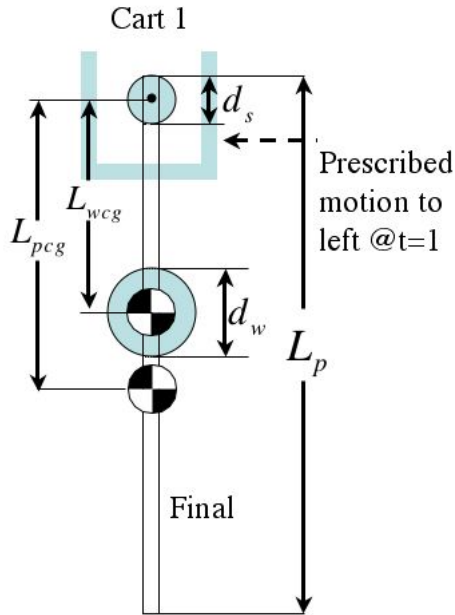


ES 204  
 Mechanical Systems Crane Lab

**Objective**

Experimentally determine the best location of the moveable mass such that the crane does not move after programmed motion of the 'trolley'. You will collect data from an actual system with moveable mass, and compare to your theoretical result from the homework.



**The system**

The ME and ECE departments share the dynamic systems and controls lab in room C-116. This equipment is precisely instrumented, and includes real-time interface through desktop PCs running Simulink with Real Time Workshop. For this experiment, we will be using the ECP Rectilinear system with inverted pendulum accessory. Mounting the pendulum accessory to cart 1, we have a scale model of an overhead crane, with adjustable inertia properties.

The software is configured to move cart one 4 cm to the left in a sequence of two abrupt moves. This is a well known strategy for moving an overhead crane such that the apparatus arrives at the desired position without residual oscillation. The overall system is depicted in Figure 1.

**Figure 1: System Schematic**

The system nominal dimensions are shown below:

- pendulum mass..... $m_p = 68.5$  g
- moveable weight..... $m_{add} = 88$  g
- pendulum length..... $L_p = 43.2$  cm
- Sensor diameter..... $d_s = 2.5$  cm
- moveable weight diameter.. $d_w = 5$  cm

Note that the pivot axis goes through the center of the sensor, so the pendulum rod cg is located at a distance  $(L_p - d_s)/2$  from the pivot. During the lab, test the configurations 1 through 8 shown in the Figure 2. (The pendulum is laid out in its horizontal position for the sake of space). The added mass cg is depicted only for configuration one. Noting the dimensions above, the minimum distance from pivot to added mass cg is  $L_{cgmin} = d_s/2 + d_w/2$ . The eight suggested configurations have a distance from pivot to added mass of

$$L_{wcg} = d_s/2 + (n - 1/2)d_w, \quad n = 1, 2, \dots, 8$$

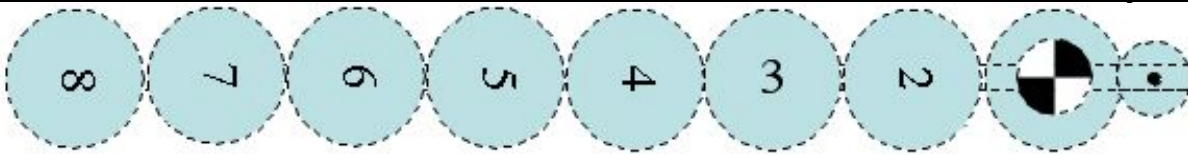


Figure 2: Experimental configurations

It may help to mark lightly in pencil the location of the bottom edge of the moveable weight for case  $i$  in order to precisely position it for case  $i + 1$ . Tables are provided at the back of the handout for recording your experimental data.

### The process

We will run each of the eight configurations using a single 4 cm move strategy and then using the double 2 cm move strategy. You will find that there is little difference between configurations; how the trolley is moved goes a long way to eliminate residual swing in the first place. The single move strategy is employed in the simulink model 'crane\_single'. For the double move strategy, use the model 'crane\_double'. For each experimental configuration, record the final angular velocity for three runs since there may be some experimental scatter. For each run, you need to do the following.

1. Move cart one at least 2cm right of center and make sure the pendulum is at rest in the **vertical** position. Run the simulink file 'ecpdsresetmdl', a picture is shown below. Click the 'connect to target' button. The 'play' button should turn black--click the play button and wait about two seconds. You have just reset the system encoders. This is an important step in getting a precise measurements of angular position and velocity.

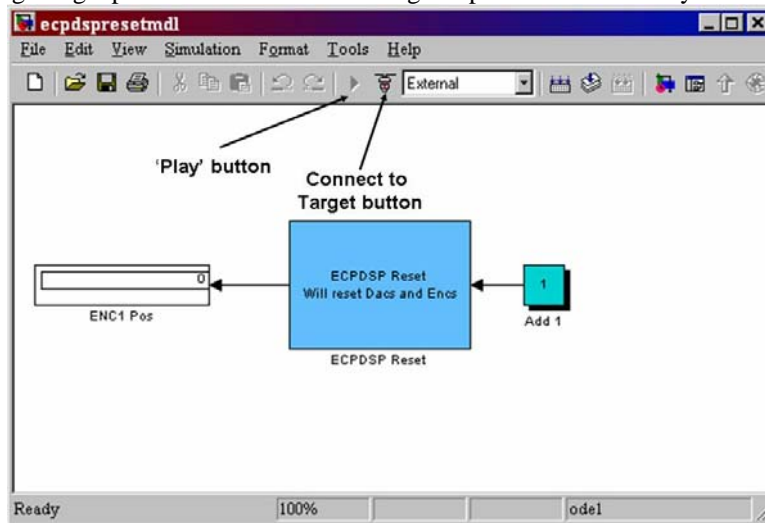


Figure 3: ecpdsresetmdl.

2. Push the black button on the big interface box which connects the computer to the device.

3. In the simulink file 'crane\_[strategy]', push the 'connect to target' button--the play button should turn black. If you get 'internal error', just ignore it, push close and try again. Push the play button and watch the pendulum. The 'final' angular velocity will be recorded as omega\_final. Record this number.

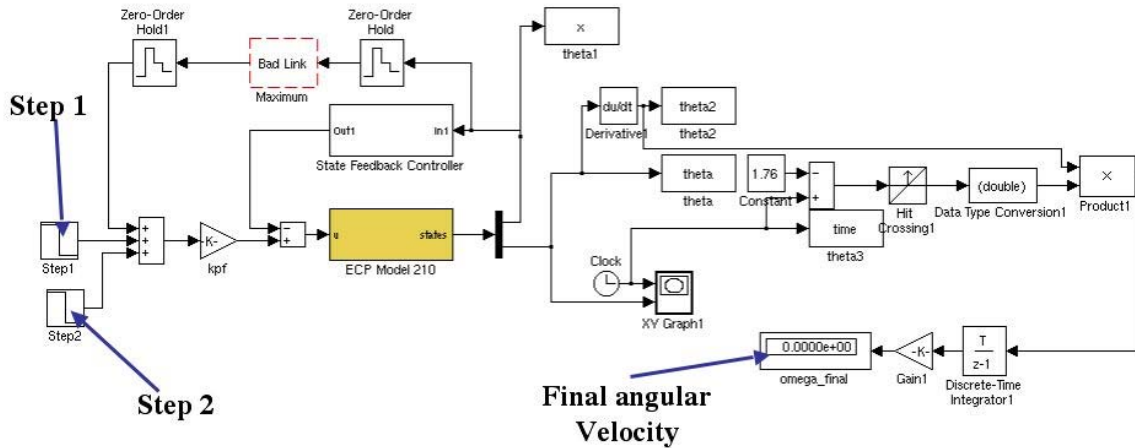


Figure 4: Crane\_double Simulink

4. Repeat the steps 1-3 three times for each configuration. Now you are ready to move the weight to the next configuration and repeat steps 1-5. An Excel spreadsheet can be downloaded from the website for recording your observations. Finally, try configuring the system according to find the an optimal location to minimize the angular velocity at the end of the run. Record any additional data you take in the spreadsheet.

5. The Excel spreadsheet, Working Model result, and analytic homework solution will be due Friday of 10<sup>th</sup> week. A cover sheet will be provided during your 10<sup>th</sup> week lab. Include Excel scatter plots of final  $\omega$  as a function of  $L_{wcg}$ . Use the 'Scatter with data points connected by smoothed Lines' option when plotting in Excel.

**Important Note:** If cart one rams into a limit switch, or in any way appears unstable, reset the system using the steps below. Note that we are using a feedback controller to precisely move the cart 2cm left and release the pendulum. This system is very dependent on reliable measurements from the sensors, so if something isn't properly reset, it could result in damage to the equipment

Quit Matlab.

Start the ECP32 program found under Start->Programs->ECP->ECP32.

Download the controller personality file by selecting Utility->Download Controller Personality File

Navigate to c:\Program Files\ECP Systems\cn\m210\_rtw3.pmc and click Open

Close the ECP32 software.

Restart Matlab.

Navigate to the Desktop\ES204 directory. Open the Simluink files and rebuild final\_four.mdl.

Now try again.