Infinity Tech: Team #13684

Creating An Infinite Stream Of Technologists

Infinity Tech's 2022 Engineering Notebook

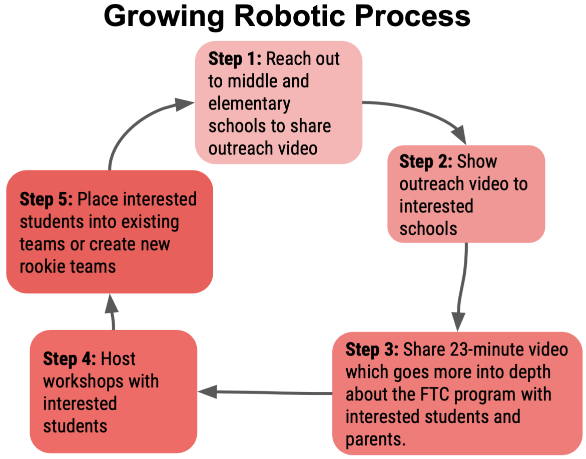
Hello, Namaste, C ào, Guten Tag, Hola, Shalom, Aloha, Zdravstvuyte, Konnichiwa, Salut, Ellohay, Kumusta and Nihao! We are Infinity Tech (Team #13684). Welcome to our Engineering Notebook!

We are a team of middle schoolers from the Plymouth-Canton community. The majority of us go to East Middle School, a school in Plymouth, MI, but some go to Liberty, Pioneer, and West Middle School. Our journey started in September 2017 when our founders went to a meeting where they watched a presentation about how FTC worked. Soon after that, our team was formed! Currently, the team member count is 15 students and 3 5th grade interns and 8 mentors, plus our robot (Lightning McThomas the Tank). We are now on our sixth season of robotics and have been to ten competitions. In this notebook, you'll find brief biographies written by our team, our design process, our outreach and fundraising, and much more!

Exposing the world to FIRST

In 2017, we were the last middle school in the Plymouth-Canton School (PCCS) district to establish a team. One year after the COVID pandemic, we were the only team left out of the 10 teams that had been associated with Plymouth-Canton Community Schools! After the pandemic, we helped create 3 teams by sending informational videos to middle schools and 5th graders, hosting robotics workshops, and connecting them to the high school teams FTC's coordinator. We are currently 1 of 7 FTC teams associated with the PCCS district who are competing this year. Our goal is to keep Infinity Tech going after we graduate from middle school as well as sustain robotics in PCCS and our community. We hope we help expose FIRST robotics at schools by mentoring at Galimore elementary school's robotics club, sending an informational video to elementary schools and middle schools across the district, and hosting and/or helping at community

Growing Robotic Process



events like Robots in the Park.

How does our team solve design problems?

We try to face problems together. Infinity Tech brainstorms ideas to fix problems and prototypes before actually building them. New ideas bring our team together, and each member of team Infinity Tech is proud and happy to be working on building, programming, business, or design. We ensured everyone had something to do even if people had to share jobs.

Infinity Tech sets an agenda for most meetings. We also have a kanban board of the tasks and goals we need to finish by the end of the week, depending on our priorities. If we don't finish a task, a small group of people will complete the tasks during the next meeting or before we meet again. Issues are not anything to panic about; we always work on the problems calmly and carefully by writing on whiteboards, discussing, and testing our hypotheses. Every problem we face makes our team stronger.

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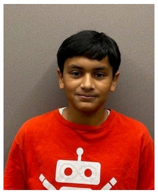
Part A

Introductions

In our introductions, you'll find the following:

1. Individual teammate biographies
2. Mentor Bios

Team Biographies



My name is Kabir and I am in 7th grade at East Middle School. My hobbies are playing video games, going outside, and coding. My favorite part of robotics is coding (I'm learning it right now)! I am a part of the programming and building teams. I joined robotics because we get to do fun things like building a robot and coding.

My name is Annabelle and I am in 8th grade at Liberty Middle School. Activities I participate in outside of robotics include dancing, track, musical theater, NJHS, and reading. I am a part of the business and building teams. I joined robotics because I enjoy problem solving and helping the community. My favorite parts of robotics are being at the competition and seeing all our hard work paying off.

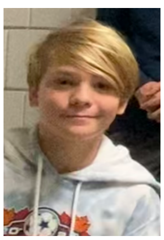
Hello! I'm Dahlia! I am an 8th-grader at Liberty Middle School. I enjoy playing guitar, Magic: the Gathering, D&D, and drawing. I am part of the business and building teams. I joined Infinity Tech because I have always been interested in how things work. My favorite part of robotics is building and helping with the engineering notebook.

My name is Karthik and I am in 7th grade at East Middle school. My hobbies are video games, soccer, and playing trumpet. I am on the build team. My part of robotics is building the robot and learning about how to buildI joined robotics because I really enjoy robotics from years of FLL and FLL Jr.

My name is Edison and I'm in 6th grade at East Middle School. My hobbies are video games, cross country, reading, and golf. I'm on the business team and building team. My favorite part of robotics is seeing the robot go from design to reality. I joined robotics because I like to see how to youth of today can affect the future of technology

My name is Adithya and I am in 8th grade, I go to Liberty Middle School. Outside of robotics I enjoy swimming. I am on the programming team and my favorite part of robotics is the programming of the robot, because I really enjoy programming. I joined robotics because it is really fun and it helps me gain more skills.

My name is Neha and I'm in 6th grade at East Middle School. My hobbies include reading, biking, and playing the piano. I am on the building team. My favorite part of robotics is: building because it helps you bring an idea to life. I joined robotics because I wanted to be part of a team that created a machine that could execute what was necessary.



My name is Luke and I'm in 6th grade, East. Outside of robotics my favorite activity is soccer. I am on the building team. My favorite part of robotics is: building the robot. I joined robotics because I enjoy building robots.

My name is Himani, I am in 6th grade at Pioneer Middle School. My favorite things to do outside of school are playing sports like basketball and soccer. I also enjoy reading and going on walks. My favorite part of robotics is that you can build stuff and program it to do anything you want. I wanted to be a part of robotics because I like building stuff and wanted to do it with a team.

My name is Donovan and I am a 6th grade student at Pioneer Middle school. My favorite activities are playing basketball, soccer and looking at expensive new shoes to buy. My favorite part of robotics is building, improving the robot and doing the math to find what we need to do to improve our robots, such as finding the gear ratio to help our motor work better. I wanted to join this team because I want to enjoy the experience of working with a team building robots.

Hi, my name is Vasmitha and I’m a 7th grade student at Pioneer Middle School. My hobbies include swimming, public speaking, playing piano, and hanging out with my friends and family. My favorite part of robotics is being a part of the business team and learning new things at almost every robotics meeting. I wanted to join robotics because I wanted to learn something new and I am interested in working with robots.

Hi, my name is Imoen and I'm in 6th grade at Liberty Middle School. I play D&D, paint, and do boy scouts. I wanted to join robotics because it was fun in boy scouts.

Hi, my name is Bonnie! I am a fifth grader at Gallimore Elementary School. I like to read, write, crochet, and listen to music. My favorite part of robotics is working with other people to get stuff done. I wanted to join robotics because I wanted to meet new people and learn new things!

Hi my name is Parker. I am a fifth grader at Farrend elementary school. I like to play games and do fencing. My favorite part of robotics is building and driving. I wanted to join robotics because it looked fun.

Zane

Aarav

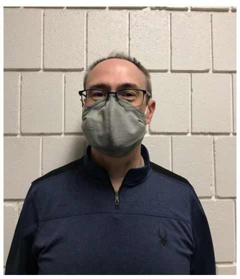
Hi, my name is Aarav and I’m an 8th grade student at East Middle School. My hobbies include swimming,listening to music and playing with my friends. My favorite part of robotics is helping in a way. I wanted to join robotics because I like coding and I wanted to code a robot again.

Griffin

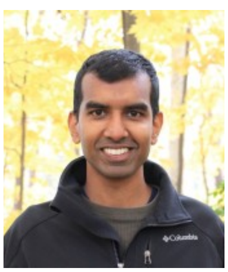
Caleb

Mentor Biographies

I'm Eddie and I'm a Sr. Safety Regulatory Engineer working on automated vehicles, crash avoidance systems, and alcohol detection research and regulatory cooperation with the federal government. I enjoy spending time with my family, traveling, snowboarding, golfing, rock climbing, and Tae Kwon Do. I am a founding member of Infinity Tech, co-coach of the building team and the mentor for the business team. I have been coaching Infinity Tech for 5 years.



I'm Eric and I work for Ford Motor Company as the Competitive Benchmarking Manager. I have Bachelors and Masters Degrees in Mechanical Engineering. I enjoy spending time with my family, learning about technology, home improvement projects, and photography. This is my third year mentoring with Infinity Tech.



I'm Kanthan and I'm a Senior Engineer at Airflow Sciences Corporation, an engineering consulting company specializing in fluid dynamics. I have a Bachelor's degree from Malaysia and a Masters Degree in Aerospace Engineering from the University of Michigan. Go Blue! I enjoy soccer, reading, and traveling with my family. This is my second year with Infinity Tech, and I am the programming mentor.

Part B

Outreach and Fundraising

In this section you will find:

- **Field Trips**
- **Mentoring**
- **Fundraising**
- **Recruiting**
- **Outreach**

Outreach Done in the Past

2017-2018	2018-2019	2019-2020	2020-2021	2021-2022
• Demoed the Dodsoı FLL team • 6th grade orientation presentati • Got our firs sponsors	• Mentore Dodson and Gallimor elementa robotics teams ar demonst -ed with our robo • "Robots the Park booth	• Presentatio at East's feeder schools • "Robots in t Park" booth • Field trip to University d Michigan • Sponsor Vi	• We wer to Caresof in Livon MI • The pandem made outreac difficult	• We went to Caresoft • Sent a vide the homerooms Liberty Midd School to ge people into robotics


What We Did/Plan This Year

Workshops

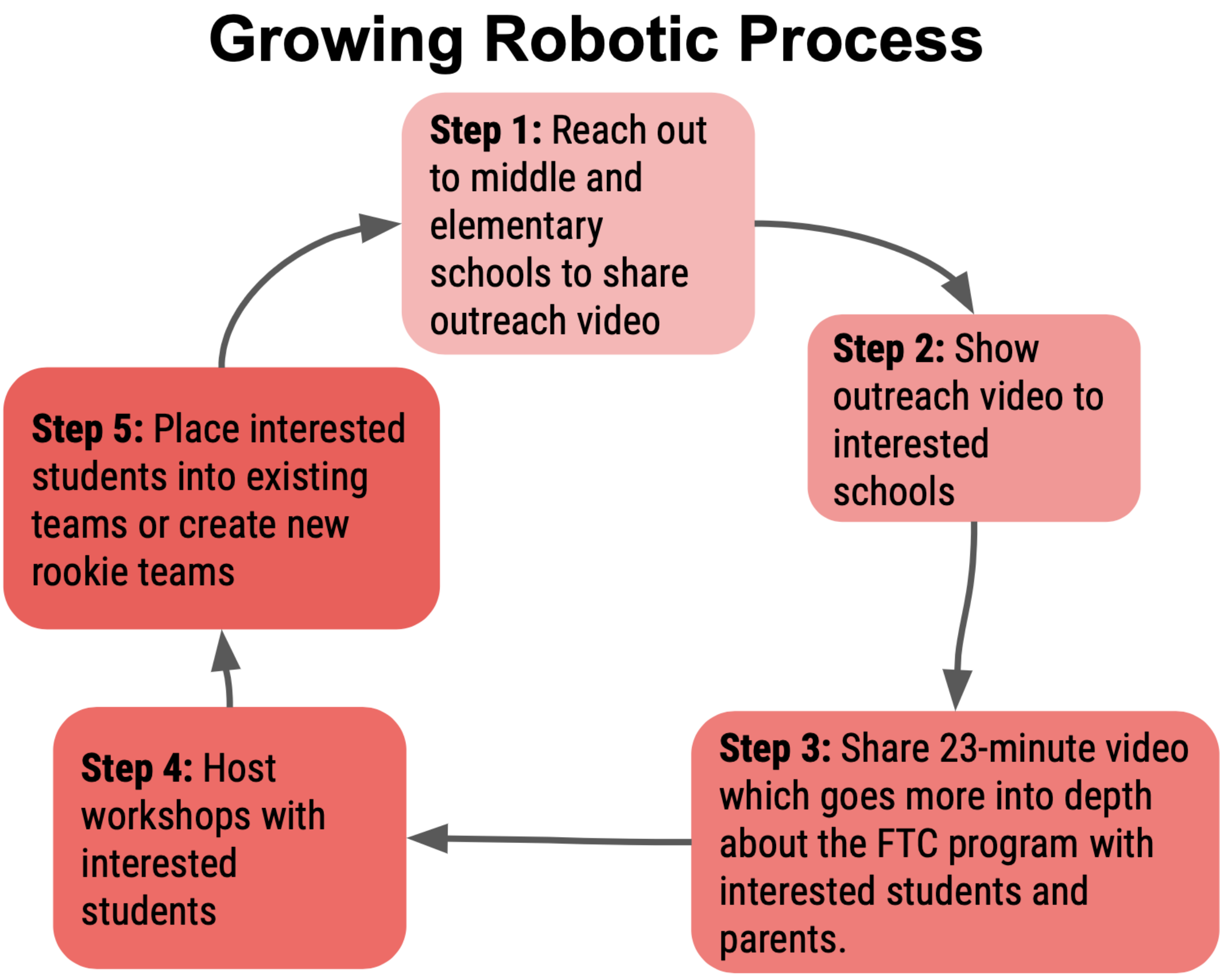


Figure A. Our process to grow robotics in PCCS

2022- We hosted 2 workshops for 5th-8th students this year to expose more students in FTC robotics. Through the workshop we found 50 kids interested in robotics and started and mentored three new Plymouth-Canton Community Schools FTC teams! At our workshops, we made lego-like build instructions (figure B) to both train our new FTC team members but also provide the opportunity for new students to learn how FTC works. Students built a pincher claw with lego-like instructions.

After the New Year, we are planning to host 2+ (we want to host more than last year) workshops depending on the amount of students interested. This year we are going to create instructions for a golf club-like mechanism that students can build, program and test. We decided to change the mechanism students build because the claw was challenging for some students and there wasn't time to fully build and program it in one workshop.

Some teams disbanded due to Covid. Some of the teams had extra parts, and supplies, so we picked up those parts from the schools and we split them up between rookie teams. This included tetrix parts, tools, and business supplies.

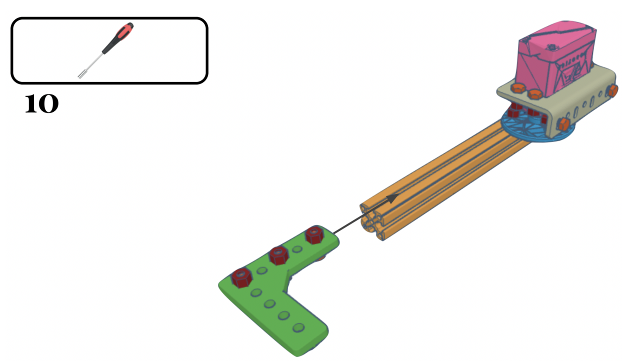


Figure B- Pincher Claw Instructions

2023- We hosted another workshop this year. In the past the mechanism (pincher-claw) the students built took too long and was too complex to build. So we made a mechanism that looks like a golf putter, which was much simpler and students could program it with a servo programmer. They also drove the robot and it was a very successful event! We are continuing to work and refine our workshops and plan to make them short and hopefully host at least one more this year, maybe directed for elementary schools and use the EV3 robots we have.

5th Grade Roundup Robotics

2023- When we were sending out an interest video to middle and elementary schools we noticed that there were no interested 5th graders despite sharing a video with almost all of the elementary schools. However about half of the interested students were 6th graders that we missed last year. Therefore these students missed out on a year of robotics and we wanted to fix this. We collaborated with Lightning Robotics (our FRC team) to host an event for 5th graders to get them interested in joining middle school robotics. In total ~60 students participated in the event from 13 different elementary schools. We had four activities for them: paper rockets (inspired by NASA), human coding and marble run (provided by Lightning Robotics) and robot driver’s license (inspired by Dark Matter). We also shared a less serious info video than our normal presentation and we liked it a lot more because it was more engaging and shorter. 34 students signed up for a team after this event (about half of all interested students who want to join a team).

Gallimore Demo

2022- During Gallimore’s Robofest season, we demonstrated our robot to the teams and informed them about robotics. We talked to 12 teams, which came out to be forty-eight 4th and 5th grade students.

FLL Explorer Festival

We are going to volunteer at the FLL Explorer Festival hosted by Lightning Robotics next week.

Girl Scout Robotics Exploration Event

Lightning Robotics invited us to volunteer at their Girl Scout Robotics Exploration Event. This event was for girl scouts grades 1st-?

Mentored 16 Gallimore Teams / Volunteered at Gallimore's Robofest Competition

2022 & 2023- The head teacher for Gallimore reached out to our team, inviting us to mentor the Gallimore Robofest robotics teams which are comprised of 4th and 5th grade students. Both this year and last year we assisted the teams in programming and building. We also volunteered at the Robofest competition as judges, photographers, and proctors. In total we mentored 24 teams of 4-5 students.

50 States Outreach

We are working to reach out to a team in every state. We wanted to share ideas

FLL Explorer Dodson Demo

Our team went to Dodson Elementary School(a school in our district) and did a demo for all four teams and let them drive our robot. Be explained the next level, FTC to them, and showed how we are different and alike with them. Each team included 5-6, and inspiring about 20 kids.

Lightning Robotics #862(FRC) Mentoring Our Team

Lighting Robotics (our high school team) allows us to meet at the school and use their rooms and tools. They also provide us student mentors during our entire season. They also let us volunteer at some of their events like the Girl Scout event and FLL Explorer Festival. Many thanks to our mentors and team members of Lightning Robotic!!!

Bottle/can return fundraiser

We raised about $480 worth of cans/about 72 bags of cans from friends, family, and others who were returning cans at the same time as us. We set up a bottle drive through our local Busch's grocery store. Thank you to all donors! We are planning on completing another bottle/can return fundraiser this year.

Recruiting

2022- From our workshops and marketing videos sent to Plymouth-Canton elementary and middle schools, we had seventeen applicants to our team in total and recruited five new students this year, three 6th graders, one 7th grader and one 8th grader. We had an application and interview process to find the best possible people for the team. We also wanted to have a mix of all grades to help in sustaining the team in the future. Those who did not make it on our team, we helped place them on new teams.

2023- From our workshops and marketing videos sent to Plymouth-Canton elementary and middle schools, we had 30 applicants to our team in total and recruited 10 new students this year, three 5th graders, three 6th graders, four 7th graders. We had an application and interview process to find the best possible people for the team. This helped our tema know how to interview and gives experience to the students we interview. We wanted to have a mix of all grades to help in sustaining the team in the future. Those who did not make it on our team, we helped place them on new/ current teams.

Starting New Teams

2022- In total we got 50 students interested in robotics by sending out a video to all the middle schools in PCCS. We reached out to the elementary schools to share our video with 5th graders, but only 4 out of 14 schools showed the video. Next year, we plan to reach earlier and hopefully get more responses! Another way we get students interested in robotics was through a demo at Gallimore Elementary School during their Robofest season. Once we got students interested, we shared a 23 minute video with them to inform them more about FTC and how we run our team to get an idea of what the program is like. We helped start 3 new FTC teams with 11-12 students and five mentors each. We worked to find the best balance between grades, gender, mentors and students' area of interest. Our team offered to have sessions for new mentors to learn more about the program and get started before the new game came out. The business team offered a crash course to the new teams and shared templates and examples of the engineering notebook, portfolio, presentation and a checklist for them to follow.

2023- In total 103 new students were interested in FTC robotics through reaching out over social media and to the school district. We started to send out a video to the middle and elementary schools for them to place in their newsletters early to mid- December. From this alone we got 40 new students interested in robotics. Towards the middle of February we started to plan for 5th grade robotics roundup, which continued to spread interest in robotics with another 62 students interested. Out of the 103 students, 63 signed up to actually join a team. So far we have started 1 team with other students on a waitlist until we can get more mentors.

Caresoft Event

Like last year, we visited Caresoft in Livonia and learned about benchmarking cars. We invited 2 of the rookie teams we created, but unfortunately they were unable to attend. 11 people from our team were able to attend the event. We learned about how they benchmark cars and use virtual reality (VR) to look at cars. We also got a tour of their facility.

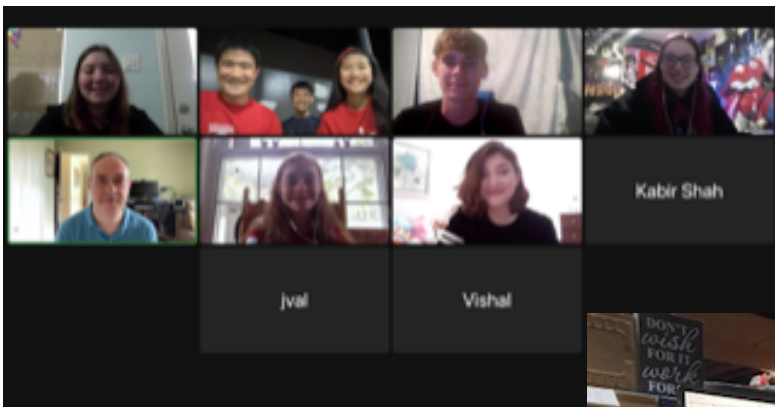
Restarting Robotics Interest at Middle and Elementary Schools Process(Same as creating a new team?)

Before the pandemic there were ___ FTC team affiliated with PCCS, after the pandemic we were the only FTC left associated with the district. The past two years we have started to build up the middle school teams and now there are 8 teams!

Once we finished our Lake Orion qualifier, we started to do the process above again for this year. We edited the video from last year to make it be able to be used every year without any changes. So far about 102 students have reached out about being interested in robotics for this season since the beginning of December. This is a little bit more than double of what we did last year! To our knowledge 17 of our 19 middle and elementary schools have responded about the video and have shared information about FTC robotics at school.

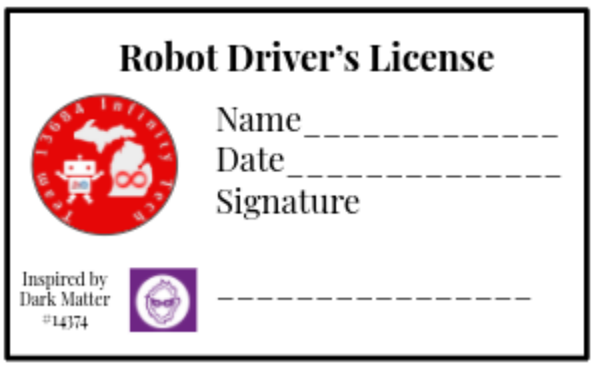
Meeting with Dark Matter Team #14374

We met with Dark Matter over zoom to inform them about how our workshops worked. They found us and our workshops through our Instagram account. Dark Matter shared some outreach ideas with us and showed us parts of their engineering portfolio. This was a very informational meeting for both teams to learn more about cool things the other team does.



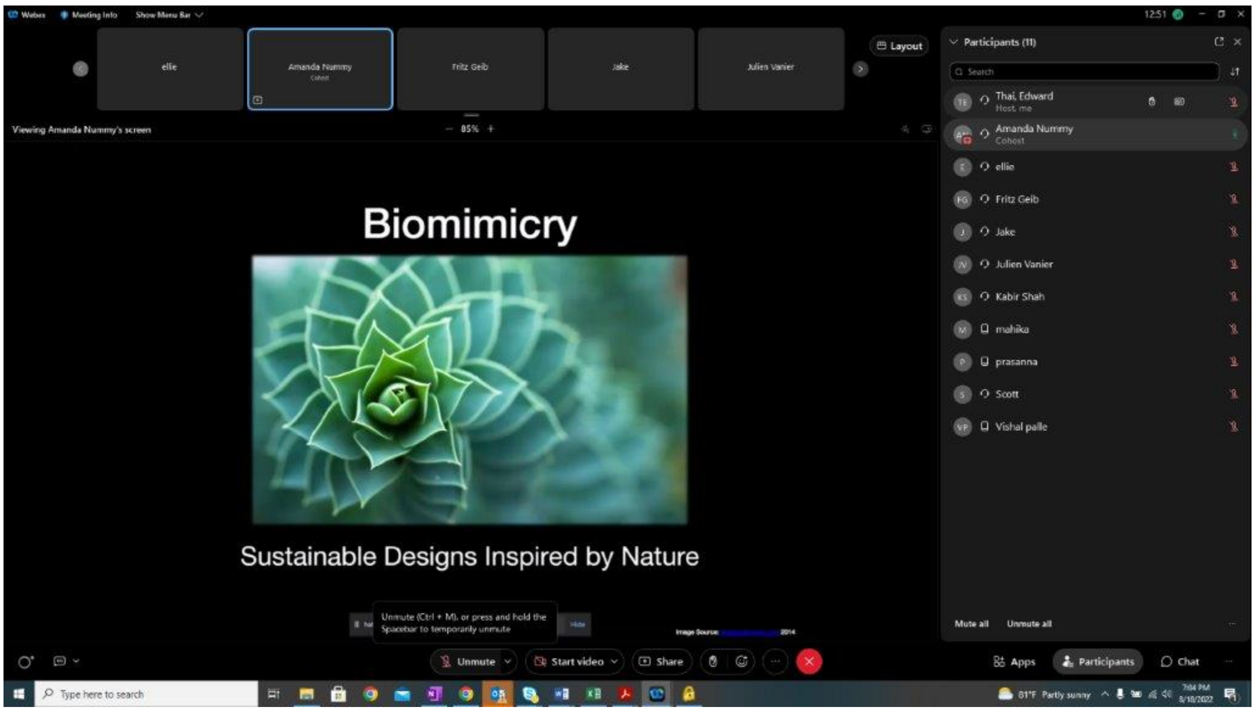
Co-hosting a Library Event with N.E.R.D. Bots #14353

N.E.R.D. Bots #14353 reached out, inviting us to their event at the library. During the event, N.E.R.D. Bots presented the different levels of FIRST and we shared more about how FTC works along with our season video. We also had 2 activities for students during the event. The first activity was a paper straw rocket, with a competition on who can make theirs go the farthest with a leaderboard. Thank you NASA for the template and idea! The second activity was driving one of our chassis to receive a robot driver's license. We would like to thank Dark Matter #14374 for that great idea!



Webinars

We had a webinar with an engineer to teach us more about robotics in the real world. The first was with Ms. Amanda Nummy who taught us about biomimicry thinking. We invited the whole Plymouth Canton Community Schools middle and high school robotics community. There were a total of 12 participants.



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Operations Manual

We created an operational manual for future Infinity Tech members to help them recruit new members and grow robotics in the Plymouth-Canton community. It is a process with templates/videos and shows how to reach out to schools to share a video, host workshops, and start new teams. (see Appendix A)

Peer Awards

We give each team an award from our team, ranging from "Coolest Looking Grabber" or "Cleanest Looking Pit Area" to "Coolest Team Hats". It's one of our ways of showing Gracious Professionalism. We've brought one along to our presentation.

In our rookie year, we got dead last in all our competition and no awards, but one team gave out awards. We got "Coolest Rear Wheels" and it meant the world to us that someone recognized our work. We wanted to spread that recognition, hence the making of these awards.

Examples of awards we are giving out this year:

- Best team name
- Team name with the Greatest pun
- Cleanest pit area
- Coolest swag
- Coolest rear wheels
- Coolest front wheels
- Greatest robot name
- Coolest rear wheels
- Funniest team name
- Coolest beacon
- Best giveaway
- Longest name
- Best shirts
- Coolest Intake Mechanisms
- Coolest looking robot
- Most complex robot
- The biggest robot
- The smallest robot
- Most decorated pit area
- Best team spirit
- Best looking cart

Bipedal UofM Robotics Lab

We visited the University of Michigan's bipedal robotics lab along with the Gallimore Elementary Battlebots (a FLL team in Plymouth-Canton). Our tour guide was Mehgna Menon and she gave a tour around the lab. We talked to Professor Ram Vasudevan, he showed us some of the robots that his class programmed and answered questions that we had. Afterwards, Mehgna showed us many robots in action and how one of their robots delivered a package. Overall, it was a really good and educational experience.

PCCS School Cleanups

We have been going to schools in our district and cleaning up litter. So far we have been to Liberty Middle School,

Forgotten Harvest

7 of our members volunteered at Forgotten Harvest. We helped pack food into boxes and our shift packed a total of 7,648 pounds of food!

Part C

Our Robot’s Journey

In this section you will find

- Game Strategy
- Mechanisms
- Programming

Pre-Season

During the off season the build/business teams made LEGO-like building instructions for the wrist-hand grabber and the pincher claw. We used these instructions during workshops and trained new Infinity Tech members. These instructions were shared with FTC teams across the world.

Additionally, we have been building a catalog of mechanisms(Figure C) to both train and have ready depending on what our game strategy is for this year. We have built a GoBilda chassis with odometry wheels, wrist arm grabber, pincher claw, vertical intake, and 4-bar arm mechanisms.

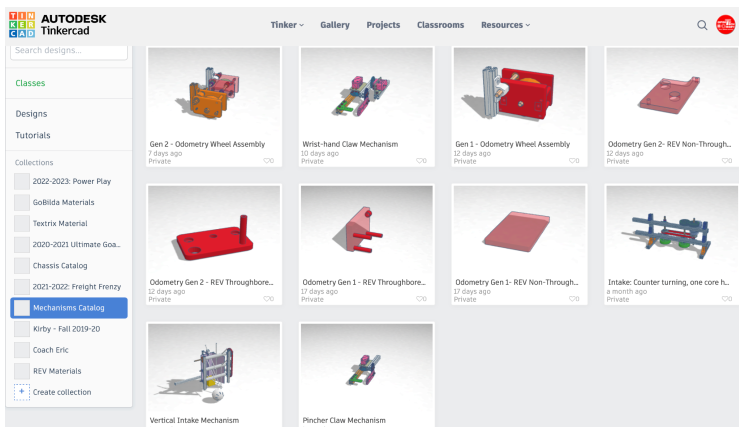
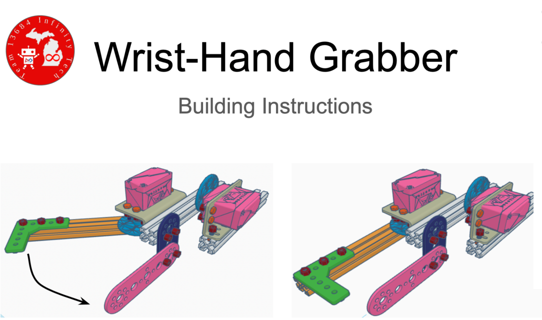
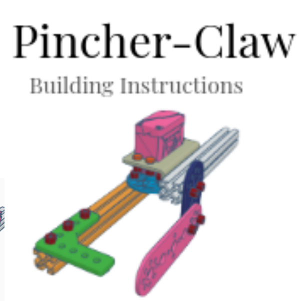


Figure C. Our mechanism catalog from over the years

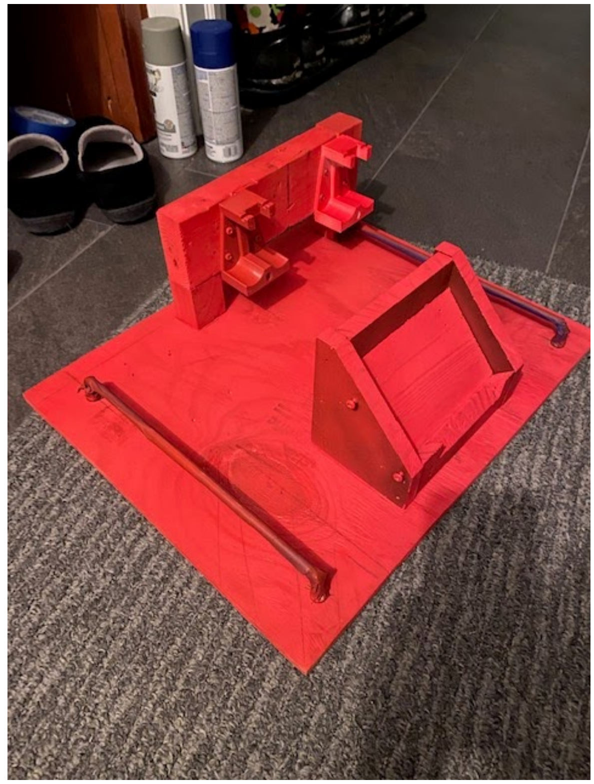




Driver Station Tray

We designed a practical and soon to be team theme-related driver pad(Figure D) for easier movement between the pits to the driver stand during competitions. It will go with our space/rocket related theme by showing team spirit and out of the box thinking. It keeps the controllers, the driver hub, and the beacon from getting damaged when we are moving the equipment.

Figure D- Driver station tray



Game Strategy

The first meeting after the game came out, our team worked on game strategy and came out with the table below. Prioritizing the most important things to the least important.

Overall, we wanted to focus on speed for our robot. Not only did we want to work on our game strategy but the foundation was to make everything to require less movements and make everything out of lighter and thinner materials.

How We Learned the Best Strategy

To help us understand the best strategy for Power Play, we made a mini-game field (Figure E) to help us practice gameplay strategy. The game is 20 seconds long and played between two people. The game pieces are washers and the junctions are screws. We score the amount of junctions owned and the circuits.

Scoring Achievement	Autonomous Points	Driver-Controlled Points	End Game Points		Priority
Navigating: Robot Parked in Terminal or Substation	2			We plan to p	
Signal: Robot Parked only on the Signal Zone that corresponds to the Signal image	10			Worth points our own sig worth more.	
Signal: Robot Parked only on the two Tiles that corresponds to the team supplied Signal Sleeve image	20			A lot of poin the top prior teams.	
Placement: Cone placed in a Terminal	1	1	1	Circuits	
Cone Secured on Ground Junction	2	2	2	Circuits	
Cone Secured on Low Junction	3	3	3	Main scorin	
Cone Secured on Medium Junction	4	4	4	Second highest points for junctions and may be easier to place cones on because it moves less.	8
Cone Secured on High Junction	5	5	5	The high jun and is a part	
Ownership: Junction Owned by Cone			3	We want to c we are becau each junctio or keep them	
Ownership: Junction Owned by Beacon			10	Capping with own a juncti are trying to	
Circuit: Completed Circuit			20	We want to b prevent the c the circuit b points.	
Navigating: Robot Parked In Terminal			2	We can scor instead of p so we plan t seconds left to place another cone.	5

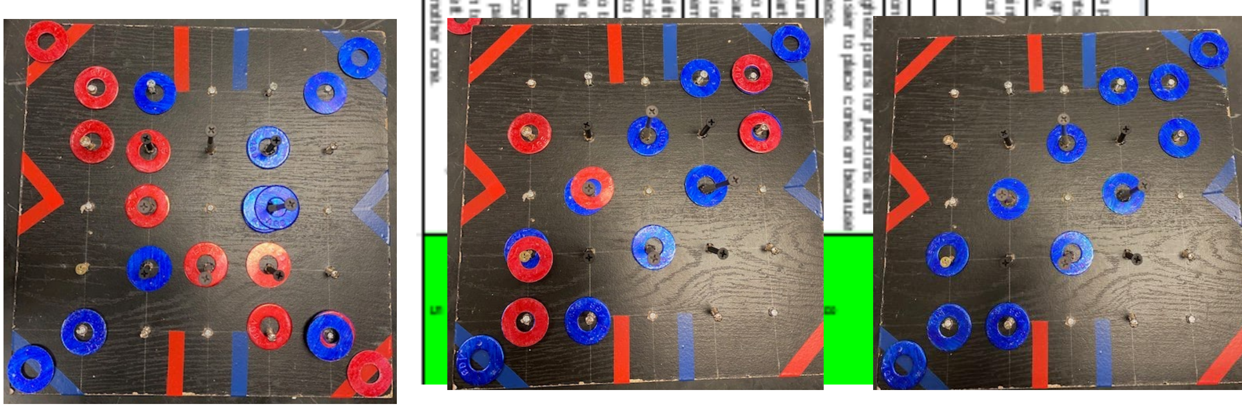


Figure E. Mini game field to help us practice our strategy

Figure F. Shows a way to block alliances when creating a circuit

The mini-game helped us develop our game strategy and the best way to score points. This game taught us the following:

- Our minimum cones are placed to make a circuit with 13 cones and it is very hard for the opposing alliance to stop it. (Figure F)

- Owning junctions is a major key to winning.
- Try to own the 6 junctions closest to your alliance's substation storage because it will be hard for the opposing alliance to reach quickly.
    - Ground junctions should be a priority because they are quick to own, many next to each other, and it takes time for the opposing alliance to overtake.
- Make sure to cap your team's beacon because it can make a big difference in points.
- Try to cap your alliance's beacon on the high junction to optimize points.
- Play defense and try to stop the opposing team's circuit on the high junction to optimize points

Building

Mechanisms

Chassis

By: the whole team
Quick facts and stats:

- **Motor count:** 4
- **Servo count:** 0
- **Sensor count:** 4

Hardest aspect of this specific part: Balancing how small the chassis had to be to drive between the junctions and strafing. If the chassis were too big, it'd be harder to drive but too small it would be more unstable and could be more difficult to package everything and not tip over.

Why did we choose this design?

- We wanted a smaller chassis (diagonal 16 inches) to make it easier to drive between junctions when cones were placed.
- We picked a goBilda chassis over the rev chassis we used last year because it is faster.

How does it work?
We have a goBilda strafing chassis this year. We made the chassis smaller to be able to fit between junctions easier and tried to keep it big enough to package the cone manipulator.

Issues we encountered	How we fixed them
The motors were taking up too much room going horizontal.	We made the motors go vertical like pillars.

When we put the mechanism on the smaller chassis which raised the center of gravity and pushed it to whatever side the 4 stage slide is on. This could cause the robot to tip over.	-A combination of powering down the motors so the robot will stop slower and add a weight at the bottom of the robot to keep the center of gravity lower. -The cone positioner mechanism might be able to help avoid tipping over -Move the four-stage slider as close as possible to the center of the turret
Cones can get stuck in the chassis possibly causing damage to sensor	Made slide so the cone would fall out

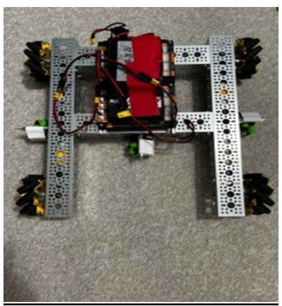


Figure G: Test chassis to learn how odometry pods work and work parallel with mechanical build team

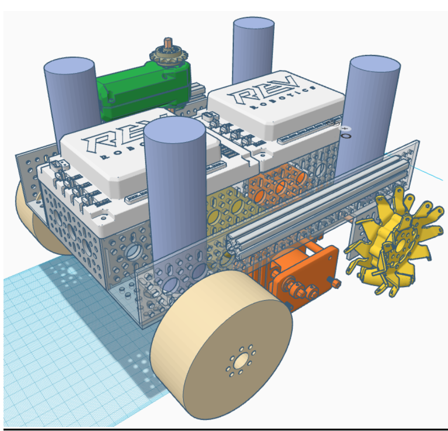


Figure H: Smaller 16” diagonal chassis with vertically mounted motors

<u>Turret(removed)</u>

By: Adithya, Edison, Coach Eric, Coach Ed

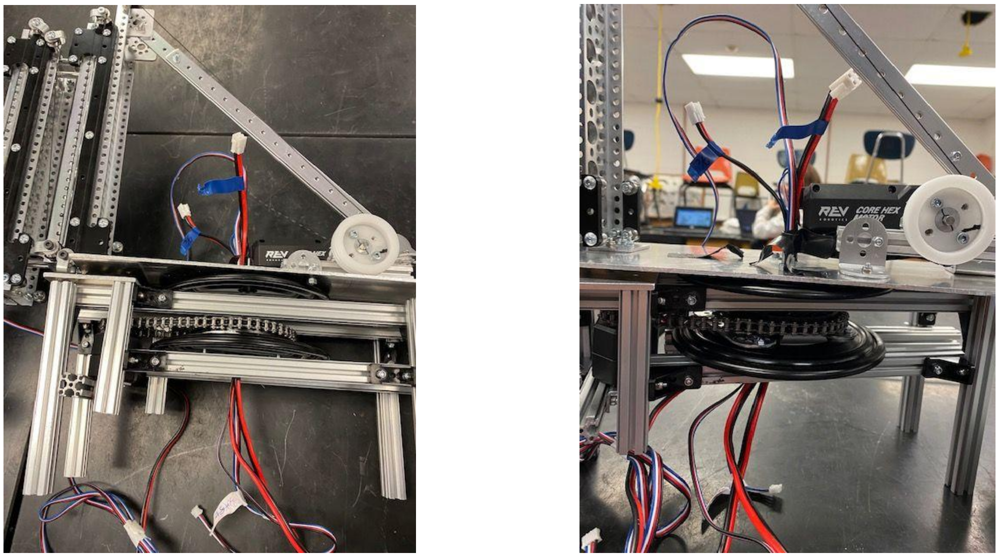
Quick facts and stats:

- **Motor count:** 1
- **Servo count:** 0
- **Sensor count:** 1
- **Hardest aspect of this specific part:** Finding the center of the lazy susan relative to the sprocket with not a lot of room for the wires to go through the center of both.

Why did(n't) we choose to add(keep) this to the robot? We want to be able to rotate only the turret and not the entire robot to make it easier to place the cones on the high junctions. We think this is the fastest way to place the cones A couple weeks before our first competition we decide to remove the turret because it was shakey when we drove the robot and wasn't helping us on the field like we wanted it to.

How does it work? A gear is sandwiched between two sprockets that spins a ball bearing lazy susan so the top part can spin without the bottom part moving. We use PID to control the position of the lazy susan for four D-pad positions on the operator's game pad. Additionally, we allow for finer adjustment.

Issues we encountered	How we fixed them
Lining up the center of rotation of the lazy susan to the sprockets was very difficult to know where to mount.	Had to place paper on the lazy susan to best line up the rotating centers and needed many hands to help.
Wires would get caught when rotating	Put a hole in the middle of rotation so the wire wouldn't get tangled
Wires would get pulled out when spinning in only one direction	Program to only go to 360 degrees and back to zero only.
Standoffs would get loose after operating for a day of operating	Added locktite to lessen the screws from loosening
The sprocket "sandwich" was thicker than anticipated	Cut the top of the slider off to meet 18" maximum limit
Due to the inability to center the lazy susan, it was too shaky and hard on control	Removed the mechanism from the robot



Figures I & J. Turret in a lazy susan-sprocket-lazy susan “sandwich” to spin the top independent from the chassis driving

Odomentry Wheels

By: Karthik, Kabir, Neha, Coach Eric, Coach Ed
Quick facts and stats:

- **Motor count:** 0
- **Servo count:** 0
- **Sensor count:** 3

Hardest aspect of this specific part: The hardest part of this mechanism was the space we had available and where we could mount the odometry. The first two designs would make the robot drive funny. Our third generation odometry pods lowered the pivot

Why did we choose to add this to the robot?
If the robot gets stuck or caught on something– where the robot's motor encoders would spin but may not actually move– we wanted to understand the distance actually traveled.

How does it work?
The odometry sensor is connected to a dual-wheel through the axle that is sandwiched between two 3D printed plates and independent from the robot's motor encoders. The odometry pods are mounted on three sides of the chassis– two on the sides and one in the front– to move around autonomously and keep track of its path.

Issues we encountered	How we fixed them
The odometry wheel was flipping around when the chassis is moved left so the wheel wouldn't work.	We added a screw to keep the wheel from flipping. We also made the post to mount the odometry wheels sub-assembly strong so that the wheels would buckle and flip.
We had to change the axle of the odometry wheel through-bore sensor and the dual wheel axis so that they fit better. [Figure J]	We temporarily fixed the problem by wrapping tape to fill up the gaps between the axle and the wheel. Our next solution is to print new side plates for the odometry sub-assembly to prevent the wheel from flipping and how we are going to mount it on the robot.
The side plate for the odometry wheel was 11.5mm instead of 12 mm. The bearing won't fit inside of the hole.	We used a caliper to measure the hole and changed the size of the hole to print it correctly.
The odometry wheels were too bulky.	We 3-d printed a new casing that was smaller and lighter.

Our second design had too high of a pivot, and it was going over center, making the whole robot go up. (Figure K)	We have a third design that is kind of like a sandwich and the pivot is lower, keeping the robot driving better.
The second design was not inline with the structure and was slanted.	We centered the odometry pod with the center of the structure.

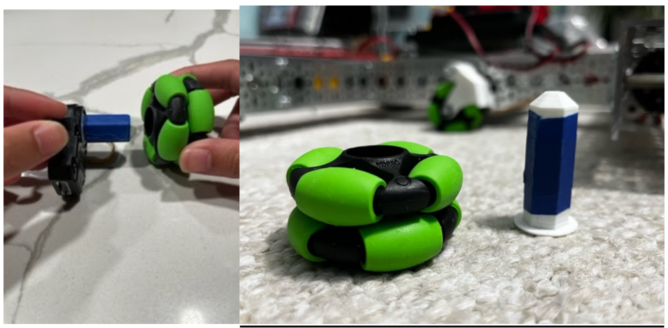


Figure K: Fixing the gap between the axle & dual-wheels on gen. one odometry pod

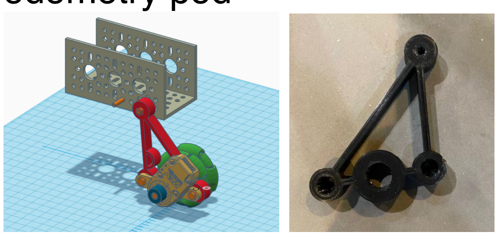


Figure L: - Second generation odometry CAD design

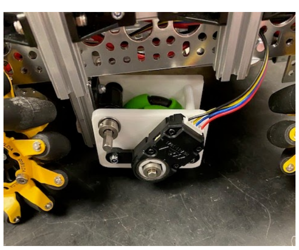


Figure M: Third generation odometry pods, centered, and lowered pivot

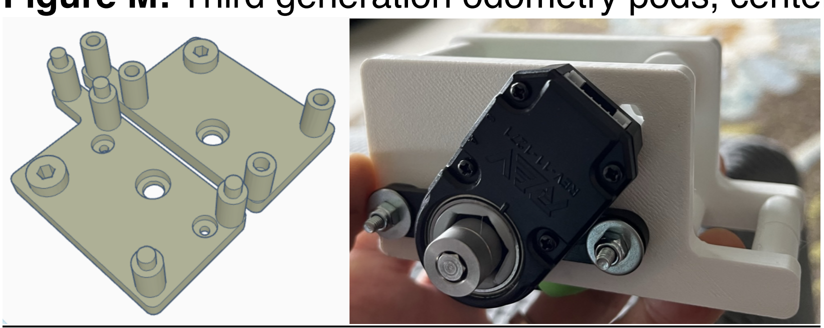


Figure N: Fourth generation pods with thicker connectors to make more robust

Pick-Up Grabber

By: Vishal, Karthik, Adithya
Quick facts and stats:

- **Motor count:** 0
- **Servo count:** 2 (maybe 1?)
- **Sensor count:** 1

Hardest aspect of this specific part: We did not know if a two-prong grabber would have enough force to hold onto the cones while driving around.

Why do we choose to add this to the robot?
It could be slow to pick up cones but we will test to find and measure how many cones it can place.

How does it work?
It has two or more prongs on a servo(s) to make the prong(s) close and open.

What did we change for States?
We changed our grabber from a 2 servo grabber to a fin ray grabber. This can grabs objects easier because it has a compliant structure made from TPU (Thermoplastic polyurithane) filament and 3D printed through several iterations.

Issues we encountered	How we fixed them
2 prong with 1 servo requires too much driving accuracy.	We added another servo so they can open both to make a wider angle and to position/push cones on junctions.
Two-prong was too heavy using the aluminum extrusions.	Used lighter aluminum and thinner materials
The mechanism has to be low enough to pick up the cone and go high enough with the chain-bar to place on the low junction in one move, but it makes it hard to drive because you can hit ground junctions more easily.	Adjusted the chain-bar angle up slightly so that the grabber would be level to the ground when it’s holding its own weight.
Grabber mechanism is made of aluminum and the cone slipped out sometimes	Put foam on the grabber arms to grip the cone better
Has two servos and may be heavier than using two gears	Build a mech with one servo and add two gears and compare the weight

Operator has many tasks and buttons to push	Use a distance sensor to notify the operator, via LED, or automatically close the grabber when it's close to the cones
The foam on the grabber wasn't always fitting the shape of the cones when we grabbed them at the top of the cone.	We changed to a fin-ray compliant grabber which is a TPU filament 3-d printed claw. It can hard grab or soft grab an object and grips it better. It causes more friction between the cone and grabber.

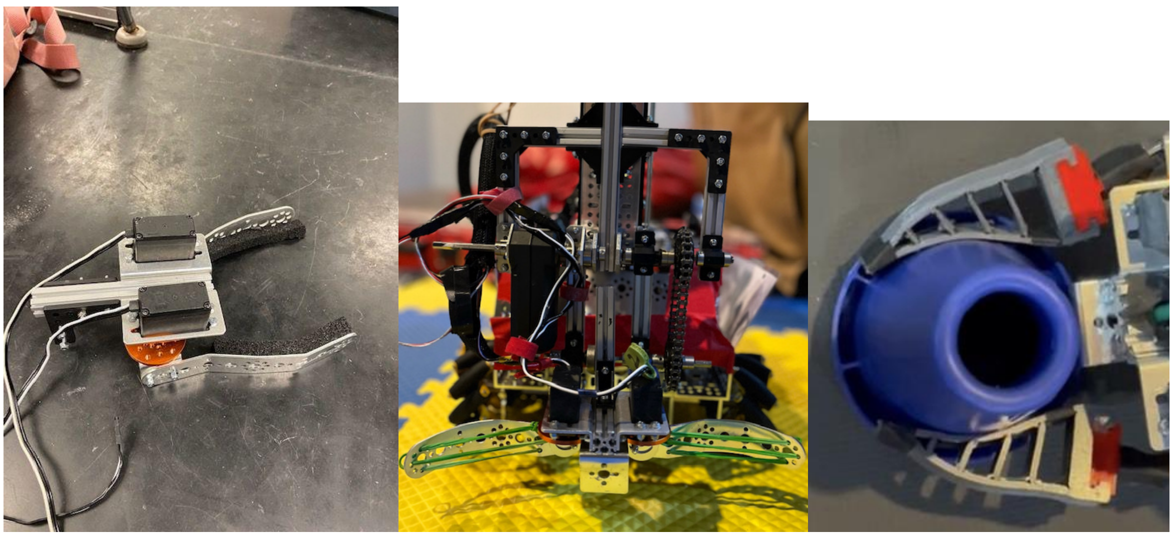


Figure O: Two servo grabbers iterations using foam, rubberbands, and fin-ray

4-Stage Slide

By: Annabelle, Edison, Adithya, Coach Ed, Coach Kanthan, Coach Eric, Vishal
Quick facts and stats:

- **Motor count:** 1
- **Servo count:** 0
- **Sensor count:** 1

Hardest aspect of this specific part: Balancing the location of the 4-stage slide and motor so that the robot could be more balanced.

Why did we choose to add this to the robot?
It is a fast vertical mechanism and high enough to go to the high junction so we can place the most cones during a match.

How does it work?
The slide has 4 stages that go up and down using a pulley. The stage can reach about 36 inches when it is not mounted on the chassis

What did we change for states?
We changed from a go-builda slide to a misumi slide because it is faster and smoother along with more stability while up high.

Issues we encountered	How we fixed them
By moving the motor away from the slider, we were unable to pull down the slider.	We have to live without the pulling down mechanism.
The position we need to put the 4-stage slider on the turret to allow us to move the cone around the robot without having to move the chain-bar up– to be faster–we have a chance to tip over if we brake too fast.	-Tuning the software to brake softer and put a steel plate low on the chassis to lower the center of gravity -Move the slide closer to the center of the turret to reduce the risk of tipping over
The goBilda 4-stage cascading slider was not as strong and balanced as we'd like, bent to the side due to rigging, and was wobbly when in the high junction position.	We removed the goBilda 4-stage and replaced it with six misumi sliders because they are smooth, light, strong, and, with two towers, much easier to maneuver the robot when extended.

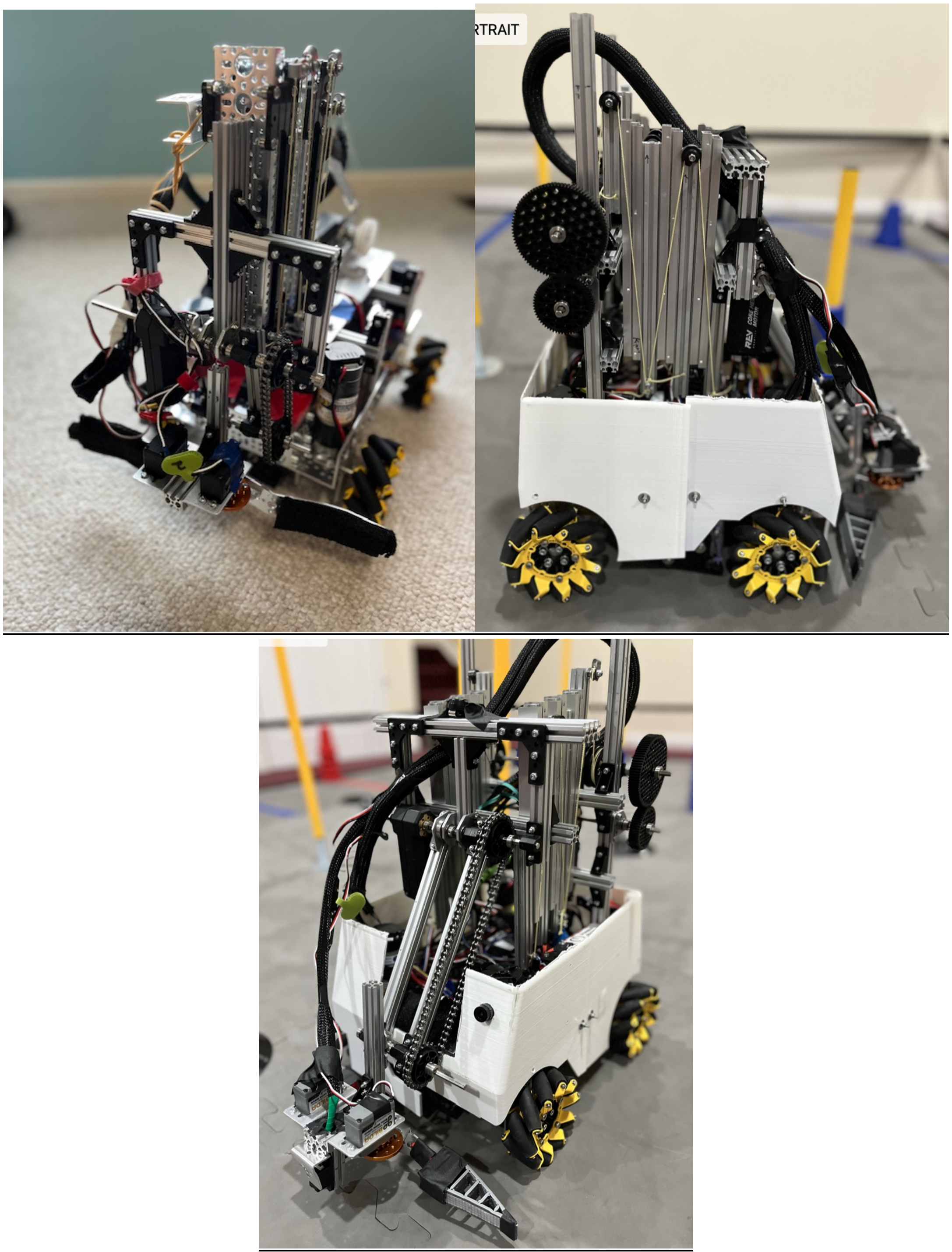


Figure P: Upgraded our Lake Orion qualifier 4-stage slide with two sets of Misumi slides to improve stability, strength, speed, and balance.

Rubberband Cone Pick-Up(removed)

By Karthik, Coach Kanthan, Vishal, Kabir, Neha
Quick facts and stats:

- **Motor count:** 0
- **Servo count:** 1
- **Sensor count:** 1

Hardest aspect of this specific part: Getting the distance between the spinning shafts and gears available, with the correct amount of gears to spin the shafts to pick up the cone and beacon, while keeping the packaging with the 18” cubed volume and light.

Why did we choose to add this to the robot?
The rubberband mechanism holds on to the cones well and can pick up the cones fast

How does it work?
There are two counter spinning gears with rubber bands laced through the gears powered by a servo. The rubber band picks the cone up when the slide goes up and goes down on the cone to pick it up.

Issues we encountered	How we fixed them
After we prototyped this mechanism, we realized that the forward facing shafts didn’t have much room to be misaligned when we were driving.	We made the rubber band pick up mechanism so that the axles were facing left and right so it would allow the driver to have a little more tolerance when driving the robot.
Rubber bands were not going through the gears easily without ripping or ruining them.	We figured out that there is a specific way you should cut the rubberband to make sure the rubber bands fit through the little gear holes.
During prototyping, the mechanism was too large to fit on the robot. The cone would not stay between the two gears when we picked the cones off the ground.	We made a more compacted version of the mechanism so the cones would stay in the mechanism when it moved.
The gears would shift a lot because we couldn’t get the exact size for cones to fit.	Trial and error and using a ruler to measure the size we needed.
Many parts and potentially heavier than a grabber making it more difficult to drive	Continue to lightweight it and compare to the grabber during driving dynamics and placing amount of cones

There seemed to be extra moves required to get the cone compared to the two servo grabber	We have kept the two servo grabber but do have a rubber band pick-up mechanism, as a backup plan.

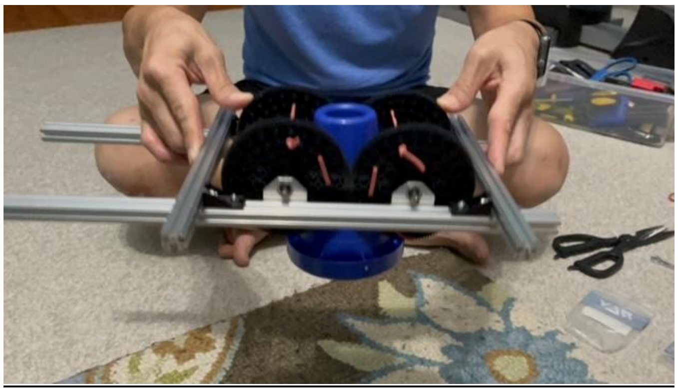


Figure Q: First prototype of rubber band grabber to see if it would be faster.

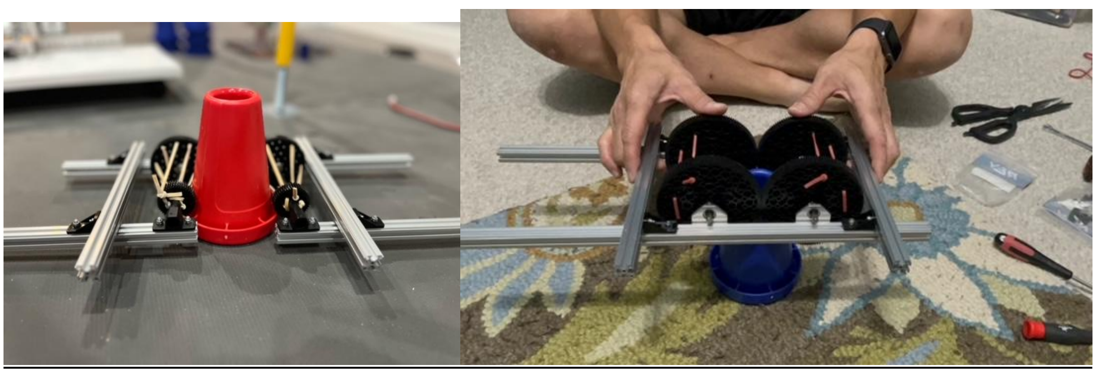


Figure O: Prototype of cone-like rubber band grabber to see if it would be faster. It didn't pick up the cones well.

Cone & Junction Positioning Mechanism(removed)

By Dahlia, Vishal, Karthik, Edison
Quick facts and stats:

- **Motor count:** 0
- **Servo count:** 0
- **Sensor count:** 0

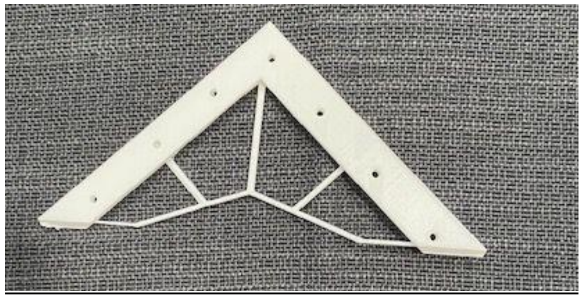
Hardest aspect of this specific part: Finding places to mount the positioning mechanism on a smaller chassis and trying to position ourselves from the junction with and without cones.

Why did we choose to add this to the robot?
We wanted to make it easier to position cones over the junctions and make an accurate placement. This would save us time trying to make the cone line up with the junction.

How does it work?
This mechanism can push cones to the ground junctions or terminal quickly without having the move the grabber or 4-stage slider. It will save us time instead of picking up a cone lifting it slightly and dropping it again. Also, if there are cones on the junction than we would line up the mechanism to the cone and drop our cone on top without hopefully missing the junction and dropping the cone wasting time to pick it back up.

Issues we encountered	How we fixed them
We needed something on the sides of the cones for the mechanism so we could position the cones on the ground junctions correctly.	We put cardboard on the side for one pusher and metal on the other one.
We wanted to create a positioner that would work with a junction when it did and did not have a cone	The solution was to slide underneath the cone to position off the junction, making it difficult for placing the cone onto the ground junctions. We are putting this solution in the backlog if we have more time as this is not a high priority.
This could be helpful or get in the way when using a grabber mechanism	We have to test while driving to see if it is helpful or not
Packaging the positioner on all four sides can be difficult due to the smaller chassis	We may need to 3-D print some positioners so that we can easily mount them on the robot

Difficult to drive and push the cones onto the ground junctions with a positioner that didn't actuate	Deciding to use the main two-servo grabber to place the cones on the ground junctions



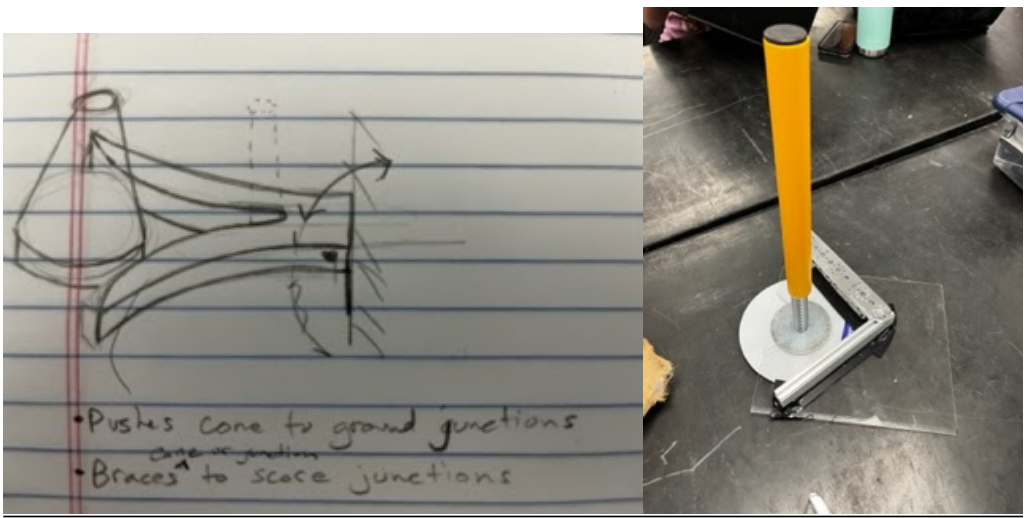


Figure R: Various positioners we prototypes to see what worked and didn't

Chain-Bar Linkage

By: Karthik, Coach Kanthan, Neha, Coach Ed
Quick facts and stats:

- **Motor count:** 1
- **Servo count:** 0
- **Sensor count:** 1

Hardest aspect of this specific part: We needed the robot to be nearly completely assembled before setting the chain length. Also, the chain-bar was new to us so learning how to put it together took a little bit of time.

Why did we choose to add this to the robot?
The chain-bar linkage keeps the cone picker-upper mechanism parallel to the ground at all times, like a four bar but more compact and with more rotation range. It is also possible to use the chain-bar even if the 4-stage slider is not working so we could still own the ground and low junctions.

How does it work?
There are two sprockets, 3 bars, and a chain. The two sprockets are fixed–one on the slider and one on the end that holds the cone manipulator. The center bar has a bearing so the hex shaft can spin freely. Lastly, you set the angle you want for the cone manipulator and place the chain on both sprockets and put it under tension to lock in the angle. Now, move the motor and the arm will rotate up and down while keeping the cone manipulator in the same position.

What did we change for States?
We extended the extrusions to make the chain bar linkage longer so it will reach the high junction because when we changed to the misumi slide, it didn’t reach the high junction without an extended chain-bar linkage.

Issues we encountered	How we fixed them
The chain-bar mounting bracket was made of plastic and could “strip” with the amount of torque on the reaction point that’s mounted on the 4-stage slider	Changed to metal brackets to increase the torque where the arm mounts to the 4-stage slider
Chain-bar hit the slider brackets when going up	Chain-bar had to be mounted with standoffs from the 4-stage because it interfered with the slider

Wanted to increase speed by being able to reach the low junction by actuating the chain-bar and not needing the 4-stage slider to move	Tuned the chain-bar mounting location on the 4-stage slider to be able to pick up the cone and deliver to the low junction without moving the slider
The chain is heavy and increases the risk of tipping over.	Investigating using a belt instead of the chain to lessen the weight
When we changed over to the Misumi slides, the chain bar linkage didn't reach the high junction.	We extended the extrusions to make the chain bar linkage longer so it will reach the high junction.

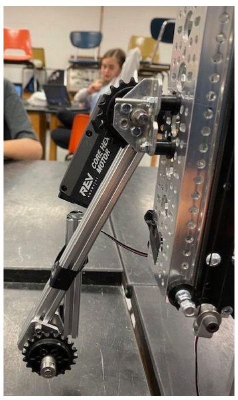


Figure S: Chain-bar mounted on the slide

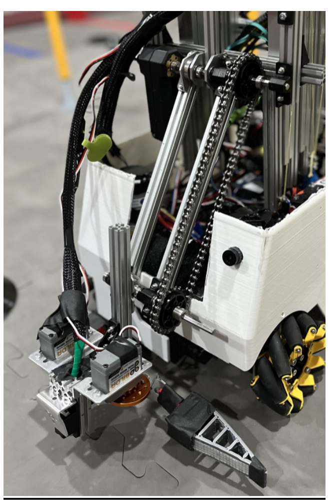


Figure T: Chain-bar extended after upgrading the elevator mechanism

Battery holder

By: Arnav, Vishal, Adithya
Quick facts and stats:

- **Motor count:** 0
- **Servo count:** 0
- **Sensor count:** 0

Hardest aspect of this specific part: To be able to remove and place the battery in the compartment so that we can quickly change batteries and not worry about losing power during a match

Why did we choose to add this to the robot?
Every robot needs energy and we wanted to place it as low as possible to try to keep the center of gravity down

How does it work?
The battery is placed in and the door is shut so it will not move during competition

Issues we encountered	How we fixed them
The screws would scrape the battery when taking it in and out	Placed tape on the screw caps

Back-up Plans

We had built-in back up designs & multiple teams building mechanisms to have backup plans if we were unsatisfied with a mechanism or there was a failure during a match. Please see the below table for our back up plans.

Mechanism	Purpose
Rubberband Intake Mechanisms	Pick up cones from the top
Chain-bar interface	Designed to accept many types of cone manipulators to be able to change mechs quickly
Motor Encoders	In case the odometry pods are not functioning
Encoder Pod (Odometry Wheel Pods)	Pre-built odometry pods in case there are issues w/ the mounted pods
Positioning Junction & Cone Mechanism	Work in tandem with the rubberband intake to position the cone in the correct place
3 degrees of freedom (DOF) gripper (Gripper w/ 2 servos)	Building to address the use-case where the cone is on its side & place
4-bar (Chain bar back-up)	In case the chain-bar did not work out
Copy of each one-off Critical Part	In case something goes wrong during competition
Chain-bar actuation to low junction	If the 4-stage slider loses function during a match, the chain-bar can still place cones on ground & low junctions

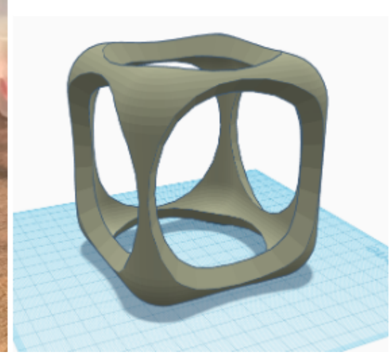
Grabber with one servo & two gears	Decrease the weight of the grabber to move better

Beacon

This year we created a beacon that would be easy to place no matter what side we pick it up from. It is a cube with large squares holes in the middle that taper in allowing more positions possible to score. It will be picked up from the grabber mechanism and placed on the junctions.

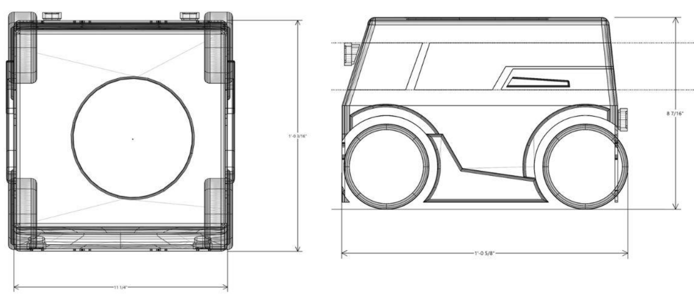
What did we change for states?

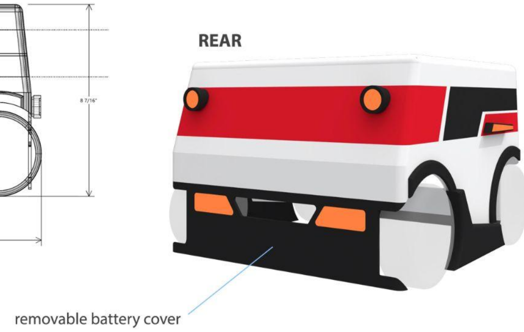
We changed our original beacon (The red beacon below) to prevent several flaws in our beacon during our qualifier. Our original beacon was sharp in some areas and had several weak, breakable points. For our state beacon, we hollowed out the original CAD design so the flaws were removed. Now, the beacon no longer has has sharp areas or hazards, no weak breaking points, and the holes are larger to allow less precision to score.



Robot Body Panels

This year, with help of a professional industrial designer and mechanical engineer, we designed and 3D printed 4 separate panels that serve several purposes. These panels are an effective outer casing to our robot to protect our mechanisms, electrical, sensors, odometry, and more from possible damage from objects on the field. As well as serving as a protective casing, our panels are based on an electric car and designed to perfectly fit our robot's body and is convenient for servicing the robot to access our structure, batteries, and our control hub.





Driving

We worked to improve our drive team in many ways throughout the season. One way we improved the drive team was to have drive trials so we could find the best possible drive team.

We created a rubric (figure H) that the whole team could see to make the drive trial process as transparent and fair as we could. The rubric adds points for their game strategy practice on the mini-game field, focus during the season, gracious professionalism, etc. Each student signed a contract to help them learn about making a promise and sticking with their word. This helps prevent conflict during the drive team selection.

To help communications during a match, we made a system to help our drive team know which junction to drive to. Each junction is labeled something like "A1" & "C3" as shown in the chart below (figure V) in a grid system. Terminals are labeled in clockwise order starting in the top left corner. During a match, the driver coach uses this system so the driver knows where to go during a match quickly. We also describe the junction type and point so the driver and the entire drive team definitely know where we should go.

Lastly, we created a model of the field (figure U), made from a wooden board, screws, and washers. This helped us practice our game strategy. It also helped us communicate with our alliance on what each team wanted to do. It was easier to show where each of us would place cones and park with a 3-d model.

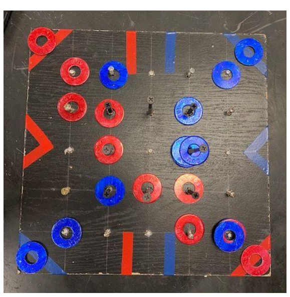


Figure U- Mini Strategy Game game field

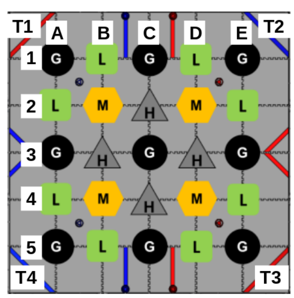


Figure V- Junctions names on the

Programming

Pre-season

As a part of summer training, the programming team error-proofed our robot from last year. For example if, buttons were pressed in the wrong order going down, then our arm could be broken. We fixed it, so that you can no long press the buttons going down in the wrong order can placed limits on how far things can go. We’re making it easier to drive for younger students at demos. We also programmed our goBilda chassis and odomentry wheels to be prepared for the competitions.

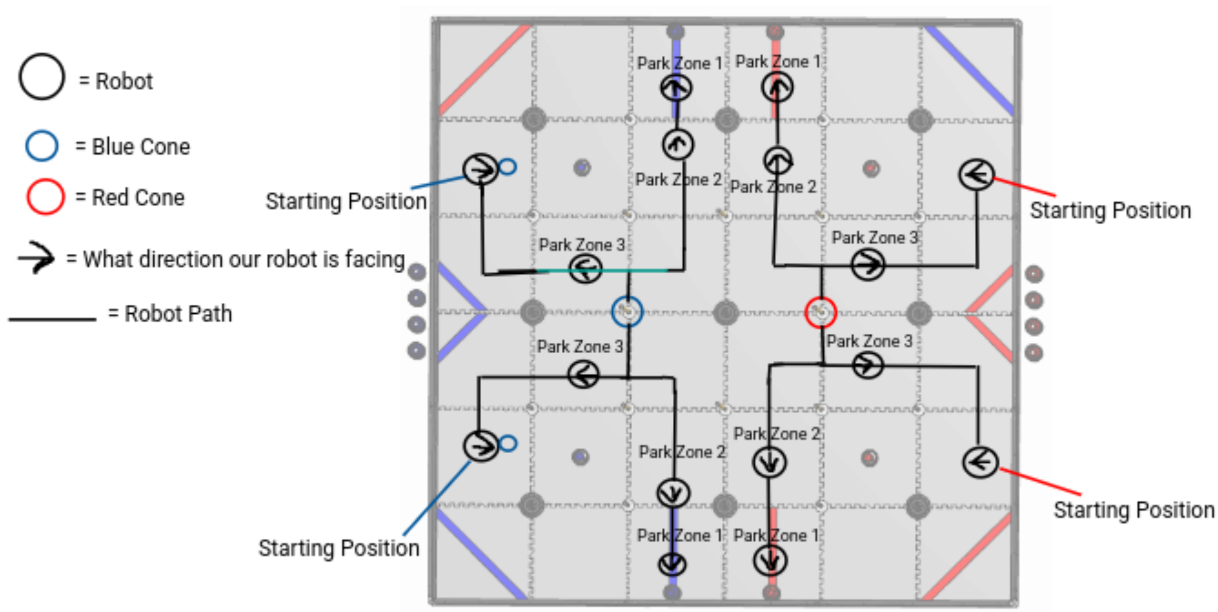
Overcoming Obstacles

Our lead programming mentor quit two days before the state championship due to a student-led decision he did not agree with. Our lead programming student had to step up and took the lead in finishing the code. Our other mentors quickly reached out to programming mentors and students from the high school team for support and we're hoping to minimize the impact to our team. We learned that we need to keep finding ways to move forward when life puts obstacles in our way.

Autonomous

We're using odometry to track the position of the robot on the field and have the motor encoders connected too in case there is an issue with the odometry pods. Our strategy is as follows:

- Option 1: Read customized signal sleeve, place cone on high-junction, and park in the correct signal zone
- Option 2: Read customized signal sleeve, place cone on high-junction, pick up cone from the stack, and place cones on as many ground or high-junctions as possible to own more junctions.
- Generally we'll:
    - Make a possible-paths playbook and mini-game board to work with alliances more effectively
    - Insert time intervals between paths in case of overlapping paths with the alliance partner and can add changes quickly



Error-proofing the code

Turret:

- We programmed the turret so that it can only turn 360 degrees and not twist the wires and break them.
- We're using the D pad and P ID to get the robot to the correct position
- The chain bar mechanism will be programmed so it will not hit the wheels when rotating with a turret

Chassis

- Smooth out the power so the robot doesn't accelerate or decelerate too drastically, especially when changing directions abruptly
- Odometry pods have back-up motor encoders in case odometry fails

4-stage slider

- Set limits for the top and bottom of travel to keep tension on the string so it doesn't jump off the pulley and/or v-bearings
- Provide finer manual controls with limits for min and max travel

Chain-bar linkage

- Set limits for the top and bottom of travel to make it easy for operators
- Provide finer manual controls with limits for min and max travel

We are automating the grabbing using a distance sensor. We used proportional integral and derivative (PID)65 hold the arm and chain bar at a certain position and keep it there. We also used PID to turn the turret. We are setting positions for the 4-stage slider so it doesn't go above the maximum height and break the string that moves it. It also allows us to have a button that we use to go to each junction separately.

Indicator-LED Lights(In progress)

The light indicator will blink red when endgame is near. This will help us get to the beacon and substation on time.

Motor Encoders(removed)

As a back-up for the odometry, we have motor encoders that count the amount of turns the motor is making to count distance.

Distance Sensor

We add a color and distance sensor to the robot so during autonomous period we can find the stacks and grab more cones during autonomous. During tele-op, we programmed the grabber so that when the cone is a certian distance away, the grabber will automaticly grab a cone. This helps prevent human error when grabbing cones and our drivers wouldn't grab the cones in the wrong place and drop them.

Gamepad Configuration

We spilt the gamepads into a driver(Figure X) and an operator(Figure W). The driver mainly moves the robot around the game field. The operator mainly moves the mechanism that manipulates game pieces. We have a distance sensor so that the fin ray grabber will automatically grab a cone. This saves a step for the operator and a few seconds per cone. The driver also has the option to manually control the slide and can adjust the chain linkage bar. The driver and operator have the option to manually override the distance sensor, when picking a cone up from the stack or when dropping it on a ground junction.

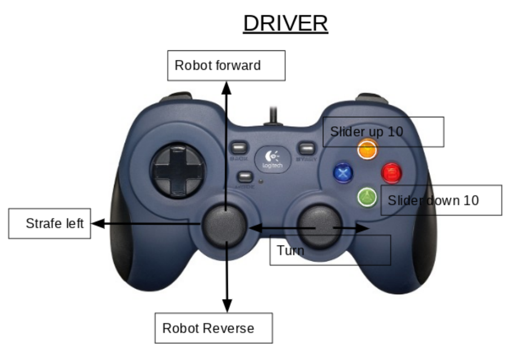


Figure W- Operator's Controls

Figure X- Driver's Controls