Laboratory Rules and Guidelines

1. Please check the website for your laboratory assignment before coming to class.
2. Please print out single sided, blank laboratory reports before coming to class. If you prepare your laboratory report during the class hours, then you may use the printer in the laboratory.
3. Please do not scribble or write on the laboratory manuals.
4. Please show all work on back pages of the laboratory report. Do not plug values into your equations until the final step.
5. Please write the date, section number, and names of all group members on the first page of each report of laboratory experiment.
6. Please turn off the controller box before leaving.
7. Please clean up your desk area and push in your chair before leaving.

General Laboratory Procedure

1. Set up physical hardware
2. Set a trajectory
3. Define and implement a controller
4. Define which data you wanted to be recorded
5. Execute your trajectory
6. Plot your results

Before running your experiment, you must define the trajectory that you want your system to track. For example, if you have a mass connected to the end of a linear actuator, you may want the mass to oscillate. For this case, you would choose a Sinusoidal trajectory. Or you may wish to displace the mass at time $t=0$, let the mass the “dwell” at that position for some time without moving, and then have it return to its original position at some later time. For this case, you would use a Step trajectory.

To define a trajectory, select Trajectory under the Command menu. Aside from Step and Sinusoidal, you can choose Impulse, Ramp, Parabolic, Cubic, and Sine Sweep. After choosing the desired type of trajectory, you can define its parameters by clicking on Setup.

In some experiments, you will physically provide the input to system (as opposed to an actuator). For example, you may twist a disk or push a carriage. In these instances, you will use a Step trajectory to record the system response. Under the Setup menu for the Step trajectory, the Step Size should be set to “0”. You set the amount of time for which the computer will record data by varying the dwell time and Number of Reps.

After selecting your trajectory, you will need to implement a controller (in most cases, but not all). Why would you want to use a controller? Well consider your actual trajectory; i.e., the actual recorded response of your system. For example, let your command be a mass to follow a specified trajectory. When you execute this trajectory, you will notice that the actual trajectory does not exactly match up with the desired trajectory. In other words, the system may not perfectly “track” its reference input. To improve tracking and make the system response more closely follow the specified trajectory, we implement a controller. Note that the specified trajectory is called Commanded Position in the software that we use. This discipline within engineering is known as Control Theory or Feedback Control of Dynamic Systems.

ME 455 is the first of many courses that explores this topic.
To implement a trajectory, choose Setup and then Control Algorithm. The lab manual will specify the type of controller (PID, PI w/ velocity feedback, etc.) and type (Continuous or Discrete). After specifying these parameters, choose Setup. Here, you will implement parameters that you have previously calculated. After clicking OK, you need to click on Implement Algorithm. Make sure that the controller box is On when you execute this operation.

Under the Data menu, choose Setup Data Acquisition. Make sure you have all of the right parameters selected before running your experiment. The lab manual will always specify which parameters need to be selected.

After you have defined your trajectory and implemented your controller, you may run the system by selecting Execute from the Command menu.

Finally, you will need to plot your results after your system executes the trajectory. To do this, click on Plotting and then Setup Plot. The lab manual will guide you in what to select in this window. After you have completed the experimental part of your laboratory work, click Plot Data to view your plot.

More helpful hints:
1. Convert from Hertz to radians when using frequency in a calculation
2. Make sure the controller box is turned on and make sure it is on when you implement your control algorithm.
3. Always “zero” the encoders before executing a new trajectory. Under Utility, select Zero Position to perform this operation.
4. If you are sure your hardware and software is set up correctly and you are still not seeing reasonable results, try the following:
   a. abort your controller and re-implement it
   b. select Reset Controller from the Utility menu
   c. unplug the power cord from the controller box, wait 10 seconds, and the plug the cord back into the box
5. Very often you will generate plots and need to determine the natural frequency and damping ratio from the plot. For all of these experiments, we can assume that damped frequency is equal to the natural frequency because the damping ratio is small. We may also using the following equation to find the damping ratio:

\[ \zeta = \frac{1}{2\pi} \log \left( \frac{X_0}{X_n} \right) \]

When you record frequency from your plot, it will be in units of Hertz. Be sure to convert this value to radians per second before using it in any equations.

6. If your experiment goes crazy, push the red off button on the controller box or click abort controller in the bottom right-hand corner of the ECP software screen.