Exp.No: 7 **Stability analysis of linear systems using Bode plot**

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Aim and PROBLEM STATEMENT:

i) Draw the bode plot

ii) determine stability of the system through gain margin and phase margin

Problem-1: The open loop transfer function of certain unity feedback control system is given by

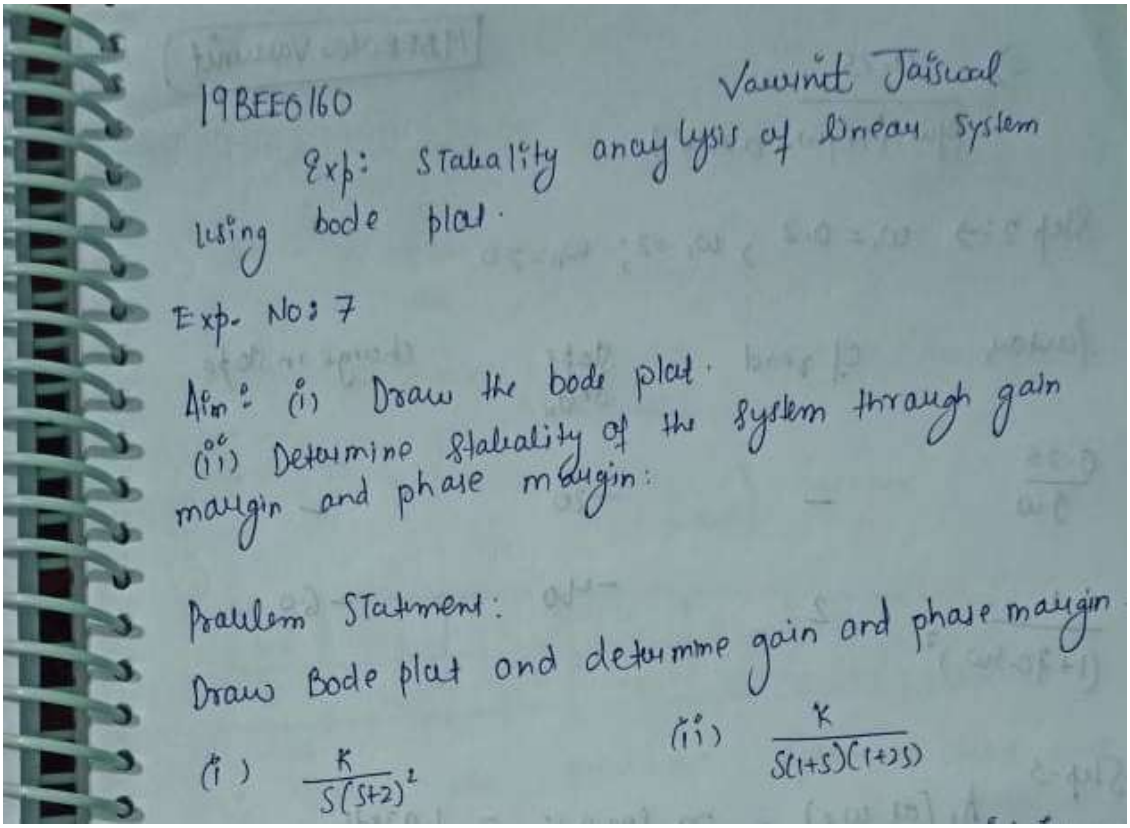
$$G(S)=\frac{K}{S(S+2)^2}$$

Draw the bode plot and determine gain margin and phase margin.

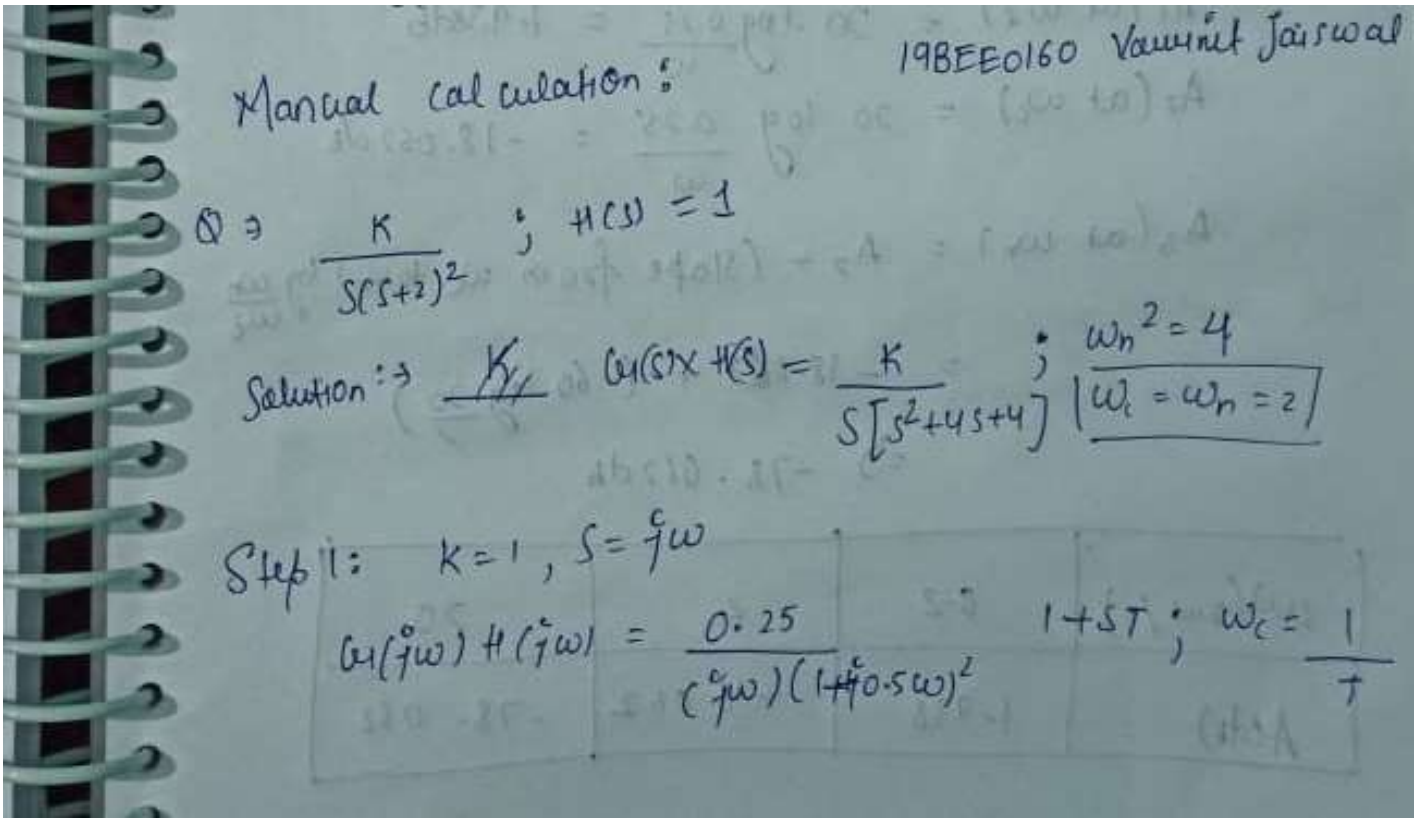
Problem-2: The open loop transfer function of certain unity feedback control system is given by

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

Draw the bode plot and determine gain margin and phase margin.



MANUAL CALCULATION :



Manual calculation :

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Q ⇒ $\frac{K}{S(S+2)^2}$; $H(S) = 1$

Solution :⇒ $G(S) \times H(S) = \frac{K}{S[S^2+4S+4]}$; $\omega_n^2 = 4$

$\omega_c = \omega_n = 2$

Step 1: $K = 1$, $S = j\omega$

$G(j\omega) H(j\omega) = \frac{0.25}{(j\omega)(1+0.5\omega)^2}$; $1+ST$; $\omega_c = \frac{1}{T}$

$$\Rightarrow \frac{0.25}{(j\omega)(1+\frac{j\omega}{2}-0.25\omega^2)}$$

Step 2:→ $\omega_1 = 0.2$, $\omega_c = 2$; $\omega_n = 20$

factors	of read	Slope dB/dec	change in slope
$\frac{0.25}{j\omega}$	–	−20	–
		−40	−60
$\frac{1}{(1+\frac{j0.5\omega}{2})^2}$	2		

Step-3

A_1 (at ω_1) $= 20 \log \frac{0.25}{\omega} = 1.938$db

A_2 (at ω_c) $= 20 \log \frac{0.25}{\omega} = -18.062$ db

A_3 (at ω_n) $= A_2 + (\text{Slope from } \omega_c \text{ to } \omega_n) \log \frac{\omega_n}{\omega_c}$

$= -18.062 + (-60 \log \frac{20}{2})$

$\Rightarrow -78.062$ db

ω (rad/s)	0-2	2	20
A(db)	1.938	−18.062	−78.062

Step-4: phase Angle Calculation :-

$$\phi = \angle G(j\omega)H(j\omega) \quad ; \quad G(j\omega)H(j\omega) = \frac{0.25}{j\omega(1+j0.5\omega)^2}$$

$$\phi = -90^\circ - 2\tan^{-1}0.5\omega$$

$$\phi_1 = -90^\circ - \tan^{-1}\left(\frac{\omega}{1-0.25\omega^2}\right) \qquad \omega \le \omega_n \ (\omega_n = 2)$$

$$\phi_2 = -90^\circ - \left(180^\circ + \tan^{-1}\frac{\omega}{1-0.25\omega^2}\right) \qquad \omega > \omega_n$$

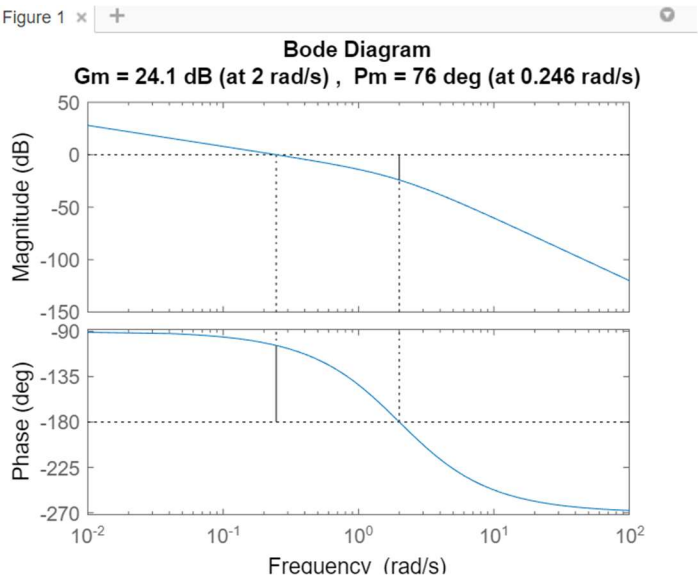
ω	0.2	1	2	5	10	20
ϕ	-101.4°	-145°	-180°	-226.4°	-247°	-258.6°

$\therefore$ $G_m = +18db$ $\quad PM = +70^\circ$ System is stable and closed loop.

Program And MATLAB Output

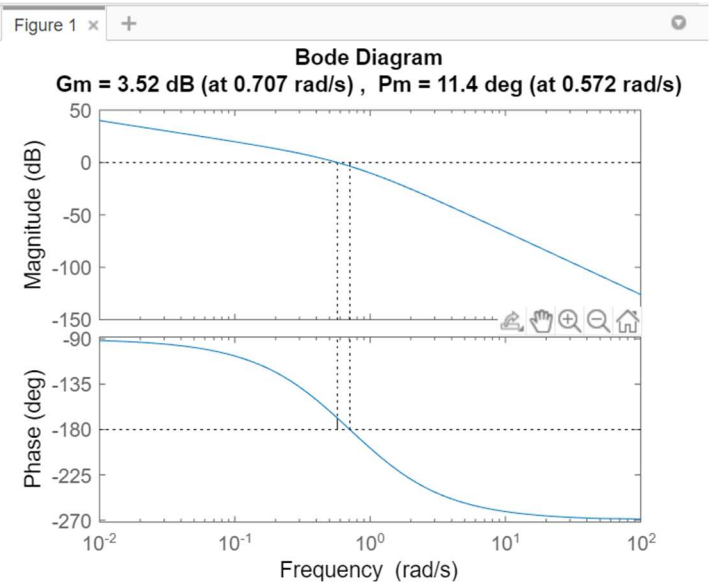
1:

```
%Varrnit Jaiswal
num=0.25;    %% from time constant form
den=[0.25 1 1 0];    %% from time constant form
sys=tf(num,den)
bode(sys);
margin(sys);
```



2:

```
%Varrnit Jaiswal 19BEE0160
num=1;    %% from time constant form
den=[2 3 1 0];    %% from time constant form
sys=tf(num,den)
bode(sys);
margin(sys);
```



Inference: