Name: ______________________________ (please print)

Signature: ___________________________

ECE 3355 – Quiz #2
September 24, 2019

Keep this quiz closed and face up until you are told to begin.

1. This quiz is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution which is not given in a reasonable order will lose credit.
3. Show all units in solutions, intermediate results, and figures.
4. If the grader has difficulty following your work because it is messy or disorganized, you will lose credit.
5. Do not use red ink. Do not use red pencil.
6. You will have 35 minutes to work on this quiz.

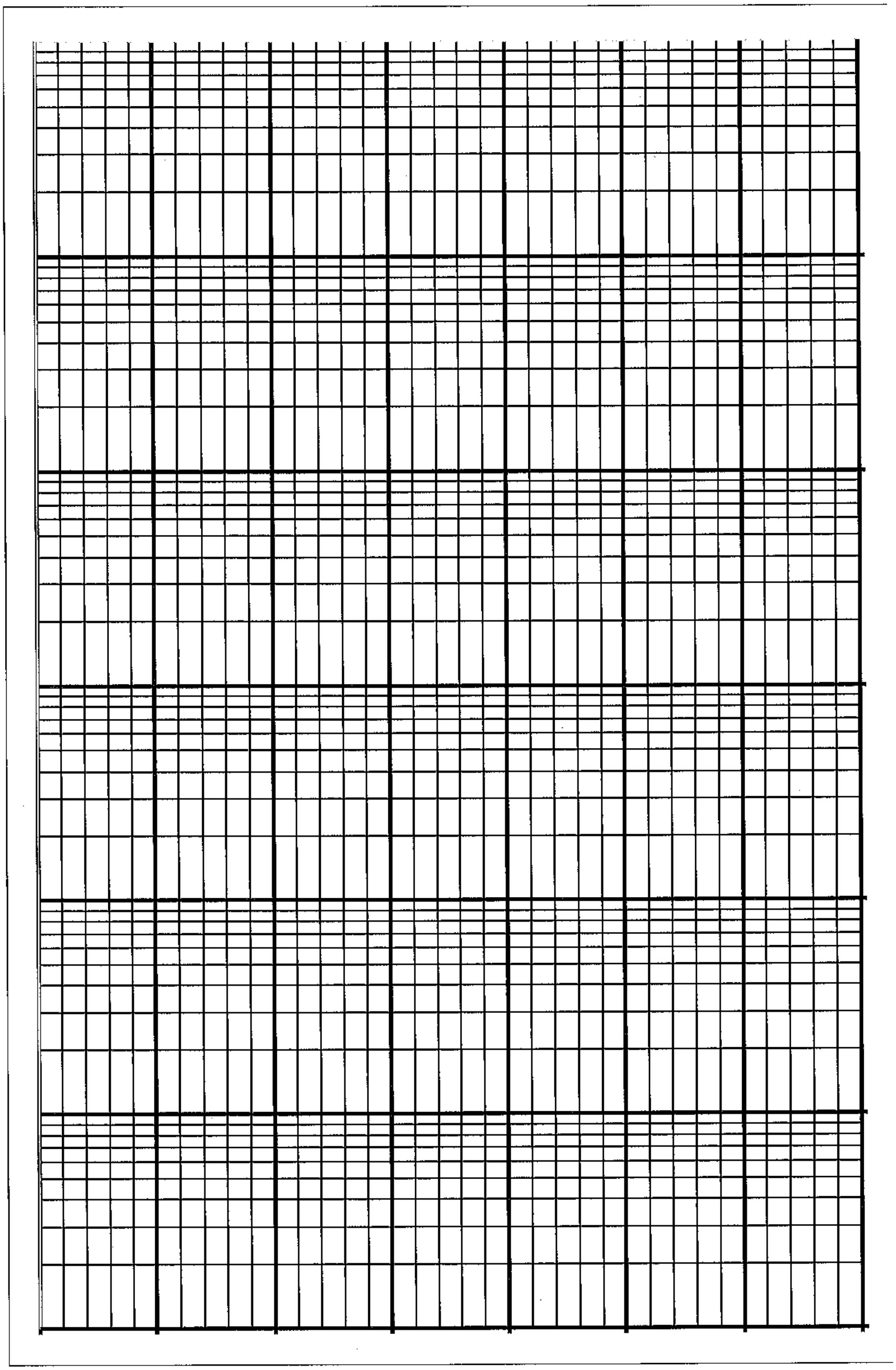
__________________/25

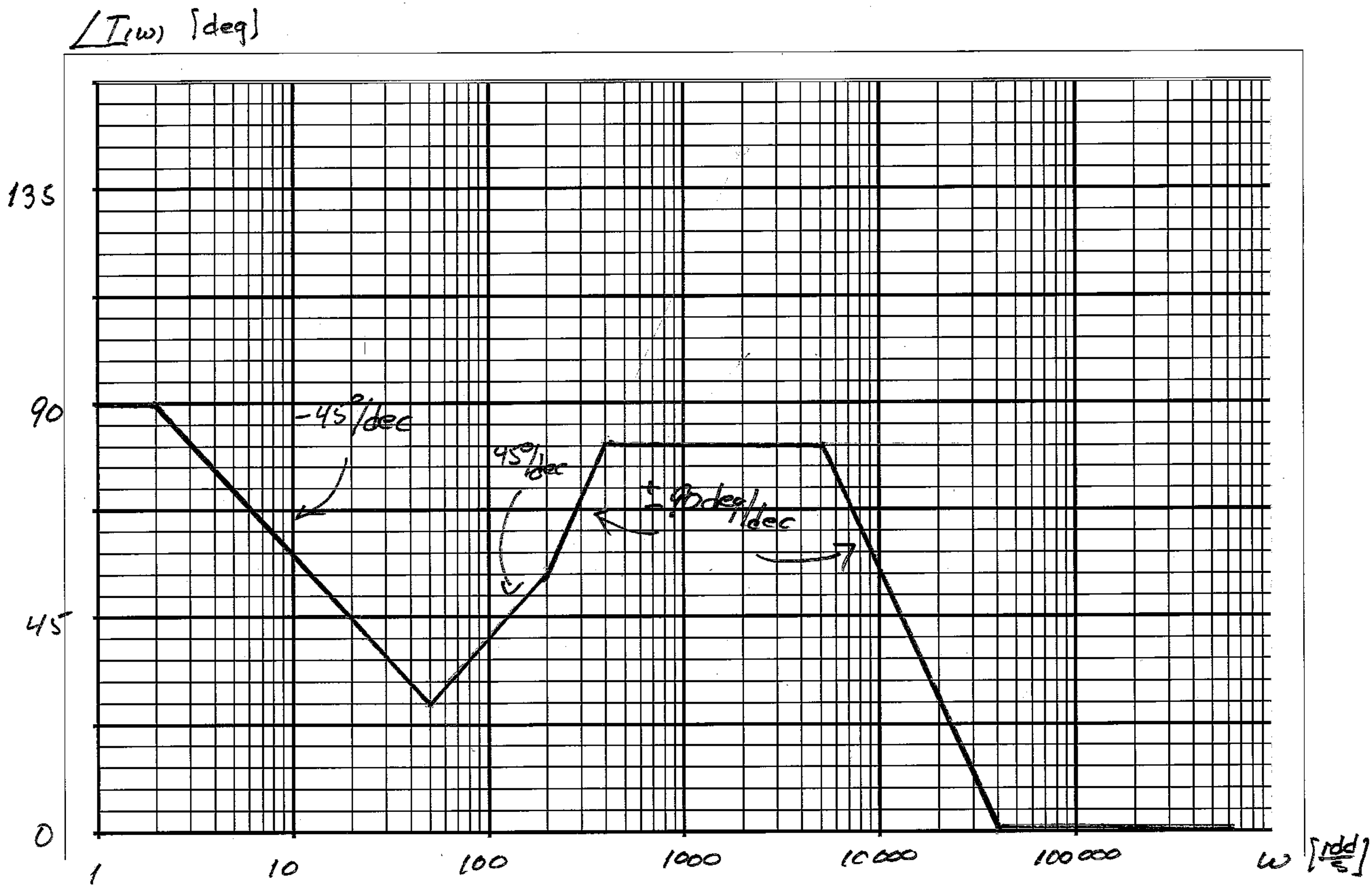
Room for Extra Work

The figure on the last page shows the straight-line approximation to the phase Bode plot of a transfer function T(ω). We are given that as ω becomes very large ($\omega \rightarrow \infty$) the magnitude of T(ω) is 20dB.

a) Find the transfer function T(ω), including any multiplication factors.

b) Draw the magnitude Bode plot on the log-lin paper given on the next page.





$\angle I(\omega)$ [deg]
135
90
45
0
1
10
100
1000
10 000
100 000
ω [rad/s]
-45°/dec
45°/dec
± 90 deg/dec

The figure on the last page shows the straight-line approximation to the phase Bode plot of a transfer function T(ω). We are given that as ω becomes very large ($\omega \rightarrow \infty$) the magnitude of T(ω) is 20dB.

a) Find the transfer function T(ω), including any multiplication factors.

b) Draw the magnitude Bode plot on the log-lin paper given on the next page.

a) $\angle T(\omega)$ begins ($\omega \to 0$) at 90° ⇒ zero at $\omega_{z_1} = 0$

- -45°/dec at $\omega = 2$ rad/s ⇒ pole at $\omega_{p_1} = 20$ [rad/s]
- $+45^\circ$/dec at $\omega = 50$ rad/s : This is happening before ω_{p_1} finishes at 200 rad/s ⇒ double zero at $\omega_{z_2} = 500$ rad/s
- $+90^\circ$ happens at 200 rad/s because ω_{p_1} has finished
- 0°/dec at $\omega = 400$ rad/s ⇒ double pole at $\omega_{p_2} = 4000$ rad/s
- -90°/dec happens at 5000 rad/s because double zero at 500 rad/s has finished.
- 0°/dec at 40000 rad/s happens because double pole is finished.

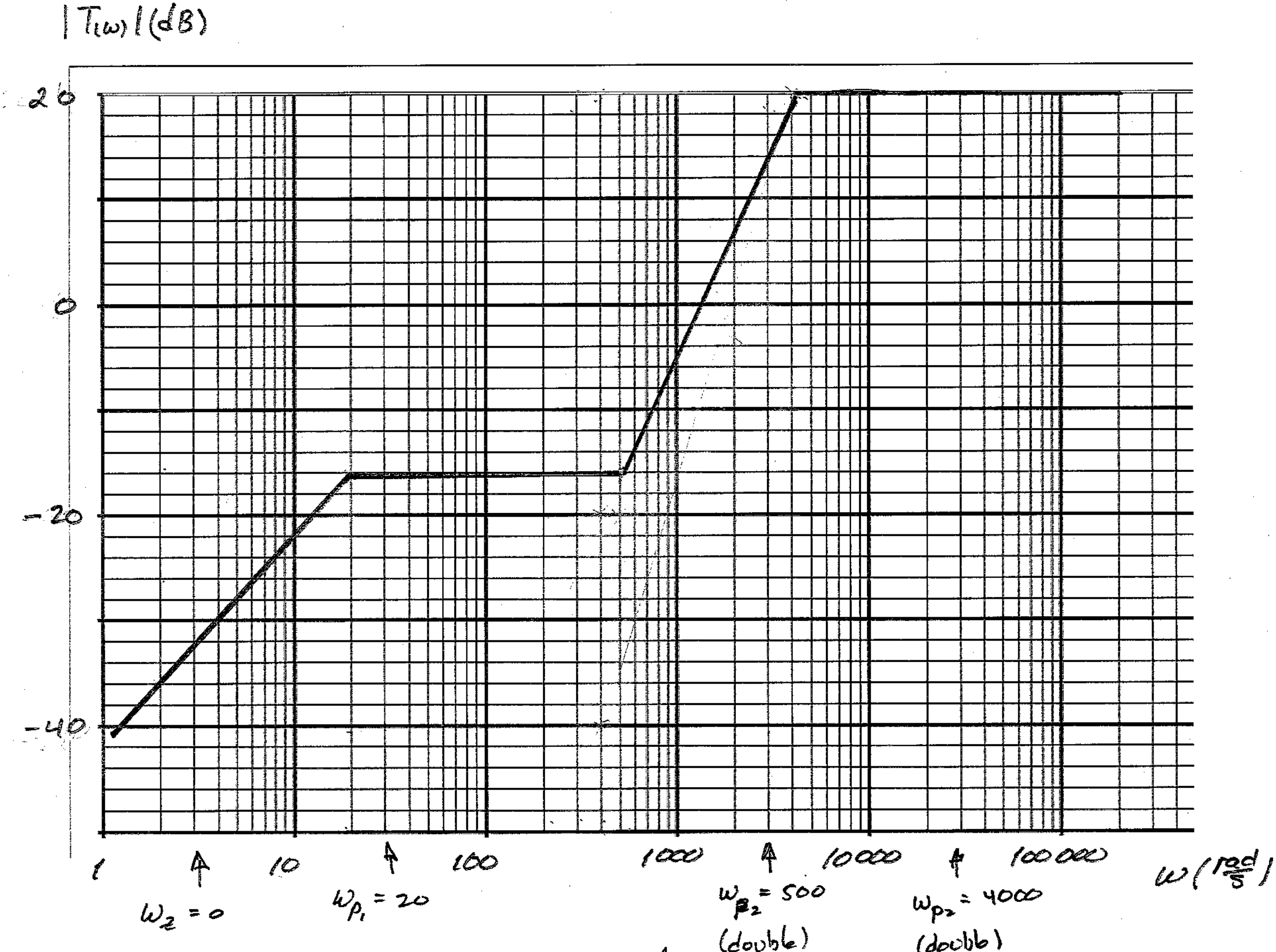
So we have ...

amplitude adjustment ↓

$$T(\omega) = K \frac{j\omega (j\omega + 500)^2}{(j\omega + 20)(j\omega + 4000)^2}$$

$$\omega \to \infty \Rightarrow T(\omega) \to K \frac{j\omega (j\omega)^2}{(j\omega)(j\omega)^2} = K$$

So $|K| = 20$ dB ⇒ $K = 10$.



|T(ω)| (dB)
20
0
-20
-40
1
10
100
1000
10000
100000
ω (rad/s)
$\omega_z = 0$
$\omega_{p_1} = 20$
$\omega_{p_2} = 500$
(double)
$\omega_{p_2} = 4000$
(double)

Here is a MATLAB generated plot of the Bode plots for this problem. This can be done by first expressing the transfer function in polynomial form, with jω = s:

$$T(s) = 10\frac{s^3 + 1000s^2 + 2.5 * 1E5\ s}{s^3 + 8.002 * 1E3\ s^2 + 1.616 * 1E7\ s + 3.2 * 1E8}$$

Converting the transfer function from what we usually work with into polynomial form is tedious, but it can be done by MATLAB through a symbolic script function.

Then the MATLAB commands are

T = tr([10, 10000,2.5*1E5,0],[1,1.6002*1E5,1.616*1E7,3.2*1E8]);

Bode(T)

I have also (roughly) sketched the straight-line approximation on top of the plot.