Decibels (dB)

Prove a change in gain of a factor of 10 causes a change of 20dB and a change of √2 gives a change of 3dB.

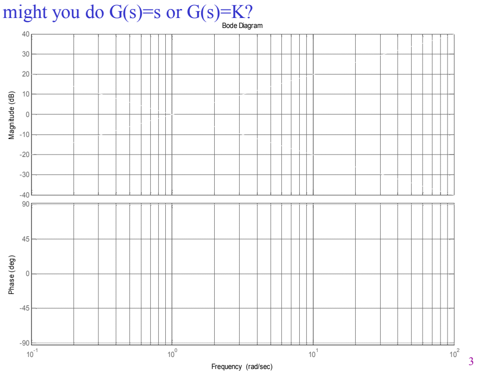
Find gain and phase of G(s)=1/s and hence sketch Bode plots. How might you do G(s)=s or G(s)=K?

freq	0.1	0.5	1	4	7	10	50	100
(dB)								
(degrees)								

freq	0.1	0.5	1	4	7	10	50	100
(dB)								
(degrees)								

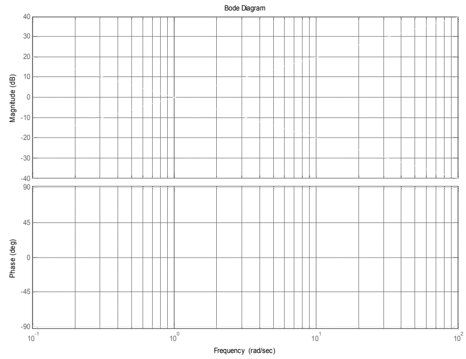
2

Find gain and phase of G(s)=1/s and hence sketch Bode plots.
How might you do G(s)=s or G(s)=K?



3

Sketch the Bode of s+4 and 1/(s+4)

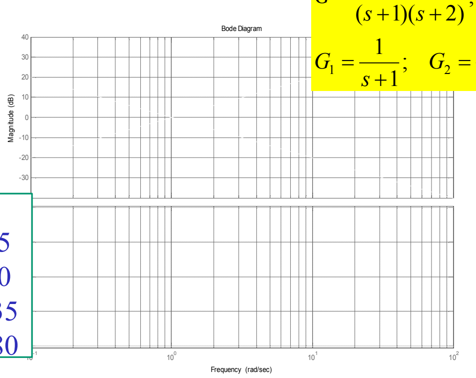


4

Sketch the Bode

$$G=\frac{1}{(s+1)(s+2)};$$

$$G_1=\frac{1}{s+1};\quad G_2=\frac{1}{s+2}$$



0
-45
-90
-135
-180

Example G(s)=(s+1)/[(s+2)(s+3)]

	jw+1	jw+2	jw+3	G(jw)
w<1				
1<w<2				
2<w<3				
w>3				

STEP 1: extract the key gain and phase information needed for asymptotes.

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Example G(s)=(s+1)/[(s+2)(s+3)]

	G(jw)	gain	Phase
w<1	1/6		
1<w<2	jw/6		
2<w<3	jw/(3jw)		
w>3	jw/(jw.jw)		

STEP 2: put this information onto the gain and phase diagrams.

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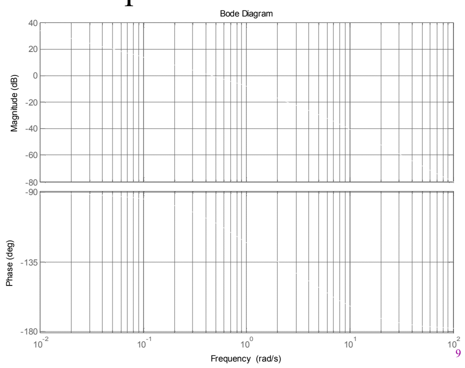
Try the example G=(s+2)/[s(s+1)(s+4)]

				Slope	Phase

Space for sketch



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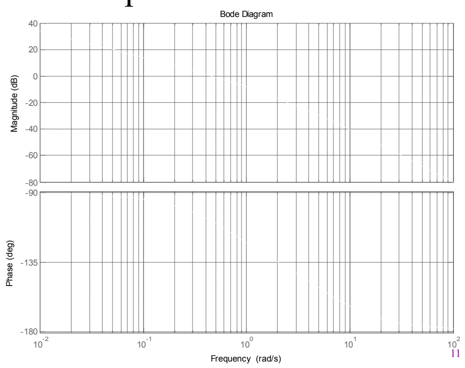
Try the examples $H(s)=\frac{10}{s(4+s)}$; $G=\frac{(s+2)(s+6)}{s(s+1)(s+3)(s+10)}$

				Slope	Phase

Space for sketch



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Evaluate gain/phase of G(s) = (s+2)/[s(s+1)(s+4)] at the corner frequencies.

$$|G| =$$

$$\angle G =$$

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Asymptotes G(s)=(s+1)/[s(s+2)(s+3)]

	G(jw)	Gain/slope	Phase
w<1			
1<w<2			
2<w<3			
w>3			

At w=1, G=1/[w(2)(3)] = 1/6.
Place point (w=1, gain =20log10(1/6) onto gain plot.
Sketch asymptotes to right and left using usual procedure.

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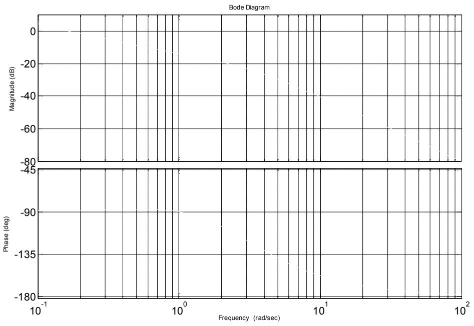

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More examples to try.

Use bodeasymptote.m to check

$$G(s)=\frac{s+1}{s(s+3)(s+4)}$$

$$H(s)=\frac{(s+4)}{s^2(s+8)(s+10)}$$

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Summary bookwork questions

1. How do you interpret the information in the Bode plots ?
2. What is frequency response?
3. How do you do a quick sketch of the bode plots?
4. Where do the sketches need to be accurate?
5. Why do gain plots always go to zero as frequency increases?
6. Why does phase lag tend to increase with frequency?
7. Can you compute freq. response for an individual freq. from G(s) ?
8. Can you compute asymptotes reliably? Do you understand how the asymptotes are derived?
9. Would you be comfortable sketching a Bode plot within just a few minutes.
10. Can you extract data from the Bode plot to evaluate the output response at a given frequency?

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Tutorial questions

Sketch, using asymptotes, the Bode diagrams of the following transfer functions and verify them in MATLAB. How would the Bode plots change if G were modified as G → GK where K=(s+1)/(s+5) and K=(s+5)/(s+1):

$$\frac{100}{s+5};\quad \frac{20}{s+3};\quad \frac{10}{(s+1)(s+2)};\quad \frac{100}{(s+3)(s+4)};$$

$$\frac{10}{s(s+1)(s+2)};\quad \frac{0.4}{s(s+2)(s+5)};\quad \frac{0.2(s+1)}{(s+2)(s+3)};\quad \frac{5(s+2)(s+1)}{s^2(s+3)};$$

Common compensators (Lead and Lag) take the form

$$G(s)=K\frac{s+a}{s+ra};\quad r>1 \qquad G(s)=K\frac{s+ra}{s+a};\quad r>1$$

Plot the bode gain and phase plots for K=1, a=1 and r=10 for each of these. What do you notice that is different about them?

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Bandwidth

How is bandwidth defined in the context of closed-loop control?
Illustrate with a Bode diagram.

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Resonance

- When a system has a large gain in a very small frequency range. (Note use of large and small are relative not absolute).
- This means certain frequencies are amplified disproportionately to those around them. Recognise by a sharp peak in the gain plot.
- Where might resonance occur in an aircraft and why is it undesirable? In most systems either the resonance is designed out, or the excitation freq. must be avoided. **WHY?**

Create some examples of systems with resonance and illustrate by creating the Bode diagrams (using MATLAB).

Reinforce this by comparing time responses to sinusoidal inputs of different frequencies around the resonant frequency.

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