ECE 461/661 Handout #39

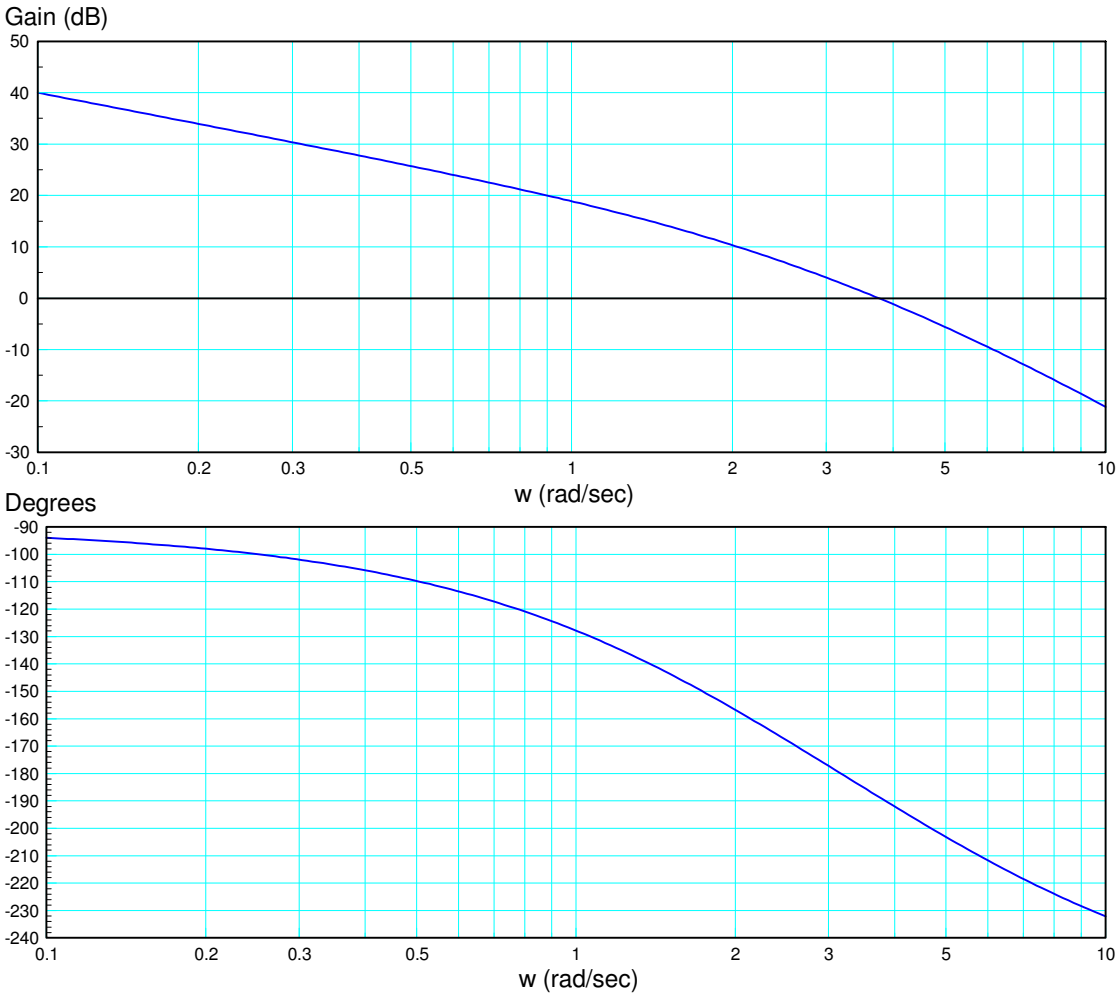
Meeting Design Specs in the Frequency Domain

Assume

$$G(s) = \left(\frac{100}{s(s+2)(s+5)} \right)$$

Design a compensator so that

- There is no error for a step input
- The 0dB gain frequency is 3 rad/sec, and
- The phase margin is 50 degrees



Solution:

You don't really need the Bode plots - all you care about are two points:

- Where the open-loop phase is -130 degrees (too close to minus one), and
- At 3 rad/sec (the design point)

This is already a type-1 system. Don't add a second pole at s = 0.

$$K(s) = k\left(\frac{s+a}{s+b}\right)$$

i) What frequency starts to resonante you increase the gain? This determines where you place the zero.

From the Bode plot, you get a 50 degree phase margin at 1 rad/sec

- Place the zero 1..3 times 1 rad/sec

Option #2: Cancel the pole at s = 2

$$K(s) = k\left(\frac{s+2}{s+a}\right)$$

ii) How much phase do you need to add at 3 rad/sec?

For a 50 degree phase margin at 3 rad/sec, you want

$$GK(j3) = 1\angle -130^0$$

Plugging in what we know

$$\left(\frac{100}{s(s+2)(s+5)}\right)\left(\frac{(s+2)}{1}\right)_{s=j3} = 5.717\angle -120.964^0$$

We want the phase to be -130 degrees. This means

$$\angle(s+a) = 9.036^0$$

$$a = \frac{3}{\tan\left(9.036^0\right)} = 18.864$$

and

$$GK = \left(\frac{100k}{s(s+5)(s+18.864)}\right)$$

At 3 rad/sec, the gain should be one

$$GK(j3) = 0.299k\angle -130^0 = 1\angle -130^0$$

so

$$k = \frac{1}{0.299} = 3.341$$

and

$$K(s) = 3.341\left(\frac{s+2}{s+18.864}\right)$$