Chapter 5 HW 2 Hints

Problem 1. This is an unstable plant whose linear transfer results from the linearization of the "inverse-square" magnetic law.

(a) Be careful when you factor the denominator of the transfer function: the roots are *not* complex.

(b) The discretization is pretty standard.

(c) I used a lead compensator to meet the specifications; I used the zero of the lead compensator to cancel one of the plant poles (not the unstable one—*never* cancel unstable poles!)

(d) Introduce reference input x_r in the "standard" manner, and find the two desired step responses.

I decided to use `Simulink` to simulate this system, since I could examine both the ball position x and the amplifier current i using the same model.

Problem 2. You can discretize the plant in the usual way and find the z-plane regions that are acceptable to place the poles.

(a) You can actually meet these specifications using proportional control $D(z) = K_p$.

(b) Redraw the block diagram to show grade G_r as the input and velocity V as the output. The sensor, sampler, compensator $D(z)$, ZOH, throttle dynamics, and fuel dynamics will all migrate to the feedback path. You'll need to discretize the forward path (vehicle dynamics) and the feedback path (all the aforementioned stuff) separately to get an effective "$G(z)$" and "$H(z)$"...then apply the grade step input of "3" and see how much speed output you get. This speed output *is* the error. Ideally a grade disturbance should cause *no* speed output (this is disturbance rejection). My controller had a speed error of a little over 1 mph for the 3% grade disturbance.

(c) To reduce the error to zero, you need to increase the system *Type*. This is done by adding an integrator, so at the least you will need PI control. However, you *do not* need PID control.

If you've ever driven a car with a cruise control that "hunts" you know the desirability of a cruise control with critical damping or even overdamping.