ESE GATE
State Engg. Exams

MADE EASY
WORKbOOK 2026

Detailed Explanations of
Try Yourself *Questions*

Electrical Engineering
Control Systems

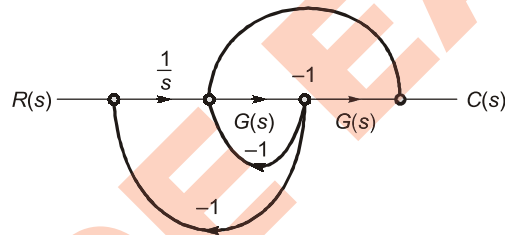
MADE EASY PUBLICATIONS

1 Mathematical Models and Block Diagram

T1. (b)

Drawing SFG of the above

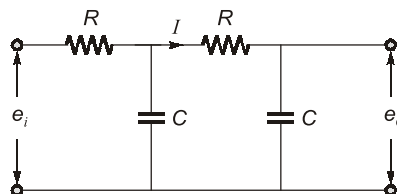Here, $P_1 = \dfrac{G^2(s)}{s}$; $L_2 = -G(s)$; $L_1 = -G^2(s)$; $L_3 = -\dfrac{G(s)}{s}$

$$\frac{C(s)}{R(s)} = \frac{\dfrac{G^2(s)}{s}}{1 - \left(-G^2(s) - \dfrac{G(s)}{s} - G(s)\right)}$$

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

Put $G(s) = s$,

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

T2. Sol.

$$E_0(s) = \frac{1}{sC}I(s) \qquad \ldots(i)$$

$$I(s) = \frac{E_i(s)}{\left[R + \dfrac{\left(R + \dfrac{1}{sC}\right) \times \dfrac{1}{sC}}{\left(R + \dfrac{1}{sC} + \dfrac{1}{sC}\right)}\right]} \times \frac{\dfrac{1}{sC}}{\left(R + \dfrac{1}{sC} + \dfrac{1}{sC}\right)}$$
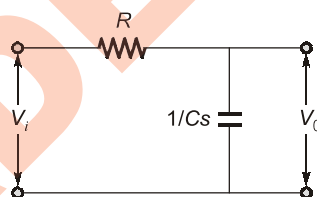
(Using current division rule)

$$= \frac{E_i(s)}{R + \dfrac{\dfrac{1}{sC}}{sCR+2} + R} \times \frac{1}{sCR+2} = \frac{E_i(s)}{\left(R + \dfrac{1}{sC}\right) + R(sCR+2)}$$

$$E_0(s) = \frac{\dfrac{1}{sC} \times E_i(s)}{\dfrac{(1 + RSC) + SCR(SCR+2)}{SC}}$$

$$\frac{E_0(s)}{E_i(s)} = \frac{1}{S^2 C^2 R^2 + 3\,SCR + 1} = \frac{1}{S^2 T^2 + 3ST + 1}$$

T3. (b)

$$\frac{V_0}{V_i} = \frac{1/Cs}{R + \dfrac{1}{Cs}} = \frac{1}{RCs+1}$$

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Time Response Analysis

Detailed Explanation
of
Try Yourself Questions

T1. Sol.

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

Now, the closed loop system

$$T(s) = \frac{K}{s^2 + sp + K}$$

∴ Comparing it with standard equation

$$K = \omega_n^2$$

$$2\xi\omega_n = p$$

$$t_s = \frac{4}{\xi\omega_n}$$

$$\Rightarrow \qquad \xi\omega_n = 1$$
$$\therefore \qquad p = 2$$

now,

$$e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}} = 0.1$$

$$\xi = 0.537$$

$$\therefore \qquad \omega_n = \frac{p}{2\xi} = 1.69$$

$$\therefore \qquad K = \omega_n^2 = 2.85$$

T2. Sol.

Taking Laplace transform we get

$$X(s) = \frac{1}{(s^2 + 6s + 5)} \cdot 12 \left[\frac{1}{s} - \frac{1}{(s+2)} \right]$$

$$X(s) = \frac{12}{s(s+5)(s+1)} \cdot 12\left[\frac{1}{s} - \frac{1}{(s+2)}\right]$$

Now, using final value theorem

$$\lim_{t\to\infty} x(t) = \lim_{s\to 0} sX(s)$$

$\therefore$

$$X(s) = \lim_{s\to 0}\left[\frac{12}{(s+5)(s+1)} - \frac{12s}{(s+5)(s+1)(s+3)}\right]$$

$$= \frac{12}{5} = 2.4$$

T3. Sol.

To find the impulse response let us difference the response.

$$c'(t) = 12\,e^{-10t} - 12e^{-60t}$$

tanking inverse laplace transform we get

$$C'(s) = \frac{600}{(s+10)(s+60)}$$

$$C'(s) = \frac{600}{s^2 + 70s + 600}$$

$\therefore$ $c'(s)$ is the impulse response thus comparing it with the standard equation.

$$2\xi\omega_n = 70$$

$$\omega_n = \sqrt{600}$$

$\therefore$

$$\xi = 1.428 \approx 1.43$$

T4. Sol.

Since real port of the given second order equation is at –0.602 thus they can be considered as dominant poles.

Thus

$$t_p = \frac{\pi}{\omega_d}$$

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

$$\omega_n = \sqrt{2.829} = 1.6819$$

and

$$2\xi\omega_n = 1.204$$

$$\xi = \frac{1.204}{2\times 1.6819} = 0.3579$$

$\therefore$

$$\omega_d = 1.6819\sqrt{1-\xi^2}$$

$$\omega_d = 1.577$$

$\therefore$

$$t_p = 1.999 \approx 2$$

■■■■

3 Stability

T1. (d)

T2. (d)

The correct sequence of steps needed to improve system stability is to use negative feedback, reduce gain and insert deviation action.

T3. Sol.

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

$$\Rightarrow \quad s\tau_1\left[1 + s(\tau_1 + \tau_2) + s^2\tau_1\tau_2\right] + K = 0$$

$$s^3\tau_1^2\tau_2 + s^2\tau_1(\tau_1 + \tau_2) + s\tau_1 + K = 0$$

Using R-H criteria

$$
\begin{array}{ccc}
s^3 & \tau_1^2\tau_2 & \tau_1 \\
s^2 & \tau_1(\tau_1 + \tau_2) & K \\
s^1 & \dfrac{\left[\tau_1^2(\tau_1 + \tau_2) - K\tau_1^2\tau_2\right]}{\tau_1(\tau_1 + \tau_2)} & \\
s^0 & K &
\end{array}
$$

$$\Rightarrow \quad K > 0 \; ; \; \tau_1 > 0 \; ; \; \tau_2 > 0$$

Also,

$$\frac{\tau_1(\tau_1 + \tau_2) - K\tau_2}{(\tau_1 + \tau_2)} > 0$$

$$K\tau_2\tau_1 < \tau_1(\tau_1 + \tau_2)$$

$$\Rightarrow \quad K < \left(1 + \frac{\tau_1}{\tau_2}\right)$$

$$0 < K < \left(1 + \frac{\tau_1}{\tau_2}\right); \quad [\tau_1 > 0 \text{ and } \tau_2 > 0 \text{ and this is the only possible case.}]$$

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4 Root Locus Technique
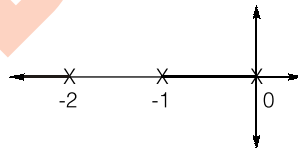
T1. Sol.

Characteristic equation is given as

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

On comparing this characteristic equation with the equation given in problem, we have

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

P = Number of open loop poles = 3 = number of branches on root locus

Z = 0 = Number of branches terminating at zeros.

Angle of Asymptotes: The $P - Z$ branches terminating at infinity will go along certain straight lines.

Number of asymptotes = $P - Z$

$$= 3 - 0 = 3$$

$$\theta = \frac{180°(2q+1)}{P-Z} \qquad\qquad q = 0, 1, 2 \dots$$

$$\theta_1 = \frac{180 \times (2 \times 0 + 1)}{3} = 60°$$
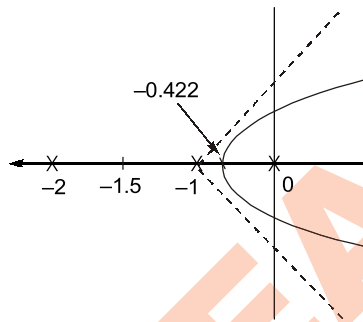
$$\theta_2 = \frac{180°(2 \times 1 + 1)}{3} = 180°$$

$$\theta_3 = \frac{180°(2 \times 2 + 1)}{3} = 300°$$

Centroid: It is the interpection point of the asymptotes on the real axis. It may or may not be a part of root locus.

$$\text{Centroid} = \frac{\Sigma \text{ Real part of open loop poles } - \Sigma \text{ Real part of open loop zeros}}{P - Z}$$

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

Centroid $\rightarrow$ (–1, 0)

Break-away or break-in points: These are those points on whose multiple roots of the characteristic equation occur.

$$s(s^2 + 3s + 2) + K = 0$$

$$K = -(s^3 + 3s^2 + 2s)$$

$$\frac{dK}{ds} = -(3s^2 + 6s + 2) = 0$$

$$s = -0.422, -1.577$$

Now verify the valid break-away point

$$K = 0.234 \text{ (valid) at } s = -0.422$$

$$K = \text{negative (not valid) at } s = -1.577$$

T2. Sol.

$$OLTF = \frac{K}{s(s^2 + 4s + 8)}$$

Poles are at

$$s_1 = 0$$

and

$$s_{2, 3} = \frac{-4 \pm \sqrt{16 - 32}}{2} = -2 \pm j2$$

There are 3 poles and no zero with root loci, all terminating at infinity.

$$\phi = \frac{(2q + 1)180°}{P - Z} = 60°, 180°, 300° \text{ for } q = 0, 1, 2 \text{ (angle of asymptotes)}$$

$$\text{Centroid} = \frac{0 - 2 + j2 - 2 - j2}{3} = \frac{-4}{3} = -1.33$$

$$1 + \frac{K}{s(s^2 + 4s + 8)} = 0$$

$$\Rightarrow \qquad K = -s(s^2 + 4s + 8) = -(s^3 + 4s^2 + 8s)$$

for break away points, $\qquad \dfrac{dK}{ds} = 0$

$$\Rightarrow \qquad \frac{dK}{ds} = -(3s^2 + 8s + 8)$$

$$s_{1,2} = -\frac{8 \pm \sqrt{64 - 4 \times 8 \times 3}}{2 \times 3}$$

$$= -\frac{8 \pm \sqrt{64 - 96}}{6} = -1.33 \pm j0.943$$

As $\dfrac{dK}{ds}$ is imaginary, there is no breakaway point from the real axis.

Imaginary axis crossing:

$$\text{Characteristic equation} = s(s^2 + 4s + 8) + K$$
$$= s^3 + 4s^2 + 8s + K = 0$$

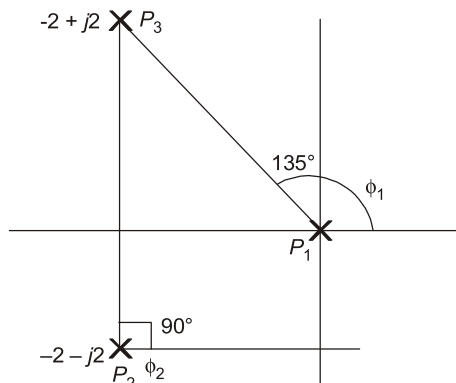|		
s^3	1	8
s^2	4	K
s^1	$\dfrac{32 - K}{4}$	
s^0	K	

From Routh-Hurwitz Criteria:

For $K = 32$, the system is marginally stable and beyond $K = 32$ the system becomes unstable.

Hence, $\qquad 4s^2 + K = 4s^2 + 32$

$$s = j2\sqrt{2} = j\omega$$

$$\omega = 2\sqrt{2} = 2.83$$

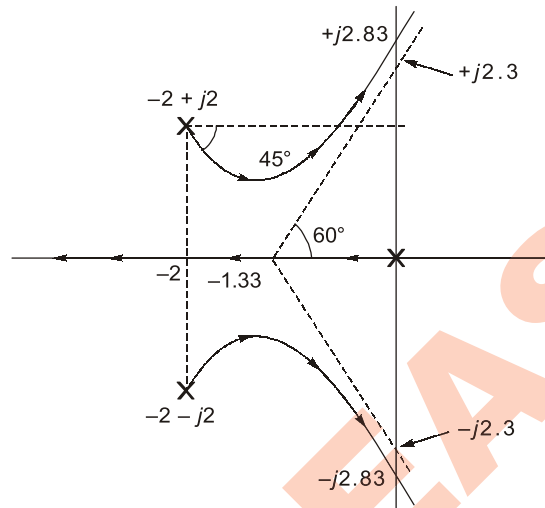The root locus cuts the imaginary axis at $\pm j2.83$.

$$\phi_1 = 180° - \tan^{-1}\left(\frac{2}{2}\right) = 135°$$

$$\phi_2 = 90°$$
$$\Sigma\phi_p = \phi_1 + \phi_2 = 135° + 90° = 225°$$
$$\phi = \Sigma\phi_2 - \Sigma\phi_p = 0 - 225° = -225°$$

Angle of departure,

$$\phi_D = 180 + \phi = 180 - 225° = -45°$$

Root locus of the given system:

T3. Sol.

$$G(s)\,H(s) = \frac{K}{s(s+1)(s+4)}$$

Step-1 Number of open loop poles ;

$$P = 3$$

Number of open loop zeros ; $Z = 0$

Number of branches terminating at infinity

$$= P - Z = 3$$

Step-2 Angle of asymptotes

$$\theta = \frac{(2q+1)180°}{P-Z} \quad \text{where } q = 0, 1, 2$$

$$\theta_1 = \frac{180°}{3} = 60°$$

$$\theta_2 = \frac{3 \times 180°}{3} = 180°$$

$$\theta_3 = \frac{5 \times 180°}{3} = 300°$$

Step-3 Centroid $= \dfrac{\Sigma \text{ real part of open loop poles} - \Sigma \text{ real part of open loop zeros}}{P-Z}$

$$= \frac{(-1-4)-(0)}{3-0} = -\frac{5}{3}$$

Step-4 Break away point

$$K + s(s^2 + 5s + 4) = 0$$

$$K = -s^3 - 5s^2 - 4s$$

$$\frac{dK}{ds} = -3s^2 - 10s - 4 = 0$$

$$3s^2 + 10s + 4 = 0$$

$$\Rightarrow \qquad s_1, s_2 = -0.4648, -2.8685$$

Valid break-away point will be -0.4648

(i) Routh array table

$$
\begin{array}{c|cc}
s^3 & 1 & 4 \\
s^2 & 5 & K \\
s^1 & \dfrac{20-K}{5} & 0 \\
s^0 & 1 &
\end{array}
$$

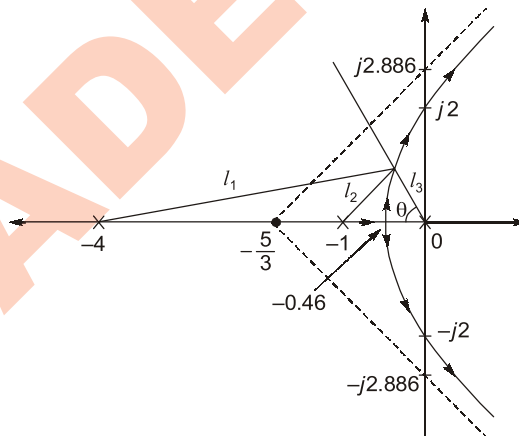For system to be stable

$$20 - K > 0 \quad \Rightarrow \quad K < 20$$

For system to be marginally stable.

$$K = 20$$

$$A(s) = 5s^2 + 20 = 0$$

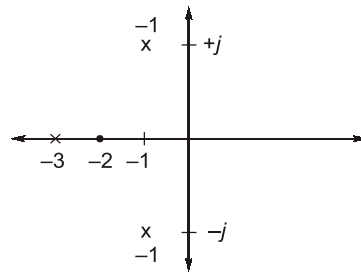$$\Rightarrow \qquad s = \pm 2j$$

(ii) To find K,

$$\theta = \cos^{-1}\xi = \cos^{-1}(0.34) = 70.123°$$

$$K = l_1\, l_2\, l_3$$

$$\text{Gain margin } (GM) = \frac{K(\text{Marginal stability})}{K(\text{desired})}$$
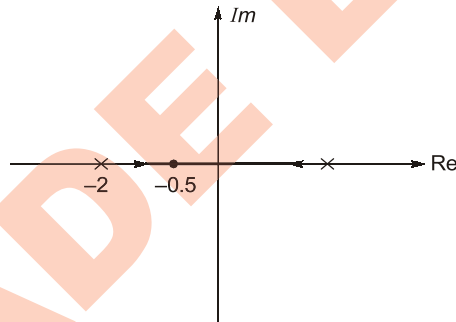
T4. Sol.

$$\phi_d = 180 - (\phi_p - \phi_z)$$

$$= 180° - \left(180 + \tan^{-1}\left(\frac{1}{2}\right) + 90° - 225°\right)$$

$$= 108.4°$$

T5. Sol.

Given that

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

Using root locus method, the break point can be

obtain as

$$\Rightarrow \qquad 1 + G(s) = 0$$

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

or $\qquad K = -(s+2)(s-1)$

$$\frac{dK}{ds} = -2s - 1 = 0$$

or $\qquad s = -0.5$

To have, both the poles at the same directions

$$\big|G(s)\big|_{s=0.5} = 1$$

$$K = 2.25$$

■■■■

5 Frequency Response Analysis

T1. Sol.

Given,

$$G(s) = \frac{K(1+0.5s)(1+as)}{s\left(1+\dfrac{s}{8}\right)(1+bs)\left(1+\dfrac{s}{36}\right)}$$

$(1 + as)$ is addition of zero to the transfer function whose contribution in slope = +20 dB/decade or –6 dB/octave.

$(1 + bs)$ is addition of pole to the transfer function whose contribution in slope = –20 dB/decade or –6 dB/octave

Observing the change in the slope at different corner frequencies, we conclude that

$$a = \frac{1}{4}\text{ rad/s and } b = \frac{1}{24}\text{ rad/s}$$

From
$$\omega = 0.01\text{ rad/s to }\omega = 8\text{ rad/s,}$$
$$\text{slope} = -20\text{ dB/decade}$$

Let the vertical length in dB be y

$$\therefore \quad -20 = \left(\frac{0-y}{\log 8 - \log 0.01}\right)$$

or,
$$-20 = \frac{y}{\log 8 + 2}$$

or,
$$y = 58\text{ dB}$$

Applying
$$y = mx + C \text{ at } \omega = 0.01\text{ rad/s,}$$

we have:
$$58 = -20\log 0.01 + C$$

or,
$$C = 58 - 40 = 18$$

Now,
$$C = 20\log K$$

or,
$$\log K = \frac{18}{20} = 0.9$$

$$\therefore \qquad K = \log^{-1}(0.9) = (10)^{0.9} = 7.94$$

$$\therefore \qquad \frac{a}{bK} = \frac{\left(\dfrac{1}{4}\right)}{\left(\dfrac{1}{24}\right) \times 7.94}$$

$$= \frac{24}{4 \times 7.94} = 0.755$$

$$\therefore \qquad \frac{a}{bK} = 0.755$$

T2. Sol.

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

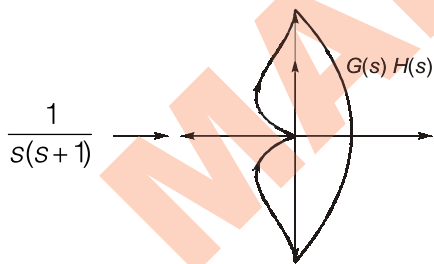For unity feedback system,

$$H(s) = 1$$

$$\therefore \qquad \text{CLTF} = \frac{G(s)}{1 + G(s)H(s)} = \frac{\dfrac{1}{(s+2)^2}}{1 + \dfrac{1}{(s+2)^2}}$$

$$= \frac{1}{s^2 + 4s + 5}$$

$\therefore$ Close loop poles will be the roots of $s^2 + 4s + 5 = 0$

i.e. $\qquad s = -2 + j$ and $-2 - j$

T3. (b)

$\dfrac{1}{s(s+1)}$

After adding pole at origin

$\dfrac{1}{s^2(s+1)}$
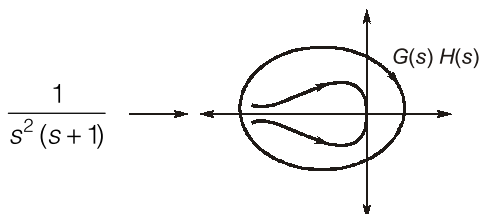
So, nyquist plot of a system will rotate by 90° in clockwise direction.

T4. Sol.

For gain margin we have to find

$$G(s)H(s) = \frac{0.75}{s(1+s)(1+0.5s)}$$

Phase over freqeuncy

$$-180° = -90° - \tan^{-1}(\omega) - \tan^{-1}(0.5 - \omega)$$
$$-90° = \tan^{-1}(\omega) + \tan^{-1}(0.5\,\omega)$$

$$\frac{1.5\omega}{1-0.5\omega^2} = \tan(90°)$$
$$0.5\,\omega^2 = 1$$
$$\omega = \sqrt{2}$$

∴ $$\left|G(j\omega)H(j\omega)\right| = \frac{0.75}{\omega\sqrt{1+\omega^2}\sqrt{1+0.25\omega^2}} = \frac{0.75}{\sqrt{2}\sqrt{1+2}\sqrt{1+0.5}} = \frac{1}{4}$$

∴ Gain margin $$= 20\log\frac{1}{\left|G(j\omega)H(j\omega)\right|}$$
$$= 20\log 4 = 12\text{ dB}$$

T5. Sol.

$$-90° - \tan^{-1}(2\omega) - \tan^{-1}(3\omega) = -180°$$
$$\tan^{-1}(2\omega) + \tan^{-1}(3\omega) = 90°$$

$$\frac{5\omega}{1-6\omega^2} = \tan(90°)$$

∴ $$1 - 6\,\omega^2 = 0$$

$$\omega = \frac{1}{\sqrt{6}} = 0.41$$

T6. Sol.

The Bode plot is of type zero system
thus steady state error

$$e_{ss} = \frac{1}{1+K_p}$$

Where K_p = propational error constant
K_p = 40 db
or K_p = 100

∴ $$e_{ss} = \frac{1}{1+100} = \frac{1}{101} = 0.009$$

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6 Controllers and Compensators

T1. Sol.

The given compensator represents phase lead compensator having maximum phase

$$\phi = \sin^{-1}\left(\frac{1-\alpha}{1+\alpha}\right)$$

Here,

$$\alpha = \frac{R_2}{R_1 + R_2} = \frac{(1/2)\ \Omega}{1 + (1/2)\ \Omega} = 0.333$$

$$\therefore \qquad \phi = \sin^{-1}\left(\frac{1-0.333}{1+0.333}\right) = \sin^{-1}\left(\frac{0.667}{1.33}\right) = \sin^{-1}(0.5) = 30°$$

T2. (a)

The effect of addition of a zero to a transfer function is providing a phase lead.

T3. Sol.

$$G(s) = \frac{\left(1 + \dfrac{s}{4}\right)}{\left(1 + \dfrac{s}{25}\right)}$$

Comparing it with the standard transfer function of phase lead compensator

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

$$T = \frac{1}{4}, \quad \alpha T = \frac{1}{25}$$

Now, frequency ω_m occurs at

$$= \sqrt{\frac{1}{\alpha T} \cdot \frac{1}{T}} = \sqrt{25 \times 4} = 10 \text{ rad/sec.}$$

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7 State Space Analysis

<div style="text-align:center">

Detailed Explanation
of
Try Yourself Questions

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T1. **(b)**

T2. **Sol.**

Given

$$\dot{x}(t) = Ax(t), \quad x(0) = x_0$$

Taking the Laplace transform

$$sX(s) - x(0) = AX(s)$$
$$[sI - A]\,X(s) = x(0)$$
$$X(s) = [sI - A]^{-1}\,x(0)$$
$$x(t) = \mathcal{L}^{-1}[sI - A]^{-1}\,x(0) \qquad \qquad ...(i)$$

Conditions given are

For

$$x_0 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}, \quad x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$$

For

$$x_0 = \begin{bmatrix} 0 \\ 1 \end{bmatrix}, \quad x(t) = \begin{bmatrix} e^{-t} - e^{-2t} \\ -e^{-t} + 2e^{-2t} \end{bmatrix}$$

Using the linearity property in equation (i)

$$K_1\,x_1(t) = \mathcal{L}^{-1}[sI - A]^{-1}\,x_1(0)\,K_1$$
$$K_2\,x_2(t) = \mathcal{L}^{-1}[sI - A]^{-1}\,x_2(0)\,K_2$$

Using the linearity property as

$$K_1\,x_1(t) + K_2\,x_2(t) = \mathcal{L}^{-1}[sI - A]^{-1}$$
$$[K_1 x_1(0) + K_2 x_2(0)] \qquad \qquad ...(ii)$$

Also

$$X_3(s) = [sI - A]^{-1}\,x_3(0)$$

So,

$$K_1\begin{bmatrix} 1 \\ -1 \end{bmatrix} + K_2\begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$$

$$\begin{bmatrix} K_1 + 0K_2 \\ -K_1 + K_2 \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$$

$\Rightarrow$
$$K_1 = 3$$
$$K_2 = 8$$

So, from equation (ii), we get $x(t)$

$$x(t) = K_1 x_1(t) + K_2 x_2(t)$$

$$= 3\begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix} + 8\begin{bmatrix} e^{-t} - e^{-2t} \\ -e^{-t} + 2e^{-2t} \end{bmatrix}$$

$$= \begin{bmatrix} 11e^{-t} - 8e^{-2t} \\ -11e^{-t} + 16e^{-2t} \end{bmatrix}$$

T3. Sol.

Given
$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

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

$$[sI - A] = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} s & -1 \\ 0 & s \end{bmatrix}$$

$$[sI - A] = s^2$$

$$\phi(t) = \mathcal{L}^{-1}[sI - A]^{-1}$$

$$= \frac{1}{s^2}\begin{bmatrix} s & 1 \\ 0 & s \end{bmatrix}$$

$$= \mathcal{L}^{-1}\begin{bmatrix} \frac{1}{s} & \frac{1}{s^2} \\ 0 & \frac{1}{s} \end{bmatrix} = \begin{bmatrix} 1 & t \\ 0 & 1 \end{bmatrix}$$

T4. (b)

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

$$y = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

$$A = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -2 \end{bmatrix}, \; B = \begin{bmatrix} 0 \\ 4 \\ 0 \end{bmatrix}, \; C = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$

Check for controllability:

$$Q_c = [B : AB : A^2B]$$

$$= \begin{bmatrix} 0 & 4 & -8 \\ 4 & -4 & 4 \\ 0 & 0 & 0 \end{bmatrix}$$

For controllable

$$|Q_c| \neq 0$$

Here, $\quad |Q_c| = 4(0) = 0 \; \therefore \;$ Uncontrollable.

Check for observability:

$$Q_o = [C^T : A^T C^T : A^{2T} C^T]$$

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

For observable

$$|Q_o| \neq 0$$

Here $\quad |Q_o| = 1 \quad \therefore \;$ Observable.

T5. Sol.

Characterstic equation $= \left| (sI - A)^{-1} \right|$

$$= \begin{bmatrix} 2 & -1 \\ 3 & s+5 \end{bmatrix}^{-1}$$

$$= s(s + 5) + 3$$
$$= s^2 + 5s + 3$$

■■■■