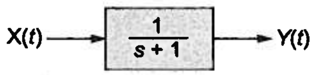
5 Frequency Response Analysis

Multiple Choice Questions

Q.1 For $X(t) = \sin t$. Find $Y(t)$.



(a) $\sqrt{2}\sin(t+45°)$ (b) $\frac{1}{\sqrt{2}}\sin(t-45°)$

(c) $\sqrt{2}\sin(t-45°)$ (d) $\frac{1}{\sqrt{2}}\sin(t+45°)$

Q.2 A u.f.b. system has forward path transfer function

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

The resonant frequency and B.W. are respectively

(a) 7.07 r/s, 12.7 r/s
(b) 12.7 r/s, 7.70 r/s
(c) 7.70 r/s, 1.27 r/s
(d) 1.27 r/s, 7.07 r/s

Q.3 The transfer function of a system is

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

When $r(t) = P\sin(2t-90°)$
and $C(t) = \sin(2t-60°)$
The value of 'P' will be

(a) $\frac{1}{\sqrt{3}}$ (b) $\frac{2}{\sqrt{3}}$

(c) $\sqrt{3}$ (d) 1

Q.4 The phase margin (in degrees) of a system having the loop transfer function

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

(a) 45° (b) –30°
(c) 60° (d) 30°

[GATE-1999]

Q.5 The system with the open loop transfer function

$G(s)H(s) = \frac{1}{s(s^2+s+1)}$ has a gain margin of

(a) –6 dB (b) 0 dB
(c) 3.5 dB (d) 6 dB

[GATE-2002]

Q.6 The open loop transfer function of a unity feedback system is given by $G(s) = \frac{3e^{-2s}}{s(s+2)}$.

The gain and phase margins of the system will be

(a) –7.09 and 87.5°
(b) 7.09 and 87.5°
(c) 7.09 dB and –87.5°
(d) –7.09 dB and –87.5°

[GATE-2005]

Q.7 A second order system has

$$M(j\omega) = \frac{100}{100-\omega^2+10\sqrt{2}\,j\omega}$$

Its M_r (peak magnitude) is

(a) 0.5 (b) 1
(c) $\sqrt{2}$ (d) 2

[GATE-2007]

Q.8 The phase angle of the system

$G(s) = \frac{s+5}{s^2+4s+9}$, varies between

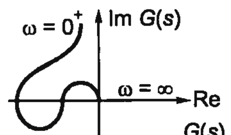
(a) 0° and 90° (b) 0° and –90°
(c) 0° and – 180° (d) – 90° and – 180°

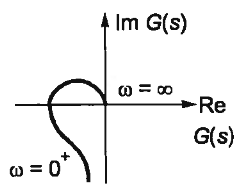
[ESE-2001]

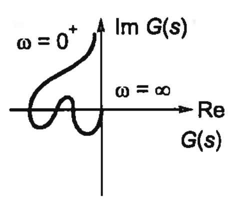
Q.9 The open-loop transfer function of a unity negative feed-back system is

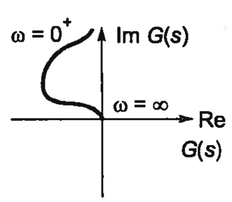
$$G(s) = \frac{k(s+10)(s+20)}{s^3(s+100)(s+200)}$$

The polar plot of the system will be

(a)


(b)


(c)


(d)


[ESE-1999]

Q.10 The OLTF of unity feedback system is

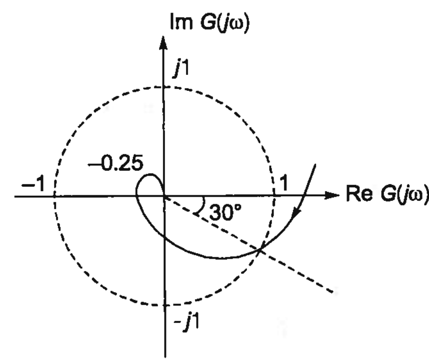
$$G(s) = \frac{as+1}{s^2}$$

The value of '*a*' to give phase margin = 45° will be

(a) $\sqrt{2}$ (b) $\frac{1}{\sqrt{2}}$

(c) $\sqrt{\sqrt{2}}$ (d) $\frac{1}{\sqrt{\sqrt{2}}}$ [ESE-2004]

Q.11 The polar plot (for positive frequencies) for the open-loop transfer function of a unity feedback control system is shown in the given figure



The phase margin and the gain margin of the system are respectively

(a) 150° and 4 (b) 150° and 3/4
(c) 30° and 4 (d) 30° and 3/4

[ESE-2000]

Q.12 The open-loop transfer function of a unity feedback control system is given as

$$G(s) = \frac{1}{s(1+sT_1)(1+sT_2)}$$

The phase crossover frequency and the gain margin are, respectively

(a) $\frac{1}{\sqrt{T_1T_2}}$ and $\frac{T_1+T_2}{T_1T_2}$

(b) $\sqrt{T_1T_2}$ and $\frac{T_1+T_2}{T_1T_2}$

(c) $\frac{1}{\sqrt{T_1T_2}}$ and $\frac{T_1T_2}{T_1+T_2}$

(d) $\sqrt{T_1T_2}$ and $\frac{T_1T_2}{T_1+T_2}$

[ESE-2001]

Q.13 The phase margin (*PM*) and the damping ratio (ξ) are related by

(a) $PM = 90^\circ - \tan^{-1}\left\{\frac{\sqrt{-2\xi^2+\sqrt{1+4\xi^4}}}{2\xi}\right\}$

(b) $PM = \tan^{-1}\left\{\frac{2\xi}{\sqrt{-2\xi^2+\sqrt{1+4\xi^4}}}\right\}$

(c) $PM = 90^\circ + \tan^{-1}\left\{\frac{\sqrt{2\xi+\sqrt{1+4\xi^4}}}{2\xi}\right\}$

(d) $PM = 180^\circ - \tan^{-1}\left\{\frac{\sqrt{2\xi-\sqrt{1+4\xi^4}}}{2}\right\}$

[ESE-2003]

Q.14 **List-I** and **List-II** show the transfer function and polar plots respectively. Match **List-I** with **List-II** and select the correct answer:

List-I

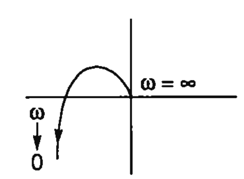
A. $\frac{1}{s(1+sT)}$

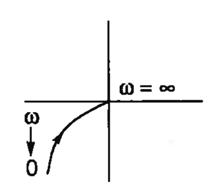
B. $\frac{1}{(1+sT_1)(1+sT_2)}$

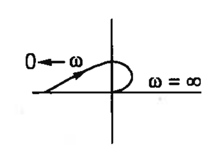
C. $\frac{1}{s(1+sT_1)(1+sT_2)}$

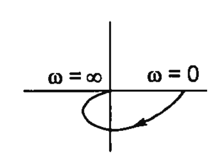
D. $\frac{1}{s^2(1+sT_1)(1+sT_2)}$

List-II

1.


2.


3.


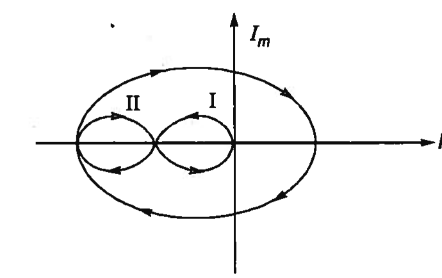
4.


Codes:

	A	B	C	D
(a)	2	1	4	3
(b)	3	4	1	2
(c)	2	4	1	3
(d)	3	1	4	2

[ESE-2002]

Q.15 Consider the Nyquist diagram for given $KG(s)$ $H(s)$. The transfer function $KG(s)$ $H(s)$ has no poles and zeros in the right half of s-plane. If the (–1, *j*0) point is located first in region I and then in region II, the change in stability of the system will be from

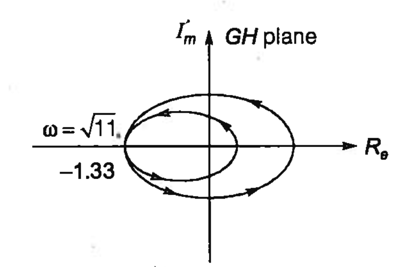


(a) unstable to stable
(b) stable to stable
(c) unstable to unstable
(d) stable to unstable

[ESE-2002]

Q.16 The Nyquist plot of a unity feedback system having open loop transfer function

$G(s) = \frac{k(s+3)(s+5)}{(s-2)(s-4)}$ for K = 1 is as shown below. For the system to be stable, the range of values of K is



(a) 0 < K < 1.33 (b) 0 < K < 1/1.33
(c) K > 1.33 (d) K > 1/1.33

[ESE-2003]

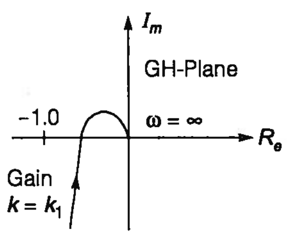
Q.17 A unity feedback control system has a forward loop transfer function as $\frac{e^{-Ts}}{[s(s+1)]}$. Its phase value will be zero at frequency ω_1. Which one of the following equations should be satisfied by ω_1?

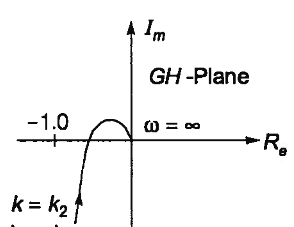
(a) $\omega_1 = \cot(T\omega_1)$ (b) $\omega_1 = \tan(T\omega_1)$
(c) $T\omega_1 = \cot(\omega_1)$ (d) $T\omega_1 = \tan(\omega_1)$

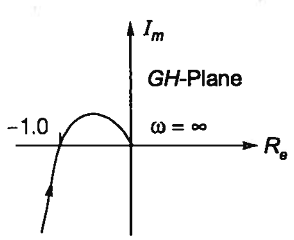
[ESE-2004]

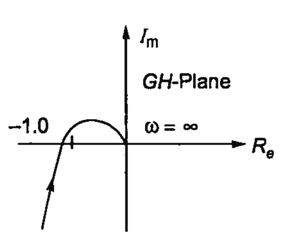
Q.18 Match List-I **(Nyquist Plot)** with **List-II (Frequency Response)** and select the correct answer using the code given below the lists:

List-I

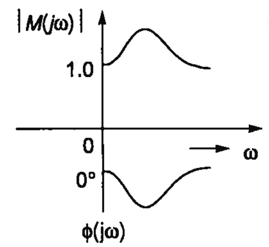
A.


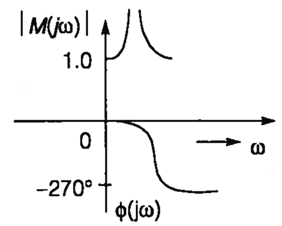
B.


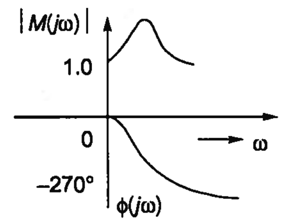
C.


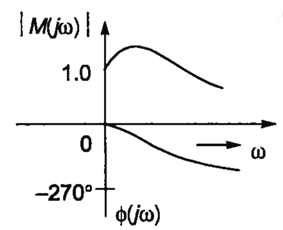
D.


List-II

1.


2.


3.


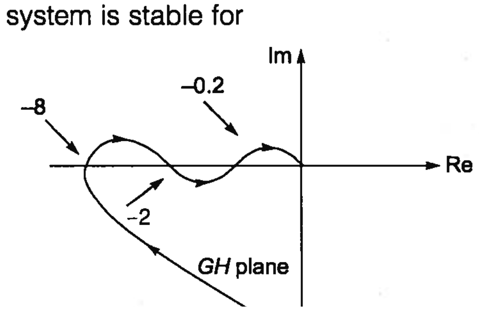
4.


Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	4	2	1	3
(c)	2	1	3	4
(d)	2	4	3	1

[ESE-2006]

Q.19 The polar diagram of a conditionally stable system for open loop gain $K = 1$ is shown in the figure. The open loop transfer function of the system is known to be stable. The closed loop system is stable for



(a) $K < 5$ or $\frac{1}{2} < K < \frac{1}{8}$

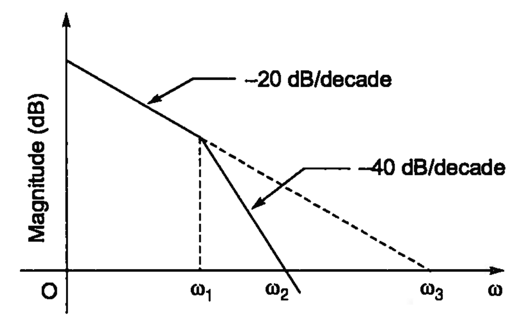
(b) $K < \frac{1}{8}$ or $\frac{1}{2} < K < 5$

(c) $K < \frac{1}{8}$ or $5 < K$

(d) $K < \frac{1}{8}$ or $K < 5$

[GATE-2005]

Q.20 Consider the following statements regarding the frequency response of a system as shown below:



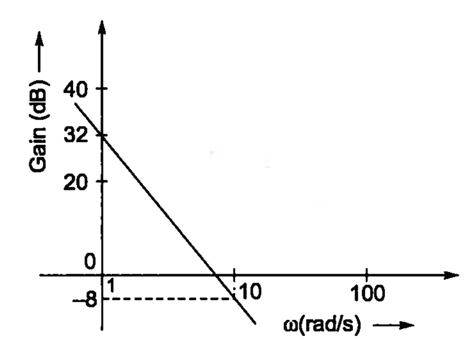
1. The type of the system is one
2. ω_3 = static error coefficient (numerically)
3. $\omega_2 = \frac{\omega_1 + \omega_3}{2}$

Select the correct answer using the codes given below

(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

[ESE-2003]

Q.21 The Bode plot of a transfer function $G(s)$ is shown in the figure below:



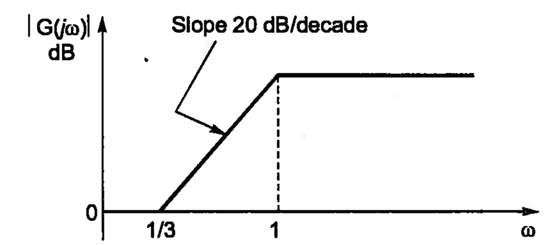
The gain $(20\log|G(s)|)$ is 32 dB and –8 dB at 1 rad/s and 10 rad/s respectively. The phase is negative for all ω. Then $G(s)$ is

(a) $\frac{39.8}{s}$ (b) $\frac{39.8}{s^2}$

(c) $\frac{32}{s}$ (d) $\frac{32}{s^2}$

[GATE-2013]

Q.22 The magnitude Bode plot of a network is shown in the figure



The maximum phase angle ϕ_m and the corresponding gain G_m respectively, are

(a) –30° and 1.73 dB
(b) –30° and 4.77 dB
(c) +30° and 4.77 dB
(d) +30° and 1.73 dB

[GATE-2014]

Q.23 The polar plot of the open loop transfer function $G(s) = \frac{10(s+1)}{s+10}$ for $0 \le \omega < \infty$ will be in the

(a) first quadrant (b) second quadrant
(c) third quadrant (d) fourth quadrant

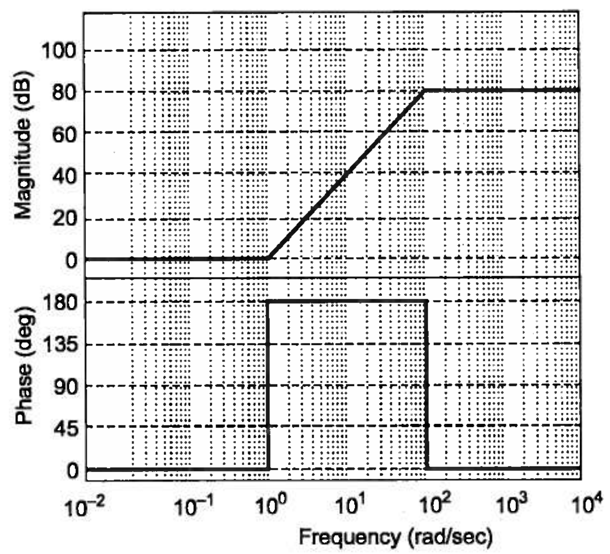
[GATE-2015]

Q.24 The number and direction of encirclements around the point $-1 + j0$ in the complex plane by the Nyquist plot of $G(s) = \frac{1-s}{4+2s}$ is

(a) zero. (b) one, anti-clockwise.
(c) one, clockwise. (d) two, clockwise.

[GATE-2016]

Q.25 The transfer function $G(s)$ of a system which has the asymptotic Bode plot shown below is:



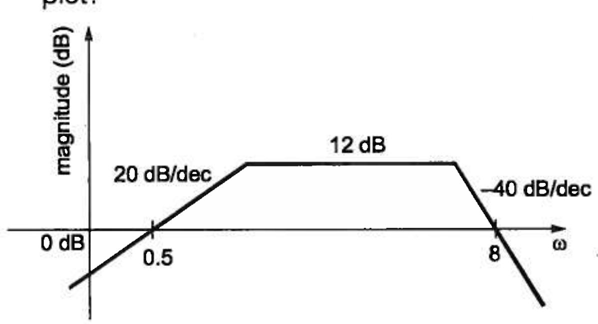
(a) $10^4\dfrac{(s-1)^2}{(s+100)^2}$ (b) $10^4\dfrac{(s+1)^2}{(s+100)^2}$

(c) $10^4\dfrac{(s+1)}{(s+100)^2}$ (d) $10^4\dfrac{(s-1)^2}{(s-100)^2}$

[IN: GATE-2016]

Q.26 Consider the following asymptotic Bode magnitude plot (ω is in rad/s).

Which one of the following transfer functions is best represented by the above Bode magnitude plot?



(a) $\dfrac{2s}{(1+0.5s)(1+0.25s)^2}$

(b) $\dfrac{4(1+0.25s)}{s(1+0.25s)}$

(c) $\dfrac{2s}{(1+2s)(1+4s)}$

(c) $\dfrac{4s}{(1+2s)(1+4s)^2}$ [EE: GATE-2016]

Q.27 Loop transfer function of a feedback system is

$G(s)H(s) = \dfrac{s+3}{s^2(s-3)}$. Take the Nyquist contour in the clockwise direction. Then, the Nyquist plot of $G(s)H(s)$ encircles $-1 + j0$

(a) once in clockwise direction
(b) twice in clockwise direction
(c) once in anticlockwise direction
(d) twice in anticlockwise direction

Numerical Data Type Questions

Q.28 _____ rad/sec is frequency at which the steady state sinusoidal response becomes zero.

$$G(s) = \frac{(s^2+9)(s+2)}{(s+3)(s+4)(s+5)}$$

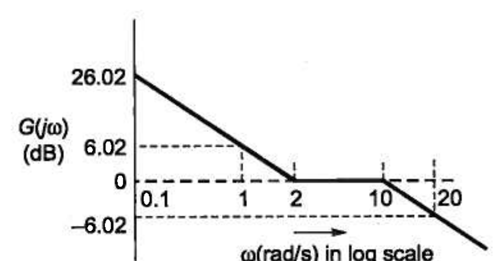
Q.29 _____ is the value of damping ratio when resonant peak is unity?

Q.30 The phase margin in degrees of

$G(s) = \dfrac{10}{(s+0.1)(s+1)(s+10)}$ calculated using the asymptotic Bode plot is _____.

[GATE-2014]

Q.31 The Bode asymptotic magnitude plot of a minimum phase system is shown in the figure.



If the system is connected in a unity negative feedback configuration, the steady state error of the closed loop system, to a unit ramp input, is_____.

[GATE-2014]

Q.32 The transfer function of a mass-spring-damper system is given by

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

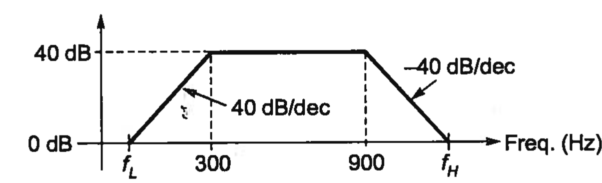
The frequency response data for the system are given in the following table.

ω in rad/s	$\lvert G(j\omega)\rvert$ in dB	arg $(G(j\omega))$ in deg
0.01	–18.5	–0.2
0.1	–18.5	–1.3
0.2	–18.4	–2.6
1	–16	–16.9
2	–11.4	–89.4
3	–21.5	–151
5	–32.8	–167
10	–45.3	–174.5

The unit step response of the system approaches a steady state value of _____.

[GATE-2015]

Q.33 Consider the Bode plot shown in figure. Assume that all the poles and zeros are real valued.



The value of $f_H - f_L$ (in Hz) is _____.

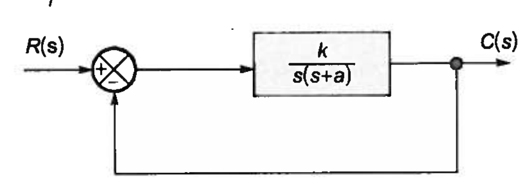
[GATE-2015]

Q.34 The phase margin (in degrees) of the system having open loop transfer function

$G(s) = \dfrac{10}{s(s+10)}$ is _____.

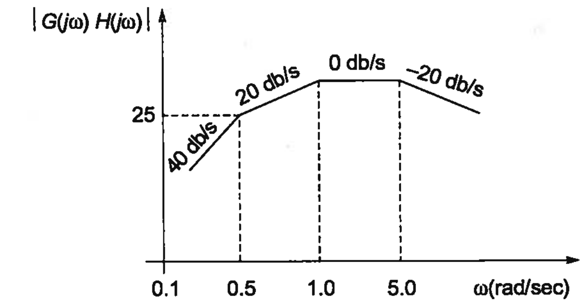
[GATE-2015]

Q.35 For the system shown in the figure, obtain the values of k and a, to satisfy, M_r = 1.04 and ω_r = 11.55 rad/sec.



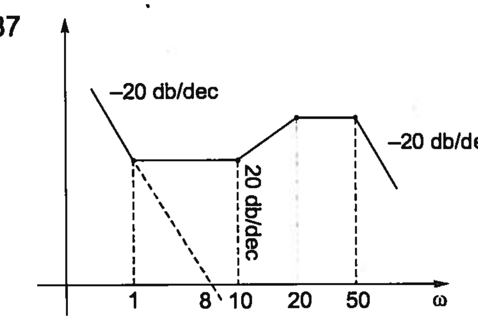
[ESE-2007]

Q.36 Determine the open loop transfer function, $G(s)$ $H(s)$, of a feedback control system whose Bode-Plot's magnitude characteristic is shown in the figure.



[ESE-2008]

Q.37



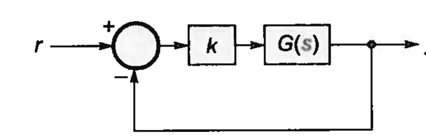
Find the transfer function?

Q.38 A minimum phase function has 3 finite poles and 1 finite zeroes. Its phase angle as $\omega \to \infty$ will be $-k \times \pi/2$ rad.

Then the value of k is _________.

Q.39 In the feedback system shown below

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

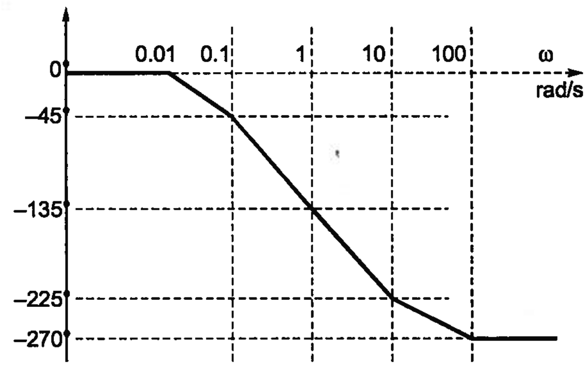


The positive value of k for which the gain margin of the loop is exactly 0 dB and the phase margin of the loop is exactly zero degree is _____.

[GATE-2016]

Q.40 The asymptotic Bode phase plot of

$G(s) = \dfrac{k}{(s+0.1)(s+10)(s+p_1)}$, with k and p_1 both positive, is shown below.



The value of p_1 is ________

[GATE-2016]

Q.41 The input $i(t) = 2\sin(3t + \pi)$ is applied to a system whose transfer function $G(s) = \frac{8}{(s+10)^2}$. The amplitude of the output of the system is________.

[IN: GATE-2016]

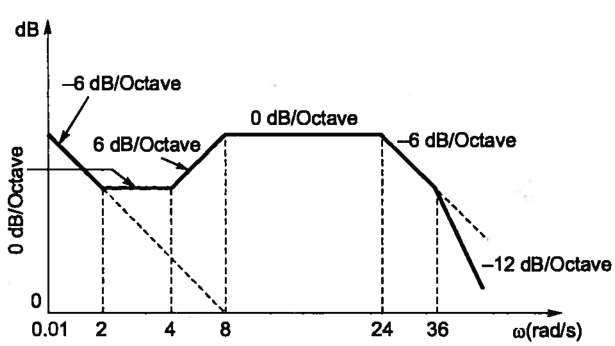
Try Yourself

T1. The Bode magnitude plot of the transfer function

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

is shown below.

Note that –6 dB/octave = –20 dB/decade. The value of a/bK is ___________.



[Ans: 0.755 (0.7 to 0.8)]

T2. An open loop T.F. of a unity feedback system is given by

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

The closed loop transfer function will have poles at _____.

[Ans: $-2 + j$; $-2 - j$]

T3. By adding a pole at the origin of s-plane, the Nyquist plot of a system will rotate by

(a) 90° in anti-clockwise direction
(b) 90° in clockwise direction
(c) 180° in anti-clockwise direction
(d) 180° in clockwise direction

[Ans. (b)]

T4. Using polar plot method, find the gain margin of a feedback system whose open-loop transfer function is given by

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

[Ans: gain margin in dB = 20 log4 = 12 dB]

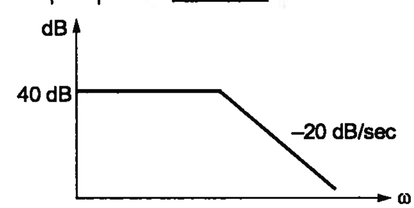
T5. The open-loop transfer function of a system is

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

The phase crossover frequency is ______ rad/sec

[Ans: 0.41]

T6. The Bode plot for a transfer function is given below. The steady state error corresponding to a unit step input is ______



[Ans: 0.009]