Due at 1700, Fri. Mar. 3 in homework box under stairs, first floor Cory.

Note: up to 2 students may turn in a single writeup. Reading Nise 8, 9.

Midterm: Thurs. Mar. 9, Location: 277 Cory, 0810-0930 am.

1. (22 pts) Root locus (Nise 8.7)

Given the unity gain feedback system in Fig. 1, where

\[ G(s) = \frac{K(s + 15)(s + 40)}{(s + 30)(s^2 - 20s + 200)} \]

[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 \( \zeta = 0.5 \) and \( T_s \approx 0.2 \) for the system’s dominant closed-loop poles.
[2 pts] e) Use MATLAB to plot the step response for c) and compare to approximation estimate.

2. (25 pts) Root locus (Nise 8.6, 8.9)

Consider the unity gain feedback system in Fig. 1 with \( G(s) = \frac{k(s - 10)(s - 5)}{(s + 20)(s + 10)(s + 2)} \). Here \(-\infty < k < \infty\)

[6 pts] b) Find the jω 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. (26 pts) PI compensation (Nise 9.2)

Consider open loop plant

\[ G(s) = \frac{2000K}{(s + 10)^2(s + 20)} \]

and unity feedback.

[5 pts] a) find \( K \) such that overshoot is 20%.
[11 pts] b) Design a PI controller with the same 20% overshoot such that steady state error is 0, with \( T_s \leq 1 \) sec. (Hint: PS4-1)
[6 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.
[2 pts] e) Find the steady state error for a step for both systems.

4. (27 pts) PD compensation (Nise 9.3)

Consider open loop plant

\[ G(s) = \frac{144K}{s(s + 4)(s + 12)^2} \]

and unity feedback.

[5 pts] a) find \( K \) such that overshoot is 20%.
[12 pts] b) Design a PD controller (i.e. find zero location) such that \( T_p \approx 0.8 \) sec, with the same 20% overshoot.
[6 pts] c) Hand sketch the root locus for the original system and the system with a PD 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.
[2 pts] e) Find the steady state error for a step for both systems.