8872 Robopocalypse

Adrian C. Wilcox High School

Santa Clara, CA

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Strategic Plan

S.W.O.T. Analysis:

Strengths:

- High quality tools and materials
- Good fundraising
- Physics based engineering process
- Supportive mentors
- Experienced 3D Design team

Weaknesses:

- Poor scheduling habits
- Bad cleaning strategies
- Small workspace
- Poor scouting skills
- Few mentors
- Poor student training programs
- Lacking working efficiency

Opportunities:

- Steam Expo and school events
- New member education program
- Making connections with other local teams
- Getting more mentors from industries

Threats:

- COVID-19
- Declining membership
- Loss of mentors in a few years
- Loss of skilled members
-

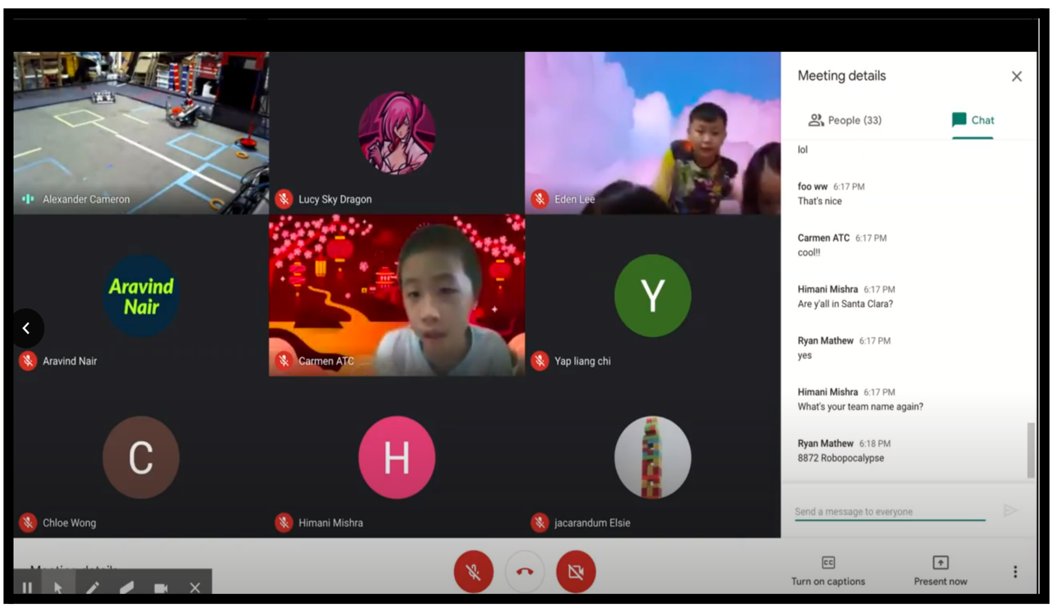
Team Goals/Plan

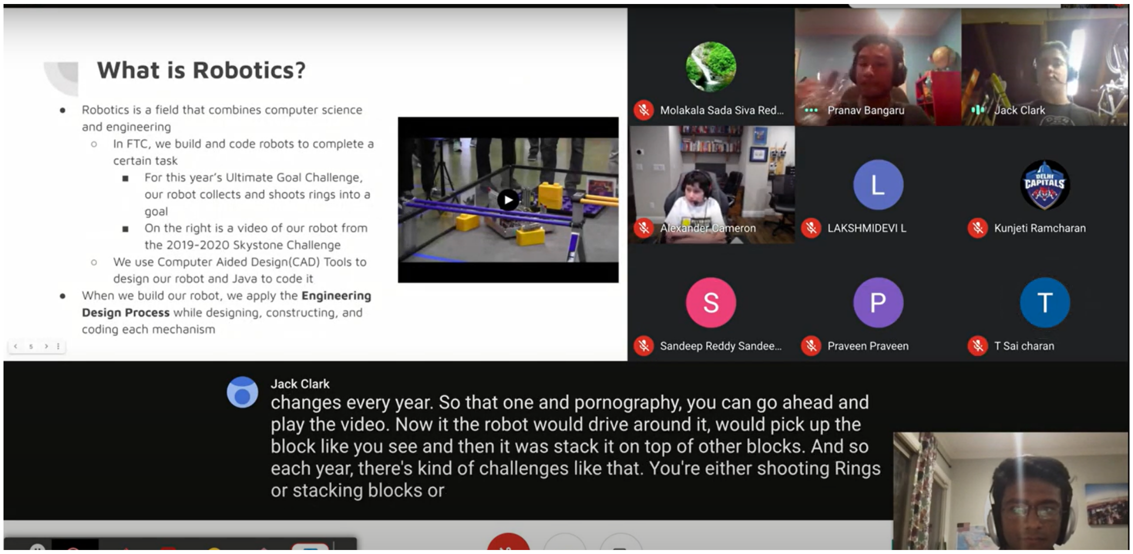
Strategy	Actions	Group Responsible	Completion
make efforts to do more international presentations in nations like India and Kazakhstan.	After a great reception from our presentation partnered with TutoringMalaysia, 8872 Robopocalypse has made a vow to spread STEM through nations in Southern Asia to cultivate a younger generation in STEM.	Business / Leads	June 2022
Boost recruitment by setting up a stand for the team during school Open house and club fair events.	We have recruited through school club fairs and community outreach events	Business Team / Leads	April 2022
Work with current mentors to help find other teachers at our school who are willing to take up the mantle as old mentors leave	Our current mentors have already started looking for new ones among the staff population at our high school	Leads / Mentors	April 2023
Collaborate with other teams and help them grow	At our school, we have a sister team, 13190 Roblivion, who we help educate each year. For next year, we want to interact more with another local team Astrobruins. This year, we helped them with their robot and they helped us with our portfolio	Business / Hardware	December 2021
Purchase some heavier machinery and new tools to boost our hardware capabilities	With a huge budget boost this year, we have allocated some funds for new tools and have even received some via donation	Leads / Hardware	December 2021
Coordination among divisions - In the past, hardware has spent more time working on the robot which prevents the software team from having ample time to fix issues in the code leading to issues at tournaments.	Using Trello and Slack, we can now notify certain members and divisions when tasks are needed to be done on certain days. This allows a quick transition from hardware to software.	Hardware, Software, Business, Leads	December 2021
Develop and master team member's hardware and software skills	This year, with a record increase in rookie members to Robopocalypse, we are developing all member's skills for robotics, especially in specialty skills like CADing	Hardware, Software Leads	April 2022

Robopocalypse's Outreach and Fundraising Statement

Outreach:

This year, we had the opportunity to do some international outreach through one of our team members to a foreign country. He teaches English to Malaysian middle school students through a program called MalaysiaTutoring so we worked with him and to have the opportunity to give a live presentation of our Robot, STEM, the engineering process, the FIRST Program, and values, and even teach them about Gracious professionalism, all through Zoom to kids on the other side of the world! We were glad to have this new outreach opportunity to expand our impact on the world and inspire future engineers. Our outreach truly has no borders! We followed the momentum from our presentation in Malaysia and introduced a presentation in international schools in India, attracting over a hundred interested students, constantly interacting with us.



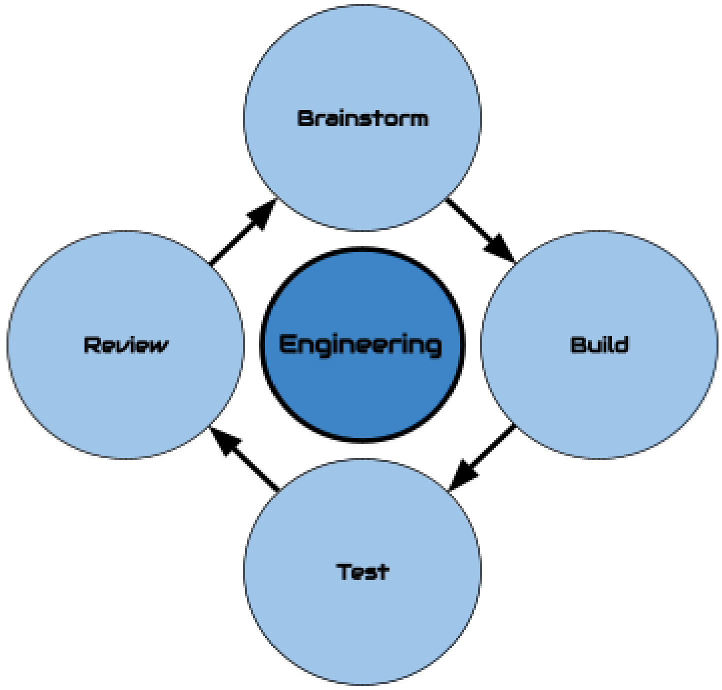


Fundraising:

This past year, we received around $8,000 from our generous sponsors through various grants. We received $5,000 from Northrop Grumman, $1,000 from ARM, $750 from Intuitive Surgical, $500 from 02 Micro, and $500 from the Rotary Club of Santa Clara. We also received funding for robot parts from generous parents of members and graduates from our team. In addition to this, we had some funds carried over from the previous season when we made and sold lemonade and funnel cakes at the Santa Clara Art and Wine Festival.

Engineering Process

Whenever we face an engineering challenge, we try our best to stick to this pattern (brainstorm -> build -> test -> review -> repeat) until we have a successful prototype.



- **Brainstorm:**
  - After analyzing the problems at hand, we meet as a team to discuss our different approaches to the challenges
  - We use programs such as Sketchpad and Fusion 360 to create 2D and 3D CAD models of our plans
- **Build:**
  - We then turn our visions into reality and create quick prototypes of our designs to see if the idea is feasible
    - These initial prototypes are cheap and easy to build and have the sole purpose of determining how or if we should build the final model
- **Test:**
  - Testing is the next key stage for the engineering process in which we experiment with our prototype in different scenarios to see what worked and what didn't
- **Review:**
  - Learning from our mistakes is what will allow us to advance our prototype, so we make sure to spend time figuring out potential improvements in our design for the next prototypes

The process simply repeats, we keep finding problems and ways things can be improved or upgraded until we reach our final model.

Robot Development

Title: Early In-Person

Date: 9/16/20 - 9/28/20

The 2020-2021 season has begun! The game for this year is announced and the team leaps into brainstorming immediately. These days are the first of many sketching, 3D designing, prototyping, and testing.

Design Ideas:

- Chassis: changes to last year's chassis were unanimously agreed on regardless of robot design.
    - Favored a belt powered drive-train
        - All motors are centralized at the back of the robot
            - The back two motors are direct drive (attached directly to wheel)
            - Front two motors belt driven
        - Leaves space in the front of the robot, ideal for a ramp to allow easy pickup of rings
- Several designs for robot mechanism presented:
    - "Straight Shooter"
        - This generic design is easy to design and build
            - The ring enters one side of the robot → Slides up the ramp to the shooter
            - Fired out the opposite side of the robot, hence "Straight Shooter"
    - "Curved Shooter"
        - Takes the ring in on one side of the bot and shoots it out the same side, making the robot able to cycle through rings faster (doesn't have to turn around).
        - This would save precious time during the driver-controlled and autonomous periods
- Several designs for Ring Launcher Mechanisms presented:
    - Two parallel motors (inspiration from a football passing machine)
        - Does not cause the rings to rotate → the rings will not be stable in the air.
        - Favors "Straight Shooter"
    - Curved with motors on one side (inspiration from a frisbee launcher)
        - Causes the rings to rotate around themselves → the rings are stable in the air.

        - Spinning objects are more stable than objects that are not spinning, making this the ideal design
- Several Designs for ring Intake presented
    - Tying rubber surgical tubes to a spinning axle
        - Would not contact the rings
    - Compliant wheels spinning
        - Has greater contact with the rings to easily pick them up

Date: 9/29/20 - 10/25/20

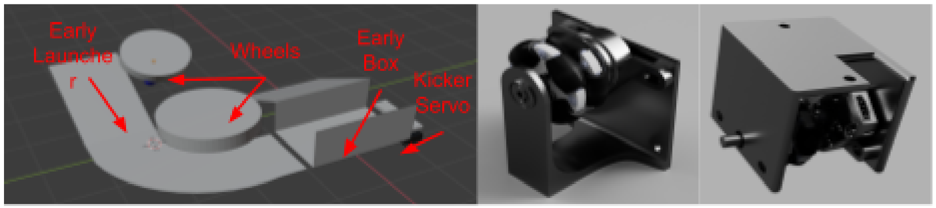
Title: Working In-Person

In-person is approved by the school and several people can come to help work on the bot. Most of the time spent during this period was spent testing, prototyping, and further designing the chassis and launcher.

Design Evolution:

- At the beginning of working in-person, we spent a lot of time deliberating over how to design the robot, and after a week or so of designing we came up with this:
    - We would have a wheel intake system to transfer the rings up a ramp into a collection box (actual design undecided)
    - For the launcher we decided to go with a "curved shooter" design (see previous entry), firing from the same side we intake from (pictured below)
    - A kicker servo would dispense each ring into the launcher mechanism
    - The launcher itself used a Curved motor set-up (see previous entry), with two wheels propelling the ring out of the robot
- Odometry
    - The odometry pod(left) that we designed for the competitions in our previous season was bulky and not space-efficient
        - The poor design prevented us from having space and flexibility to install other robot mechanisms
    - We decided to improve on the design(right) this year, keeping in mind that the new pod had to be durable and space-efficient
    - To make the design more sturdy, we increased the thickness of the pod so it doesn't bend and decrease our accuracy
    - We eliminated any extra surfaces of the pod so we could easily access the insides of the pod such as the encoder, the wheel, the set screw, and the axle

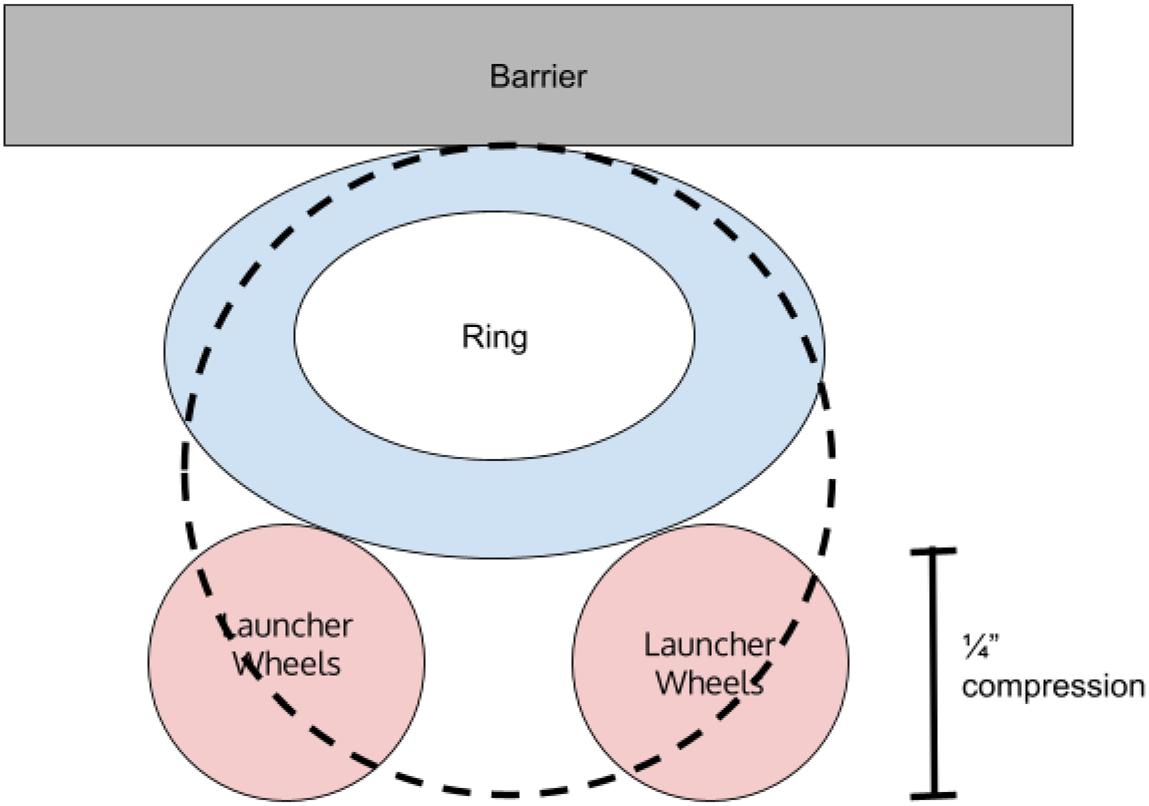
- Since we couldn't find any axles that would fit within the pod, we designed a 3d axle that included a collar that decreased the width of the odometry pods by nearly 1.5"



(Figure 1): *Early robot design (left), last year odometry pod (middle), new pod (right)*

Challenges:

One challenge that we faced with the prototype launcher was the optimal compression distance between the flywheel and the wall that kept the ring in place (see below). If the compression was too high, when the ring left the launcher it would stray off course, and if there was too little compression, the wheels would slip on the rings. We turned to the engineering process and started brainstorming. We came up with some ideas of what could be wrong, made the necessary changes to our prototype, and started testing our ideas, testing each hypothesis so we could eliminate them in turn. Finally, after a lot of testing, we found out the right amount of compression to have the ring fly pretty straight was ¼". Overall this experience taught us a lot about testing and refining a model, which in this case was the amount of ring compression.



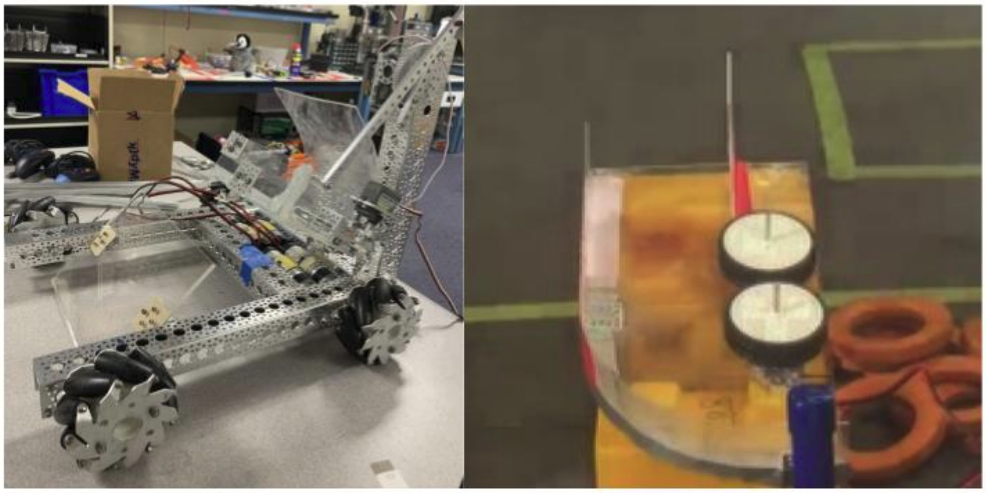
(Figure 2): *drawing showing ring compression*

Date: 10/26/20 - 11/16/20
Title: Late In-Person

Design Evolution:

- We switched the launcher to the other side of the robot and moved both wheels into the same plane and
  - We did more tuning with the launcher curve (we bent it a bit more) and got pretty consistent shooting, we ran some tests and found we had an accuracy of 75% when trying to score in the high goal (15/20 rings)
- We changed the design such that now the rings are stacked in a box that rotates up to the same angle as the launcher (we prototyped this out of acrylic)
  - After some basic testing, we found our acrylic box prototype had too high of a coefficient of friction (it was too rough for the rings to travel smoothly into it, they would get stuck) so we started plans to 3D print our box.
- We began designing the intake with first a straight ramp at 45 degrees with two rows of compliant wheels to grip the rings
  - The wheels were attached to the axle with custom made hex mounts

- After testing we found that a flat ramp intake with a set row height would struggle to grab the rings since the transition between horizontal and 45 degrees was too harsh We tested a curved ramp
- We redesigned the first row so that it can rotate up and down (it's attached to the second row via flat brackets)



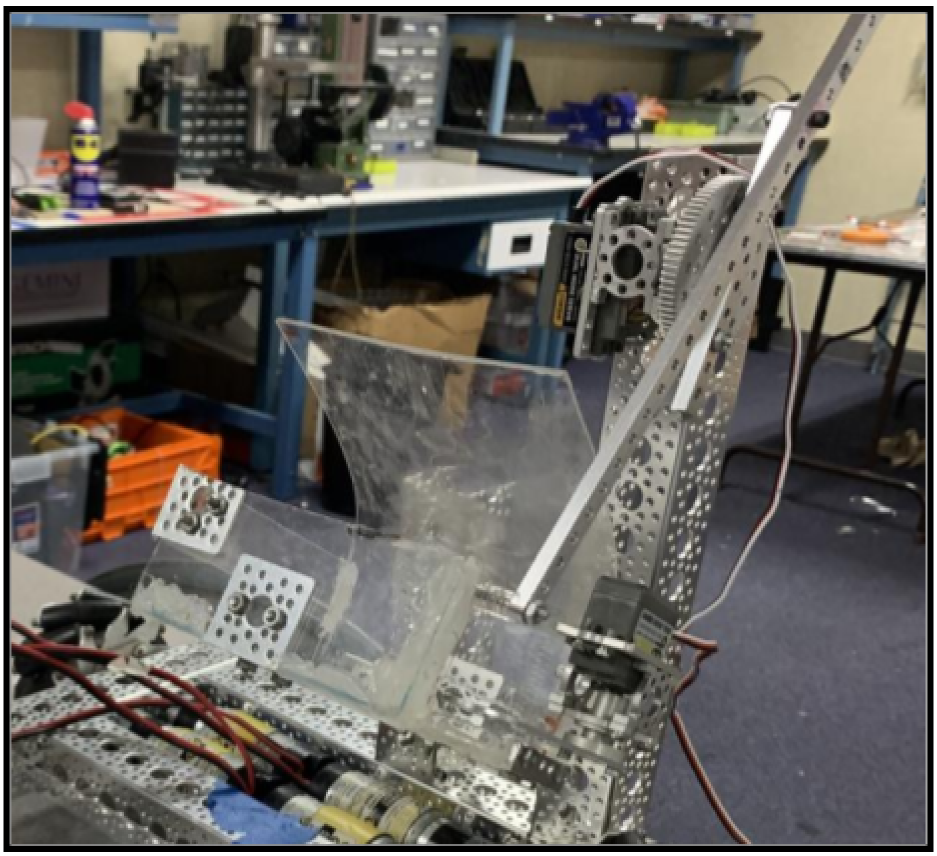
Early ramp and rotating box

Curved launcher using aluminum mounts (mounts are hard to see)

(Figure 3): *ramp and box prototypes*

Challenges:

Shortly after its creation, we faced a significant challenge with the box mechanism. When feeding the rings into the box, they would not stack properly consistently. The ring stack mainly depends on the position of the first ring, which would sometimes get stuck at an angle inside the box. This was due to several factors. First, the material of the bottom of the box was acrylic which is very smooth but has a very high coefficient of friction. This meant that the ring couldn't slide completely into the bottom of the box. Next, the box itself about ½ of an inch away from the intake ramp, causing the ring to get caught on the front edge of the box. To solve our first problem, we tried attaching different smoother materials onto the inside surfaces of the box such as blue painter's tape but eventually resolved the problem by lightly sanding the acrylic. To solve the second problem, we extended the length of the box to sit very close to the ramp. While these changes improved the consistency of the ring stacks, it wasn't perfect. We planned on 3D printing a new box out of PLA, which surprisingly is naturally very smooth, using the improved design and new additions to the acrylic box as a baseline. However, with changing COVID-19 restrictions we were unable to do this while on campus, but we found time almost directly after the new restrictions.



(Figure 4): The old acrylic box

Date: 11/7/20 - 1/19/21

Title: Work at Cameron's House

With new California lockdown orders, the robot is moved to a hardware member's house and work continues there, sometimes with multiple people or just one to keep up with the ever-changing restrictions.

Design Evolution:

- Massive amounts of progress were made on the robot as a whole during this time
  - Box fully redesigned, 3D-printed, and uses a Gobilda "Super Speed" servo to kick the rings into the launcher
  - Work continues on intake, problems continue with the bent ramp and even the new rotating first row doesn't fix it
    - We try some other materials to help but eventually just change the ramp back to a straight ramp but keep the rotating first row and we finally find success
  - Launcher final version begun, went through many stages:
    - V1: Two thin acrylic plates supported by Rev channels, c channel attachment point
      - Too weak, hard to manufacture
    - V2: One aluminum plate and one thin acrylic plate with c channel supports
      - Supports unnecessary and complicated
    - V3: One aluminum plate and one thick acrylic plate, no supports
      - Motor attachment is still complex with Rev channel
    - V4: Motors attached directly to the top plate
      - Simple and durable, but hard to assemble with c-channel in the back
    - V5: C channel replaced with solid plastic block
      - Simple, easy to manufacture, durable
  - Encountered some errors in driving, robot weight distribution is uneven, we planned on exploring the problem more when the robot went to a software members house

(Figure 5): *launcher CAD (left) , finished intake, box, and launcher (right)*

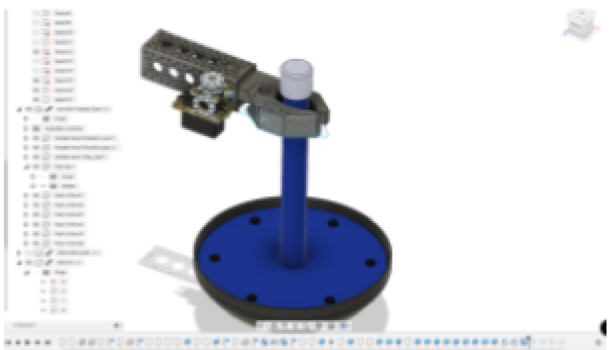
Date: 1/20/21 - 2/20/21

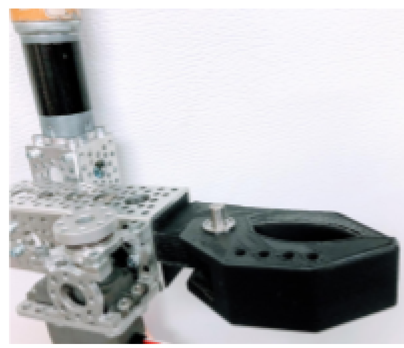
Title: Off-Campus Software Work

After lots of hardware work, the robot begins to move between software members' houses, and massive amounts of work on teleop, odometry/roadrunner, and autonomous work began (with minor hardware changes).

Design Evolution:

- We wanted to create a wobble goal mechanism to score extra points in our matches
- We used a single upright c-channel in the front left corner of the bot with a horizontal pivoting arm coming off of it, powered by a bevel gearbox
  - At the end of the horizontal arm, we 3D modeled a claw controlled by a servo
  - The servo was connected to the moveable jaw of the claw via a aluminum linkage, giving it a mechanical advantage and tidying up the design



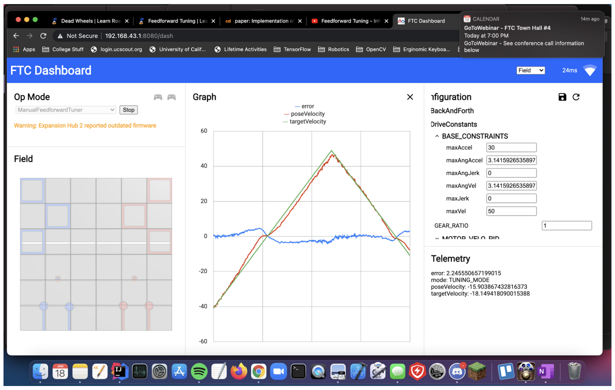
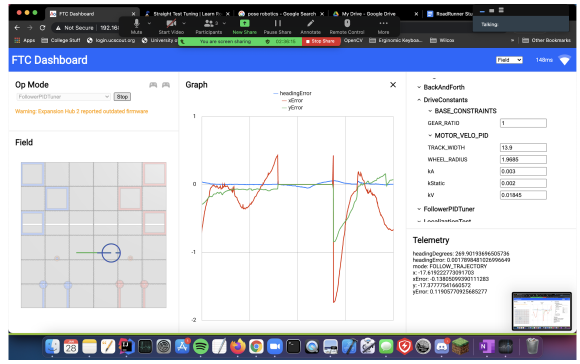


(Figure 7): *The wobble goal grabber CAD (left) actual mechanism (right)*

Wobble Goal Programming

When programming the wobble goal to travel to a target position, it would exceed that position and continuously spin. This resulted in the **motor shaft bending**, as it would stall on other parts of the motor. To fix the issue, we had to increase the target position tolerance, so it wouldn't continue to run the encoder if it exceeded it by a small amount. As an extra precaution, if the wobble goal arm exceeded a certain encoder tick amount, a software stall will be set onto the motor. setting its velocity to zero. Still, the motor shaft ended up becoming bent if we didn't set the correct initial position. The best solution to prevent the motor from exceeding the target position would be setting a hard hardware limit, compared to reading encoder values.

```
wobbleGoalMotor.setTargetPositionTolerance(110);
```

	
Feedword tuning lacking a plateau, as the motor cannot reach the maximum velocity	Follower PID TUNER - finding discrepancies with the x, y, and heading error.

When working on feedforward tuning, I noticed that throughout different voltages, the robot would exceed or be way lower than the target velocity values. To account for the issue, we had to increase the kStatic value to around 0.04. This also helped give accurate values in both **Strafe Test** and **Straight Test**, which are meant to act as a test toward feedforward tuning.

Next after doing feedforward tuning, we had to do a track width tuner. In previous steps, we tuned the lateral multiplier which is meant to figure out the distance between the two vertical odometry wheels. Tuning this value would help make sure the robot accurately goes to the heading it was specified. We were getting very unusual values when tuning track width, around 3 to 4 inches when the actual distance of our robot was around 13 - 14 inches. To solve the issue, we manually tuned the track width by running a turn test, until the robot went 180 degrees.

The next step was to apply the correction to the heading of the robot and its x and y movement, in case it went off due to weight distribution or slight discrepancies with the feedforward tuning. When going back and forth, the robot remained relatively in the same place. Follower PID Tuner, which causes the robot to run in a square, allowing minor discrepancies to build up and be detected by the user. When running FollowerPIDTuner we saw that the graph displayed 1 to 2 inches in the heading and translation position, yet the robot would eventually go off the field after 30 seconds. We tried increasing the correction present on the robot by increasing the pID constants, but that had little to no effect. We realized this is a problem with the localization, especially the heading not being perfectly accurate. To reduce this issue, we increased the spring force pushing the odometry wheels to the ground, reducing the larger errors present in the localization test.