Graduate Independent Project

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ITIS 5358 - Physical Computing

Section 1: Planning & Design

Original Plan

For my Graduate Independent Project, since it was a project for STEAM learning, I knew I could do something related to my job as an Instructional Assistant. Early on in the semester, we teach binary conversion in ITSC 1212 Introduction to Computer Science I. I also knew that each semester, we would have students struggling with this concept, and I have even heard from students this semester that still have never learned binary, because it wasn't taught in 1212 back then.

I came up with an idea of a physical device that I could use to help teach this topic. The plan was fairly simple, and the process seemed to be as well. I would create a device that had 8 toggle buttons/switches, each corresponding to a different LED or some other light, which represent the 8 bits of a byte. Then the device would take that input and run some calculations to display what the decimal and ASCII representations of that byte are. I also drew up an initial sketch of this idea during one of my other classes.

Tinkercad

To make this project easier, Tinkercad has a digital version of an existing chip that does exactly what I wanted for this project, and it ended up working on my other project as well. The PCF8574 I2C 8 Port Expander reads or writes inputs and outputs using a byte. For my project, I connected the toggle switches to one chip and the lights to another. This allows one to be an "input" chip and one to be an "output."

I also needed to introduce a secondary input type, since I had two outputs already (LED and LCD). To accomplish this, I brought in another toggle switch to switch from a "binary" input mode to a "decimal" input mode using a potentiometer. The potentiometer was mapped to 0-255, representing each decimal number achievable in a byte. Because I had one chip as input for the toggle switches and one as output for the LEDs, I could very simply use only the output chip to also display what the binary would be for that decimal number.

3D Printing

Along with the initial circuit design, the plan was to 3D print a box that could contain all of the necessary parts, making it a singular handheld device. This would

allow for less confusion by hiding all the crazy wiring and electronics. I was not planning on doing any laser cutting.

Background/Inspiration

In ITSC 1212, we have been teaching binary every semester that I have been an IA. Currently, we teach this concept by giving a short lecture in the lab about how binary works. There are 8 bits in a byte, a bit is a 0 or a 1, a full byte of 8 bits can represent a decimal from 0 to 255, and decimals 32-127 also have an ASCII representation, or a character that isn't just 0, 1, or a number. After giving this short lecture, the students go off on their own to answer a set of 9 questions:

- Q1: If you flip up the cards 64, 16, and 1, what decimal number do you get?
- Q2: What ASCII character does it represent?
- Q3: What is the decoded message? (they are given a string of light bulbs)
- Q4: How many bits are needed for your first name?
- Q5: How many bits are needed for your full name? Remember to include spaces!
- Q6: Write the binary, decimal, and ASCII for the first three letters of your name. Use your last name if your first name is shorter than three letters.
- Q7: Write the binary, decimal, and ASCII for the second representation of your letters.
- Q8: What differences do you see in the binary codes between uppercase and lowercase letters?
- Q9: Why do you think ASCII assigns different values for uppercase and lowercase?

For this activity, we would also provide them with a website that had 8 digital binary cards, each representing a bit in a byte. As of now, this website is no longer available, which was not the case when I made my original proposal. To make this entire process easier for some students, I came up with the idea for this device.

After having a conversation about it with my professor, Dr. Najjar, about this device, we found that it would be helpful. This device would allow us to give the students something they can physically interact with to help them understand the ins and outs of binary conversion. This serves as my first source of background/information.

For my secondary source, I found it difficult to find information on this topic, meaning there may be room for growth in this area. However, I did find one ACM Inroads article specifically about teaching binary representation of numbers and how it may positively affect students who are interested in software development (Walker & Grinnell College, 2023). In this paper, Professor Henry M. Walker concluded that knowledge of binary representation of data can have a "substantial impact on the writing of programs."

Section 2: Creating & Testing

Arduino Circuit

Creating the physical circuit proved not to be super difficult. I followed my Tinkercad design and did some simple testing, and it all worked out. However, as soon as I introduced the LED matrix functionality to show whether the user is in binary or decimal input mode, the LCD screen stopped functioning properly. I am not quite sure why this happened, and it even showed during my demo video, but otherwise, the project went very well in terms of bringing it to life, outside of the 3D printing/laser cutting aspect.

3D Printing/Laser Cutting

The original plan was to make a 3D-printed case for the whole project. However, I had very limited time to fit this all in. Therefore, I decided to pivot and do a laser-cut display to show which lights were on and what they represented, to go along with the LCD. I created an SVG and planned to cut it out the morning before the final exam time, where I would have presented. However, the world had different plans and decided to give me the flu, and thus, I was not able to 3D print or laser cut anything for this project. However, the SVG that I would have used has still been submitted with this document.

Activity

For this device, I had a short activity in mind, similar to that which we teach in class:

- Q1: What is the highest and lowest decimal representation achievable with a byte? Do they have ASCII representations?
- Q2: What is the lowest byte that has an ASCII representation? Highest?
- Q3: What are the byte and decimal representations of the letters that make up your favorite color?
- Q4: Using the decimal input mode, find the byte of the lowercase letter “o”.
- Q5: Using the decimal input mode, find the byte of the number “0”.

The intention for this activity is to allow the user to get familiar with the two input modes, while also achieving some tasks similar to the original activity we do in class. For the most part, this device would be used during that original activity in class.

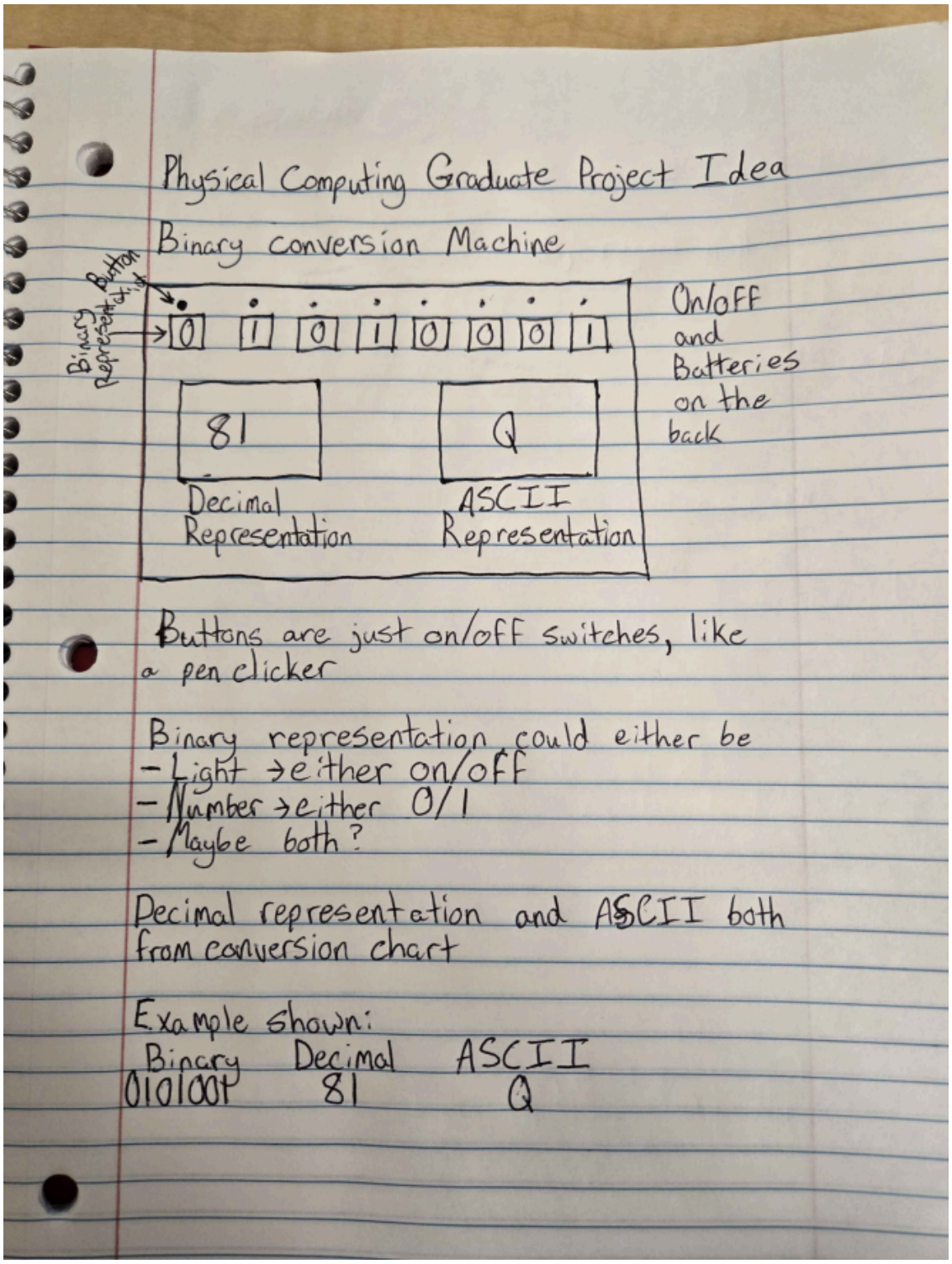
Section 3: Conclusion

Overall, I think this project was a success. I did end up with a device that achieved the same thing I was planning in the first place. However, this project was not without its mishaps. In particular, the biggest mishap was the 3D printing/laser cutting portion, which did not happen at all. Had this been successful, I think the project would have turned out a lot better. However, I would have needed to come

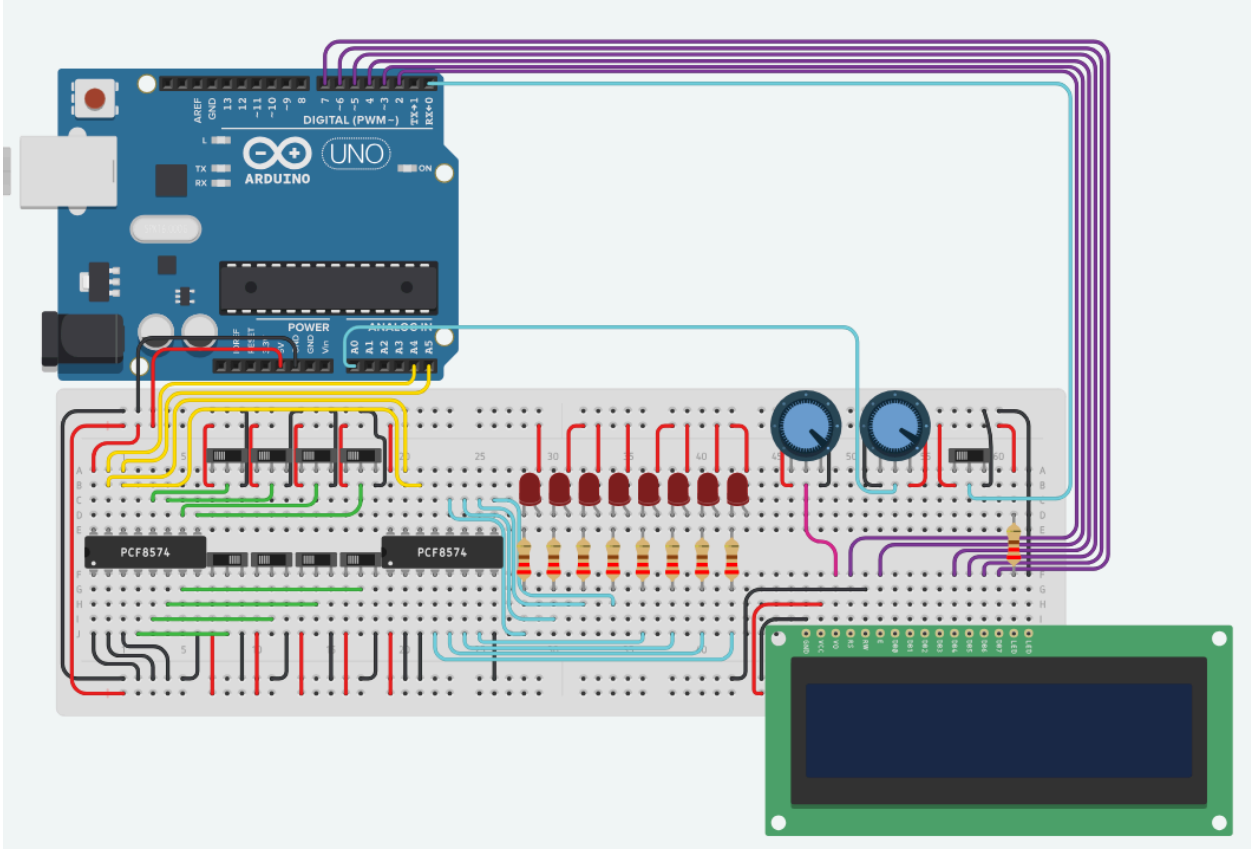
up with another solution than the toggle switches I used. This is because the ones I used did not connect to Dupont wires, so they had to be directly connected via the breadboard.

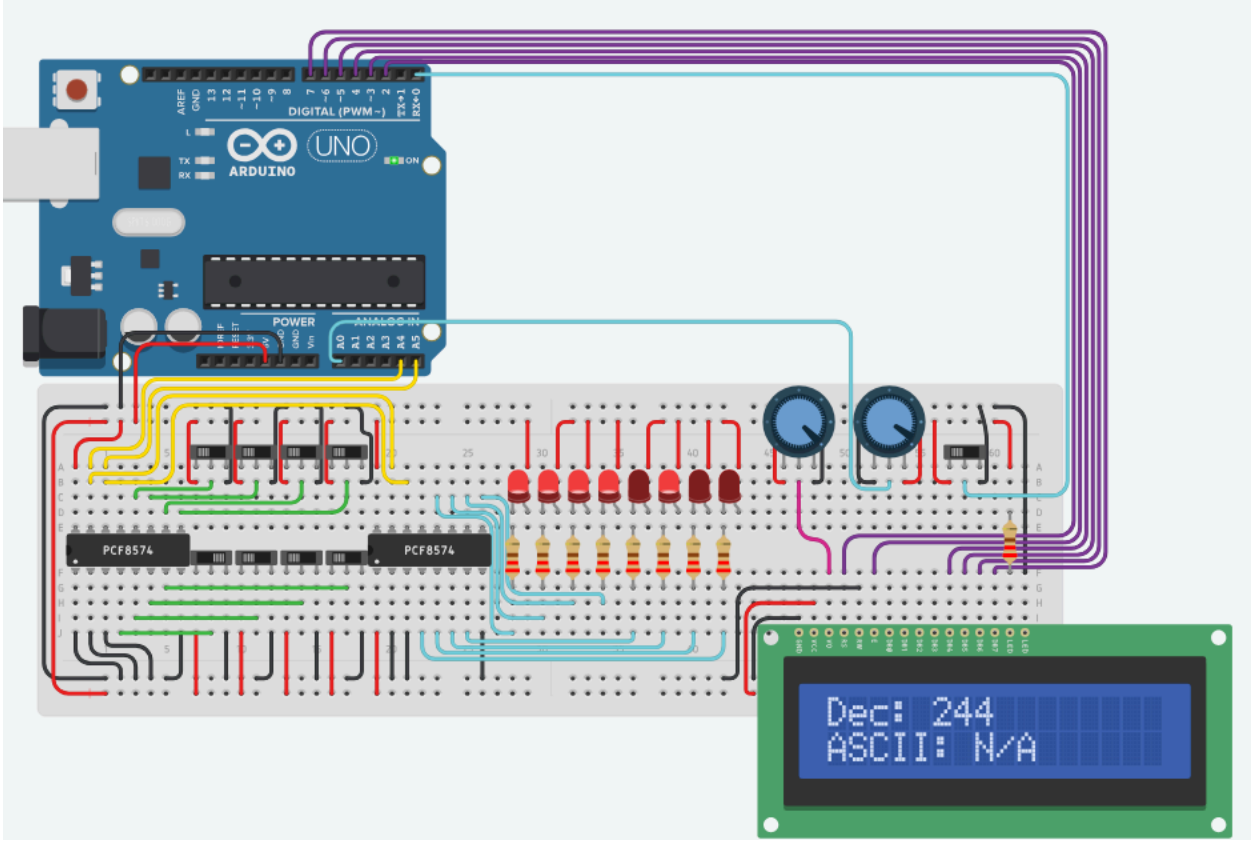
Section 4: Pictures and Screenshots

Initial Sketch

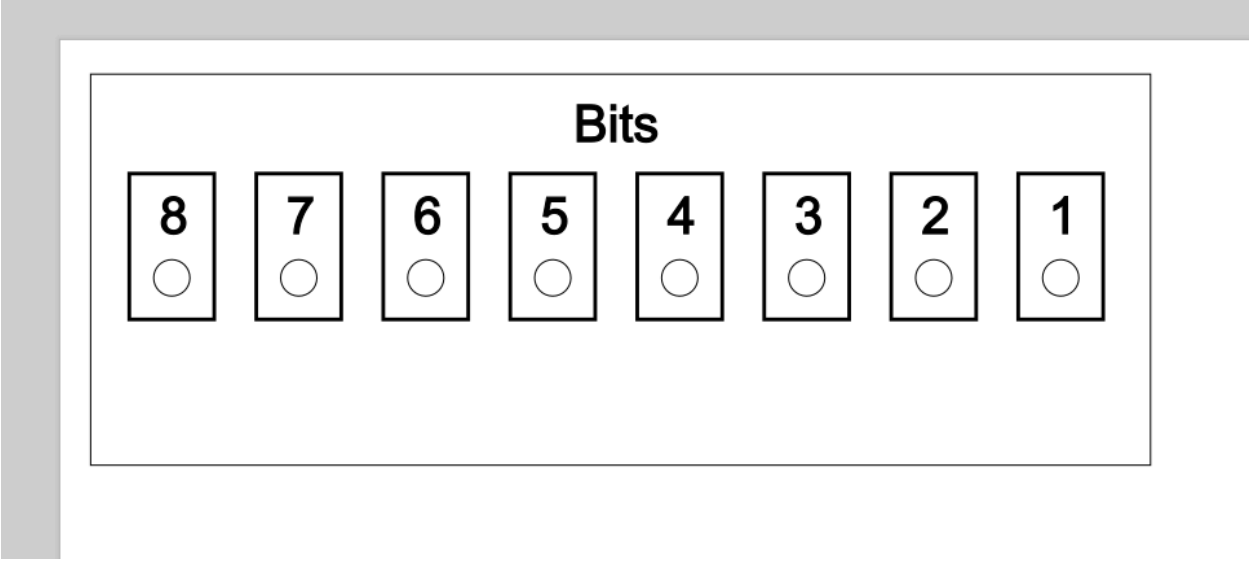


Tinkercad Screenshots

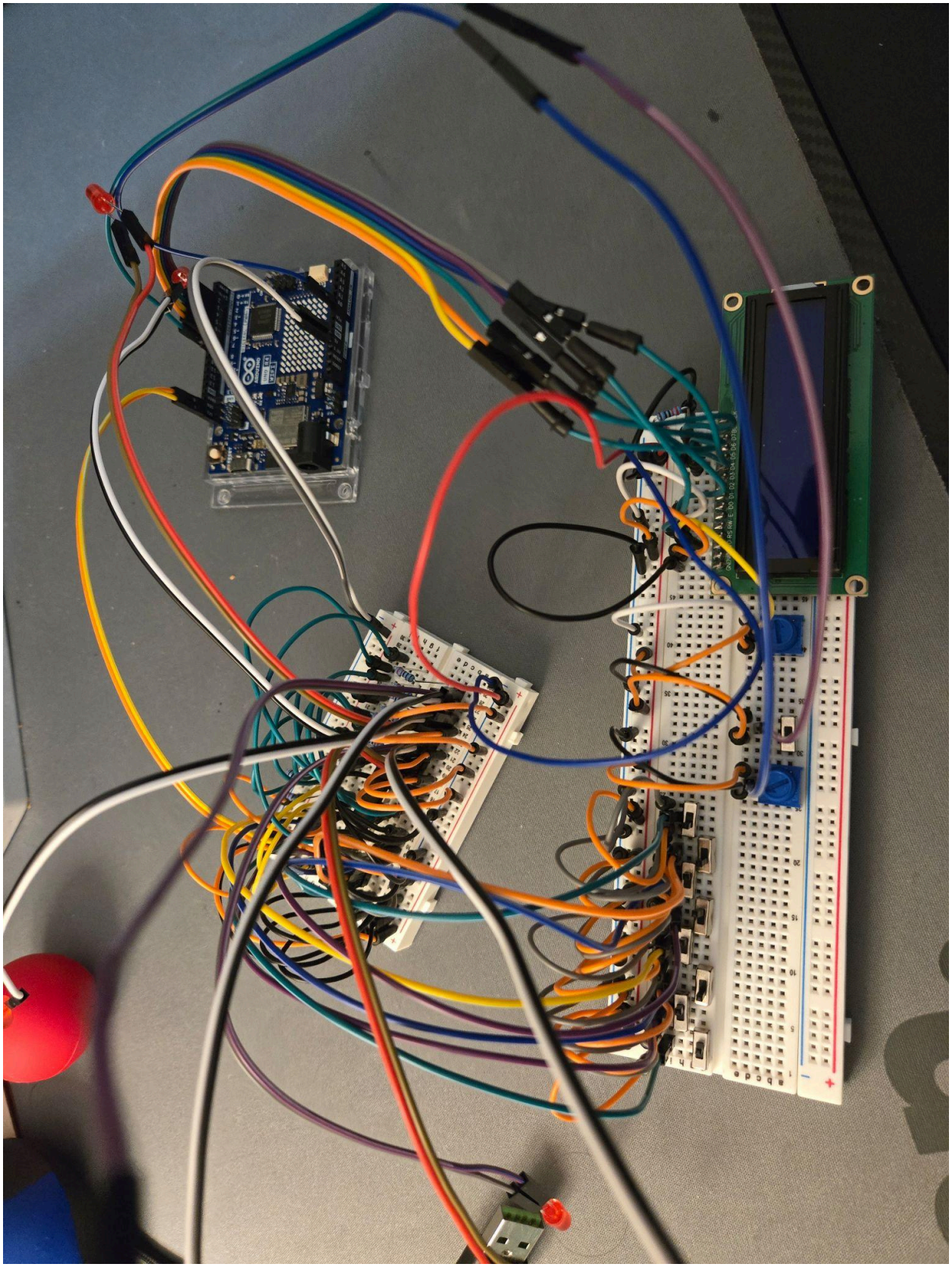


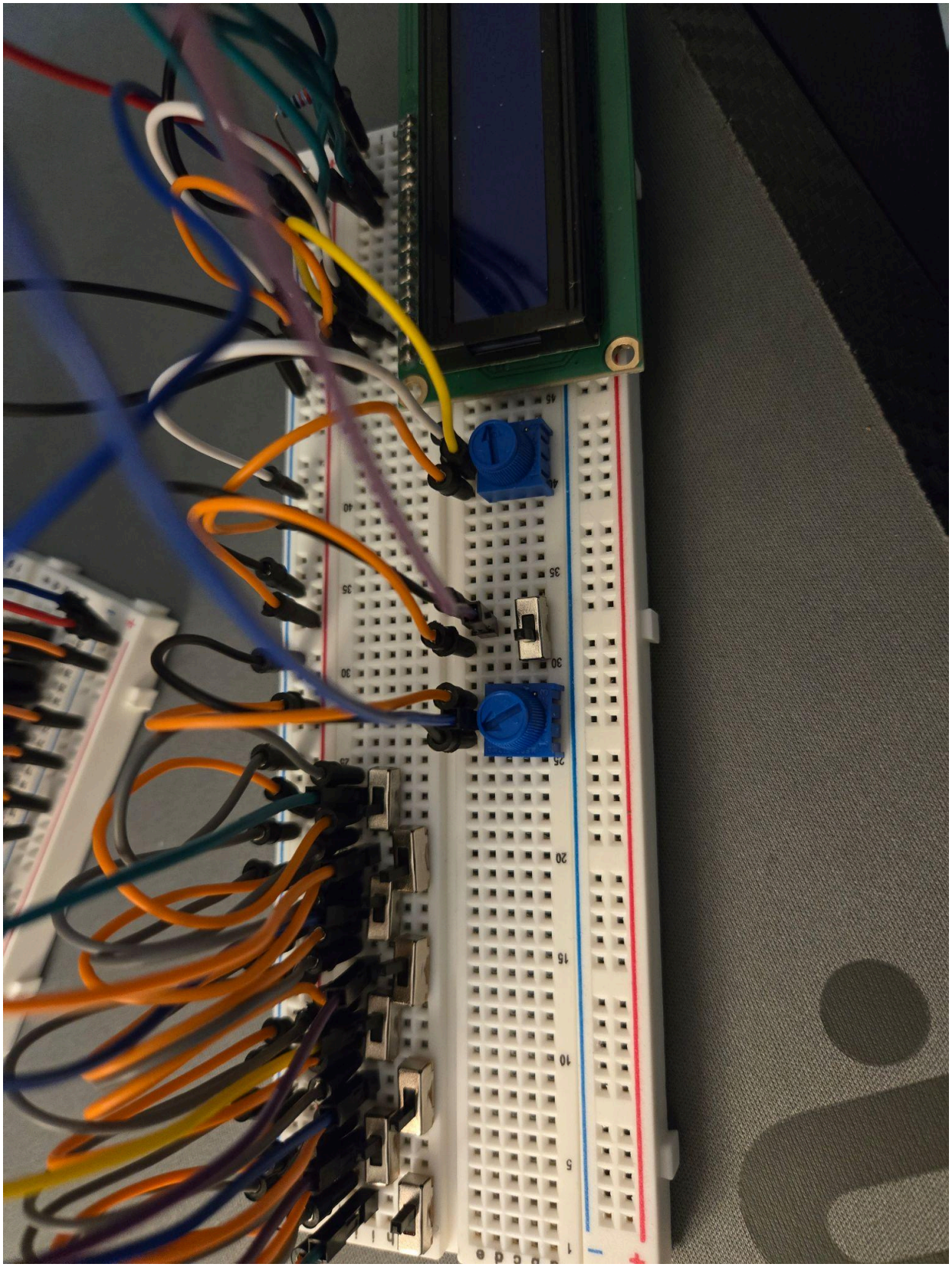


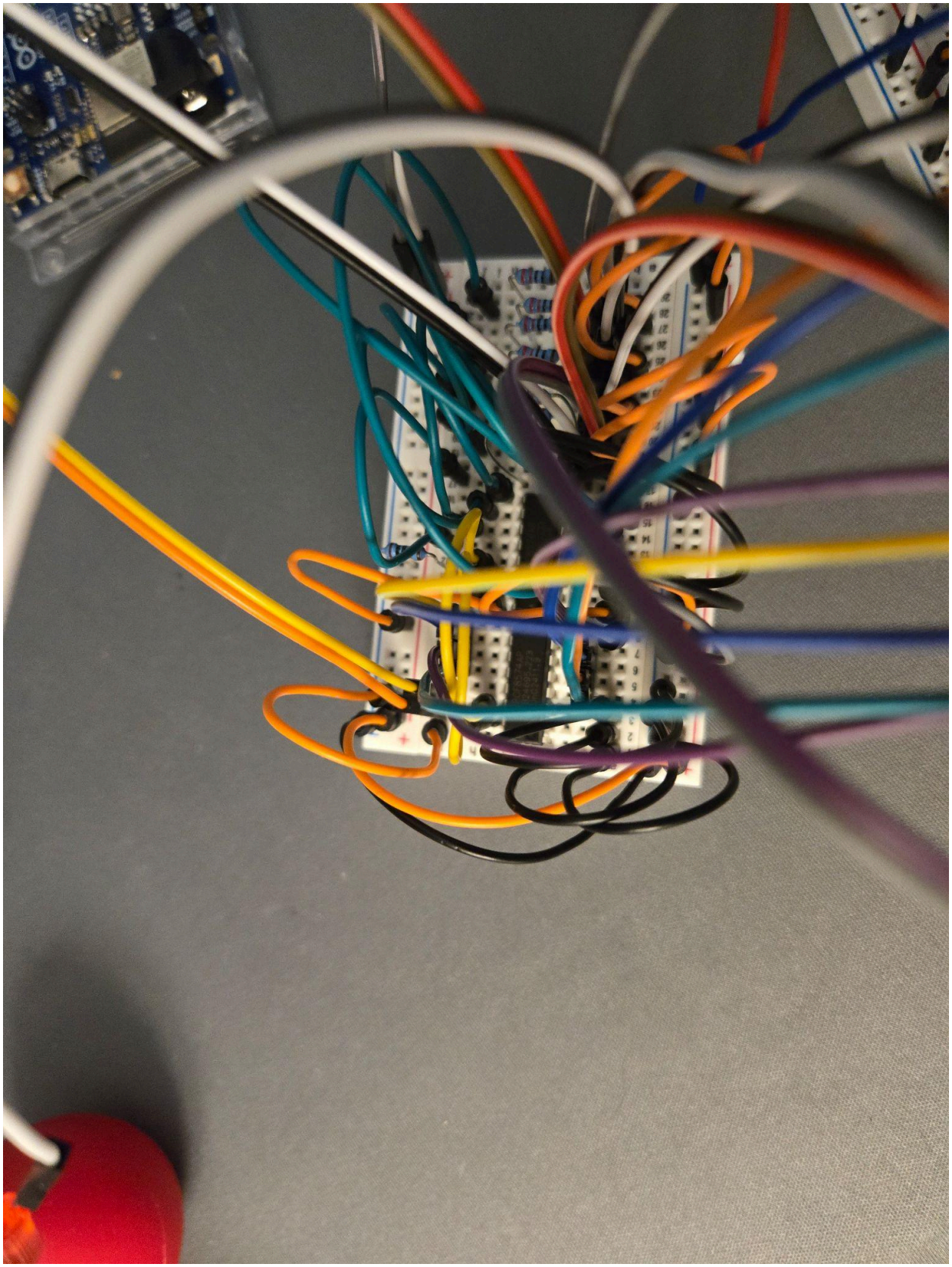
Laser Cutting Screenshots

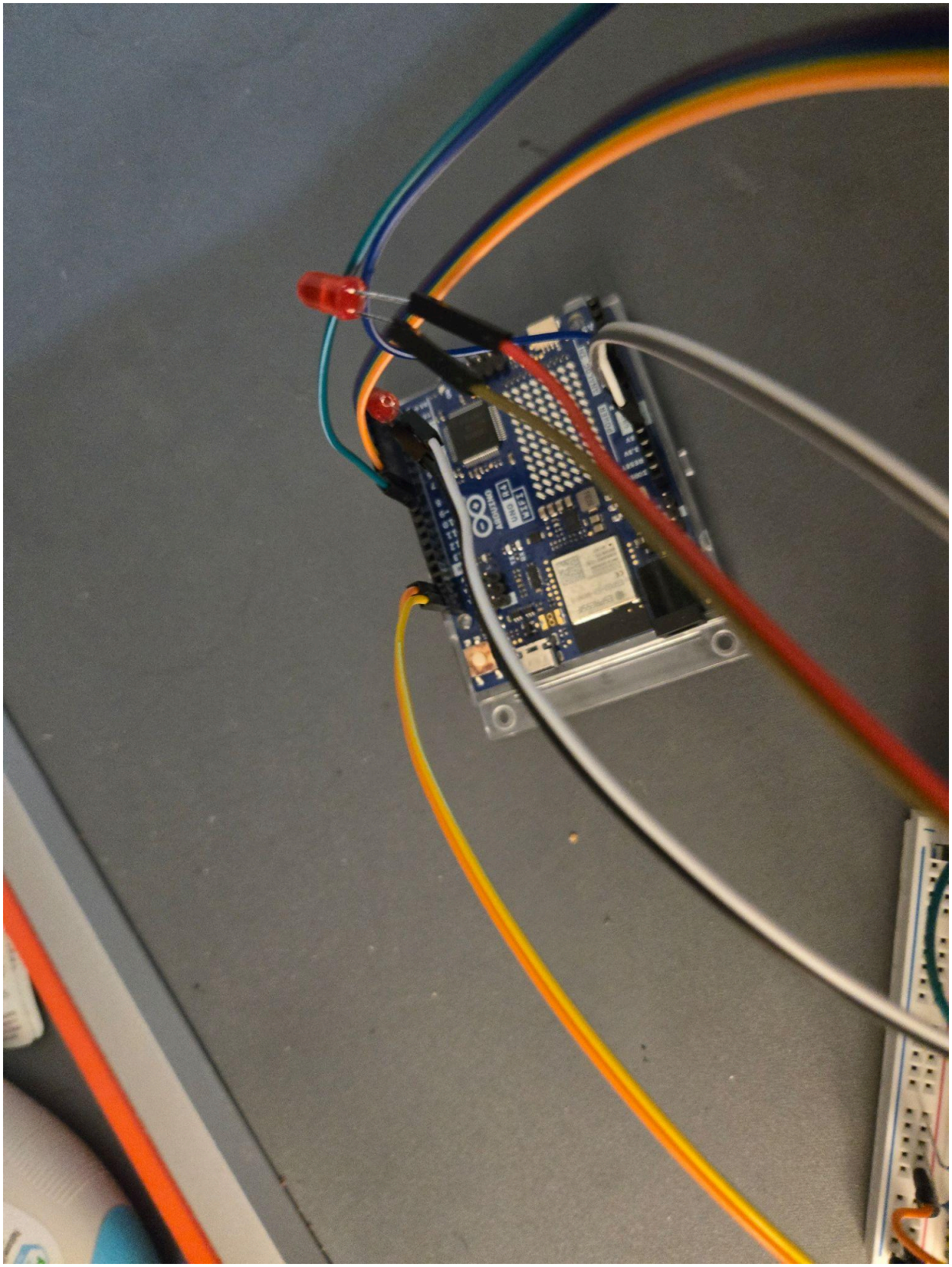


Arduino Pictures









References

Walker, H. M. & Grinnell College. (2023). Teaching binary representation of numbers, highlighting payoffs for students interested in software. In *Acm Inroads*. https://dl.acm.org/doi/pdf/10.1145/3627171