Due at 1700, Fri. Nov. 8 in gradescope. .

Note: up to 2 students may turn in a single writeup. Reading Nise 10, 11, 12.2

1. (18 pts) Nyquist Plot (Nise 10.5)

Consider a closed loop system with unity feedback and gain k. The open loop transfer function is:

$$G(s) = \frac{1000\sqrt{10}(s-10)}{(s+10)^2(s+10\sqrt{10})^2}$$

[6pts] a) Hand sketch the asymptotes of the Bode plot magnitude and phase for the open-loop transfer function.
[6pts] b) Hand sketch Nyquist diagram.
[4pts] c) From Nyquist diagram, determine range of k for stability.
[2pts] d) Verify sketches with MATLAB (`bode()` and `nyquist()`) and hand in.

2. (15 pts) Gain and phase margin (Nise 10.7, 10.10)

A closed loop system with unity gain feedback has open loop transfer function:

$$G(s) = \frac{\sqrt{10}(s-1)}{s+10}$$

[6pts] a) Hand sketch the asymptotes of the Bode magnitude and phase plots for the open loop system.
[6pts] b) Determine the gain and phase margin.
[3pts] c) Verify sketches with MATLAB (`bode()`) and hand in.

3. (17 pts) Time Delay (Nise 10.12)

Given a unity feedback system with forward path O.L. transfer function

$$G(s) = \frac{720}{s(s^2+36s+100)} \ .$$

Assume an added delay in the feedforward 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 15° reduction in phase margin for the system with delay.
[5pts] c) Estimate overshoot and settling time from second order approximation for both cases.
[2pts] 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.)

4. (25 pts) Lag Compensation (Nise 11.3)

Given unity feedback system with OLTF:

$$G(s) = k\frac{3(s+10)}{(s+0.1)(s+1)^2(s+30)}$$

[7pts] a) Sketch by hand the Bode plot for $G(j\omega)$.
[15pts] b) Design a lag compensator (using methods of Ch 11) such that the phase margin is at least 45°, and the static error constant = 100 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 (with $k=1$), 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:

$$G(s) = \frac{1875(s+10)}{(s+5)^2(s+15)}$$

[7pts] a) Sketch by hand the Bode plot for $G(j\omega)$.
[15pts] b) Design a lead compensator using frequency domain techniques (of Ch 11) , such that DC gain of the system is unchanged, and phase margin is 45°, and sketch the Bode plot for the compensated OLTF.
[3pts] c) Use Matlab to plot the closed-loop ~~ramp~~ **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.