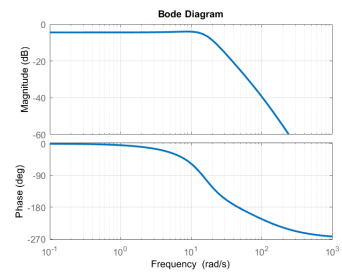
Due at 1700, Fri. Mar. 24 in homework box under stairs, first floor Cory .
Note: up to 2 students may turn in a single writeup. Reading Nise 10, 11

1. (20 pts) Time Delay (Nise 10.12)
Given a unity feedback system with forward path transfer function

$$G(s) = \frac{10000}{(s+10)^2(s+30)}$$

. Assume a total delay in the feedback path for example from camera frame rate limit of ΔT.
[2pts] a) Draw a block diagram for the system, including ΔT propagation delay for error $e(t)$ to reach the controller/plant $G(s)$.
[8pts] b) Draw Bode diagrams for the system without delay, and estimate gain and phase margin. Determine ΔT for a 10° reduction in phase margin for the system with delay.
[6pts] c) Estimate overshoot and settling time from second order approximation for both cases.
[4pts] d) Use Matlab to plot the step response for the closed loop system with and without delay and compare to the estimate from part c. (Use `Gdelay=tf(num,den,'InputDelay',deltaT)` to include time delay in the system.)

2. (15 pts) TF from Bode (Nise 10.10, 10.13)
The Bode plot for a stable closed-loop system $T(s) = \frac{G(s)}{1+G(s)}$ is shown to the right.
[10pts] a) Estimate $T(s)$ from the Bode plot.
[5pts] b) Estimate the open loop transfer function $G(s)$.



3. (15 pts) Gain Adjustment (Nise 11.2)
Given unity feedback system with OLTF:

$$G(s) = \frac{K(s+2)(s+20)}{s(s+10)^3(s+15)}$$

[8pts] a) Sketch by hand the Bode plot for $G(j\omega)$.
[4pts] b) Estimate the value of K and phase margin such that the step response has an approximate 15% overshoot.
[3pts] c) Use Matlab to plot the step response for this value of K and compare ζ from this step response with estimate from part b). Also use the `margin` command to check estimates from hand drawn bode plot.

4. (25 pts) Lag Compensation (Nise 11.3)
Given unity feedback system with OLTF:

$$G(s) = \frac{81(s+10)}{(s+0.03)(s+3)^2(s+30)}$$

[7pts] a) Sketch by hand the Bode plot for $G(j\omega)$.
[15pts] b) Design a lag compensator such that the phase margin is at least 45°, and the DC gain of the system is increased by 10dB, and sketch the Bode plot for the compensated OLTF.
[3pts] c) Use Matlab to plot the closed-loop step response for the compensated and uncompensated system, and compare steady state error. Also use `margin` to check design spec is met.

5. (25 pts) Lead Compensation (Nise 11.4)
Given unity feedback system with OLTF:

$$G(s) = \frac{400000(s+5)^2}{(s+2)^2(s+30)^2(s+100)}$$

[7pts] a) Sketch by hand the Bode plot for $G(j\omega)$.
[15pts] b) Design a lead compensator such that the phase margin is 40°, and the DC gain of the system is unchanged, and sketch the Bode plot for the compensated OLTF.
[3pts] c) Use Matlab to plot the closed-loop step response for the compensated and uncompensated system, and compare steady state error and settling time. Also use `margin` to check design spec is met.