ENG ME 404: Activity 2: Use of feedback

or: why you should look at how wrong you are

Goal: To develop some intuition about the role of feedback

Description: The m-file `secondOrder.m` will show you the response of a second order system in either open loop or closed loop (with a simple gain) mode. Your goal is to design the gain k for both open loop and closed loop so that the output settles on the desired value y_{ss}. While a second-order system has dynamics $a_2\ddot{y}+a_1\dot{y}+a_0y = u$, because we are only concerned about the steady state value, you can assume $\ddot{y} = \dot{y} = 0$.

All together:

1. Open Matlab, download secondOrder.m, and read through the help.
2. Draw the block diagram structure of the *open loop* control system. Be sure to have a box for the *plant* and the *controller* and to label all relevant signals.
3. Run the m file with the following choices: $y_{ss} = 5$, $k_p = 1$, FB=0, T = 3, seed = 1. Should we increase or decrease our gain to improve the performance? What do we even mean by performance here?
4. Let's discuss the result. Is this controller any good? How accurate is our simple $\ddot{y} = \dot{y} = 0$ approximation?

In-class and with your group:

5. Decide analytically (**without Matlab!**) what your control input should be so that your steady state system output y is 5. Since we are primarily concerned with the final value, you are looking for a constant input, expressed in terms of none, some, or all of the parameters a_0, a_1, a_2. Explain your reasoning.
6. Simulate the system, using a fixed random generator seed given by the average of the favorite numbers of your group members. Tune your input until you get the output you wanted. Based on this, what do you think a_0 is? Describe what you did and your reasoning behind your answer.
7. Simulate the system multiple times, now using a generator seed of 0 (which simply tells my file to be random). Describe the results and discuss what might be going on.
8. Suppose now you are going to close the loop using negative feedback, that is you will choose a pure proportional controller, that is $u = k_pe$. Draw the closed loop block diagram. Determine an expression for the error $e = y_{ss} - y$ in terms of the controller gain and the desired steady state. From that, find an expression for the value of y in terms of those same things. How does the error depend on your choice of the closed loop gain? How about the final value of the system?