ECE-205 Lab 2

Introduction to Mobile Studio

Throughout this lab we will focus on the use of the Mobile Studio board for measuring the response of first and second order circuits. Our goal is to become familiar with some of the features of this board and how to use it. We will also continue to introduce some Matlab programming.

The end result of this Lab will be a memo written to me that includes the figures you generated using either Mobile Studio or Matlab. Each figure needs to have a figure number and a caption. The body of the memo should be fairly short (less than one paragraph). Do not reiterate what you did in the lab, but tell me what parts of the lab were confusing, what you liked and what you didn't like.

PART 1

1) Using a bread board construct the following circuit using a 1 μf capacitor and a 1 kΩ resistor. These components should be available in your lab kit. We will measure the output of the circuit as the voltage across the capacitor. We will be trying to estimate the time constants for this circuit as we vary the resistance. The time constant for this circuit is $\tau = RC$, and we will measure the time constant by determining the 10%-90% rise time, t_r, and using the formula

$$\tau = \frac{t_r}{\ln(9)}$$

that you derived in homework.
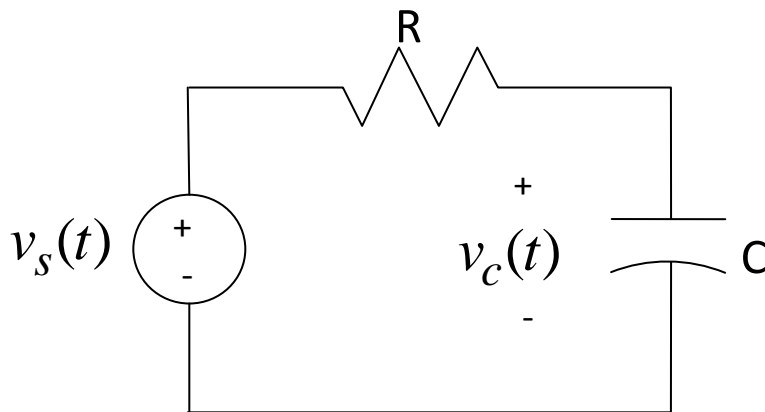
2) The connection pins for the Mobile Studio boards are shown in the figure below:
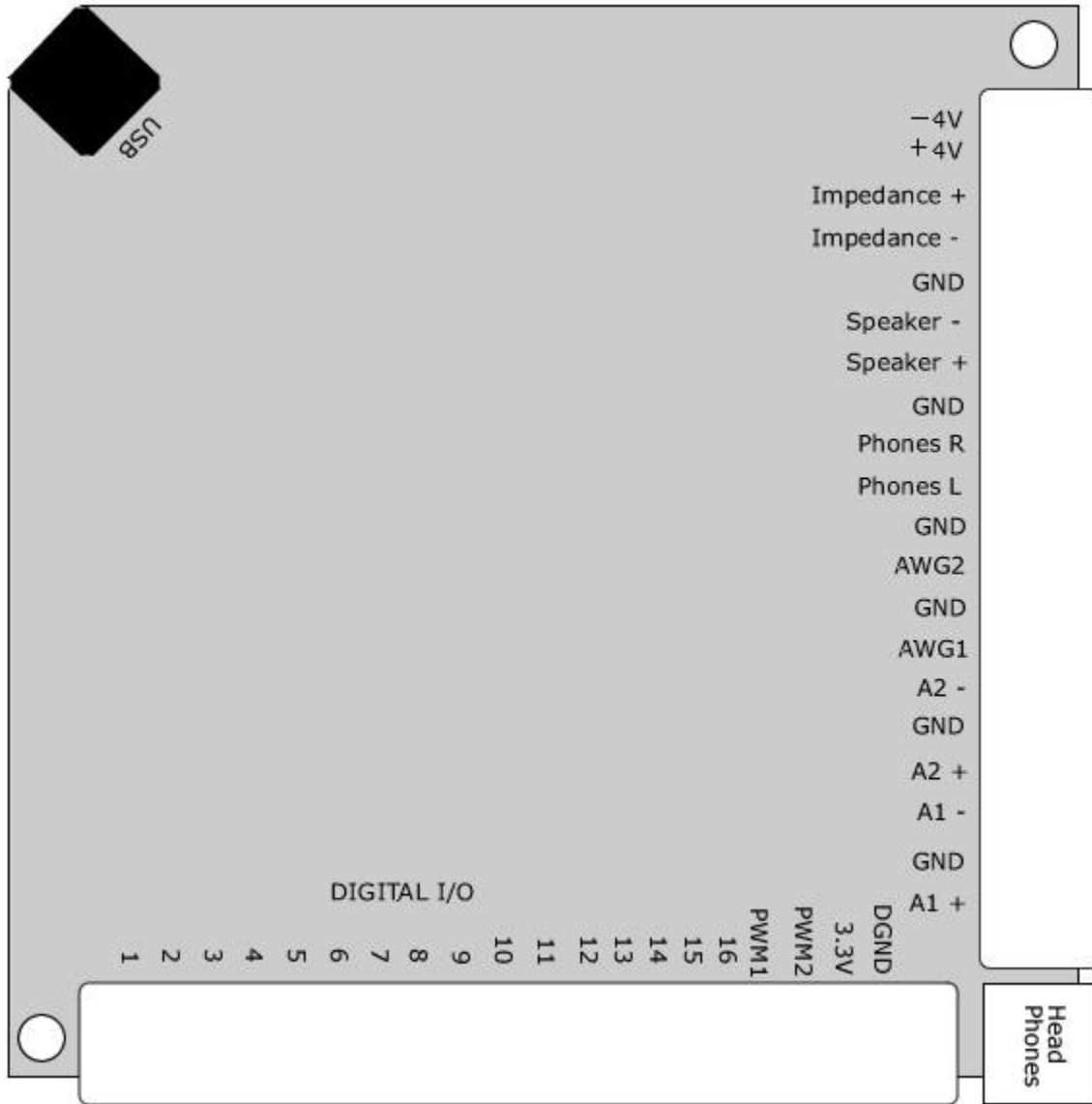

Connect the source (**AWG1**) and ground (**GND**) as the input to your circuit, and connect **A1+** to the positive end of the capacitor (where you think it will be positive) and connect **A1-** to the negative end of the capacitor. If you get these reversed you will just get an output that is the negative of what you expect.

3) Start Mobile Studio. If you cannot find the icon, use

Start →All Programs→ Rensselaer→ Mobil Studio Desktop →Mobil Studio Desktop

4) Start the **Function Generator.** Set channel 1 to a 50 Hz square wave, with a 0 DC offset and peak to peak value of 2.0 volts. Set channel 2 to a zero output (we will not be using it). Use the push pin to minimize the function generator once it is set.

5) Start the **Oscilloscope.** Set channels 1 and 2 to 500 mV/div and to DC coupling. Set the input on channel 1 to **A1-Diff** (this measures the voltage across the capacitor, or the difference between **A1+** and **A1-**), and the input on channel 2 to **AWG1** (the signal being generated). Be sure to **Enable** both of the channels.

6) Locate the right hand panel with the word **Trigger** at the top. Set the **Mode** to **Normal** and the **Source** to **Ch2**. On the left edge of the oscilloscope you will see a short segment of a red line. Hover the cursor over the line until you see a line across the screen, this is the triggering threshold. It needs to be in the middle of a well defined signal (such as channel 2). If your oscilloscope does not seem to be able to lock onto a signal, be sure to check your triggering level. (You may also want to play with changing the trigger to the Falling or Rising edge of a signal).

7) Lower down in the same column you will find controls for the **Horizontal** scaling. In this panel set the **Time/Div** to 2.00 ms and the **Mode** to Y-T.

8) Start the system, by clicking on the **Start/Stop** button in the lower left of the screen. You should get a scope that looks more or less like the following: a capacitor changing and then discharging repeatedly.
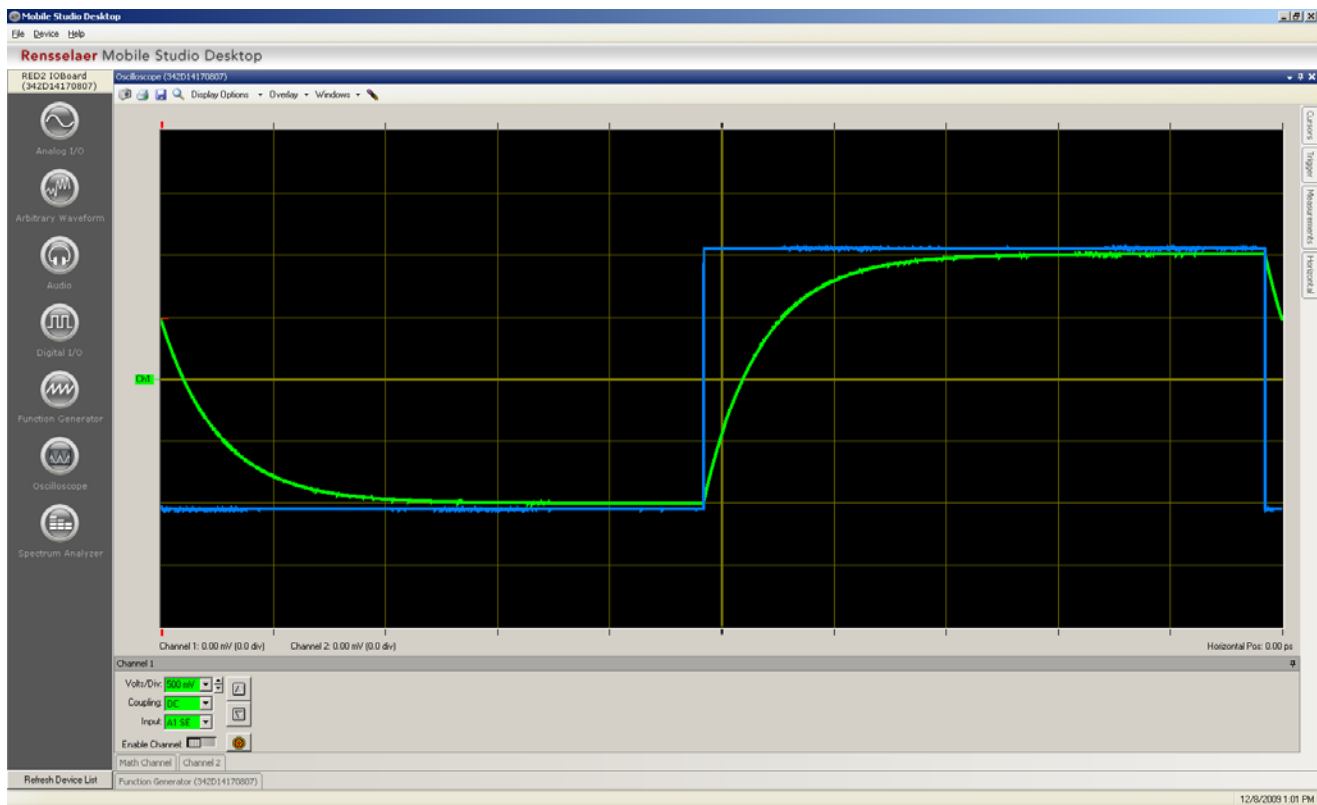
9) Next we want to make measurements on our signal. On the right panel, **Enable** the cursors. We will be making measurements on channel 1, so you will need to find the **green** cursors. You may find them in the middle of the screen, or lurking just at the edges. *The measurements are taken from the location of the special symbols on the cursors*. See the bottom of the cursor panel for the shape of these symbols.

10) Align one of the cursors at the top of your output signal, and the other at the bottom of your output signal. The difference of these two cursors will be displayed in the **Cursors** panel (under **Delta**) . The output signal should be around 2 volts peak to peak. Let's assume you measured the peak to peak value as Δ, so we have ch1_high – ch1_low $=\Delta$ Then align one of the cursors at an amplitude of ch1_low $+ 0.1\Delta$, and the other at an

amplitude of ch1_high – 0.1 Δ , this will give us a measure from 10% to 90% of the signal. Now look again at the Delta for this signal, but look at the absolute value of the time difference. This should be the rise time, t_r . Using this rise time, compute the time constant using the formula

$$\tau = \frac{t_r}{\ln(9)}$$

Your time constant should be very close to 1 ms for this circuit. Compute your percent error, and if it is more than 15% off ask for help. Record your work computing your error and include it in your memo.

11) Next we want to capture a screen shot to put into your memo. Near the top left corner of the oscilloscope is a **camera icon**. Click on the camera icon to save a screen shot to a file. Then (***right now!***) include this screen shot in your memo for this lab. Do not wait to see if it all worked out! Put in a figure number and an appropriate caption.

12) Finally, we would like to get the data that the scope is plotting. Near the top left of the oscilloscope, there is a **(floppy) disk icon**. Click on that and save your data to a .csv file. You should save this file in a convenient folder, such as the folder you made last week, since we will next be using Matlab.

PART II

In this part we are going to learn how to read in the data from the scope and plot it. We will also learn how to make measurements on the data.

1) Open the .csv file you generated, and remove the first row. Matlab often has difficulty reading text and data (it forms a data structure, but we don't want to deal with that now). Save the file. I saved my file as **bobdata.csv.**

2) Start Matlab and open a new m-file.

3) We first read in the data as a matrix, then extract the columns of the matrix. The first column is the time, the second column is the data for channel 1, and the third column is the data for channel 2. The following Matlab commands should accomplish this:

data = importdata('bobdata.csv'); % read in the data file
t = data(:,1);   % get the first column
ch1 = data(:,2);   % get the second column
ch2 = data(:,3);   % get the third column

4) Now plot both channel 1 and channel 2 as a function of time. Be sure to use two different line types and two different colors. Also include a legend and label the x and y axes. The **xlabel**, **ylabel**, **grid**, and **legend** commands will help. Your plot should look more or less like the following:
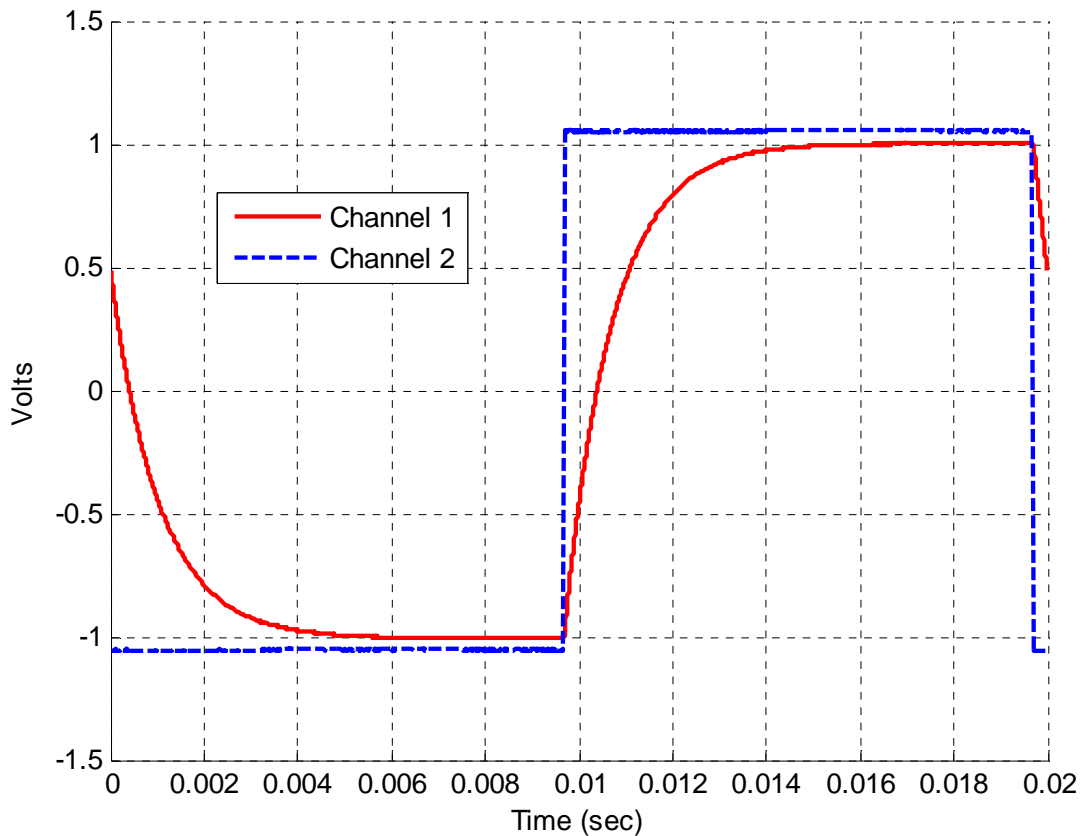
5) Now we want to measure data from this figure. In the top of the Matlab figure, locate the **Data Cursor** icon and click it. Then go to the output graph and click on it. The cursor will show the data points. You can slide this cursor up and down the curve as you wish. Use these data points to gain estimate the time constant for the system. To get a second cursor, right click on the first cursor and choose **Create New Datatip.** You should end up with a graph something like the graph on the following page. Note that Matlab only has available the data points from the data, so you will not be able to exactly get the points you want. Include this figure in your memo (with a figure number and caption), and show your work estimating the time constant on your work sheet.

 6) To copy this figure into your memo, on the figure click **Edit** and then **Copy Figure**. Then you can paste it into your word file.
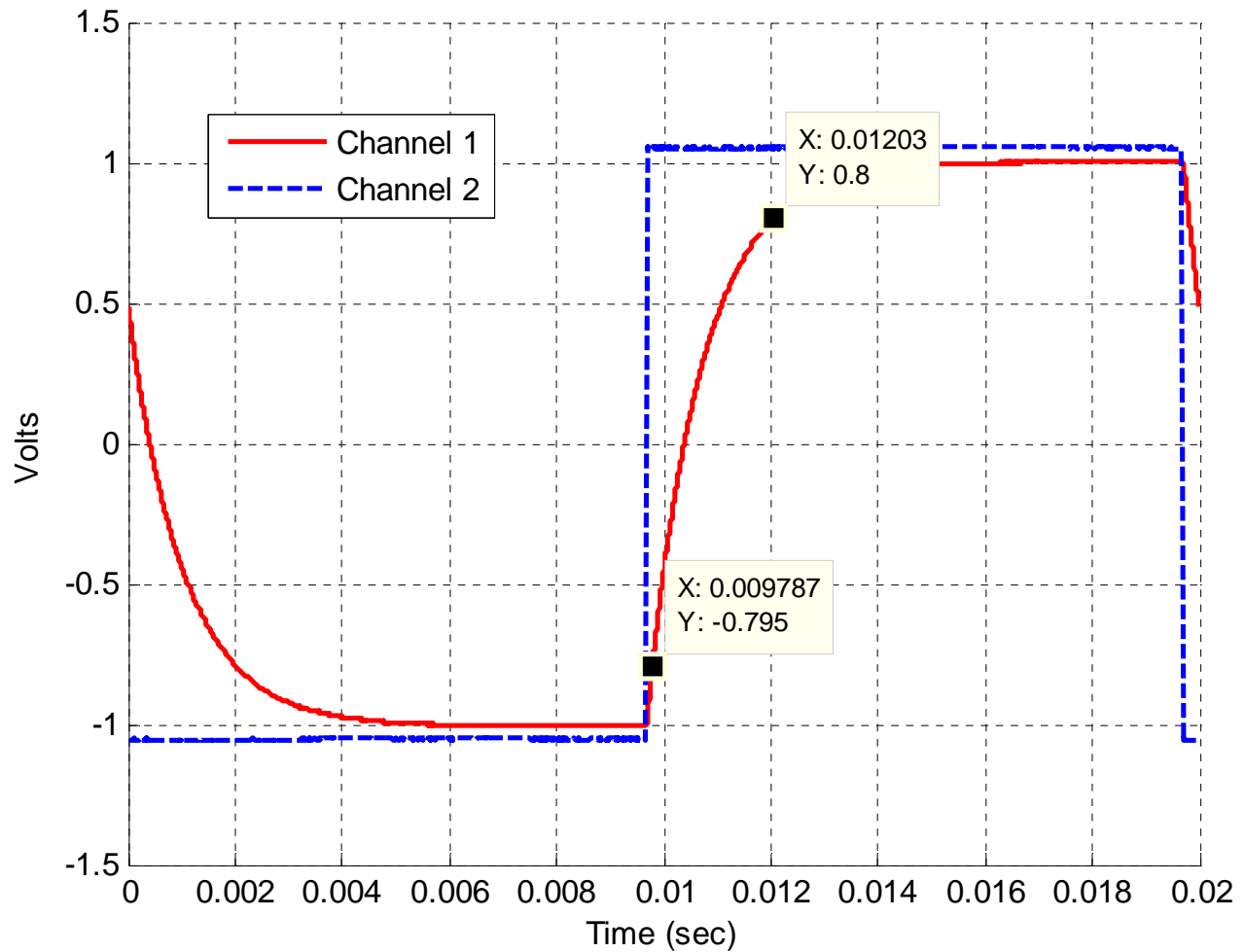
Part III

We are now going to repeat the above procedures for two different time constants. Hopefully you will get more of a feel for what a time constant means by doing this. In what follows, *be sure your signal has reached steady state.* This means it is not changing and is basically **flat**. It should start and end flat (the slope of the signal is zero)

1) Replace the 1 kΩ resistor with the variable resistor in your lab kit. You may need to bend the outside edges a bit. I connected the input to an outside leg and the output to the middle leg. One of the outside legs should not be connected to anything.

2) Adjust the resistor so the time constant is **significantly smaller** than our original 1 ms time constant. Change the **Time/Div** (x-axis) so you get a reasonably good graph. You may also need to change the **frequency** of the signal generator. *You should not have more than three periods of the output waveform on the graph.*

3) Go through the above steps to use the cursors to estimate the time constant, then include a screen capture in your memo, export the data and use Matlab to plot the result again. This should produce two more time constant estimates, though this is a new time constant. Be sure to show your work estimating these time constants in your memo.

4) Adjust the resistor so the time constant is **significantly larger** than our original 1 ms time constant. Change the **Time/Div** (x-axis) so you get a reasonably good graph. You may also have to change the **frequency** of the signal generator. *You should not have more than three periods of the output waveform on the graph.*

5) Go through the above steps to use the cursors to estimate the time constant, then include a screen capture in your memo, export the data and use Matlab to plot the result again. This should produce two more time constant estimates. Be sure to show your work estimating these time constants in your memo.

At this point you should have six graphs in your memo, three from screen captures and three from Matlab. You should have six estimates of time constants (two per time constant).

PART IV

In this final part, we will look at the response of a second order circuit and how changing the damping ratio changes the characteristic of the output.

1) Construct the following second order circuit:
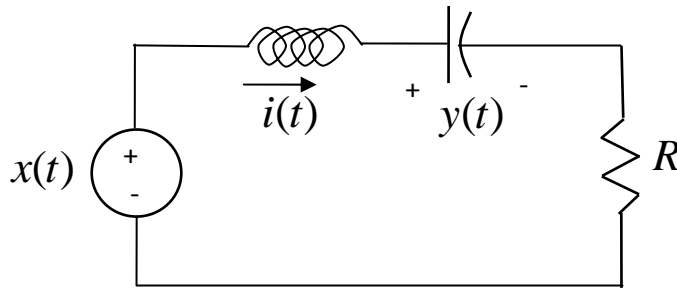
For this circuit, use your variable resistor for R, use a 0.01 μ fcapacitor, and a 33 mH inductor. ***You will need to get the inductor from me.***

2) Set up Mobile Studio to provide the input and measure the output. The input should be a 1.2 kHz square wave with a 0.5 volt offset and 1 volt peak to peak. The output is the voltage across the capacitor.

3) You will need to vary the **Time/Div** to get a good view of what is going on. Start off with the potentiometer somewhere in the middle of its range.

4) The parameters for this problem are $\omega_n = \dfrac{1}{\sqrt{LC}}$ and $\zeta = \dfrac{R}{2}\sqrt{\dfrac{C}{L}}$, so by varying the resistor we can directly vary the damping ratio but not change the natural frequency.

5) Choose a resistance to provide no overshoot. Try to get as close to an overshoot as you can though. Get a snapshot of your waveform, and put it in your memo (no Matlab here). Be sure to number your figure, and give it a good caption.

6) Choose a resistance to provide an overshoot between 40 and 50%. Use the cursors to verify the overshoot. Get a snapshot of your waveform and put it in your memo (no Matlab here). Be sure to number your figure, and give it a good caption. Include your calculation of the overshoot in your memo.

All Done!

Your memo should have 5 snapshots, 3 Matlab figures, and a page or two of calculations. Be sure the figures are large enough an old guy can see them. Finally, the body of your memo should indicate anything you found confusing or cool about this lab. It should be short.