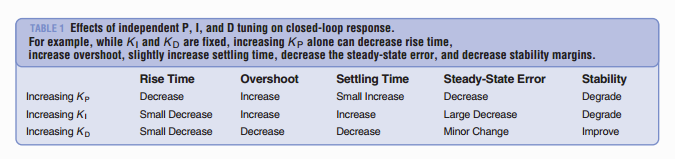
Grading Document - Lab 5

For your grading of lab 5.

## Pre Lab

1. PID:
   1. What is bang-bang control?
      1. Answer: Bang-bang control consists of three states of control: full-speed forwards, full-speed backwards, and stopped. When there is an error, the controller will send us as fast as possible in the direction of the setpoint.
   2. What does PID do?
      1. Answer: PID adjusts a control variable for a system based on feedback compared to a given setpoint.
   3. What does PID calculate?
      1. Answer: Answers may range. Technically, PID outputs a number that you assign meaning to by giving it a range and other attributes. Other acceptable answers are a system response… \*\*\*
   4. What does the P component do? What effect does it have on the system?
      1. Answer: P stands for proportional, this component acts proportionally to the error present in the system.
      2. For reference (as well as the following two questions)([ref](http://eprints.gla.ac.uk/3815/1/IEEE_CS_PID_01580152.pdf)):



* 1. What does the I component do? What effect does it have on the system?
     1. Answer: I stands for integral, this component acts on the steady state error present in the system.
  2. What does the D component do? What effect does it have on the system?
     1. Answer: D stands for derivative, this component controls how fast the system responds to the error present in the system.

1. Constant Tuning
   1. How does the Ziegler-Nichols tuning method work?
      1. Answer: This tuning method involves calculating your constants from a value of K\_p that causes stable and consistent oscillations. These values are calculated from the period of the oscillations and the oscillation-causing value of K\_p ([ref](https://en.wikipedia.org/wiki/Ziegler%E2%80%93Nichols_method)).
   2. How does the given practical method differ?
      1. Answer: Constant finding is done by trial and error. K\_p is kept at the value that causes oscillations ([ref](https://robotics.stackexchange.com/questions/167/what-are-good-strategies-for-tuning-pid-loops)).

## Discussion Questions

1. **Discussion Question 1:** What could be improved in this response?
   1. For context, this is asking about the Bang-bang controller response.
   2. Answer: Based on data, but generally: It doesn’t settle.
2. **Discussion Question 2:** What does the K\_p constant do?
   1. Answer: Yes, this is a repeat question but I think its necessary to repeat it so it sticks in their heads more. See answer from prelab, however they should include observations from their data.
3. **Discussion Question 3:** What does the K\_d constant do?
   1. Answer: Same as above. See answer from prelab, however they should include observations from their data.
4. **Discussion Question 4:** Which plots are underdamped? Which constant contributes more towards an underdamped system?
   1. Answer:
      1. Plots that are underdamped are the ones that oscillation occurs in.
      2. No right answer here, look for explanations based on the data that make sense.
5. **Discussion Question 5:** Which plots are overdamped? Which constant contributes more towards an overdamped system?
   1. Answer:
      1. Overdamped systems are ones that take forever to get to the setpoint.
      2. No right answer here, look for explanations based on the data that make sense.
6. **Discussion Question 6:** How does the delay affect your stable, critically damped PID controller?
   1. Answer:
      1. 1, 10, and 100 should be fine (100 might actually give the best response).
      2. Delays of 1000 and 5000 should give large oscillations.
7. **Discussion Question 7:** What constant contributes most to phase lag in your response? Why?
   1. Answer:
      1. Our setup is kind of bad for figuring this out, be lenient with this question.
      2. No right answer here, look for explanations based on the data that make sense.
8. **Discussion Question 8:** What constant contributes to signal attenuation most in your response? Why?
   1. Answer:
      1. Our setup is kind of bad for figuring this out, be lenient with this question.
      2. No right answer here, look for explanations based on the data that make sense.

## Lab Reports

1. **What does the ‘&’ sign do in your code?**
   1. Answer: Ok, relatively complex coding concept here. Base everything on the supplementary document I sent out.
      1. From document: “ When we put the ‘&’ sign before a variable, what we are saying is that we are telling the arduino where the [variable] is located.”
2. **What does the setMode function do in the PID library?**
   1. Answer: From the website: “Specifies whether the PID should be on (Automatic) or off (Manual.) The PID defaults to the off position when created. “ ([ref](https://playground.arduino.cc/Code/PIDLibrarySetMode))
3. **List all of the display functions built into the PID library.**
   1. Answer: The display functions built into the PID library are: GetKp(), GetKi(), Getd(), GetMode(), GetDirection() ([ref](https://playground.arduino.cc/Code/PIDLibraryDisplayFunctions)).
4. **PD vs. PI controllers.**
   1. **What is a PI and PD controller?**
      1. Answer: A PI and PD controller are PID controllers that don’t use a D or I constant, respectively.
   2. **What kind of controller did we use in lab?**
      1. Answer: We used a PD controller in lab.
   3. **What kind of situation is best for a PI controller?**
      1. Answer: From reference: “This means that it will track small changes well but in the event of a large change it will be prone to overshooting. Good for systems which are inherently heavily damped” ([ref](https://engineering.stackexchange.com/questions/12479/difference-between-pi-and-pd-controller)).
   4. **What kind of situation is best for a PD controller?**
      1. Answer: From reference: “It handles large changes well with minimal overshoot but isn't great for tracking small changes or errors. Good for systems which inherently have a lot of momentum” ([ref](https://engineering.stackexchange.com/questions/12479/difference-between-pi-and-pd-controller)).
   5. **What is more common: PD or PI?**
      1. *Note:* you will have to search online for the answer to Question 4e.
      2. Answer: PI is more common ([ref](https://www.csimn.com/CSI_pages/PIDforDummies.html)).
5. **Apply PID to the following sensor scenario:**

Consider an air conditioning scenario. We will be controlling the temperature of a single room, which we will measure with an analog thermometer in the room. Our air conditioner can both push out varying degrees of hot and cold air. In software, the magnitude is set with a variable called Control\_val. The range of values that can be accepted in Control\_val are: 0-750 (when heating), and 0-500 (when cooling).

1. **What is the input of the PID control system?**
   * + 1. Answer: the temperature from the analog thermometer in the room.

B. **What will we use for feedback?**

* + - 1. Answer: Trick question, its the temperature from the analog thermometer in the room.

**C. What will we use as our setpoint?**

* + - 1. Answer: Our desired temperature.

D**. What is the range of values that the PID should output?**

* + - 1. Answer: -500 to 750.