B)\ CD$

$$= \frac{4+s}{s^2+4}\times\frac{k}{s+4}\times\frac{1}{s+1}$$

$$\frac{k}{(s^2+4)(s+1)}$$ Choice (C)

33. Characteristic equation

$= (s^2 + 4)(s + 1) + k$

$= s^3 + s^2 + 4s + 4 + k$

s^3	1	4
s^2	1	4 + k
s^1	–k	0
s^0	4 + k	

$-k > 0$

$\Rightarrow k > 0$

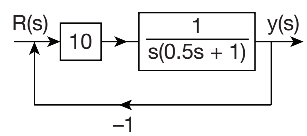
$4 + k > 0$

$k > -4$

$-4 < k < 0$ is the range of k for the system to be stable.

Choice (C)

34.



$$= \frac{10\times 2}{s(s+2)}$$

$$k = \underset{s\to 0}{Lt}\ s\frac{20}{s(s+2)} = 10$$

$$e_{ss} = \frac{1}{10} = 0.1$$ Choice (D)

35. Transfer function

$$H(s) = \frac{K_A}{s(0.5s+1)+sK_B+K_A}$$

$$= \frac{2K_A}{s^2+2s(1+K_B)+2K_A}$$

Given that damping ratio is 0.7

$2\ x\ (1 + K_B) = 2\ x\ 0.7\ x\ \sqrt{2K_A}$

and steady state error is to be 0.1

$$0.1 = \frac{1}{\dfrac{2K_A}{2(1+K_B)}}$$

$\Rightarrow (1+k_B) = 0.1K_A$

$\Rightarrow$ $K_A = 98$

$K_B = 8.8$ Choice (A)