AME 30315; Spring 2015; Homework 10; Due April 15th, 2015

Read: Section 9.6.

Problems:

The purpose of Homework 10 is to get comfortable using the pendulum system and to develop a transfer function to represent the pendulum for the purpose of designing a controller homework sets 11 and 12.

Problem 1: Using the standard feedback loop block diagram (Fig. 1), identify which major equipment components on your pendulum setup correspond to the elements of the feedback loop diagram. You may need to augment this feedback loop with extra elements as your system is partially a virtual system and partially a physical system.

Problem 2:

Place the pendulum system in the hanging configuration and then follow the instructions given in document ND_Pendulum_Project_Getting_Started.pdf, using code StudentCode.c as your source file on your pendulum. The code will apply a series of step function torques to the pendulum. From this experiment you will derive an approximate model of the pendulum dynamics in the hanging configuration. We are applying multiple torque pulses with multiple torque magnitudes to get an average linear response – remember that you linearized the plant.
model in Homework 9 and thus we can only find an approximate linear model that describes the system.

The output from this experiment will be tabulated in three columns. The first is the angular position of the pendulum in degrees multiplied by 100. The second column is the time multiplied by 100. The third column is the applied torque. The applied torque will have a magnitude of 100 for a few oscillations, then 150, then 200. The angular position and time must be divided by 100 once it is exported to MATLAB for it to be useful.

You do not know the units of the applied torque, but you do know the relationship between the applied torque and the pendulum response (pendulum response measured in degs). Using your data and the second order model you developed for the hanging pendulum in Homework 9, develop a transfer function relating the applied torque to the pendulum response in terms of $\bar{k}$, $\omega_n$, and $\zeta$. You can find numbers for $\bar{k}$, $\omega_n$, and $\zeta$ by plotting your experimental results and matching up your ideal linear system response from Homework 9 and adjusting $\bar{k}$, $\omega_n$, and $\zeta$ until the experimental and linear system responses match; if you did not get the correct answer in Homework 9, check the homework solutions so that you can get an accurate model from here forward. Do this for each torque pulse and then average all of your estimate $\bar{k}$, $\omega_n$, and $\zeta$ values to get an average system model. **Report your $\bar{k}$, $\omega_n$, and $\zeta$ values for each trial, average $\bar{k}$, $\omega_n$, and $\zeta$ values, and plot 3 representative pulse responses of your system. Attach all code used to get your model.**

Problem 3: Given your average $\bar{k}$, $\omega_n$, and $\zeta$ values from Problem 2 and your comparison between the hanging and inverted system models in Homework 9, derive a transfer function model for the pendulum in the inverted position. Report your model and pole locations for this inverted, unstable system.