

2023 Summer Break

Day 1: 2023-07-26

I bought an existing exoskeleton online and took it apart to modify the design

Learned $y = \text{map}(x, 0, 1023, 0, 90)$ (just an example)

- It can convert one set of measurements to another after you put in the minimum and maximum of both sets

```
void loop() {  
  Blinker.run ();  
  x = digitalRead (2);  
  a = analogRead (A1);  
  Serial.println (a);  
  b= map (a, 0, 1023, 0, 255);  
  c = map (b, 0, 255, 0, 180);  
  d = 180 - c;  
}
```

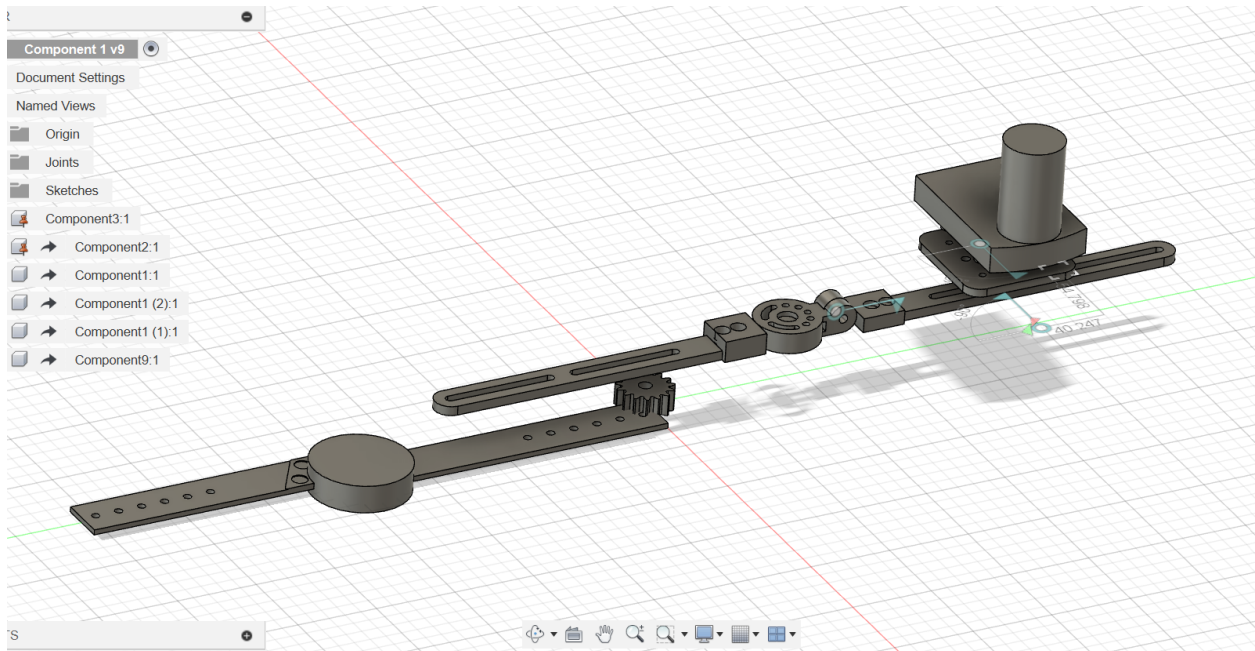
The screenshot on the left is an example of how I used the code. I converted the potentiometer's ADC values of 0-1023 to 0-180 degrees.

I plan to spend the next few days learning more skills that will help me complete my project. Because I plan to use an existing exoskeleton and then attach steering motors and other components that are programmed, I need to research and get more familiar with these materials.

Day 2: 2023/07/27

I started to build a tiny model of the exoskeleton to program the steering motors. I constructed the model from wood, imitating the structure of human thighs and calves. I then attached small steering motors to places where the wood pieces connected (the motors acted as joints). The process was pretty tricky because I had to program the model so that it could imitate a person walking. It was hard to imagine a normal walking process and then translate that to code. I did not finish coding on this day so I knew I had to continue with trial and error multiple times in the following days.

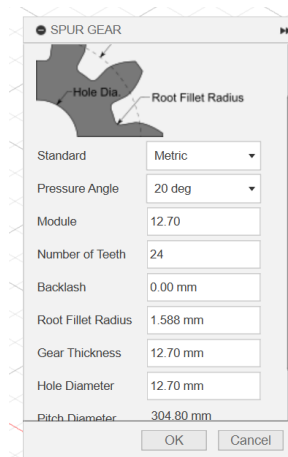
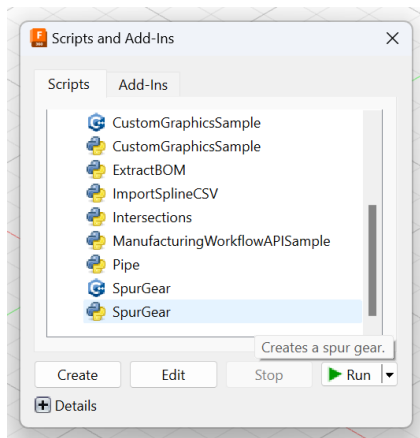
Apart from creating this model, I started to sketch out the main structure of the exoskeleton I bought in Fusion 360. Although it was a very tedious and complicated process, I believe that it will help me significantly when it comes to deciding where and how I want to place the gears, steering motors, straps, etc. I learned how to



Day 3: 2023/07/28

Learned how to quickly draw gears in Fusion360 and related concepts

- Shift+S → Choose the Spur Gear Python module
- Teeth number (z), module (m), hole diameter

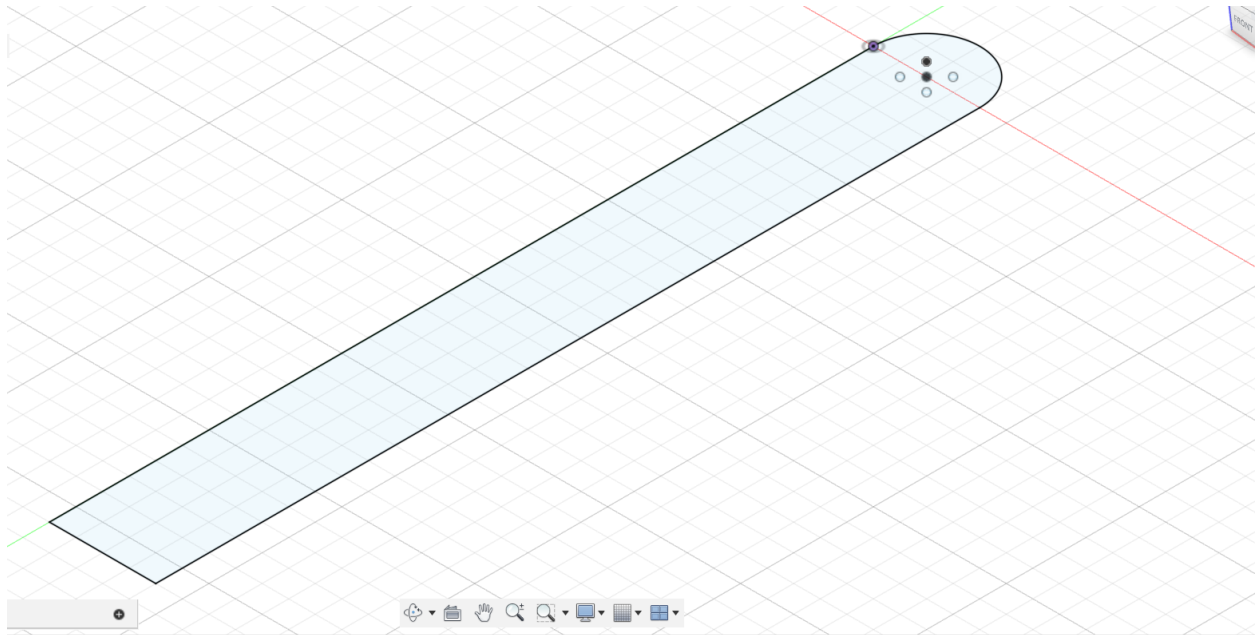


I needed to learn how to draw gears because the steering motor would be attached to a pair of gears, allowing the exoskeleton to work. This combination of components would serve as the joint of the metal legs. Drawing a gear by hand would be too time consuming (I'll have to spend hours learning how and then actually designing it) and it could result in inaccuracies.

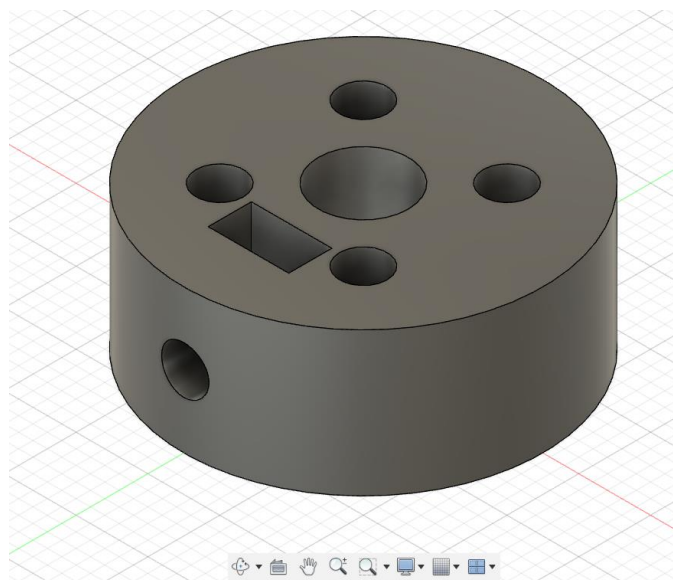
Day 4: 2023/08/01

1. Design components for data collection and testing

a. AutoCAD: 3 wooden panels will be attached to the leg using adhesive straps. Panels will be laser-cut



b. Fusion360: 3D component that attaches a tracker and the 3 panels together. This component will be placed where my joints are so that the wooden panels can rotate freely as my legs move.



2. Write code for tracker using -90° , 0° , and 90° as benchmark degrees

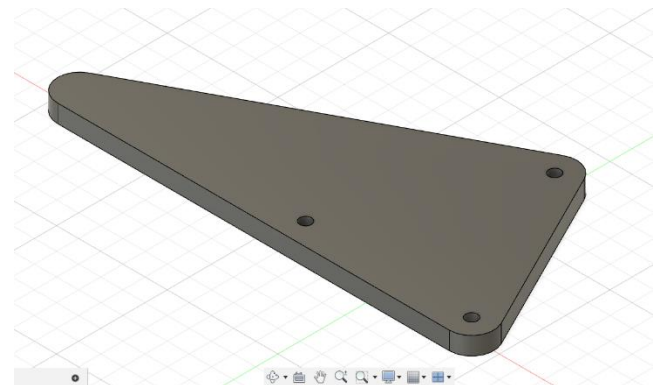
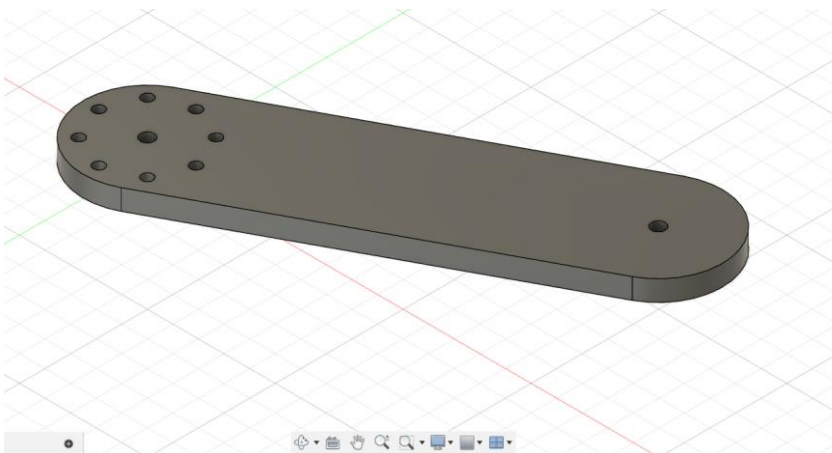
This data collection model will help me determine what degrees I should set the steering motor to. After I complete this model, I will wear it around my legs and walk naturally to record the degrees of my joints' movements.

Day 5: 2023/08/02

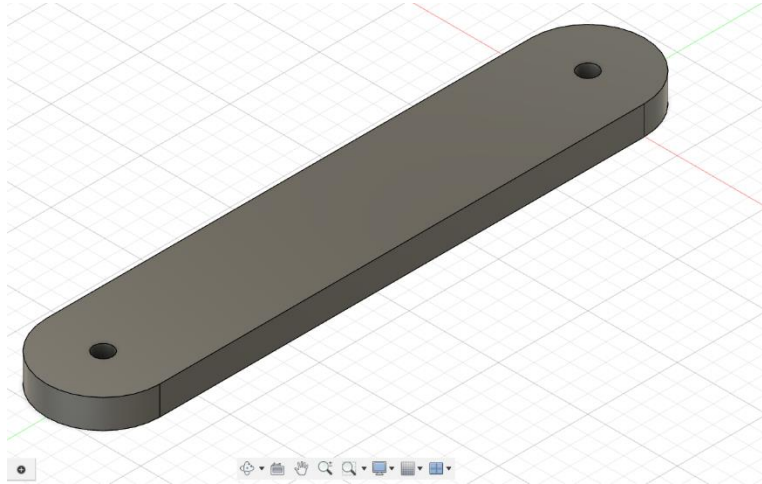
Lots of trial and error as I started the data collection process and continued with my designs. For example, the cylinder attachment piece I designed and printed yesterday started to break apart after I screwed it tightly to the wooden panel because the diameter was too small. Thus, I had to increase its thickness so it wouldn't break so easily.



- Designed two components to attach the servo and gear to the metal leg part of the exoskeleton. They will be cut from an acrylic board and form a parallelogram.



- Printed another acrylic piece to connect the two components I created earlier.



Started data collection but couldn't copy the data from Arduino's Serial Monitor

- I downloaded an older version of Arduino (1.8.15), but I still had trouble copying all the data
- Finally, I found CSV → added to "tools" → upload the code → click ArduSpreadsheet → save the data → open it in Microsoft Excel

Day 6: 2023/08/03

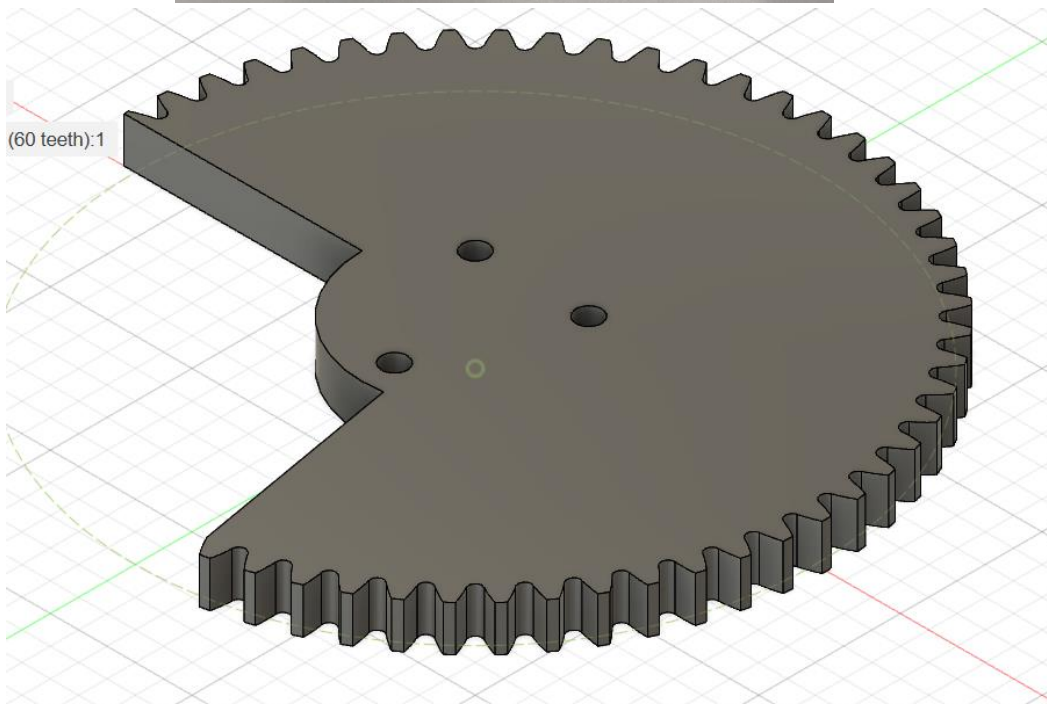
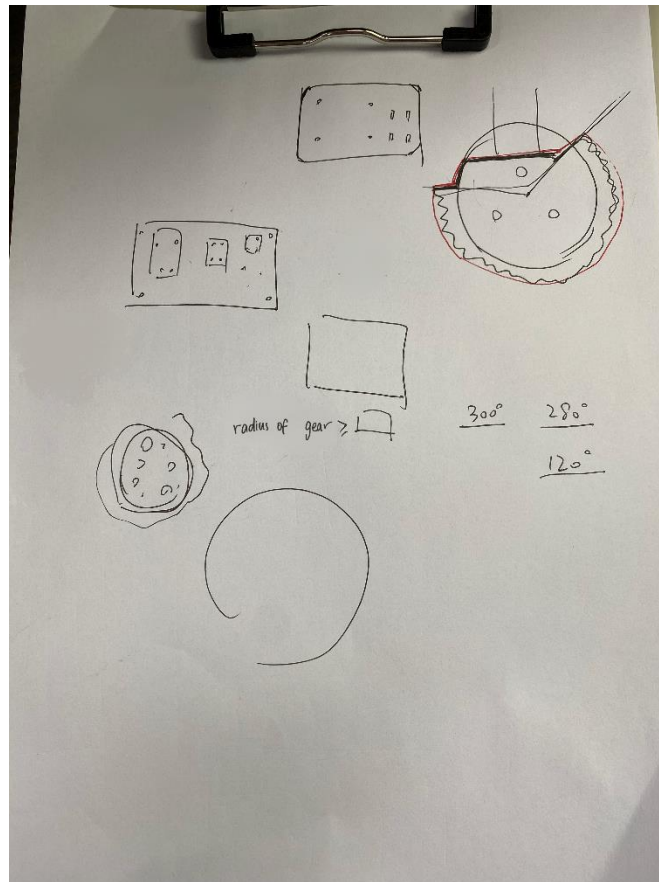
I changed the length of one of the parallelogram components from 83.853 mm to 147.50 mm.

Now that I learned how to copy down the data from Arduino's Serial Monitor thanks to yesterday's efforts, I started to collect the data using the model I built previously (see DAY 10 and 11). The picture below shows the results for the right leg. After I finish testing and see the data in Arduino's Serial Monitor, I export them into an Excel file. It's incredibly useful that the ArduSpreadsheet included timestamps to indicate when my joints hit the indicated degrees. The middle column, which shows less change between each movement, is the data from the upper tracker placed at my hip joint. Thus, the right-most column shows information for my right knee.

05:14.5	-7	20
05:14.5	-7	20
05:14.5	-7	21
05:14.5	-7	20
05:14.5	-7	20
05:14.5	-7	20
05:14.5	-6	20
05:14.6	-6	20
05:14.6	-6	20
05:14.6	-5	20
05:14.6	-5	20
05:14.6	-5	19
05:14.6	-5	19
05:14.6	-5	19
05:14.6	-4	19
05:14.6	-4	19
05:14.6	-4	19
05:14.6	-4	19
05:14.6	-4	19
05:14.6	-4	19
05:14.6	-3	19
05:14.6	-3	20
05:14.7	-3	19

Day 7: 2023/08/04

Planned and designed the gears located at the thigh, connected to the bars that link the waist and thigh together using the method I learned on 7/28.



Assembled said gears with the metal bars and servo

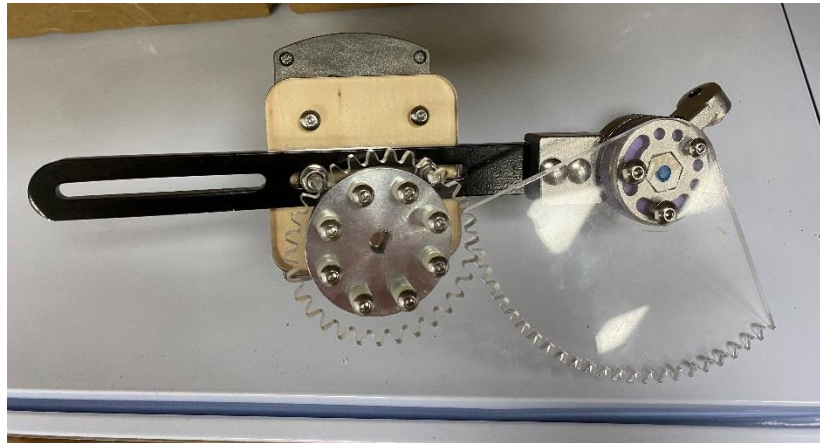
The metal bars kept slipping and moving around even after screwing them together because I changed the placement of these bars to suit my design. Therefore, I designed and printed a 3D component to put in between the attachment places and add more friction.

DAY 8

2023-08-05

I ensured that I had all the necessary components prepared, and I promptly printed the ones that were missing from my setup. While waiting for the 3D printers to finish, I continued with my data collection process, ensuring a seamless and efficient workflow.

I also combined the gears I designed and laser-cut yesterday with the Servo steering motor. This metal bar would connect the thigh component to the waist, and the cut-out gear would serve as the hip joint of the exoskeleton.



I also assembled the other metal bar with another Servo, the 3D-printed connecting square, and the laser-cut acrylic parallelogram combination. This silver, thicker metal bar would be placed next to the user's calf.



DAY 9

2023-08-06

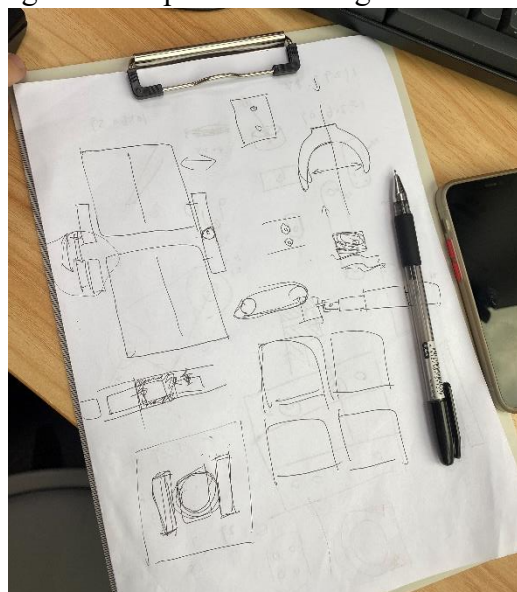
Finally started to assemble the parts I've been designing and building over the past week. I started with the hip area. I had to 3D print out the smaller gear because the acrylic board I laser cut it on was too thin for my liking. 8 cm \rightarrow 9 cm.

DAY 10

2023-08-08

Continued to assemble (attach thigh/hip black metal bar to the waist support thing)

Designed and printed the part that connects the gears to the user's leg. C-shape. Has a slot to pull an adhesive nylon strap through and wrap around the leg.



Started to solder the wires.

Thought about the impact of this project

- My grandfather fell during early spring, which reminded me that the elderly doesn't have that much leg strength. Using a cane or a walking stroller thingy doesn't guarantee walking support because if you have weak arms, you'll still fall. Also causes their spinal cords to bend. My project has a high-waisted structure that can also provide spinal and waist support. Customizable leg straps allow people with all kinds of body types to use them.

Day 11 2023-08-09

Finished printing all 6 C-shape leg attachments

Got rid of the Lower Calf C Attachment

Inserted adhesive nylon straps

Changed Triangular Connection Part (added more holes so I could connect the Upper Calf C Attachment)

Designed and laser cut new components (check 3mm and 5mm thingy, a component the teacher modified from Aluminum and Gear Part Connection)

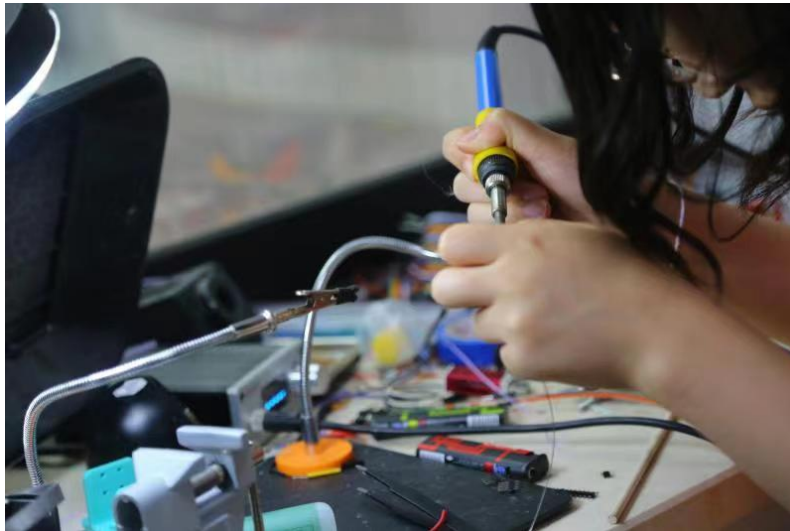
Removed the Connecting Square (see DAY 14 8/5, where I assembled it with the silver metal bar)

Added aluminum bars

Fixed some mistakes (e.g. one of the gears and one of the metal bars were put in the wrong/opposite face)

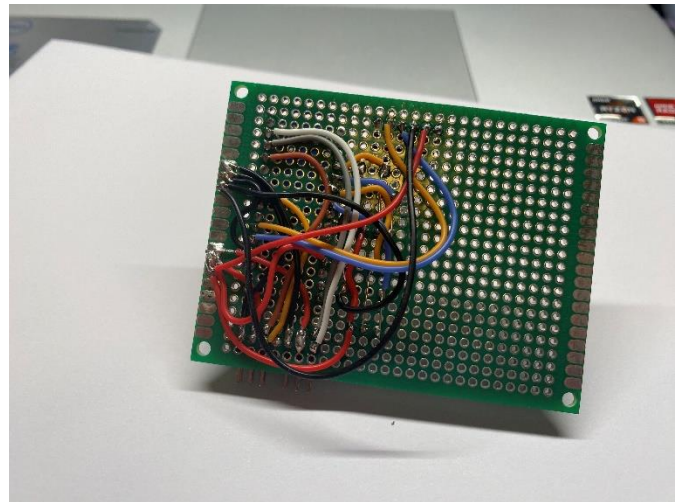
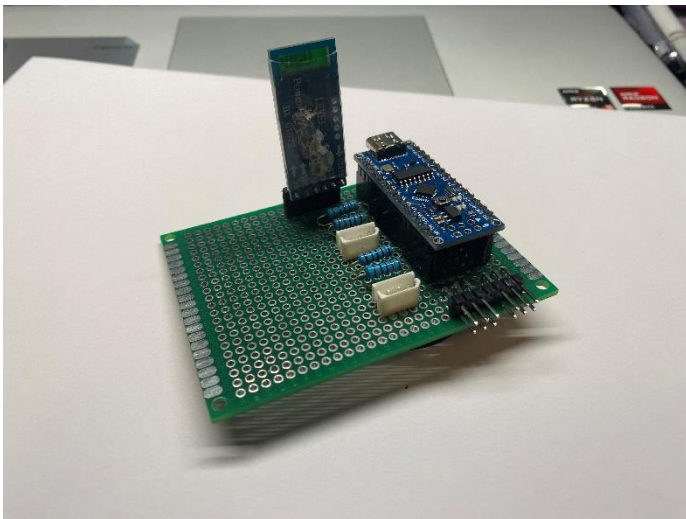


Started assembling cables and pressure sensors and connecting them to the gears and continued with bonding the wires.




I used an Arduino Nano board and attached it to a protoboard. Apart from setting up the outlets for the pressure sensors and Servo steering motors, I also inserted a Bluetooth module, which allows me to use the app Blinker to start and stop the exoskeleton's movements.

The picture at the left below shows one side of the protoboard with the Nano board, Bluetooth modules, and other outlets. The photo at the right shows the other side, which has all of the wires/cables I connected.



Day 12 2024-02-04


After taking a break from this project (I still did a little bit of work and research every day, but the progress of a single day was too little to document. Most of this project's work was accumulative), I resumed my progress by first ordering an adapter cable to connect my Servos to a 12V lithium-ion battery.

ORDER PLACED February 4, 2024	TOTAL \$13.64	SHIP TO [REDACTED]	ORDER # 702-8756931-3034612 View order details Invoice
Delivered 6 February Package was left near the front door or porch			Track package
 AAOTOKK DC 5525mm to XT60 Adapter Cable Male XT60 Bullet Connector to DC5.5x2.5mm Male Power Charging Adapter Cable for TS100 Soldering Iron, FPV Monitor Power, Drone Power Cord.(DC 2.5mm-M/30cm-2Pack) Return window closed on March 7, 2024			Get help
Buy it again View your item			Leave seller feedback
Archive order			Write a product review

I continued to use the data collection device while intentionally walking with different gaits to collect data for later use.


Day 13 2024-02-06

After receiving my previous order, I discovered that I had purchased the wrong model. The head connecting to the Servo wires should be a female XT60 connector. I placed another order.

ORDER PLACED February 6, 2024	TOTAL \$13.64	SHIP TO [REDACTED]	ORDER # 702-8492481-8729055 View order details Invoice
Delivered 8 February Package was left near the front door or porch			Track package
 <p>AAOTOKK XT60 to DC Adapter Cable XT60 Bullet Connector Female to DC 5.5mm X 2.5mm Female Power Jack Adapter Cable for TS100 Soldering Iron, FPV Monitor Power, Drone Power Cord.(30 cm-2Pack) Return window closed on March 9, 2024</p>			Get help
Buy it again View your item			Leave seller feedback
Archive order			Write a product review

Day 14 2024-02-8

Although I got the XT60 connector type correct in my last order, I accidentally chose the female power jack adapter instead of the male. I placed another order.

ORDER PLACED February 8, 2024	TOTAL \$13.64	SHIP TO [REDACTED]	ORDER # 702-1193084-7352208 View order details Invoice
Delivered 10 February Package was left near the front door or porch			Track package
 <p>AAOTOKK DC 5.5x2.5mm to XT60 Adapter Cable Female XT60 Bullet Connector to DC 5.5X 2.5mm Male Power Jack Adapter Cable for TS100 Soldering Iron,FPV Monitor Power,Drone Power Cord.(DC2.5mm-M/30cm-2Pack) Return window closed on March 11, 2024</p>			Get help
Buy it again View your item			Leave seller feedback
Archive order			Write a product review

Day 15 2024-02-10

I finally received the correct power cord with the correct connector models. I started uploading my codes to the four Servos. Since today was a Saturday, I had enough time to experiment with the Servos' rotational movements and made sure they matched my different gaits. Although it was a very tedious process, I essentially repeated the same steps: test exoskeleton → modify the numbers in the for loops → upload code → repeat.

I added pressure sensors at the end of the day and recorded the data shown in the Serial Monitor for each different gait I walked in. I did three trials for each gait. Then I calculated the average of the pressure values for each gait.