

**First, go to the Google sign-up sheet and select one of the following: Active Damper on a Pendulum, Ball-and-Beam or Programmable Logic Controller (PLC).**

**Active Damper on a Pendulum OR Ball-and-Beam**

1. Write down which of the lab exercises you have chosen.
2. Write out the rotational equation of motion for the system. Include proportional and derivative feedback  $\tau = k_p(\theta - \theta_s) + k_d\dot{\theta}$  or  $\theta = k_p(x - x_s) + k_d\dot{x}$  in your equation.
3. Re-arrange the equation to be in form of a damped harmonic oscillator.
4. Derive a formula for the natural resonance frequency  $\omega_n'$  in terms of the feedback gains and system parameters.
5. Derive a formula for the damping ratio  $\zeta'$  in terms of the feedback gains and system parameters.

**Programmable Logic Controller (PLC)**

1. You will use the Arduino Opta PLC. Look through the user manual for the Opta PLC and bookmark it on your computer.

<https://docs.arduino.cc/tutorials/opta/user-manual/>

2. Arduino has developed a new IDE platform capable of programming ladder logic. Browse the website for the Arduino PLC IDE software to see what it is all capable of doing.

<https://www.arduino.cc/pro/software-plc-ide/>

3. Download the Arduino PLC IDE software and install it on you or your lab partner's laptop. (Contact the instructor if neither of you have a Windows laptop.) Instructions for the installation and PLC set-up can be found here:

<https://docs.arduino.cc/software/plc-ide/tutorials/plc-ide-setup-license/>