Due at 1700, Fri. Oct. 5 in bcourses.
Note: up to 2 students may turn in a single writeup. Reading Nise 8, 9-9.3
Midterm: Thurs. Oct.18. Location: tba, 1710-1830 am.

1. (25 pts) Root locus (Nise 8.7)
Given the unity gain feedback system in Fig. 1, where

$$G(s) = \frac{K(240)(s+10)}{s(s+20)(s+30)(s+40)}$$

[14 pts] a) Find and approximately hand sketch the root locus using RL rules 1-8 for $k > 0$.
[4 pts] b) Find the range of K which makes the system stable.
[5 pts] c) Using the second order approximation (assuming dominant 2nd order poles) find the value of K that gives $\zeta \approx 0.30$ for the system's dominant closed-loop poles.
[2 pts] e) Use MATLAB to plot the actual step response for c) and compare to 2nd order poles approximation estimate.

2. (26 pts) Root locus (Nise 8.6, 8.9)
Consider the unity gain feedback system in Fig. 1 with $G(s) = \frac{k(s^2+3s+2)}{s^2-4s+5}$. Here $-\infty < k < \infty$
[14 pts] a) Apply root locus rules: specify real axis segments, break-away and break-in locations on real axis, and angle of departure from complex poles.
[6 pts] b) Find the $j\omega$ crossing using Routh-Hurwitz.
[4 pts] c) Hand sketch the closed-loop root locus for positive and negative k.
[2 pts] d) Find the range of k for stability.

3. (22 pts) Generalized Root locus (Nise 8.8)
Given the unity gain feedback system in Fig. 1, where

$$G(s) = \frac{20(s+\alpha)}{(s+2)^2(s+10)^2}$$

[5] a) Determine the characteristic equation for the closed loop system.
[14] b) Find and approximately hand sketch the root locus using RL rules 1-6 with respect to positive values of α ($0 \leq \alpha < \infty$), showing direction in which α increases on the locus.
[3] c) Find the zero location α such that closed-loop system has one pair of poles near $-1 \pm 3.1j$ (Matlab ok).

4. (27 pts) PI compensation (Nise 9.2)
Consider open loop plant

$$G(s) = \frac{4000K}{(s+10)(s+30)^2}$$

and unity feedback.
[5 pts] a) find K such that overshoot is 30%.
[11 pts] b) Design a PI controller with the same 30% overshoot such that steady state error is 0, with $T_s \leq 1$ sec.
[7 pts] c) Hand sketch the root locus for the original system and the system with a **PI** compensator, and verify with Matlab.
[2 pts] d) Use Matlab to compare the step response for the closed-loop compensated and uncompensated systems, transient and steady state response. Is there pole-zero cancellation for the PI compensator?
[2 pts] e) Find the steady state error for a step for both systems.

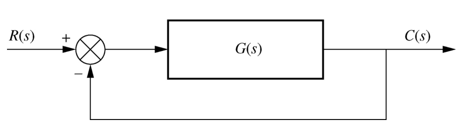

Fig. 1. Unity Gain Feedback.