CLASS TEST

S.No.: 01 SK_EC+EE_E+F_07623

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CONTROL SYSTEMS

EC | EE

Date of Test : 07/06/2023

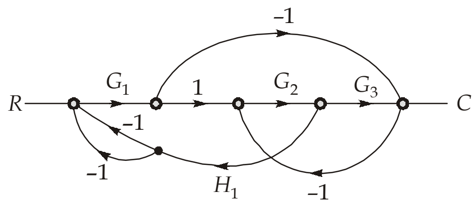
ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

The signal flow graph for the given block diagram can be drawn as



As per signal flow graph, the loops are

$$L_1 = G_2G_3(-1) = -G_2G_3$$
$$L_2 = G_1G_2H_1(-1) = -G_1G_2H_1$$
$$L_3 = G_1G_2H_1(-1) = -G_1G_2H_1$$
$$L_4 = G_1(-1)(-1)G_2H_1(-1) = -G_1G_2H_1$$
$$L_5 = G_1(-1)(-1)G_2H_1(-1) = -G_1G_2H_1$$

$\therefore$
$$\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5)$$
$$= 1 - (-G_2G_3 - G_1G_2H_1 - G_1G_2H_1 - G_1G_2H_1 - G_1G_2H_1)$$
$$= 1 + G_2G_3 + 2G_1G_2H_1 + 2G_1G_2H_1$$
$$= 1 + G_2G_3 + 4G_1G_2H_1$$

and
$$P_1 = G_1G_2G_3$$
$$\Delta_1 = 1$$
$$P_2 = G_1(-1) = -G_1$$
$$\Delta_2 = 1$$

$\therefore$
$$\frac{C}{R} = \frac{P_1\Delta_1 + P_2\Delta_2}{\Delta} = \frac{G_1(G_2G_3 - 1)}{1 + G_2G_3 + 4G_1G_2H_1}$$

2. (c)

Given,
$$y(t) = 2te^{-5t}$$
$$x(t) = u(t)$$

Taking Laplace transform, we get,

$$Y(s) = \frac{2}{(s+5)^2} \quad \text{and} \quad X(s) = \frac{1}{s}$$

$\therefore$ Overall transfer function,

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

3. (b)

The characteristic equation of the given system is,

$$1 + G(s)H(s) = 1 + \frac{K}{4s^3 + 2s^2 + 3s} = 0$$

or
$$4s^3 + 2s^2 + 3s + K = 0$$

Using Routh's tabular form,

s^3	4	3
s^2	2	K
s^1	$\frac{6-4K}{2}$	
s^0	K	

For stability,

$$K > 0$$

and $$\frac{6-4K}{2} > 0$$

or $$4K < 6$$

$$K < \frac{3}{2}$$

So, the required condition is $0 < K < \frac{3}{2}$.

4. (a)

The closed loop transfer function,

$$\frac{C(s)}{R(s)} = \frac{12}{s(s+5)+12} = \frac{12}{s^2+5s+12}$$

Here, on comparing with standard second order transfer function, we get,

$$\omega_n = \sqrt{12}$$

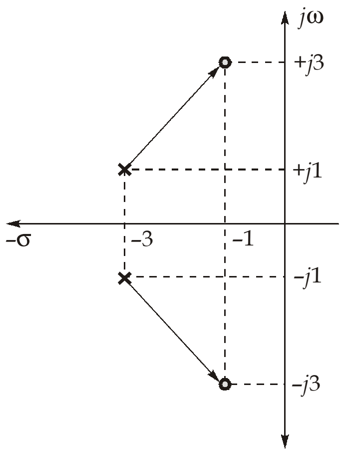
and $$\xi\omega_n = \frac{5}{2}$$

For 2% tolerance,

$$\tau_s = \frac{4}{\xi\omega_n} = \frac{4}{5/2} = \frac{8}{5} = 1.6 \text{ sec}$$

5. (d)

$$G(s)H(s) = \frac{K(s^2+2s+10)}{(s^2+6s+10)}$$



For, $s^2 + 6s + 10 = 0$

$$s = \frac{-6 \pm \sqrt{36-40}}{2} = -3 \pm j$$

For, $s^2 + 2s + 10 = 0$

$$s = \frac{-2 \pm \sqrt{4-40}}{2} = -1 \pm j3$$

$\therefore$ $$G(s)H(s) = \frac{K(s+1+j3)(s+1-j3)}{(s+3+j)(s+3-j)}$$

$\therefore$ There will be no break points.

6. (c)

The characteristic equation is,

$$1 + G(s)H(s) = 0$$
$$s(s+3)(s+4) + 5(s+2) = 0$$
$$s^3 + 7s^2 + 12s + 5s + 10 = 0$$
$$s^3 + 7s^2 + 17s + 10 = 0$$

s^3	1	17
s^2	7	10
s^1	$\frac{17\times7-10}{7}$	
s^0	10	

$\because$ The total number of sign change in the first column of Routh array is zero.

$\therefore$ Number of poles on LHS = 3.

7. (b)

The standard form of transfer function of the compensator is

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

$\therefore$ In time constant form,

$$G_c(s) = \frac{1(1+100s)}{10(1+10s)}$$

Here, T = 100 and $\alpha T = 10$

or $$\alpha = \frac{10}{100} = 0.1$$

$\because \alpha < 1 \therefore$ Lead compensator.

8. (b)

The characteristic equation is given by

$$|sI - A| = 0$$

$$\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} = \begin{bmatrix} s & -1 \\ 1 & s \end{bmatrix}$$

$\therefore$ $$|sI - A| = \begin{bmatrix} s & -1 \\ 1 & s \end{bmatrix} = s^2 + 1$$

$$s = \pm j$$

As the roots are purely imaginary, thus the system has undamped response.

9. (b)

For $\omega = 0$, the plot starts at 0°, that means there will be no pole at origin, hence the type of the system is 0.

For $\omega = \infty$, the plot terminates at 270° i.e., the order of the system should be 3.

10. (a)

As the initial slope is 0 dB/dec.

$$20\log K = -20$$
$$\log K = -1$$

or $K = 0.1$

at ω = 1 rad/sec, the slope changes to 20 dB/dec, thereby adds a zero at ω = 1 rad/sec

at ω = 10 rad/sec, the slope changes to 0 dB/dec thereby adds a pole at ω = 10 rad/sec.

at ω = 100 rad/sec, the slope changes to –40 dB/dec thereby adds two poles at ω = 100 rad/sec

∴ Resultant transfer function is,

$$T(s) = \frac{0.1\left(\frac{s}{1}+1\right)}{\left(\frac{s}{10}+1\right)\left(\frac{s}{100}+1\right)^2} = \frac{10^4(s+1)}{(s+10)(s+100)^2}$$

11. (d)

The location of the poles are given by, $-\xi\omega_n \pm j\omega_d$ ...(i)

where, ξ = damping ratio

ω_n = natural frequency of oscillation

ω_d = damped frequency of oscillation

Using maximum peak overshoot, the value of ξ can be obtained as

$$e^{-\pi\xi/\sqrt{1-\xi^2}} = 0.15$$

$$\frac{\xi}{\sqrt{1-\xi^2}} = 0.604$$

Squaring both the sides,

$$\xi^2 = 0.364(1 - \xi^2)$$

or $$\xi^2 = \frac{0.364}{1.364} = 0.267$$

or $$\xi = 0.517 \quad \text{...(ii)}$$

now, peak time, $$\tau_p = \frac{\pi}{\omega_d} = 3$$

or $$\omega_d = \frac{\pi}{3} = 1.047 \text{ rad/sec}$$

∵ $$\omega_d = \omega_n\sqrt{1-\xi^2} \quad \text{...(iii)}$$

∴ From equation (ii) and (iii), we have

$$\omega_n = \frac{\omega_d}{\sqrt{1-\xi^2}} = \frac{1.047}{\sqrt{1-0.517^2}}$$

$$\omega_n = 1.223 \text{ rad/sec} \quad \text{...(iv)}$$

∴ Location of poles are,

$$P = -\xi\omega_n \pm j\omega_d$$
$$= -(0.517 \times 1.223) \pm j1.047$$
$$= -0.632 \pm j1.047$$

12. **(d)**

Steady state error,

$$e_{ss} = \lim_{s \to 0} sE(s)$$

$$= \lim_{s \to 0} s \times \frac{R(s)}{1+G(s)H(s)}$$

$$= \lim_{s \to 0} \frac{s \times \left(2+\frac{5}{s}\right) \times \frac{1}{s}}{1+\frac{K}{s(s+3)}}$$

$$= \lim_{s \to 0} \frac{\frac{s(2s+5)}{s}}{s[s(s+3)+K]}$$

$$= \lim_{s \to 0} \frac{\frac{(2s+5)}{s} \times s(s+3)}{(s^2+3s+K)}$$

$$= \lim_{s \to 0} \frac{(2s+5)(s+3)}{s^2+3s+K}$$

$$2.75 = \frac{15}{K}$$

or $$K = \frac{15}{2.75} = 5.45$$

13. **(d)**

For any point to lie on the root locus the angle condition must be satisfied.

$$\angle G(s)H(s)\big|_{s=(-1+j2)} = \pm 180°$$

$$\therefore \quad G(s)H(s)\big|_{s=(-1+j2)} = \frac{K(-1+j2+1)}{(-1+j2+9)(-1+j2+3)} = \frac{K(j2)}{(8+j2)(2+j2)}$$

$$\therefore \quad \angle G(s)H(s)\big|_{s=-1+j2} = 90° - \tan^{-1}\left(\frac{2}{8}\right) - \tan^{-1}(1)$$

$$= 90° - 14.036° - 45°$$

$$= 30.96°$$

$$\because \quad \angle G(s)H(s)\big|_{s=s_0} \neq \pm 180°$$

Angle condition does not satisfy.

14. **(b)**

The steady state error is defined by

$$e_{ss} = \lim_{s \to 0} \frac{s \times \frac{1}{s^2}}{1+\frac{(s+\alpha)}{s} \times \frac{(s+2)}{s^2-1}}$$

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

$$e_{ss} = -\frac{1}{2\alpha}$$

$$\therefore \quad S_{\alpha}^{e_{ss}} = \frac{\frac{\partial e_{ss}}{e_{ss}}}{\frac{\partial \alpha}{\alpha}} = \frac{\partial e_{ss}}{\partial \alpha} \times \frac{\alpha}{e_{ss}} = \frac{\partial}{\partial \alpha}\left(\frac{-1}{2\alpha}\right) \times \frac{\alpha}{-\frac{1}{2\alpha}}$$

$$= -\frac{\alpha^2}{\alpha^2} = -1$$

15. (a)

The characteristic equation is,

$$K(s-2) + (s+1)(s+2) = 0$$

$$s^2 + 3s + 2 + Ks - 2K = 0$$

or $$s^2 + (3+K)s + (2-2K) = 0 \quad \text{...(i)}$$

It is required that one pole should lie at origin. Let other pole lie at $-x$.

$\therefore$ Required characteristic equation becomes

$$(s+0)(s+x) = 0$$

or $$s^2 + xs = 0 \quad \text{...(ii)}$$

On comparing (i) and (ii), we have

$$2 - 2K = 0$$

$$2K = 2$$

or $$K = 1$$

16. (c)

The characteristic equation is,

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

$$s^2(s+a) + K\left(s + \frac{4}{3}\right) = 0$$

For $K = 6$

$$s^3 + as^2 + 6s + 8 = 0$$

Using Routh's method for 3rd order system for stability,

$$6a \geq 8$$

$$a \geq \frac{8}{6}$$

$$a \geq \frac{4}{3}$$

$\therefore$ For system to be unstable $a < \frac{4}{3} = 1.33$

17. (c)

The characteristic equation is,

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

$$s(s+1)(s+2)(s+4) + K = 0$$

$$s^4 + 7s^3 + 14s^2 + 8s + K = 0$$

Using Routh's tabular form, we have

s^4	1	14 K
s^3	7	8
s^2	12.86	K
s^1	$\frac{102.88-7K}{12.86}$	
s^0	K	

For system to be oscillatory

$$\frac{102.8-7K}{12.86} = 0 \quad \Rightarrow K \approx 14.697$$

∴ Auxiliary equation,

$$12.86s^2 + K = 0$$

$$s^2 = \frac{-K}{12.86} = -\frac{14.697}{12.86} = -1.142$$

or $s = \pm j1.07$

∴ $\omega = 1.07$ rad/sec

18. (d)

$$\frac{V_0(s)}{V_s(s)} = \frac{R_2}{\frac{R_1}{R_1Cs+1}+R_2} = \frac{R_2(R_1Cs+1)}{R_1+R_2+R_1R_2Cs}$$

By rearranging, we get,

$$\frac{V_0(s)}{V_s(s)} = \frac{R_2}{R_1+R_2}\times\left(\frac{1+R_1Cs}{1+\frac{R_2}{R_1+R_2}\cdot R_1Cs}\right)$$

∴ $\alpha = \frac{R_2}{R_1+R_2}$

19. (b)

The phase margin is given by,

$$PM = 180° + \phi$$

$$60° = 180° + \left[-90° - \tan^{-1}\omega - \tan^{-1}\frac{\omega}{3}\right]$$

$$-30° = -\tan^{-1}\left(\frac{\frac{\omega}{1}+\frac{\omega}{3}}{1-\frac{\omega^2}{3}}\right)$$

$$\tan 30° = \frac{\omega+\frac{\omega}{3}}{1-\frac{\omega^2}{3}}$$

$$\frac{1}{\sqrt{3}} = \frac{\frac{4\omega}{3}}{1-\frac{\omega^2}{3}}$$

or
$$1-\frac{\omega^2}{3} = \frac{4\omega}{\sqrt{3}}$$

$\Rightarrow$
$$\omega^2 + 4\sqrt{3}\,\omega - 3 = 0$$

On solving the above equation, we get,

$$\omega = 0.408 \text{ rad/sec and } -7.33 \text{ rad/sec}$$

Considering positive value of frequency for $\omega = \omega_{gc}$, we have,

$$|G(j\omega)H(j\omega)|_{\omega = \omega_{gc}} = 1$$

$$\frac{K}{\omega\sqrt{\omega^2+1}\,\sqrt{\omega^2+9}} = 1$$

$$K = 0.408\sqrt{1.166}\times\sqrt{9.166}$$

$$K = 1.33$$

20. (b)

From the given state model, the transfer function can be calculated as

$$T(s) = C(sI - A)^{-1} B$$

$$= \begin{bmatrix}1\\2\end{bmatrix}^T \begin{bmatrix}s & -1\\ 2 & s+5\end{bmatrix}^{-1} \begin{bmatrix}0\\1\end{bmatrix}$$

$$= [1 \quad 2]\times\frac{1}{s(s+5)+2}\begin{bmatrix}s+5 & 1\\ -2 & s\end{bmatrix}\begin{bmatrix}0\\1\end{bmatrix}$$

$$= [1 \quad 2]\times\frac{1}{s(s+5)+2}\begin{bmatrix}1\\ s\end{bmatrix}$$

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

$\therefore$ Open loop transfer function for unity negative feedback system becomes

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

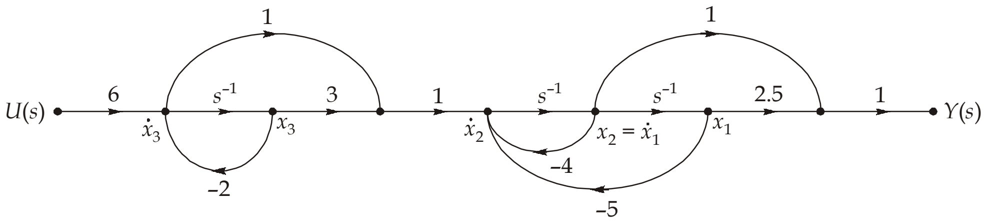
For unit step input,

$$K_p = \lim_{s\to 0} G(s)H(s) = \lim_{s\to 0}\frac{1+2s}{s^2+3s+1} = 1$$

$\therefore$
$$e_{ss} = \frac{1}{1+K_p} = \frac{1}{2} = 0.5$$

21. (c)

The state diagram of the system shown in below figure is the cascade of the state diagram of two sub-systems.



From this state diagram, the input output equations can be written as

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = -5x_1 - 4x_2 + 3x_3 + 6u$$

$$\dot{x}_3 = -2x_3 + 6u$$

$$y = 2.5x_1 + x_2$$

$$\therefore \quad \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ -5 & -4 & 3 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 6 \\ 6 \end{bmatrix} u$$

$$y = [2.5 \quad 1 \quad 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

22. (b)

The closed loop transfer function has the characteristic equation,

$$(s + 1)(s + 10) + 10K = 0$$

$$s^2 + 11s + 10 + 10K = 0$$

On comparing with standard second order system, we have,

$$2\xi\omega_n = 11$$

or $$\xi\omega_n = \frac{11}{2}$$

$\because$ $$M_r = 1.58$$

$\therefore$ $$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}} = 1.58$$

$$\frac{1}{1.58} = 2\xi\sqrt{1-\xi^2}$$

$$0.100 = \xi^2(1 - \xi^2)$$

or $$\xi^4 - \xi^2 + 0.100 = 0$$

or $$\xi^2 = 0.8872 \text{ and } 0.112$$

$\Rightarrow$ $$\xi = 0.9419 \text{ and } 0.334$$

$\because$ $$\xi < 0.707$$

$\therefore$ $$\xi = 0.334 \text{ has to be considered}$$

and hence, $$\omega_n = \frac{11}{2 \times 0.334} = 16.434$$

$\therefore$ $$10 + 10K = \omega_n^2 = 270.089$$

$$10K = 260.089$$

or $$K = 26.008 \approx 26$$

23. (c)

The initial part of the resultant magnitude plot is a straight line with a slope of –20 dB/decade. It corresponds to a pole at the origin.

Corner frequencies = 2.5 rad/sec, 40 rad/sec

Each corner frequency contributes a slope of –20 dB/dec, so both corner frequencies represent the poles of system,

$$\text{T.F.} = \frac{K}{s\left(\frac{s}{\omega_{c1}}+1\right)\left(\frac{s}{\omega_{c2}}+1\right)}$$

Here, $\omega_{c1} = 2.5$

and $\omega_{c2} = 40$

$$\text{T.F.} = \frac{K}{s\left(\frac{s}{2.5}+1\right)\left(\frac{s}{40}+1\right)}$$

In low frequency region $\omega < \omega_{c1}$

approximate, $\text{T.F.} = \frac{K}{s}$

$$T(j\omega)\big|_{\text{dB}} = 20\log K - 20\log\omega$$

at $\omega = \omega_{c1}$, $|T(j\omega)| = 40$ dB

$$40 = 20\log K - 20\log 2.5$$
$$20\log K = 47.96,$$
$$\text{Log } K = 2.399$$
$$K = 10^{2.4} = 251$$

So, $$T(s) = \frac{251}{s(1+0.4s)(1+0.025s)}$$

24. (c)

For controllability, $|Q_c| = |B : AB| \neq 0$

Given, $A = \begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$

$$AB = \begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix}\begin{bmatrix} 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 2 \\ -7 \end{bmatrix}$$

$$|Q_c| = \begin{bmatrix} 1 & 2 \\ 2 & -7 \end{bmatrix}$$

$$Q_c = -7 - 4 = -11 \neq 0$$

The system is controllable,

For observability, $|Q_o| = \left|C^T : A^T C^T\right| \neq 0$

$$A^T C^T = \begin{bmatrix} 0 & -1 \\ 1 & -3 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} = \begin{bmatrix} -1 \\ -2 \end{bmatrix}$$

$$|Q_o| = \begin{vmatrix} 1 & -1 \\ 1 & -2 \end{vmatrix} = -2 + 1 = -1 \neq 0$$

The system is observable.

25. (c)

$$G(s) = \frac{1 + 0.5s}{1 + 1.25s}$$

By comparing standard equation,

$$\frac{E_0(s)}{E_i(s)} = \frac{1 + sT}{1 + s\beta T}$$

Where, $\beta = \dfrac{R_1 + R_2}{R_2}$

and $T = R_2 C$

$$T = 0.5$$

$$R_2 = \frac{0.5}{10 \times 10^{-6}} = 0.5 \times 10^5 = 50 \text{ k}\Omega$$

$$\beta T = 1.25$$

$$\beta = 2.5 = 1 + \frac{R_1}{R_2}$$

$$R_1 = 1.5\, R_2 = 75 \text{ k}\Omega$$

26. (d)

The characteristic equation is

$$s^2 + 1.6s + 16 = 0$$

comparing with the second order characteristic equation i.e.

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

$$2\xi\,\omega_n = 1.6$$

and $\omega_n = \sqrt{16} = 4$ rad/sec

then damping ratio for the system without derivative feedback control is

$$\xi = \frac{1.6}{2\omega_n} = \frac{1.6}{2 \times 4} = 0.2$$

$$\frac{C(s)}{R(s)} = \frac{(1 + sT_d)\omega_n^2}{s^2 + (2\xi\omega_n + \omega_n^2 T_d)s + \omega_n^2}$$

$$\xi' = \frac{2\xi\omega_n + \omega_n^2 T_d}{2\omega_n} = \xi + \frac{\omega_n T_d}{2}$$

$$0.8 = 0.2 + \frac{4T_d}{2}$$

$$T_d = 0.3$$

27. (c)

Forward paths:

$$F_1 = G_1G_2G_3G_4 \quad ; \quad \Delta_1 = 1$$
$$F_2 = G_1G_6G_4 \quad ; \quad \Delta_2 = 1$$
$$F_3 = G_1G_7 \quad ; \quad \Delta_3 = 1 - G_5$$

Individual loops:

$$L_1 = G_2H_1 \quad ; \quad L_2 = G_5$$

Two non-touching loops,

$$L_{12} = G_2H_1(G_5)$$
$$\Delta = 1 - G_2H_1 - G_5 + G_2H_1G_5$$

$$\therefore \quad \frac{X_5}{X_1} = \frac{G_1G_2G_3G_4 + G_1G_4G_6 + G_1G_7(1-G_5)}{1 - G_2H_1 + G_2G_5H_1 - G_5}$$

28. (d)

Characteristics equation is

$$s^5 - 2s^4 - 2s^3 + 4s^2 + s - 2 = 0$$

s^5	1	−2	1
s^4	−2	4	−2
s^3	0(−1)	0(1)	0
s^2	2	−2	0
s^1	0(4)	0	0
s^0	−2		

Auxiliary equation-1 is,

$$-2s^4 + 4s^2 - 2 = 0$$
$$\frac{d}{ds}(-2s^4 + 4s^2 - 2) = 0$$
$$-8s^3 + 8s = 0$$
$$-s^3 + s = 0$$

Auxiliary equation-2 is,

$$2s^2 - 2 = 0$$
$$\frac{d}{ds}(2s^2 - 2) = 0$$
$$4s = 0$$

3 sign changes in the first column.

Therefore 3 poles are in RHP out of which 2 are symmetric.

29. (a)

$$1 + KG = 0$$
$$s^3 + 6s^2 + 12s + Ks + 8 - 4K = 0$$
$$(s^3 + 6s^2 + 12s + 8) + K(s - 4) = 0$$
$$1 + \frac{K(s-4)}{s^3 + 6s^2 + 12s + 8} = 0$$

∴ Open loop transfer function,

$$G(s) = \frac{(s-4)}{s^3 + 6s^2 + 12s + 8}$$

s^3	1	12
s^2	6	8
s^1	$\frac{72-8}{6} = 10.66$	
s^0	8	

There is no sign change in first column of RH table.
∴ Open loop system is stable.

30. (d)

$$K_v = \lim_{s\to 0} s \cdot G(s)$$
$$K_v = \lim_{s\to 0} s \cdot \frac{K(s+10)(s+15)}{s(s+3)(s+7)(s+20)}$$
$$K_v = \frac{K(10)(15)}{(3)(7)(20)} = \frac{K(5)}{14}$$
$$e_{ss} = \frac{25}{K_v} = \frac{25}{K(5)} \times 14$$
$$0.1 = \frac{5 \times 14}{K}$$
$$K = \frac{5 \times 14}{0.1} = 700$$

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