EE/AA 448: Sensors and Actuators

Laboratory Module #6

Modeling the Pendulum Rig

Assigned: Feb. 13, 2009

Due: 12:30 PM, Monday Feb. 23, 2009 (In Class)

WARNING: THE PENDULUM RIGS HAVE POWERFUL MOTORS AND CONTROL BIG PIECES OF FAST MOVING ALUMINUM. THEY RUN ON HIGH VOLTAGES AND STRONG CURRENTS. DO NOT DO ANYTHING UNLESS YOU KNOW APPROXIMATELY WHAT WILL HAPPEN WHEN YOU DO IT. BE CAREFUL!!!!

Objectives

The objective of this lab is to find the parameters of the pendulum rig.

You Will Need...

To complete this module, you will need

1. A pendulum rig
2. A power supply
3. A multimeter
4. An I/O card and workstation

Calibrate the Sensor

With the pendulum motor off, calibrate the sensor. For each of several angles, measure the angle and the voltage across the potentiometer sensor. Fit a line to this curve and use the slope and intercept in your code to determine the angle (in radians) from the voltage.

You might have to do this every time you start on a new rig, at least to determine where zero radians is. Figure out an easy way to change this in your code.

Measure the H-Bridge Gain

Turn on the system. For each of several (not too big) signals sent from the I/O card to the board, record the applied voltage and measure the voltage across the motor. Use this to get the relationship (a constant multiplier) between the applied voltage and the motor voltage. When we speak of the voltage input to the system, we mean the voltage across the motor.

Measure the Natural Frequency and Damping Ratio

With the power disconnected (or the motor switch off) and the circuit open (so no current flows), swing the pendulum back and forth and record the angle in LabView. Use these data pairs to estimate the natural frequency and damping ratio according to the lecture notes. Do this about ten times to obtain error bars.

From these values and the values of m and l written on the bobs, determine the moment of inertia J of the pendulum. The values of m and l will appear on the web page.

Measure the Motor Constant, K

Apply a constant voltage input. Apply only enough to raise the pendulum to about $\pi/8$ radians. After the system comes to equilibrium, measure the steady state current and position and use these values to determine K. Do this several times too to obtain error bars. Note that the pendulum will come to rest at different angles depending on which side of the steady state position you start.

Simulate the System

Using the parameters you measured and the values of m, l, R and L given to you by the instructional staff, come up with a Simulink model of the system. Plot the impulse response of the system in all states (θ, ω and I) and compare to the actual system. Your simulation will be nonlinear due to the $\sin\theta$ term.