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% ENGR 130 Module 6.2 Report
% Section E
% December 3rd, 2023
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Lab 3

1. **What is the frequency in Hz of the signal driving the motor? How does this frequency change with the duty cycle?**

   We were unable to record a good frequency measurement for the signal driving the motor, but we observed an estimated value of ~480Hz. We also observed that this value did not change as we played with the duty cycle.

2. **Attach the .png file of the data you saved in Part 4.e.iv. and fill in the values describing your control into Table 1 as shown below.**

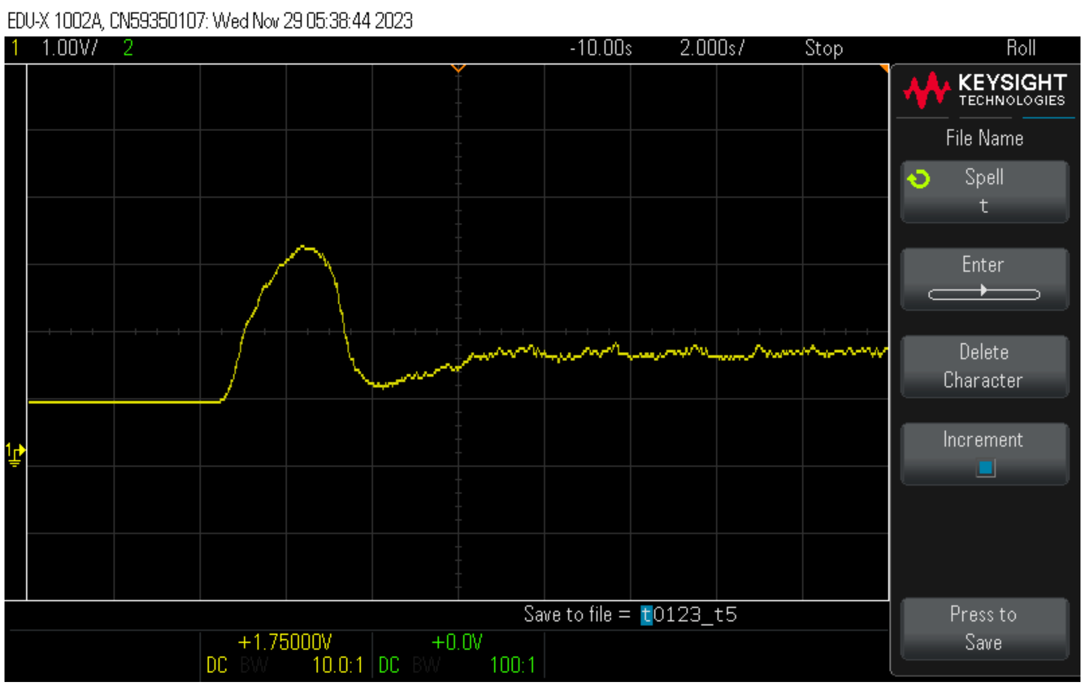

Table 1: Manual Control Parameters of Levitating Ball.

Final Value (cm)	Max Overshoot %	Rise Time (t_r)	Settle Time (t_s)
8.77	86.2312	0.3281	19.90625

3. **How difficult was it to control the ball's position using the potentiometer? Do you think you could drive a car with this control, with practice?**
   It was very difficult to control the puck's position, as even the smallest adjustments to the potentiometer caused large changes in the puck's position. Something as small as a 1% change in fan speed caused a 2 cm height difference in some of our trials. Although we were able to get control over the puck after a while, there are definitely better ways to perform system control tasks such as this one. It was also very difficult to start the puck, as we would often overshoot by a very large amount in our experiments. Driving a car, with practice, could theoretically be done, but it would put the safety of all other drivers in jeopardy. With enough training from all possible drivers, this control could be of use, but some type of technology, whether it be the engine system or an ABS, would make the vehicle significantly safer.

4. **Before Spring 2023, the circuit in Fig. 3 was built on a breadboard (Fig. 4). Explain the benefits and drawbacks of using a breadboard vs. the wiring harness for circuitry that you used in the current lab.**

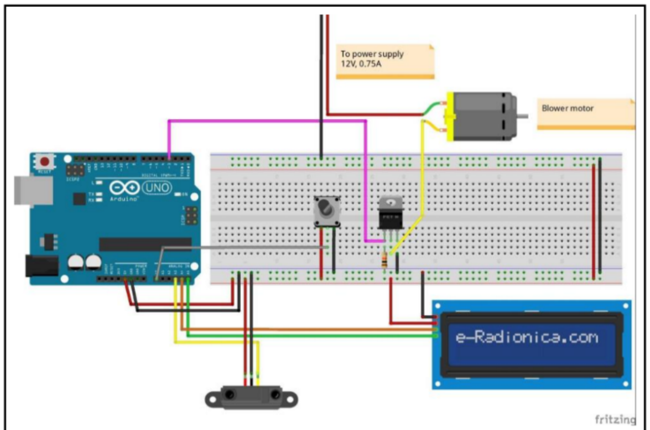

Figure 4: PWM control circuit

   a. The benefits of using a breadboard is that the points of connection of the circuit are slightly more organized and clear, while the wiring harness is likely to be tangled. The breadboard allows for easier disassembly, which is suitable for a lab environment.
   b. The drawbacks of the breadboard are that the wiring is more fragile and they are more suitable for simpler circuits. They have limited complexity if additional wiring was needed and it would become complicated to keep track of the positions of each connection. It is also difficult to have to set up all of the wiring every class period, as that takes away a lot of time from the actual systems control part of the lab. The wiring harness keeps things together for longer periods of time, which is suitable for an environment that sees multiple lab groups every day.

Lab 4

1. **Which P, I, and D gains worked best for your control? Give numerical values and explain what criteria you used to define the "best" control system.**
   We found that the best gains for our control were: P = 72, I = 36, D = 28. The "best" control system was one that had a brief, defined overshoot and initial fluctuation, which quickly evened out to the steady state with little noise observed in the signal. We used such a high P value in order to get the puck off the ground the quickest, the issue with this was that it would overshoot too high, which is why we increased the D value to the level we did. We chose the I value that we did because, experimentally, it led to the least amount of 'bobbing' experienced by the puck.

   Table 5: Final PID Response

Final Value (cm)	**Max Overshoot %**	**Rise Time (t_r)**	**Settle Time (t_s)**
2.4978	12.5738	2.5781	16.9922

2. **Overall, did the manual or PID control work better?**
   The PID control worked better. With PID, there were more knobs that could be manipulated to gain better control of the puck compared to manual control. There was also less influence from us, which decreases the chance for human error. Although we had to assign the values for P, I, and D, the arduino was the one actually doing the heavy lifting. This led to the PID control working better overall.

3. **What are some major differences between the simulated control system from Lab 1 and the real system we worked with? Think about the difference between the physics of the two systems and how that changes the controller's response.**
   In real systems everything may not always act as expected, so we had difficulties finding numbers that worked consistently, while with a simulated control system the same numbers work the same way every time. There are numerous outside factors that play into realworld systems, like friction, drag, and human error. The simulation we ran in Lab 1 was purely theoretical, assuming perfect conditions that are nearly impossible to achieve in the real world without heavy reliance on advanced technology and equipment.

4. **You might notice there is a lot of noise in the signal. What are some ways you can reduce the noise and get a more accurate reading of the position?**
   It may have been beneficial to use an IR sensor that was more advanced or more accurately calibrated. This would have led to more accurate data being recorded and displayed by the oscilloscope. We could have also played with the time scale or mode on the oscilloscope in hopes to gather less noisy data. The noise may also have been a result of the puck's deformities, so a more perfect fitting puck may have increased data accuracy.

5. **What could be improved about the system?**
   The system could include a puck that was of a larger size so that it didn't rattle around as much in the tube and instead was the perfect volume of the tube. The puck's rattling caused it to lose energy, and that interfered with the accuracy of our data. The fan could have also been improved. In our model, some of the data may be slightly skewed as there were slight variations in the fan speed that had nothing to do with code, and was instead a hardware issue. As commented on by our TA, our fan and arduino appeared to behave in an unexpected manner, as the exact same PID values would sometimes yield completely different results. Even pressing the red reset button on the arduino would not fix the inconsistencies observed. This proved problematic in data collection, as it became increasingly difficult to find PID values that were desirable. Also, some of our wiring, especially the ones that linked to the oscilloscope, were very inconsistent, and better connections may have helped our data.

	ENGR 130 Module Planning		Module	6	Section	E	Team	1	
			Scheduled		Actual				
#	Task	Deadline	Start	End	Start	End	Primary	Secondary	% Complete
	Type teams code for Lab 1	11/14	11/14	11/14	11/14	11/14	Karis	Lily	100
	Write algorithm for Lab 1	11/14	11/14	11/14	11/14	11/14	Trevor	Jack, Lily	100
	Double check function	11/14	11/14	11/14	11/14	11/14	Trevor	All	100
	Fill out table 1	11/14	11/14	11/14	11/14	11/14	Karis	n/a	100
	Type teams code for Lab 2	11/16	11/16	11/16	11/16	11/16	Trevor	Karis	100
	Fill out table 2	11/16	11/16	11/16	11/16	11/16	Jack	Trevor	100
	Fill out table 3	11/16	11/16	11/16	11/16	11/16	Karis	Trevor	100
	Fill out table 4	11/16	11/16	11/16	11/16	11/16	Lily	Trevor	100
	Test electrical componets	11/16	11/16	11/16	11/16	11/16	Trevor	Jack	100
	Build circut for lab 2	11/16	11/16	11/16	11/16	11/16	Lily	Jack	100
	Discuss Lab 2 Questions	11/19	11/16	11/19	11/16	11/16	Jack	Lily	100
	Type teams responses for Lab 2	11/19	11/16	11/19	11/16	11/16	Lily	Jack	100
	Assemble Module 6 Part 1 Report	11/20	11/19	11/20	11/16	11/16	Trevor	n/a	100
	Proofread Module 6 Part 1 Report	11/20	11/19	11/20	11/16	11/16	All	n/a	100
	Submit Module 6 Part 1 Report	11/20	11/19	11/20	11/16	11/16	Trevor	n/a	100
	Build the circut for Lab 3	12/4	11/28	11/28	11/28	11/28	Jack	Lily	100
	Use the osciliscope with the circut	12/4	11/28	11/28	11/28	11/28	Karis	Trevor	100
	Calibrate the Infared Sensor	12/4	11/28	11/28	11/28	11/28	Trevor	Karis	100
	Build the Puck Levitation System	12/4	11/28	11/28	11/28	11/28	Lily	Jack	100
	Control the Puck manually	12/4	11/28	11/28	11/28	11/28	Trevor	all	100
	Type code for Lab 3	12/4	11/28	11/28	11/28	11/28	Lily	Karis	100
	Discuss Lab 3 Questions	12/4	11/28	11/30	11/28	11/28	Karis	Trevor	100
	Type Responses for Lab 3	12/4	11/28	11/30	11/28	11/28	all	n/a	100
	Type Code for Lab 4	12/4	11/30	11/30	11/30	11/30	Jack	Lily	100
	Use Oscilliscope for Lab 4	12/4	11/30	11/30	11/30	11/30	Trevor	Karis	100
	Discuss Lab 4 Questions	12/4	11/30	12/2	11/30	11/30	Lily	Karis	100
	Type teams responses for Lab 4	12/4	11/30	12/2	11/30	12/3	all	n/a	100
	Assemble Module 6 Part 2 Report	12/4	12/2	12/2	11/30	12/3	Karis	all	100
	Proofread Module 6 Part 2 Report	12/4	12/2	12/3	11/30	12/3	all	n/a	100
	Submit Module 6 Part 2 Report	12/4	12/2	12/3	11/30	12/3	Jack	n/a	100
			Last Updated						
			Trevor	12/3					