

# ME 72 Design Notebook

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Team Pharaobots

Other team members: Daniel, Ana, Hannah, Miina, Lily, Sophia



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## 9/30 - First ME 72 class

On the first day of class, the competition details were released and I took notes on the competition. These notes are below.

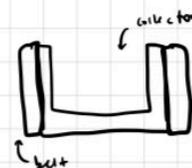
i wanna ask how the delivery  $\rightarrow$  pellets going down the curved side works

also abt the beacon thing

questions abt the 72 challenge:

- how does pellet  $\rightarrow$  curved side work
- how do you race it? catch it?
  - $\hookrightarrow$  deposit one at a time or multiple?

- chassis should be mostly covered prob to prevent bad damage



## BUDGETING

- shipping + taxes NOT INCLUDED in cost
- 3D printing free
- RC controllers not included in cost
- Some lipo batteries included
- Some roboclaws included
  - $\hookrightarrow$  good for current rating

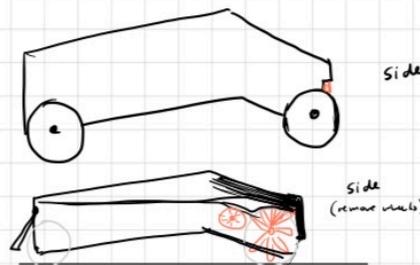
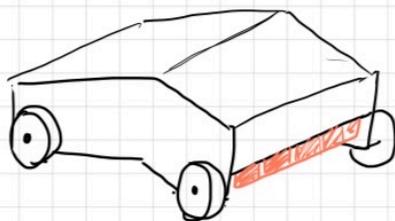
**MOTOR SELECTION** - the art & science of motor collection

- use formula + slides to calculate current (in A) through motor to create torque in worst-case scenario (climbing up hill).
- $\hookrightarrow$  is everything electronic going to survive the current?

check AGW Gauge of wires

- motor efficiency
  - you can generate the curves as a fn of angular speed of the motor if given the correct params from the manufacturer
- weight limit:  $\sim$  6 kg

first quick ideas of chassis/intake design:



## 10/5 - First group meeting

In our first meeting of the term, we tried to better understand the competition rules and went through the rules document together. We took notes on the competition document and began researching.

### Meeting 1 (10/5/2025)

- Things to figure out:
  - How to divide the tasks between robots and how to optimize points?
    - Have one robot 'focused' on climbing
    - Have one robot 'focused' on being fast and picking up/collecting
  - What is the basic design of the robot we want to use (4 wheels/materials for frame/etc.) and how do we plan to turn?
  - How do we want to command the robot (ie. how do we tell it when to turn, speed up, etc.) – what controllers are involved?
  - How do we pick up the pellets?
  - Later on: machining plan and budget (how much extra budget space do we want to have?)?
  - Subdivide up the robot designing and making initial diagrams?
    - Ie. two people per robot figure out the materials and specific dimensions required for all parts
- Carwash intake mechanism
- Calculations
  - Calculate whether we bottom out the robot when going up the incline
  - Calculate how tall the robot needs to be to successfully get on top of pyramid.
- Should we get a robot that goes to the top and stays at the top restricting everyone else?
- Strategy thoughts:
  - Have a robot that zooms out and pushes the button to get the energy tax reduction
  - Task of most importance: being able to collect the pellets
- 
- PDR Content
  - Robot 1:
    - Climber + Pusher - high torque
  - Robot 2:
    - Picker upper - low torque (fast) + autonomous
  - Robot 3:
    - Climber - intermediate torque
- Motor choice

**10/5**

- 4 higher torque motors for climbing 37 degrees
- 4 intermediate torque motors for 37 degrees
- 4 intermediate/less torque motors for 1 in: 3in → 18 degrees
- Conveyer belt and intake motors (1 for conveyer belt, 3 for intake)
- Wheel choice
  - Climber with grippier & bigger wheels
  - Smaller for others?
- Robot design
  - Intake mechanism
    - Wheels vs spindles
    - Intake motor
    - Free hanging vs pinned down
  - Flat base or tilted base (inverse pyramid)
  - convey belt + reservoir + dumping mechanism
- Main material
  - Structure materials
  - Shielding materials (protection)
- Conveyer belt
  - Motor
  - Belt material
    - A material that is able to grip the pellets → rubber?
  - dimensions
- Overview budget
- Rough schedule

**TO DO:**

- Intake mechanism
  - Anya
  - hannah
- Motor Research
  - Miina
  - Daniel
- Wheels research
  - Lily
  - Ana

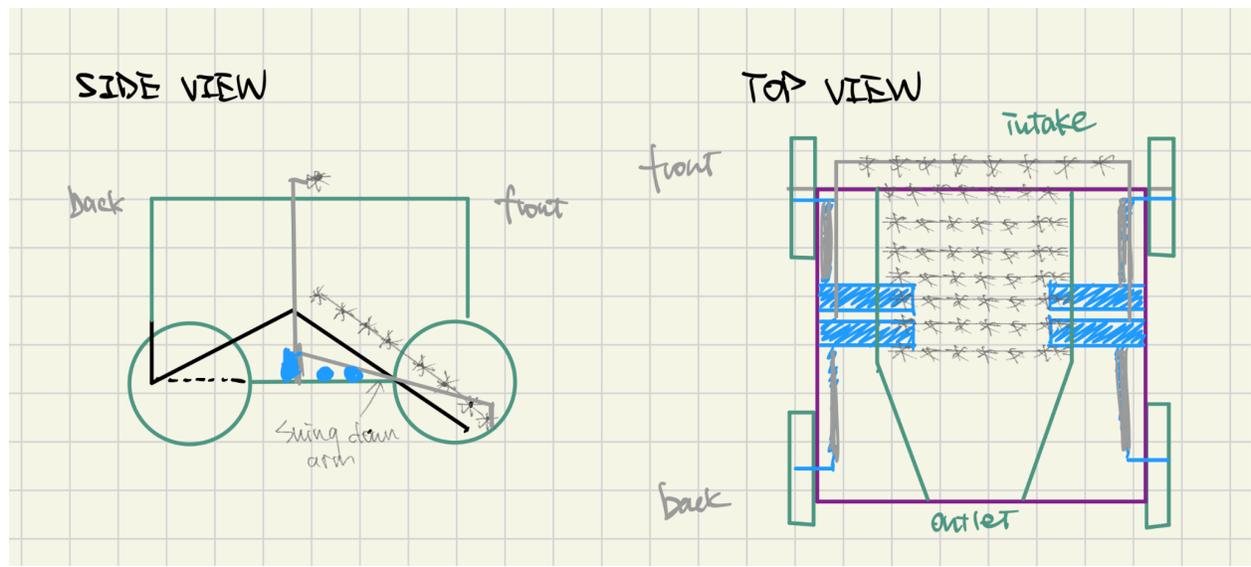
Link for intake video: <https://www.youtube.com/watch?v=RCfMzZY3IC0>

*Handwritten signature*

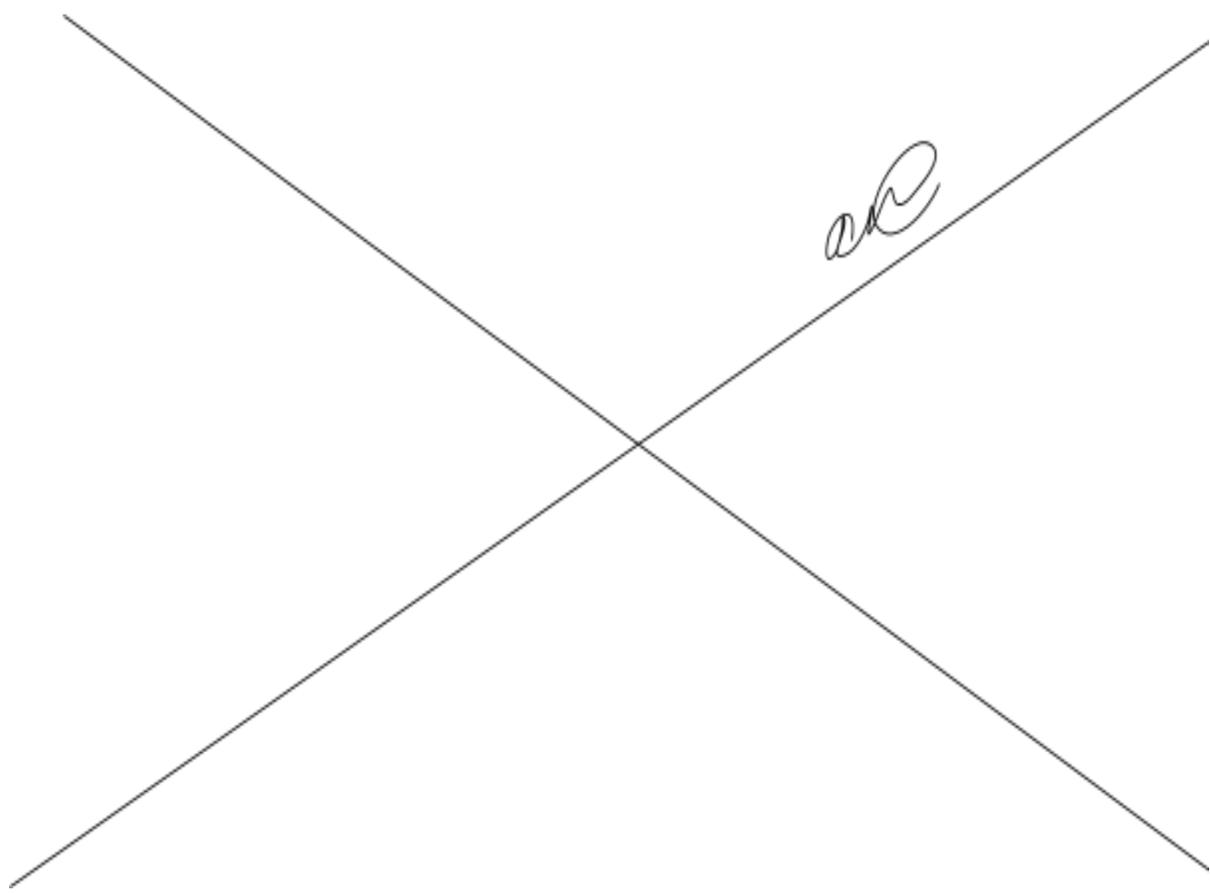
10/5

Another intake video: <https://www.youtube.com/watch?v=QiQPEfmqbWU>

Also kinda cool: <https://www.youtube.com/shorts/dCKSPGX2xfg?feature=share>



1 sq = 2 inches (to scale)





**10/7**

To Do

- Wheels:
  - Calculate the pushing force of wheels
  - Decide 3 in vs 3.5 in vs 4in
  - Wheel base design/chassi
    - Anya and lily**
- Intake mechanism
  - Pro/cons for spindles or conveyer belt: decide
  - Space between spindles rotating and how many
  - Angled of intake ramp
    - Anya and lily**
- Overall game strategy
  - Daniel**
- Electronics
  - Control
  - Calculate battery (after motors)
    - miina**
- Dumping Mechanism (**Hannah, Ana**)
  - Hinge motor/servo that can overpower the force of the magnets + weight of pellets
- General dimensions
  - Calculate the angle we need the ramp to be for gravity to do the work of putting pellets down. Include weight of pebbles and friction force (**hannah, ana**)
  - Calculate clearance from floor of front ramp (<0.5in)
  - Good to scale drawing of design - to make sure everything fits (**Hannah, ana**)
- Motors:
  - Wheel motor (decide which ones) (2 high torque one low torque)
  - Spindle motors (
  - Decide speed of other robot (Daniel - the fast one)
  - Will we use roboclaw (only brushed dc motors)? And how?
  - Costs



### 10/8 - Intake mechanism research

As our first task, Lily and I paired up to work on intake mechanism research. We compiled our notes into this google doc:

[https://docs.google.com/document/d/1jWol\\_F\\_zL2oryKMQvdWf0PAvALD7GdXoBtbNfciabx0/edit?usp=sharing](https://docs.google.com/document/d/1jWol_F_zL2oryKMQvdWf0PAvALD7GdXoBtbNfciabx0/edit?usp=sharing)

Later, Hannah joined me and we continued the research. I also interviewed some of my friends that did the sumobots competition last year to ask about how their intake mechanism worked.



### 10/11 - Initial electronics requirements research

Ana and I did research on electronics requirements for the robots, as shown below. I interviewed one of my friends who led his electronics team last year to ask about how they designed their schematic.

Brain:

- Raspberry Pi or Arduino Mega for autonomous robot
- From ME129: Raspberry Pi 4 Model B
- Arduino Mega: robust and might be in lab
- Motor controller board – Roboclaw is provided for other two robots
- Each board drives 2 motors
- Another roboclaw controller for smaller motors

Sensors:

- IR Sensors - to help with line following
- Motor controller: regulates power from battery

Battery:

- The one from ME14. 14.8V

Power:

- Motor behavior

Battery → motor controller → motors, arduino, receiver

Remote controller → receiver → arduino → motor controller → motor

All motors need a source of power

Servo:

- For servo, you might not need a motor controller, but might need to step down the power
- Mosfet power distribution boards
- Controlled by Arduino

Extra Notes:

- Electrical tape and hot glue before competition

## 10/14 - Initial battery research

Daniel found a few possible battery options, which are shown below.

[https://www.google.com/aclk?sa=L&ai=DChsSEwi1idS3rKWQAxVfPUQIHafmPFoYAClCCAEQDRoCZHo&ae=2&aspm=1&co=1&ase=2&gclid=Cj0KCQjw6bfHBhDNARIsAIGsqLgP4lj1UGdHiURQYqcKoacmXgozB9K8XVHeNB72TjDzorES6l\\_-KOwaAubjEALw\\_wcB&cid=CAASN-Roq1lxGtkf\\_T1pMMn3o9YWi3WO3Ju3tZGbR1Uk1XRHly7JNTR7FOE76GS0i-MUnfuwfs5SA6U&cce=2&category=acr\\_cp\\_v1\\_35&sig=AOD64\\_007DILHH9CaAc0-UruSq8vM62YIA&ctype=5&q=&nis=4&ved=2ahUKEwi5g8-3rKWQAxViJEQIHbJIFgEQ9aACKAB6BAgFEFk&adurl=](https://www.google.com/aclk?sa=L&ai=DChsSEwi1idS3rKWQAxVfPUQIHafmPFoYAClCCAEQDRoCZHo&ae=2&aspm=1&co=1&ase=2&gclid=Cj0KCQjw6bfHBhDNARIsAIGsqLgP4lj1UGdHiURQYqcKoacmXgozB9K8XVHeNB72TjDzorES6l_-KOwaAubjEALw_wcB&cid=CAASN-Roq1lxGtkf_T1pMMn3o9YWi3WO3Ju3tZGbR1Uk1XRHly7JNTR7FOE76GS0i-MUnfuwfs5SA6U&cce=2&category=acr_cp_v1_35&sig=AOD64_007DILHH9CaAc0-UruSq8vM62YIA&ctype=5&q=&nis=4&ved=2ahUKEwi5g8-3rKWQAxViJEQIHbJIFgEQ9aACKAB6BAgFEFk&adurl=)

\$65

[https://rcbattery.com/lipeior-5000mah-6s-65c-22-2v-lipo-battery-with-ec5-plug.html?gad\\_source=4&gad\\_campaignid=12748770885&gbraid=0AAAAACRJLSaNmWLM5eFkNtRnkTI6ua4xP&gclid=Cj0KCQjw6bfHBhDNARIsAIGsqLhmUV96yO3NOrt7MHU6ankq1qEgj-OrY3TW2JHCKuFXDMR21VXrSTwaAnO1EALw\\_wcB](https://rcbattery.com/lipeior-5000mah-6s-65c-22-2v-lipo-battery-with-ec5-plug.html?gad_source=4&gad_campaignid=12748770885&gbraid=0AAAAACRJLSaNmWLM5eFkNtRnkTI6ua4xP&gclid=Cj0KCQjw6bfHBhDNARIsAIGsqLhmUV96yO3NOrt7MHU6ankq1qEgj-OrY3TW2JHCKuFXDMR21VXrSTwaAnO1EALw_wcB)

We also took some notes on calculating peak current needs in our electronics document:

### Considerations:

#### 1. Voltage requirements

- Climber robot
  - Driving motors
    - 24V DC rated voltage required for the motors, so **24 V** voltage for the entire 2x60 A roboclaw
  - Intake Motors
    - 12V rated voltage per intake motor (2 intake motors), **24 V total** if powered separately, **12 V total** if powered in parallel
  - Back Door Motor
    - **6V** operating voltage (max case)
  - Arduino MEGA
    - 7-12 V to power, let's say **12 V** to stay on the higher side
  - Roboclaw
    - **Additional 5 V ? need more research**
  - **TOTAL VOLTAGE: 24 V**
- Speedy robot
  - Driving motors
    - 24V DC rated voltage required for the motors, so **24 V** voltage for the entire 2x60 A roboclaw
  - Intake Motors
    -

10/14

- 12V rated voltage per intake motor (2 intake motors), **24 V total** if powered separately, **12 V total** if powered in parallel
  - Back Door Motor
    - **6V** operating voltage (max case)
  - Arduino MEGA
    - 7-12 V to power, let's say **12 V** to stay on the higher side
  - **TOTAL VOLTAGE: 24 V**

## 2. Continuous Current

- Climber robot
  - Driving Motors
    - <2.6 Amps rated current per motor, **10.4 A total**
  - Intake Motors
    - Rated Current: 0.6Amp, **1.2 A total**
  - Back Door Motor
    - Online says ~1.2 A for stall current, let's be on the safe side and assume ~**1 A** required to run (worst case)
  - Arduino MEGA
    - ~ **5A???? Idk im confused**
  - **TOTAL CONTINUOUS CURRENT: 17.6 A**
- Speedy robot
  - Driving Motors
    - <2.6 Amps rated current per motor, **10.4 A total**
  - Intake Motors
    - Rated Current: 0.6Amp, **1.2 A total**
  - Back Door Motor
    - Online says ~1.2 A for stall current, let's be on the safe side and assume ~**1 A** required to run (worst case)
  - Arduino MEGA
    - ~ **5A???? Idk im confused**
  - **TOTAL CONTINUOUS CURRENT: 17.6 A**

## 3. Peak Current

- Climber robot
  - Driving Motors
    - < 21 A
    - 21 A stall current each, but since all four motors are technically in parallel (in parallel for each roboclaw output, and each roboclaw output is in parallel), the **total stall current is 84 A**

10/14

- Intake Motors
  - Stall current unknown (estimate 5 A), 2 of them = **10 A** total
- Back Door Motor
  - Online forums say **~1.2 A** stall current
- Arduino MEGA
  - **~0.5 A** to run
- **MAX/PEAK TOTAL CURRENT: 95.7 A**
- Speedy robot
  - Driving Motors
    - < 21 A
    - 21 A stall current each, but since all four motors are technically in parallel (in parallel for each roboclaw output, and each roboclaw output is in parallel), the **total stall current is 84 A**
  - Intake Motors
    - Stall current unknown (estimate 5 A), 2 of them = **10 A** total
  - Back Door Motor
    - Online forums say **~1.2 A** stall current
  - Arduino MEGA
    - **~0.5 A** to run
  - **MAX/PEAK TOTAL CURRENT: 95.7 A**

#### 4. mAh:

- Assuming the robots are operating for the entire 4 mins 30 seconds (worst case)
  - Climber robot:  $17600 \text{ mAh} * (0.075 \text{ hours}) = \mathbf{1320 \text{ mAh}}$
  - Speedy robot:  $17600 \text{ mAh} * (0.075 \text{ hours}) = \mathbf{1320 \text{ mAh}}$

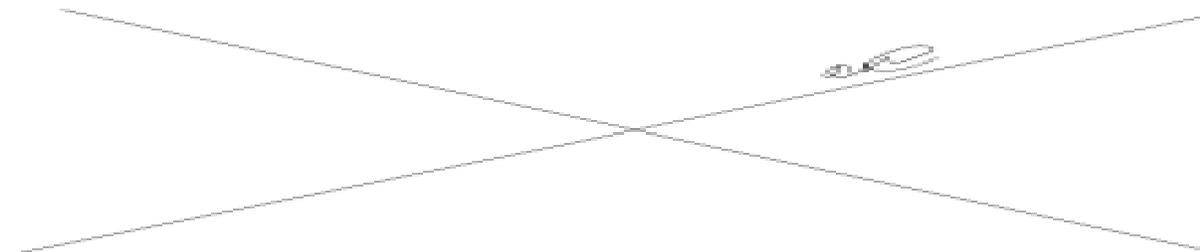
#### Battery Criteria:

Capacity ~5000 - 6500 mAh

Voltage ~ 22.2 - 24 V

Current > 100 A

C - rating > 15C - 20C (depending on capacity and current)



## 10/15 - Electronics research

### Morning:

Today, we did research on batteries that we can use for the robot.

### Batteries we can put in series:

- <https://www.walmart.com/ip/2x-14-8V-6500mAh-4S-LiPo-Battery-XT90-for-Rc-Helicopter-Airplane-Boat-Car-Truck/17703465586?wmlspartner=wlp&selectedSellerId=102820850>
  - 14.8V 6500 mAh 4S Lipo
  - Pack of 2
  - \$76.25
  - At least 1 of these in the shop
- <https://www.amazon.com/Socokin-Connector-Airplane-Quadcopter-Helicopter/dp/B0FK9ZGKRH>
  - 11.1V 5200 mAh 3S Lipo
  - Pack of 2
  - \$46.74
  - At least 1 of these in the shop

### Other considerations:

- [https://hobbyking.com/en\\_us/turnigy-5000mah-6s-25c-long-lipo-pack.html?srltid=AfmBQooLdtmz5p1dDvEEhAQ15UzicVfQXQ3i\\_\\_5lftLzpGQpWwLRJeS6&utm\\_source=chatgpt.com](https://hobbyking.com/en_us/turnigy-5000mah-6s-25c-long-lipo-pack.html?srltid=AfmBQooLdtmz5p1dDvEEhAQ15UzicVfQXQ3i__5lftLzpGQpWwLRJeS6&utm_source=chatgpt.com)

Expensive but high mAh

[https://rcbattery.com/liperior-7000mah-6s-35c-22-2v-lipo-battery-with-ec5-plug-for-rc-planes-rc-helicopters-drones.html?gad\\_source=1&gad\\_campaignid=12748770885&gbraid=0AAAAACRJLSa7lw\\_b25m3iNp3DYZSN5uCk&gclid=Cj0KCQjwjL3HBhCgARIsAPUg7a4N\\_I1OBn98hGXPG5jyzDfeyUYdsblbls-ME5uFvI9VINMnFhbnEalaAoJbEALw\\_wcB](https://rcbattery.com/liperior-7000mah-6s-35c-22-2v-lipo-battery-with-ec5-plug-for-rc-planes-rc-helicopters-drones.html?gad_source=1&gad_campaignid=12748770885&gbraid=0AAAAACRJLSa7lw_b25m3iNp3DYZSN5uCk&gclid=Cj0KCQjwjL3HBhCgARIsAPUg7a4N_I1OBn98hGXPG5jyzDfeyUYdsblbls-ME5uFvI9VINMnFhbnEalaAoJbEALw_wcB)

### Night:

At night, we finalized our slides and practiced the presentation for the CDR tomorrow. We are generally pretty prepared and are under time, which is good.

## 10/19 - CDR planning

Today, we met for a long meeting to discuss what we needed to get done for the CDR. Our notes are below.

### Meeting 6 (10/19) - CDR planning

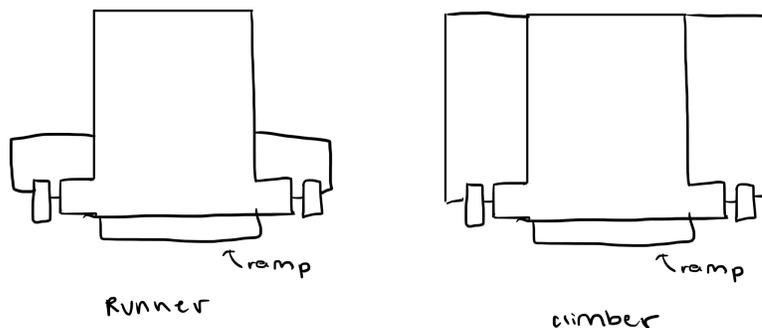
- CAD assembly
  - Assembly of drivetrain (the chain and motors and wheels)
    - Involves the inner walls and wall closest to the wheel
  - CAD the bottom plate with slots and how it will connect to ramp/inner walls
  - CAD the super outer protective walls → threaded rod structure
  - Assemble bottom plate to the inner walls
- GD & T
  - Inner wall
- Electronics wiring and more specific electronic calculations
  - Anya and daniel
- Deflection calculation for the chassis
  - Lily
- Magnets testing (jig design, holder)
  - Sophia
- The slip calculation (for incline running up and stopped on incline), necessity of magnets
  - lily
- Motor cooling (heat sinks, size, weight, etc)
  - Anya
- Plot angular speed vs. torque for motor
- Figure out how sorting of ECs vs pellets works in back storage of robot (not for cdr)

### Meeting 6 (10/19) - CDR planning

- What Mello wants based on PDR notes:
  - The slip calculation for the robot when moving up the ramp and when stuck in one place on the ramp (in lecture notes)
    - [https://caltech.instructure.com/courses/8785/files/1990768?module\\_item\\_id=341438](https://caltech.instructure.com/courses/8785/files/1990768?module_item_id=341438)
  - More information about the magnets we plan to use under the robot
    - How do we have clearance while also having magnets close to the surface?
    - We should consider redoing the magnet section of PDR – maybe having magnets on the wheels (the thin side of the magnet would need to have north/south)

10/19

- compute and plot power versus angular speed (and torque) to estimate maximum power and efficiency
  - Remember that the maximum torque occurs at stall, which is not a sustainable operating point
  - Ensure your motors can provide adequate steady-state power for climbing.
- Continue designing for fast assembly and disassembly to facilitate quick repairs.
- Detailed Gantt chart??
- More details on electrical wiring diagram
- From TA notes to clarify
  - Also confirm that planetary-gear motors and sprockets won't yield under torque?
  - Clarify in your CDR how you'll handle a motor that lacks an encoder and whether you plan to add one later.
  - Verify that Roboclaws can handle the current demand of your chosen motors.
    - I think we have this already...?
- What we need to still decide design-wise:
  - What material are we using for the side walls (acrylic, etc.)?
    - Aluminum
    - Have different front design for climbers or the speedy robot
    - Should start CAD from the inner walls of the robot to see how ramp is attaching and all other parts would attach
    - 8 in minimum for the inner size of the robot



- Does the intake extend to the chassis bottom layer with motors or not (ie. are they one connected plate that goes upward)?
  - Have a long inner wall that reaches up to the top of the inclined
  - Find bearings for the spindle  $\frac{1}{2}$  inner diameter
  - Thick bottom plate to support all the parts being connected to it
  - Thick side plates to protect wheels connected through rods

10/19

- Do we want to adapt to longer spindles to take in the energy credits also? And this would mean an overall increase in size between the two inclined plates inside the robot to fit ecs also?
  - Yes spindle size is now 1.7 in radius
- Does our ramp need to reach even lower to pick up pellets 0.5 in vs 0.6 in?
- What belt mechanism are we using for the spindle connection (will this be located inside the gear train section of the robot)?
- Should we change out the gears to be less costly?
- What we need to CAD:  
Base visualization:

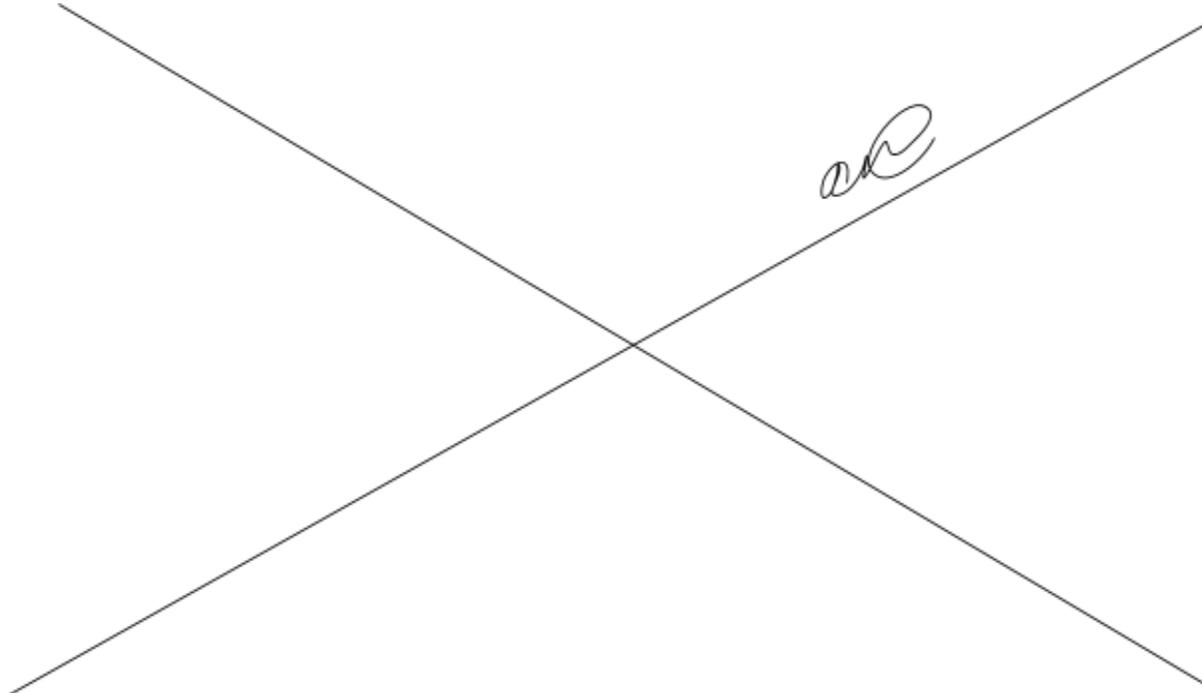


<https://www.instructables.com/Designing-Our-FTC-Bot-2023-2024-1/>

- The mounts for all the motors
- The chassis bottom layer
- The intake mechanism - motors, spindles, and their connection
- The smaller robot → how are we achieving the desired decrease in weight? (what do we plan to cut out)
- The dumping mechanism CAD
- What units are we doing CAD in?
- How do we split or not?

**10/19****To do:**

- Send next questions email
  - Anya
- Email petitioning for the battery (and to move cdr please)
  - Daniel and Anya
  - Miina for section on motors
- Look for alternative motors that can be powered by 4S batteries
  - Sophia
- Slip calculations
- Magnet stuff, and calculation with strongest magnet
- Complete electronics schematic
  - Daniel and Anya
- Meet with Trent again for electronics
  - Daniel and Anya
- CAD inner chassis wall
- CAD back wall
- CAD motors and wheels
  - Miina
- Find bearings for spindle rod (1/2")
  - Lily
- Cardboard model testing of clearances



### 10/21 - Writing battery and motor selection petitions

Daniel, Miina, and I worked on writing a battery proposal to use the 22.2 V battery over the 14.8 V battery from the shop in order to support more powerful motors following the battery requirement changes to the rules after the PDR. We drafted this proposal in the link below and emailed it to Professor Mello:

[https://docs.google.com/document/d/1lQ8EBDHlxkhZlZci\\_ctgxOqehNm2OsuHXRj3hKdwwY/edit?tab=t.0](https://docs.google.com/document/d/1lQ8EBDHlxkhZlZci_ctgxOqehNm2OsuHXRj3hKdwwY/edit?tab=t.0)

Professor Mello also asked for a table with our motor option specifications, so Daniel and I worked on this so that Prof. Mello could check our motor calculations. This table is below:

#### Climber Bot Integrated Gear Motor

[https://www.robotshop.com/products/e-s-motor-36mm-diameter-high-torque-planetary-gear-motor-24v-440rpm?pr\\_prod\\_strat=e5\\_desc&pr\\_rec\\_id=2ae7d25cc&pr\\_rec\\_pid=7487499698337&pr\\_ref\\_pid=7487504318625&pr\\_seq=uniform](https://www.robotshop.com/products/e-s-motor-36mm-diameter-high-torque-planetary-gear-motor-24v-440rpm?pr_prod_strat=e5_desc&pr_rec_id=2ae7d25cc&pr_rec_pid=7487499698337&pr_ref_pid=7487504318625&pr_seq=uniform)

Spec	Value
Rated Voltage	24 V
No-Load Speed	440 RPM
No-Load Current	< 500 mA
Rated Speed	330 RPM
Rated Current	< 2.6 A
Rated Torque	21 kg-cm
Stall Torque	60 kg-cm
Stall Current	< 21 A
Gear Ratio	1:27

#### Speedy Bot Integrated Gear Motor

<https://www.robotshop.com/products/e-s-motor-36mm-diameter-high-torque-planetary-gear-motor-24v-90rpm?qd=6c7f8dec114b652a6858faa5e4322687>

Spec	Value
Rated Voltage	24 V
No-load Speed	630 RPM
No-Load Current	< 500 mA

*AB*

Rated Speed	490 RPM
Rated Current	< 2.6 A
Rated Torque	14 kg-cm
Stall Torque	50 kg-cm
Stall Current	< 21 A
Gear Ratio	1/19

*AB*

## 10/22 - Battery calculations for CDR

The night before the CDR, I continued working on finalizing the calculations of the battery for the presentation and justified our choice of the battery and electronics. I created tables which made it easier to visualize the total current needed for all of our electronics, as shown below.

### All Electronics Parts

#### Runner Robot

Part	Link	Quantity	Voltage needed	Current needed	Peak current	Total voltage	Total cont. current	Total pk. current
Driving Motor	<a href="https://www.robotshop.com/product/sun-s-motor-42m-robot-diameter-gear-motor-12v-31-6rpm">https://www.robotshop.com/product/sun-s-motor-42m-robot-diameter-gear-motor-12v-31-6rpm</a>	4	12 V	~6 A	12 A	12 V	24 A	48 A
Backdoor Motor	<a href="https://www.sumotoc.com/usa/robot-gear-motor-rc-servo-motor-3v3rpm">https://www.sumotoc.com/usa/robot-gear-motor-rc-servo-motor-3v3rpm</a>	1	4.8-6 V	~0.4 A	~1.2 A	~5 V	0.4 A	1.2
Intake Motor	<a href="https://www.amazon.com/Greentree-Electric-Reducer-Centric-Diameter/dp/B07295G5GR?th=1">https://www.amazon.com/Greentree-Electric-Reducer-Centric-Diameter/dp/B07295G5GR?th=1</a>	2	12 V	0.5 A	Not listed	12 V	1 A	??
Receiver	<a href="https://www.amazon.com/GoRC-FS-48B-Receiver-Compatible-Transmitter/dp/B07XJWDMF9?th=1">https://www.amazon.com/GoRC-FS-48B-Receiver-Compatible-Transmitter/dp/B07XJWDMF9?th=1</a>	1	4.0-6.5 V	~0.5 A (not listed)	Not listed	~5 V	~0.5 A	--
Arduino MEGA	<a href="https://docs.arduino.cc/hardware/mega-2560/tech-specs">https://docs.arduino.cc/hardware/mega-2560/tech-specs</a>	1	5 V	0.05 - 0.07 A (depends on what is run, probably want to recalculate more thoroughly later)	Not listed (depends on what is run, probably want to recalculate more thoroughly later)	5 V	0.07 A	--
Infrared sensor	<a href="https://www.digikay.com/en/product/510050/22116814">https://www.digikay.com/en/product/510050/22116814</a>	3	3.3-5V	~0.01 A (not actually listed)	Not listed	3.3 - 5 V	~0.03 A	--
2x60 A Roboclaw	<a href="https://www.gobilda.com/roboclaw-2x60a-motor-controller?setCurrency=1&amp;sku=MC414&amp;ad_source=1&amp;ad_campaign=122899794&amp;ad_brand=0AAAAA7C78-IP8WUYAYoAaF1QH0Q47Adp&amp;gclid=CjwKCAjwXp0HIBhAcEwAm1SweEu-3FX7gZwK-AF1WY-RZ6MmTZAVY64Y0KH8KacCev9PwWBYuRoC0WgQAVD_BWE">https://www.gobilda.com/roboclaw-2x60a-motor-controller?setCurrency=1&amp;sku=MC414&amp;ad_source=1&amp;ad_campaign=122899794&amp;ad_brand=0AAAAA7C78-IP8WUYAYoAaF1QH0Q47Adp&amp;gclid=CjwKCAjwXp0HIBhAcEwAm1SweEu-3FX7gZwK-AF1WY-RZ6MmTZAVY64Y0KH8KacCev9PwWBYuRoC0WgQAVD_BWE</a>	1	-	-	-	Supplies additional 5 V voltage	Supplies additional 3A current	--





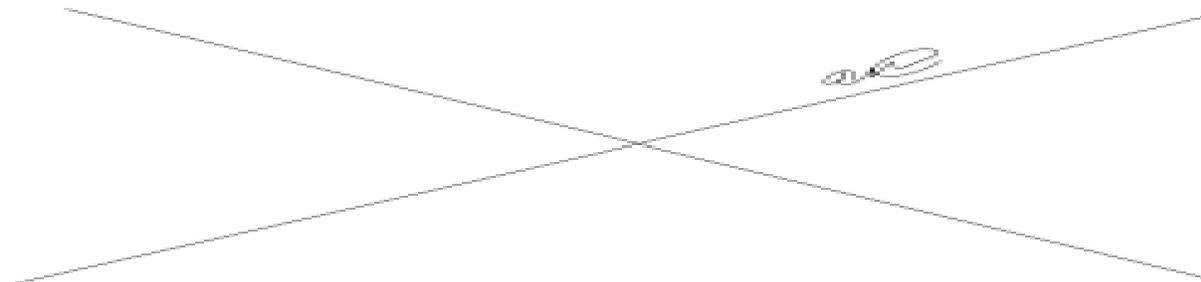
### 10/23 - CDR

Leading up to the CDR, I worked on finalizing the electronics schematic and formatting of the slide deck for the electronics section, as well as practicing my parts of the presentation. The presentation ended up going very well and some of the questions were helpful. Prof. Mello did not have time to respond to our battery petition before the CDR, but he provided feedback that we had done more than enough research into electronics to ensure that if we wanted to use the larger battery, he would let us. Following the CDR, I would like to improve the organization of our team by switching from a text group chat to a discord server so that we can organize our files and information through channels.

### 10/27 - Motor selection post-CDR

Following the CDR, we read through our feedback and discussed a bit about what design changes we needed to make. We agreed that there should be a front plate on the robot, as well as a bottom plate which provides increased structural stability. We also decided on the 12V 315RPM motors for the first robot due to the high torque and high velocity we expect it to provide. Although this puts an initial strain on our budget and will require us to change our drivetrain (among other reasons), we have cheaper motors that can specialize for high torque that can be bought for the second robot. We decided against the 24V motors for multiple reasons. If we wanted to run the motors at 24V, we would need to purchase new batteries which are not as frequently used in the shop. If we wanted to run 24V motors at 12V instead, the motors would lose significant performance making them the exact same as the cheaper alternative motors we plan to use in case of budgeting issues.

We also discussed cutting down the heights of the outside walls in order to cut the amount of aluminum (and thus cost) we need. We also decided to instead make the ramp and top plate 3D printed so that we can save cost on aluminum.

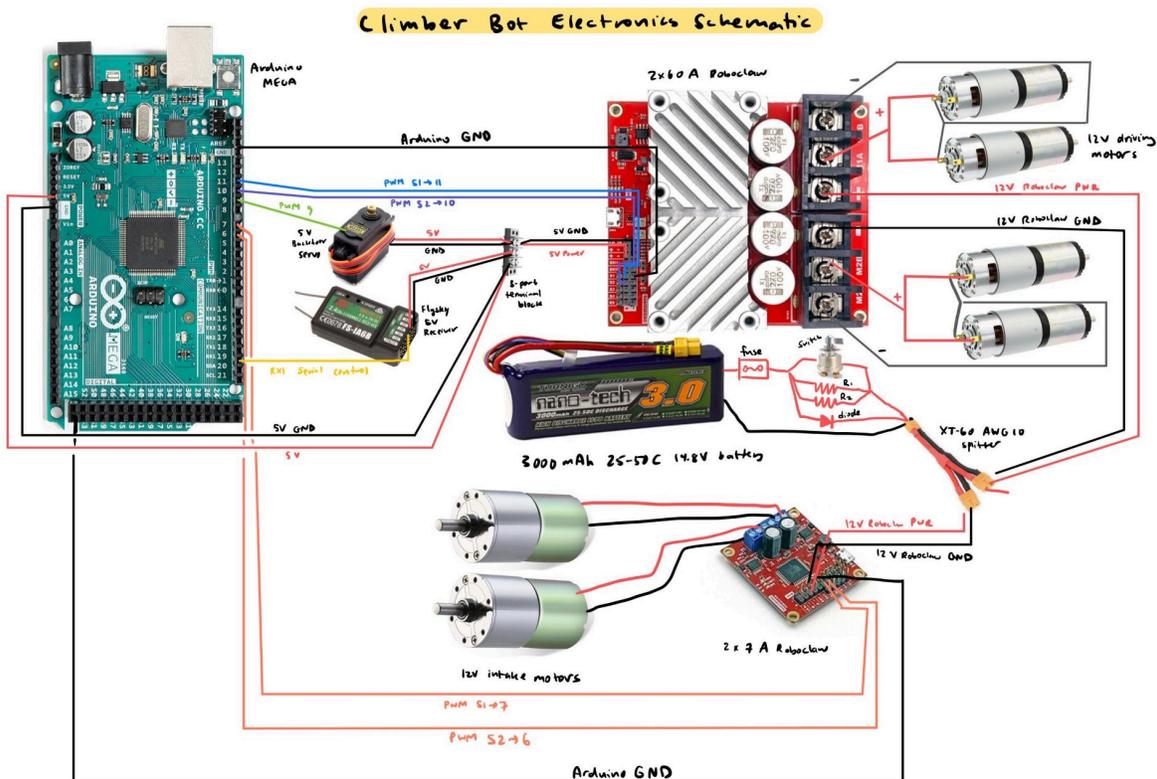


## 11/1 - Decided on L298 H-Bridge intake motor controller

Electronics todo:

- replace mosfets with motor controllers (free!)
- confirm 12 V manual switch choice
- confirm fuses
- confirm terminal ports
- go over schematic w david

We were able to find an LN298 H-Bridge in the shop, and have elected to use this instead of mosfets for the intake motors, since we will be able to control the speed of the motors, making it easier to test the intake mechanism and make changes where they are needed. We updated the electronics schematic to reflect these changes, as can be seen here:



Electronics schematic with H-bridge instead of mosfets.

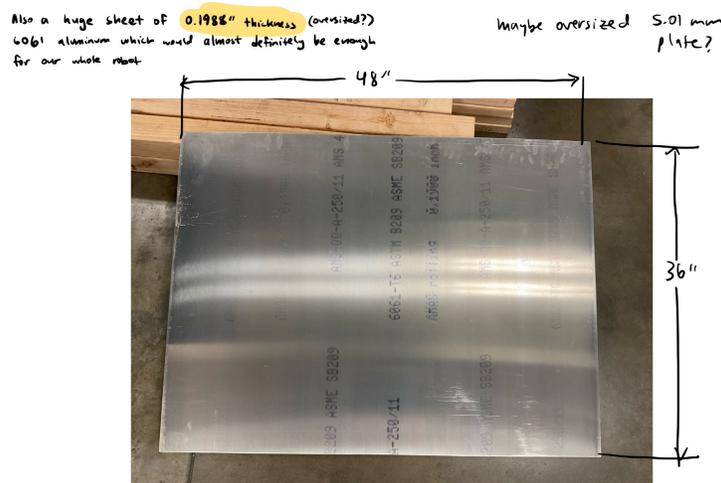
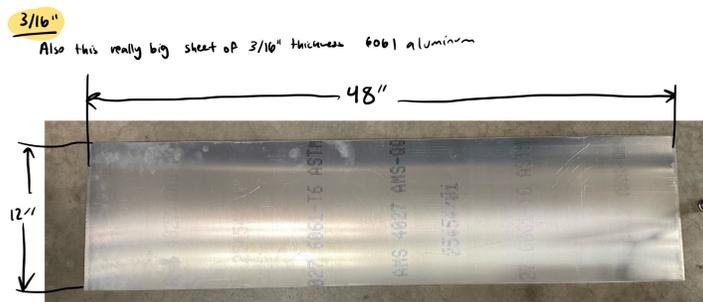
### 11/4 - Measuring aluminum sheets and resistor selection

Before my morning class, I came into the shop to measure the dimensions of the available aluminum plates in the shop so that we can use the sheets of aluminum at half price. I plan to finish measuring the dimensions of the plate after class.

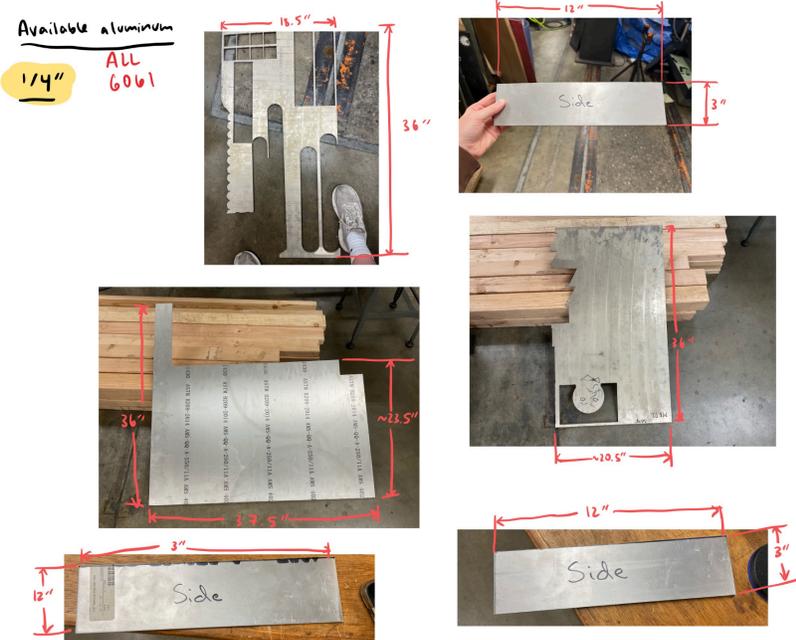
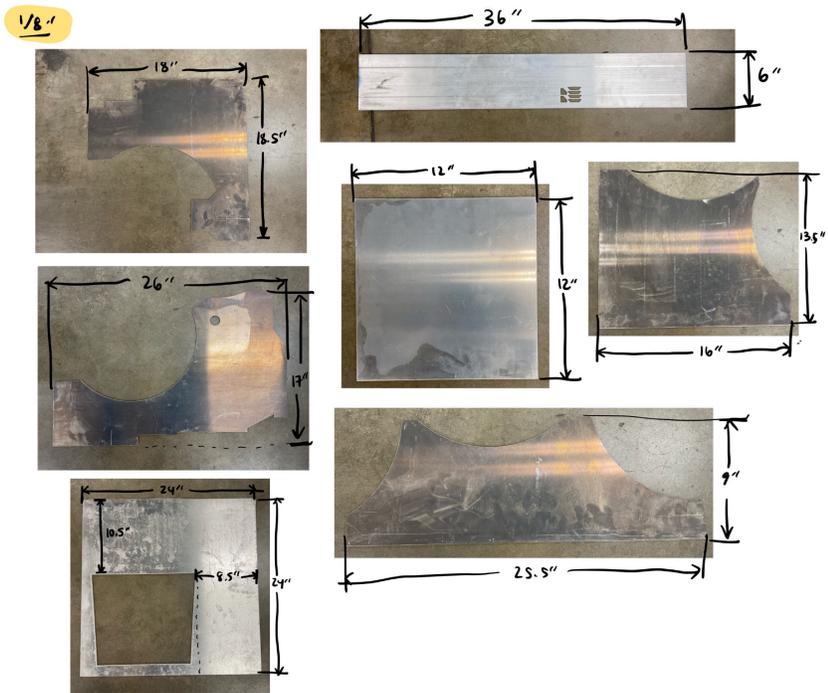
any todo in shop after pe:

- measure aluminum extrusions
- measure 1/8" plate dimensions
- look for resistor for battery in shop
- look for the awg wire we need in shop
- put switchback and fuse diode on bom

The dimensions of the plates are in the following pictures. I sent these to the manufacturing team so they can try to waterjet plates early before the available aluminum runs out.



11/4



Later in the afternoon, I came back in to figure out which resistors to use across the switch. In the roboclaw manual, the instructions were a bit confusing about how to pick the resistance and power ratings of the resistor. Daniel is going in later, so he will be asking Trent:

### 11/4

- why the placement of the diode is slightly different between the two diagrams
- how we are supposed to know the resistor specs since it lists it for a different voltage robotclaw

Daniel responded about the questions, and said:

- 1.) the wiring in the shop is free to take as we please, they have 12awg and 10awg
- 2.) Trent says 12awg seems reasonable for the 48amp peaks we expect from the motors, trent recommends silicon 12awg because better at higher temps
- 3.) The resistor will be different, he said it has something to do with the capacitor. He said the safe thing is to meet the resistor they have but we can likely get a way with a 1k, 1/4W resistor or maybe even two 2k, 1/4 in parallel.
- 4.) He said he isn't too sure on why the diode is in parallel vs in series with the resistor between the two manuals. His intuition is that it would be better to have the diode in series with the resistor but we can email him and he'll look into it for us, OR we can even email roboclaw themselves because apparently they are good at responding

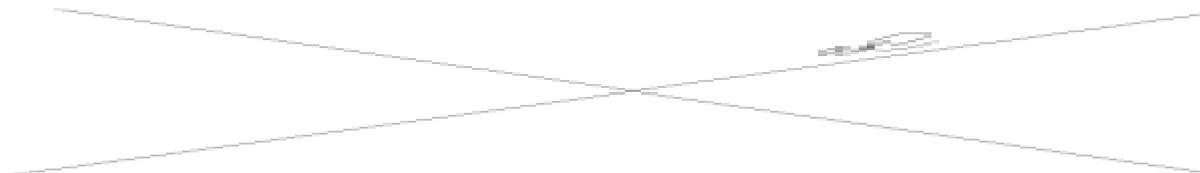
I ended up going into the shop again and finding the resistors that are available for anyone to take. I talked to Trent about how to select one again, and found that power adds in parallel so 2 of the 2.2 kOhm resistors in parallel with have a total resistance of 1.1 kOhm and total power of 1/2 W, which is sufficient for our roboclaw.

### TODO: priority (tonight)

- reconsider 12 AWG now with the shorter wires bc of fear of melting and lighting machine shop on fire
- based on this decision, pick the fuse (consider the above FACT)
- ~~email trent above the above + roboclaw schematic difference questions (location of diode) + our updated schematic with the resistors, diode, switch. ask if we can possibly get the fuse paid for by the shop since everyone has the same battery~~

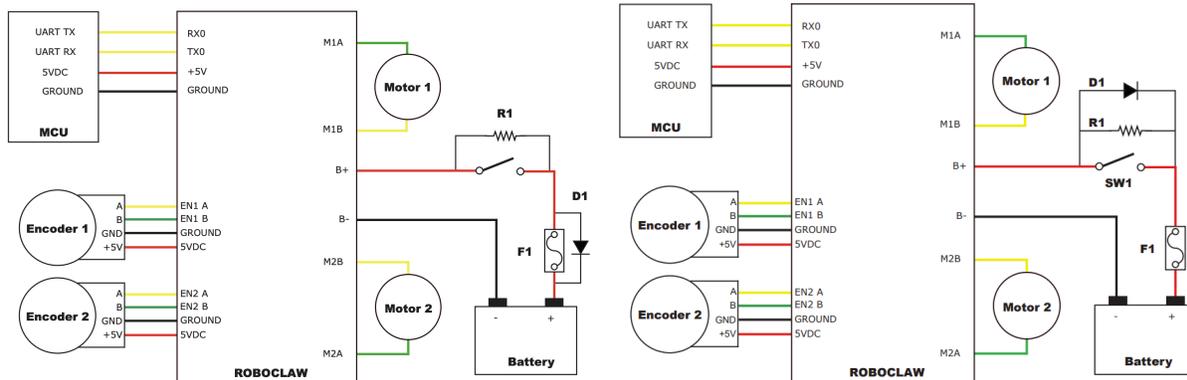
### end of this week

- IF motors arrive, start working with motion studio and figure out how roboclaw interface works
- either way, research into how to map controls -> motor motion
- maybe start basic wiring with a breadboard and the arduino



## 11/5 - Sorting out Roboclaw manual discrepancy

We noticed a discrepancy in the two wiring diagrams between the Roboclaw manual for a 2x60 A roboclaw, which is what we are using, and the general user guide for all roboclaw user manuals. In the general Roboclaw manual, the diode is placed in series with the resistor. In the 2x60A Roboclaw manual, the diode is in parallel with the resistor. This is shown below.



Trent was also not sure, so he emailed the roboclaw company for us and confirmed that the fuse should be in series with the switch, while the resistor and diode should indeed be in parallel with the switch. This helped us confirm our electronics schematic and move forward with the wiring process.

## 11/7 - Researching RC Controller & Testing RC Controller

Yesterday, Daniel found a tutorial on the Flysky RC controller and how to wire the receiver and began taking notes in a separate Google doc. He used the following video to start a tutorial on RC controllers and plan out how we are going to start testing with the controller and receiver:

[https://www.youtube.com/watch?v=BACBNgaCnJU&list=PLWNDWPACIRVoIZzsX-SkR5Br0\\_ZtRscxZ&index=12](https://www.youtube.com/watch?v=BACBNgaCnJU&list=PLWNDWPACIRVoIZzsX-SkR5Br0_ZtRscxZ&index=12)

### To do:

- ~~anya download motion studio~~
- ~~anya download arduino~~
- ~~install libraries to read ibus and for motion studio code~~
- test motors manually in motion studio
- ~~connect re controller to servo motors~~
- redo roboclaw tutorial from me 14
- ~~go through lipo safety document again~~
- charge the lipos we will be using
- ask trent for battery monitor for us to use/look in closet
- do some tests on the batteries we are using (checking capacity, etc.)
- from trents email decide fuse

---

### Notes on RC controllers:

Helpful Video: RC Robot Car - RC Controls and Arduino - DroneBot Workshop

[https://www.youtube.com/watch?v=BACBNgaCnJU&list=PLWNDWPACIRVoIZzsX-SkR5Br0\\_ZtRscxZ&index=9](https://www.youtube.com/watch?v=BACBNgaCnJU&list=PLWNDWPACIRVoIZzsX-SkR5Br0_ZtRscxZ&index=9)

Article based of video: Radio Control – Use the Flysky FS-I6X with Arduino & Build an RC Car

<https://dronebotworkshop.com/radio-control-arduino-car/>

RC control model: FS-i6x Flysky

User Manual: <https://files.banggood.com/2016/09/FS-i6X%20User%20manual.pdf>

Receiver model we NEED for iBUS Product Model: FS-IA6B

Specifications: <https://www.flysky-cn.com/ia6b-canshu>

### Side notes:

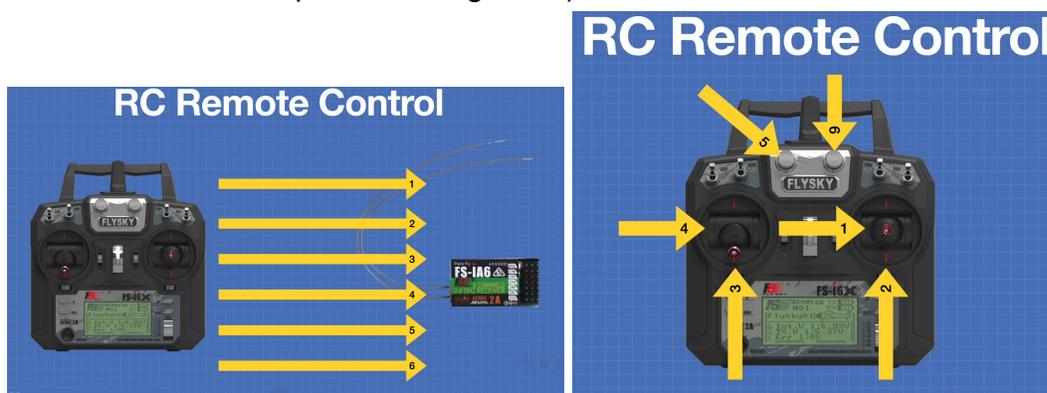
- Old units/models require unique channels/frequencies to avoid interference
- New units (that use 2.4Ghz) require line of site operation

## 11/7

- If you're using the Flysky FS-I6X, you will need to be sure that you power up the receiver AFTER the transmitter, this is true for many other RC Controllers as well. You'll also need to have all the switches in the up position and the throttle control (left stick) down all the way. Both of these requirements are safety precautions to avoid an uncontrolled vehicle or one that starts with the motors running.

### Controller Channels:

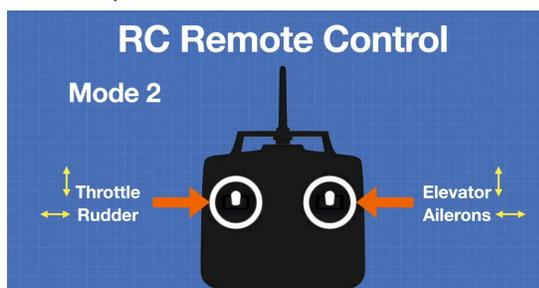
- 6 Channels, (video mentions that firmware update can possibly update the controller to have 10 channels but that would require a new receiver that has 10 outputs? Unsure how this works if we plan on using iBUS)



- Receiver has 6 3-pin outputs with PWM or PPM  
 - We should use iBUS serial output & input (already in wiring schematic) since iBUS will only require us to connect one wire making the setup cleaner. It is also apparently faster at communicating.

- These outputs are at the top (two outputs out at the top)

Modes (we can decide on the mode later):



### Basic mapping of controls (need to look at the manual)

- By default the 5th and 6th channels go to the pucks which seems useful for opening/closing or controlling the speeds of the back door motors as well as the intake motors. If we instead want to make it so that the backdoor motor only needs to turn on and off, we can map one of the switches (next to the pots) to that channel. The instructions for this are in the manual.

**11/7****Wiring**

- Can confirm that the wiring on the schematic is correct. iBUS DATA connected to -> 19 (RX1) on arduino.
- However, according to some sources online, you can connect both iBUS output and PMW channels at the SAME time.

**Notes & Code: Roboclaw -> Motors (bypassing arduino)**

- There's been increasing suggestions to ignore the arduino and connect/code directly in roboclaw/motion studio. While I argue that we should use the arduino in our final design (further research pending) this could be used for prototyping between the motors, roboclaw, and receiver/controller directly.

- Ultimately it seems that we will for sure need an arduino to be able to run the autonomous robot.

Possible tutorial here:

<https://resources.basicmicro.com/roboclaw-rc-controlled-differential-drive-setup/>

**Notes & Code: Arduino -> Motors**

- First download Arduino IDE & Basic Micro Motion Studio

**SETUP**

Within Arduino IDE:

- We require a library to read the ibus data and to interact with Roboclaw
  - IBusBM Library:
    - Go to Tools -> Manage Libraries -> download IBusBM
  - Roboclaw Arduino Library: [link here](#)
  - Download 2x60a Arduino Library and Examples from the link above
  - Go to Sketch -> Include Library -> Add .ZIP Library -> arduino.zip (what you should have downloaded)

**Prototyping:**

These initial tests will be to make sure we know what the fuck we are even doing. #1 seems pretty chill to do since we don't need the motors to be here so we can test it out with any battery?

**1.) Test motors manually in motion studio (connect solely the motors and the roboclaw to a laptop?)**

**1.5) Test receiver by connecting to small servo motors directly**

**11/7**

**2.) Test that the RC controller is connected to the arduino using iBUS (just use RC and arduino) \* NO MOTORS**

**3.) Test the motors directly from the RC controller (connect the motors to the roboclaw to the receiver, and link receiver to the controller)**

**n.) Test the entire set up without the intake and servos (connect the motors to the arduino to the roboclaw, to the receiver, to controller**

---

We got through a large portion of the tutorial, but quickly ran into the issue of how to power the receiver. At first, I couldn't find a 5 V battery pack to power the receiver, so I decided to power it using the 5 V output of our arduino MEGA. After wiring with the arduino, I was unfortunately not able to get the arduino MEGA to connect to my computer. I came to the conclusion that the arduino was not working properly. I'm not sure why it was left in the shop cabinet, but I added it to one of our team's drawers and labeled it as faulty. I found another off-brand arduino which has almost all of the same pins and seems to be based off of the arduino MEGA design. This one connected to my computer when I plugged it in and we plan to continue using this arduino.

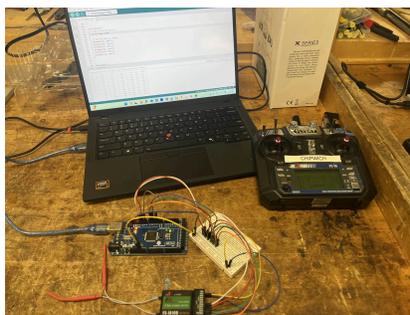
As a preliminary test, as the video follows, I wired the receiver to four small microservo motors to see if I could control the microservo motors using the receiver. As I mentioned, I initially powered the receiver from the arduino 5V output. However, after looking at an online forum, I realized that this could overdraw current from the arduino and brown it out since even though the receiver requires less than the 3A the 5V output of the arduino supplies, the microservo motors connected to the receiver will draw additional currents. To fix this, Daniel came to the shop and ended up finding a battery pack that I did not see in the shop cabinet and instead using that to power the receiver.

We were able to successfully control all four microservo motors using the RC controller and receiver and got more comfortable with the settings of the RC controller. We also performed a test (as the video did) where we read PWM input from the receiver to the arduino and printed it in the console log of the arduino application and read the output signal magnitudes as we moved the joysticks of the RC controller, and this worked as expected.

11/7



*Using the RC controller to control each of the four microservo motors.*



*Image of wiring of receiver to arduino, used for intermittent testing.*

We also noted that IBUS channels have faster response times, so we eventually plan to use these channels for the driving motors and the PWM channels for the intake and dumping motors, but we are constrained by only 2 available IBUS channels.

tonight:

- put fuse and diode on BOM

weekend:

- read up on roboclaw manual
- get basic understanding of arduino code -> roboclaw (from video ?)

monday:

- redo me 14 roboclaw tutorial
- control small intake motor using small roboclaw + receiver so lily can test intake with arduino
- check on saved lipo voltages + re-learn how to charge



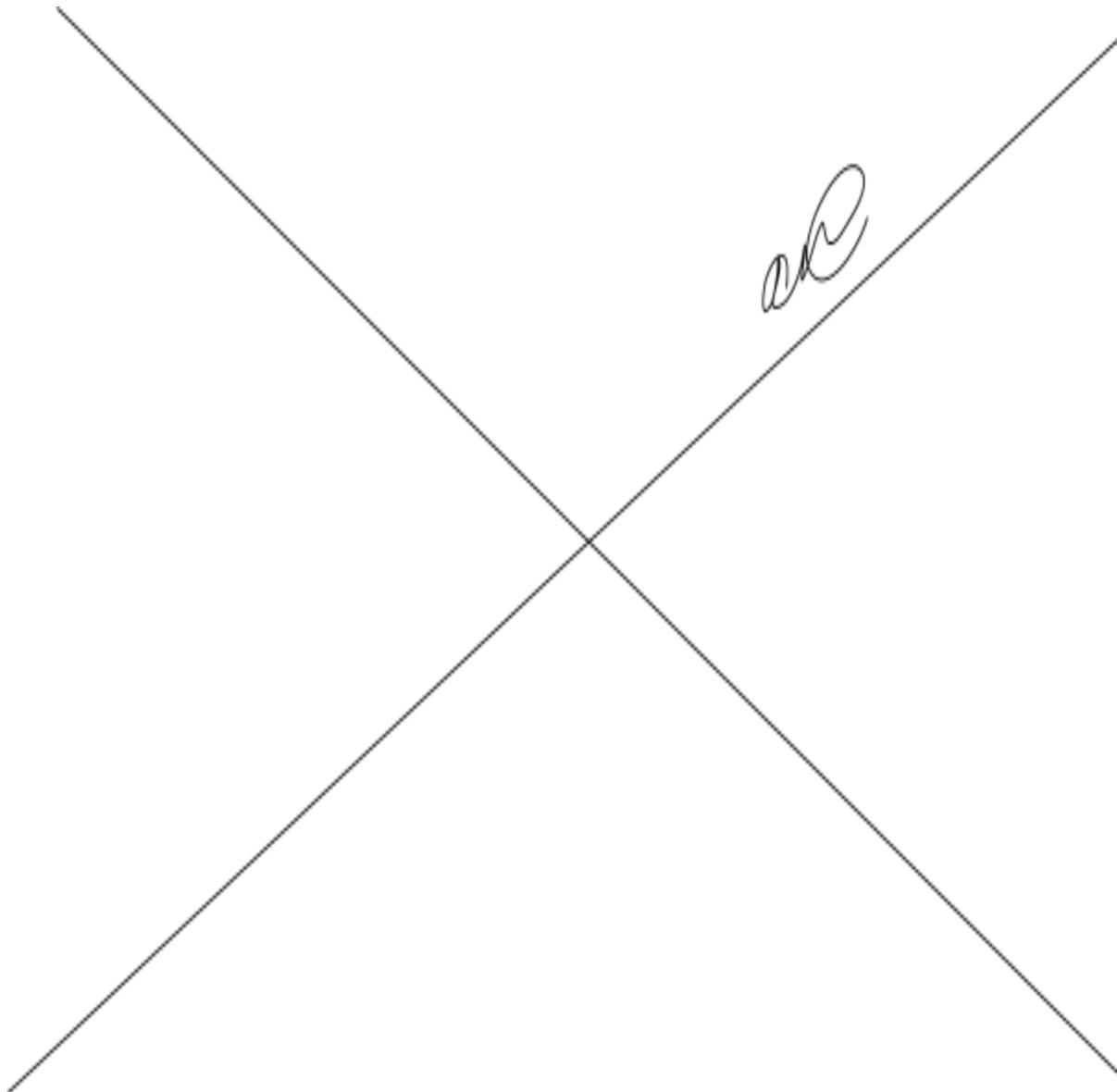
### 11/8 - Picking diode

Today, Daniel and I were able to pick out a diode and found the link to the intake motors that we found in the shop. We confirmed the choice with Trent and are ready to order.

diode:

[https://www.digikey.com/en/products/detail/littelfuse-inc/5KP24A/286072?gclid=CjwKCAiA8bvIBhBJEiwAu5ayrlc-oyMqTZhiQDzo-ebMkL1JrX-G9784uo9eUs1tNLAw3r4jAeEQrRoCJLAQAvD\\_BwE](https://www.digikey.com/en/products/detail/littelfuse-inc/5KP24A/286072?gclid=CjwKCAiA8bvIBhBJEiwAu5ayrlc-oyMqTZhiQDzo-ebMkL1JrX-G9784uo9eUs1tNLAw3r4jAeEQrRoCJLAQAvD_BwE)

intake motors: [https://www.handsontec.com/dataspecs/motor\\_fan/550-Motor.pdf](https://www.handsontec.com/dataspecs/motor_fan/550-Motor.pdf)



## 11/14 - Lipo charging and intake motor prototyping

I went into the shop briefly this morning to re-learn the lipo charging procedure. I read through the handbook and also had one of the TAs re-explain the procedure so that we could avoid making mistakes when charging and damaging the lipo battery.

### LIPO CHARGING PROCEDURE:

- plug sensor into 4S port
- plug main thing into channel
- go to current, set to 2.2 A (general rule of thumb is 1 C charge rate to not damage longevity of battery, and  $1\text{ C} * 2.2\text{ Ah capacity} = 2.2\text{ A charge rate}$ )
- note: max current it can be charged at is  $8 * 2.2 = 17.6\text{ A}$ , but this is the maximum and can still damage the battery life. only would get to a higher charge rate if we needed the battery charged faster.
- should take ~1-2 hrs to go from fully dead to fully charged
  - the max voltage our battery can be charged to is  $4.2\text{ V} * 4\text{ S} = 16.8\text{ V}$

Daniel also found these videos, which we began working through about H-bridge motor controllers:

<https://www.youtube.com/watch?v=ygrslqWOH3Y>

[https://www.youtube.com/watch?v=\\_l-7XYaAtAo](https://www.youtube.com/watch?v=_l-7XYaAtAo)

We wanted to start with the H-bridge motor controller before working with the roboclaws because they are less likely to get damaged and because the intake subteam is a bit bottlenecked since they do not have motors to work with yet. We started by finding a 12 V battery pack (which was rather difficult to find in the shop) and connecting that directly to the motors without the H-bridge and were able to get the intake motors to spin so that the intake team could start prototyping with them.

Next, we wanted to confirm that the default jumper wires were sufficient to connect to the H-bridge without melting. We consulted Trent and he told us to confirm that the voltage drop should have at most a 3-6% voltage drop across them. We looked up how to measure the voltage drop across a multimeter (which was a bit harder than we thought) and confirmed that the jumper wires only had a voltage drop of 2% across them, which satisfied the voltage drop requirement.

We also determined the diode we will be using between the lipo and the roboclaw, and determined that the diode will be in parallel with the switch, and added this to our next BOM and submitted it in the weekly report.

**11/14**Rough Electronics Timeline:**Week 8 (11/17-11/21):**

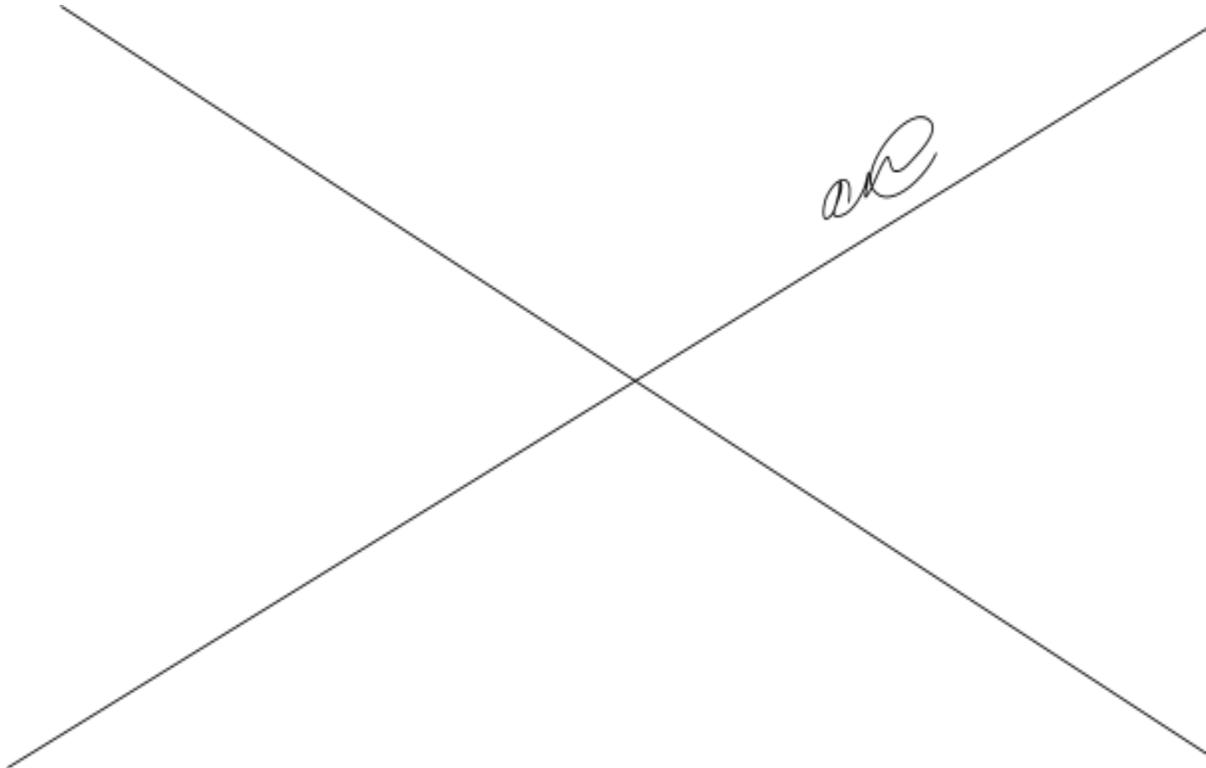
- Monday: Finish Intake Mechanism wiring and add option to control speed of motor for intake prototyping
- Tuesday-Wednesday: Prototype 2x60A roboclaw + LiPo + Motors along with writing out the code on motion studio
- Thursday-Friday: Begin creating a more complete set of code + wiring layout necessary for proper driving. Begin integrating the RC controller and receiver into the wiring.

**Week 9 (11/24 - 11/28):**

- Monday-Wednesday: Continue working on the complete roboclaw + RC controller set up.
- Thursday - Friday: Finish roboclaw + RC controller setup and begin investigating the layout/setup on the robot. (what 3D holders need to be printed, how will the wiring be organized).

**Week 10 (12/1 - 12/3):**

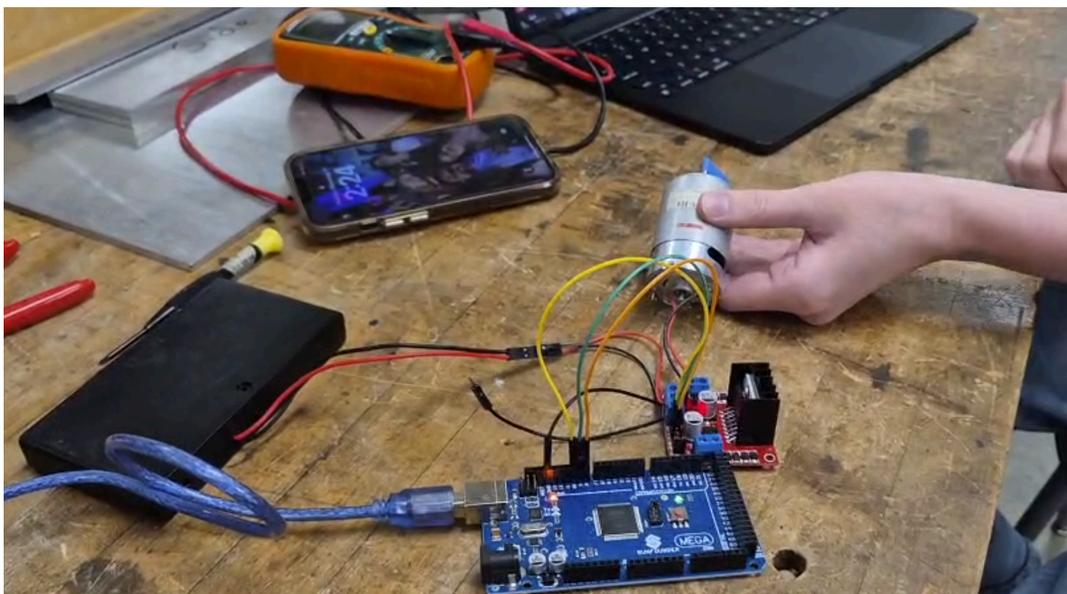
- Complete electronics -> chassis integration



### 11/17 - Completing H-Bridge tutorial

Today is our final day of working with the LN298 H-bridge to create a prototype with working code that can be used for the testing of the intake mechanism. When we plugged in the H-bridge, we found that it couldn't connect to my computer. We were very confused by this and did some testing to see if the issue was with the arduino or the H-bridge. After performing some tests, we found that the issue was with the H-bridge. We replaced the H-bridge with a different one we found in the shop and labeled this faulty H-bridge and placed it in our team drawer.

Once we replaced the H-bridge, we were able to get code provided from the tutorial video running with some of our own modifications that made the intake motor start off, then slowly increase in RPM to the maximum value, stay there, slowly decrease to 0 RPM, pause, and repeat. Now that we completed this, we showed our team so that the intake subteam could start working on their prototype.



*Working intake motor prototype with an LN298 H-Bridge and an Arduino MEGA*

Finally, since we anticipate needing to write arduino code either by the end of this term or at the start of next term, we created a GitHub repository and cloned it to our laptops and Daniel uploaded his Arduino code to the repository.

<https://github.com/anyamischel/me-72-pharaobots>



### 11/18 - Testing receiver and completing roboclaw tutorial

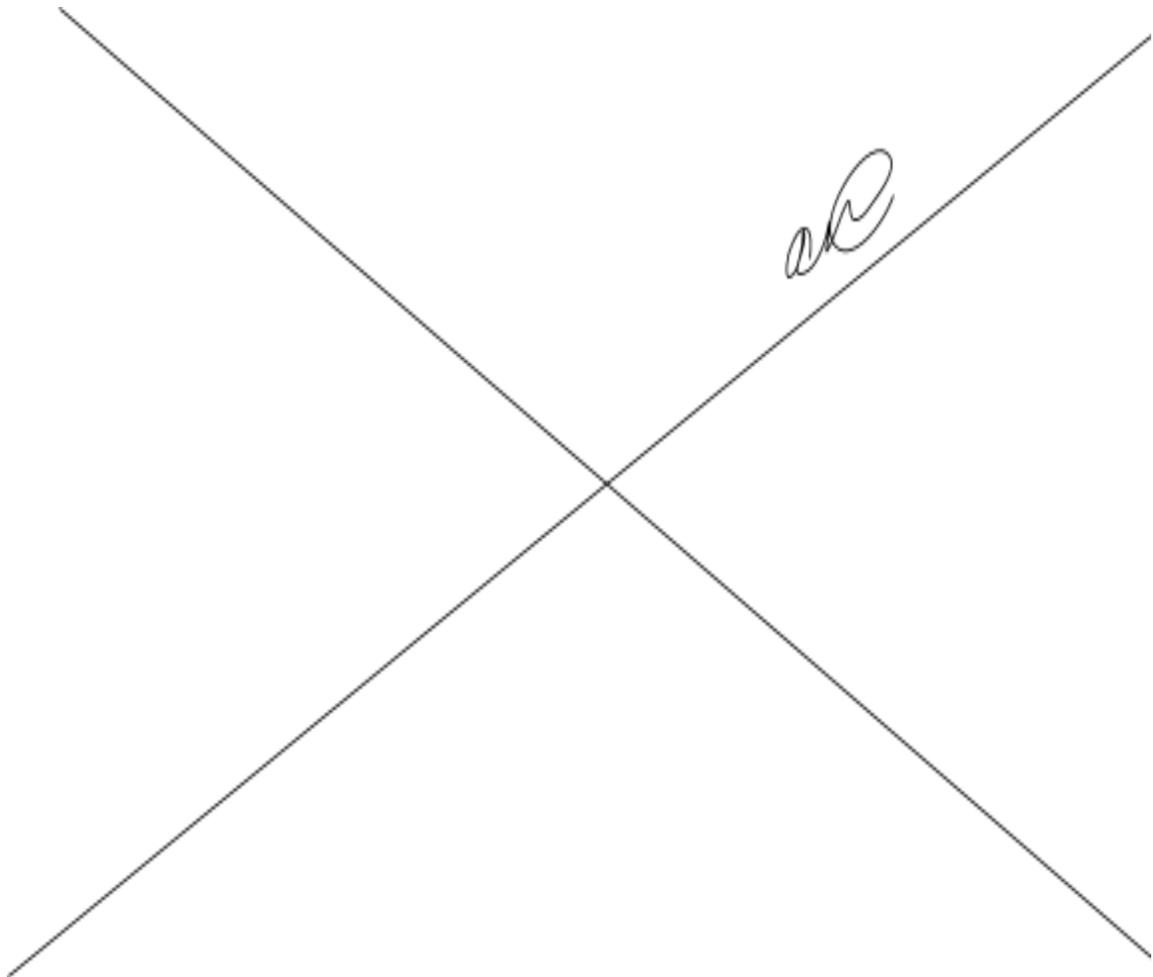
Today, I went into the shop to work on testing the receiver connections and followed this youtube video to understand how the receiver connects to the Roboclaws:

<https://www.youtube.com/watch?v=7mKcj2DIFhY>

We are still not sure about certain details of the wiring such as if we should wait to solder the resistors until we have finalized the layout. We also redid the ME 14 Roboclaw tutorial to make sure that we are not going to damage the roboclaw and felt much more confident using the roboclaw after we finished these tutorials.

Remaining questions:

- Should we solder the resistors now?
- Can you solder two things in parallel onto one wire?
- Is it alright to use 12 AWG wire?
- Is Trent still ordering more 12 AWG wire?



### 11/19 - Connect receivers and electronics redesign

Today, we came into the shop to finish the electronics setup with the receiver and the 2x60 A roboclaw. First, we installed the drivers so that we could connect to the roboclaw. This allowed us to connect to it. Then, I plugged it into my computer and set current limits at the stall current for each of the motors and set the minimum close to 0. I was able to control 2 motors using the sliders on my computer and Daniel and I crimped the small ring terminals onto the 12 AWG wire and connected that to the screw terminals of the 2x60 A roboclaw. We had also connected the receivers to the 2x60 A roboclaw and demonstrated the ability to control two motors with the RC controller.



*Controlling the motors attached to the Roboclaw using the RC controller*

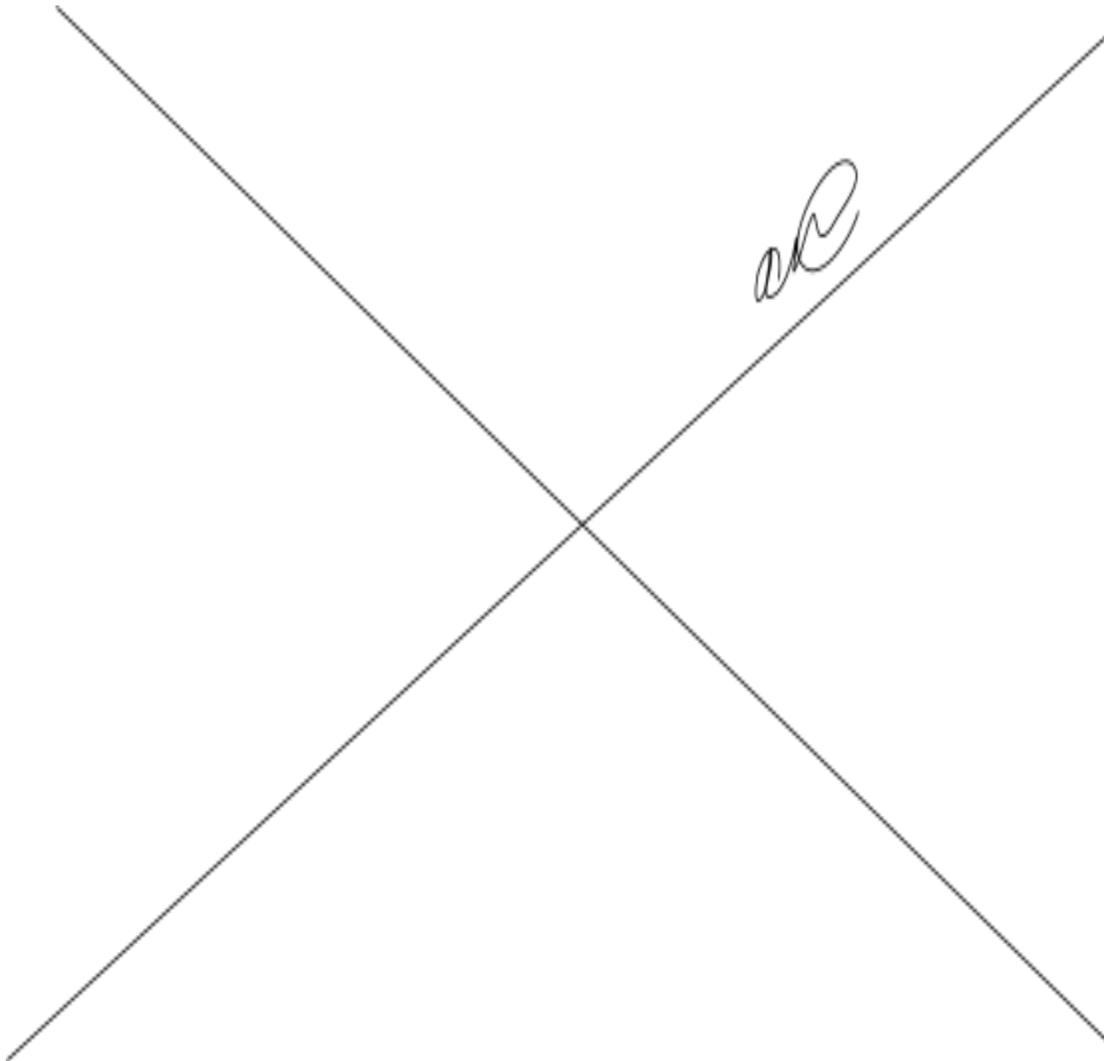
While this was good news, we next planned to wire the other two motors to the roboclaw and asked Trent to double check how to wire two motors in parallel out of one output of the Roboclaw. When we asked him, he looked at our wiring diagram and realized an important problem which had not been brought to our attention during the PDR or CDR. He pointed out that having two motors wired in parallel out of one roboclaw output will create issues when one of the motors experiences a higher load than the other. He said that the roboclaw will end up sending most of its current to whichever motor has a lower load, effectively only turning the wheel under less load. This would create huge problems when driving over bumpy surfaces, where one of the wheels might just end up free-spinning while the other might end up stuck and unable to get over the object. Daniel and I asked if there were any other roboclaws available in the shop, and Trent got us an extra 2x30 A roboclaw and a 2x45 A roboclaw which we can use instead of a singular 2x60 A roboclaw. This eliminates our design issue entirely,

**11/19**

since now we can have one motor per output channel of the roboclaw. We will have to double check the wire we need and rewire and change the way we mix/control the mappings between the receiver and the roboclaw, but that shouldn't be too big of an issue. We started working on this but will continue with it tomorrow.

**To do before end of weekend:**

- Change mapping of receiver controls
- Calculate if we can use a higher AWG wire
- Double check resistor's value, but check with trent
- Set up 4 motors with 2 of the 2x30 A roboclaws
- If assembly is done, combine with chassis for prototype and determine location of electronics in chassis



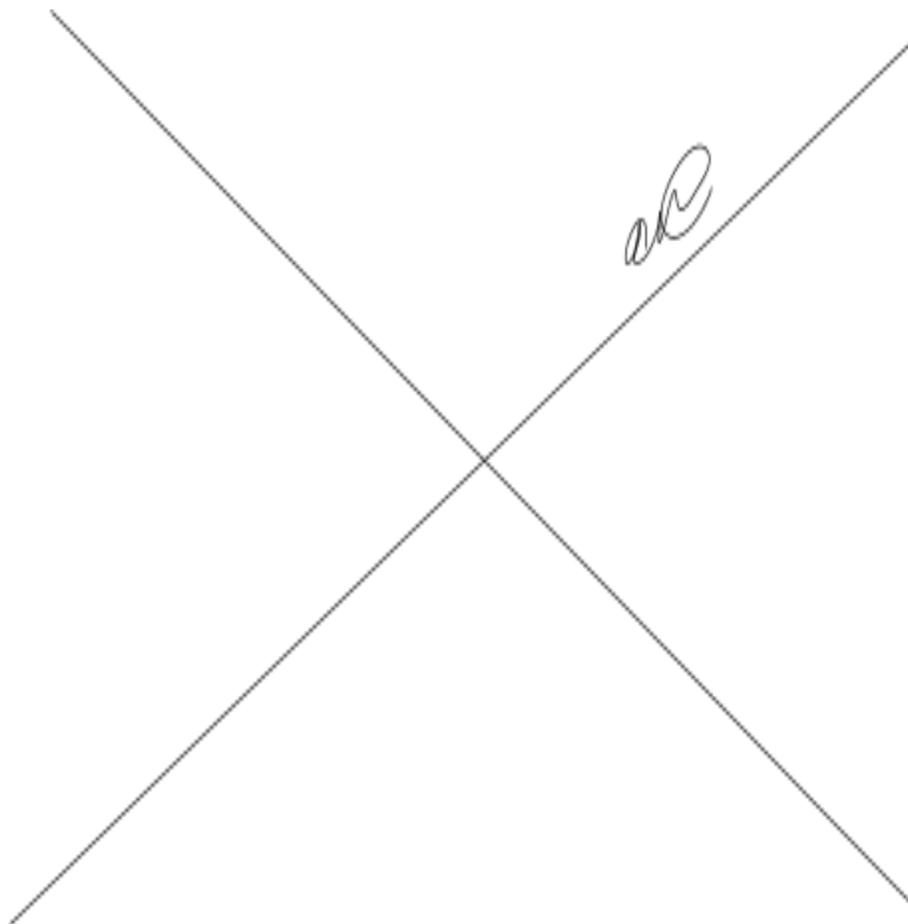


### 11/20 - Wiring progress for 2 roboclaws

I did not have as much time today, but I came back into the shop to work on the electronics wiring. We talked to Trent and determined that we should be able to use 14 AWG wire for our battery and lipos. We restripped the 14 AWG wires and began wiring. We wrapped the leads around the switch temporarily and soldered the resistors and diode in parallel so they could be placed across the switch. We also just bent the ends of these leads around the switch since we do not have ring terminals yet.

### 11/21 - Soldering Y-split on battery wire

Since we are now using two roboclaws, we now need the main wire from the battery to split after the fuse into two paths which lead to the separate roboclaws. We do not have to solder the positive leads together since we can just purchase two ring terminals (1/positive wire) that come out of the switch so there are fewer failure points. We do have to solder the ground wires that go back into the battery together, though, since those do not pass through the switch. I came into the shop to solder those wires together briefly and shrink wrapped them. I ensured that I could still plug everything into the battery and that the connection was strong by tugging on the wires.



## 11/24 - Switching out wires, using electronics box

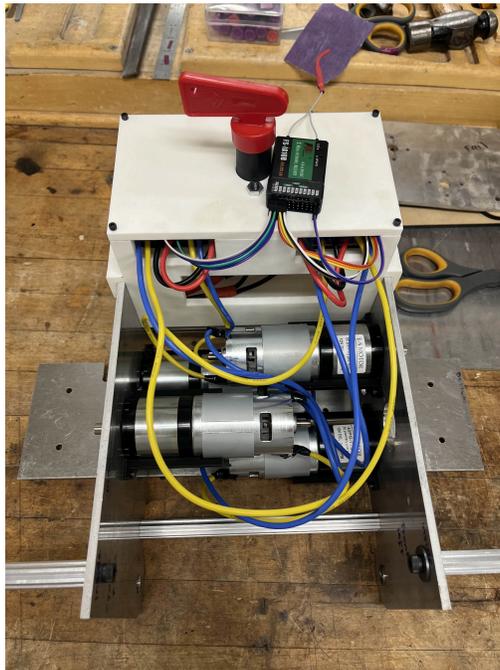
### Morning:

We placed an order for 5 ring terminal connectors for M10 stud circular 10-14 AWG crimp from Digikey with the plan of using one from the battery to the switch, 2 from the parallel output from the switch to the roboclaws, and one for either end of the diode/resistors across the switch.

Since we made the switch from the larger roboclaw to the two smaller ones, I went into the shop and stripped a new set of 14 AWG wires after the switch while preserving the 12 AWG wire from the battery to the switch. I couldn't quite finish crimping the small ring terminals onto the other ends of the wires leading to the Roboclaws, so Daniel did this when he came into the shop. Daniel also wrapped the wires around the ends of the switches and secured it using electrical tape. Daniel confirmed that turning on the switch and the controller caused the roboclaws to turn on and flash, indicating that they worked as expected.

### Evening:

I came into the shop again to put all the electronics inside the electronics box which Hannah 3D printed. The box fit the electronics well and made it much easier to use the switch. However, the lid was also 3D printed which made it difficult to see the lights of the roboclaw, so Hannah suggested changing it to be made out of acrylic. I tried to find velcro to secure the roboclaws to the box but couldn't. Luckily Daniel was able to and we finished securing the electronics.



Electronics box housing the two roboclaws, switch base, wires, and lipo battery.

### 11/25 - Remixing for total driving

In the morning, I went into the shop and plugged the lipo into the electronics and turned on the RC controller and tried to control the motors with the controller. After a few seconds, I had difficulties where two of the motors stopped moving entirely or only moved a little bit and made a weird buzzing noise. I originally thought this was because the resistors and diode in parallel with the switch allowed the current to flow through them which causes the Roboclaw lights to be lit for a brief period, even when the switch isn't turned on. I was also having issues where the error light and all others were blinking rapidly which made me suspicious that there were further issues with the Roboclaw.

Daniel came into the shop with me and we reconnected to the Roboclaws using a microusb to our computers and found that if we disconnected the second output channel on both roboclaws for the motors that weren't spinning, we could turn on mixing on Motion Studio and move two motors with one controller.

We changed the endpoints on the RC controller's settings so that the motors on the same side no longer spun in opposite directions. Frustratingly, when we put all of the electronics back into the box, the mixing seemed to have turned off and only one motor was running per input. We figured that either we did not save the settings to the controller correctly or the roboclaws reset the mixing when we connected to them with the microusb cable.



Default joystick → channel mappings from the RC controller to the roboclaw.

**11/25**

We also noticed after more testing that one of our motors started smoking and producing a bad smell and buzzing. We consulted Trent and he inspected our motors for damage and confirmed that they were fine but that the brushes had not been fully worn in and suggested we run the motors at 20% speed for around 5-10 minutes.

We eventually decided to connect S1 and S2 to all channels on the receiver. We decided to connect S1 on the left roboclaw to CH4 so that both wheels on the left side move in the same direction for inputs on CH4. We then changed the endpoints on CH3 to go from 0% → 0% only when all other electrical components are turned off.

We then connected S1 on the right roboclaw to CH2. That way, both wheels on the right side moved in the same direction for inputs on CH2. We then changed the endpoints of CH1 to be 0% → 0%. This configured the robot to have tank controls (CH4 controls the robot's left wheels, CH2 controls the robot's right wheels).

We also tried driving with this but it was not very intuitive, especially because CH 4 is horizontal while CH 2 is vertical, so driving straight does not just equate to both joysticks forward. Having one joystick to the side while the other was forward in order to drive straight did not make much intuitive sense so we want to switch this next week.

To do next week (break because of Thanksgiving):

- Look into both elevon
- Look into mixing using only the roboclaw
- If we still can't figure it out by the demo, go back to the controls we currently have.





### 12/1 - Adding elevon & soldering wires to motors

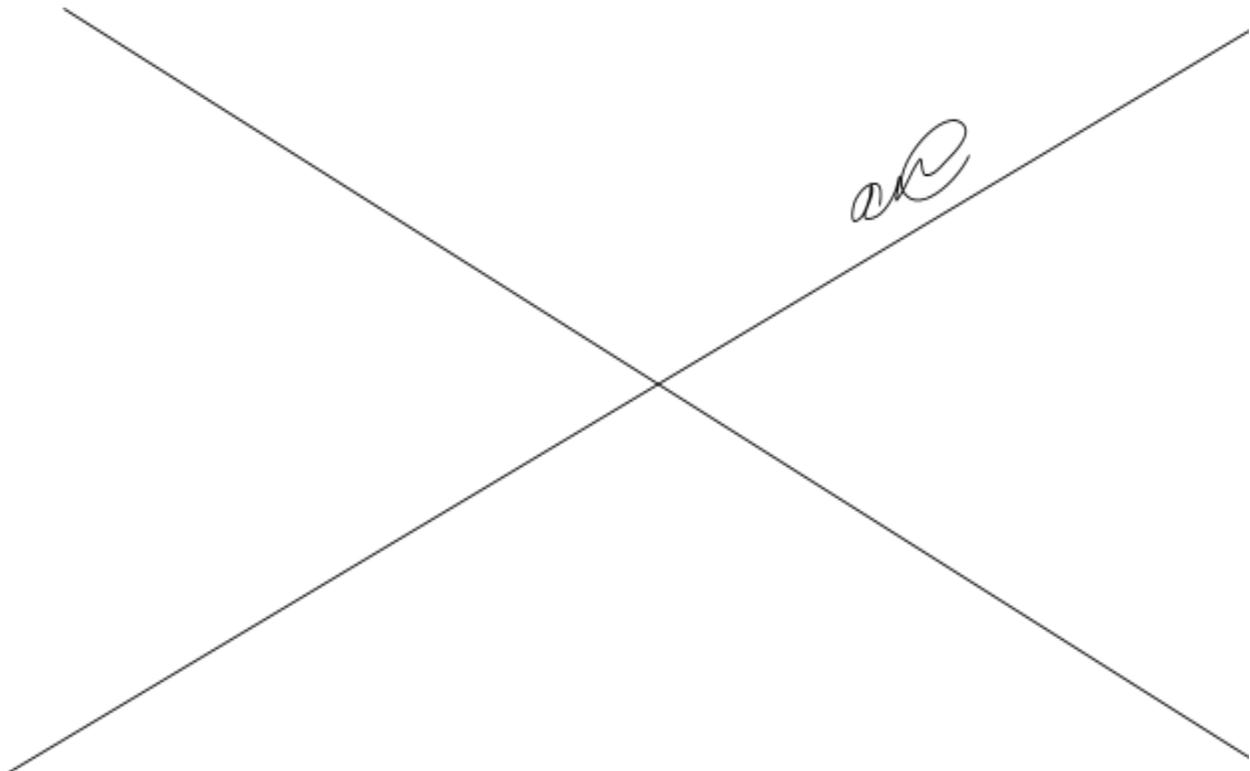
I came into the shop to cut the lengths of the wires between the motors and the roboclaw. I marked where on the wires I needed to cut them and then cut them using the wire cutters and soldered them directly onto the motors. I had some difficulty with getting the wire to stay attached to the motor's leads and probably should have been using a clip but eventually got it working with some effort. I shrink wrapped the outside of the leads and used electrical tape to patch up any other exposed areas of metal. I connected the RC controller and confirmed that driving worked as expected.

<https://www.youtube.com/watch?v=fU0cFLLZ7jY>

Later, Daniel and I watched the video on Elevon for an RC plane (linked above) and adjusted the settings on our own RC controller. We did the following steps.

#### Solution to driving:

- Physically switched Channels 2 and 4 on the receiver
- Changed end points of Ch3 and Ch4 to be 0% - 0%
- Reversed just channel 1
- Enabled Elevon with the configuration: CH1: -100% and CH2: 100%
- Then realized that our turning was flipped so we physically switched CH2 and CH1 on the receiver

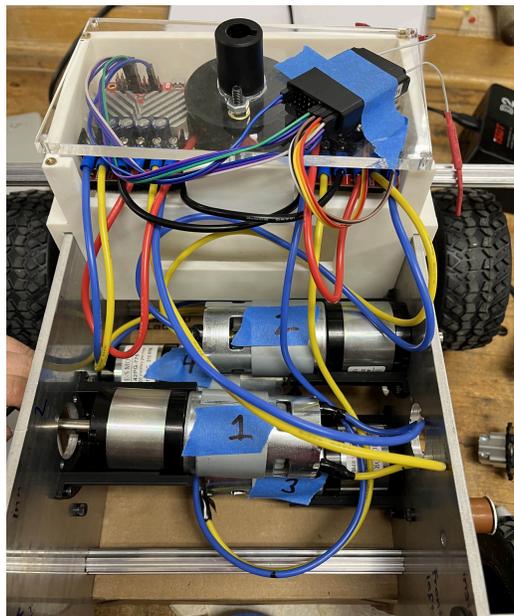


## 12/2 - Soldering ring terminals, fixing mixing, testing climbing

### Morning:

The ring terminals arrived, so I went into the shop in the morning and removed the electrical tape around the switch. I stripped the wires to be a bit shorter and soldered the wires onto the ring terminals and used heat shrink to protect the exposed wire. I re-fastened the ring terminals onto the switch and placed everything back into the electronics box. I noticed that some of the threaded inserts in the electronics box were starting to come completely out, which is making it difficult to screw the lid into the box.

Soldering the wires onto the ring terminals was actually quite difficult and took much longer than I expected. I'm not sure if the ring terminal material is different from the wires I was using, but it seemed to do a much worse job at sticking to the solder. It felt like my connections were not as good as a result, but tugging on the wires did not seem to loosen anything, so I left it. I connected the RC controller and confirmed that everything worked as expected.



Electronics box.

### Night:

The manufacturing subteam caught up in assembly and was ready to test, but Daniel was in the shop with them and was having some issues with testing because it seemed that the RC controller settings had been reset when he updated the roboclaw. However, he figured out what the old settings were and we conducted some tests of the driving and ensured that it worked as expected. We ended up using mixing and elevon on the RC controller only and this was able to map the joysticks to the controls we wanted.

**12/2**

We also tested the robot's ability to climb up the pyramid. We found that no matter the speed we drove the robot at the pyramid, it did not seem to gain enough traction to pull itself up the pyramid. We added some normal force to the robot by pushing directly on the robot into the ramp and found that under this situation, the robot could climb the pyramid. We taped small aluminum blocks onto the robot to test if that allowed it to climb the pyramid, and while this helped, it did not seem to entirely fix the issue. We determined that we needed to create a box to contain additional weights since using masking tape was also not properly holding up the weights.

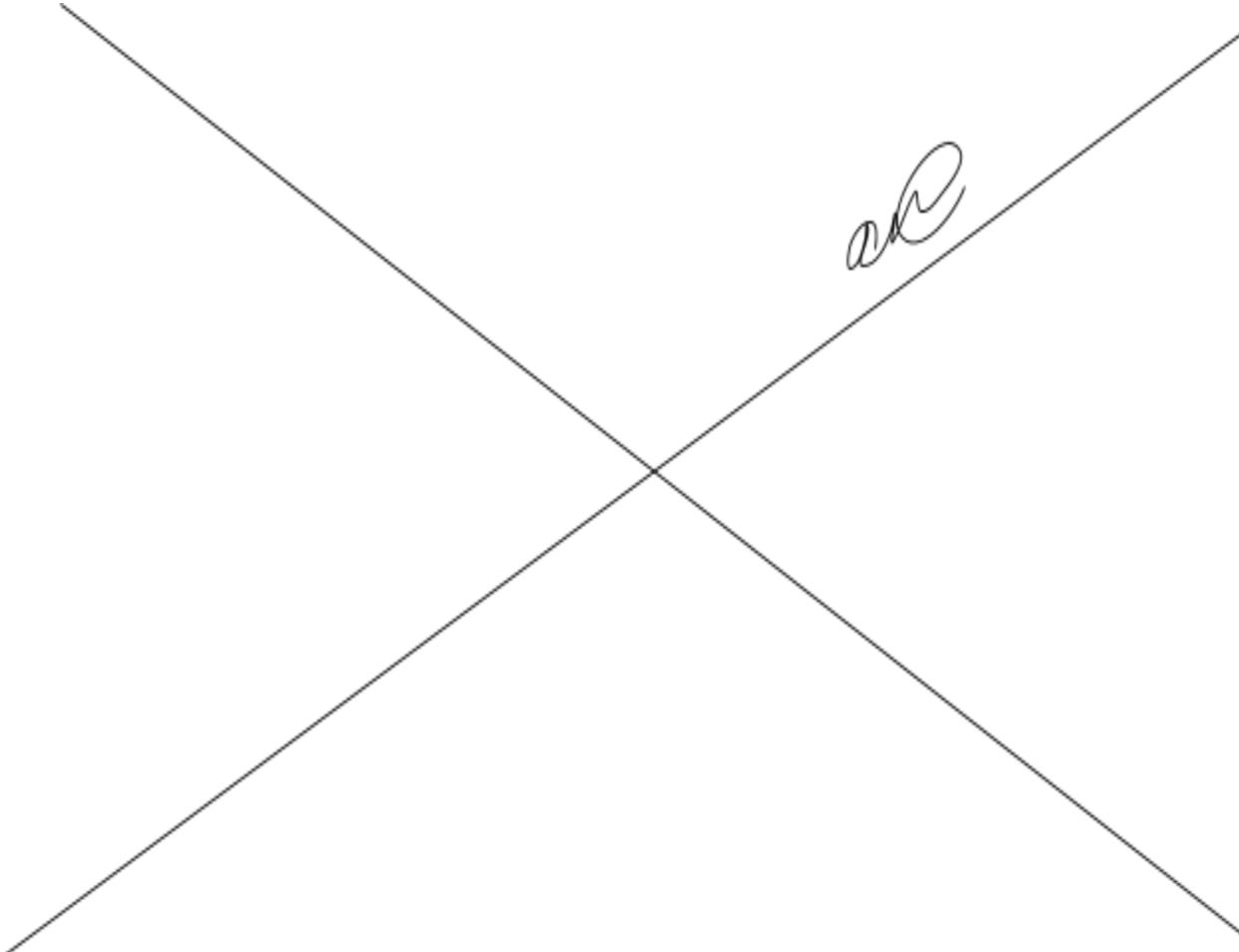


Pictures from testing of the robot attempting to climb the hill (with some help)



### 12/3 - Additional testing of climbing

We came into the shop for a few more hours to try additional testing of the robot's ability to climb. We now have the 3D Printed box with the extra weight installed in the front bottom of the robot, but this alone did not seem to be enough to allow the robot to drive. We tried adding additional weights and tried putting weights on top of the bottom plate in between the front and back wheels, but this didn't really seem to fix the issue. We noticed that driving on wood is a bit easier than on the steel plates. We also found that using only 2 additional weights in the front was the best driving situation, so we will be keeping that for the mobility demo. Tomorrow, we will try incorporating rubber bands onto the wheels' surfaces to see if that increases traction. We are currently brainstorming ways to increase traction for next term. Some ideas are a higher gear ratio, different wheels which have better surface area contact (since our wheels are made more for rough terrain applications than smooth surfaces), and a lower center of mass. However, all of these are not changes we can make within one night, so we hope that using rubber bands tomorrow will help with traction.





## **12/4 - MOBILITY DEMO DAY**

### Before the demo:

Today was the mobility demo. I went into the shop at 1 PM with hopefully some time to do final testing before the mobility demo at 4 PM. Lily mentioned that she had rubber bands, so we disassembled our outer walls and stretched a lot of rubber bands all over our wheels to try and completely cover the surface area in an effort to improve traction. We put the outer wall back onto our robot and then tested driving with it. We first tried driving forward and didn't notice any major issues like the rubber bands sliding off or getting caught in the chain. Afterwards, we tested climbing, but were still not successful. This was pretty frustrating because last night we felt like we had tried every possible combination of center of mass rearrangements and increases in weights, but nothing seemed to be working. We gave up on the rubber bands and cut the rubber bands off our robot to disassemble it.

Then, until the rest of our team arrived for the mobility demo, we practiced driving and turning. We noticed that after the rubber bands, there were some new issues with the robot. The driving felt a bit less efficient than before, and the turning acted very strangely/unexpectedly. We did normal tests of turning and discovered that right turns acted normally but seemed to be happening less efficiently. However, we found that on left turns, the front left wheel would stall and jerk, which was not how it was behaving last night. This made it so that the robot would pivot about the back left wheel when it was turning left, so the robot could no longer turn in place like we had hoped. We tested different parts of the drivetrain not being fixed properly to the shaft by rotating them manually with our hands, but it seemed that additional tightening on the shaft collars did not do much. We were not able to fix our turning entirely or climb before the demo.

### Results of the demo:

We were able to complete the straight driving and driving around cones tests rather easily, but were not able to climb the pyramid during this part of the demo. We cleaned our robot's wheels and the pyramid's surface before the climbing portion and that allowed us to climb around a foot before slipping and falling back down. Jimmy looked at our robot more and noticed that the motor of the front wheels were spinning, but the motors themselves were not. At first, we thought this was an issue with having 3D printed hubs for the wheels and began planning how we would try to lathe new hubs out of aluminum before winter break starts. However, Jimmy noticed that the problem was actually that the inside of the wheel was spinning with the shaft, while the outside part of the wheel was fixed. He demonstrated this by holding the front wheels fixed with his hand while driving the motors forward, and seeing that the motors and inside of the wheel spun. Thus, the wheels we are using are not sufficient for the high torque application of this competition and we decided that we need to get new wheels.

**12/4**

We began researching wheel types and found that colson wheels might work. We found two wheels in the shop cabinet that we could test that are both 4" (which is too small for our breakover angle) that we could test with. We found that these wheels are on the Andymark website and are called Sushi & stealth wheels. The gray and blue wheels correspond to the higher durometer values, so they are the hardest out of the wheels in this link:

<https://andymark.com/products/stealth-and-sushi-wheels>



I asked Jimmy more about wheels and he recommended against compliant wheels since they are specialized for intake. He mentioned colson wheels or the above sushi/stealth wheels. We will need to do further research into the wheels but would like to at least like to try these wheels. We sent an email to Professor Mello about discovering our issue with the robot, and plan to purchase new wheels before the end of the term. Later at night, I also started designing a way to integrate magnets into the chassis design. One of the biggest issues with magnets which had caused us to not consider them was that any location we could have put them on our chassis would have been too large of a distance from the ground the robot drives on to have any real magnetic force to keep the magnet on the pyramid. We had also tried seeing if taping them to the wheels would help with driving, but even an inch of clearance is too big. I started designing a small mount which could be drilled into the inner wall and house the magnets a few millimeters off the ground. We may try 3D printing these before winter break to test if they could help increase the normal force between the robot and the surface of the pyramid.

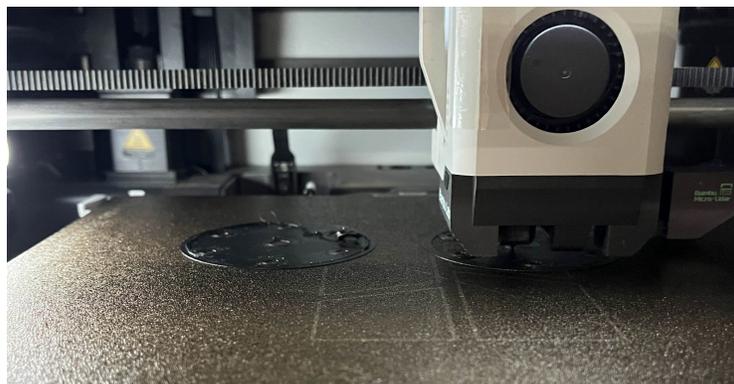
To do:

- CAD new hubs for the 4" wheels (gray and blue, should be the same)
- 3D print new hubs for the wheels
- Test new wheels by taking off the old ones and replacing them with the shop wheels
- Test driving with the new wheels

### 12/5 - 3D printing new wheel hubs & designing magnet mounts

Today I 3D printed wheel hubs for the new shop's wheels. These wheels are 4" in diameter and are "stealth and sushi wheels". There are both gray wheels and blue wheels, but we are planning to use the blue wheels since they have a slightly lower durometer than the gray wheels.

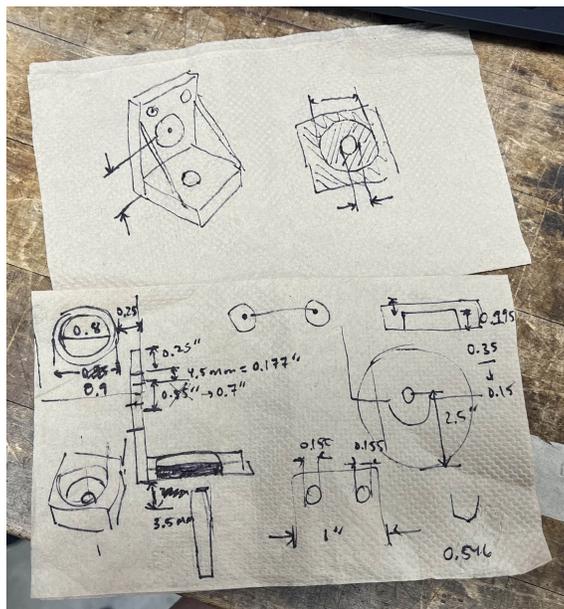
Miina had made a copy of the old wheel hub CAD and adjusted the location of the attachment holes last night, so this morning I uploaded the STL file she linked in the ME 72 Google drive and printed the hubs. Unfortunately, the first 2 times of printing did not work and the PLA was peeling off of the bed. I tried washing the plate with soap and water in the back of the shop but this didn't help that much since one of the wheel hubs on the third print failed, so I had to skip it while it was printing and print the last wheel hub by itself later in the day.



Once I had all the wheel hubs, I came back into the shop in the evening and attached the wheel hubs to the shop wheels and hand tightened them. After this, I began disassembling the robot by unscrewing the churros and then removing the outer walls, and afterwards taking the shafts out of the inner wall's bearings. I tried to remove the old wheels from the shaft by unscrewing the wheel hub from the old wheels, but I couldn't fit the allen key in the space between the sprocket and wheel hub. Because of this, I decided to instead move the shaft collar so that I had more room to remove the wheel, but got the allen key stuck in the screw for a while. I talked to Ana about this and she said that the manufacturing subteam had been having consistent problems with the allen key getting stuck in the same screw for multiple weeks. I was able to get one of the wheels off by moving it towards the sprocket and then loosening the shaft collar. However, I had much more difficulty with the other wheels and realized that this was because the wheel hubs were press fitted onto the shaft, and the wheel that I was able to take off was not press fitted very well onto the shaft. Because the bigger press fit removal machine was not on the student benches and the shop was closed, we decided to work on replacing the wheels on Monday.

**12/5**

Daniel was also in the shop with me in the evening working on the disassembly of the robot. We also discussed the idea that I had the previous night about how to incorporate magnets to the chassis design through 3D printed mounts. We were looking for which bolts to use but are deciding between #8 screws and M4 screws, but since we didn't have access to the shop, we couldn't go in and check what was available. We began making the CAD of the magnet holder mount for the 5" wheels, but we will probably need to print magnet holder mounts for both the 5" wheels and the 4" wheels so that we can test with the 4" wheels, but we will probably eventually drive with 5" wheels once we can order some new ones.



Quick drawings/sketches of the magnet mounts for the improved robot.

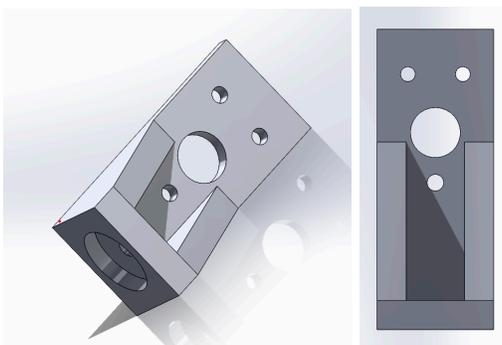


### 12/7 - Adjusted CAD of magnet mounts

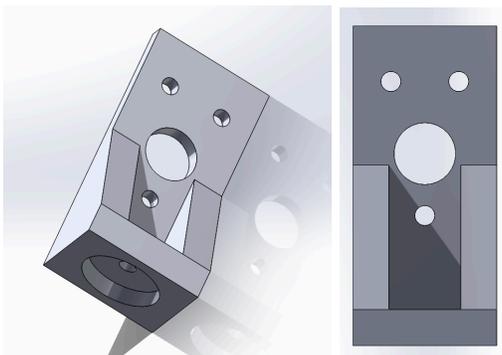
Today, I worked on fixing the CAD of the magnet mounts with the 5" wheels, and also made the CAD of the magnet mount for the 4" wheels so that we could test the mobility demo this week. I had some difficulties getting used to some of the features since I have not used SolidWorks in a while.

#### All fasteners for the magnet mounts will be #8 bolts with nuts.

Each mount needs 4 of these bolts (assuming Trent confirms that adding the extra hole is alright), totaling  $4 \times 4 = 16$  bolts for the robot.



Magnet holder CAD for 5" wheels.



Magnet holder for CAD 4" wheels.

While designing this, I set the dimension from the center (shaft) hole to the hole into the inner wall to be something arbitrary since the shop is closed over the weekend and I was not able to measure the width of the aluminum around the shaft hole.

#### Plan for tomorrow:

- MORNING:
  - ask Trent about the third hole and infill of print
  - measure location of it and fix in cad
  - start print of magnet mounts
- AFTERNOON AND TUESDAY (after prints are done):
  - go in with Miina to replace wheels and mill holes

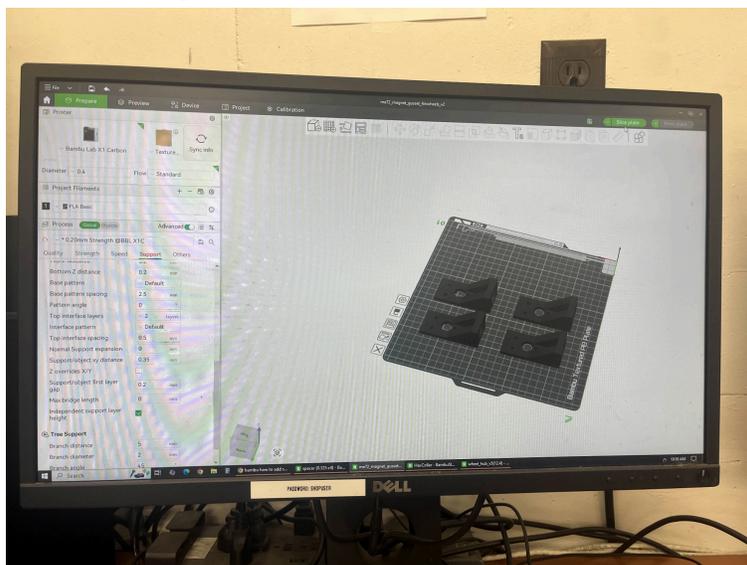
## 12/8 - Added magnet holders, replaced wheels, & successfully climbed

### Morning:

Today I am 3D printing the magnet holders. I asked Paul about whether we have enough space between the shaft hole and the bottom of the plate and he confirmed that it should be alright since the load per magnet is only ~2 lbs. We plan to use 6-32 screws instead of 8-32 screws per his recommendation as well since it will save us some space. I adjusted the CAD of the magnet holders to adjust for the new screw size but kept the hole size of the magnet's bolt the same since those fit the magnets. I picked out twelve 6-32 screws and nuts for all four magnet holders. I also adjusted the width of the gussets on the holders so that there is a 0.1" clearance for the nut so that I don't have to fit a wrench when tightening the screws.

I found online that the width between flats of an 8-32 nut is 0.344". Thus, with the 0.1" clearance, the gussets should be 0.444" apart. Thus width of each gusset is  $(\text{plate width} - \text{distance between gussets})/2 = (1.4 - 0.444)/2 = 0.478"$

I started prints of both the magnet holders for the 4" wheels and the 5" wheels.



Magnet holders for 4" wheels loaded in Bambu

To do this afternoon:

- Remove wheels from shafts
- Press fit new wheels onto shafts
- Take off inner walls
- Drill holes in inner walls
- Reassemble if time allows. If not, reassemble tomorrow
- Get VPN for CAD

Afternoon:

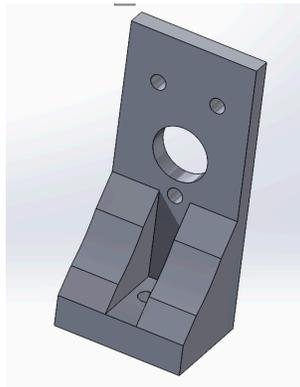
## 12/8

I got the printed 4" wheel magnet mounts out of the printer, but they have some issues which I will address and hopefully re-print before Miina and I machine the holes and switch the wheels tonight.

Problems with current magnet mounts:

- Shaft hole should be bigger to accommodate for shaft collar
- Gussets are running into sprocket
- Gussets too far apart, screwing in nut is hard
- Clearance from ground should probably be 3 mm, losing quite a bit of force from the extra 0.5 mm

Need 0.345" between gussets now. Width of each gusset:  $(1.4 - 0.345) / 2 = 0.5275$ "



Updated CAD of magnet mount for 4" wheels

## Evening:

We went back into the shop once the magnet holders were printed. We took them out and aligned them with the shaft and realized that the bottom of them was sticking too high up and running into the sprockets. To fix this, I used the vertical band saw to make cuts into the mounts to make more space for the sprocket. We will eventually 3D print the mounts again, but this temporary solution was just used so that we could test the climbing of the robot. In the meantime, Miina undid the press fits on the old wheels and then redid them with the 4" wheels we found in the shop.

We first tested driving with the new wheels before committing to adding the magnet mounts. The robot was able to climb around 2-3 inches before slipping and falling back again, so we decided to add the magnets.

Miina and I disassembled the robot and drew marks for the holes on the inner wall for the mount and took the inner walls to the drill press and drilled these holes. One of them

**12/8**

we accidentally used too big of a drill bit, but it still worked to keep the magnet holders in place. We didn't anticipate very much force on each of the holders (~2.8 lbs/magnet). All of the holes were aligned sufficiently and we screwed the mounting holes into the inner wall.

After this, we reassembled the robot. This took a while since we had difficulty getting the motors screwed into the inner plate. Once we got the motors screwed in, we tested driving. Driving seems to be less smooth on the new wheels, and the new wheels seem to collect dust extremely easily. Because of this, we would like to eventually use lower durometer wheels since the new ones we tested have a durometer of 80, which is rather higher. We then tried climbing and were able to climb and interestingly much better in the forwards direction than in the reverse direction. We believe this is because the back left wheel is the pivot point when turning due to the way we made mixing work on the RC controller, so having this wheel in the back instead of the front allows the robot to still drive up the ramp while it is driving. Driving it backwards up the ramp and also turning to the right would cause the robot to slip backwards because of this stationary wheel. We also weren't able to get all the way to the top of the pyramid because of the breakover angle with the smaller wheels, so we would like to order softer 5" wheels.



Robot chassis with magnet holders installed (see cuts in gussets) and 4" wheels

**To do for robot:**

- Order 5" wheels with lower durometer
- Adjust CAD of magnet holder mounts for 5" wheels
  - Make sure plate is smaller to avoid clearance issues
  - Remove part of gusset or extrude rectangle into it to avoid interference with sprockets

### 12/9 - Demonstrated climbing again

Today I went into the shop in the afternoon to charge the lipo batteries and redo the climbing section of the mobility demo. After last night, we were confident that the robot would drive correctly. We demonstrated that the robot could climb up and get down the pyramid easily and demonstrated the robot turning around on the top of the pyramid a few times to show Professor Mello that we could turn within small spaces. The largest limiting factors seem to be the wheels and the mixing, causing the back left wheel to be stationary as the robot turns in either direction. As mentioned yesterday, this is why the robot works better driving up the ramp forwards and not turning around at the top. We took three time trials of the robot driving up and down the ramp and the times are as follows:

- Trail 1: 16.35 s
- Trial 2: 11.70 s
- Trial 3: 11.60 s

My driving definitely improved for the last two trials. I also tried standing on the stool so that I could see the top of the pyramid and that also made it a lot easier to drive since I wasn't as worried about driving the robot off the top of the pyramid.



*Driving the robot to the top of the pyramid.*

**\* End of fall term**

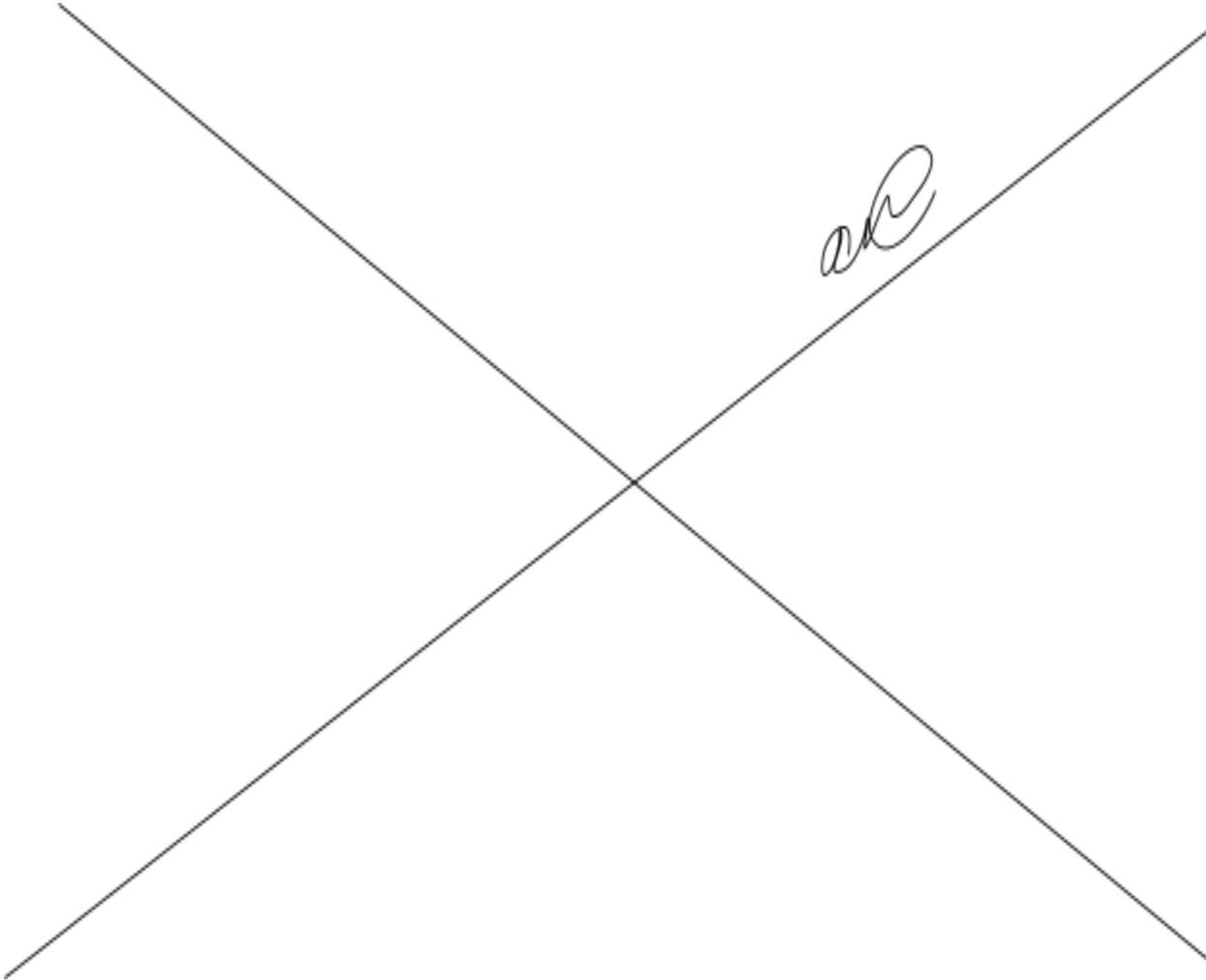


### 12/26 - Updated magnet mount CADs

Today, I updated the magnet mount CAD for the 4" wheels, and created a new CAD for the magnet mounts for the 5" wheels. The adjustments are as follows:

- Made the side supports into small fillets.
- Made the width of the mount thinner.
- Made the back plate thinner.
- Changed the clearance from 4 mm to 0.15" (slightly smaller than 4 mm) since we can afford this smaller clearance, and since we want to work entirely in customary units moving forwards.
- Confirmed the fasteners for the magnet are #8 bolts, while the fasteners into the inner wall are #8 bolts (all customary).
- Ensured the top holes are still 0.66" apart for the 5" wheel version.

I also drafted a spreadsheet for the weekly hours tracking to address the problem we had last term, but didn't realize Daniel had also created one and I think his is more effective.


### 1/6/26 - 3D Printing Magnet Mounts, Wheels Research, and CAD

Today I went into the shop in the morning and 3D printed the new magnet mounts for the 5" wheels and the 4" wheels so that we could reassemble the robot as soon as possible with the glued 5" wheels. I also spoke to Paul and asked him about glue options for the rubber 5" wheels and he said it was based on the material of the wheels. I looked into the Studica website for the wheels ([Studica](#)), but they do not list the material of the outer tire or the inner rim anywhere. I contacted Studica using their online form and found the type of glue that is best suited for the wheel type. Their response is below.

#### Question about Studica 125mm All-Terrain Robotics Wheel Set

[Summarize](#)


Janet Ebert <janete@studica.com>



To: Mischel, Anya B.

Tue 1/6/2026 11:17 AM

Hi Anya,

Thanks for reaching out. The inner hub is PC+ABS and outer portion is rubber although I am not sure of the exact rubber composition. They are intentionally not attached as they were designed allow the inner foam to be changed if desired. If you would like to glue them, our suggestion would be to use a Medium/Thick Rubber CA Tire Glue, a type of cyanoacrylate (super glue) with added rubber reinforcement and increased viscosity, specifically designed for bonding rubber RC tires to plastic wheels. You can find many options if you do a Google search for Medium/Thick Rubber CA Tire Glue.

Regards,

Janet Ebert  
**Studica, Inc.**  
 888.561.7521

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I asked Trent about it and we decided to use a silicone adhesive, which is not as good as the glue that Studica recommended, but should still work well enough. I also asked Trent about the best way to go about machining our walls, now that they are larger in size than the area of the waterjet. Unfortunately the big waterjet will not be fixed by the

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end of the year, so we decided that it would be best to conversationally mill all four walls since we can cut out the shape of the walls using this method, and it will fit on the mills without an issue.

I was able to remove the outside tire of the wheels with some difficulty and sanded them down using brass wool. Miina and I later came into the shop to glue the wheels. This was very difficult since the glue got everywhere and it was hard to get it into the crevices. After gluing, we waited for the wheels to dry for 24 hours. Tomorrow, Lily and Sophia will disassemble the robot and reassemble with the old glued wheels so that we can test them.

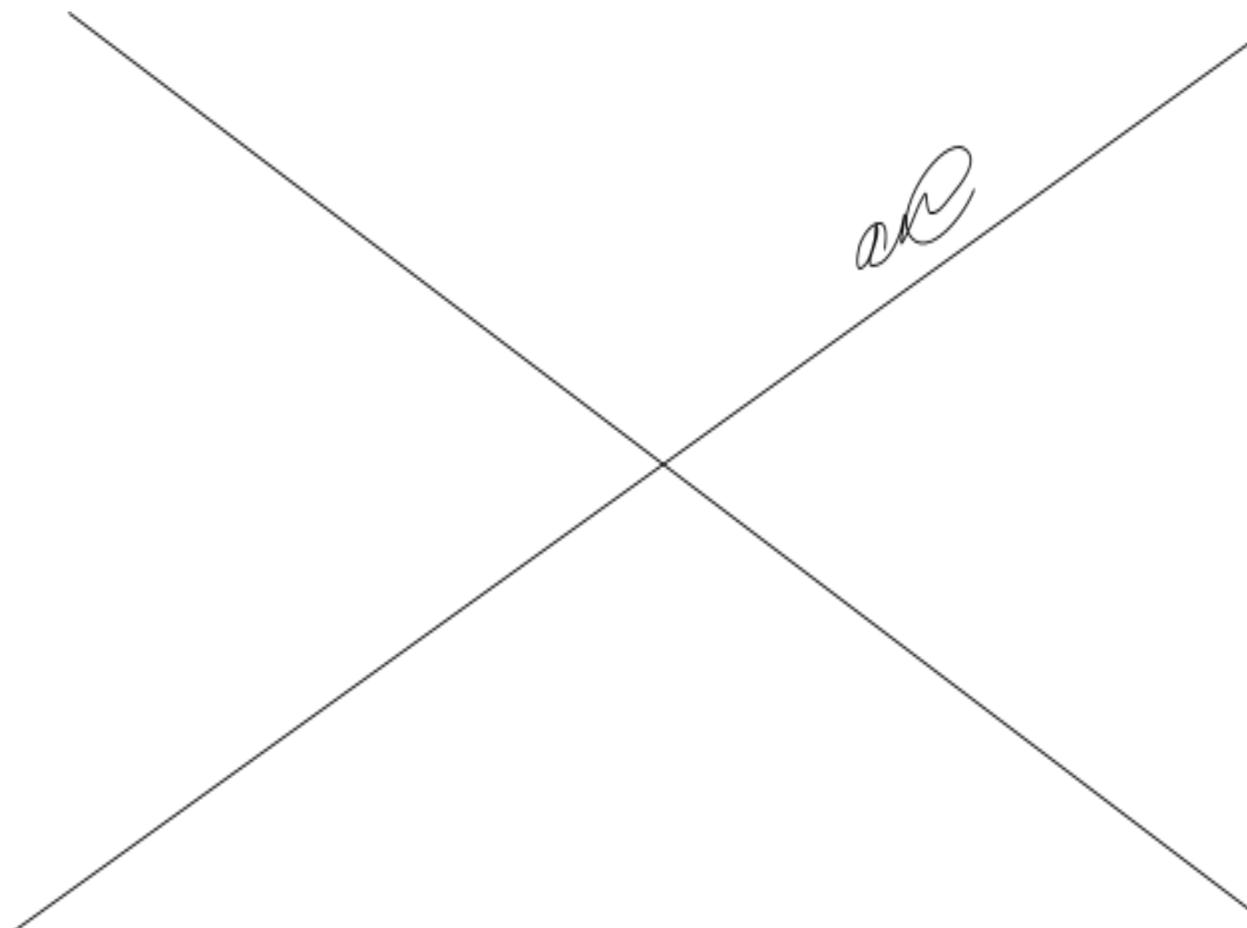




### 1/7 - Testing reassembled robot with glued wheels & CADding new robot

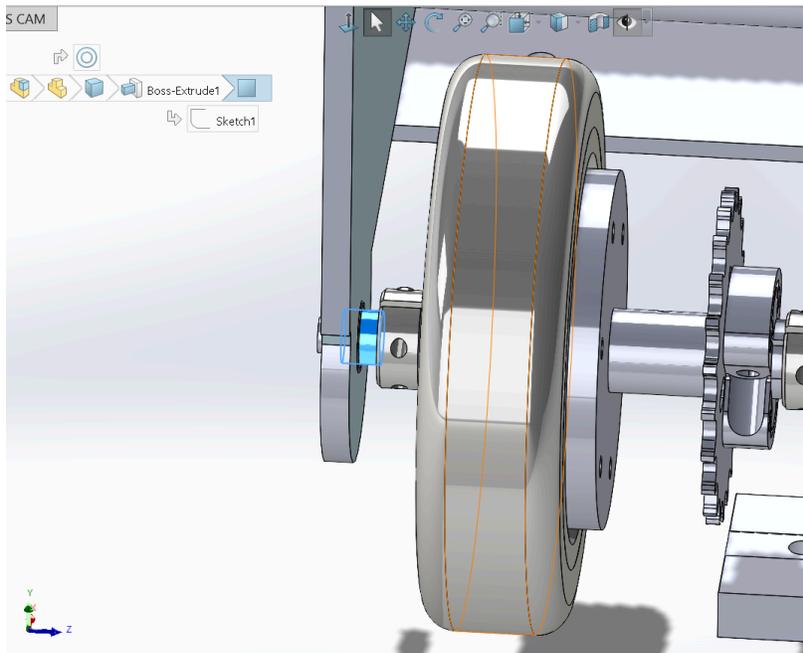
Today, I came into the shop briefly to help with testing the robot with the old, glued wheels. Unfortunately, when testing climbing, the wheels quickly slipped and did not regain traction like we had hoped. We noticed that the glue was not sufficiently securing the tires to the hubs and that it would not work, so we decided that we will be going back to the old shop wheels that are 4".

In addition to working on the testing, I was mostly focused on finishing the CAD of the new robot. Ideally, we only wanted the CAD to have longer inner and outer walls, without changing much of the other parts of the CAD. However, this was quite difficult to do, since I found that there were a lot of mating issues with the old assembly. Furthermore, I noticed that the way that the inner and outer walls were CADded did not make the most sense and would be a bit hairy to make adjustments. Instead, I decided to create new CAD models for the inner and outer walls from scratch. This was pretty time-consuming but ultimately a very good decision, because it revealed other mistakes that were previously made with our CAD models which had shown up in the misalignment of holes in the first robot that I could now correct.

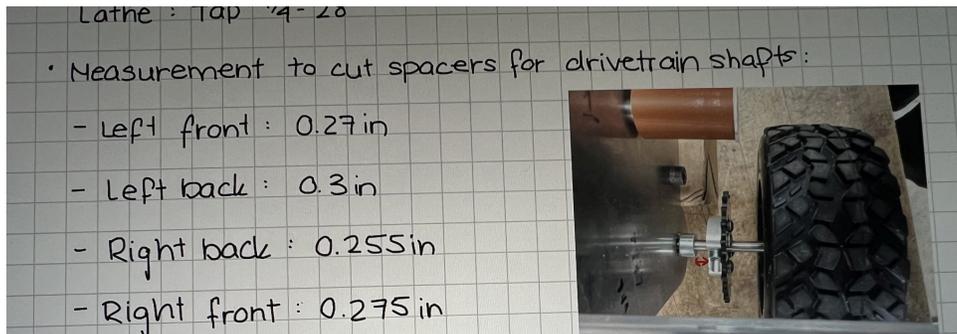


## 1/8 - Fixing mates and adjusting CAD model

I realized some issues with the mating, such as spacers running into the bearing holes. I also found that the holes of the motor mounts and the locations of the holes were incorrect, which had created issues with the first robot. I fixed these issues by deleting all the old mates and re-adding mates with my new inner and outer walls axially. I had to set some new distance mates, which I got from Hannah.



*Issue with spacers running into the outer wall*



*Measurements for spacer lengths for the old drivetrain*

### CAD to do:

- replace other inner wall
- fix mating on bottom plate
- fix spacers
- finish mating of things on shaft axially after choosing spacer lengths
- fix distances between holes for the chain length thing

## 1/12 - Continuing to work on mates and adjusting holes

We had a group meeting, and Miina and I talked about the location of the motor holes and we determined the locations they needed to be. She sent me a picture of them, which is below:

- Illustrated on sketch w the center to center distances

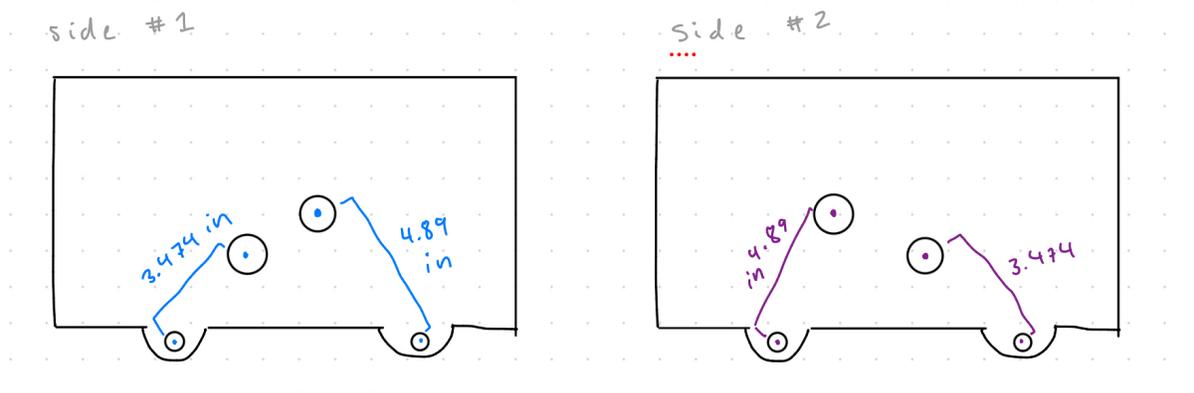


Diagram of the location that the motor holes need to be on the inner walls.

Miina also told me: “the 4.89 results in 50.1 links which we used on one side on the old robot (and it worked ok) and the 3.474 should now result in 42.1 links for the other motor”. Miina also showed me a picture which shows the spacing needed between the inner and outer walls, which is below:

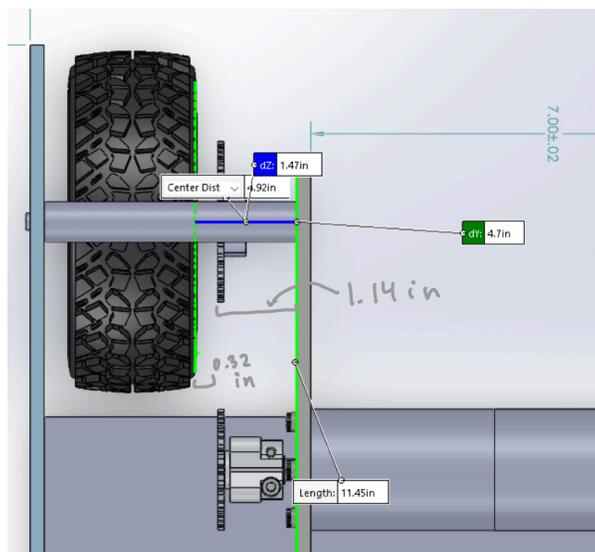
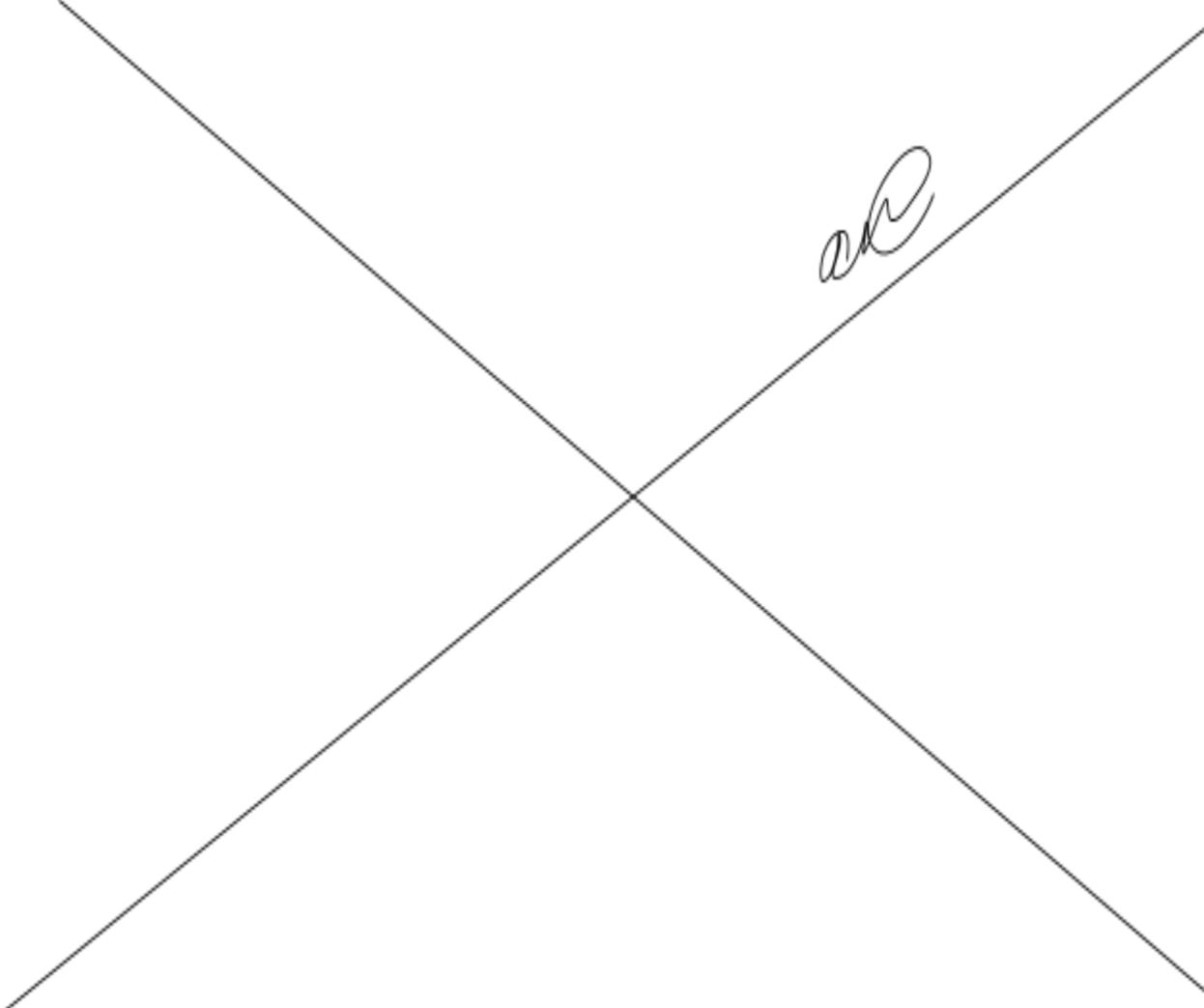


Image of the drivetrain between the inner and outer walls from Robot 1's CAD to be replicated.

This informed the matings for the new assembly with the updated walls. I also adjusted the motor mounts so that they could be slightly lower, which would allow for the ramp to have a bit more space and not need to be as steep. I made these adjustments and then uploaded the new assembly to the drive.

**1/12****ASSEMBLY CAD TO-DO.**

- confirm size of spacers so i can fix axially
- ~~fix holes for motors~~
- ~~upload new magnet holders (this is why mating isnt working rn)~~
- ~~fix discrepancy between motor mount and inner wall holes fix sizing of holes for motor mounts make sure sprockets are in line make sure spacing between wheel and sprocket is correct and sprocket and wall are correct make sure motors on the same side are diagonally at least 96.4 mm apart make some of the mounts flush with the ground~~
- add bottom plate
- add front plate



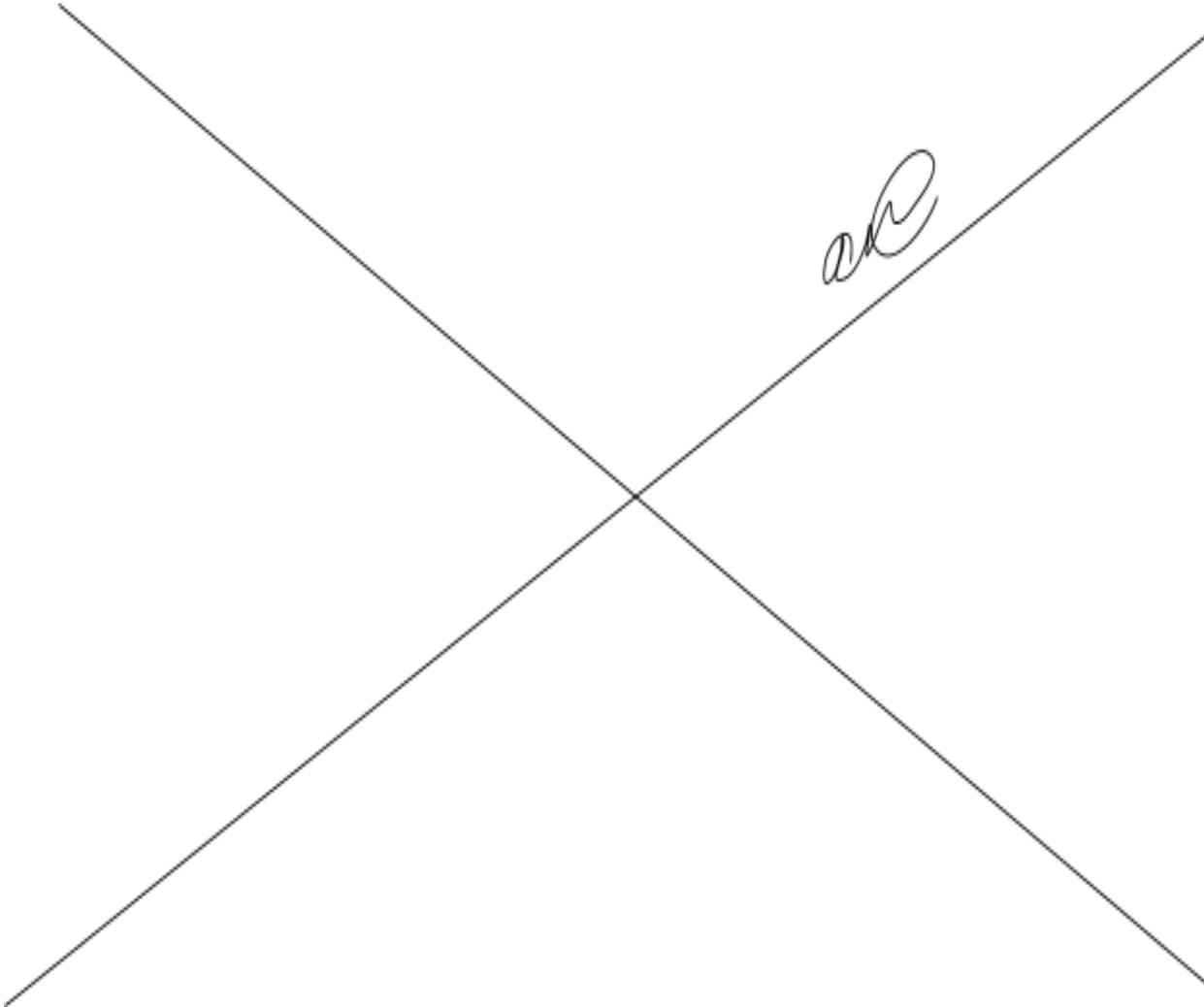


### **1/25 - Team Meeting & Catch Up**

I unfortunately missed almost two weeks of time due to a family emergency, as I had to fly home and was not able to work very much besides slight CAD adjustments until I returned. I was caught back up to speed with my group on Sunday, and when reviewing the updates to the CAD, we realized that the location of the intake rods were not far enough away from the ramp to allow for sufficient clearance when collecting the EC's.

### **1/26 - Disassembling Robot 1**

This morning, I went with Hannah to help 3D print some of the inner walls for the intake. Afterwards, I went to the machine shop and disassembled the rest of Robot 1. I also replaced the gray wheels with the blue wheels and tightened everything and labeled some of the parts so that they are ready for reassembly on Wednesday with the new inner and outer walls.




**The remainder of this notebook is still in progress of being written.**