ECE 3510 homework # Bd5 a

1. Ch. 10, prob.30 in Nise, 3rd Ed., page 677. Similar to example 10.17 on page 658 (in section 10.12)
   Ch. 10, prob.30 in Nise, 4th Ed., page 682. Similar to example 10.17 on page 663 (in section 10.12)
   Ch. 10, prob.30 in Nise, 5th Ed., page ___. Similar to example 10.17 on page ___ (in section 10.12)
   Ch. 10, prob.30 in Nise, 6th Ed., page 614. Similar to example 10.17 on page 600 (in section 10.12)

   Given a unity feedback system with a forward-path transfer function $G(s) = \dfrac{K}{s\cdot(s+3)\cdot(s+12)}$

   and a delay of 0.5 second, make a second-order approximation and estimate the percent overshoot if $K := 40$

   Use Bode Plots and frequency response techniques or you may calculate where $|G(j\omega)| = 1$ to

   find ω and then the the phase margin. You may also use Matlab.

   You may use the estimate from eq. 5.57 in Bodson text: $\zeta \simeq \dfrac{PM}{100\cdot deg}$ (PM in degrees and may include delay effects)

   Also helpful: $\%OS = 100\%\cdot e^{\frac{-\zeta\cdot\pi}{\sqrt{1-\zeta^2}}}$

2. In section 5.3.9 of Bodson's book, he discusses using a lead controller to stabilize a system (plant) represented by a double integrator. Give one or more examples of real systems that are essentially double integrators.

3. Problem 5.14 (p.176) in the text.

   a) Consider the lead controller for the double integrator. For the design that makes the crossover frequency equal to ω_C, obtain the polynomial that specifies the closed-loop poles (as a function of a/b and ω_C). Show that one closed-loop pole is at s = - ω_C no matter what a/b is.

   Hints: Find: $G(s) = P(s)\cdot C(s)$

   Find the denominator of the closed-loop transfer function: $D_G + N_G$

   Substitute in a, b, and k_c like eq. 5.71 in book.

   Use polynomial division to show that $D_G + N_G$ can be divided by $(s+\omega_c)$ with no remainder.

   b) Compute the other closed-loop poles, as functions of ω_C, when $a/b = 5.83$, 9, and 13.9.

   Hint: The "other" roots are the roots of the quotient.

   c) Use Matlab SISO or other software of your choice to confirm the results of part c) and the % overshoot figures expected from the phase margins. ($20\cdot\%$ $14\cdot\%$ $9.5\cdot\%$)

Answers

1. Calculated 0dB freq: $\omega := 1.045$ expect about 30% overshoot
2. Any system with mass where a force is the input and position is the "output". $F = m\cdot a = m\cdot\dfrac{d^2}{dt^2}x$
3. b) $a/b = 5.83$: $(-0.7071 - 0.7071\cdot j)\cdot\omega_c$ & $(-0.7071 + 0.7071\cdot j)\cdot\omega_c$

   $a/b = 9$: $-\omega_c$ & $-\omega_c$ (making 3 all at ω_c)

   $a/b = 13.9$: $-0.436\cdot\omega_c$ & $-2.292\cdot\omega_c$

   c) Poles are confirmed with $\omega_c := 10$ $k_p := 1$ gain = 1

   Overshoots are about double expected values $35\cdot\%$ $27\cdot\%$ $21\cdot\%$