S.1.1

1) $1.0 \cdot 10^5 \Rightarrow 100dB$

2) $0.001 \Rightarrow -60dB$

3) $\sqrt{10^4} \Rightarrow 40dB$

4) $1000 \cdot 40dB \Rightarrow 60+40dB = 100dB$

5)

S.1.2

1) $26dB \Rightarrow 19.953$

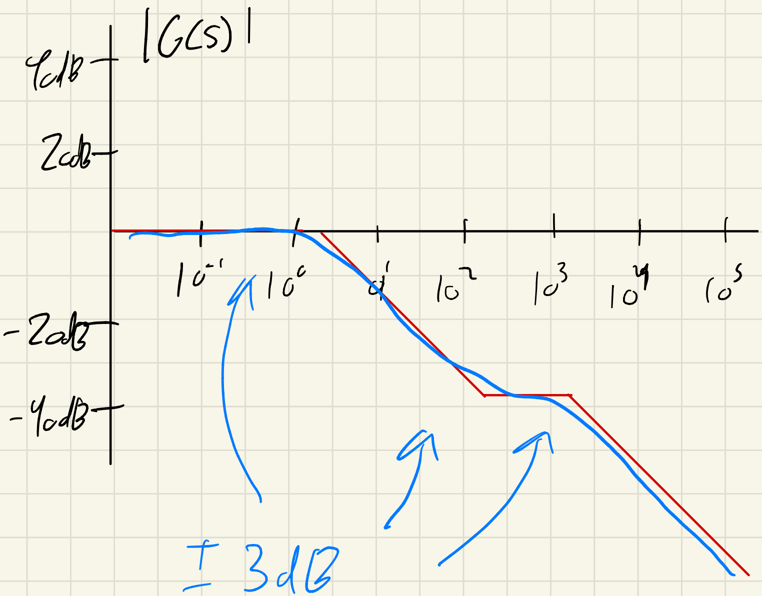
2) $-50dB \Rightarrow 0.00316$

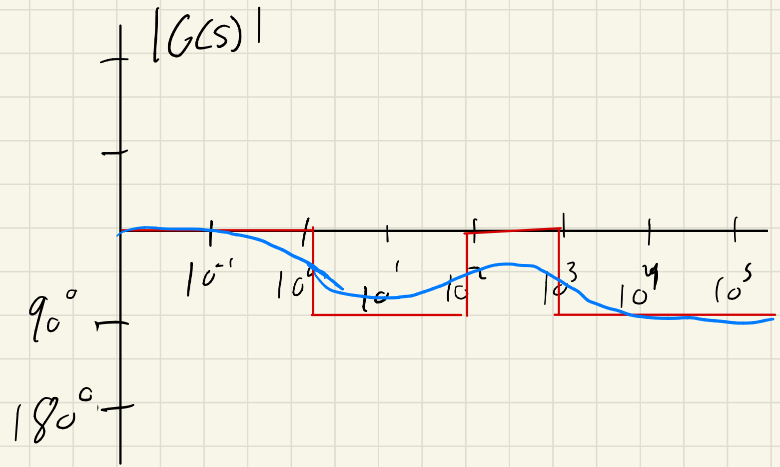
3) $3dB \Rightarrow 1.413$

4) $\frac{20\log_{10}(64)}{2} dB \Rightarrow 8$

9.3

$$G(s) = \frac{31.6\,(s+100)}{3160\,\left(\frac{s}{3.16}+1\right)\left(\frac{s}{100}+1\right)} = \frac{3160\,\left(\frac{s}{100}+1\right)}{3160\,\left(\frac{s}{3.16}+1\right)\left(\frac{s}{100}+1\right)} = \frac{\left(\frac{s}{100}+1\right)}{\left(\frac{s}{3.16}+1\right)\left(\frac{s}{100}+1\right)}$$





• Cartaa • real

5-4

5.4 Bode Plot: complex conjugate poles

Plot the Bode magnitude and phase plots by hand for

$$H(s) = \frac{10^3(s+1)}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

for

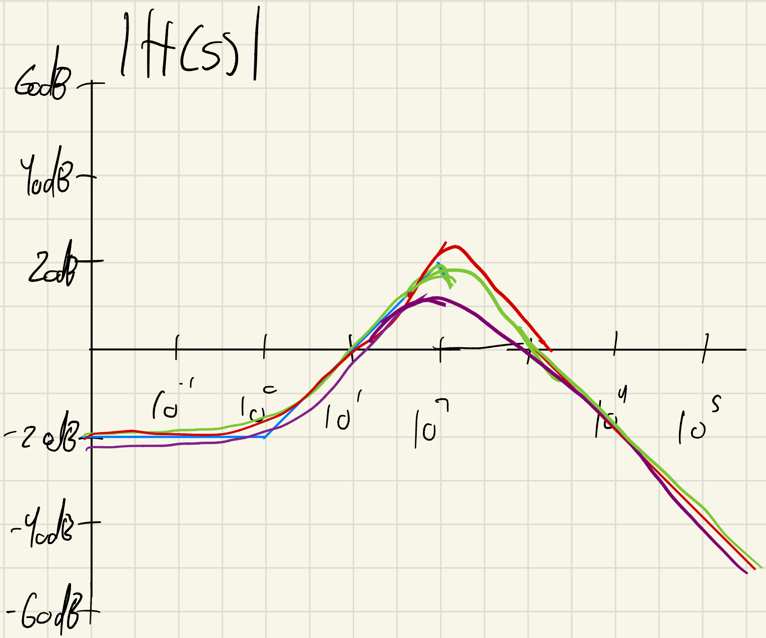
$$\omega_n = 100,\ \zeta = [0.1, 0.5, 1.0]$$

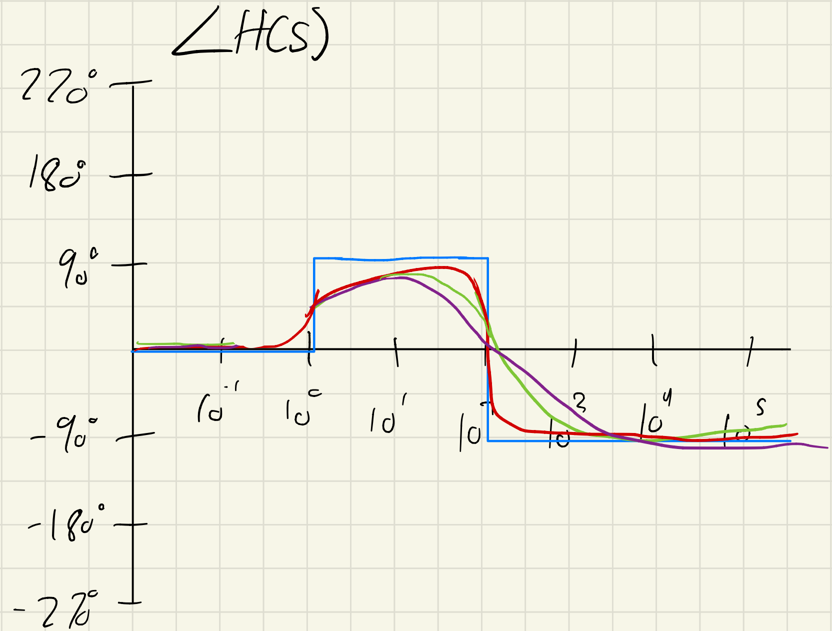
Overplot all ζ-version plots on a single set of mag and phase axes.

$$H(s) = \frac{10^3(s+1)}{10^4\left(\frac{s^2}{\omega_n^2} + \frac{2\zeta}{\omega_n}s + 1\right)} = \frac{(s+1)}{\underbrace{10}_{-20\,\mathrm{dB\ offset}}\left(\frac{s^2}{\omega_n^2} + \frac{2\zeta}{\omega_n}s + 1\right)}$$

-20dB offset

Cartoon $\zeta = 0.1$ $\zeta = 0.5$ $\zeta = 1$





- Remember:
  - Slopes sum
  - exp(1) poles aren't effected by damping

5.3 Bode Plot 1

NOTE: If the problem asks for a hand drawn plot, you may use the computer to check your work, but you must turn in a hand-drawn plot. Do not turn in computer output unless the problem asks for that. Remember, you will not have the computer in exam situations.

Plot the Bode magnitude and phase plots by hand for

$$H(s) = \frac{31.6(s+100)}{(s+3.16)(s+1000)}$$

Draw straight line asymptotes as well as a smoothed version using $\pm 3dB$ corrections on Mag. plot and similar smooth corrections on phase plot. **Hint:** Use the plotting range

$$0.1 < \omega < 10^5$$

5.4 Bode Plot: complex conjugate poles

Plot the Bode magnitude and phase plots by hand for

$$H(s) = \frac{10^3(s+1)}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

for

$$\omega_n = 100, \ \zeta = [0.1, 0.5, 1.0]$$

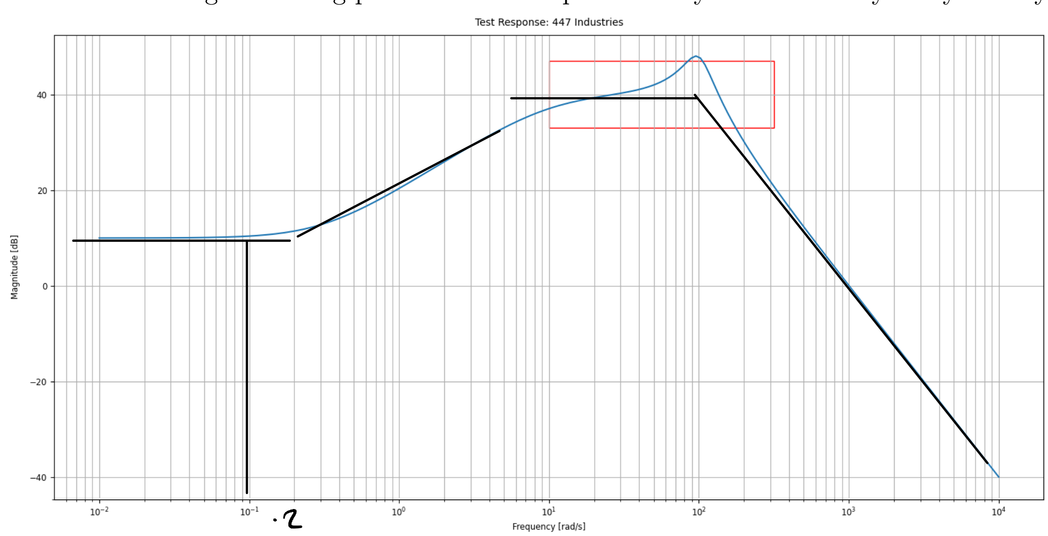
Overplot all ζ-version plots on a single set of mag and phase axes.

5.5 Python Bode plots

Write a python script to repeat the same plots as the two previous problems. Give your script the ability to switch between 5.3 and 5.4 above (not overplot the two probs.)

5.6 TF from Bode Plot and Modifications

Consider the following Bode Mag plot which was experimentally measured on your system by a testing lab.



Zero - 10^{-1}

5.6.1

Derive a transfer function that fits this data well.

5.6

$+10\,dB$

zero: 10^{-1}

pole: 10^{1}

: 10^{2} + 5dB offset   0.25 damping

$$H(s) = \frac{(s+.2)}{(s+10)(s^2+2\cdot 0.25\cdot 100s+10000)}$$

$$\frac{a \cdot .2\left(\frac{s}{.2}+1\right)}{10 \cdot 10000\left(\frac{s^2}{10{,}000}+\frac{0.5}{100}s+1\right)\left(\frac{s}{10}+1\right)}$$

$$\frac{a}{.3^{-1} \cdot 10\,0000} = \sqrt{10}$$

$$a = 10^6$$

$$H(s) = \frac{10^6 \quad (s+.3)}{(s+10)(s^2+2 \cdot 0.25 \cdot 100s+10000)}$$

5.6.2

- Need to delay pole, just change pole freq for minimal
- If I change ω of pole, must change coefficient

$$\omega_n = 300 \frac{rad}{s} \qquad \frac{a}{10 \cdot 90000 \cdot .3^{-1}} = \sqrt{10}$$

$$a = 9486833$$

$$H_m(s) = \frac{as + a \cdot .3}{(s+10)(s^2 + .5 \cdot 300s + 300^2)}$$

$$(s+10)(s^2+150s+9000)$$

$$(s^3+150s^2+9000s+10s^2+1500s+90000)$$

$$H_m(s) = \frac{as+a.}{(s^3+160s^2+91500s+900000}$$