

CLASS TEST

S.No. : 01 CH1_EE_E_120619

Control Systems



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CLASS TEST 2019-2020

ELECTRICAL ENGINEERING

Date of Test : 12/06/2019

ANSWER KEY ➤ Control Systems

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

DETAILED EXPLANATIONS

1. (d)

$$(s + 3 + j4)(s + 3 - j4) = 0$$

$$(s + 3)^2 - (j4)^2 = 0; s^2 + 6s + 9 + 16 = 0; s^2 + 6s + 25 = 0$$

$$\omega_n = \sqrt{25}; \quad \omega_n = 5 \text{ rad/sec}; \quad 2\zeta\omega_n = 6$$

$$\zeta = \frac{6}{2 \times 5} = 0.6$$

2. (b)

Since, all the poles of the open loop system lie on the LHS of s-plane hence, the open loop system is stable. However, the number of encirclement to the critical point is two means two closed loop poles are located on the RHS of s-plane. Therefore, the closed loop system is unstable.

3. (c)

For given Nyquist plot,

We can find that, type of the system = 3

and complete the Nyquist plot as shown in figure

For $(-1, 0)$ point of position A,

$$N = P - Z$$

Here, $N = -2$ and $P = 0$

$$\therefore -2 = -Z,$$

$$\Rightarrow Z = 2$$

Therefore system is unstable at point A.

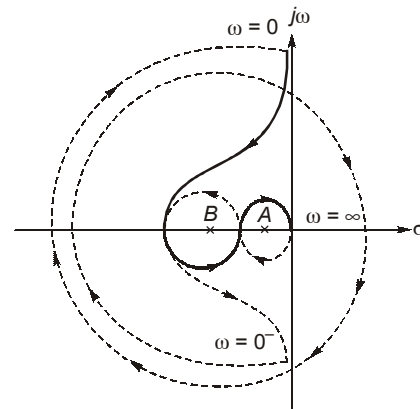
For $(-1, 0)$ lying at position B,

$$N = P - Z$$

Here, $N = 0, P = 0$

$$\therefore Z = 0; \text{ i.e. stable system.}$$

Therefore, system is stable at point B.



4. (d)

Using Routh Table:

s^6	1	6	10	5
s^5	1	5	5	
s^4	1	5	5	
s^3	0	0		

The Routh table construction procedure breaks down here, since the s^3 row has all zeros. The auxiliary polynomial coefficients are given by the s^4 row. Therefore the auxiliary polynomial is,

$$A(s) = s^4 + 5s^2 + 5$$

$$\frac{dA(s)}{ds} = 4s^3 + 10s$$

Replacing the s^3 row in the Routh table with the coefficients of $\frac{dA(s)}{ds}$, we have

s^6	1	6	10	5
s^5	1	5	5	
s^4	1	5	5	
s^3	4	10		
s^2	$\frac{20 - 10}{4} = 2.5$		5	
s^1	$\frac{25 - 20}{2.5} = 2$			
s^0	5			

Examining the first column of this table we see that there are no sign changes. Hence, there is no root lying in the RHS of s-plane.

5. (d)

2nd order characteristics equation $s^2 + 2 \xi \omega_n s + \omega_n^2 = 0$ have poles at $-\xi \omega_n \pm j \omega_d$

On comparing, we have

$$-1 \pm j \pi$$

$$\omega_d = \pi$$

$$\Rightarrow t_p = \text{peak time} = \frac{\pi}{\omega_d} \text{ (first peak)}$$

$$= \frac{\pi}{\pi} = 1 \text{ sec.}$$

6. (b)

$$\dot{x}_1 = x_1 - 5x_2$$

$$\dot{x}_2 = (8 - g_1)x_1 - g_2x_2$$

$$\therefore A = \begin{bmatrix} 1 & -5 \\ 8 - g_1 & -g_2 \end{bmatrix}$$

$$\text{Characteristic equation} = |(sI - A)| = 0$$

$$= \begin{vmatrix} s & 0 \\ 0 & s \end{vmatrix} - \begin{vmatrix} 1 & -5 \\ 8 - g_1 & -g_2 \end{vmatrix} = 0$$

$$= \begin{vmatrix} s - 1 & 5 \\ -8 + g_1 & s + g_2 \end{vmatrix} = 0$$

$$= (s - 1)(s + g_2) - 5(g_1 - 8) = 0$$

$$= s^2 + s(g_2 - 1) + (-g_2 - 5g_1 + 40) = 0$$

$$\Rightarrow \omega_n = \sqrt{40 - 5g_1 - g_2} = \sqrt{2}$$

$$\Rightarrow +5g_1 + g_2 = +38$$

and $\xi = \frac{1}{\sqrt{2}}$

$$(g_2 - 1) = 2 \frac{1}{\sqrt{2}} \times \sqrt{2}$$

$$\Rightarrow g_2 = 3 \text{ and } g_1 = 7$$

7. (b)

Method 1:

$$H(s) = 1$$

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

$$\frac{s+4}{s^2+7s+13} = \frac{\frac{s+4}{s^2+6s+9}}{1 + \frac{s+4}{s^2+6s+9}}$$

$$\text{So, } G(s) = \frac{s+4}{s^2+6s+9}$$

$$\text{or, } G(s) = \frac{4}{9} \cdot \frac{(1+s/4)}{\left(1 + \frac{6}{9}s + \frac{1}{9}s^2\right)} \quad (\text{In time constant form})$$

Thus, open loop DC gain of given system = $\frac{4}{9}$.

Method 2:

$$\begin{aligned} G(s) &= \frac{\text{Num}}{\text{Den} - \text{Num}} = \text{O.L.T.F.} \quad (H(s) = 1) \\ &= \frac{s+4}{(s^2+7s+13) - (s+4)} = \frac{s+4}{s^2+6s+9} \end{aligned}$$

$$\text{Put } s = 0, \quad G(0) = \frac{4}{9}$$

8. (b)

$$\text{Error} = 20 \log(2\xi)$$

$$\text{Error} = 20 \log(2 \times 1.4)$$

$$\text{Error} = 8.94 \text{ dB}$$

9. (b)

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

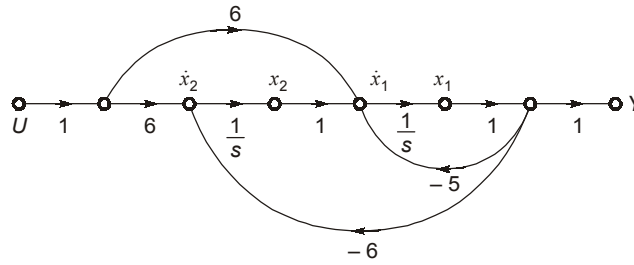
Comparing with the standard form

$$\omega_n = \sqrt{6} \text{ and } 2\xi\omega_n = 2$$

$$\therefore \xi = 0.408$$

$$\begin{aligned} M_p &= e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}} \times 100 = e^{\frac{-\pi \times 0.408}{\sqrt{1-0.408^2}}} \times 100 \\ &= 24.56\% \approx 24.6\% \end{aligned}$$

10. (b)



Here

$$\dot{x}_1 = 6U + x_2 - 5x_1$$

$$\dot{x}_2 = 6U - 6x_1$$

and

$$Y = x_1$$

∴

$$A = \begin{bmatrix} -5 & 1 \\ -6 & 0 \end{bmatrix}$$

11. (b)

$$\text{Impulse response} = \frac{d}{dt} [\text{step response}]$$

Now, as we know at $t = 0; c(t) \neq 0$

Here, we can write $c(t) = (1 - e^{-3t} + 3e^{-t}) u(t)$

Now, $t = 0; c(t) = 0$

$$\text{Hence, } h(t) = \frac{d}{dt} [c(t)]$$

$$h(t) = \delta(t) - e^{-3t} \delta(t) + 3e^{-3t} u(t) + 3e^{-t} * \delta(t) - 3e^{-t} \cdot u(t)$$

$$= \delta(t) - \delta(t) + 3\delta(t) + (3e^{-3t} - 3e^{-t})u(t)$$

$$h(t) = 3\delta(t) + (3e^{-3t} - 3e^{-t}) u(t)$$

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

$$= \frac{3(s^2 + 4s + 3) - 6}{(s+3)(s+1)} = \frac{3(s^2 + 4s + 1)}{3\left(1 + \frac{s}{3}\right)(1+s)}$$

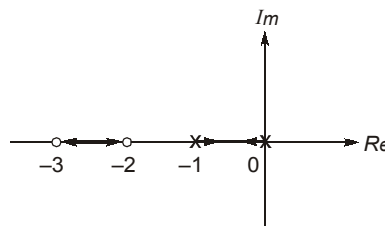
Thus,

$$\text{Gain} = 1$$

12. (d)

The transfer function

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



The break points can be calculated as

$$\frac{dK}{ds} = 0$$

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

$$\text{or, } 1 + \frac{K(s+2)(s+3)}{s(1+s)} = 0$$

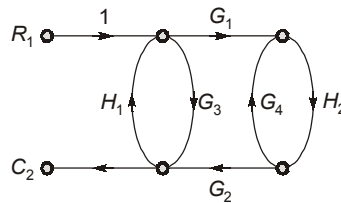
$$K = \frac{-(s^2 + s)}{s^2 + 5s + 6}$$

$$\begin{aligned} \frac{dK}{ds} &= \frac{(s^2 + 5s + 6)(2s + 1) - (s^2 + s)(2s + 5)}{s^2 + 5s + 6} = 0 \\ &= -2.37 \text{ and } -0.634 \end{aligned}$$

Here break in point is -2.37 and break away point is -0.634 .

13. (c)

Assuming $C_1 = 0$ and $R_2 = 0$.



$$\begin{aligned} \text{Here, forward path } P_1 &= G_3 & ; \Delta_1 &= (1 - G_4 H_2) \\ P_2 &= G_1 G_2 H_2 & ; \Delta_2 &= 1 \end{aligned}$$

LOOPS

$$L_1 = G_3 H_1, \quad L_2 = G_4 H_2, \quad L_3 = G_1 G_2 H_1 H_2$$

and

$$L_4 = G_3 G_4 H_1 H_2 \text{ (Non touching loops)}$$

\therefore

$$\begin{aligned} \frac{C_2}{R_1} &= \frac{G_3(1 - G_4 H_2) + G_1 G_2 H_2}{1 - G_3 H_1 - G_4 H_2 - G_1 G_2 H_1 H_2 + G_3 G_4 H_1 H_2} \\ &= \frac{G_3 + H_2(G_1 G_2 - G_3 G_4)}{1 - G_3 H_1 - G_4 H_2 + H_1 H_2(G_3 G_4 - G_1 G_2)} \end{aligned}$$

14. (b)

$$G(s) = \frac{40}{s^2(s+18)}$$

e_{ss} due to parabolic input

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

where

$$K_a = \lim_{s \rightarrow 0} s^2 G(s) = \lim_{s \rightarrow 0} s^2 \times \frac{40}{s^2(s+18)} = \frac{40}{18}$$

$$e_{ss} = \frac{3 \times 2}{40/18} = 2.7$$

15. (b)

$$\frac{d^2y}{dt^2} + 3\frac{dy}{dt} + 2y = x(t)$$

$$s^2 Y(s) + 3s Y(s) + 2 Y(s) = X(s)$$

$$x(t) = 2 u(t)$$

$$X(s) = \frac{2}{s}$$

$$\therefore (s^2 + 3s + 2) Y(s) = \frac{2}{s}$$

$$Y(s) = \frac{2}{s(s+2)(s+1)} = \frac{A}{s} + \frac{B}{s+2} + \frac{C}{s+1}$$

$$2 = A(s+2)(s+1) + B(s)(s+1) + C s(s+2)$$

$$s = 0;$$

$$2 = A2$$

$$A = 1$$

$$s = -1;$$

$$2 = -C$$

$$C = -2$$

$$s = -2;$$

$$2 = 2B$$

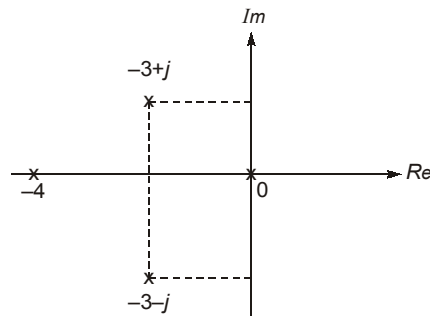
$$B = 1$$

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

$$y(t) = [1 + e^{-2t} - 2e^{-t}] u(t)$$

16. (b)

$$\phi_d = 180^\circ - \phi$$



$$\phi = 90^\circ + 45^\circ + 161.565^\circ = 296.56^\circ$$

\therefore

$$\phi_d = 180^\circ - 296.565^\circ = \mp 116.56^\circ$$

17. (b)

The transfer function can be

$$G(s) H(s) = \frac{K \left(1 + \frac{s}{2}\right)}{s} = \frac{4 \left(1 + \frac{s}{2}\right)}{s}$$

or, $K = 4$

With starting slope of -20 dB/dec, at $\omega = 2$ rad/sec

$$-20 \log_{10}(2) + 20 \log_{10}(4) = 6 \text{ dB}$$

18. (d)

The loop equations considering the Laplace transform of the network is

$$\begin{aligned} s I_1(s) + I_1(s) - I_2(s) &= V_i(s) \\ (s + 1) I_1(s) - I_2(s) &= V_i(s) \quad \dots(i) \end{aligned}$$

$$\text{and } I_2(s) - I_1(s) + I_2(s) + s I_2(s) = 0$$

$$I_1(s) = (s + 2) I_2(s) \quad \dots(ii)$$

Substituting equation (ii) in equation (i),

$$(s + 1)(s + 2) I_2(s) - I_2(s) = V_i(s)$$

$$I_2(s) = \frac{V_i(s)}{s^2 + 3s + 1}$$

also,

$$V_0(s) = s I_2(s)$$

$$V_0(s) = \frac{s V_i(s)}{s^2 + 3s + 1}$$

$$\frac{V_0(s)}{V_i(s)} = \frac{s}{s^2 + 3s + 1}$$

19. (b)

Characteristic equation

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

$$\Rightarrow 1 + \frac{11\beta}{s^3 + 4s^2 + 3s + 1} = 0$$

$$\text{or, } s^3 + 4s^2 + 3s + 1 + 11\beta = 0$$

Routh array

$$\begin{array}{c|cc} s^3 & 1 & 3 \\ s^2 & 4 & (11\beta + 1) \\ s^1 & \frac{12 - (11\beta + 1)}{4} & 0 \\ s^0 & (11\beta + 1) & \end{array}$$

for stability,

$$\frac{12 - (11\beta + 1)}{4} \geq 0$$

$$\text{or } 12 \geq (11\beta + 1)$$

$$\text{or } \beta \leq 1$$

20. (b)

Comparing with standard transfer function

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

$$T = \frac{21}{97}$$

$$\alpha T = \frac{1}{33}$$

or,
$$\alpha = \frac{97}{33 \times 21} = 0.1399$$

$\therefore \alpha < 1$ lead compensator

$$\begin{aligned} \phi &= \sin^{-1} \left(\frac{1-\alpha}{1+\alpha} \right) \\ &= \sin^{-1} \left(\frac{1-0.1399}{1+0.1399} \right) = 48.97^\circ \end{aligned}$$

21. (d)

$$\text{Transfer function} = \frac{64}{s^2 + 14s + 64}$$

Where,
$$\begin{aligned} \omega_n^2 &= 64 \\ 2\xi\omega_n &= 14 \end{aligned}$$

or,
$$\xi = \frac{14}{2 \times 8} = 0.875 \text{ (underdamped)}$$

$$\tau_{\text{sett}} = \frac{4}{\xi\omega_n} = \frac{4}{7} = 0.571 \text{ sec}$$

22. (b)

Let $K = 4$ then,

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

$$\text{Characteristic equation} = 1 + G(s)H(s) = s^2 + 4s + (4 + K) = 0$$

Routh array

$$\begin{array}{l|ll} s^2 & 1 & (4+K) \\ s^1 & 4 & 0 \\ s^0 & 4+K & \end{array}$$

For stability $K > -4$
now, calculating ω_{pc}

$$-180^\circ = 2 \tan^{-1} \omega_{pc}$$

or
$$\omega_{pc} = \infty$$

Hence
$$\text{GM} = 0 \text{ dB} = \infty$$

and
$$|G(\omega)H(\omega)| = \frac{4}{\left(\sqrt{(j\omega_{gc})^2 + 2^2} \right)^2} = 1$$

$$\frac{4}{(\omega_{gc}^2 + 4)} = 1$$

or
$$\omega_{gc}^2 = 0$$

$$\omega_{gc} = 0$$

$$\begin{aligned} \text{PM} &= 180^\circ - \tan^{-1} \frac{\omega_{gc}}{2} - \tan^{-1} \frac{\omega_{gc}}{2} \\ &= 180^\circ \end{aligned}$$

23. (d)

1 pole at origin ($\omega = 0$) $\downarrow -20$ dB/dec2 poles at $\omega = 2$ rad/s $\downarrow -60$ dB/dec2 poles at $\omega = 4$ rad/s $\downarrow -100$ dB/dec1 zero at $\omega = 10$ rad/s $\downarrow -80$ dB/dec \therefore The slope of the line between frequency of 4 rad/s and 10 rad/sec is -100 dB/decade.

24. (d)

Check for controllability-

$$Q_c = [B : AB]$$

$$= \begin{bmatrix} 0 & 0 \\ 1 & -4 \end{bmatrix}$$

$$\therefore \rho(A) \neq \rho(Q_c)$$

$$\text{and } |Q_c| = 0$$

 \therefore System is uncontrollable.

Check for observability-

$$Q_o = [C^T : A^T C^T]$$

$$= \begin{bmatrix} 1 \\ 0 \end{bmatrix} : \begin{bmatrix} -2 & 0 \\ 0 & -4 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 1 & -2 \\ 0 & 0 \end{bmatrix}$$

$$\therefore \rho(A) \neq \rho(Q_o)$$

$$\text{Also } |Q_o| = 0$$

 \therefore System is unobservable.

25. (a)

$$\text{Given, } G(s)H(s) = \frac{1}{s^2(s-a)(s-b)(s-c)}$$

$$\text{Put } s = j\omega, \quad G(j\omega)H(j\omega) = \frac{1}{(j\omega)^2(j\omega-a)(j\omega-b)(j\omega-c)}$$

$$|G(j\omega)H(j\omega)| = \frac{1}{\omega^2 \sqrt{\omega^2 + a^2} \cdot \sqrt{\omega^2 + b^2} \cdot \sqrt{\omega^2 + c^2}}$$

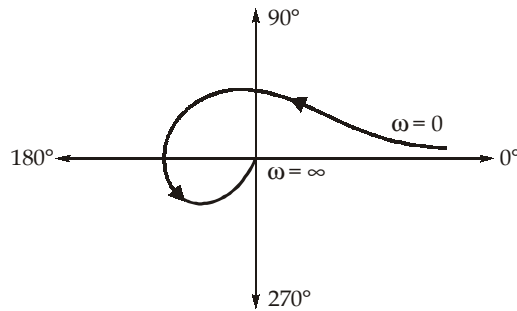
$$\text{when, } \omega = 0 \quad \text{Magnitude} = \infty; \quad \text{Phase} = 0^\circ$$

$$\omega = \infty \quad \text{Magnitude} = 0; \quad \text{Phase} = 270^\circ$$

$$\angle G(j\omega)H(j\omega) = -\left[180^\circ + \left(180^\circ - \tan^{-1}\left(\frac{\omega}{a}\right)\right) + \left(180^\circ - \tan^{-1}\left(\frac{\omega}{b}\right)\right) + \left(180^\circ - \tan^{-1}\left(\frac{\omega}{c}\right)\right)\right]$$

$$\phi = \tan^{-1}\left(\frac{\omega}{a}\right) + \tan^{-1}\left(\frac{\omega}{b}\right) + \tan^{-1}\left(\frac{\omega}{c}\right)$$

Note: Since a , b and c are positive values, for $\omega = 1$, phase of $G(j\omega)H(j\omega)$ will be a positive quantity. So, the polar plot will start into the first quadrant.



26. (d)

$$T(s) = \frac{C(s)}{R(s)} = \frac{50}{(s^2T + s)(1 + 0.5s) + 50}$$

Characteristic equation

$$Ts^3 + (1 + 2T)s^2 + 2s + 100 = 0$$

Using Routh array

s^3	T	2
s^2	$(1 + 2T)$	100
s^1	$\frac{2(1 + 2T) - 100T}{(1 + 2T)}$	0
s^0	100	

$$\therefore T > 0 \text{ and } T > -\frac{1}{2}$$

Also $2 - 96T > 0$

or, $T < \frac{1}{48}$

The system becomes unstable for

$$T = \frac{1}{48}$$

27. (a)

The open loop transfer function is

$$G(s) = \frac{K}{s(s+1)(s+2)}$$

(a) Finite poles are at $s = 0, -1, -2, (P = 3)$

Finite zeros are nil ($z = 0$)

(b) Number of asymptotes = $P - Z = 3$

The centroid σ (or the meeting point of the asymptotes) is at

$$\sigma = \frac{0 - 1 - 2}{3} = -1$$

The angles of the asymptotes are given by

$$\begin{aligned}\theta_K &= \frac{(2K+1)\pi}{P-Z}, K = 0, 1, \dots, (|P-Z|-1) \\ &= \frac{(2K+1)\pi}{3}, K = 0, 1, 2 = 60^\circ, 180^\circ, 300^\circ (-60^\circ)\end{aligned}$$

(c) The breakaway points are given by

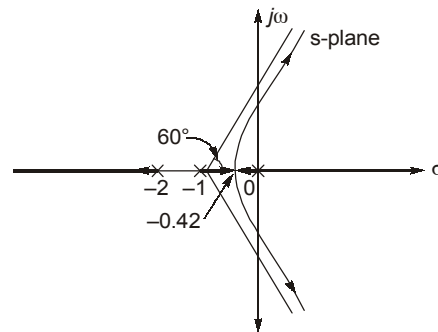
$$\frac{dK}{ds} = 0 \quad \text{or} \quad \frac{dK}{ds} = \frac{d}{ds}[-s(s+1)(s+2)] = 0$$

$$\text{or} \quad -(3s^2 + 6s + 2) = 0$$

$$\text{or} \quad s = \frac{-6 \pm \sqrt{36 - 24}}{6} = -0.42, -1.577 \text{ (invalid)}$$

Thus, $s = -0.42$ is only valid break away point

(d) The number of branches of the root loci is the greater of P and Z , viz, 3. Using all the above information, we plot the root loci,



Hence choice (a) is correct.

28. (a)

Zeros $s = -2$

Poles: $s = -1 + j2, -1 - j2$

The transfer function is

$$G(s) = \frac{K(s+2)}{(s+1-j2)(s+1+j2)}$$

where $K = \frac{\text{multiplication of vector lengths drawn from all poles}}{\text{multiplication of vector lengths drawn from all zeros}}$

$$= \frac{\sqrt{10} \times \sqrt{2}}{\sqrt{5}} = 2$$

$$\begin{aligned}G(s=j1) &= \frac{2(j1+2)}{(j1+1-j2)(j1+1+j2)} = \frac{2(2+j1)}{(1-j1)(1+j3)} \\ &= \frac{2 \times 2.236 \angle 26.6^\circ}{1.4142 \angle -45^\circ \times 3.162 \angle 71.57^\circ} = 1 \angle 0^\circ\end{aligned}$$

Hence choice (a) is correct.

29. (c)

$$G(s) = \frac{10}{s(s+1)^2}$$

Putting

$$s = j\omega,$$

$$G(j\omega) = \frac{10}{j\omega(j\omega+1)^2} = \frac{10}{j\omega(-\omega^2+2j\omega+1)} = \frac{10}{-2\omega^2+j(\omega-\omega^3)}$$

This can be divided into the real and imaginary parts as shown below

$$\begin{aligned} G(j\omega) &= \frac{10\{-2\omega^2 - j(\omega - \omega^3)\}}{\{-2\omega^2 + j(\omega - \omega^3)\}\{-2\omega^2 - j(\omega - \omega^3)\}} \\ &= \frac{-20\omega^2}{4\omega^4 + (\omega - \omega^3)^2} - \frac{10j(\omega - \omega^3)}{4\omega^4 + (\omega - \omega^3)^2} \end{aligned}$$

In the real axis at $\omega = \omega_0$,
the imaginary portion goes to zero.

$$\text{Hence } \frac{\omega_0 - \omega_0^3}{4\omega_0^4 + (\omega_0 - \omega_0^3)^2} = 0$$

$$\text{or } \omega_0 - \omega_0^3 = 0$$

$$\text{or } \omega_0(1 - \omega_0^2) = 0$$

which gives the possible solution

$$\omega_0 = 0, 1$$

At $\omega_0 = 0$,

$$\text{Real part of } G(j\omega) = \frac{-20\omega_0^2}{4\omega_0^4 + (\omega_0 - \omega_0^3)^2};$$

$$\text{Re}\{G(j\omega)\} = \infty$$

Similarly at $\omega_0 = 1$,

$$\text{Re}\{G(j\omega)\} = \frac{-20}{4+0} = -5$$

Hence the real part and ω_0 are $-5, 1$ respectively.

30. (a)

The equations of performance for the system are.

$$B_1(\dot{X}_1 - \dot{X}_0) + K_1(X_1 - X_0) = K_2 X_0$$

or $(sB_1 + K_1)X_1(s) - (sB_1 + K_1)X_0(s) = K_2 X_0(s)$

$$\frac{X_0(s)}{X_1(s)} = \frac{sB_1 + K_1}{sB_1 + K_1 + K_2}$$

$$T = \frac{K_1 \left(1 + \frac{B_1 s}{K_1} \right)}{(K_1 + K_2) \left(1 + \frac{sB_1}{K_1 + K_2} \right)}$$

Let $\frac{K_1 + K_2}{K_1} = a$

where $a > 1$

and $\frac{B_1}{K_1 + K_2} = T;$

Then, $\frac{X_0(s)}{X_1(s)} = \frac{1}{a} \left(\frac{1 + aTs}{1 + Ts} \right)$

Therefore zero is nearer to origin than pole i.e. Lead network.

