Due at 1700, Fri. Mar. 6 in homework box under stairs, first floor Cory .
Note: up to 2 students may turn in a single writeup. Reading Nise 9, 10-10.2.
Midterm: Thurs. March 12. Location: 160 Kroeber, 1230-2pm.

1. (20 pts) Transient response by gain adjustment (Nise 8.7)
Consider open loop plant

$$G(s) = \frac{K(s^2 + 2s + 2)}{(s+2)(s+4)(s+5)(s+6)}$$

with unity feedback.
a) Sketch the root locus by hand, and verify using Matlab.
b) Find the range of gain, K, that makes the system stable.
c) Using a second order approximation for a pair of dominant closed-loop poles, find the value of K that yields a closed-loop step response with rise time of 0.15 sec.
d) Find all closed loop pole locations for K found in part c).
e) Compare Matlab step responses (using K found in part c)) for the second order approximation and the actual closed loop system. Is the approximation used appropriate and accurate?

2. (20 pts) PD compensation (Nise 9.3)
Consider open loop plant

$$G(s) = \frac{K(s+6)}{(s+2)(s+3)(s+5)}$$

with $K = 150$ and unity feedback.
a) Design a PD controller such that settling time is reduced by a factor of 3, with the same rise time as for the uncompensated system.
b) Hand sketch the root locus for the original system and the system with a lead compensator, and verify with Matlab.
c) Use Matlab to compare the step response for the closed-loop compensated and uncompensated systems, transient and steady state response.

3. (20 pts) Lag-Lead compensation (Nise 9.4)
Consider open loop plant

$$G(s) = \frac{K}{s(s+10)(s+5)}$$

with unity feedback.
a. Find the gain K for the uncompensated system to operate with 20% overshoot.
b. Find the peak time and K_v for the uncompensated system.
c. Design a lead-lag compensator to decrease the peak time by a factor of 2, decrease the peak overshoot by a factor of 2, and reduce steady state error for a ramp by a factor of 10 (increase K_v by a factor of 10). Specify poles, zeros and gain.
d. Hand sketch the root locus of the original and compensated system, and verify with Matlab.
e. Show before and after step response using Matlab.

4. (25 pts) Bode Plot (Nise 10.2)

Sketch (by hand) the asymptotes of the Bode plot magnitude and phase for each of the following open-loop transfer functions. Verify sketch using MATLAB plot with same axes scales, and turn in.

a) $\frac{2\times10^3}{(s+20)(s^2+4s+104)}$ b) $\frac{s^2-4s+104}{s^2+4s+104}$

c) $\frac{10(s+2)}{(s+20)(s+0.2)}$ d) $\frac{400(s+1)}{(s+20)(S+0.2)}$

e) $\frac{400(s-1)}{(s+20)(S+0.2)}$

5. (15 pts) Compensation Network (Nise 9.6, 10.2)

For the ideal op amp circuit below:

a) Determine the transfer function $T(s) = \frac{V_{out}(s)}{V_{in}(s)}$. Express the transfer function as a standard rational function (polynomial numerator, polynomial denominator).

b) Hand sketch the Bode plot for magnitude and phase for R1 = 1K Ω , R2 = 10K Ω , R3 = 100K Ω, C1 = 10 μF , and C2 = 1 μF.

c) Verify sketch using MATLAB plot with same axes scales, and turn in.