FIRST TECH CHALLENGE

POWER PLAY

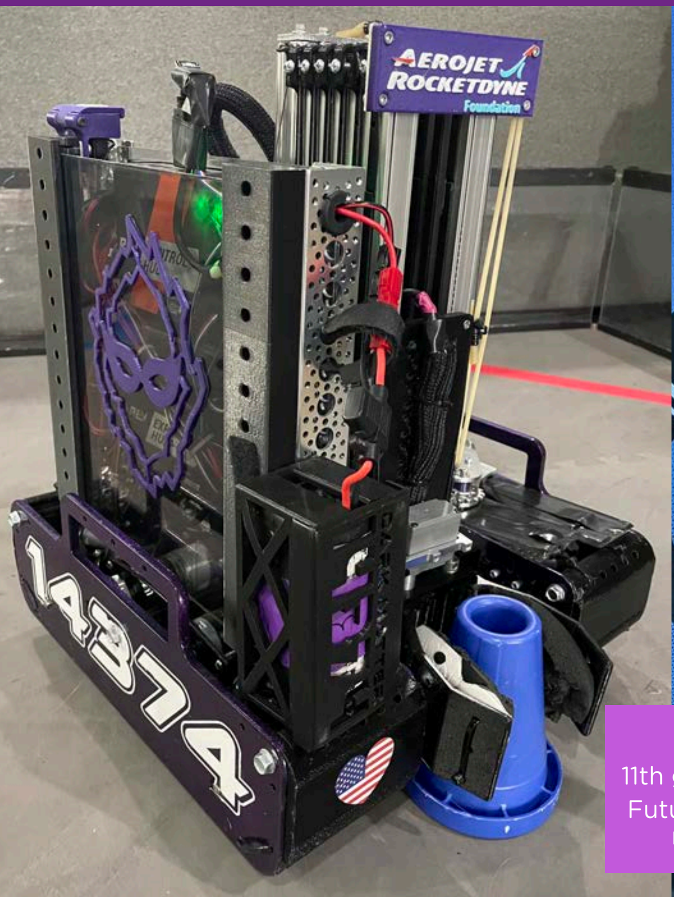
PRESENTED BY Raytheon Technologies

DARK MATTER ROBOTICS

#14374

ENGINEERING PORTFOLIO

2022-2023 Power Play



GABY
11th grade • 5th season
Future: wants to build rocket engines

PARKER
10th grade • 3rd season
Future: wants to be and airforce mechanic

RILEY
10th grade • 4th season
Future: wants to study computer science

TEAM PLAN

Team Summary: We are a student-led community-based FTC team of highschoolers located in Southeast Louisiana. 14374 is a continuation of Dark Matter 10337 of Mandeville Jr. High which turned into a community team for the 2018-19 season. We are in our 5th season as a community team. Currently 3 girls, all homeschooled. Although a small team due to our rural location, we are excited to keep our team goingin order to impact our community and continue to grow our enginering skills.

GOAL	PLAN	OUTCOME
Team Mission/Vision Build a passionate team excited about STEM, Robotics and FIRST community involvement: Learn, Grow, Impact, Connect.	Adhere to the values of FIRST by showing Gracious Professionalism and Coopertition in all we do. Stay engaged in outreach while building a unique, efficient robot.	• As a team we have learned alot of new things this year and accomplished our goals. • Desire to grow our knowledge and .
Marketing/Communication • Spread the word about FIRST, increase our brand awareness, and engage with followers. • Keep public & supporters informed.	• **Logo & Colors** • **Team Shirts & Hats** • **Banners** • **Brochures** • **Business Cards** • **Robot Licenses** • **Newsletters** • **Website** • **Social Media**	• Reached over 100K on Instagram and grew followers. • Attended large events that reached a large number of people.
Connections SEE PG5 • Learn about STEM careers and promote FIRST involvement. • Introduce more people to FIRST and get them involved.	• Reach out to tech community and introduce them to FIRST, FTC and our team. • Give Presentations. • More recognition for FTC level.	• Helping to start FIRST programs • Our team made multiple connections this season including LSU College of Engineering, Aerojet Rocketdyne, Nasa Michoud.
Outreach SEE PG3-4 • Community involment all season. • Get kids excited about STEM! • Meaningful interactions & teach skills.	• Be proactive finding ways to get involved in local events promoting our team, STEM and FIRST. • Be active atleast 2x per month.	• 22 Outreach Events. • 5 Camps, 7 Presenations. • Great feedback on our camps. • Found lots of new opportunities.
Collaboration SEE PG4 Connect with teams to sharing experiences, ideas and learn from each other. Collaborate with teams on their projects. Share resources.	• Connect with teams through instagram. Message teams and ask questions or to meet via zoom. • Lend help to teams: Locally and virtually.	• Zoomed with 11 teams from all over the US and the World! • Helped teams, shared ideas, shared our EN, published resources. • Contributed a video to team Ink & Metal's documentary.
Funding SEE PG2 Pursue grants from large companies and supporters of FIRST. • Be resourceful	• Googled "FIRST Grants" to find grants from FIRST supporters and applied for ones elible for. • Seek out in-kind donations.	• Three new grants for a total of $2250 new income. (+1 re-grant $2195). • Powder coat donated. • Successful World's fundraising.
Host Scrimmage SEE PG4 A great way for teams to learn the game, rules and test ideas.	• Find venue, date, volunteers. • Commmunicate & Invite Teams. • Arrange details, create trophy.	Scrimmage was a success and we hope to collaborate and co-host again with LSU again next year.

Our robot centered goals are outlined in the engineering section of this portfolio – PAGES 6-15

Skill Development

Parker:
- Southeastern Summer Code Camp
- Code Academy Java lessons
- Onshape CAD tutorials

Riley:
- Southeastern Summer Code Camp
- Worked with mentor Matthew to improve java knowledge and learn to code our new mecanum.
- Utilized YouTube, gm0.org, FTClib.
- Taught team members about the FTClib interface.

Gaby:
- Southeastern Summer Code Camp
- CodeAcademy Java lessons
- Taught Parker how to build assemblies in OnShape.

BUSINESS PLAN

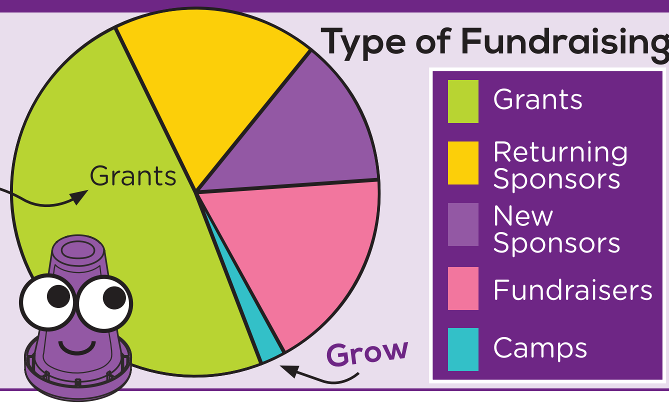
Our team understands the importance of teaching students about financial management and fundraising. Team members stay involved in the financial part of the team by: ✔ Making Mobile Deposits ✔ Balance Checkbook ✔ Order Parts ✔ Document Spending & Track Goals ✔ Approaching Sponsors ✔ Making Connections

GOAL	PLAN
• Raise funds & operate our team efficiently • Introduce new supporters to FIRST • We don't have to be rich... we can **BE RESOURCEFUL!** • Seek in-kind Donations & Connections that can benefit our team	• **Be passionate! Team members make calls and do the speaking. When they see our love to what we do, we can inspire support & involvement.** • Research grants & contact FIRST supporters • Distribute sponsor packets in our community

OUTCOME

We Reached Our Goal! Our goal was to seek more funding from grants because raising money from local businesses has been challenging the past two seasons. We started looking for and applying for grants in the off-season. Our main source of funding this year was from one re-grant and 3 new grants.

Setting Future Goals:
By evaluating our funding sources we see an opportunity to use our camps and workshops as fundraisers and a need to attract more local businesses to become sponsors during regular season.



Grants

We received the following grants:

$2195 Team Registration Re-Grants
Department of Defense DoDSTEM Science · Technology · Engineering · Mathematics
Naval Information Warfare Center ATLANTIC

$1000 AEROJET ROCKETDYNE Foundation

$750 BAE SYSTEMS

$500 Home HB Bank

In-Kind Donations

Our team approaches local businesses for services or discounts for sponsorship recognition.

PERFORMANCE Powders

- **DocuCenter** - printing discounts
- **WaterCut** - aluminum drivetrain plates discount
- **Rouses** - gift basket donation for a rafflet o raise funds for Houston travel.

Fundraising

- Barnes & Noble Book Fair $658
- Go Fund Me for Worlds $690
- Raffled a donated gift basket $280
- Raising a small amount through our camps & workshops
- Our goal is to turn our camps into a fundraising tool.

BARNES & NOBLE

Sponsorships

Dark Matter realizes the significant impact of gathering community support. We have revised our sponsor levels to offer multiple benefits for any donation over $100. This gives local small businesses an affordable opportunity to get recognition on our team shirts and website. We send every sponsor a handwritten thank you note. Our goal is to find a way to attract local businesses to support us in regular season(we tend to get more donations when we raise funds for Worlds.) *FULL LIST OF SPONSORS AT OUR PIT

Season Budget Spreadsheet

Expenses

	Planned	Actual	Diff.
Totals	$11,545	$8,215	+$3,476
Robot Parts & Tools	$3,500	$3,535	-$35
Registration Fees	$500	$495	+$5
Bank and Tax Fees	$10	$10	$0
Food/Gifts	$150	$143	+$7
Swag (buttons)	$100	$112	-$12
Game Set	$522	$522	+$
Website & Zoom	$100	$96	+$4
Office/Pit/Printing	$350	$338	+$12
T-shirt/Spirit	$251	$250	+$1
Travel Alexandria Qual	$112	$112	$0
Hotel / Worlds	$2,000	$0	+$2,000
Team Lunches / Worlds	$350	$0	+$350
Team Shirts /Worlds	$400	$0	+$400
Swag / Worlds	$700	$379	+$321
Pit /Worlds	$200	$79	+$121
Printing / Worlds	$300	$145	+$300
World's Registration	$2,000	$2,000	$0

Funding

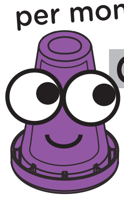
	Planned	Actual	Diff.
Totals	$9,946	$9,119	-$827
Grants	$2,500	$4,445	+$1,945
Returning Sponsors	$2,000	$1,650	-$350
New Sponsors	$4,000	$1,200	-$2,800
Fundraisers/Cash	$750	$938	+$188
Camp Profit	$196	$196	+$
GoFund Me	$500	$690	+$190

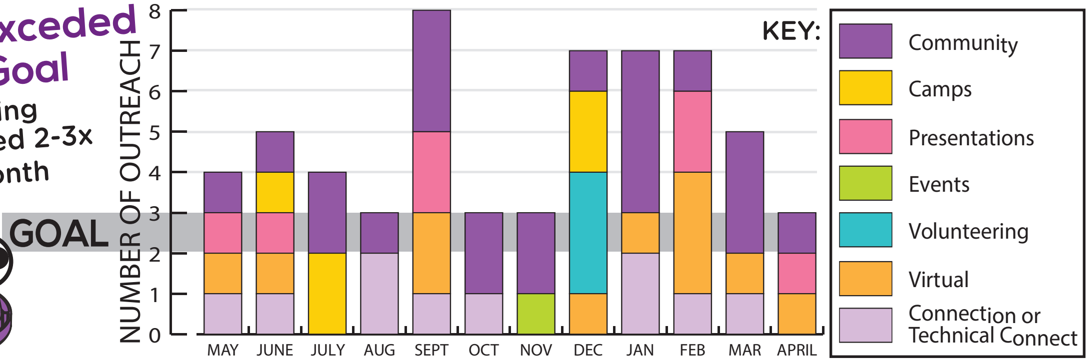
MOTIVATE & OUTREACH

Outreach is an important part of sharing our excitement about FIRST & STEM with others.

GOAL	PLAN
• Find a variety of ways to promote FIRST and our team. ie. Demos, Camps, Code, etc. • Build connections and take initiative to reach out to local event and get involved. • Spark an excitement for STEM in kids.	• Stay active in our community thru our entire season; 2-3 outreach or connections each month. • Create camps and activites that will engage kids, teach skills and spark an excitement for STEM in kids. • Track and quantify our accomplishments • Growing FIRST in our community. Start teams.

We Exceded Our Goal of staying engaged 2-3x per month



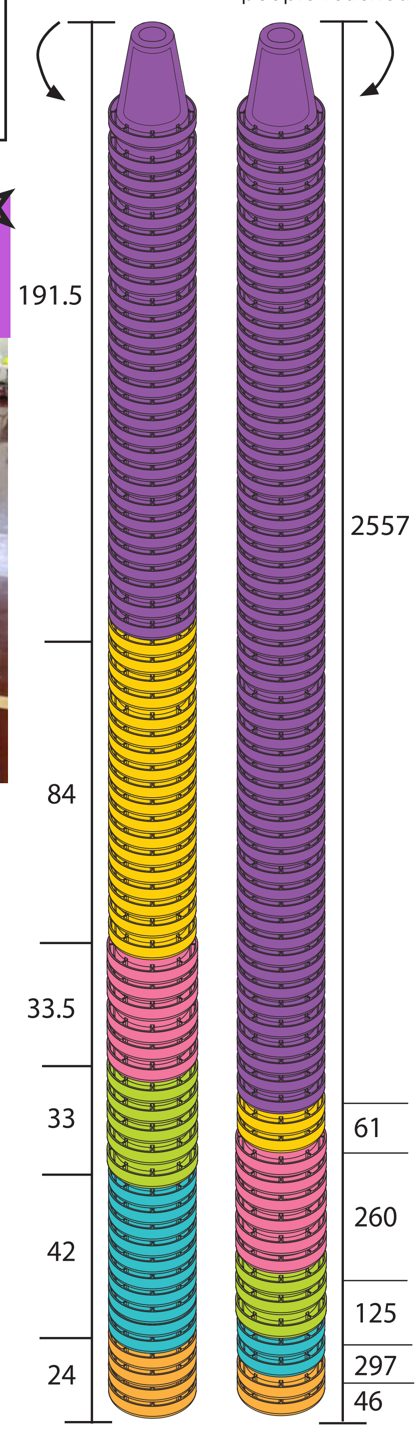


OUTREACH HOURS

408
total man hours

TEAM IMPACT

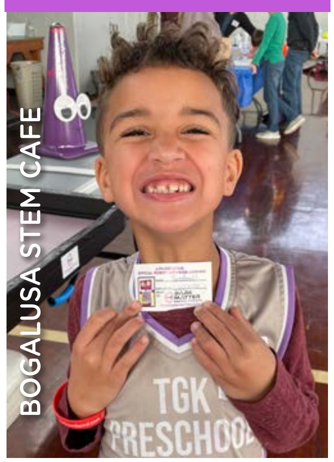
3346
estimated people reached



Community Outreach

We use our Ultimate Goal season robot as a "demo" bot at outreach. We allow kids to drive and shoot rings with the robot and earn their "robot drivers license". It really gets the kids excited. We enjoy talking with parents and kids about FIRST and helping them get involved if interested. We also bring STEM activities like KARBO coding robots to interact with kids and teach skills.

We love seeing kids excited about robots and STEM!



BOGALUSA STEM CAFE

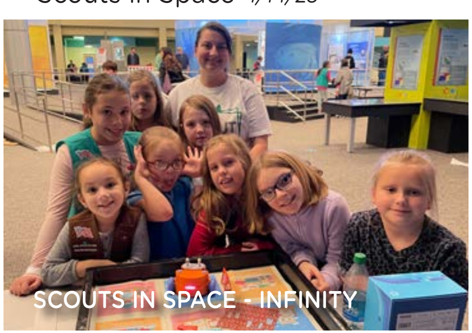
- Robot Demo at FRC Redstick Rumble *8/27/22 and 3/31/23*
- Bush Farmer's Market Robot Demo *9/24/22*
- St. Tammany Parish Fair Robot Demo *9/29-30/22*
- Night Out Against Crime - St. Tammany Police *10/4/22*
- Barnes & Nobles Book Fair Robot Demo & Fundraiser *12/18/22*
- Boys & Girls Club Covington Demo & Karbos *1/6/23*
- Boys & Girls Club Covington Lego BricQ Motion Lesson *1/27/23*
- Bogalusa STEM Cafe Robot Demo & Karbos *1/28/23*
- Pine View Middle STEM Night *3/10/23*
- Boys & Girls Club Covington Demo, FLL & Karbos *3/16/23*
- Franklinton STEM Cafe Robot Demos *3/18/23*
- City of Covington Easter Event Demos & STEM *4/8/23*

INFINITY SCIENCE CENTER

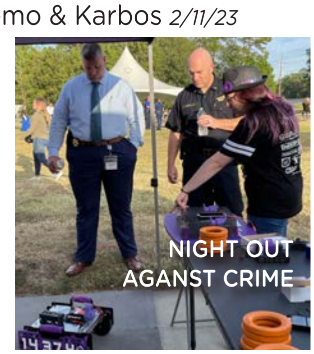
- STEM Day *4/30/22*
- INIFINIcon *6/4/22*
- Robot Demos at Astro Camps *7/22/22*
- Teacher Open House *9/22/22*
- Scouts in Space *1/14/23*

Children's Museum of St.Tammany

- Back to School Bash Childrens Museum *7/23/22*
- Boo Bash Stem Catapult Activity *10/30/22*
- Stem Quest Day 1 Robot Demo *11/21/22*
- Stem Quest Day 2 Karbo Coding Robots *11/22/22*
- Women in STEM - Demo & Karbos *2/11/23*


SCOUTS IN SPACE - INFINITY


CMST STEM Quest


NIGHT OUT AGANST CRIME

Camps

Last season we set a goal to hold more camps to share STEM learning with local youth.

- Researched STEM activities and created 3 lesson plans Encorporated hands-on STEAM activites and lessons in our camps to keep kids engaged.
- Found Pitsco Code Cubes - these are a great way to teach kids to code.
- FTC team Greendale suggested KARBO Robots to us.
- We used Parker's knowledge on circuits for a workshop.

- Stem Code Cube Camp (Pelican Park) / June 16-17, 22
- Code Cube Camp (Pelican Park) / July 25-26, 22
- Code Cube Camp (Northshore Tech) / July 27-28, 22
- Karbo Coding Workshop / Dec. 20, 2022 morning
- Breadboard Circuits Workshop / Dec. 20, 2022 afternoon





We share all our camp resources & curriculum with other teams on our website.

We also share our presentations.

Presentations

- Ask the Inspire Presentation hosted by #19510 VolTech
- We created a Spike prime code presentation and Gaby presented to FLL teams at an LSU FLL jumpstart event.
- Marketing/Branding & Fundraising Presentation at FTC kickoff.
- Team #5773 Video Presentation for FIRST® Documentary
- Aerojet Rocketdyne - on FIRST, FTC, Team, & Volunteering
- IBEW Local 130 - Spoke about FIRST, Power Play game and our robot.


FIRST Volunteering

- FTC Dutchtown Qual 1 (Gaby & Riley)
- FLL Qualifier Denham (Gaby-ref)
- FLL Qualifier at LSU (Gaby-ref)

Organized and Hosted Scrimmage

We organized everything from finding a host location, team signups, coordinating volunteers, setup & teardown and providing volunteer lunches.

Scrimmages are a great way for teams to test their initial ideas for their robot. The experience aid teams in refining their robot, learning game rules and testing game strategy. This event also gave LSU Society of Peer Mentor students a change to learn about FTC through volunteering at the event.

FTC Team Connections

We connected with 10 FTC teams from all over the world to CALLABORATE - SHARE - & LEARN from each other.

We met over zoom

- FTC #19510 VolTech Inspire (California)
- FTC #13684 Infinity Tech (Michigan)
- FTC #19512 Technobots (Lagos, Nigeria)
- FTC #17713 Delta Force (Arad, Romania)
- FTC #19367 Greendale "ALIEN" (Wisconsin)
- FTC #15298 Roboten (Israel)
- FTC #5773 Ink and Metal (California)
- FTC #16091 Team Without a Cool Acronym (Utah)
- FTC #17844 RubixTeam (Blaj, Romania)
- FTC #21036 Team Justice (Brazil)

Assisted Teams

- Various teams who reached out with questions.
- Helped multiple teams at Qualifiers to fix robots or borrow parts. (ex. we let FTC #19137 Cybergriffs borrow a coil cable to qualifier and sent link to where to purchase
- Stinger Swarm & Hive Robotics - Our teams scrimmaged before Qualifer 1 & State giving our teams drivers practice in real match scenarios.
- #22032 Eaglebotics -help connecting their control hub and code a servo with blocks.

CONNECTIONS

Mentorships and Connections are how we sustain our team, learn & grown and promote FIRST. It is also how we learn about the use of STEM in the real world STEM and spread the word about our team and FIRST®. We have a **GOAL** to connect with employers, engineering firms, and tech companies in the STEM field to find out about their company, products and jobs they can offer that would utilize the skills we build in FIRST FTC. We also approach industry professionals about volunteering in FIRST®.

Technical: Aerojet Rocketdyne – at Stennis Space Center

AEROJET ROCKETDYNE Foundation

Feb. 2023

- Connected with General Manager Mike McDaniel at Aerojet Rocketdyne at an outreach event. Aerojet is a supporter of FIRST at the FRC and FLL levels and were not familiar with FTC. Mr. McDaniel worked to secure a grant for our team.
- For Engineers Week we toured their facility and gave a presentation where we talked about our team, FTC and spoke with employees about
- volunteering and our need for mentors and judges regionally.
- We are grateful for their support.

BECAME FIRST FTC TEAM SPONSORED BY AEROJET ROCKETDYNE, AT STENNIS!

Nasa Michoud Assembly Center

March 2023

We connected with a Nasa employee at a FIRST competition and were able to arrange a tour. We had an amazing tour of the NASA Michoud Assembly Center in New Orleans, LA where they are assembling the core stage for the Artemis SLS Rocket. The technology, machinery and pure size of these amazing feats of engineering was awe inspiring. We even got to meet coach Erick from the FTC Team Nerdettes who works there!

Chalmette Refinery – Steven Duct/Engineer

- To learn more about Power Play theme and sustainable energy, we reached out to Chalmette Refinery.
- Learned about their 600 million dollar Bio Diesel project.
- Lead Mechanical Engineer also gave us a virtual tour of the project's 3D CAD model.
- Learned about Engineering fields.

Chalmette Refining®

Robotics Team Visits Refinery

An aspiring team of teenage robotics aficionados, called Dark Matter, visited Chalmette Refining in August to gain inspiration for their next robotics competition. The team will spend several months researching and developing their robot in preparation for the 2022 FIRST competition qualifier in December. The theme for this year's competition is Renewable Energy, and exposure to the Refinery's Renewable Diesel Project was just what Dark Matter needed to jump start their project.

To help broaden their knowledge of the subject, **Steven Duck**, Renewable Diesel Project Advisor, gave the team an overview of the Renewable Diesel Project and how Chalmette Refining is entering the green energy sector.

"They asked a lot of really good questions," said Duck. "It was clear these students did their homework on renewable energy."

... learn about real-world applications to what we're doing or about the industry. We didn't know much about it, so getting

The Dark Matter Team with Steven Duck (at right).

connections in the community and outreach.

... this interest that they have in robotics."

Dark Matter went all the way to FIRST's world competition in April of this year, won second in the state for their robot,

Team was featured in their newsletter sent to all employees

St. Tammany Bomb Squad

We met with the St. Tammany Parish Bomb Squad to learn about their career, and how robotics is used to keep our community safe. We learned about their robot, talked about our robot and FIRST.

Pastor Jim Fatic

- Pastor Jim is a Pastor and motivational speaker. Former Life Coach.
- We met with Pastor Jim Fatic to get feedback on our Judging session.
- Gave us great feedback and confidence going into our Competition.

Ambassadors for FIRST®

the YMCA BOGALUSA

BOYS & GIRLS CLUBS OF AMERICA

We want to see more opportunities for FIRST in our community by helping start STEM Programs & FIRST® Lego Legue Teams.

Mentors

Our mentors are part-time and help us via zoom or phone on an as needed basis.

- Mr. Mike Sonnier/Computer Systems Engineer- Longtime team mentor who *is always there for our team to answer questions. Helps us work though problems, helps with fabrication & applying engineering principles.*
- Matthew Schaff /Code/Programming Mentor (FIRST Alumni) - *helps us learn new programming techniques*
- Logan Livadaus /CAD Mentor (FIRST Alumni) - *gives us feedback on our CAD. Gave feedback on our brainstorming ideas.*

- We use CAD as a main focus of our engineering process.
- This Improves accuracy as well as increases design and engineering productivity as typical challenges are addressed when building the model.
- Using CAD, fabrication and 3D printing allows us to customize our entire robot with unique & Innovative solutions.

OUR ENGINEERING DESIGN PROCESS

Define Problem/ Set Goals >
- Game strategy & game tasks we want to complete
- Problems we might face

Imagine >
- Apply knowledge
- Brainstorm & Sketch

Plan >
- Consider materials & resources
- Set timeline

Create
- Follow the plan
- Prototype
- CAD design
- Evaluate & Modify CAD

Build & Test
- Compare results to what you wanted or expected

< **Improve**
- Analyze results & reliability
- Modify
- Improve performance

< **Final Robot**

GAME STRATEGY

AUTONOMOUS
- Auto for reading the signal and parking in correct zone. Place cones because every cone scored is also scored at end game.
- Have various autos to deliver cones to alternate poles to better work with alliance partners.

TELEOP
Work with our partner to deliver as many cones as possible while also spreading cones out for circuit points and to own multiple junctions. We plan to quickly deliver multiple cones to a high pole for the first minute. Then the remaining time can be spent working on a circuit.

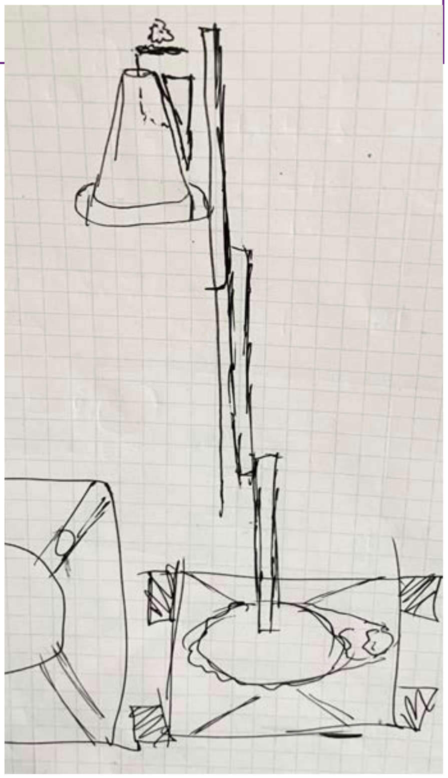
END GAME
To deliver our beacon to a pole in a strategic way that will break any possible or occuring circuits of our opponent and to keep scoring cones.

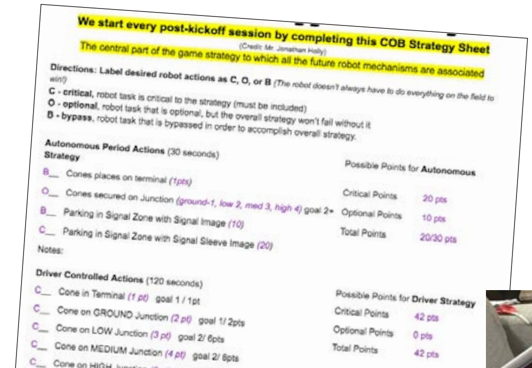
BRAINSTORMING SESSION

- We start with a COB strategy sheet- We categorize each scoring part of the game as **C**ritical, **O**ptional or **B**ypass. This helps shape our robot design and our game strategy. We listed the needed mechanisms our robot must have to complete the tasks on the field: **•Drivetrain** **•Scoring System consisting of ability to grab/intake cones and ability to lift cones to mutiple heights.**
- Drivetrain options: Mecanum or Swerve for strafing ability and easy navigation
- To score from front or back of robot: Touret system OR have a mechanism that rotates to place from any angle. This would help with navigating the field and reducing turning movements.
- Will need to reach over pole: Arm for reaching for poles OR opening between wheel wells to drive close to poles.
- Sketched Designs & Ideas
- We agreed on mecanum for maneuverability. And a lift slide system for lifting cones. And a turret to be able to place from front or back of robot.

In the following pages we will highlight the design process of each of our robot's mechanisms.

INITIAL ROBOT SKETCH




We start every post-kickoff session by completing this COB Strategy Sheet
(Credit: Mr. Jonathan Holly)
The central part of the game strategy to which all the future robot mechanisms are associated
Directions: Label desired robot actions as C, O, or B (The robot doesn't always have to do everything on the field to win!)
C - critical, robot task is critical to the strategy (must be included)
O - optional, robot task that is optional, but the overall strategy won't fail without it
B - bypass, robot task that is bypassed in order to accomplish overall strategy.

Autonomous Period Actions (30 seconds)
Strategy
B__ Cones places on terminal (1pts)
O__ Cones secured on Junction (ground-1, low 2, med 3, high 4) goal 2+
B__ Parking in Signal Zone with Signal Image (10)
C__ Parking in Signal Zone with Signal Sleeve Image (20)
Notes:

Possible Points for Autonomous
Critical Points 20 pts
Optional Points 10 pts
Total Points 20/30 pts

Driver Controlled Actions (120 seconds)
C__ Cone in Terminal (1 pt) goal 1 / 1pt
C__ Cone on GROUND Junction (2 pt) goal 1/ 2pts
C__ Cone on LOW Junction (3 pt) goal 2/ 6pts
C__ Cone on MEDIUM Junction (4 pt) goal 2/ 8pts
C__ Cone on HIGH Junction (5 pt) goal 5+ 25pts
Notes:

Possible Points for Driver Strategy
Critical Points 42 pts
Optional Points 0 pts
Total Points 42 pts

End Game Actions (last 30 seconds of driver-controlled)
O__ Parked in Terminal (2 pts)
C__ Junctions Owned by Cone (3 pts) goal 5+/ 15pts
C__ Junction Owned by Beacon (10 pts)
C__ Completed Circuit (20 pts)

Notes: A robot can only place one single beacon on a junction. (you can

Is there an opportunity for DEFENSE? :) If so, how?
Place cones in ground junctions to make it harder for larger bots to mane

DRIVETRAIN

GOAL: The main obstacle our drivetrain needed to overcome this season is navigating the field. Our previous six wheel dropcenter drivetrain design was fast but also very large. **WE SET THE MAIN GOALS FOR OUR DRIVETAIN: 1) SMALLER FOOTPRINT 2) MANEUVER AROUND THE FIELD QUICKLY (STRAFE)**

BRAINSTORM: We evaluated two drivetrain options / ideas:

MECANUM PROS/CONS

- uses 4 motors, only 4 left for mechanisms
- Ideal for forward and side motions making it easy to navigate around poles on field.
- Would be new for us to design, code and build

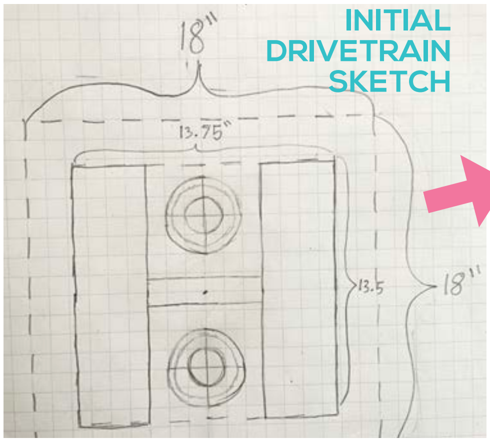
SWERVE PROS/CONS

- Can use online designs but width may be a problem. Would need redesign to move motors to make it smaller.
- This design would not need a turret
- Also uses 4 motors so only 4 left for mechanisms
- Would be our first time building and coding - both would be a lot harder than mecanum

We decided on the mechanum drive because we can get a smaller footprint with a custom design and there are more resources for programming.

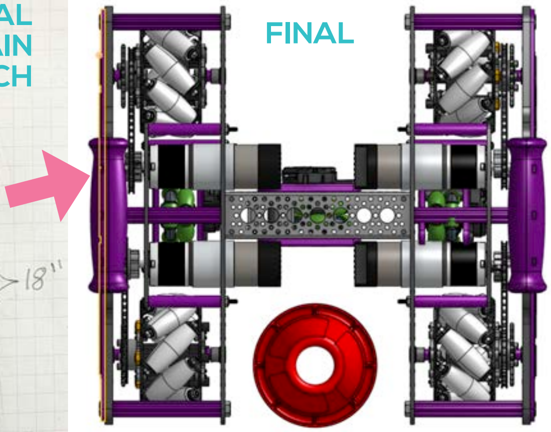
MECANUM OVERVIEW -

- **The primary advantage to mecanum drive is the maneuverability.** Mecanum drivetrains enable holonomic movement. This means that the drivetrain is able to move in any direction while rotating: forwards, backwards, side to side, translating while rotating, etc.
- Wheels have rollers at 45° angles to the rest of the wheel, creating a force 45° from parallel. Depending on how the wheels are driven, X or Y components of the force vectors can cancel which allows movement in any direction.
- The 4 mecanum wheels are oriented in an “X” shape. (angled towards the center when looking at it from above)
- By spinning the wheels of a mecanum drive in certain patterns, you can utilize the diagonal force created by the wheels to move the robot in any direction.
- A mecanum will drive slightly faster forwards/backwards than any other directions due to friction. Combining translation and rotation will also result in slower movement.
- Odometry “dead wheels’ **(pg 8)** can be used to better track the robot due to wheel slippage. Odometry uses sensor data and math to form an approximation for the robot’s pose over time. **See control on pg 14.**

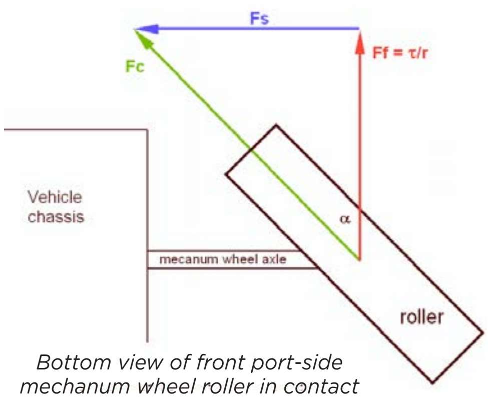


INITIAL DRIVETRAIN SKETCH

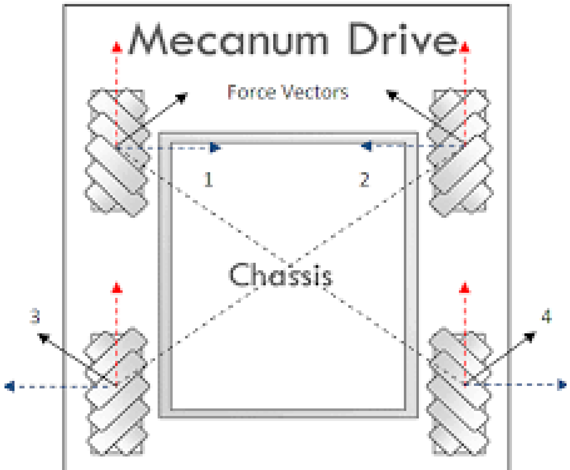
FINAL



KEY PRINCIPLES



Bottom view of front port-side mechanum wheel roller in contact with floor (wheel itself not shown)



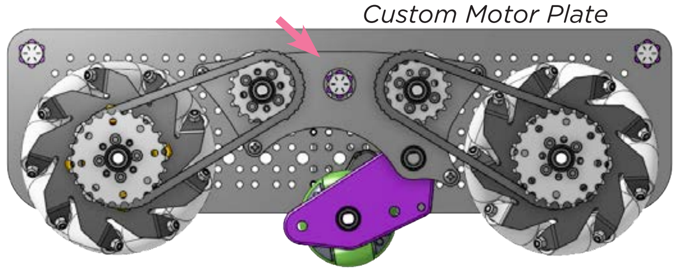
Top view / looking down on robot

In the image above, vectors 1, 2, 3, and 4 are the force vectors created by the mecanum wheels when the chassis is instructed to drive towards the top of the image. All motors are driving forward. The blue and red lines are their X and Y components, respectively.

(credit to gm0.org for the mechanum diagrams and explanations)

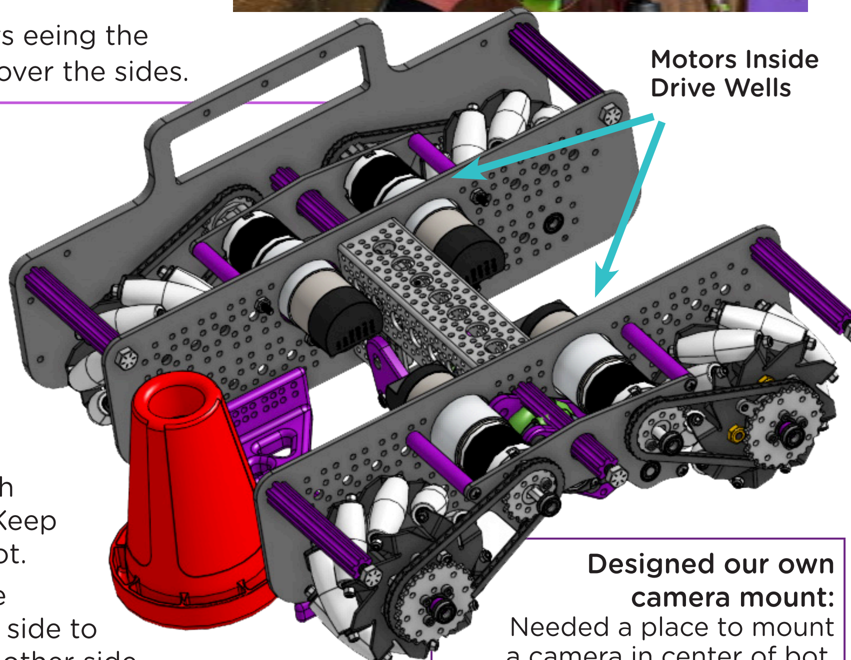
DRIVETRAIN DESIGN & BUILD

Custom Motor Plate



BUILD & DESIGN:

- Custom designed using OnShape CAD. Designed for speed, accuracy and easy navigation around junctionpoles.
- We wanted our drivetrain to be robust, fast, easy to navigate on the field.
- Wells open for intaking cone and to help line up on poles.
- Assembly stiffened by using churros to connect the exterior and interior plates of the right and left sides.
- The interior plate has additional holes cut to match the configuration of the actobotics c-channels and plates.
- GoBilda Mecanum Wheels Powered by (4) 20.1 NeveRest motors.
- Handles added for easy transportation.
- Found a sponsor to powdercoat our side plates. Afters eeing the powdercoat we decided not to put 3d printed plates over the sides.



Solutions to concerns and obstacles we faced. These help us to better acheive our goals:

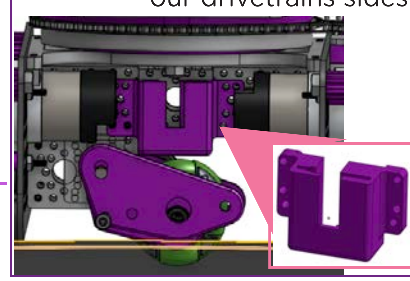
SMALL FOOTPRINT:

Solution: (1) Motors are set back toward the center of drivetrain to allow space for the cone between wells. (2) Set motors inside the drive wells with a custom motor plate and use chain to power wheels allowing for smaller width. Final Size: 13.5 x 13.75

WEIGHT DISTRIBUTION:

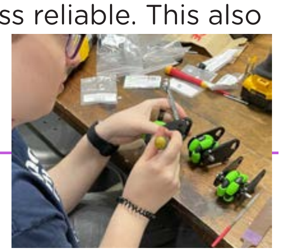
- We did not want to tip when our lift is extended. **Solution:** We made our outer wheel well plates .25 inch thickness for added weight. (Inner plates are .125 in.) Keep our center of gravity low and in the center of the robot.
- Weight should be distributed evenly for accurate drive performance. **Solution:** Added weighted plates to one side to help balance weight of electronics and battery on the other side.

Designed our own camera mount:
Needed a place to mount a camera in center of bot. Designed a mount so camera mounts between motors on the c-channel that connects our drivetrain sides.



WHEEL SLIPPAGE:

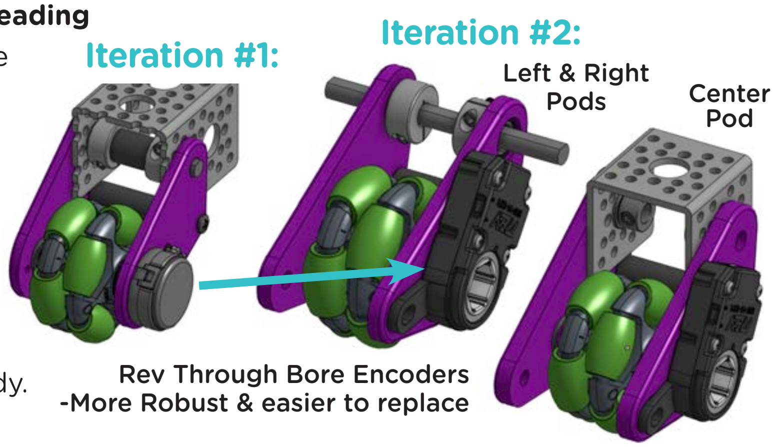
The rollers on mecanum wheels form a 45 degree angle with the wheel's axis of rotation, which means that mecanum drivetrains can't strafe as fast as they can drive forward. Wheels can slip which make encoders on wheel motors less reliable. This also means mecanum drivetrains do not have much pushing power.
Solution: Use of Odometry can help give us reliable information from encoders. PG 14



ODOMETRY

DESIGN FEATURE: **Designed to spring up/down to stay in contact with the ground at all times for accurate encoder reading**

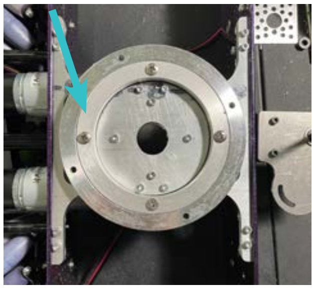
- **Iteration 1:** used US Digital encoders (these worked but are fragile) US Digital encoders cannot be replaced because once you remove shaft from encoder it is ruined.
- **Iteration 2:** We redesigned our odometry pods after scrimmage when the Rev encoders came back in stock. Rev can be replaced with just two screws and shaft easily slips in and out.
- Broke center pods on ground junction; thickened plates (1/8 in to 1/4 in) and printed 100% infill.
- Modular for easy replacement. We keep backups pods ready.



TURRET SYSTEM

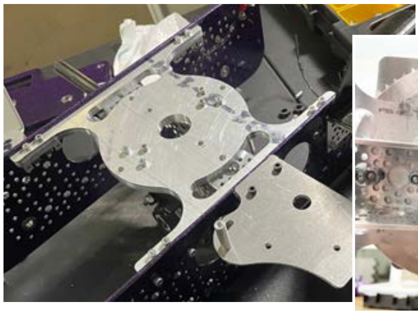
Increase our cycle times by not having to turn the robot to place on certain poles. We always brainstormed using a turret in previous games and finally wanted to design and build one.

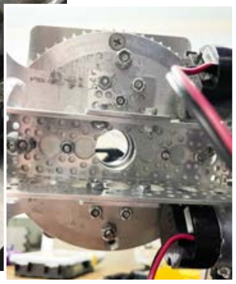
Used a 5.5 in **lazy susan bearing** from Amazon



Turret is directly centered on our robot

H PLATE:
- Bearing attaches to this plate
- Braces drivetrain sides

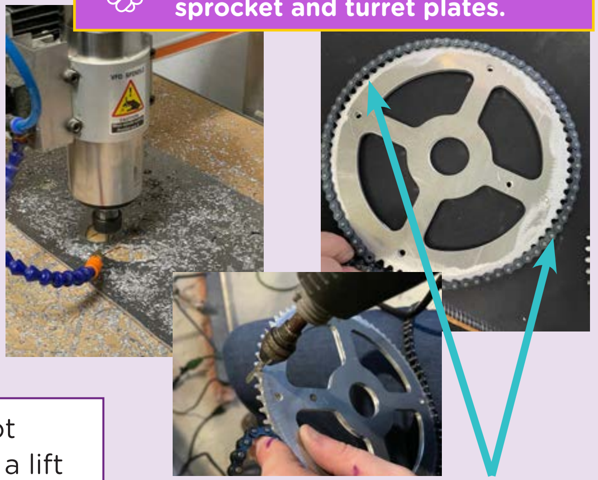




FABRICATING OUR OWN SPROCKET

Obstacle: Couldn't find a 5.5in sprocket to fit #25 chain.
Solution: make our own sprocket; used a feature script in Onshape to generate and CNC to fabricate.

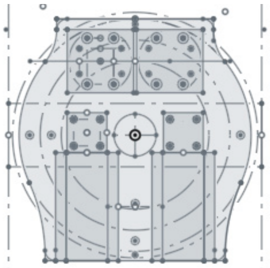
Used mentor connection to FRC team 2992 to CNC our custom sprocket and turret plates.



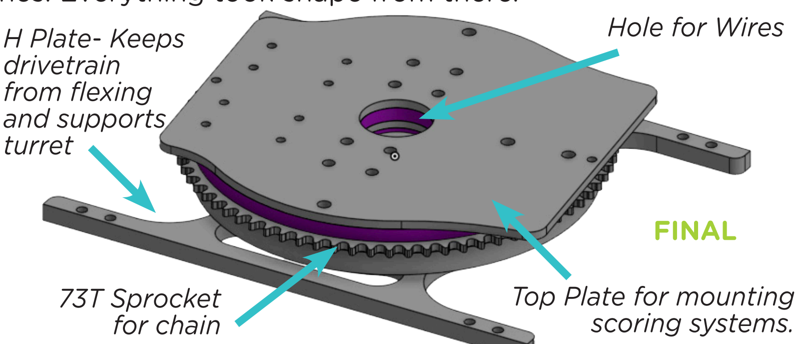
- First cut did not fit the chain.
- Tried to dremel out the teeth more and taper the teeth. The chain fit better but not around like we needed.
- Consulted with Mentor Mike Sonnier and decided we will re-cut our sprocket using .10 aluminum stock.

Solution:
- Recut with .1 stock
- Used a larger bit when cutting teeth to trick the CNC and take off more than we needed, resulting in deeper teeth to fit our chain better.
- THE 2nd ITERATION WAS A PERFECT FIT

Main challenge was fitting everything on a 5.5 inch plate in center of bot that could spin freely. We started with a sketch in CAD to plan how to fit a lift system within 5.5inches. Everything took shape from there.



BRAINSTORMING



Designed plate so it can easily be removed to service mechanisms since all mechanisms attach to this plate. This has come in handy.

Added spacers in turret:
- Top spacer raises it slightly to clear drivetrain side plates and align with the sprocket powering turret.
- Bottom spacers to avoid friction with screws.

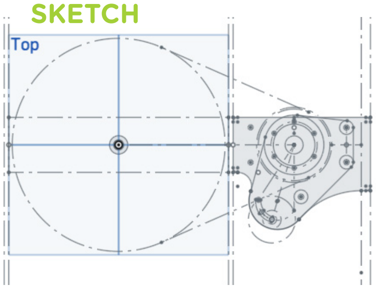
TURRET SANDWICH

POWERING TURRET & MOUNTING THE MOTOR:

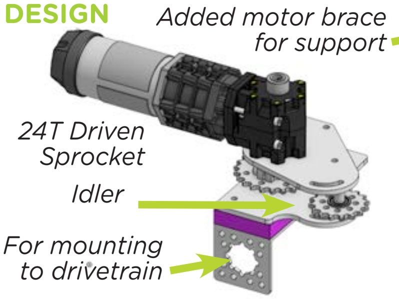
Goal: To power from the side and not interfere with turret rotation.

Solution: Designed and CNC'd motor plates to hold motor over drivewell. Use 90 degree gearbox on a Rev Ultraplanetary Motor to mount on its side to keep a low profile so claw doesn't hit it when spinning around. Added idler sprocket for chain tension.

SKETCH



DESIGN



spreadsheet for turret motor gearing:

Travels 180° in .76 seconds

Rotary Mechanism

	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
RevHDHex	6000	0.105	8.5	0.4

# Motors per Gearbox	Gearbox Efficiency		Arm Load (lbs)	Arm Length (in)
1	65%		1	3

Driving Gear	Driven Gear		Arm Rotational Speed	Arm Time to move 90 degrees
24	73	No Load:	246.6 deg/s	0.37 sec
1	4	Loaded:	238.2 deg/s	0.38 sec
1	4			
1	3			
146.00 : 1	<-- Overall Ratio			

Current Draw per Motor (loaded)	Stall Load
0.58 amps	29.40 lbs

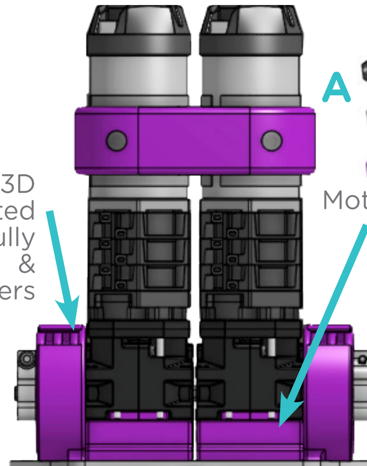
LIFT

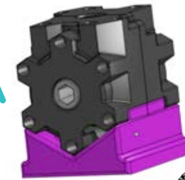
GOAL: ✔ Fast & Efficient ✔ Dependable ✔ Rigid (no shaking) ✔ Smooth ✔ Quick Cycles
✔ Use misumi drawer slides recommended by multiple teams at the World Championship.

DESIGN FEATURES:

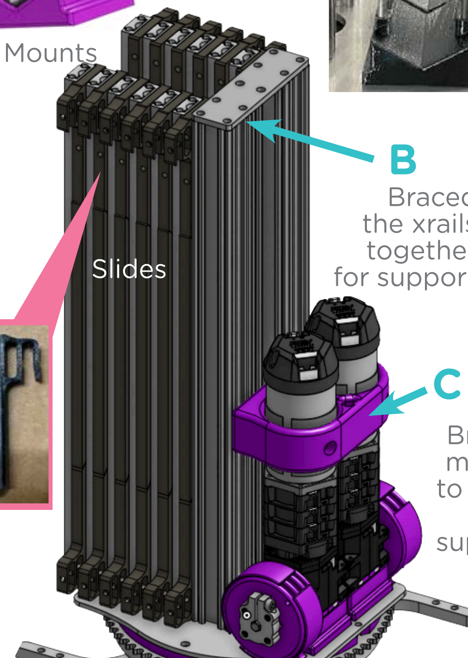
- **Compact system** to fit on our turret.
- **Two Rev Ultraplanetary Motors** to spread out the torque needed to raise our system's weight. This allows us to gear for more speed
- 1 shaft thru both motors sync pully & slides. Also will cancel and twisting forces.
- 6 stages of misumi drawer slides
- 2 sets of slides for rigidness
- Slides mounted to GoBilda xrails. They are compact (24m footprint), sturdy, & use same M4 screw needed for mounting slides.
- Pullys directly line up with string rigging to ensure proper wrapping on pully.
- Team Delta Force (Romania) shared their slide bracket → CAD file and we adjusted them in Onshape to fit our needs.

To mount motors in compact space: Designed custom 3D printed motor mounts. M3 60mm long screws attach two motors to turret top plate AND 90˚gear box to motor. **SEE A**





Vertical Motor Mounts



IMPROVEMENTS MADE IN CAD BEFORE BUILD:

- To strenghten x-rails we used long screws to mount o x-rails to the turret and a plate at the top to brace them together. **SEE B**
- To prevent rotational force on motors we braced motors to the x-rails with a bracket. **SEE C**

Our main obstacle with our lift was the rigging & speed:

Iteration #1: Cascade Rigging

Cascage rigging- less string to wrap around pully= faster & reliable. BUT weight is multiplied with every stage added (6lbs x 6stages = lifting 36lbs) requiring high gear ratio. **After lots of trial and error nothing worked consistently. Slides would bind, motors stalled, and we broke a bracket.**
SEE D (broken slide bracket)

Iteration #2: Continuous Rigging

Needed a rigging that was dependable, robust and can be fixed easy if a string were to break. We made a last minute change to continuous rigging.

Revisions for 2/4 Qualifier:

- One continuous extension string per side to raise.
- One retraction string from pully to last stage. Tubing for tension.
- More string wraps around pully. Tried to offset with our gear ratio
- Lifts exact weight of system (6lbs) = ability to use lower gear ratio

Cartridges		Travel Dist.
5 5	Gear Ratio 27.36 : 1	moves 42.5in
Pully 1.125 in	Wraps 12	Speed 3.70 seconds

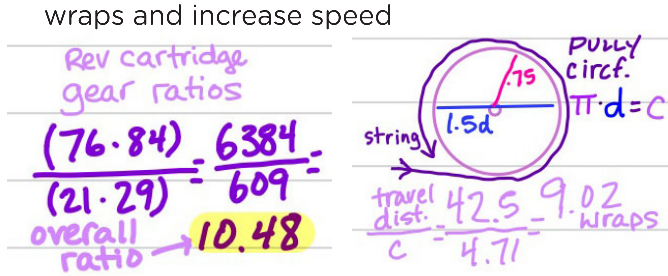
Reliable thru lots of drive practice.
AVERAGED 9 cones

Iteration #3: Need For Speed

Although rigging was reliable in matches, our lift speed was slow.

Revisions for 2/18 Qualifier:

- **Calculated and compared different gearing & pully size combinations to speed up lift.**
- Increased pully size to 1.5inches to decrease wraps and increase speed



MORE THAN DOUBLED OUR SPEED
(and faster than cascade!)

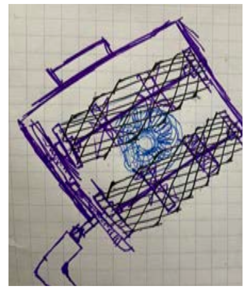
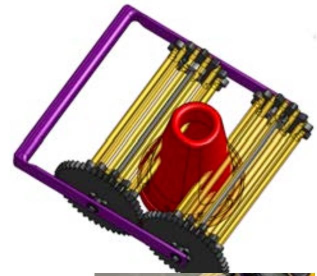
4 & 3	Travel Dist.
Pully 1.5 in	moves 42.5in
Wraps 9	Speed 1.54 seconds

See full calculation sheets in pit EN secF3

FASTER SPEED = FASTER CYCLES
AVERAGE 14+ cones

THE CLAWWW

BRAINSTORMING & PROTOTYPING

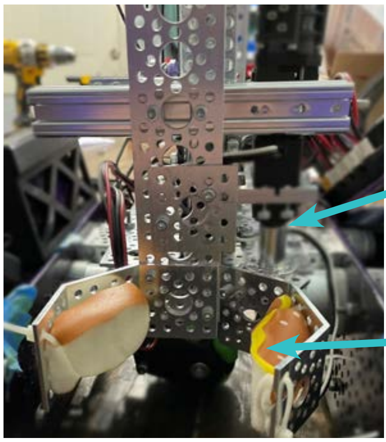




GOAL: A way to pick up a cone. Be efficient and quick. Must be able to pick up from a stack.

BRAINSTORMING:
- Use a guide to make sure cone is in exact position for grasping cone.
- A servo powered claw grabber could act as a guide and pick up.
- Arm could turn 180 to place on pole so we can intake from one side and place from the other side. Grabber turns or use a Turret.
- Figure out a way to flip cones upright or a way to pick up cones that have fallen over.
- We tested green compliant wheels and made a spinning rubber band intake prototype to suck up the cones - this worked but was hard to pick up from the wall stack because it was so big.

OBSTACLES & IMPROVEMENTS:

ITERATION 1



1 servo moved 1 side of claw

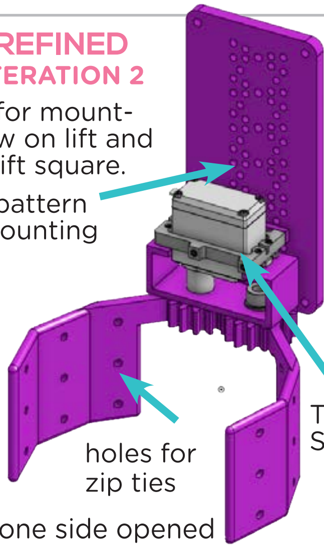
pretzel squishy for grip

We used a hands-on approach to build a claw prototype out of parts we had. We used angled brackets for the sides. One side was stationary and the other attached to a servo to open and close. We used a cut up pretzel squishy for a foam grip. Was attached to a plate and a horizontal piece of xrail to brace it onto the lift xrails.

REFINED ITERATION 2

Plate for mounting low on lift and keep lift square.

hole pattern for mounting



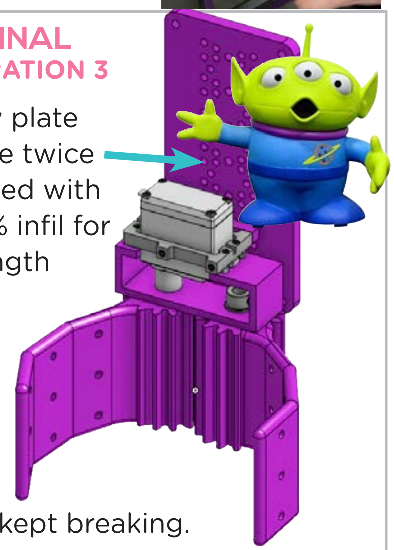
holes for zip ties

Torque Servo

Only one side opened on our prototype so we decided to improve to give us a wider opening to grasp cones - We designed in CAD to create gears that would make both sides open with one servo. Made a servo bracket for holding both shafts for turning servo.

FINAL ITERATION 3

Claw plate broke twice Printed with 100% infil for strength

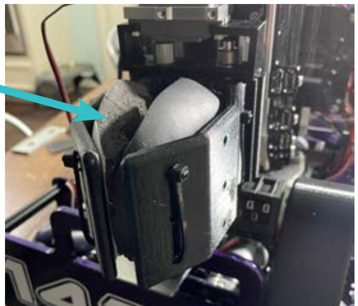


Claw kept breaking. *(got stuck on a pole and broke when the claw came down on our drivetrain side)* We took out the big hole in the back,; extended gears all the way down eliminating the small fragile piece holding side to the gears. Increased sides from .2 to .25 thickness for more support.

How do we get our grip?

A PENGUIN SQUISHY!

We used a pretzel squishy on our first iteration that worked great. It is squishy and inside is a little sticky which gives us a great grip on the cone. We decided to use team member Riley's penguin squishy because it was black on the inside.

CLAW SERVO COIL WIRE:

Problem: Servo wire would get caught on lift going up and down damaging the wire and pulling connection apart.

Solution: -We first spliced a phone cable but realized it was not proper guage specified in game manual. And it couldn't give servo enough power
-We ordered a premade coil with a bigger gage wire; spliced pwm connectors on the end of the cable to connect servo.


We let another team borrow our extra cord at Qualifier and sent them the link for where to buy it.

CONVERTING SERVO RANGE FOR SETTING OUR SERVO LIMITS IN CODE

The Gobilda servos have a range from 500 to 2500. We need to adjust this to a 0-1 scale to get our desired position point to use in code. We use a servo programmer, note the range position number then convert.

We take the range and subtract 500 then divide by 2000 giving us a decimal number range between 0-1. We think of this as a number line so we first subtract 500 so that our total range is not 500-2500 range but 0-2000 making the 0-1 conversion easier.

We use the below math for conversion:

$$x = \frac{345}{2000} \qquad \frac{845-500}{x} = \frac{2000}{1} \qquad x = \frac{w - 500}{2000}$$

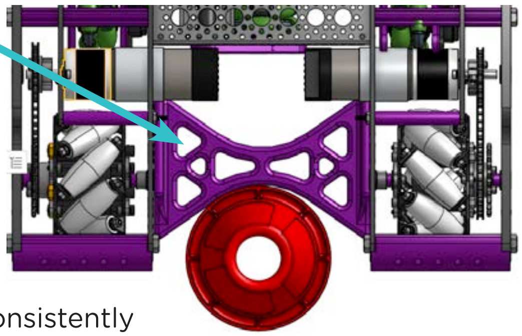
	range	*converted*
Claw Open	1585	.5425
Claw Closed	1780	.64

ADDITIONAL OBSTACLES & IMPROVEMENTS:

GUIDE:

We added a guide to keep our bot from going over ground junctions and damaging our odometry pods. OTHER BENEFITS:

- Helps us push cones onto the ground junctions.
- Helps us grab the cone consistently in the same spot.



DRIVE WELL COVERS:

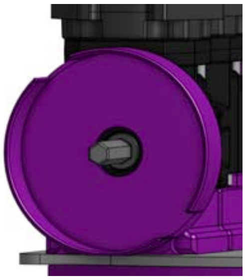
Problem: Signal cone was getting stuck in wheel well when running auto. We would also get caught on poles if we ran into them.

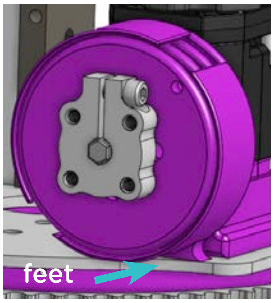
Solution: We designed these covers for the front of our drive wells. They sit on the churro and zip tie on.

PULLY COVERS:

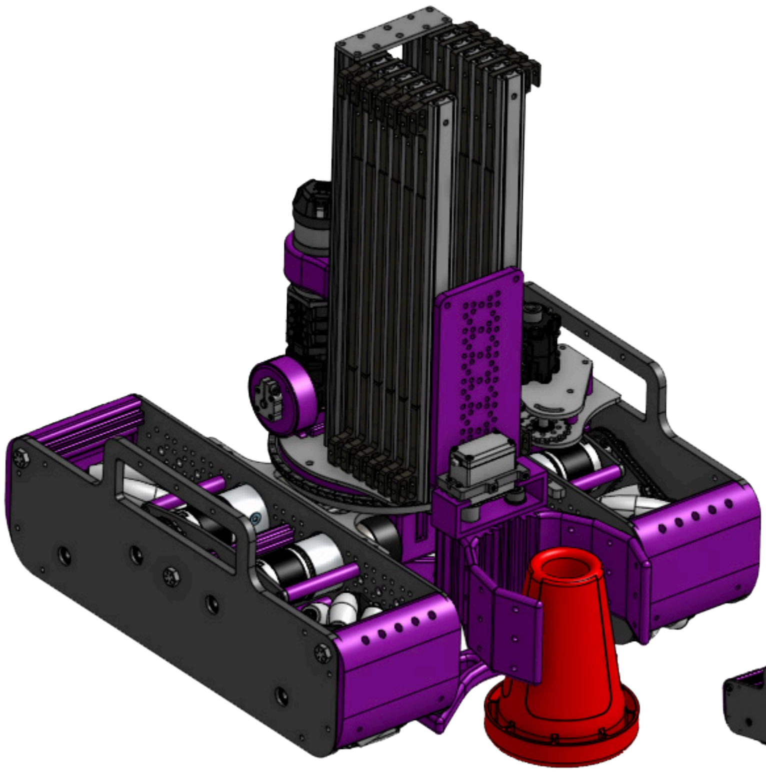
Problem: At State Championship we lost our final match because string slack caused the lift string to jump the pully. This broke our lift for the entire match.

Solution: We designed covers for our pullys to prevent this from happening. Small "feet" on the covers keep it from twisting.





OUR FINAL BOT



TEAM BEACON

Iteration 1

Iteration 2
used as backup

FINAL

GOAL: A Team beacon that would fit over a cone.
Iteration 1: We first went with a fun design of a CORN for scrimmage with plans to adjust. This design was not easy to to grab and did not stay in our claw causing us to drop it sometimes.
Iteration 2: Pick up a cone and our beacon at the same time for more points.
We made a band that would fit under our claw with a vertical piece coming off vertically to adhere to the height requirements. We then added colored strips to help it be distinguished from the colored cone it rests on. We painted our numbers on it.
FINAL: When we grab a cone and the tab is positioned a certain way, the cone would slip out of our beacon. Since our claw squishy worked so well we thought why not use a squishy beacon for better grip. **This worked great!!**

AUTONOMOUS

OBJECTIVES:

AUTONOMOUS

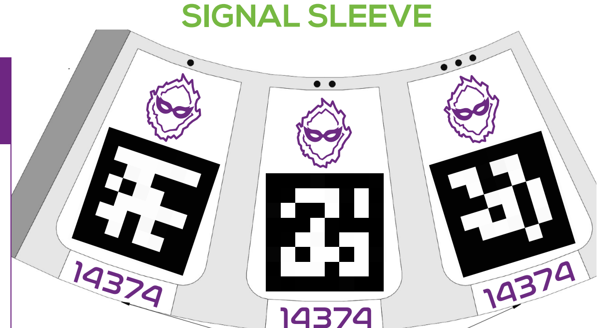
32pts	+12 end game cone points

- ✔ Scans custom sleeve
- ✔ Scores preload medium junction (4pts)
- ✔ Score 2 mid junction (8pts)
- ✔ Parks in correct zone (20pts)

ALTERNATE AUTO

Deliver pre-load to Med. and Park with sleeve (24pts)

SIGNAL SLEEVE



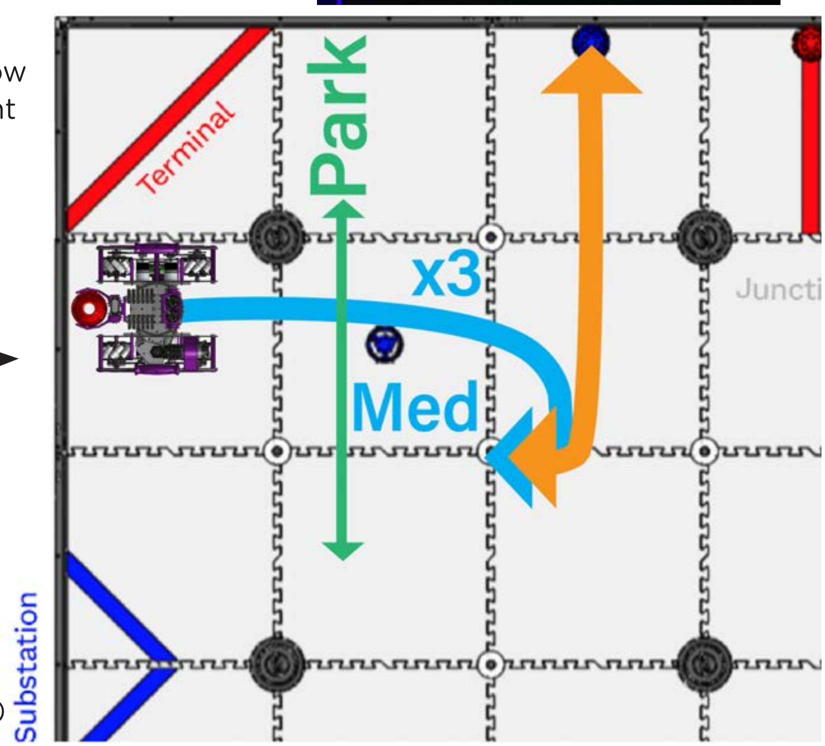
SENSOR: ELP megapixel Super Mini 720p /45degree lens USB Camera

VISION:
We use open CV and AprilTags for determining which zone to park in.

April Tags are a system of visual tags developed by researchers at the University of Michigan to provide low overhead, high accuracy localization for many different applications.

April Tags are able to achieve accuracy within 4cm of the actual pose when the camera was within 2m of the tag. If the robot was further away, the accuracy decreases proportionally to the distance from the tag.

AUTONOMOUS OVERVIEW & MAP



🔵 1) READS APRIL TAG and moves to closest medium pole and places pre-loaded cone #1

🟠 2) Moves to cone stack, removes 1 cone, placed on medium pole. Repeats 1 more time.

🟢 3) PARK: If April tag 12 then park in Zone 1
Else if April tag 13 park Zone 2
Else move to park in Zone 3

(Alternate route placed preload on medium and parks.)

CONTROL/PROGRAMMING

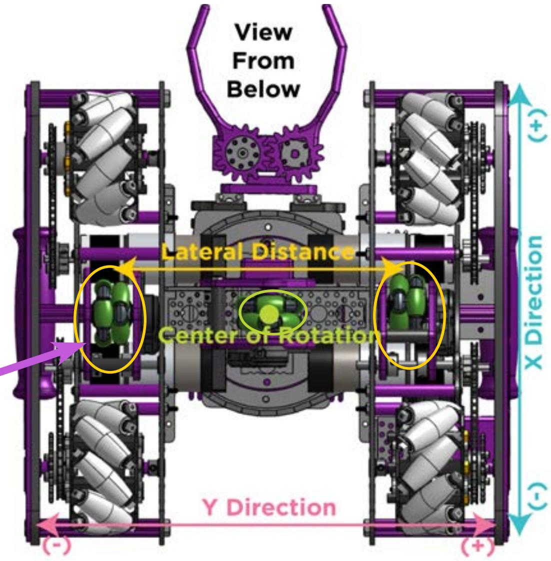
We use Java programming, FTCLIB and GetHub.

SENSORS USED:

Camera - ELP megapixel Super Mini 720p /45degree lens USB Camera

Gyro/IMU - We use the Gyro sensor in the Control Hub Teleop for field centric teleop driving. We retrieve the gyro angle and use it to update our pose (position of the robot). This tells us our heading so our robot always drives with a heading matching our joy sticks (The robot will always drive forward no matter the robot's orientation)

Rev Encoders - We use Rev encoders on our odometry pods to calculate our position on the field. The motor encoders powering the wheel tend to be inaccurate due to slippage. Encoders attached to dead wheels help track actual encoder turns. For a robot, there will be three possible sensors that you can use: two that are parallel with the robot's body in the x-direction and one that is aligned with the y-direction of movement (perpendicular to the drive wheels or dead center).



Lateral Distance/Trackwidth 8.98
Center Wheel Offset is 0 (dead center)

KEY ALGORITHMS:

Odometry

The idea of odometry is to use sensor data and math to form an approximation for the robot's pose over time. Localization is a means for being able to locate the position of the bot at some point in time. Odometry is especially useful in autonomous programs because it allows for easier implementation of different tasks on the field due to understanding one's position. FTCLib offers its own odometry classes for the use of differential and holonomic drives.

We use FTC Lib offers its own odometry classes that track robot position as a Pose2d, which means it is represented using the vector $\begin{pmatrix} x \\ y \\ \theta \end{pmatrix}$. x is the distance in the forward direction of the robot, y is the horizontal distance, and θ is the heading of the robot. Angles are in radians.

The change in pose over some very small amount of time is $\Delta\vec{x}$. . Updating the pose is done by adding the transformed change to the previous pose where $\varphi = \Delta\theta$. In order to determine the current location of the robot and update its pose, the change must be calculated using data read from the sensors (rev encoders). Tracking displacement of the sensors can tell us where our robot is located.

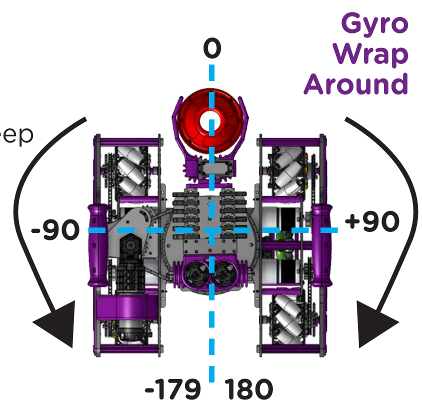
credit gm0.org

Autonomous Path Tracking & Waypoints

Path tracking algorithm calculates the robot velocity in order to reach a designated look-ahead point from the current position. It loosely follows a path determined by a set of waypoints, which are coordinates on the field. The robot move at the fastest possible speed around some path. Robot travels in non-linear paths without having to stop at corners making smoother movements.

We use Start and End Waypoints - The starting waypoint represents the first point in the path and the ending waypoint is the last point in the path.

Gyro Wrap Around - We had trouble driving in field centric. We first checked our gyro accuracy when turning. We would turn 360 but the gyro would not read accurately. We tried recalibrating then realized it wasn't calculating correctly: It would go to 360 and keep counting up instead of resetting at 0. We set our code so it would wrap around at 180.



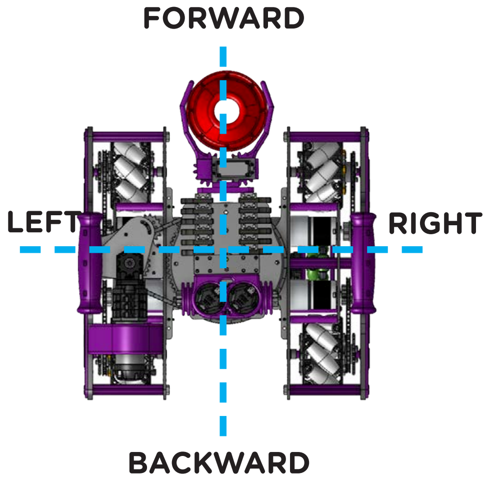
Deadzones

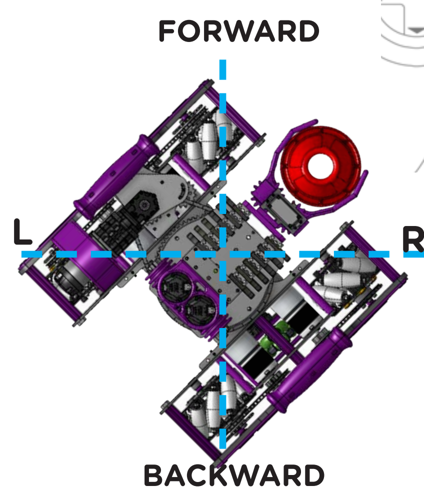
Used to keep the robot from moving when the joystick is slightly moved. We use logic to check how far the stick has moved. And set our deadzone in constants file to (0.05). This eliminates unwanted movement (so the joystick has to be moved slightly before the robot will start to move.)

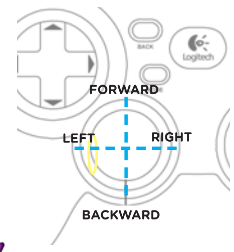
DRIVER CONTROLLED ENHANCEMENTS:

Field-Centric Driving

- Moves robot in the field's frame of reference.
- Reduces Confusion for drivers.
- Field-centric assumes that each push of the joystick is in relation to the global position of the robot—Moving joystick up always moves the robot in the same direction.



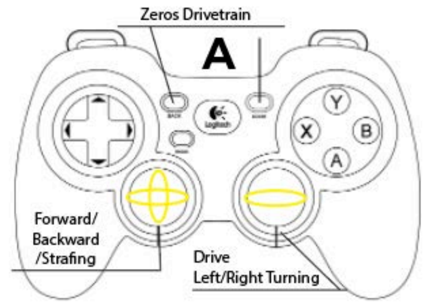


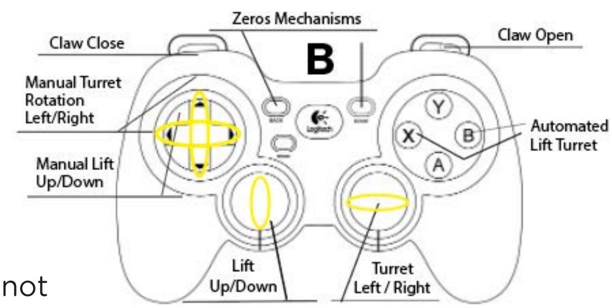


Signal Light

We use an LED Signal Light to tell B driver if the claw is open or closed. for when drivers cn't visualize the claw.

DRIVER CONTROLS





Automated Driver Controls

Driver B has two buttons incorporated into their controls that automatically move BOTH the vertical lift and turret to predetermined positions at once. Positions are measured and set using the motor encoders. Allows for faster controls in scoring cycle.

- B - Lift will move up a safe height then turns turret 180. (if lift is already up it will simply turn 180)
- X - same as B but moves opposite direction.

We have a few fail-safes in place to help drivers:

Turret Control

Code checks lift height and if lift is below a specified height it will not move.

Max position- sets limit for maximum rotation the turret will move. Height limit for height which we set in our constant file. Will not go past its minimum start position of 0.

We also use a deadzone on our turret to prevent unwanted movement.

Encoded Limits for Hardware

Programmed limits restrict movement of the turret and lift to prevent the robot from damaging itself.

Lift was missing its stop position at bottom limit because it was too fast. So we slowed our speed down as we approach our 0 limit so we don't overshoot our limit.

Zero Button Fail Safe

Field Centric orientation syncs the robot with the field in the case of heading drift or failure to adjust orientation from autonomous.

Turret: if loose our zero position the robot used in calculations we have a zero button on the A controler for zeroing the drivetrian. We orient the robot correct direction and press the zero button. A zero button on the B controller zeros the turret and lift in the down position. It needs this 0 start position set in order to know how far up to go or for turret rotation.