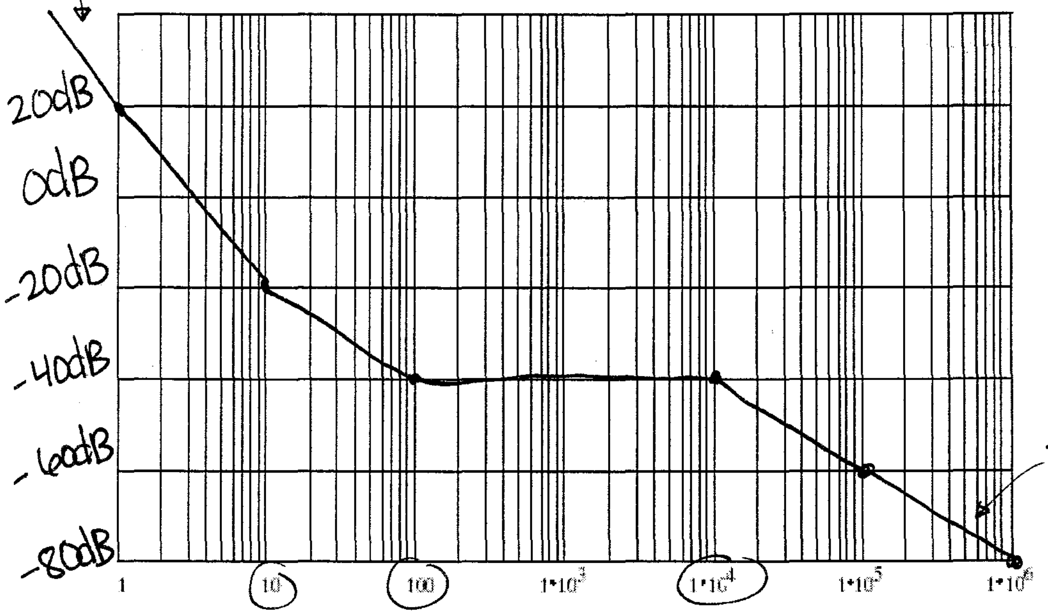
Examples #2:

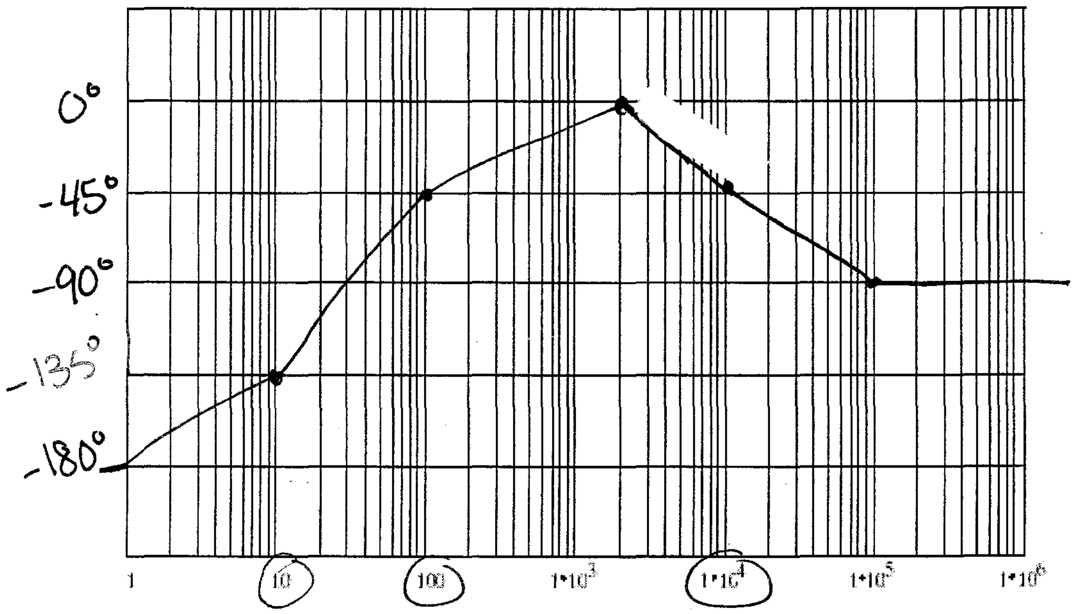
$$\text{Transfer Function} = \frac{(100)(s+100)(s+10)}{(s^2)(s+10{,}000)} = \frac{\cancel{100}(\cancel{100})\left(\frac{s}{100}+1\right)(10)\left(\frac{s}{10}+1\right)}{s^2(\cancel{10k})\left(\frac{s}{10k}+1\right)}$$

· 20log(10) = 20dB
phase → -180°
start slope → +2(-20dB/dec) = -40dB/dec at w=1

-40dB/dec.



-20dB/dec.



w=10 : -zero : +20dB/dec : +45° (w 1→10, 10→100)
w=100 : -zero : +20dB/dec : " (w=10→100, 100→1k)
w=10k : -pole : -20dB/dec : -45° (w=1k→10k, 10k→100k)

$ax^2+bx+c=0$

$x=\dfrac{-b\pm\sqrt{b^2-4ac}}{2a}$

ECE2280 FUNDAMENTALS OF ELECTRICAL ENGINEERING

Example #3:

$$\text{Transfer Function} = \frac{5x10^4\, s}{s^2+505s+2500}$$

$s=\dfrac{-505\pm\sqrt{505^2-4(2500)}}{2}$

$= -5, -500$

$(s+5)(s+500)$

$$\frac{5\times10^4 s}{5\left(\frac{s}{5}+1\right)(500)\left(\frac{s}{500}+1\right)}=\frac{20s}{\left(\frac{s}{5}+1\right)\left(\frac{s}{500}+1\right)}$$

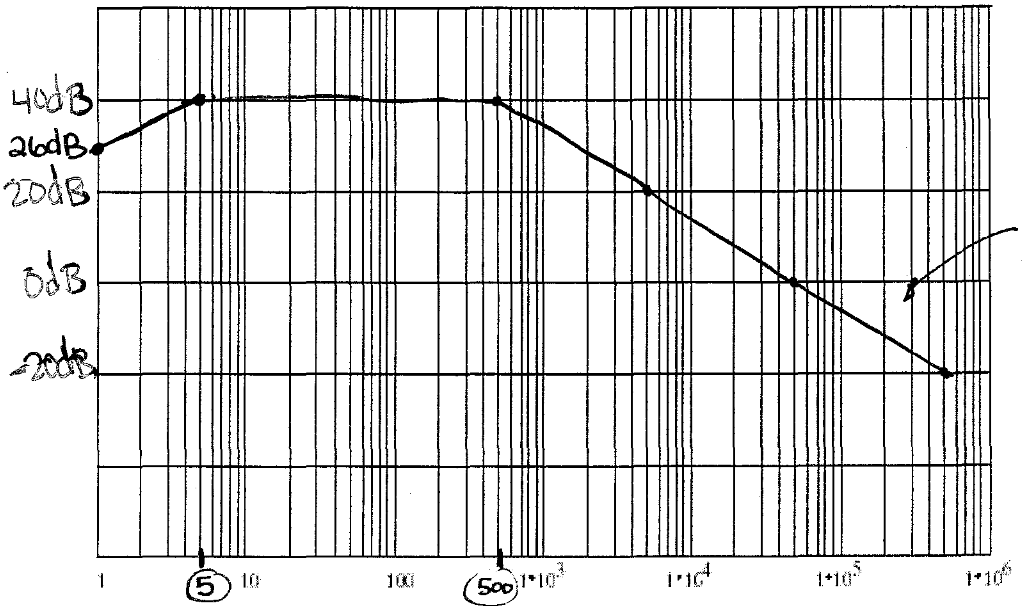
$20\log(20) = 26\text{dB} @ \omega=1$

phase start $\Rightarrow 90°$

Slope start $\Rightarrow$ +20dB/dec

$\omega=5$: -pole : -20dB/dec : -45°
(ω=0.5→5, 5→50)

$\omega=500$: -pole : -20dB/dec : -45°
(ω=50→500, 500→5k)



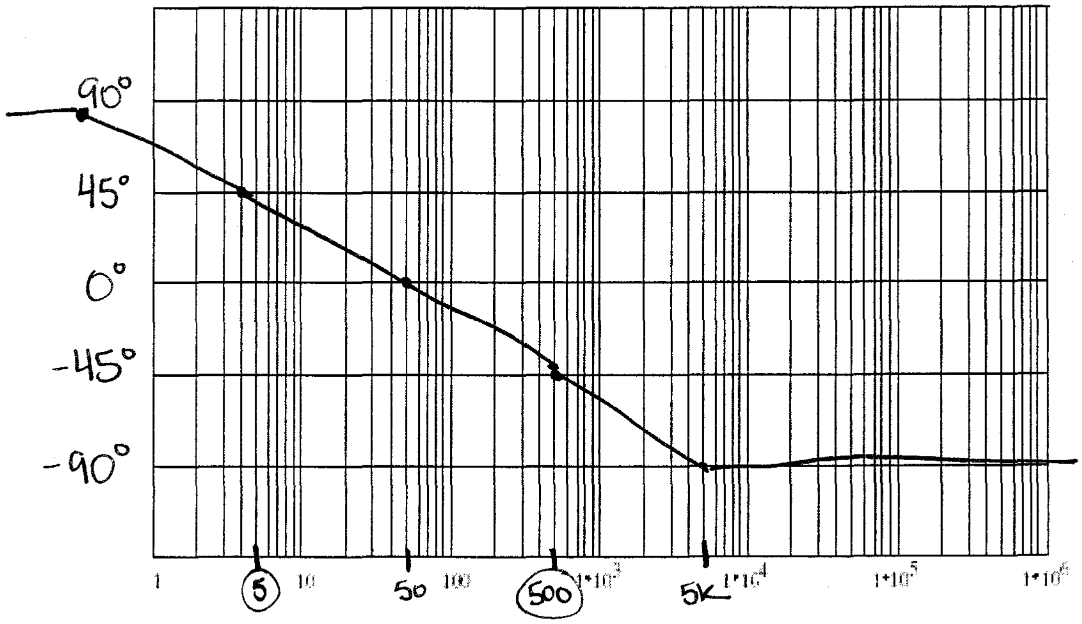
-20dB/dec

$\omega=10$:

$$\frac{20(10)}{\sqrt{\left(\frac{10}{5}\right)^2+1^2}\sqrt{\left(\frac{10}{500}\right)^2+1^2}} \cong 39\text{dB}$$

$\omega=5$:

$$\frac{20(5)}{\sqrt{\left(\frac{5}{5}\right)^2+1}\sqrt{\left(\frac{5}{500}\right)^2+1^2}} \cong 37\text{dB}$$

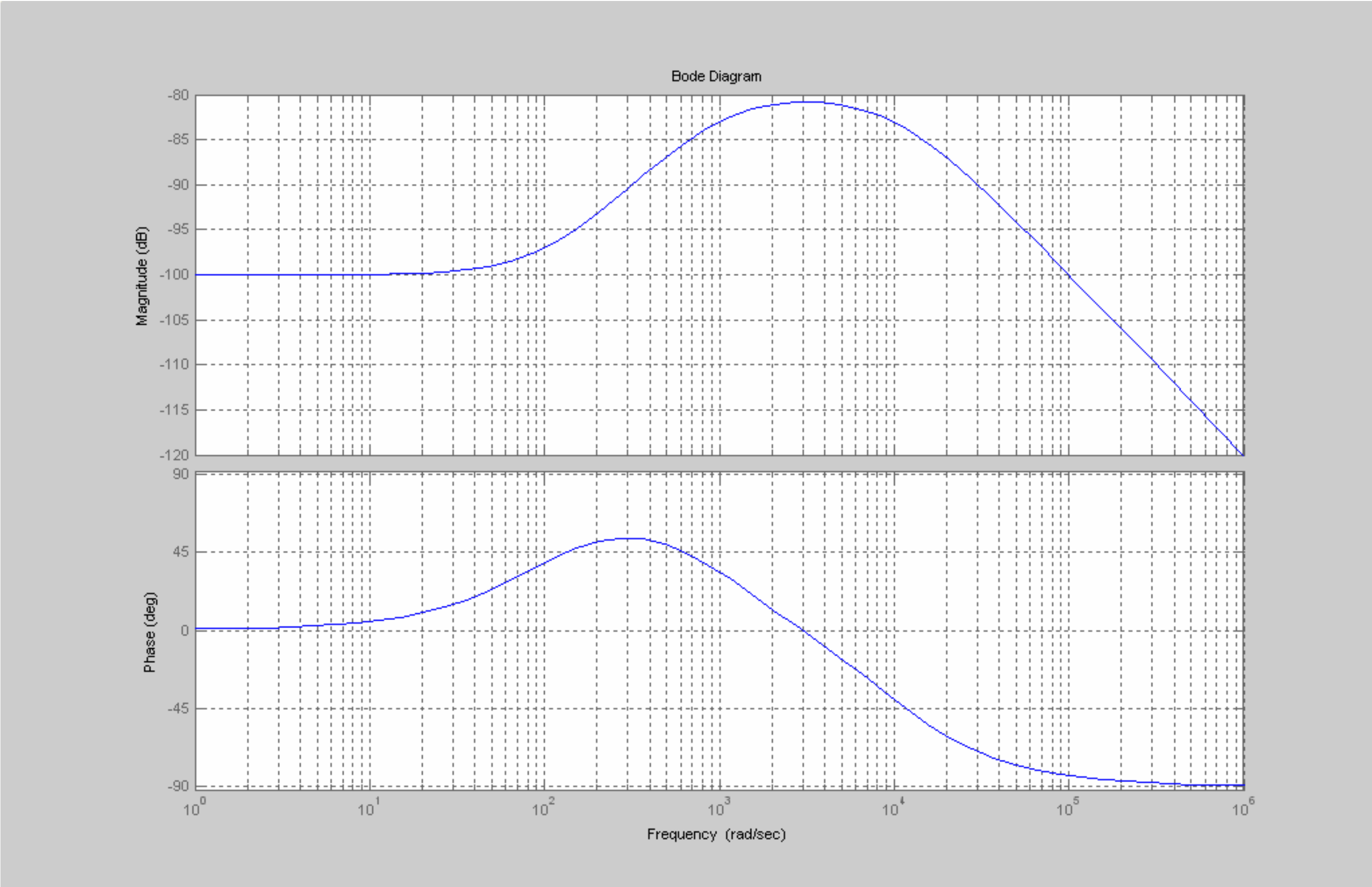


PROBLEM SESSION #1 PROBLEMS

1. Calculate Bode Plots of the following:

(a) $H(s) = \dfrac{(s+100)}{(s+10\text{^}3)(s+10\text{^}4)}$

- Start value: H(0)= 100/(10^3*10^4) = 10^-5 => $20\log_{10}$(10^-5) = -100dB
- Critical frequencies:
  - ω=100 – (negative zero) => +20dB/dec/ +45^o slope/dec (over 2 decades 10<ω<1,000)
  - ω=1,000 – (negative pole) => -20dB/dec/ -45^o slope/dec (over 2 decades 100<ω<10,000)
  - ω=10,000 – (negative pole) => -20dB/dec/ -45^o slope/dec (over 2 decades 1,000<ω<100,000)



2. Calculate the Bode plot for the following:

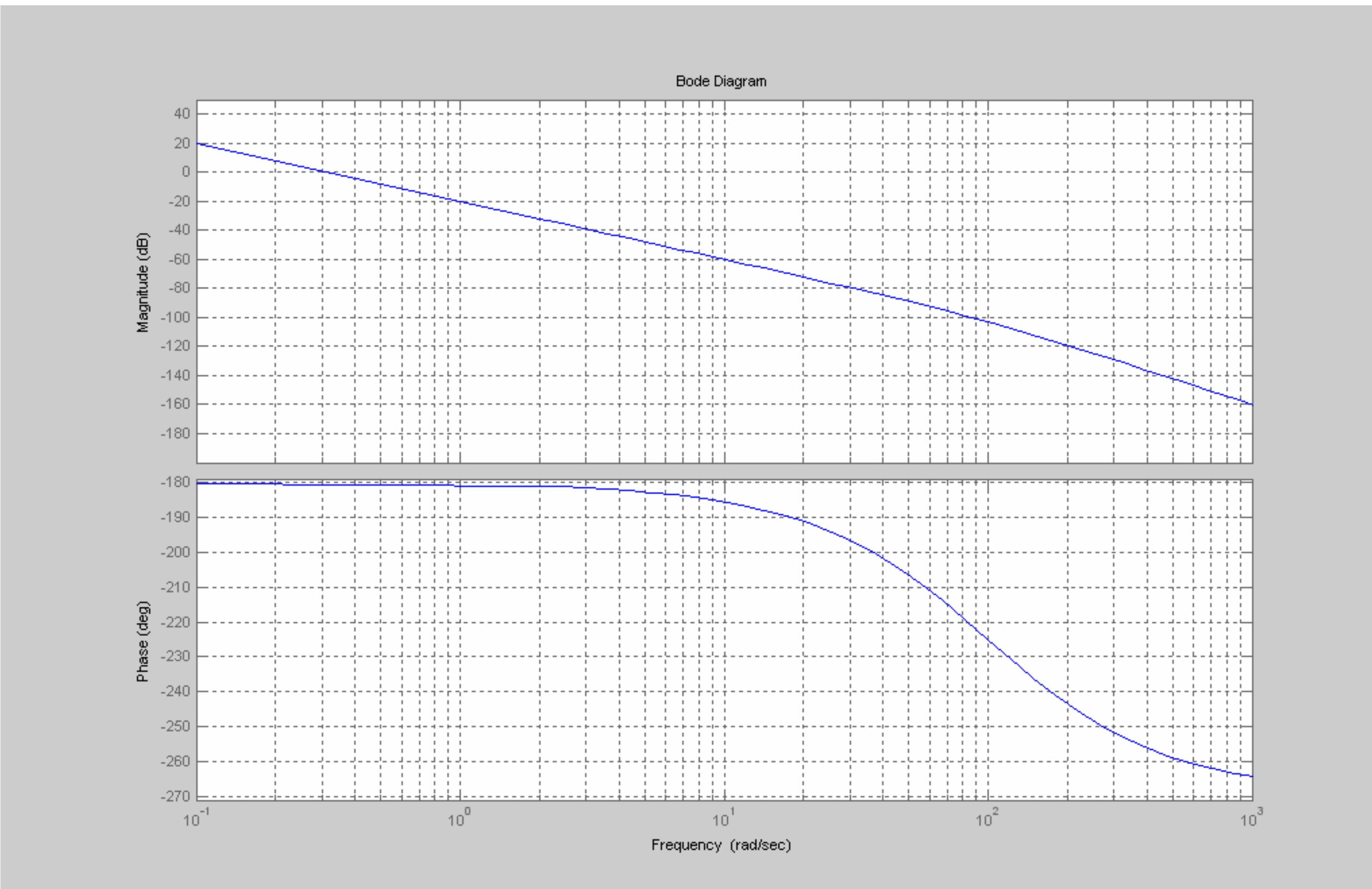
$$H(s) = \frac{10}{s^2(s+100)}$$

(a) n=-2 (the number of poles or zeros at the origin – 2 poles at the origin)

- gain: $K=H(s)*s^2\,|_{s=0} = 10/100 = .1 \Rightarrow 20\log_{10}(.1*1^{-2}) = -20dB$
  - choose $\omega_{start} = 0.1$ and you get $20\log_{10}(.1*.1^{-2}) = 20dB$
- phase: $K>0$, $n*90^o = -2*90^o = -180^o$

(b) critical frequencies:

- $\omega=0$ – (pole at origin) => -40dB/dec/ -180^o start
- $\omega=1,00$ – (negative pole) => -20dB/dec/ -45^o slope/dec (over 2 decades $10<\omega<1,000$)



4. Use Matlab for each function listed below to obtain the Bode Plot. Sketch the Bode plots using a straight-line approximation (procedures described in class) and compare the two:

a. $$H(s) = \frac{s+2}{(s+10)(s+100)}$$

b. $$H(s) = \frac{10s}{(s+1)(s+10)}$$

c. $$H(s) = \frac{10(s+1)}{s^2(s^2-2s+100)}$$

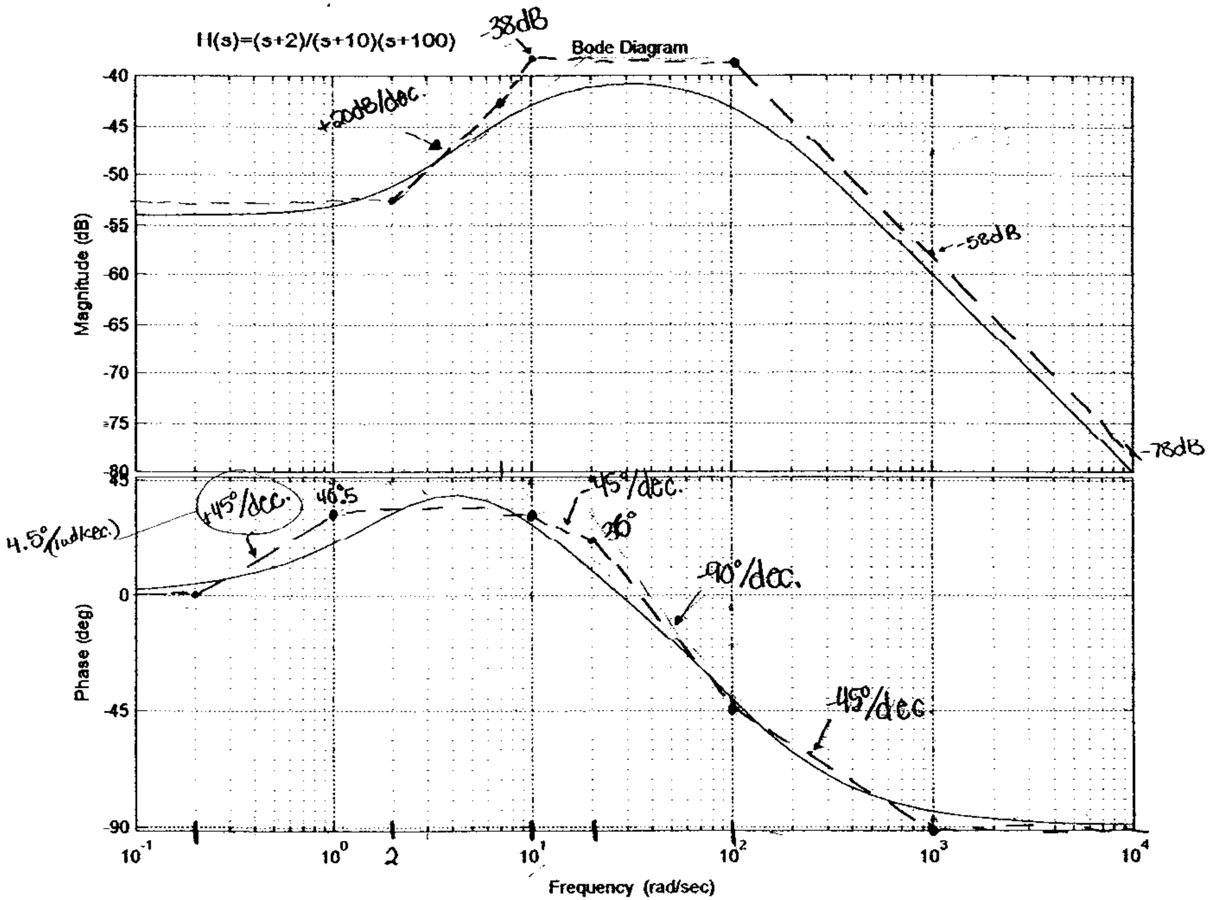
④ a. Step 1: $H(0) = \frac{2}{(10)(100)} = 2m \Rightarrow 20\log_{10}(2m) = -53.98$

since $H(0) > 0$, phase $= 0°$

Step 2: critical freq: @ $w = 2$ (negative zero): +20 dB/dec., +45°sl

@ $w = 10$ (negative pole): -20dB/dec., -45°slope

@ $w = 100$ (negative pole): -20dB/dec., -45°slope

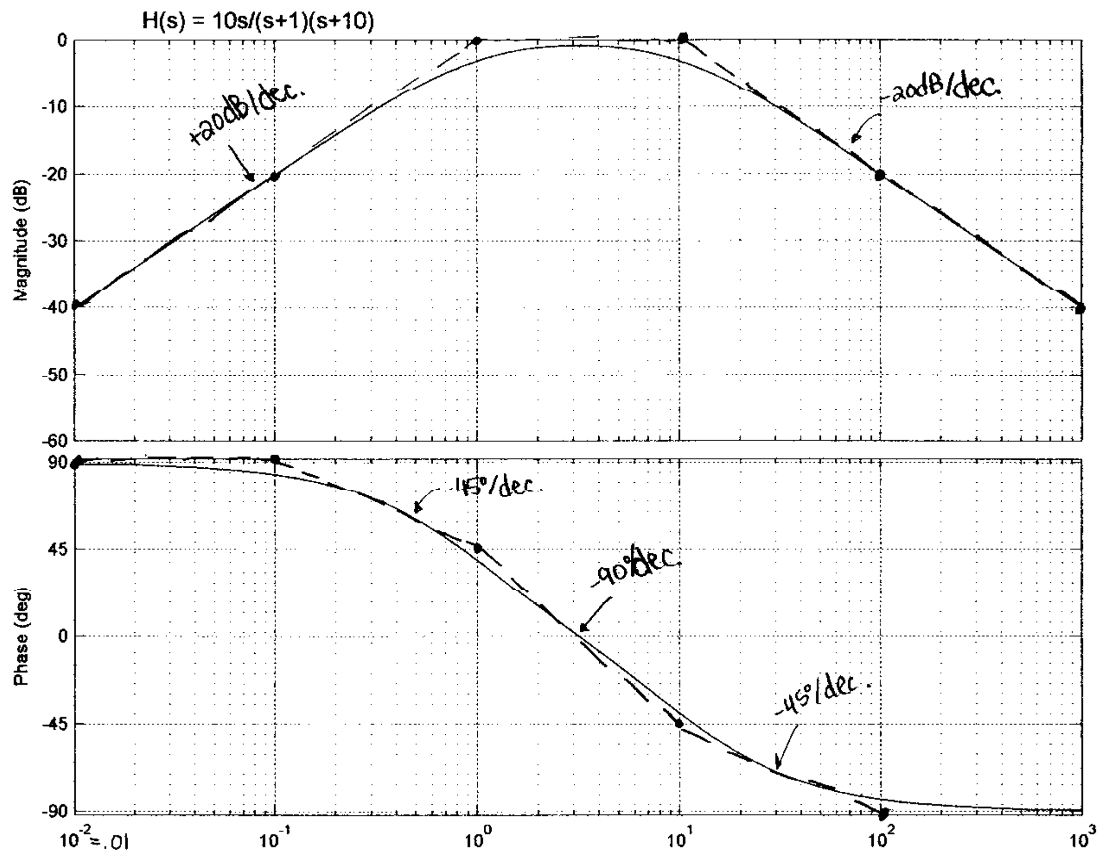


④ b. Step 1: (starting value) remove the zero from the transfer function and find the DC gain: $K = H(s)\cdot\frac{1}{s}\Big|_{s=0} = \frac{10}{1(10)} = 1 \Rightarrow 0\text{dB}$

The start value will be $20\log_{10}(|K|\cdot\omega_{start}^{n})$ where n is (+) for a zero, negative for a pole. n = # of poles or zeros at s=0. The line will be n x 20dB/dec

If $\omega_{start} = .01 \Rightarrow 20\log_{10}(|1|\cdot .01) = -40\text{dB}$.

- Draw a horizontal line at $0° + n\cdot 90°$ if $K>0$ or $180° + n\cdot 90°$ if $K<0$
  $K=1$ ∴ phase → 90° (n=1 for our case)



critical frequency's @ ω = 1 (negative pole): −20dB/dec., −45°/dec.
ω = 10 (negative pole): −20dB/dec., −45°/dec