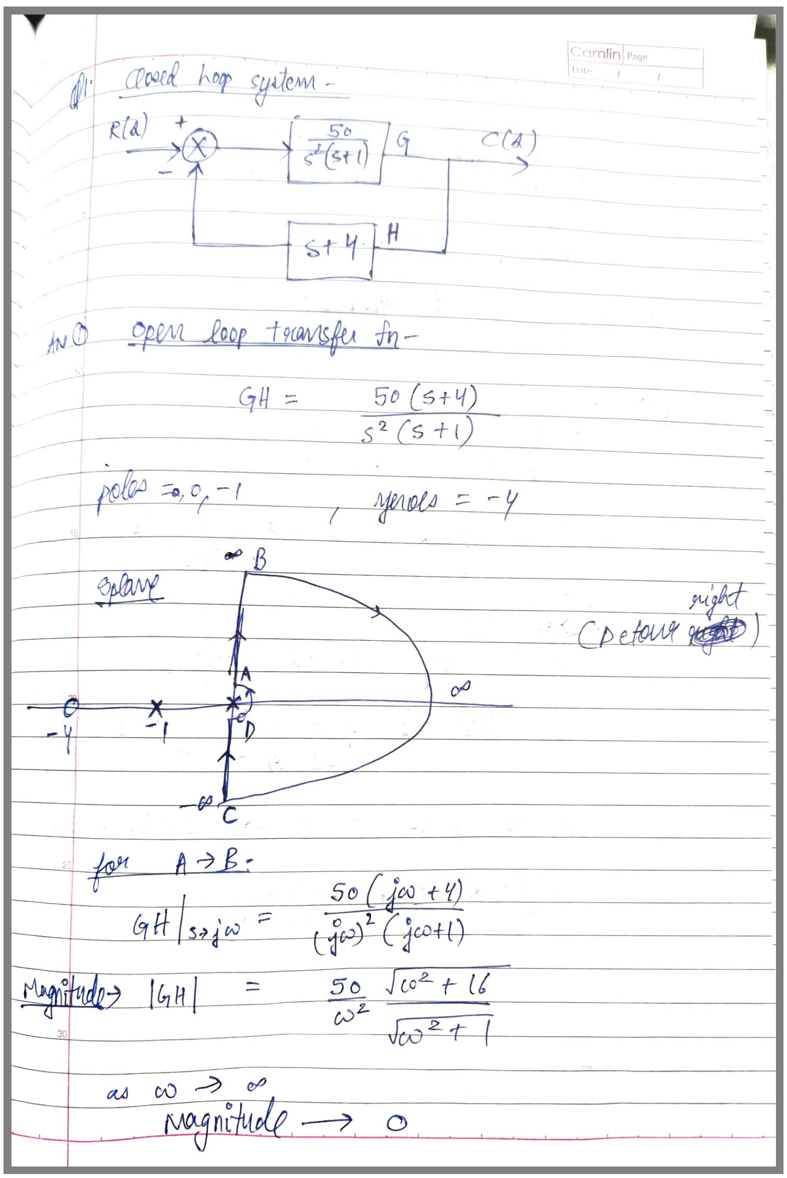
Lab8-Report

RollNo-190020021

Kushagra Khatwani

Answers-

Q1-



Ans 1) Open loop transfer fn-

$$GH = \frac{50(s+4)}{s^2(s+1)}$$

poles = 0, 0, −1 , zeroes = −4

for A → B:

$$GH\Big|_{s \to j\omega} = \frac{50(j\omega+4)}{(j\omega)^2(j\omega+1)}$$

Magnitude → $|GH| = \frac{50}{\omega^2}\frac{\sqrt{\omega^2+16}}{\sqrt{\omega^2+1}}$

as $\omega \to \infty$

Magnitude → 0

phase →

Due to pole at $-1 \rightarrow -90^\circ$

Due to zero at $-4 \rightarrow +90^\circ$

Due to poles at $0 \rightarrow 0^\circ$

so

net phase $\Rightarrow 0^\circ$ $(A \rightarrow B)$

$C \rightarrow D$ will be symmetric to $A \rightarrow B$

$B \rightarrow C$ -

Due to pole at -1 and zero at -4 $\Bigg\} \rightarrow 0^\circ$

Due to poles at $0 \rightarrow 2 \times (180^\circ) = 360^\circ$

$D \rightarrow A$

At A

it is very close to origin

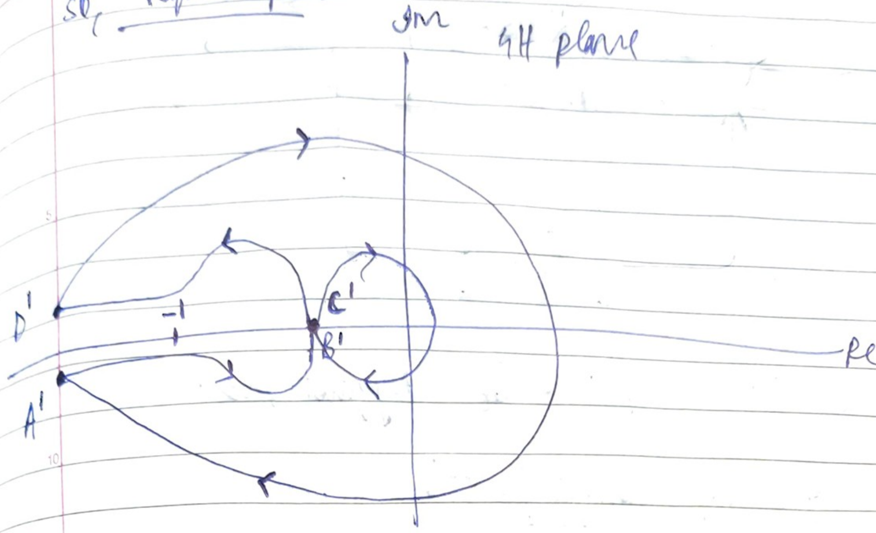
so due to zero at -4 and pole at -1 $\Bigg\} \rightarrow 0$ (cancel each other)

due to poles at $0 \rightarrow 2 \times 180^\circ = 360^\circ$

magnitude of $A \rightarrow \infty$ as $\omega \rightarrow 0$

Camlin Page
Date / /

so, Nquist plot -



② we can see -

$$Z = N - P$$

$N \rightarrow$ Number of encirclements around -1
$P \rightarrow$ Number of open loop poles in RHP

$$Z = N - 0 \qquad (\text{as } P = 0)$$

$$N = (1-1) = 0$$ (as there is one anticlock wise and one clockwise around -1)

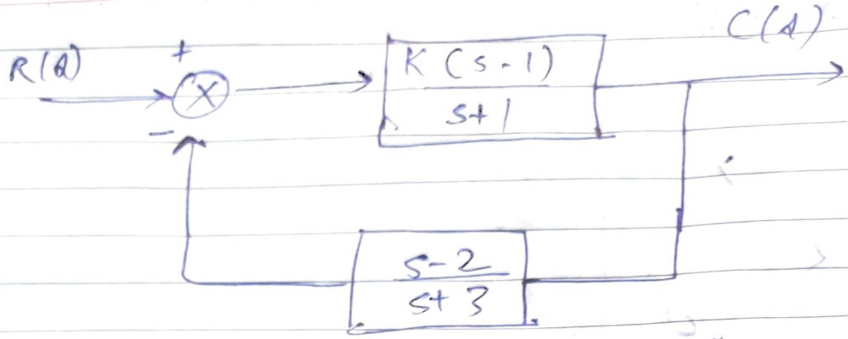
so $\boxed{Z = 0}$

No of zeroes of $1+GH$ in RHP is 0.

so poles of $\rightarrow \frac{G}{1+GH}$ in RHP is 0

so $\boxed{\text{system is stable}}$

Q2.



① For K=1, plotted the Nyquist plot.

② open loop transfer function -

$$GH = \frac{K(s-1)(s-2)}{(s+1)(s+3)} \quad \text{put } K=1$$

$$GH = \frac{s^2-3s+2}{s^2+4s+3}$$

At $s \to j\omega$

$$GH = \frac{(j\omega)^2 - 3(j\omega) + 2}{(j\omega)^2 + 4(j\omega) + 3}$$

$$GH = \frac{(2-\omega^2) - 3j\omega}{(3-\omega^2) + 4j\omega}$$

$$= \frac{((2-\omega^2) - 3j\omega)((3-\omega^2) - 4j\omega)}{(3-\omega^2)^2 + 16\omega^2}$$

putting imaginary part = 0

$\omega = 0.745 \rightsquigarrow$ This is where contour cuts -ve axis for K=1

For stability

$$Z = 0$$

$$Z = N - P = 0$$

we know $P = 0$ (as no poles in RHP)

so

$$K < \frac{1}{0.745} \quad \text{(critical value)}$$

so

$$K < 1.34$$

(3) In simulink.

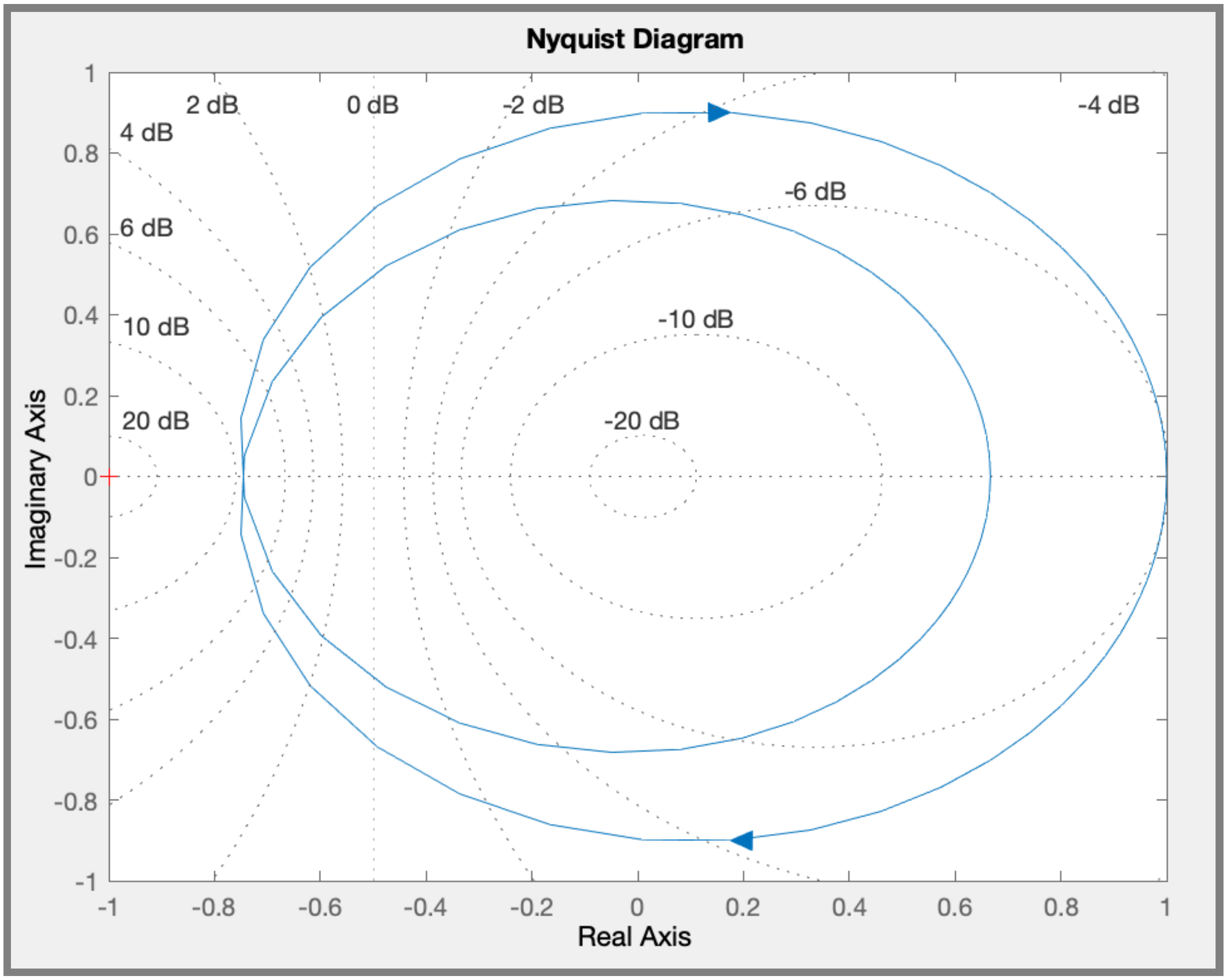
(4) } Done in MATLAB

(5)

Code Fragment for K=1-

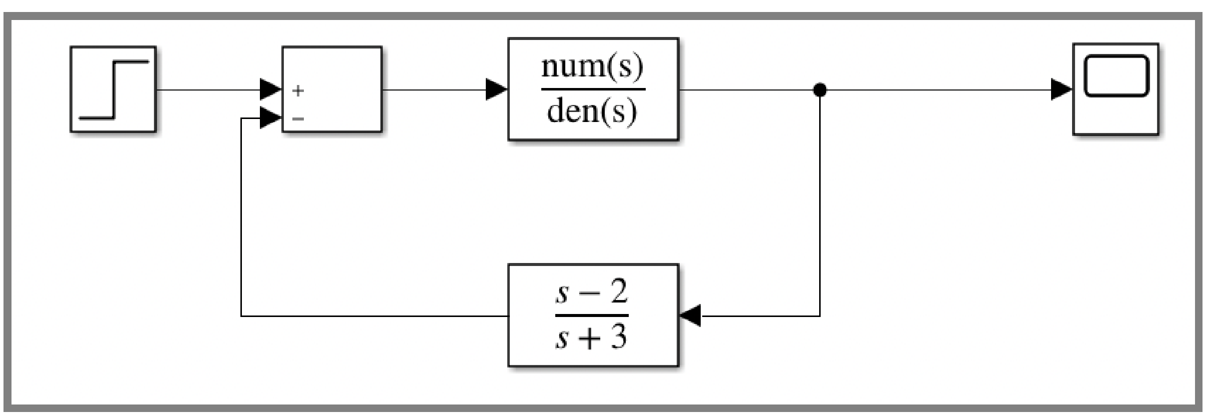
```
clear all;
clc;
clf;
numg=[1 -3 2];
deng=[1 4 3];
G=tf (numg, deng);
nyquist(G);
grid on;

pause;
```

Plot for K=1

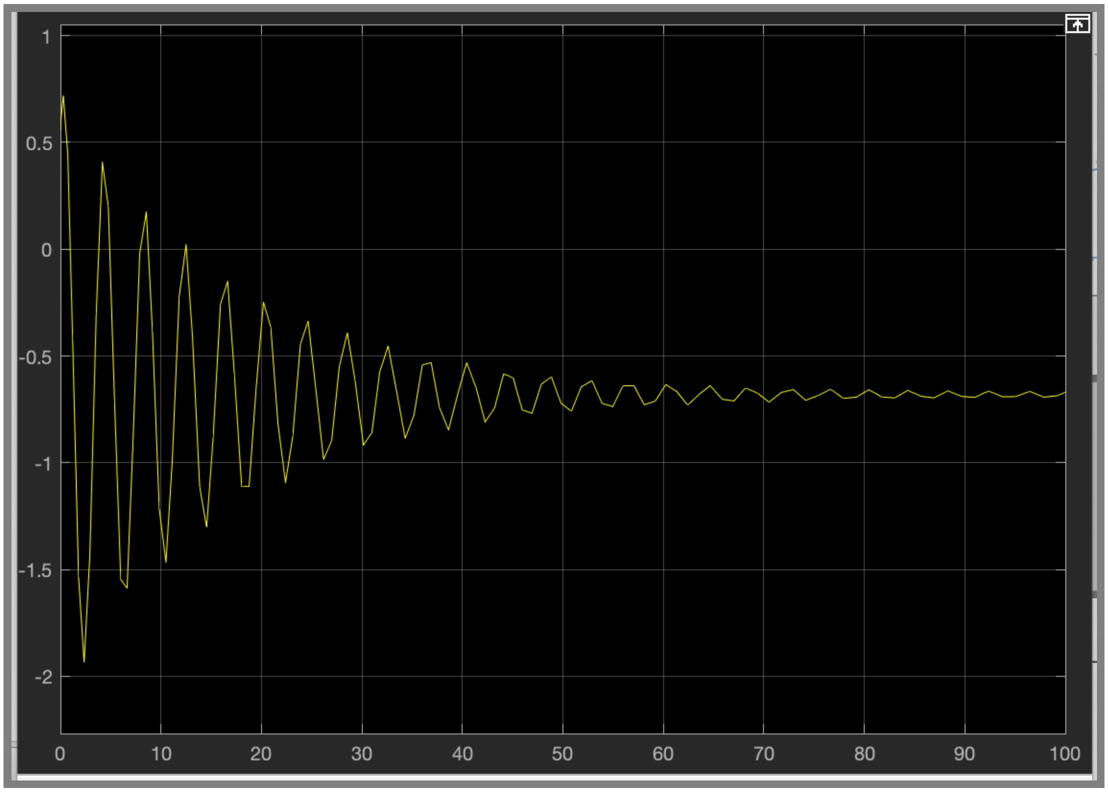


As K<1.34 for stable system so-

Simulink for K=1.25-



Plot from scope-



We can see from the above plot that for controller value of K=1.25 system is stable.

Code for Gain and Phase margins-

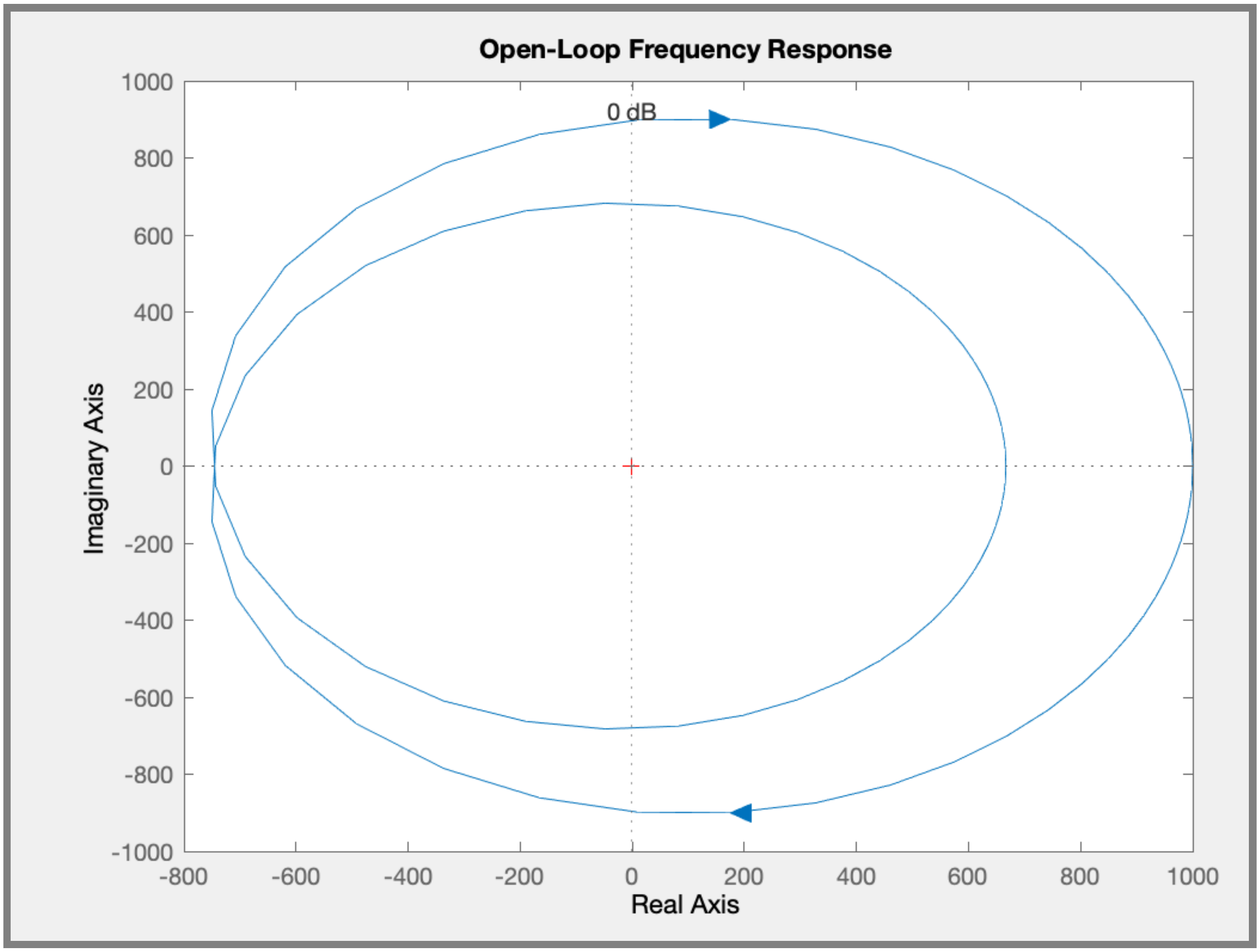
K=1000

```
clf;
clear all;
clc;
K=1000;
numg=[K -3*K 2*K];     % Define numerator of G(s).
deng=[1 4 3];          % Define denominator of G(s).
G=tf(numg, deng);      % Create and display G (s).
nyquist(G)             % Make a Nyquist diagram.
grid on;
title('Open-Loop Frequency Response');
[Gm,Pm,Wcg,Wcp]=margin(G); % Find margins and margin frequencies.

fprintf('\n gain margin = %f',20*log10(Gm));
fprintf('\n phase margin = %f \n',Pm);
```

Output-

gain margin = -57.501231
phase margin = Inf

Plot for K=1000



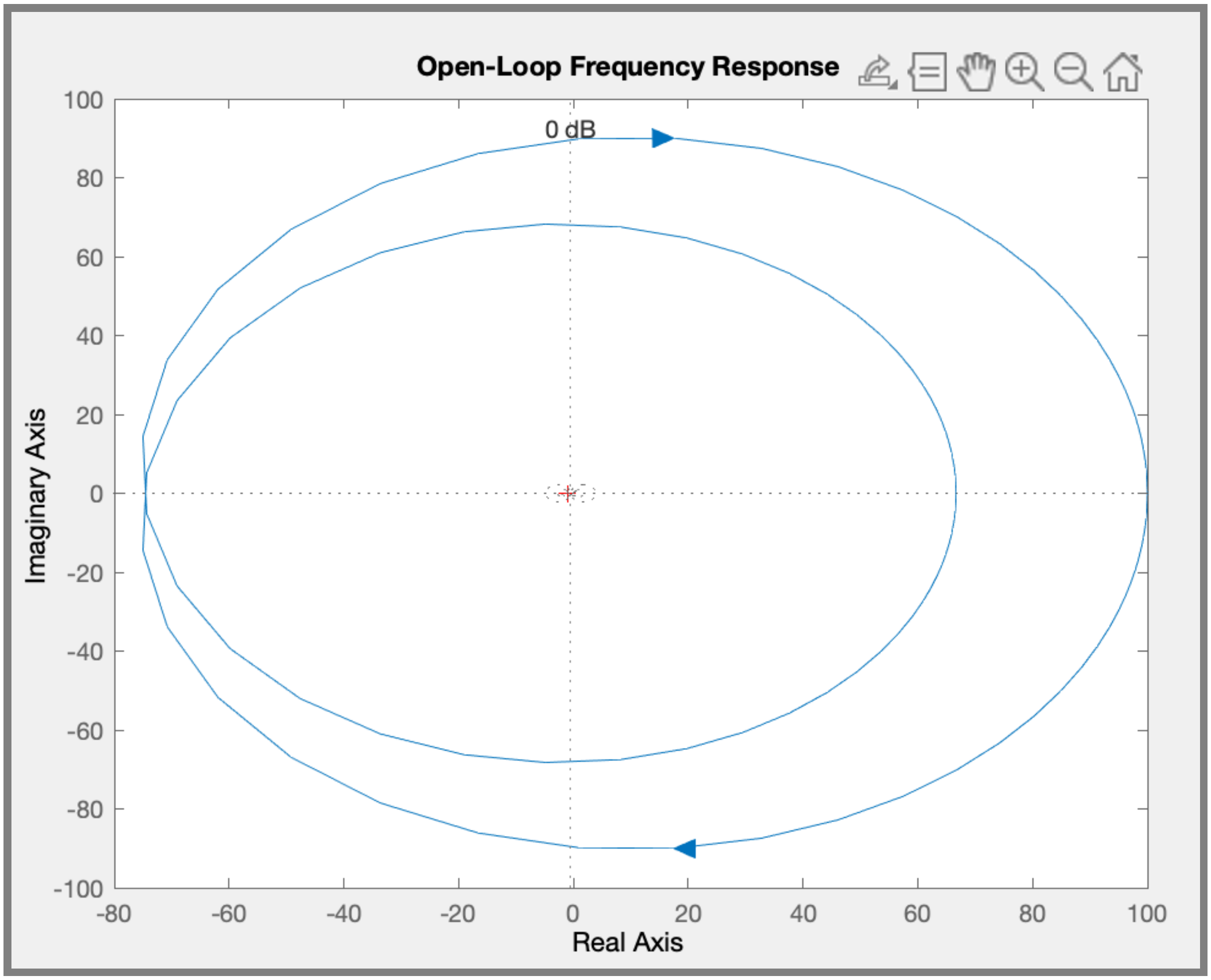
K=100

```
clf;
clear all;
clc;
K=100;
numg=[K -3*K 2*K];     % Define numerator of G(s).
deng=[1 4 3];          % Define denominator of G(s).
G=tf(numg, deng);    % Create and display G (s).
nyquist(G)           % Make a Nyquist diagram.
grid on;
title('Open-Loop Frequency Response');
[Gm,Pm,Wcg,Wcp]=margin(G); % Find margins and margin frequencies.

fprintf('\n gain margin = %f',20*log10(Gm));
fprintf('\n phase margin = %f \n',Pm);
```

Output-

gain margin = -37.501231
phase margin = Inf

Plot for K=100



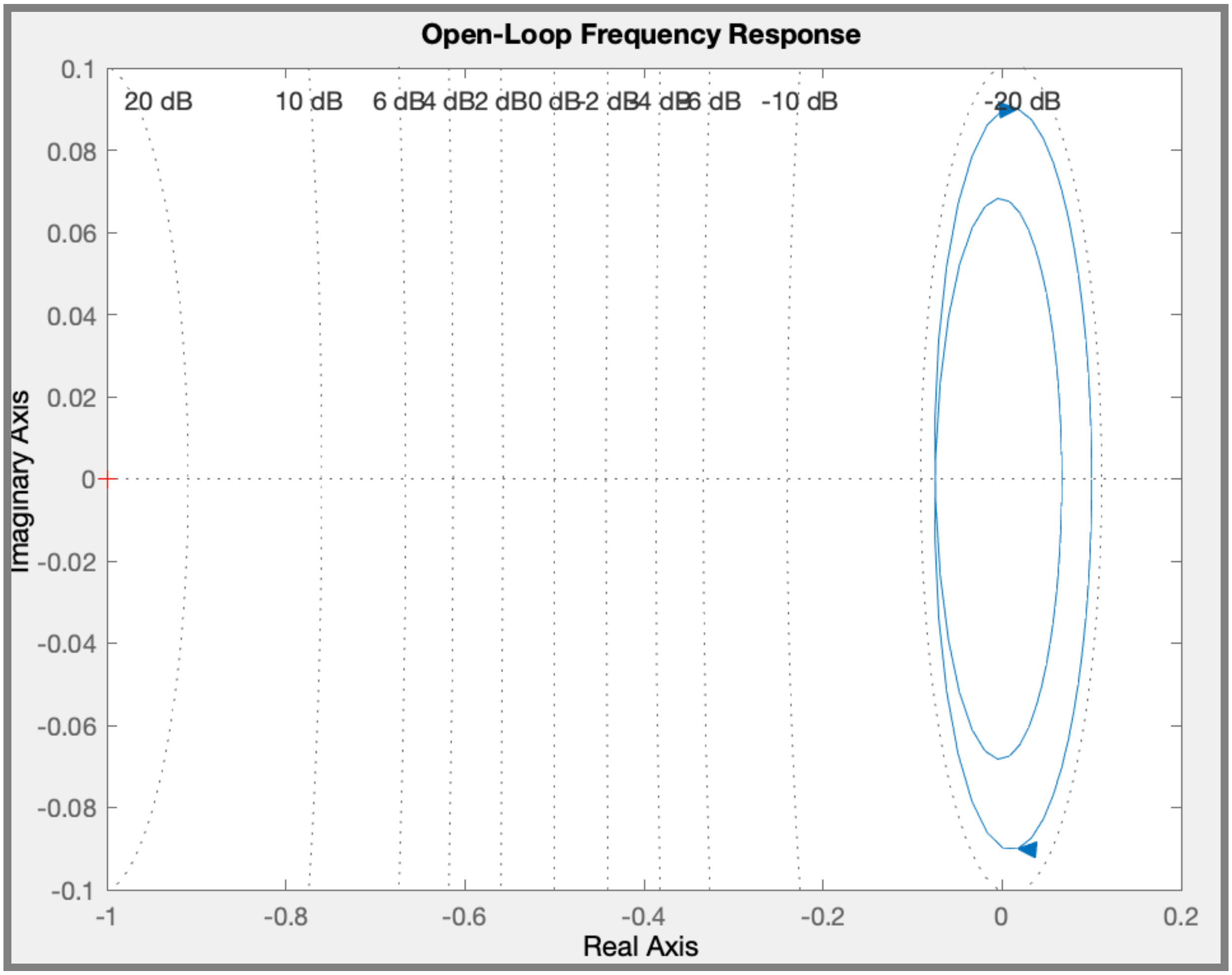
K=0.1

```
clf;
clear all;
clc;
K=0.1;
numg=[K -3*K 2*K];     % Define numerator of G(s).
deng=[1 4 3];          % Define denominator of G(s).
G=tf(numg, deng);    % Create and display G (s).
nyquist(G)           % Make a Nyquist diagram.
grid on;
title('Open-Loop Frequency Response');
[Gm,Pm,Wcg,Wcp]=margin(G); % Find margins and margin frequencies.

fprintf('\n gain margin = %f',20*log10(Gm));
fprintf('\n phase margin = %f \n',Pm);
```

Output-

gain margin = 22.498769 phase margin = Inf

Plot for K=0.1



Extra Problems on next page.

Extra Problems Answers-

Q1-

Q1. Open loop transfer function -

$$G(s) = \frac{20\,(s+2)}{(s-3)\left((s+1)^2+4\right)}$$

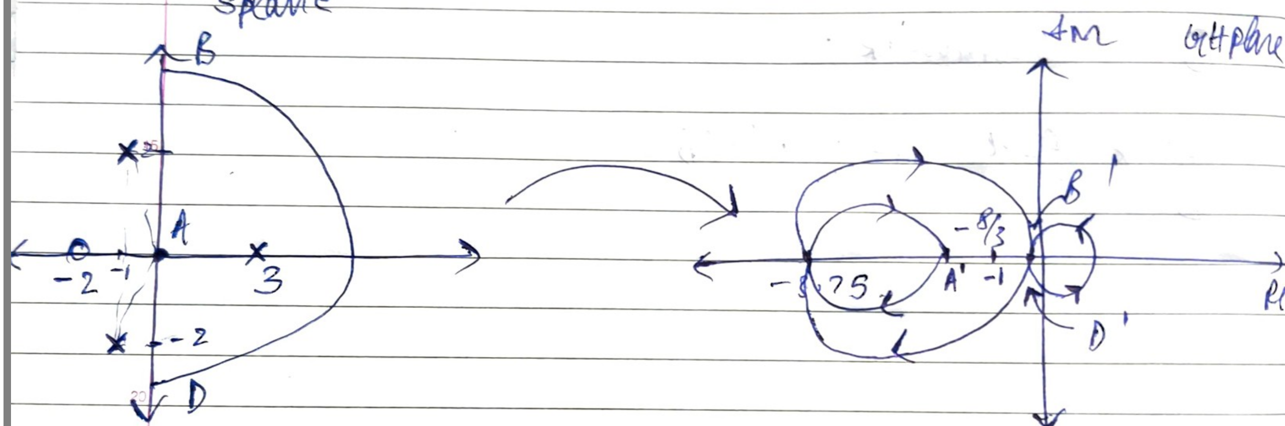
Zeroes -

$s = -2$ $\quad\left(\mathrm{Num}(G(s)) = 0\right)$

Poles -

$s = 3$, $s = -1 \pm 2i$ $\quad\left(\mathrm{Den}(G(s)) = 0\right)$

splane



Nyquist plot.

$A \rightarrow$ $\quad s = 0$

So $G(s)\big|_{s=0} = \dfrac{\cancel{20}^{\,4} \times 2}{-3 \times \cancel{5}} = -8/3$

So $A' \rightarrow -8/3$

$A \rightarrow B$ -

$$G(s)\big|_{s=j\omega} = \frac{20\,(j\omega+2)}{(j\omega-3)\left((j\omega+1)^2+4\right)}$$

Camlin Page

Date / /

$$G(s)\Big|_{s=j\omega} = \frac{20(j\omega+2)(-3-j\omega)(5-\omega^2-2j\omega)}{(9+\omega^2)\left((5-\omega^2)^2+(2\omega)^2\right)}$$

$$G(s)\Big|_{s=j\omega} = \frac{20(\omega^2-30-\omega^4)+j\omega(3\omega^2-13)}{(9+\omega^2)\left[(5-\omega^2)^2+(2\omega)^2\right]}$$

$Im(G) = 0$

at $\omega = 0$, $\omega = \pm\sqrt{\frac{13}{3}}$

At $\omega = 0$, $G = -8/3$

$\omega = \sqrt{\frac{13}{3}}$, $G = -3.75$

At $\omega < \sqrt{\frac{13}{3}}$, $Im(G) < 0$

At $\omega > \sqrt{13/3}$, $Im(G) > 0$

For all ω, $Re(G) > 0$

In $A \to B$ - angle change -

$= 90^\circ - (153.4 + 26.6) + 90^\circ$

$= 0^\circ$

In $B \to D$ - angle change -

$(-180^\circ) + (3 \times 180^\circ)$

$= 360^\circ$

$D \to A$ and $B \to A$ are symmetric

Stability -

$$Z = P - N$$

Z of $(1+GH)$ $\quad$ $P - N$ of (GH)

$P = 1$ (pole in RHP)

$N = -1$ (one clockwise encirclement around -1)

So

$Z = 2$ (No of zeroes of 1+G in RHP

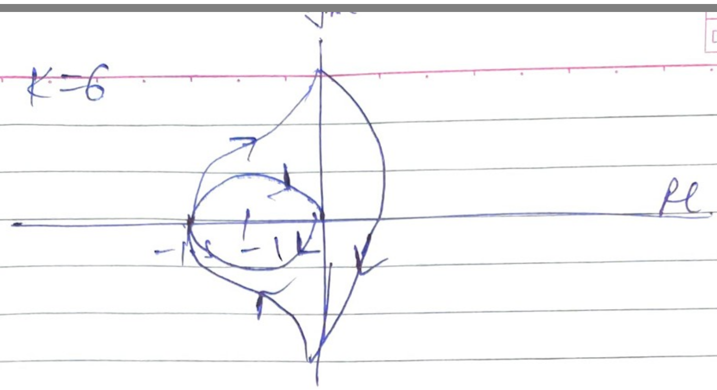
Hence system is unstable.

Q2-

K=6

Q2.

①



open loop system → stable
No of poles in RHP = 0

so
$Z = P - N$ (N = No of encirclement around −1)

$Z = 0 - (-2)$
$Z = 2$ (No of zeros of 1+GH in RHP)

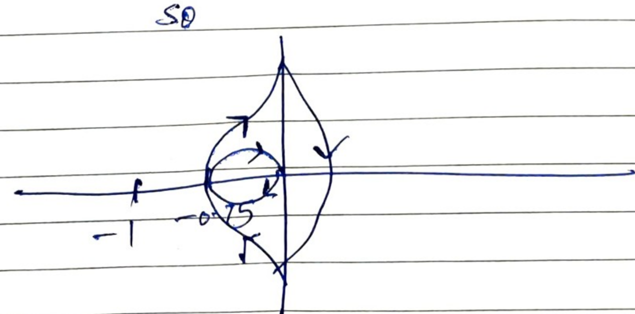
so system is unstable.

Gain margin = −1.5 (point at which plot cuts −ve real axis)

② $K \longrightarrow 3$ (changed)

GM will be scaled → −0.75

so



so
$Z = P - N = 0$

so system is stable.