

## Technical Report – Turbo Skates

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# Turbo Skates



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### ABSTRACT

Transportation by and large is a space of innovation, constantly changing to become faster, cheaper, and more efficient. These were the main goals of the Turbo Skates, with the addition, or rather, the added emphasis of safety and stowability. The goal was to take a mundane, one to seven mile commute and turn it into an enjoyable, speedy adventure. The initial design kept simplicity in mind, looking to incorporate a direct drivetrain under the foot while stowing the batteries either in the sole, or in a fanny-pack. Due to safety and logistical issues, we concluded that the design needed to have a direct drive train with the motor on the heel due to spacing, as well as the batteries being placed on the skate to avoid wires running up the user's legs. In doing so, it became vital that, with such a powerful motor, one hundred watts, we would need an extremely secure mount to control the torque exerted by it. And so, the mount was machined out of metal, similar to the skate itself. Further, the batteries, radio receiver, motor controller, and arduino needed to be housed on the skate. To allow for a lightweight, simple solution, the housing was a simple 3-D printed box strapped to the back of the skate behind the motor. The result was a functioning lead skate, with the weight of the user accounting for more than enough counterbalance for the motor and casing. Unfortunately, the motor controller only outputs a maximum of twenty-five watts of power, so the skates went slower than anticipated. However, this is an easy fix, and something the group would look to work on given further continuation of the project.

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### I. PROJECT SCOPE

The goal of our project was to provide an effective mode of transportation, and an alternative method to the expensive hoverboard or electric skateboard options. Our main clients are people living on big college campuses who need quick transportation from class to class, and a second client pool of people living and working in a big city who do not want or need to deal with inner city traffic. We decided on the solution of motorized roller skates because we estimated that the sum of parts to manufacture a motorized skate would be less than that of an e-bike or electric skateboard, providing a relatively cheap and fun alternative for just as effective transportation.

### II. DESIGN REQUIREMENTS

In order to have a successful product, the skates must be as safe, cost-effective, and fast as possible. We knew that more speed would mean more range, which would increase the effectiveness and overall appeal of our product. Before creating a full-scale product, we had to optimize the speed by making space on the skate for the biggest motor and biggest battery pack combination to supply the most power. These were the only real revisions we were focusing on in prototyping, as the group had already decided to buy the base of a regular inline skate as the base product. This optimized safety as we were guaranteed a platform that could support a human being instead of relying on our own. The clients we interviewed were satisfied with our product. Their positive feedback was about our concept and all agreed that this project was useful, if we could get it to work properly. Their negative feedback was mainly about the looks (wires sticking out) and how it currently moves very slowly.

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### III. DESIGN ALTERNATIVES

Our design alternatives to the derby skate were the “tank” skate and the inline skate. The tank skate was similar to a derby skate but had one big tank tread instead of 4 wheels per foot. This big tread would significantly increase safety and stability. The disadvantages of these skates were that it would take a significant amount of power to run, lack maneuverability, and operate at slow speeds. The inline skates would in theory be faster and easier to power the wheels evenly, however they have the disadvantage of not having any space to mount hardware below the skate and mainly being made of plastic, so we ruled these out as an option. The four-wheel approach (derby skate) dispersed the weight over a more balanced area, increasing the stability. We ultimately decided to go with the derby skates because they were mainly made of metal which made it easy to modify, there is room below the foot to store components, and we could easily incorporate a belt drive, however we still knew we were going to have to face the challenge of creating sufficient power.

### IV. FINAL DESIGN CHOICE

The first step to the final design is ordering a womens size 13 derby skate (the largest one available). The size we picked was important because it allows for the back of the skate to be altered, while keeping enough space for an average foot to be placed. The next step is to unscrew the skate boot, so only the metal base, metal trucks, and wheels remain. Our group decided to not make alterations to both skates due to time constraints, but it is certainly feasible to do so with enough time. Any changes described from this point forward were only performed on the modified skate. We removed the previous back axle and replaced it with a new custom free

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spinning back axle that is one inch longer than the previous one. This axle is now able to be free spinning or fixed with a few simple modifications. One of the back wheels was hollowed out on the side facing the inside of the skate. We used this hollowed out area to press fit our belt drive gears onto the wheel, so now when the belt spins, so does the wheel. New bearings were added to the back wheels and a  $\frac{1}{2}$  inch spacer was added to the opposite side of the wheel we just modified. The bearing will be fit to slip snugly onto the back axle. This is imperative, as it allows the wheels to spin independently from the axle. This allowed for a fixed axle, and therefore less friction due to contact from the axle/truck. The next step in the manufacturing process is the motor mount of the skate. The motor mount is made of a strong metal which can withstand the torque of whatever motor is being used. It is screwed together in an L shape, with the bottom side being mounted about three inches onto the back of the skate. The vertical side must be on the same side of the skate as the inner wheel. It is built two inches taller than the motor, so that the motor does not touch the bottom of the mount. Three holes will be drilled in the vertical side of the mount; one for the axle of the motor, and two for the motor's screw holes. The holes on the bottom must be extended to allow for adjustment of the mount itself, providing adjustability with respect to the tension of the belt. Once that is configured, it is time to add the battery and arduino pack. Coding the arduino and the remote was an iterative process. We began with hooking up a battery to the motor and checking to make sure that it spins. Then we coded the arduino and made the motor spin, then had it do the same thing but with the potentiometer. Finally, we connected the bluetooth receiver and transmitter and made that work. The battery pack should include the sufficient battery power to power your motor, and be housed in spring cases that slide into the lower level of the casing. The wires from the battery are then connected

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to the Arduino, which is already attached to the radio receiver; both are kept in the top half of the case. At this point, the motor can be connected. For simplicity's sake, the remote is a second arduino (the transmitter) which connects to a potentiometer and an nRF24 radio. Essentially, the potentiometer allows for control over motor speed with respect to its angle, while the nRF24 connects to the other radio (the receiver), allowing for wireless control. The final aspect is the straps. These are attached to the bottom of both skates, then fit onto and wrap around the feet of the user. A photo of the final design can be found at the end of Appendix C.

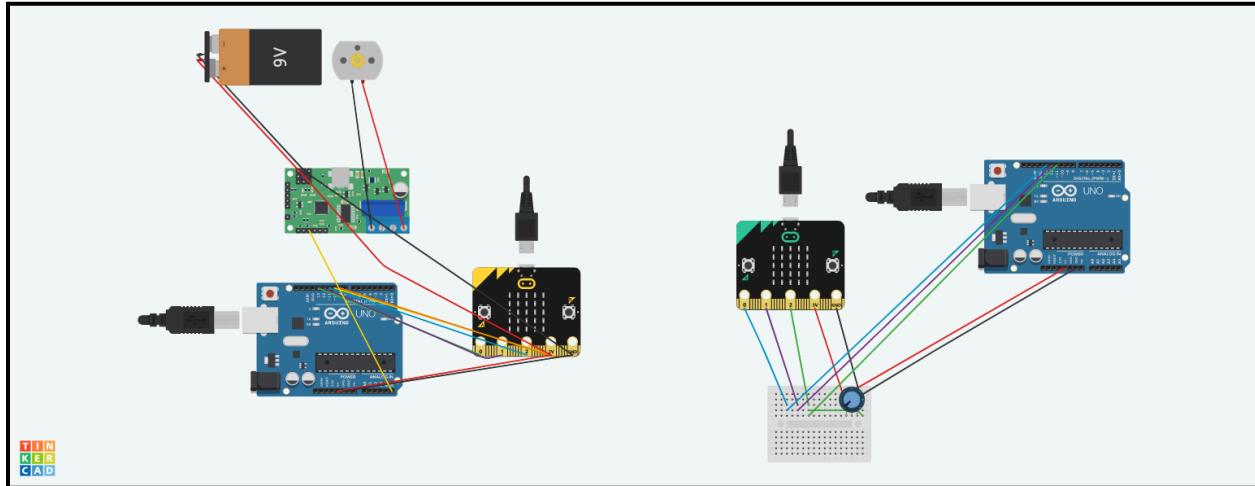
### V. CRITICAL COMPONENTS

One essential aspect of our project was creating a drive train and a mount for our motor. One of our goals was to find a way to create something that would mount to an already built roller skate and also properly balance the weight of a 100 watt motor with a motor controller. So, we ended up working with the manufacturing center to provide a steel part that would act as a mount for the motor and the drivetrain we made. All that was left was finding a controller for the motor.

The other primary half of our project was to create a controller for the roller skates so that they can actually safely transport a human without compromising their safety. We took inspiration from a project online that used a Wii nunchuck remote control and programmed chips that connect the controller to the motor controller. This design ultimately failed however because we couldn't find a way to properly code the controller. We then downscaled and used our previous knowledge from the three arduino workshops we took and used them to make a makeshift controller that depended on the angle of the potentiometer to control the motor speed.

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(A diagram is displayed below.)



This allowed our product to become complete. All we had to do was attach the radio, arduino and motor controller to our actual motor and mount it on the drive train system previously described. Combining the two aspects and making sure they run together was all a matter of putting the casing on the mount and using the skates. Unfortunately, our circuit board fried right before the expo but we were able to present a video of the working product.

### Analysis:

The method that we used to analyze the results of our project was to test and see if the skate supported the person safely and that it moved at a satisfactory speed. We knew all the parts of the project worked if the skate moved, as the project was a complete domino effect; if the remote did not work, the Arduino would not communicate with the motor, and the motor would not spin. So we knew that if one aspect was broken, the overall skate would not work. We analyzed user stability through user feedback once the motor was spinning at sufficient speeds, as well as observing them ourselves to ensure their safety was at our standards.

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### *Results & Discussion:*

As a result of our critical components and testing, we did have to make some final changes. We had to readjust and change our mount several times before we settled on something that would be able to support both the placement of the motor and the box for our electronics. As for the remote, we had to get rid of the whole Wii nunchuck idea because the components would not have fit inside the casing and we could not properly code the controller.

For final user testing, we ensured our straps worked (by doing a shake test and skating on them) as well as we used the remote and made the skates go with someone on them. They moved Helen who is 95 pounds at a very slow speed.

## VI. FINAL PRODUCT DEVELOPMENT

An essential piece of our final product is the battery case that we designed on OnShape and 3D printed. This case was dimensioned in order to fit both the battery, Arduino, and H-bridge. The hole in the back of the case is intended to connect the motor wires to the H-bridge. This case is secured to the back of the motor mount using tie down straps. The motor mount was manufactured using aluminum blocks. We cut these blocks to size, and added holes for the motor to attach to it, tapped holes to attach it to the skate, and slots to tension the belt drive while also fastening the two aluminum blocks together.

## VII. ANALYSIS AND TESTING

There was no quantitative testing that was needed for our skates to work. We knew the skate plate could support a human because they were bought from a manufacturer, so the axles,

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wheels, trucks, and plate did not need to be tested. The straps had been used in makeshift shoes before, so we knew they would hold a human foot in place. The closest thing to quantitative testing that was done was using a multimeter to test the voltage running through each 18650 battery cell, and each cell passed the test with a voltage of 3.5 volts each.

### IX. FUTURE DIRECTION

If someone were to continue this project, there are a few things they should improve. First and foremost, to unlock the full power and potential of the skates, they would need to swap the current h-bridge (motor controller) for a bigger one, as the current one only outputs twenty-five of the available hundred watts (per motor). Next, because the full potential of the motor is unlocked, they might want to think about limiting the motor's speed for safety reasons—especially if they ever motorize the second skate. Another thing that should be improved is the binding system for the feet, as a strap is not exactly the perfect solution; at least not with full power. The final thing that could be improved was the housing for all the wires and electronics. The box we created was bulky, but that was mostly due to the size of the electronics we had. If we were to find some way to cut down on the amount of wires and use a different battery setup, we could potentially have a smaller box that would also look way better. These improvements would improve the skates overall, providing a more put together product.

### X. CONCLUSION

Our project objective was to provide an alternative mode of transportation that will eliminate the hassle of other modes while also keeping commute times to a minimum. We had

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several design goals in mind. The design must be safe to use, easy to put on, compatible with all or most foot sizes, and relatively cost-efficient compared to competitors in the market. When we first did testing, we tried out our parts independently to make sure all the parts were working on their own and then we tested the parts together to see if there were any issues that we could find. We tested to see if the writing and circuitry worked, if the battery would run power to the electronics and motor, and also if the straps would keep someone safely strapped in. Our testing with all the components put together was able to efficiently move someone however it stopped working when we tried again weeks later. This project was significant because if it works, it will contribute to eliminating carbon emissions from cars. Even with the given circumstances, we were still able to prove that it did work at some point and that perhaps with more given time, this could have been a fully functioning skate.



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### APPENDIX A: Budget and Bill of Materials

Our budget was \$350. We came up with this budget because our competitors cost around \$400, and do not have the added quick release feature that we have. The outlier in price for electric roller skates is Thundrblades, which is most similar to the stats of our product, and it costs \$1,500.

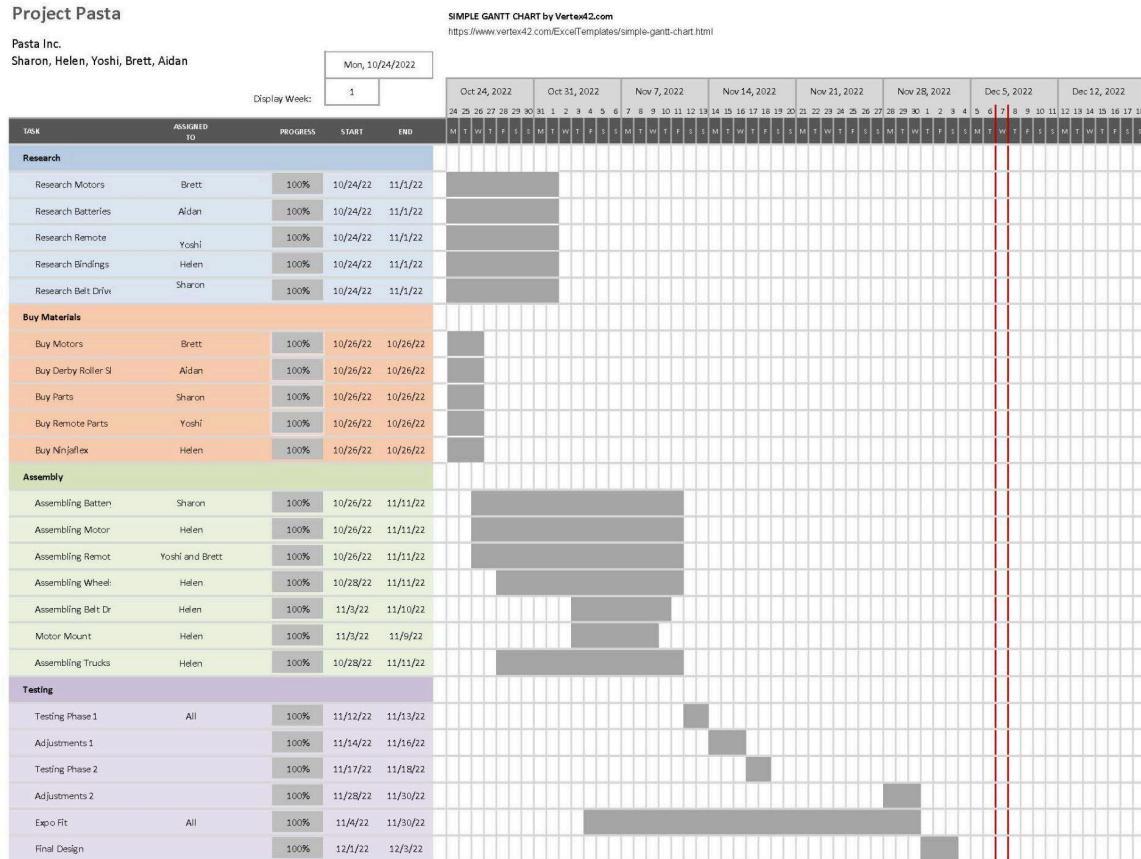
Materials	Cost
Motors	\$40.40
H-Bridges	\$37.03
Belts & Gears	\$13.60
Skates	\$53.60
Batteries	\$66.12
Battery Packs	\$10.00
RF24s	\$13.76
Hardware	\$9.00
3D Spool	\$1.04
Straps	\$8.89
<b>Total:</b>	<b>\$253.44</b>

*Pictured above is our cost breakdown. We achieved our goal and were significantly below budget.*



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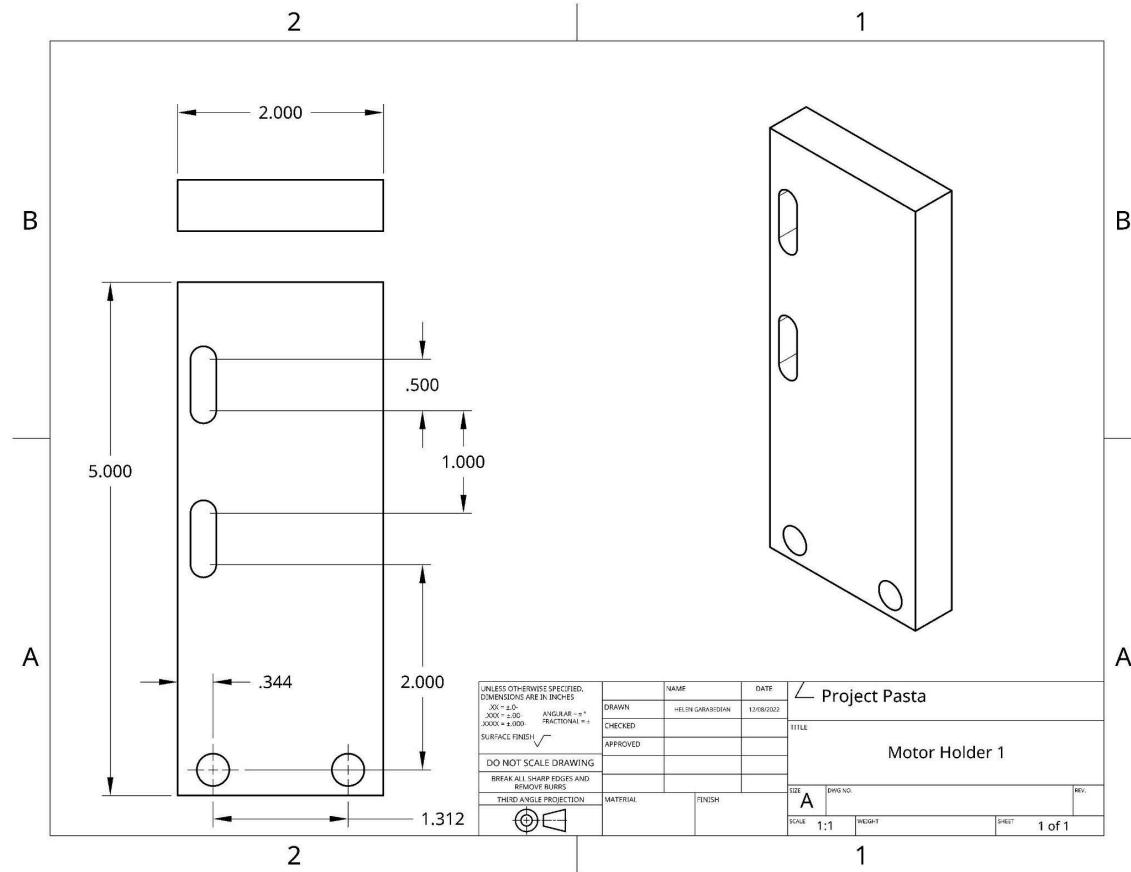
### APPENDIX B: Timeline



*Pictured above is our updated Gantt Chart.*

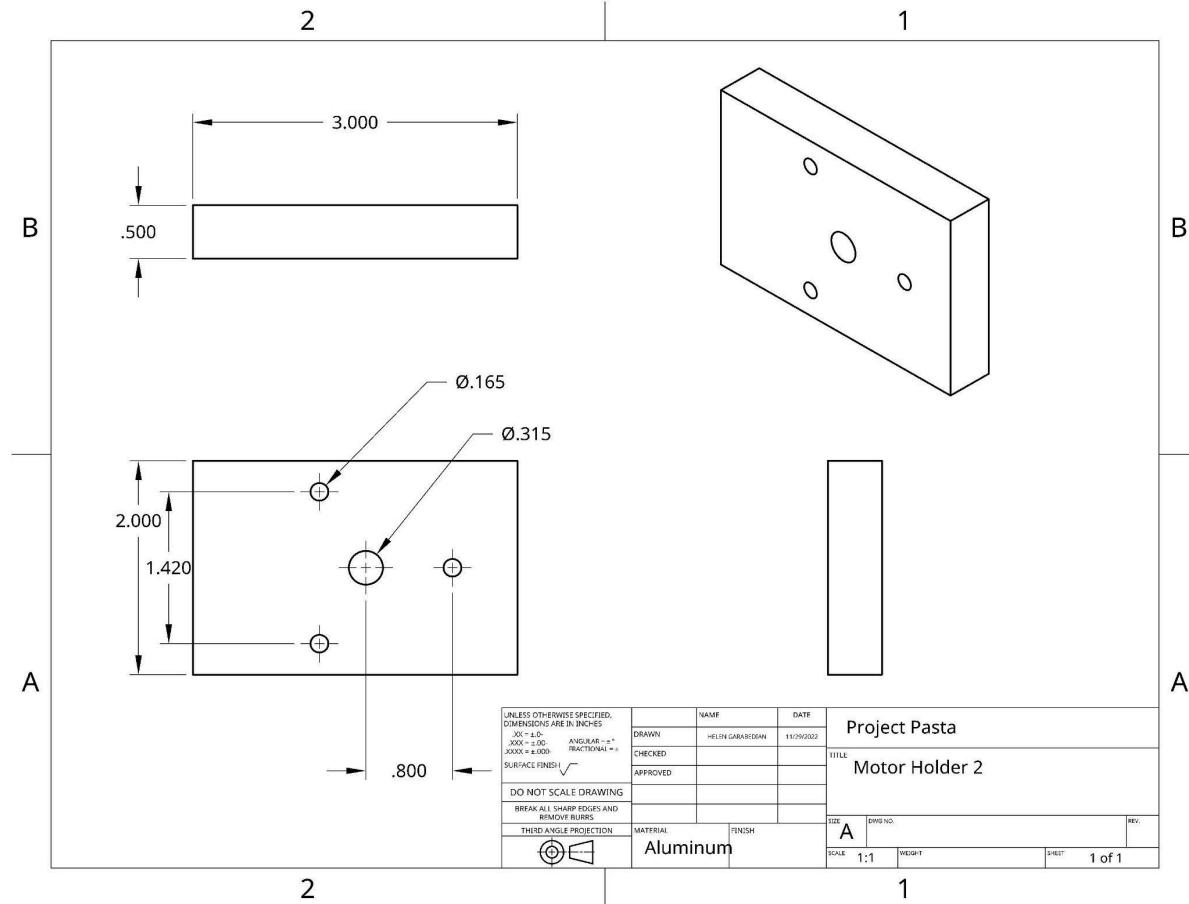
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## **APPENDIX C: Computer Aided Design Drawing**



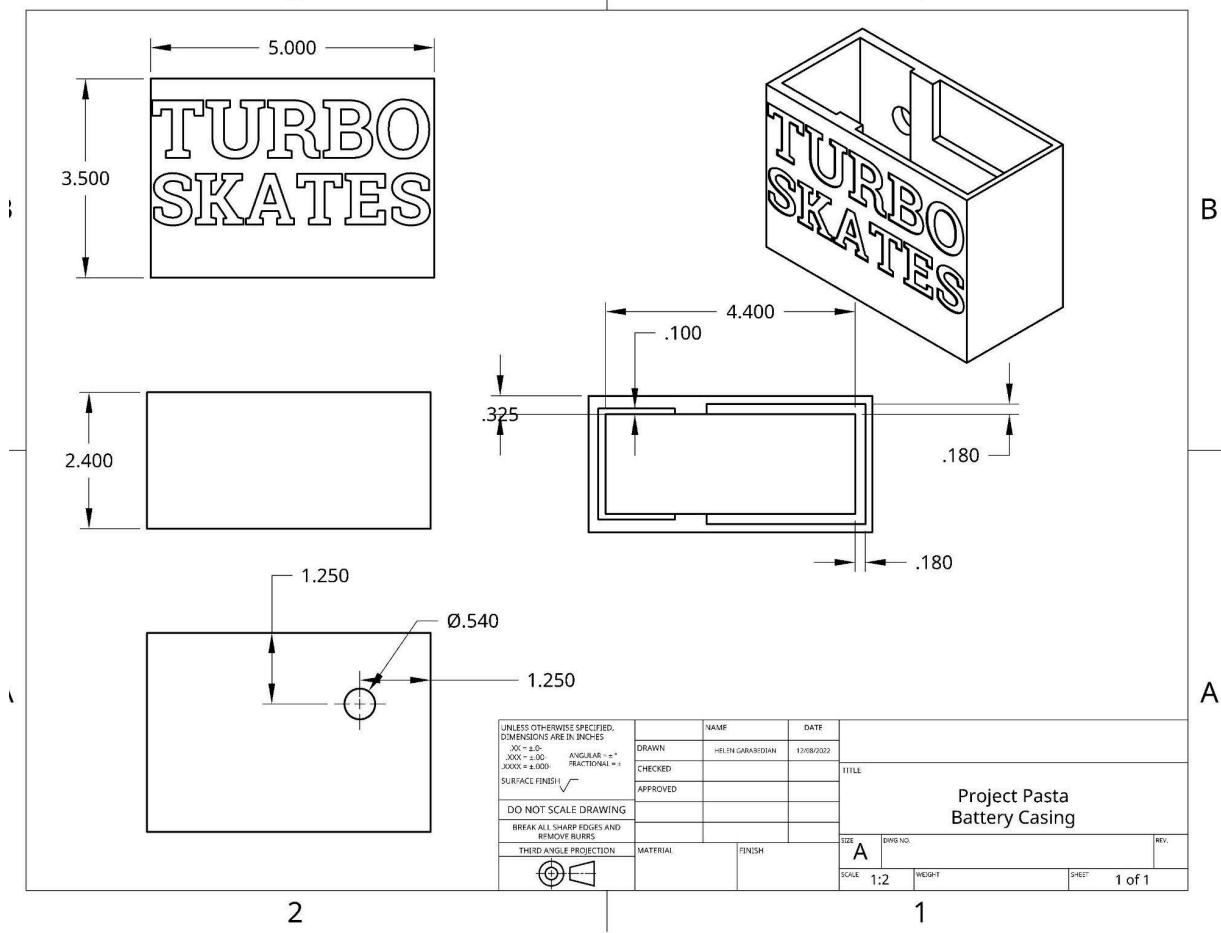
*Pictured above is the part of the motor holder that is attached to the skate. The two holes on the bottom connect to the holes that are already in the skate. The slots allow for proper belt tensioning.*

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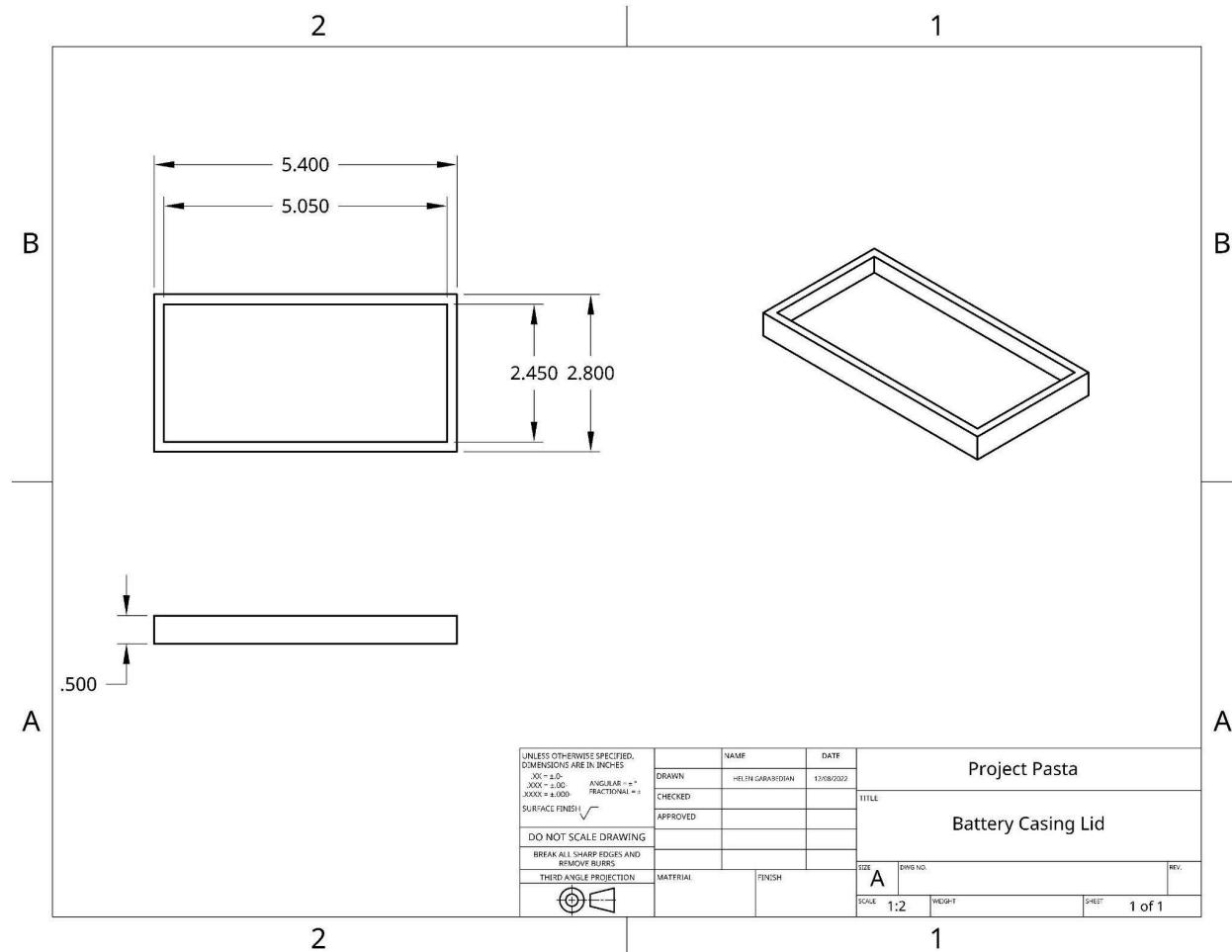
Pictured above is the motor holder that is connected to the first part pictured. The three small holes in a triangle is where the motor attaches to the motor holder.

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Pictured above is where the batteries, arduino and H-bridge are stored. The smaller cut out is for the H-bridge to slide into and the bigger slit is where the arduino rests. The batteries slide in underneath those components. The hole is where the motor connects to the electronic components.

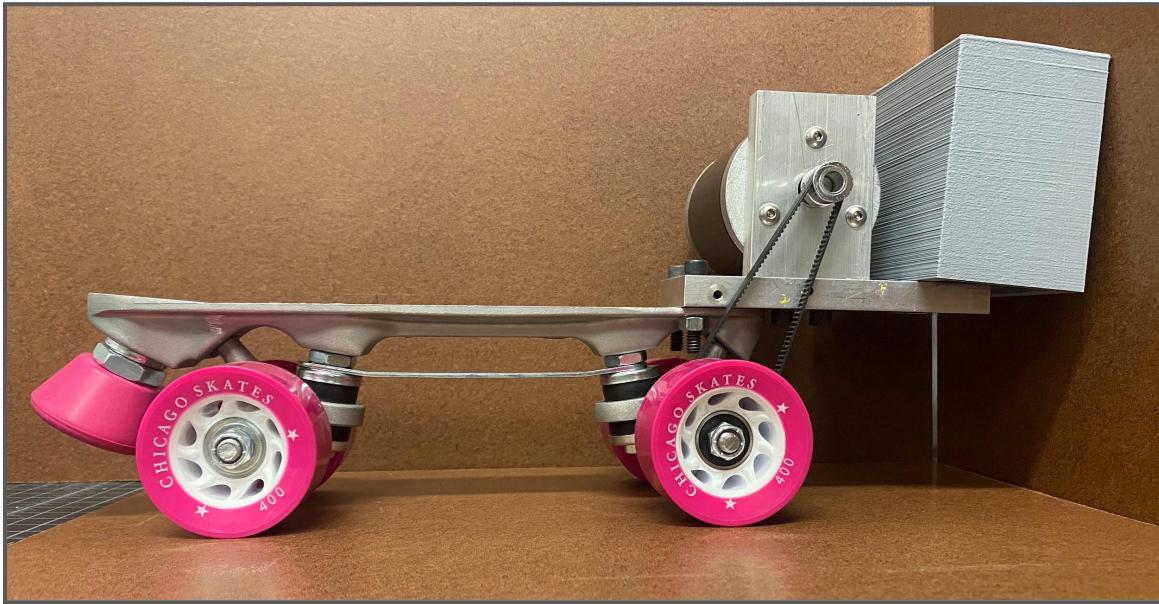
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Pictured above is the lid for the electronic component casing. It is secured on by one tie down strap.

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*Pictured above is our final product (new battery casing but pretty similar). Straps not pictured.*

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## APPENDIX D: Arduino Code Used to Control Motor

```
1 #include <RF24.h>
2 RF24 radio(9, 10); //library in which the radio runs on
3 int IN1 = 7;
4 int IN2 = 8;
5 int ENA = 5;
6 //number of the pins in which the motor controller will be inserted into so it can be programed
7
8 void setup() {
9     while (!radio.begin())
10    ;
11    radio.openReadingPipe(0, 90); //INDICATES THE "PIPE" THAT THE MESSAGE WILL BE GOING THROUGH
12    radio.startListening(); //TELLS THE AURDUINO TO LISTEN FOR A MESSAGE THROUGH SAID PIPE
13    pinMode(IN1, OUTPUT);
14    pinMode(IN2, OUTPUT);
15    pinMode(ENA, OUTPUT);
16
17
18
19    digitalWrite(IN1, LOW); //
20    digitalWrite(IN2, HIGH);
21    Serial.begin(9600);
22 }
23
24 void loop() {
25     int RXmsg;
26     if (radio.available()) {
27         radio.read(&RXmsg, sizeof(RXmsg)); //RECEIVES MESSAGE FROM THE OTHER RADIO
28         Serial.println("RADIO IS AVAILABLE");
29     }
30     int potval = RXmsg;
31     Serial.println(RXmsg);
32     int speed = map(potval, 0, 1023, 0, 255); //TRANSLATES VARIABLES THAT WERE SENT FROM THE POTENTIOMETER
33     analogWrite(ENA, speed);
34     delay(5);
35 }
```

```
1 #include <RF24.h>
2 #include <RF24_config.h>
3 #include <RF24LB1.h>
4 #include <printf.h>
5 //THIS TELLS THE AURDUINO TO USE THE RADIO LIBRARY FOR ITS CODE
6 RF24 radio(9,10);
7 int potent_pin = A5;
8 int val = 0;
9 //THIS SHOWS THE PIN THAT WILL BE CONNECTED TO THE POTENTIOMETER
10
11 void setup() {
12 while (!radio.begin());
13 radio.openWritingPipe(#90); //THIS SHOWS THE "PIPE" THAT THE MESSAGE WILL BE SENT THROUGH
14 pinMode (A5, INPUT);
15 Serial.begin(9600);
16 }
17
18 void loop() {
19 int TXmsg;
20 TXmsg = analogRead(potent_pin); //THIS TELLS THE RADIO TO "READ" THE MESSAGE RECEIVED FROM THE POTENT
21 | radio.write(&TXmsg, sizeof(TXmsg));
22 val = analogRead(potent_pin);
23 serial.print();
24 analogWrite(potent_pin, (val / 255)); //THIS TELLS THE RADIO TO SEND THE MESSAGE RECEIVED
25 delay(5);
26 }
27
28
```

Pictured above is the arduino code used to control the motor. Code for the Arduino attached to the skate is pictured on the left. Code for the remote is pictured on the right.