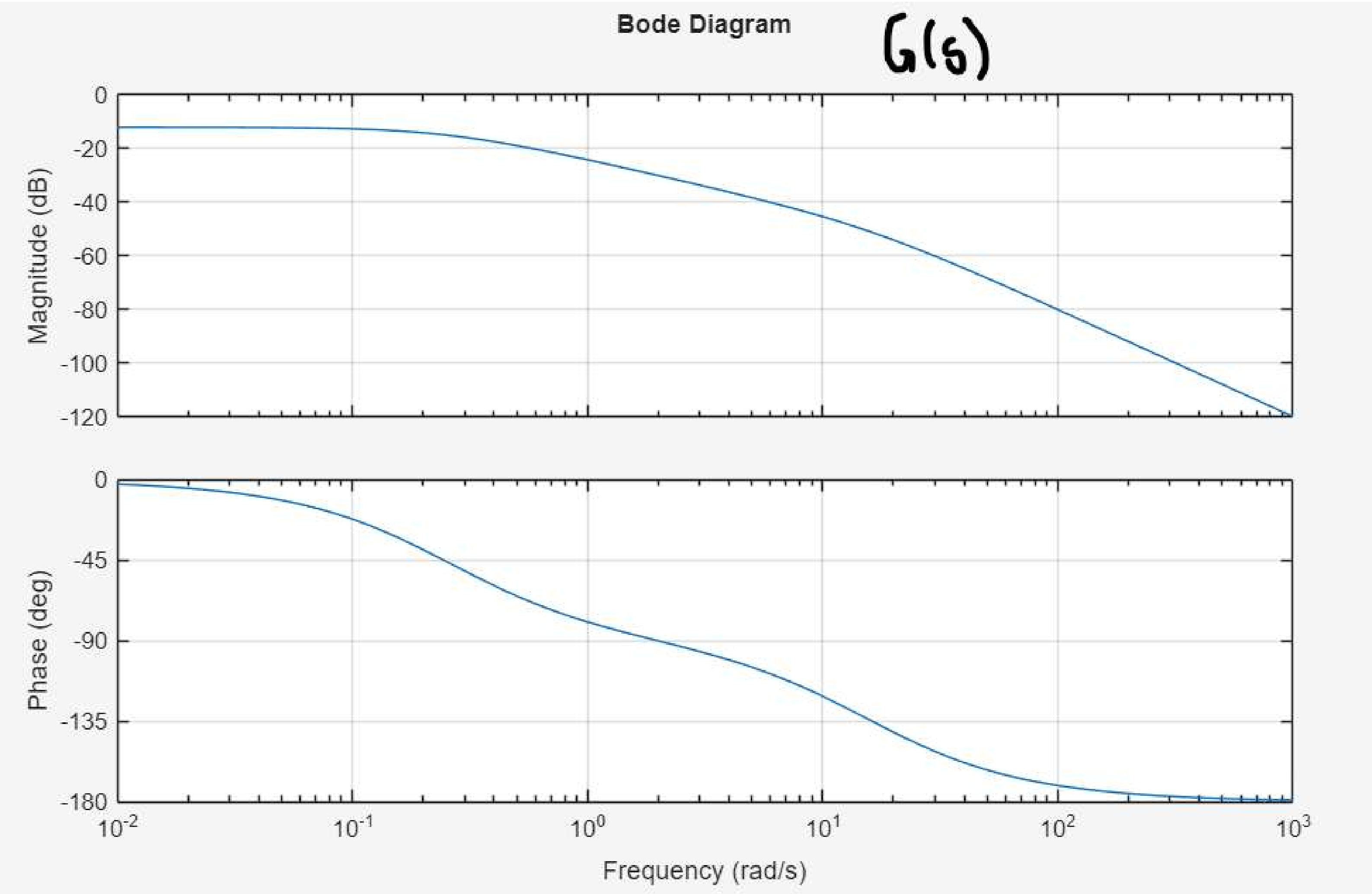
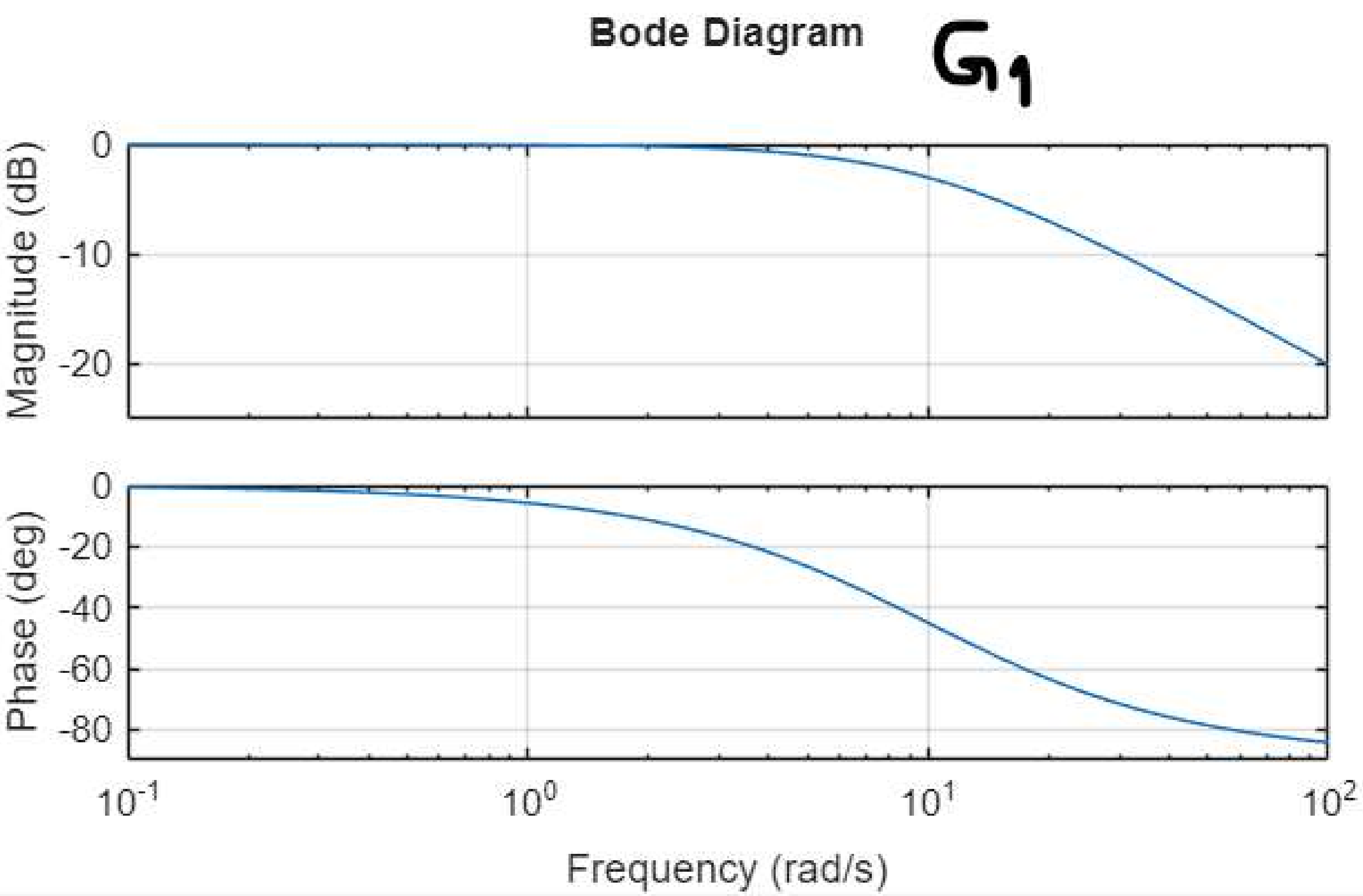
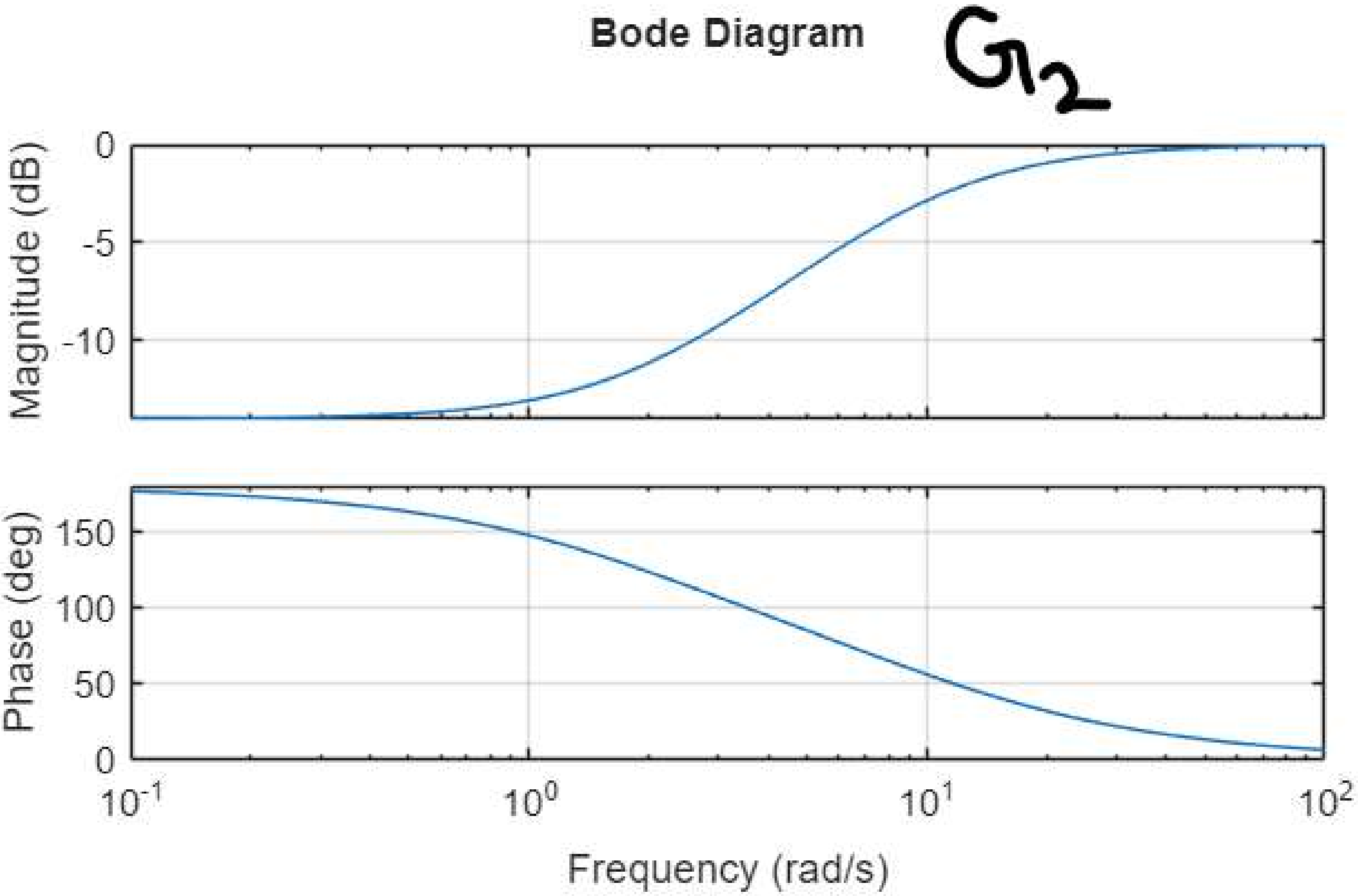
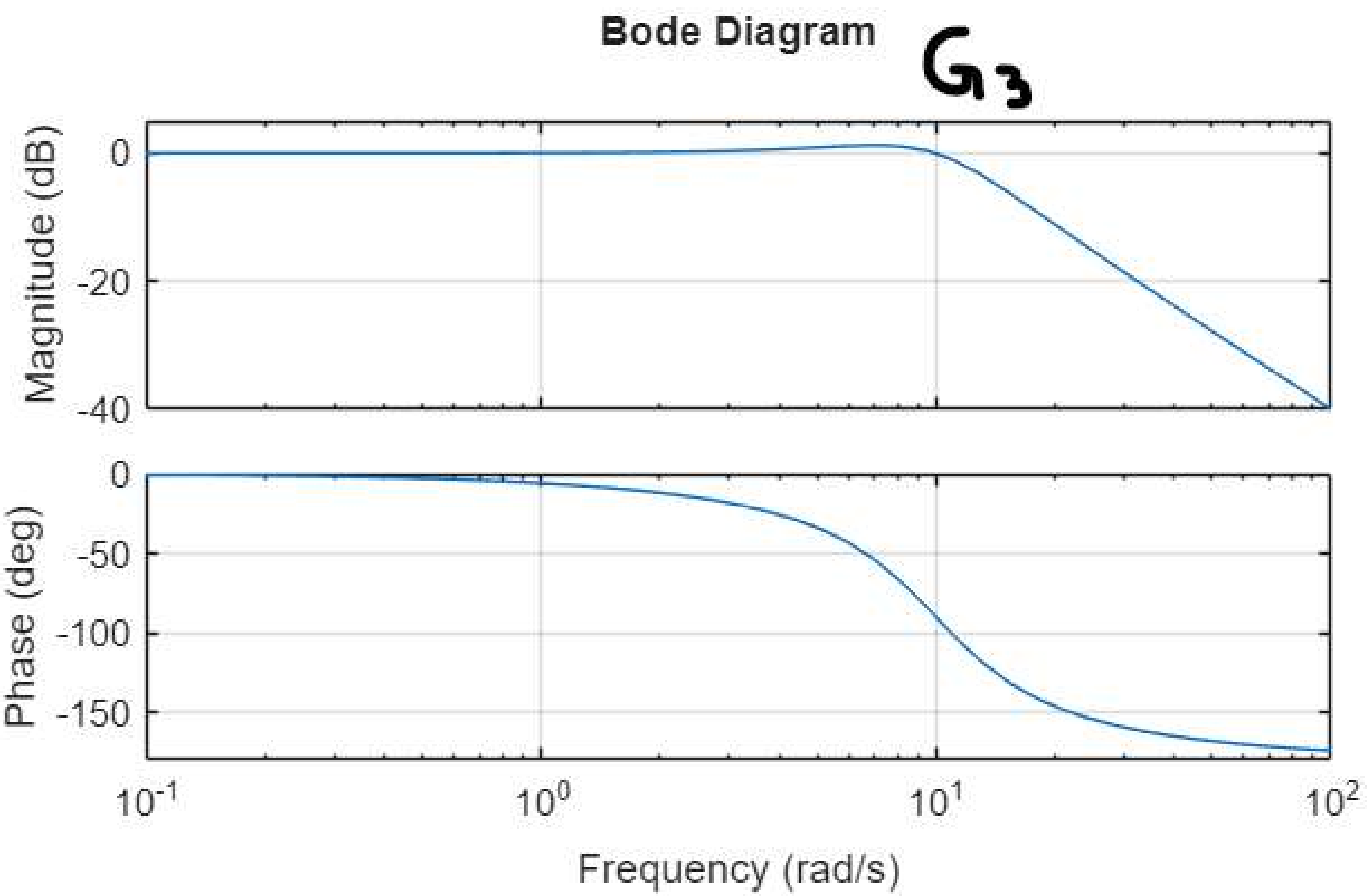


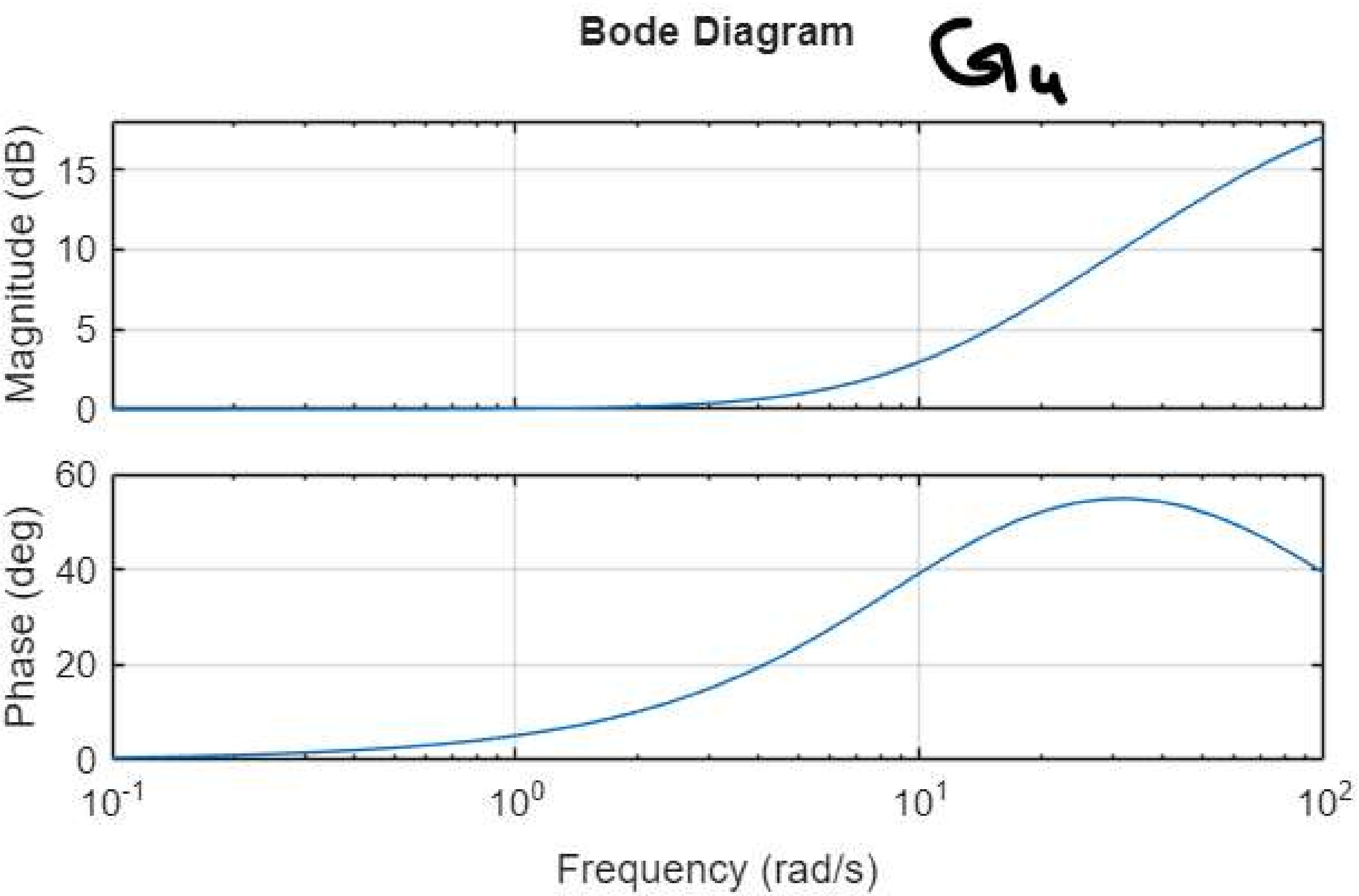
Bode Diagram
G(s)
0
-20
-40
-60
-80
-100
-120
Magnitude (dB)
0
-45
-90
-135
-180
Phase (deg)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Frequency (rad/s)



Bode Diagram
G1
Magnitude (dB)
0
-10
-20
Phase (deg)
0
-20
-40
-60
-80
10^-1
10^0
10^1
10^2
Frequency (rad/s)


Bode Diagram
G2
Magnitude (dB)
0
-5
-10
Phase (deg)
150
100
50
0
10-1
100
101
102
Frequency (rad/s)


Bode Diagram
G3
Magnitude (dB)
0
-20
-40
Phase (deg)
0
-50
-100
-150
10^-1
10^0
10^1
10^2
Frequency (rad/s)


Bode Diagram
G4
Magnitude (dB)
15
10
5
0
Phase (deg)
60
40
20
0
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)

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Assignment 0

A.1

1. Pole : $s = -10$, $G_1(0) = 1$

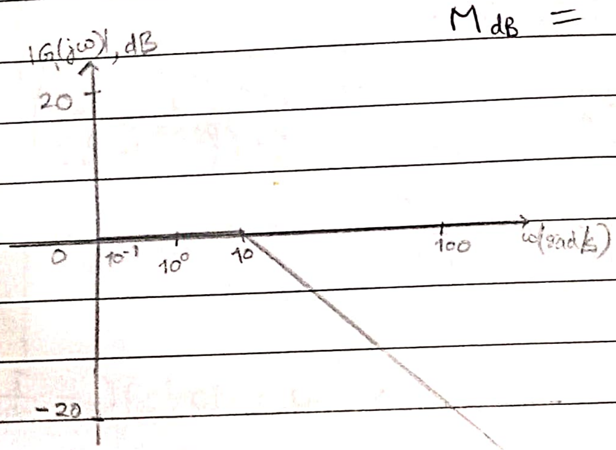
2. $G_1(s) = \dfrac{1}{1+\frac{s}{10}} \Rightarrow G_1(j\omega) = \dfrac{1}{1+\frac{j\omega}{10}}$

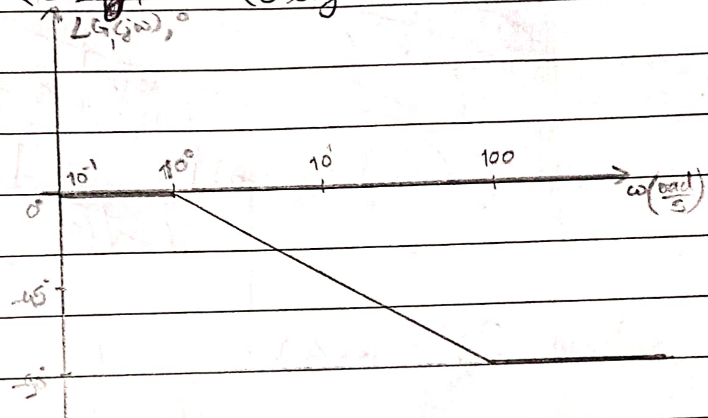
Corner freq. $\Rightarrow$ 10

$\omega < 10 \Rightarrow$ Magnitude, $M = \frac{1}{1} = 1 \rightarrow M_{dB} = 0$

$\omega > 10 \rightarrow M = \left|\dfrac{1}{j\omega/10}\right| = \left|\dfrac{10}{j\omega}\right| \Rightarrow \dfrac{10j}{\omega}$

$M_{dB} = 20 - 20\log\omega$





A.2

1. zero : $s = 2$, Pole : $s = -10$, $G_2(0) = -\frac{1}{5}$

2. $G_2(s) = \dfrac{(-2)\left(1+\frac{s}{-2}\right)}{(10)\left(1+\frac{s}{10}\right)} = \left(\dfrac{-1}{5}\right)\left(1+\dfrac{s}{-2}\right)\dfrac{1}{\left(1+\frac{s}{10}\right)}$

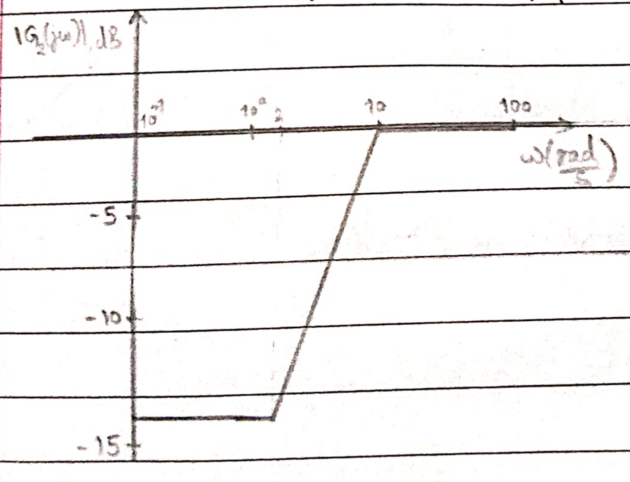
$\Rightarrow G_2(j\omega) = \left(-\dfrac{1}{5}\right)\left(1-\dfrac{j\omega}{2}\right)\dfrac{1}{\left(1+\frac{j\omega}{10}\right)}$

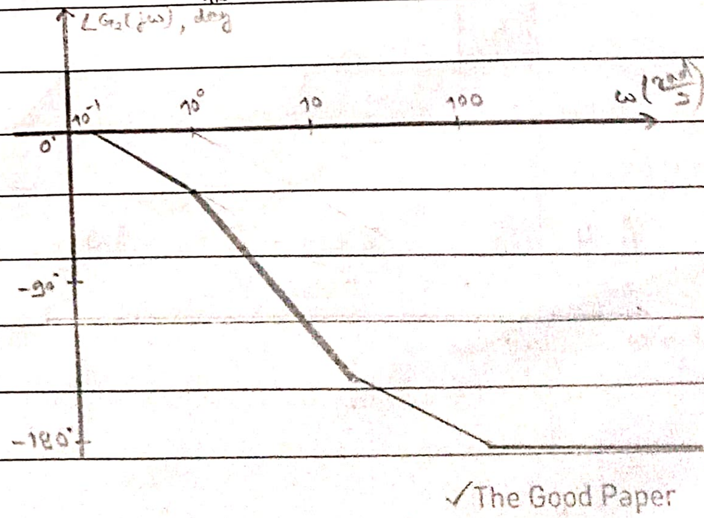
Corner frequency $\Rightarrow$ 2, 10

$\omega < 2 \rightarrow M = +\frac{1}{5} \rightarrow M_{dB} = -20\log 5$

$2 < \omega < 10 \rightarrow M = j\omega/10 \rightarrow M_{dB} = -20 + 20\log\omega$

$\omega > 10 \rightarrow M = 1 \rightarrow M_{dB} = 0$





4. Right-half plane zero causes phase decrease by 90° instead of increasing by 90°.

A.3 1. Pole: $S_{1,2} = -5 \pm j.5\sqrt{3}$

~~2.~~ $\cancel{G_3(s) = \frac{100}{\left(\frac{s}{10}\right)^2 + 2.\frac{1}{2}.\frac{s}{10} + 1} \rightarrow \omega_n = 10,\ \zeta = 0.5}$

$\cancel{M = \ldots\ 20\log\left(2\zeta\sqrt{1-\zeta^2}\right) = 20\log\left(\sqrt{3}/2\right)}$

$\cancel{20\log(100) = 40}$

~~2.~~ $\cancel{G_3(s) = \frac{1}{\left(\frac{s}{10}\right)^2 + \frac{s}{10} + 1} \rightarrow G_3(j\omega) = \frac{1}{1-\left(\frac{\omega}{10}\right)^2 + \frac{j\omega}{10}}}$

$\cancel{|G_3(j\omega)| = \frac{1}{\sqrt{\left(1-\left(\frac{\omega}{10}\right)^2\right)^2 + \left(\frac{\omega}{10}\right)^2}}}$

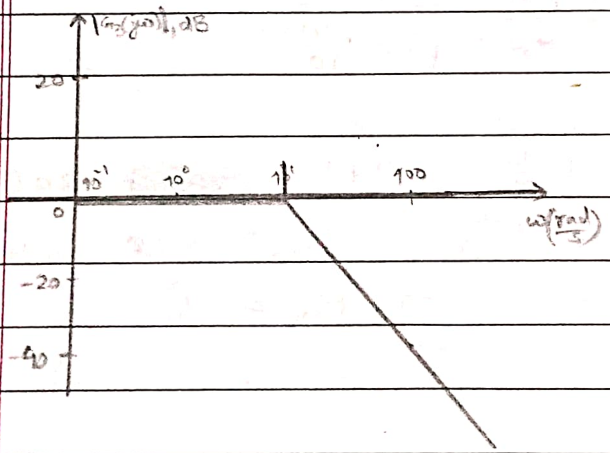
2. $G_3(s) = \dfrac{1}{\left(\frac{s}{10}\right)^2 + 2.\frac{1}{2}.\left(\frac{s}{10}\right) + 1} \Rightarrow \omega_0 = 10,\ \zeta = \frac{1}{2}$

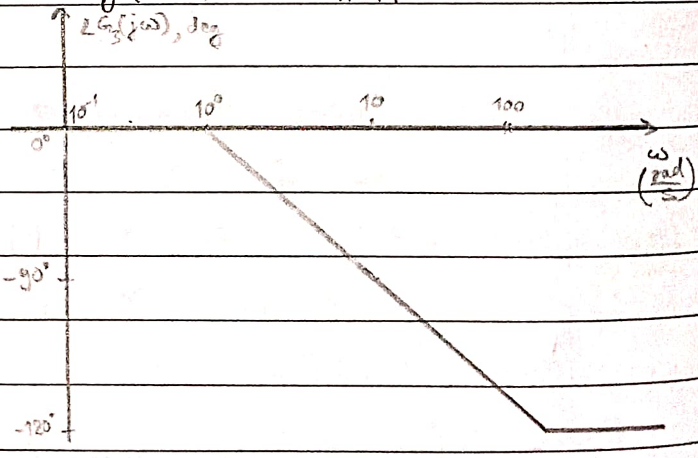
$\omega < \omega_0 \rightarrow M = 1 \rightarrow M_{dB} = 0$

$\omega > \omega_0 \rightarrow M = \dfrac{1}{\frac{\omega^2}{100}} \rightarrow M_{dB} = 40 - 40\log\omega$

$\omega = \omega_0 \rightarrow M_{dB} = -20\log\left(2\zeta\sqrt{1-\zeta^2}\right)$

$= 20\log\left(\sqrt{3}/2\right) \approx 1.249$





A.4 1. Zero: $s = -10$, Pole: $s = -100$

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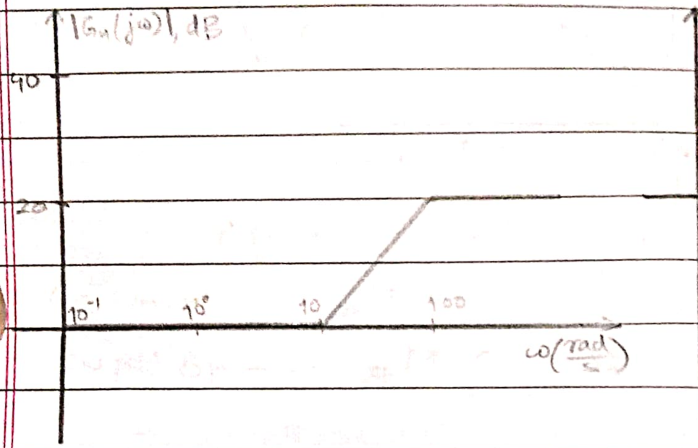
2. $G_4(s) = \dfrac{1+\frac{s}{10}}{1+\frac{s}{100}} \Rightarrow G_4(j\omega) = \dfrac{1+\frac{j\omega}{10}}{1+\frac{j\omega}{100}}$

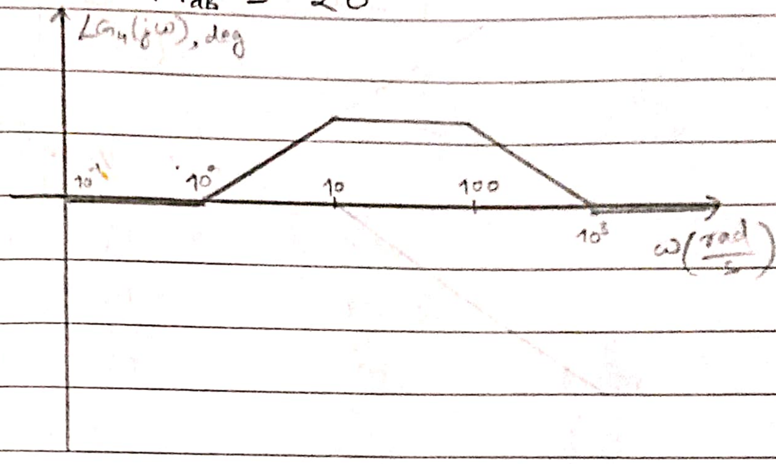
Corner freq $\rightarrow$ 10, 100

$\omega < 10 \rightarrow M = 1 \longrightarrow M_{dB} = 0$

$10 < \omega < 100 \rightarrow M = \frac{j\omega}{10} \longrightarrow M_{dB} = 20\log\omega - 20$

$\omega > 100 \rightarrow M = 10 \longrightarrow M_{dB} = 20$





4. Between zero & pole, $G_4(s)$ tend to add neither +ve nor −ve phase.

B.1 1. $\Sigma F = ma$

$\Rightarrow f(t) - kx(t) - c\dot{x}(t) = m\ddot{x}(t)$

$\therefore m\ddot{x}(t) + c\dot{x}(t) + kx(t) = f(t)$

2. Applying Laplace transform.

$\therefore m.s^2.X(s) + c.s.X(s) + k.X(s) = F(s)$

3. $G(s) = \dfrac{X(s)}{F(s)} = \dfrac{1}{ms^2 + cs + k}$

B.2 1. $G(s) = \dfrac{1}{s^2 + 16s + 4}$

2. Pole : $s_{1,2} = -8 \pm 2\sqrt{15}$

$\cancel{\omega < \omega_0 \rightarrow M = \frac{1}{4} \rightarrow M_{dB} = -20\log 4}$

$\cancel{\omega > \omega_0 \rightarrow M = \frac{1}{4} \cdot \frac{1}{\omega^2/4} \rightarrow M_{dB} = -40\log\omega}$

$\cancel{\omega = \omega_0 \rightarrow M_{dB} =}$

3. $$G(s) = \frac{1}{(s+\omega_1)(s+\omega_2)}, \quad \omega_1 = +8 + 2\sqrt{15}, \quad \omega_2 = +8 - 2\sqrt{15}$$

$$\cancel{\Rightarrow G(s) = \frac{1}{4\sqrt{15}}\left(\frac{1}{s-\omega_2} - \frac{1}{s-\omega_1}\right)}$$

$$\Rightarrow G(s) = \frac{1}{4\left(\frac{s}{\omega_1}+1\right)\left(\frac{s}{\omega_2}+1\right)}$$

$\omega < \omega_2 \rightarrow M = \frac{1}{4} \rightarrow M_{dB} = -20\log 4$

$\omega_2 < \omega < \omega_1 \rightarrow M = \frac{\omega_2}{4j\omega} \rightarrow M_{dB} = 20\log\left(\frac{\omega_2}{4}\right) - 20\log\omega$

$\omega > \omega_1 \rightarrow M = \frac{1}{\omega^2} \rightarrow M_{dB} = -40\log\omega$