EENG307: Bode Plot Examples[1]

Lecture 27

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$$G(s) = \frac{5(s+1)(s-50)}{s^2(s^2+10s+100)}$$

Step 1: Factor out constant terms

$$G(s) = \frac{5(-50)}{100s^2} \frac{(s+1)(\frac{s}{-50}+1)}{\left((\frac{s}{10})^2 + \frac{s}{10} + 1\right)}$$
$$= \frac{-2.5}{s^2} \frac{(s+1)(\frac{s}{-50}+1)}{\left((\frac{s}{10})^2 + \frac{s}{10} + 1\right)}$$

the term $\frac{-2.5}{s^2}$ is called the *low frequency term*

Step 2: List break frequencies and important info

Break Frequency	Item (P/Z? L/RHP? #?)	Magnitude Slope	Phase Slope
1 rad/s	1 LHP zero	20 dB/dec	45°/dec
10 rad/s	2 LHP poles	-40 dB/dec	-90°/dec
50 rad/s	1 RHP zero	20 dB/dec	-45°/dec

Step 3: Calculate gain and phase of low frequency term $(2.5/s^2)$. To calculate the magnitude, we pick a frequency less than or equal to all break frequencies. In this case 1 rad/s is convenient, so we plug in $s = j\omega$ with $\omega = 1$:

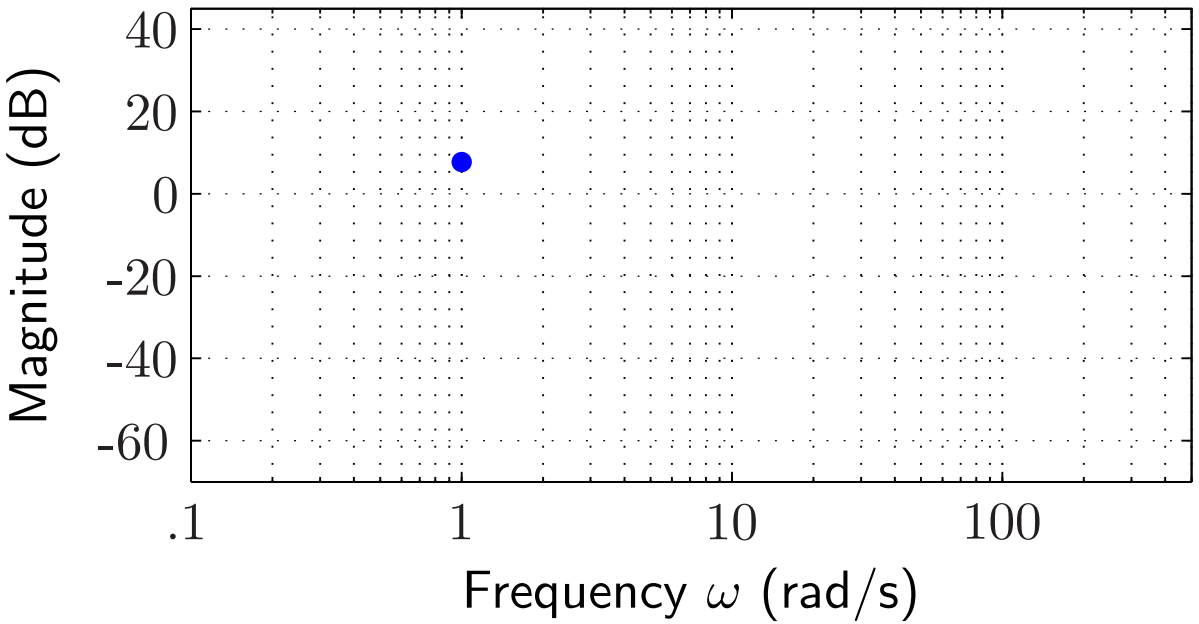
$$\left| -\frac{2.5}{s^2} \right|_{s=j} = \frac{|-2.5|}{|j^2|} = \frac{2.5}{1} = 2.5$$

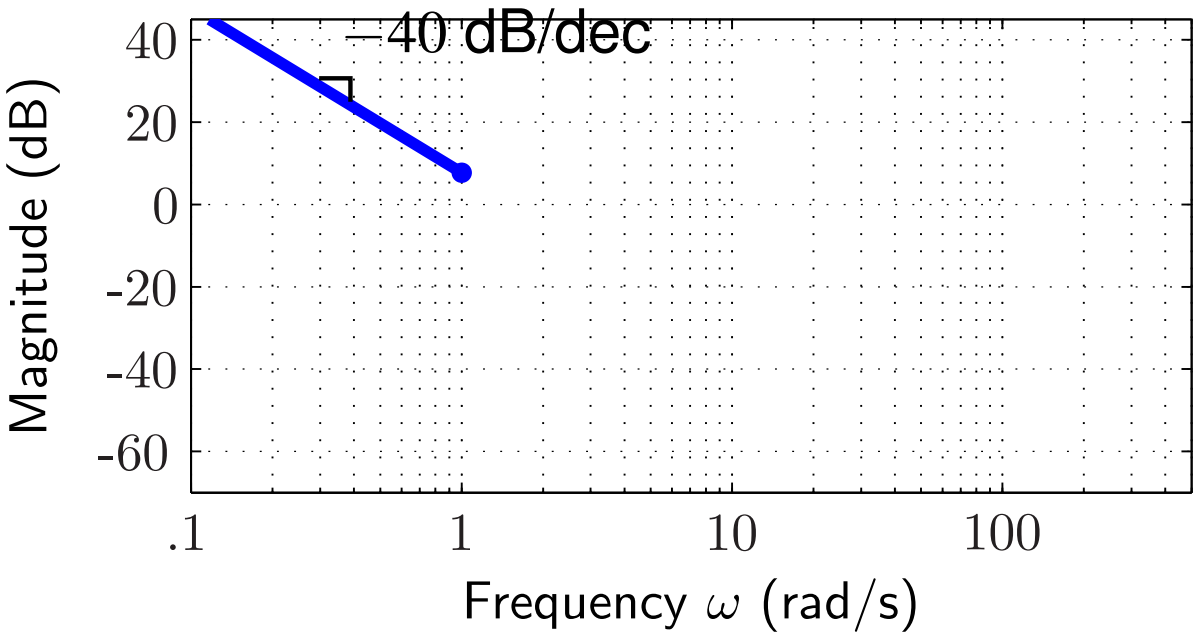
Thus, at 1 rad/s, the magnitude is $20\log_{10}(2.5) = 7.96$. To calculate low frequency phase, you can always just plug in j

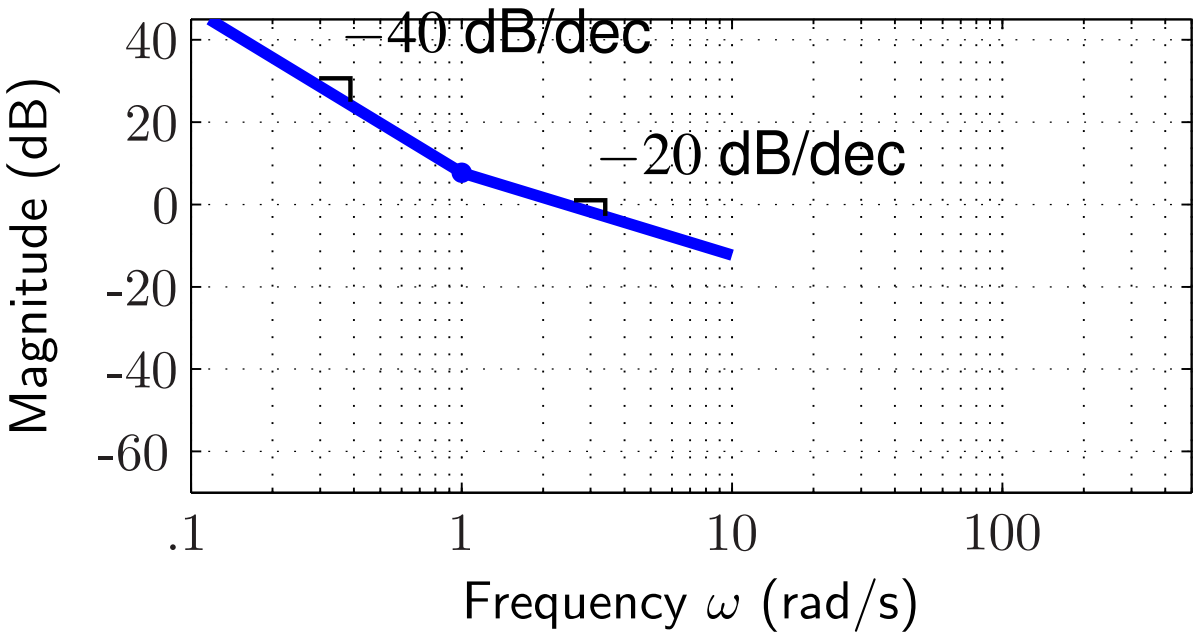
$$\angle -\frac{2.5}{s^2}_{s=j} = \angle \frac{-2.5}{j^2} = \angle \frac{-2.5}{-1} = \angle 2.5 = 0^\circ$$

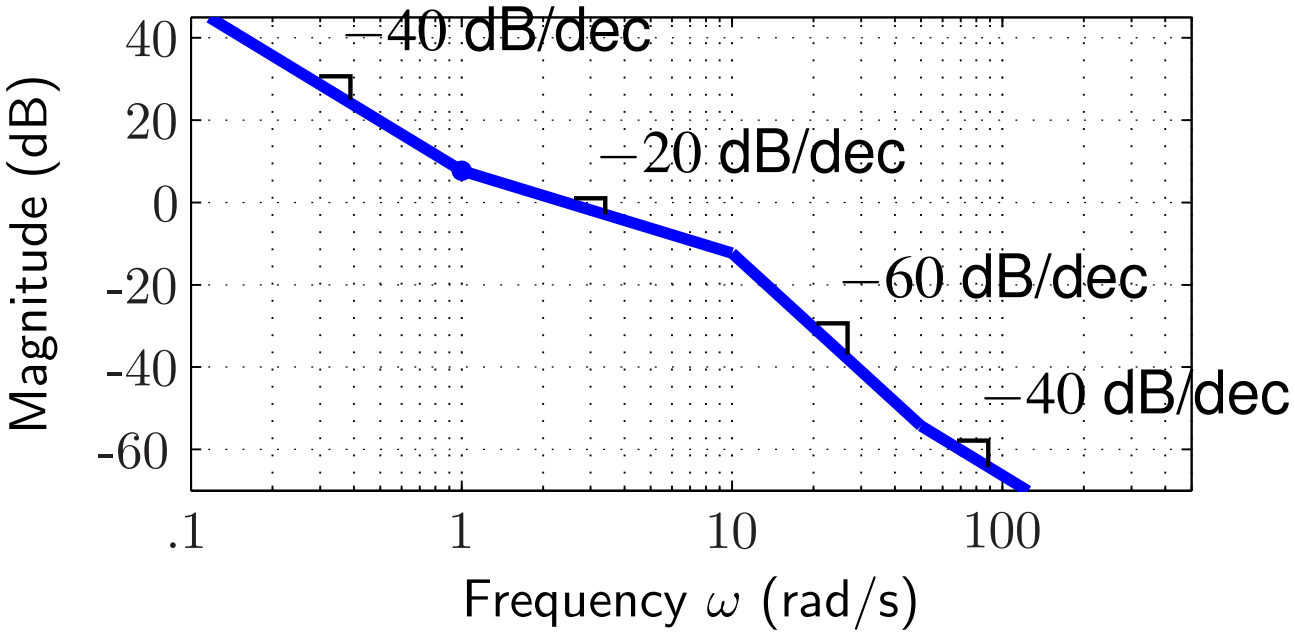
In this case, the low frequency phase is 0°.

Step 4: Draw magnitude plot, starting from lowest frequencies.

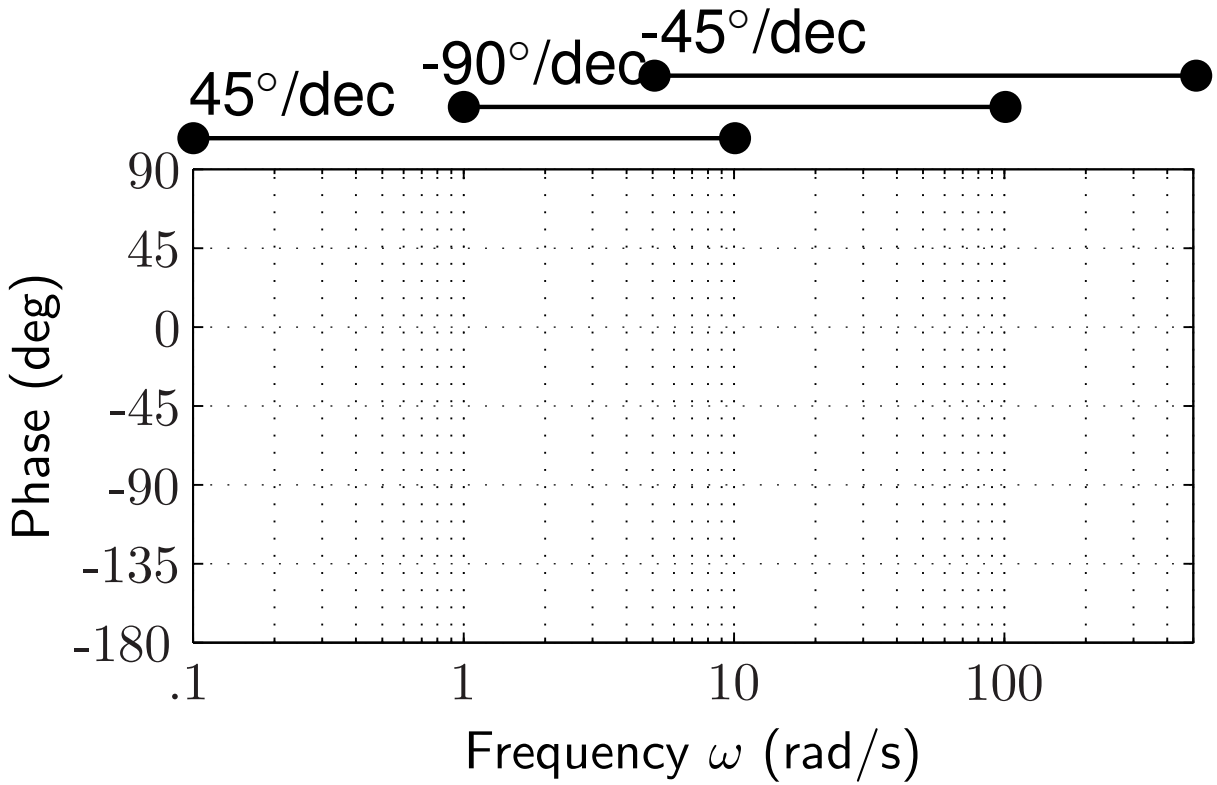


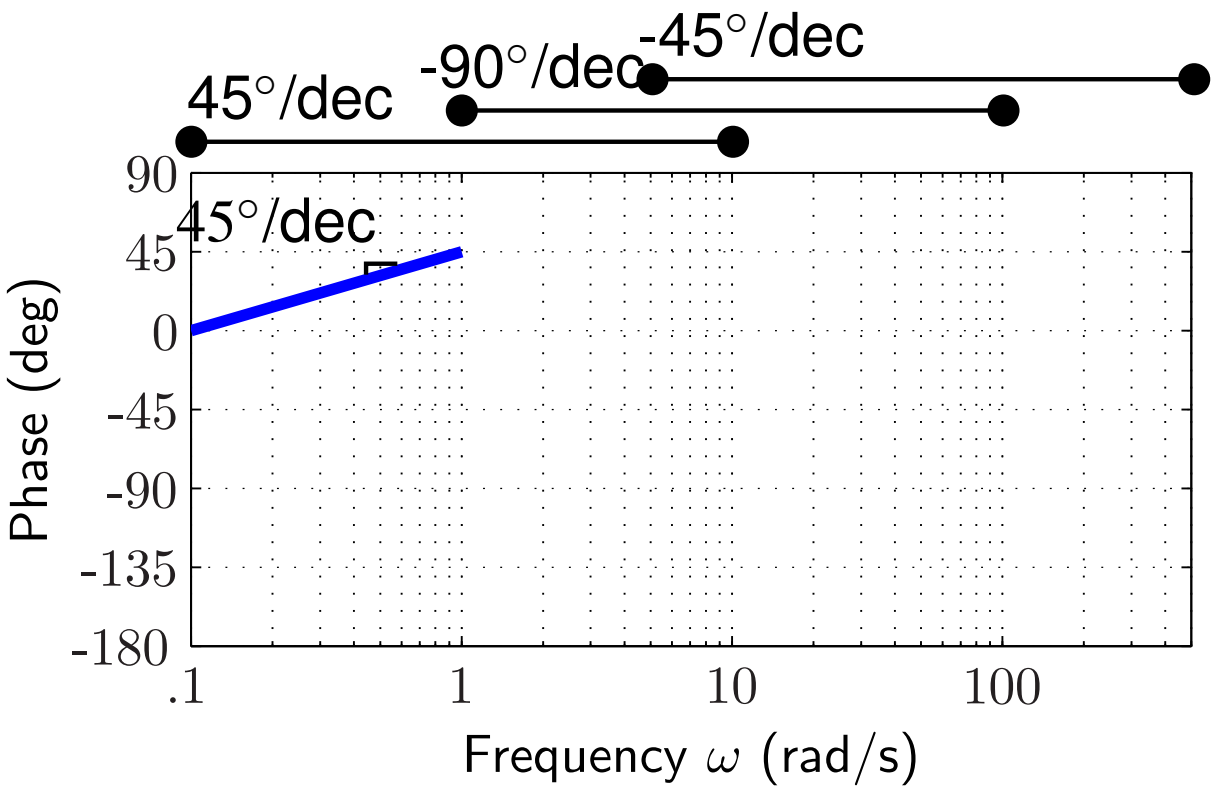

−40 dB/dec
40
20
0
-20
-40
-60
.1
1
10
100
Magnitude (dB)
Frequency ω (rad/s)

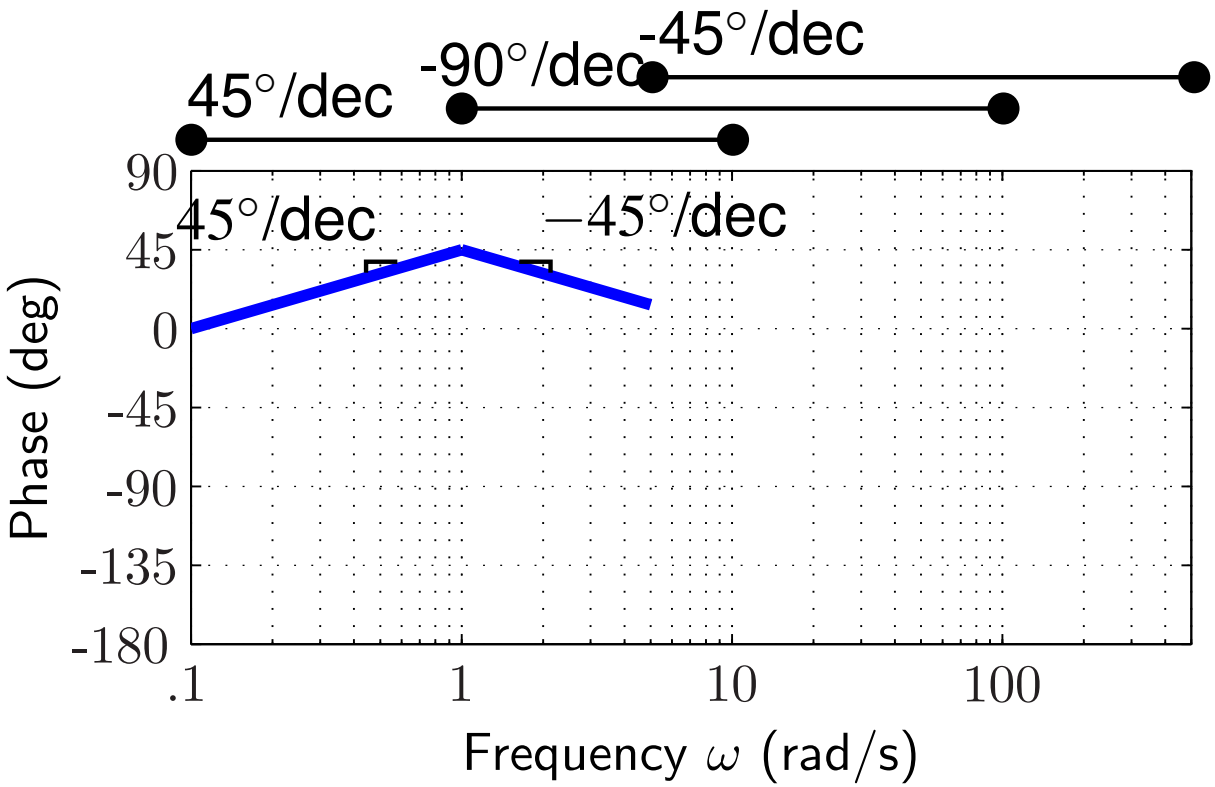

−40 dB/dec
−20 dB/dec
40
20
0
-20
-40
-60
.1
1
10
100
Magnitude (dB)
Frequency ω (rad/s)

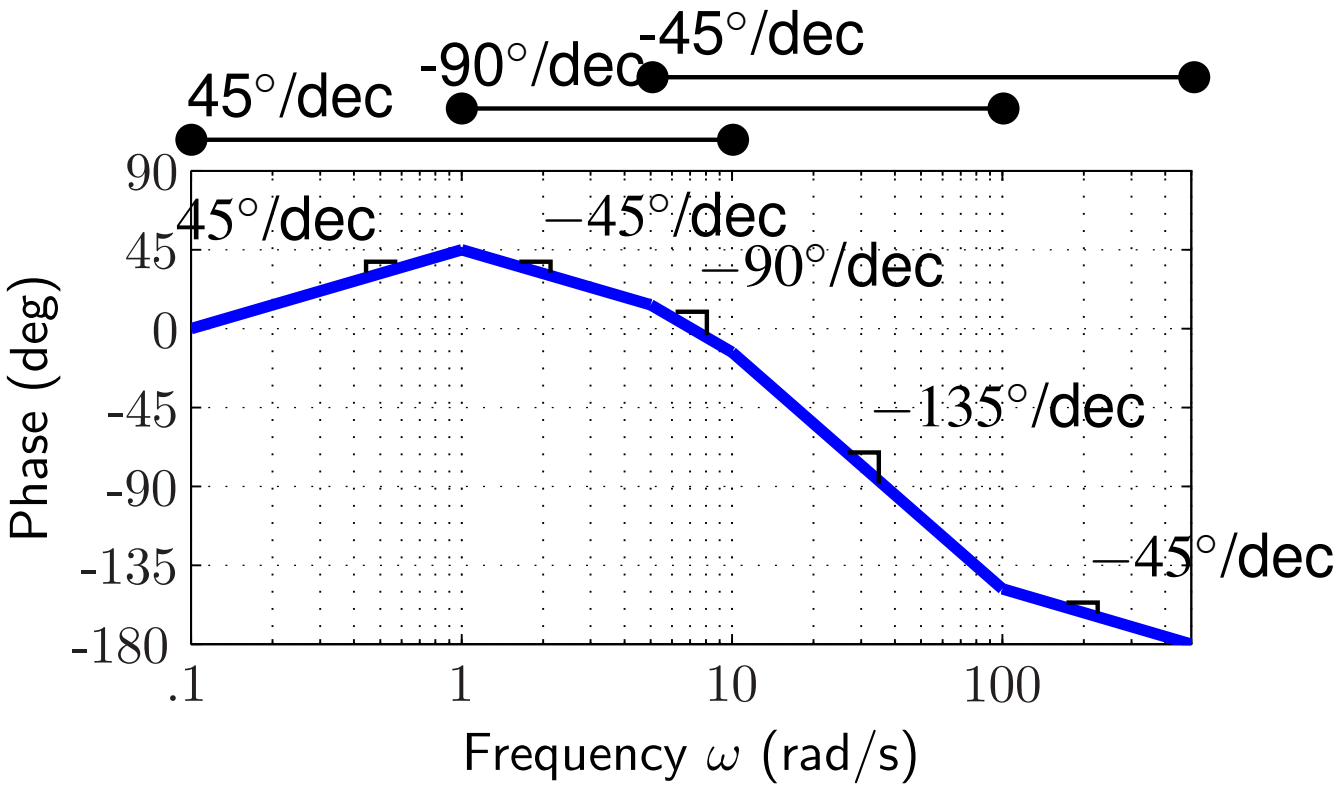

−40 dB/dec
−20 dB/dec
−60 dB/dec
−40 dB/dec
40
20
0
-20
-40
-60
.1
1
10
100
Magnitude (dB)
Frequency ω (rad/s)

Step 5: Draw phase plot




45°/dec
-90°/dec
-45°/dec
45°/dec
90
45
0
-45
-90
-135
-180
Phase (deg)
.1
1
10
100
Frequency ω (rad/s)


45°/dec
-90°/dec
-45°/dec
45°/dec
−45°/dec
90
45
0
-45
-90
-135
-180
.1
1
10
100
Phase (deg)
Frequency ω (rad/s)


45°/dec
-90°/dec
-45°/dec
45°/dec
−45°/dec
−90°/dec
−135°/dec
−45°/dec
90
45
0
-45
-90
-135
-180
.1
1
10
100
Phase (deg)
Frequency ω (rad/s)