NITTE MEENAKSHI INSTITUTE OF TECHNOLOGY
(AN AUTONOMOUS INSTITUTE AFFILIATED TO VTU, BELAGAVI)

6th Mid-Semester Examination BE Degree
(MSE-3 Scheme)
Department of Electronics and Communication Engineering

Semester: VI	**Course Name:** Control Systems
Course code: 21ECG62	Faculty Names Dr Smitha Prabhu, Dr. Harsha, Ms. Divya Section A: Section B: Section C:
Date:	**Max. Marks** 30

Q.No.	Scheme	Marks	CO;BL
1a)	~~The~~ Gain Margin:- Margin in gain allowable by which gain can be increased till system reaches on the verge of instability. —½M— or $G.M = \frac{1}{\lvert G(j\omega)H(j\omega)\rvert_{\omega=\omega_{pc}}}$ —½M— GM should be +ve for stability ½M— ~~1M~~ Phase Margin The amount of additional phase lag which can be introduced in the system till system reaches on the verge of instability is called phase margin P.M. —½M— OR $PM = 180° + \angle G(j\omega)H(j\omega)\rvert_{\omega=\omega_{gc}}$ —½M— For stability 'PM' should be +ve. —½M—	1M 1M.	
1b)	N = −P. —1M— It states that for absolute stability of the system, the no. of encirclements of the origin of F-plane by Nyquist plot must be equal to no. of poles of 1 + G(s)H(s) i.e poles of G(s)H(s) which ~~must b~~ are in the right half of s plane and in clock wise direction —1M—	2M.	

k) Mapping theorem states that the mapped locus $Z'(s)$ encircles the new origin of F-plane as many times as the difference between the no of zeros and poles of F(s) which are encircled by $Z(s)$ path in s plane mathematically

$N = Z - P$

where N = Encirclements of origin of F plane by $Z'(s)$ path

P = no of poles of F(s) encircled by $Z(s)$ path in s plane. —2M—

Z = no of zeros of F(s) encircled by $Z(s)$ path in s-plane.

2a) $F(s) = \frac{80}{s(s+2)(s+20)} = \frac{2}{s(1+s/2)(1+s/20)}$ —1M

$20\log k = 26dB$

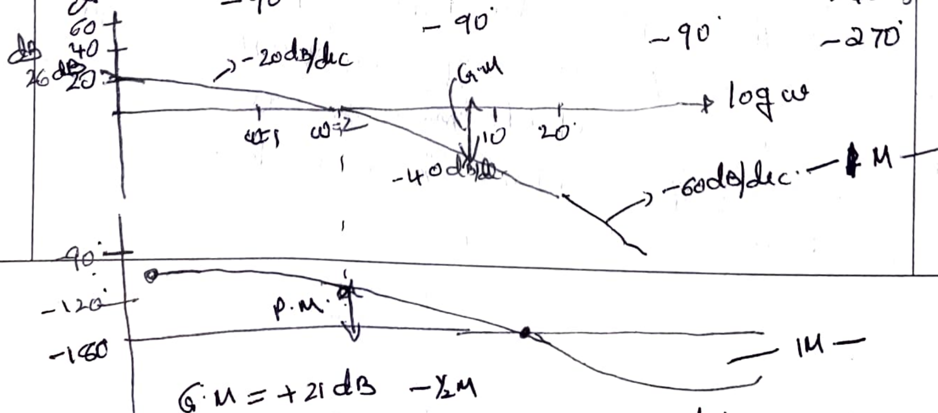
i) $K = 2$ ii) 1 pole at origin.

iii) Simple poles at $T_1 = 1/2$ $\omega_{c1} = 2$

iv) Simple poles at $T_2 = 1/20$ $\omega_{c2} = 20$ 2M.

ω	$1/j\omega$	$-\tan^{-1}\omega/2$	$-\tan^{-1}\omega/20$	ϕ_R
0.2	$-90°$	$-5.7°$	$-0.57°$	-96.27
2	-90	$-45°$	$-5.7°$	-140.7
8	-90	-75.96	$-21.8°$	-187.76
10	-90	-78.69	-26.56	-195.29
20	-90	-84.28	-45	-219.28
40	-90	-87.13	-63.43	-240.58
∞	-90	-90	-90	-270

2M. —10M—



—1M—

—1M—

$G.M = +21 dB$ —½M

$P.M = 38°$ —½M→

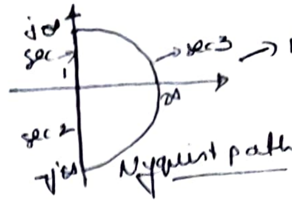
$\omega_{gc} = 2.1$ rad/sec —½M—

stability → system stable —1M.

2b) $N = -P = 0$ — 1M —

Step

$G(j\omega)H(j\omega) = \dfrac{2(1-j\omega)}{(2+j\omega)(3+j\omega)}$ — 1M



sec 3 → 1M.

Sec 1

$\omega \to \infty$ $\quad 0\dfrac{\angle -90^\circ}{90^\circ, 90^\circ} = 0 \angle -270^\circ$ $\quad 0^\circ - (-270^\circ) = +270^\circ$ } 2M

$\omega \to 0$ $\quad \frac{1}{3}\dfrac{\angle 0^\circ}{\angle 0 \; \angle 0} = \frac{1}{3}\angle 0^\circ$

Sec 2 → Mirror image of sec 1.

Intersection with negative real axis

$G(j\omega)H(j\omega) = \dfrac{2(1-j\omega)(2-j\omega)(3-j\omega)}{(2+j\omega)(2-j\omega)(3+j\omega)(3-j\omega)}$ } 2M

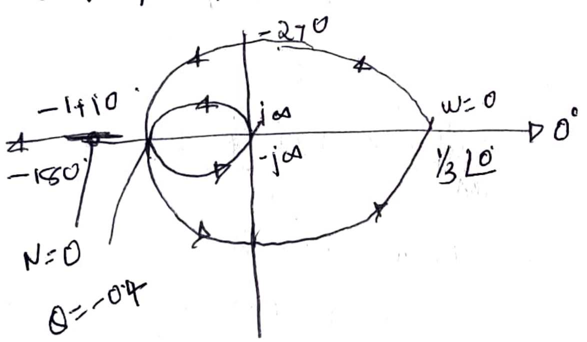
$= \dfrac{2[(6-6\omega^2) - j\omega(11-\omega^2)]}{(4+\omega^2)(9+\omega^2)}$

imaginary part to be zero, $\omega = 0$ $\quad \omega = \sqrt{11}$

$\omega = 0$ intersects at $\frac{1}{3}$. } 1M

$\omega = \sqrt{11}$, it intersects at $Q = -0.4$.

10M



→ 2M.

3a) $G(s)H(s) = \dfrac{A}{s(1+s/4)(1+s/10)}$ $\quad A = K/40.$ — 1M.

1) A is unknown

2) $1/s$ → one pole at origin

3) $\dfrac{1}{1+s/4}$ at $T_1 = 1/4$ $\quad \omega_{c1} = 1/T_1 = 4.$ } 2M

4) $\dfrac{1}{1+s/10}$ $\quad T_2 = 1/10$ $\quad \omega_{c2} = 1/T_2 = 10$

$0 < \omega < 4$ $-20\,db/dec$

$4 < \omega < 10$ $-40\,dB/dec$ 1M

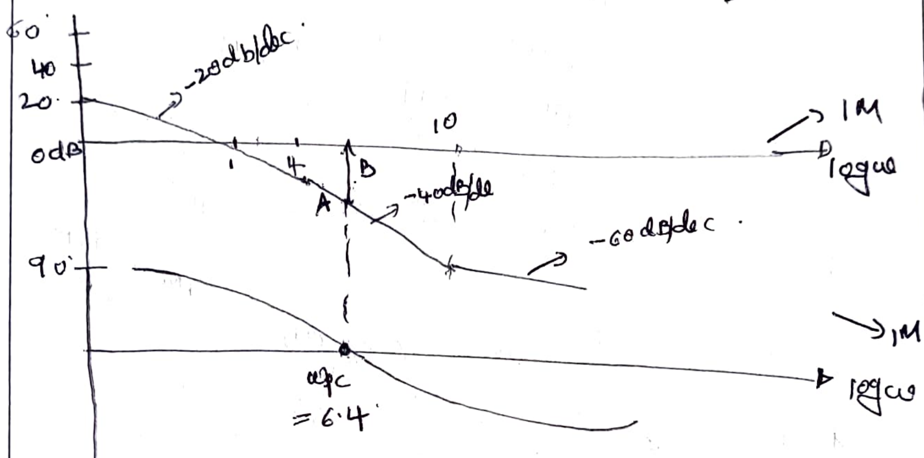
$10 < \omega < \infty$ $-60\,dB/dec$

Step 3.

$$G(j\omega)H(j\omega) = \frac{A}{j\omega(1+j\omega/4)(1+j\omega/10)}$$

ω	$1/j\omega$	$-\tan^{-1}\omega/4$	$-\tan^{-1}\omega/10$	ϕ_R
0.4	$-90°$	-5.71	-2.29	-98
4	$-90°$	$-45°$	-21.8	-156.8
10	$-90°$	-68.2	-45	-203.2
7	$-90°$	-60.2	-35	$-185.2°$

2M



10M

$20\log A = 22$ → upward shift positive

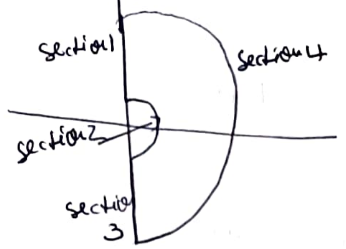
$A = 12.58$ —— 1M

$A = \frac{K}{40} \Rightarrow K = 40A = 503.57$ → for marginal stability

1M

Faculty Name (s) & Signature Section A: Section B: Section C:	MSE Coordinators Dr. B.S. Pavan&Ms. Kushalatha M R	Dr. Parameshachari B D HoD, ECE, NMIT

$N = -P = 0$ — 1M



— 1M

For stability $N = -P = 0$.

Section 1 : $s = +j\infty$ to $s = +j0$.

starting $\omega \to +\infty$ $\quad 0 \angle \frac{0^\circ}{90^\circ\ 180^\circ} = 0 \angle -270^\circ$ $\quad -90 - (-270) = +180^\circ$

Terminating $\omega \to +0$. $\quad \infty \angle \frac{0^\circ}{90^\circ\ 0} = \infty \angle -90^\circ$

Section 2 : $s = +j0$ to $s = -j0$

starting $\omega \to +0$ $\quad \infty \angle -90^\circ$ $\quad 90^\circ - (-90) = +180^\circ$

Terminating $\omega \to -0$ $\quad \infty \angle 90^\circ$

2M

Step

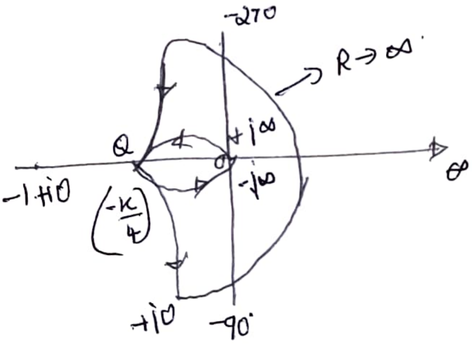
$$G(j\omega)H(j\omega) = \frac{K(-j\omega)\left[(2-\omega^2) - 2j\omega\right]}{(j\omega)(-j\omega)\left[(2-\omega^2)+2j\omega\right]\left[(2-\omega^2)-2j\omega\right]}$$

$$= \frac{-2K\omega^2 - Kj\omega(2-\omega^2)}{\omega^2\left[(2-\omega^2)^2 + 4\omega^2\right]}$$

2M

$2 - \omega^2 = 0 \quad \omega_{pc} = \sqrt{2}$.

$$Q = \frac{-2K}{(2-2)^2 + 4\times 2} = \frac{-K}{4}$$ — 1M



— 2M

10M

For stability

$|OQ| < 1$. i.e $-\left|\frac{K}{4}\right| < 1$ i.e $K < 4$. — 1M

For stability $\underline{0 < K < 4}$.

4) $\omega_{c1} = 1$

$T_1 = 1/\omega_{c1} = 1$ } 1M

The shift at $\omega = 1$ is 0 dB so $20\log k = 0\,dB$ $\therefore k = 1$.

$\omega_{c2} = \omega_2 = 10$. $T_2 = 1/\omega_{c2} = 0.1$

$(1 + T_2 s) = (1 + 0.1s)$ as simple zero } 1M

$\omega_{c3} = 100$ $T_3 = 1/\omega_{c3} = 0.01$ } 1M

$T_4 = 1/\omega_{c4} = 0.001$. $\frac{1}{1 + 0.001s}$

$$G(s)H(s) = \frac{(1 + 0.1s)(1 + 0.01s)}{(1 + s)(1 + 0.001s)}$$ } 1M

— 4M —