Electric Quahogs

252

2021-2022 SEASON
ENGINEERING PORTFOLIO

FREIGHT FRENZY

We are team 252, Electric Quahogs, an FTC team competing out of the Wheeler School in Providence, Rhode Island. We have been participating with FIRST for 14 years.

CONTENT FOR JUDGED AWARDS

Think: 5, 4, 7, 8, 9, 10, 13, 14
Connect: 1, 3, 15
Innovate: 6, 7, 8, 9, 10, 13, 14
Control: 11, 12
Design: 8, 9, 10, 14
Motivate: 1, 3, 15

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TEAM PLAN

After learning to adapt to a half virtual and half in-person structure last year, we were thrilled to return to whole-team meetings this season. Being fully in-person enabled us to more effectively teach new members and connect with our community.

Last year, we transitioned from an after-school-only model to meeting during school, incorporated with students' classes, in addition to continuing our after-school sessions. This allowed us to expand our number of active, current members significantly.

This season prioritized building team member's skills. In particular, we focused on teaching team members CAD, and different mechanisms that we can incorporate into our robot design.

SUSTAINABILITY PLAN

Our main goal for sustainability was to use past resources to set us up for future successes. Our experienced members taught new members the basics of FTC, and we leveraged the experience of five new mentors: three FIRST alumni and two industry professionals. These mentors taught our whole team new skills, and we created distinct subteams (programming, operations, and building) for the first time. We also purposefully built two very distinct robots, which can both be reused and built upon by future generations of our team.

OUR TEAM

Mayte Segura, Captain
'24
She/
Her

William Kopans, Captain
'22
He/
Him

Henry Germano
'22
He/
Him

Reed Turner-Murray
'22
He/
Him

Sam Kurtis
'22
He/
Him

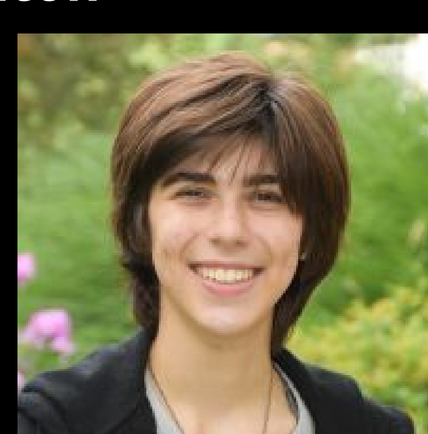
Myles Johnson
'23
He/
Him

Nathan Rego
'23
He/
Him

Beatrice Schroeder
'24
She/
Her

Jaiden Dash
'24
He/
Him

Lily Thornton
'24
They/
He/
She

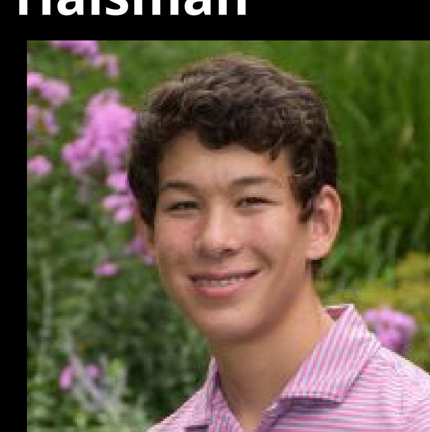


Tyler Wang
'24
He/
Him

Daniel Duarte-Baird
'25
He/
Him

Isabelle Crescenzi
'25
She/
Her

Griffin Haisman
'25
He/
Him



Seoyon Kim
'25
She/
Her

COACHES AND MENTORS

NAPALI RAYMUNDO
Mechanics/Programming Mentor
FTC Alum, #4174

ZOE RUDOLPH-LARREA
Operations Mentor
FTC Alum, #252

SOPHIE GINSBERG-HAYES
Mechanics Mentor
FTC/FRC Alum, #2856 & 8032

DYLAN RYDER
Coach
Wheeler School D-I-B Lab Director

REBECCA WOLKOFF
Programming Mentor
FRC Alum, #695

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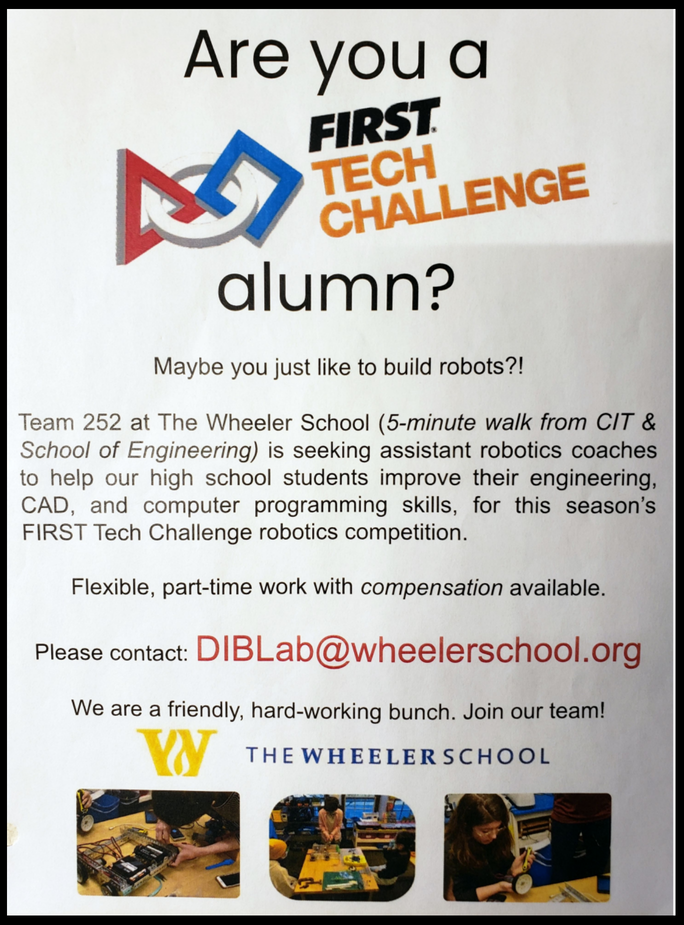
MENTORS

Rebecca Wolkoff, CTO at ChargeNet Stations
Ms. Wolkoff has volunteered her time every Friday to work with our software development team. Her guidance has been critical to our success developing a proprietary navigation system.



Recruiting FTC Alums
To recruit mentors and spread FIRST's mission, we created and posted flyers in STEM buildings on Brown University's campus. We were able to connect with 3 part-time mentors who are all STEM majors *and* FTC alums. The mentors met with our team for 18 hours per week, and each focused on advising our 3 working groups: programming, building, and operations.

TEAM DETAILS:

1.An integrated, multi-layered practice schedule:
- -Tuesday and Friday in school during our scheduled "enrichment" time.
- -Wednesday and Friday after school.
- -Two Saturdays including the North Kingstown Scrimmage.
- -This unique mix of after school and in-school meeting allowed team members to decide how much time they wanted to dedicate to FTC.

2. Members may choose specializations:
- -Team members got the choice to specialize in programming , building, or operations.
- -Members could choose more than one specialization that interests them.
- -By choosing a specialty mentors were able to give unique advice to members on the team.

We committed our team to being prepared for every aspect of competition. We practiced both judging presentation and matches prior to any events.

GAME STRATEGY

AUTONOMOUS	TELE-OP	END GAME
Place freight box on level three of the alliance shipping hub	Move freight to shipping hubs	Spin carousel wheel
Park in the warehouse	Place a freight block on shared hub to tip the hub	Move robot back to warehouse

ACTIONS:	Auto: Freight in Lvl 3	Auto: Park in Warehouse	TeleOp: Freight in Shipping Hubs	End Game: Bring duck from Carousel	End Game: Park in Warehouse
POINTS PER ACTION:	6	10	6	6	6

WEIGHTED POINT VALUE BREAKDOWN

Points	Freight at Alliance Storage	Freight at Shipping Hub lvl 1	Parked on Closest Warehouse	Parked on Storage Unit	Freight at Shared Hub	Freight at Shipping Hub lvl2	Delivering Duck or Shipping Element	Freight at Shipping Hub lvl 3	Parked in Storage Unit	Parked in closest warehouse	Balanced Shipping Hub	Parked in Closest Warehouse	Deliver Duck	Team Marker Fully Supported by Shipping Hub Pole / Another Team's Marker	Shared Hub Tipped to Alliance X
1	x														
2		x													
3			x	x											
4					x	x									
5															
6							x	x	x	x					
7															
8															
9															
10											x	x	x		
15														x	
20															x
End Game															
Auto															

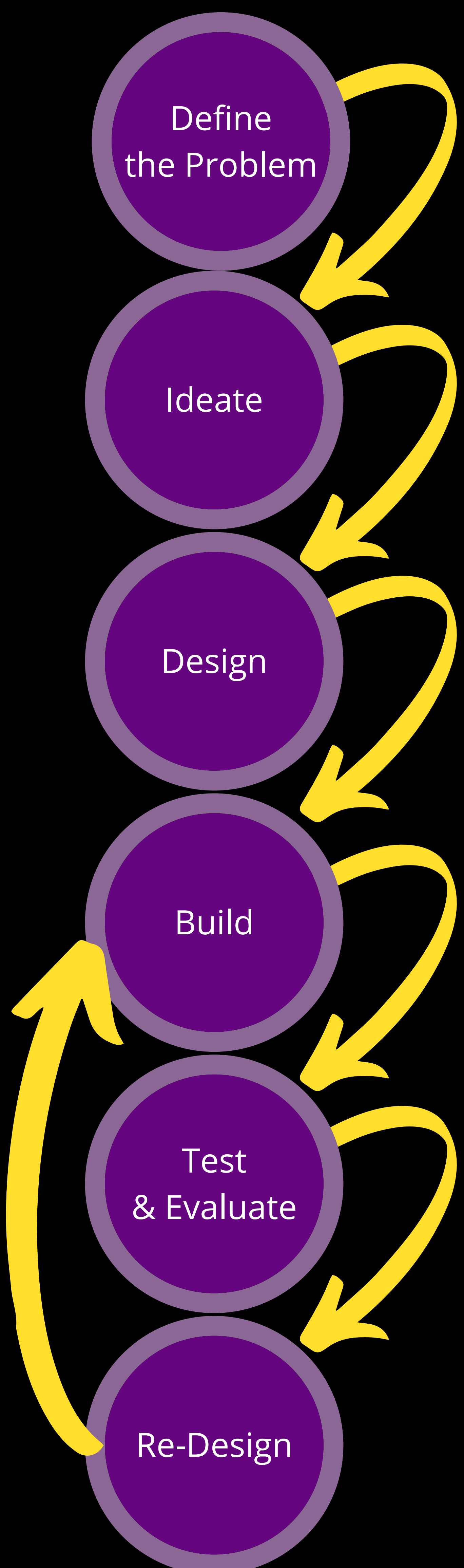
SCORE BREAKDOWN BY PERIOD

Auto		End-Game	
Play	**Point Value**	**Play**	**Point Value**
Freight at Shipping Hub - **Lvl 1**	2	Delivering Duck or Shipping Element	6
Freight at Shipping Hub - **Lvl 2**	4	Shared Shipping Hub Tipped	20
Freight at Shipping Hub - **Lvl 3**	6	Balanced Shipping Hub	10
Freight at Shared Hub	4	Alliance Shipping Hub Capped	15
Freight Completely in Aliiance Storage Unit	1	Parked **Completely** in Warehouse	6
Parked **on** Closest Warehouse	3	Parked in a Warehouse	3
Parked **on** Storage Unit	3		
Parked **in** Storage Unit	6		
Parked **in** Closest Warehouse	10		
Deliver Duck	10		
Bonus			
am Scoring Elem. Used to Detect Shipping L	20		
Duck Used to Detect Shipping Lvl	10		

Driver-Controlled	
Play	**Point Value**
Freight at Shipping Hub - **Lvl 1**	2
Freight at Shipping Hub - **Lvl 2**	4
Freight at Shipping Hub - **Lvl 3**	6
Freight **Completely** in Storage Unit	2
Freight **Completely** on Hub	6

When the Frieght Frenzy game was announced, our Operations subteam started to analyze the overview video and official game manuals to create scoring breakdowns. They shared this information with the rest of the team so we could prioritize scoring opportunities before designing our robot.

OUR DESIGN PROCESS



Define the Problem:
We identify the engineering challenges that we need to overcome, the requirements that must be adhered to, and any constraints that we must consider.

Ideate:
As a group, we brainstorm to come up with as many solutions as possible. We also research what other solutions exist.

Design:
Next, we select ideas and sketch possible designs in further detail. Drawings are made, both by hand and with CAD, to express dimension, form and function.

Build:
Using our detailed plans, we assemble prototypes that align with a design's requirements and constraints.

Test & Evaluate:
Prototypes are then evaluated through testing. We collect data on performance and note down any significant strengths and weaknesses that show themselves.

Re-Design:
Using what we learned, we go back to the design stage to improve our product, and iterate until our design goals are met.

DESIGN TIMELINE

9/21 MEETINGS BEGIN: Scoring breakdown analysis conducted

9-10/21 ROBOT 0: First two chassis designs tested

11/21 ROBOT 0: Initial gripper intake design constructed

12/21 ROBOT 0: Final chassis design assembled | 2nd gripper evaluated

1/22 ROBOT 1: 2nd robot concept fully designed in CAD prior to fabrication

1/22 ROBOT 0: Virtual 4-bar linkage arm & final intake design established

2/22 EVENT: Robot 0 competes in NK Scrimmage event

2/22 ROBOT 1: Custom intake bed & deposit bucket 3D printed

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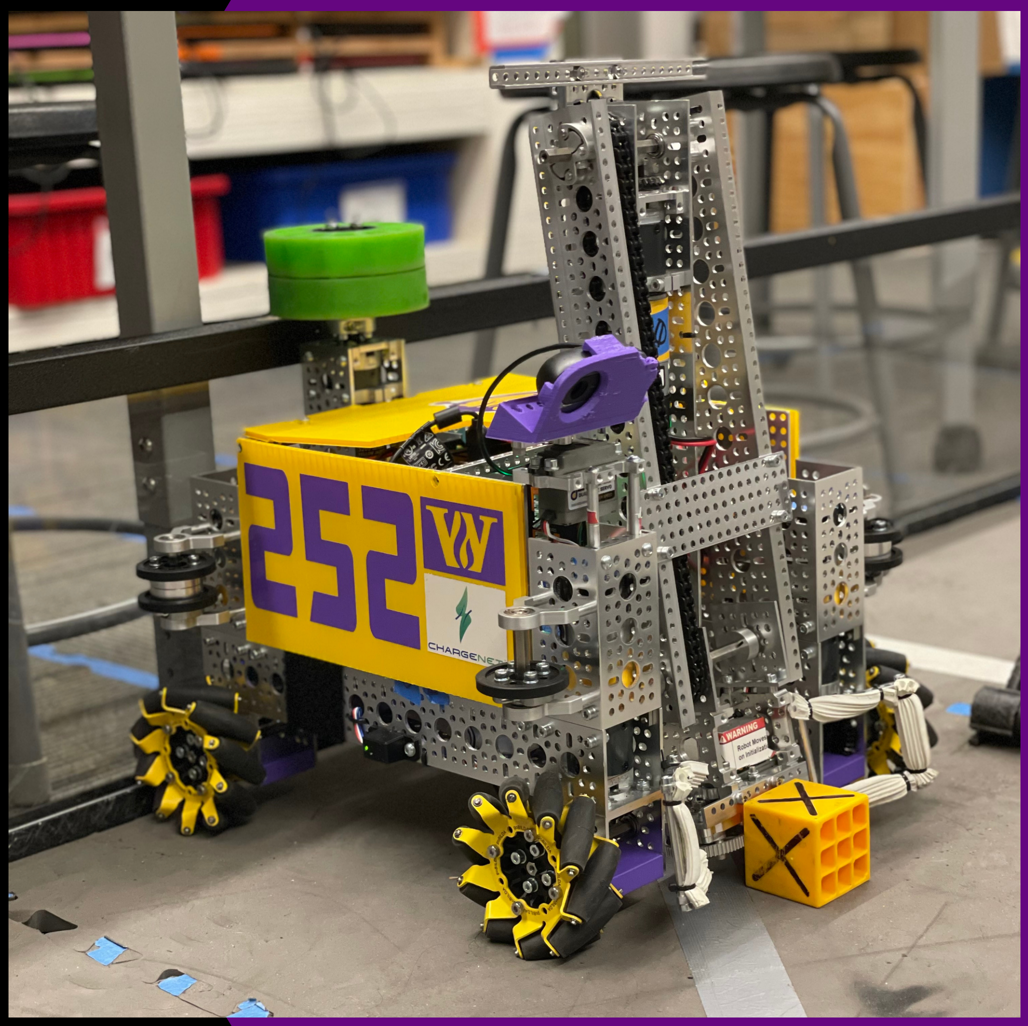
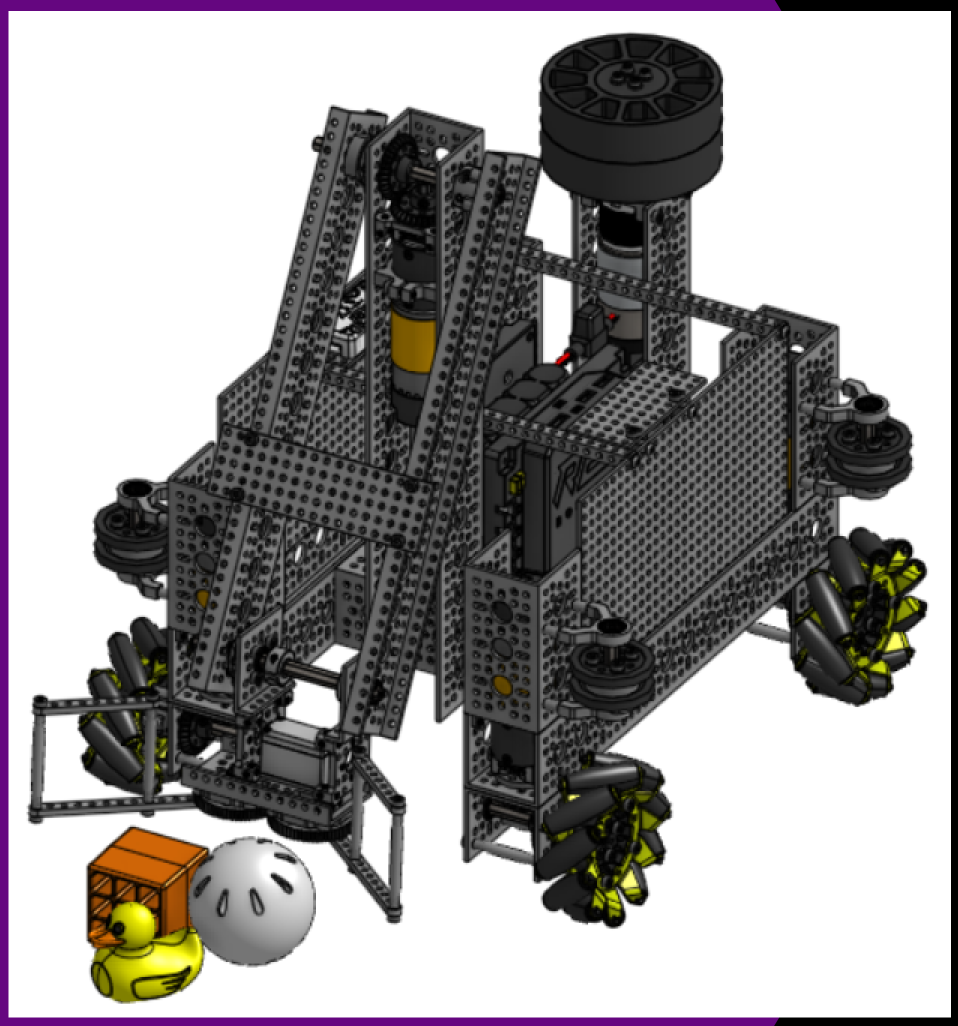
Our design journey resulted in the construction of two robots, "Robot 0" and "Robot 1". The first robot was developed from September through March, and the second robot began development in January, as a branch-off of the original design. Through testing and evaluation, we determined that our first design, Robot 0, was our best solution for Freight Frenzy match play.

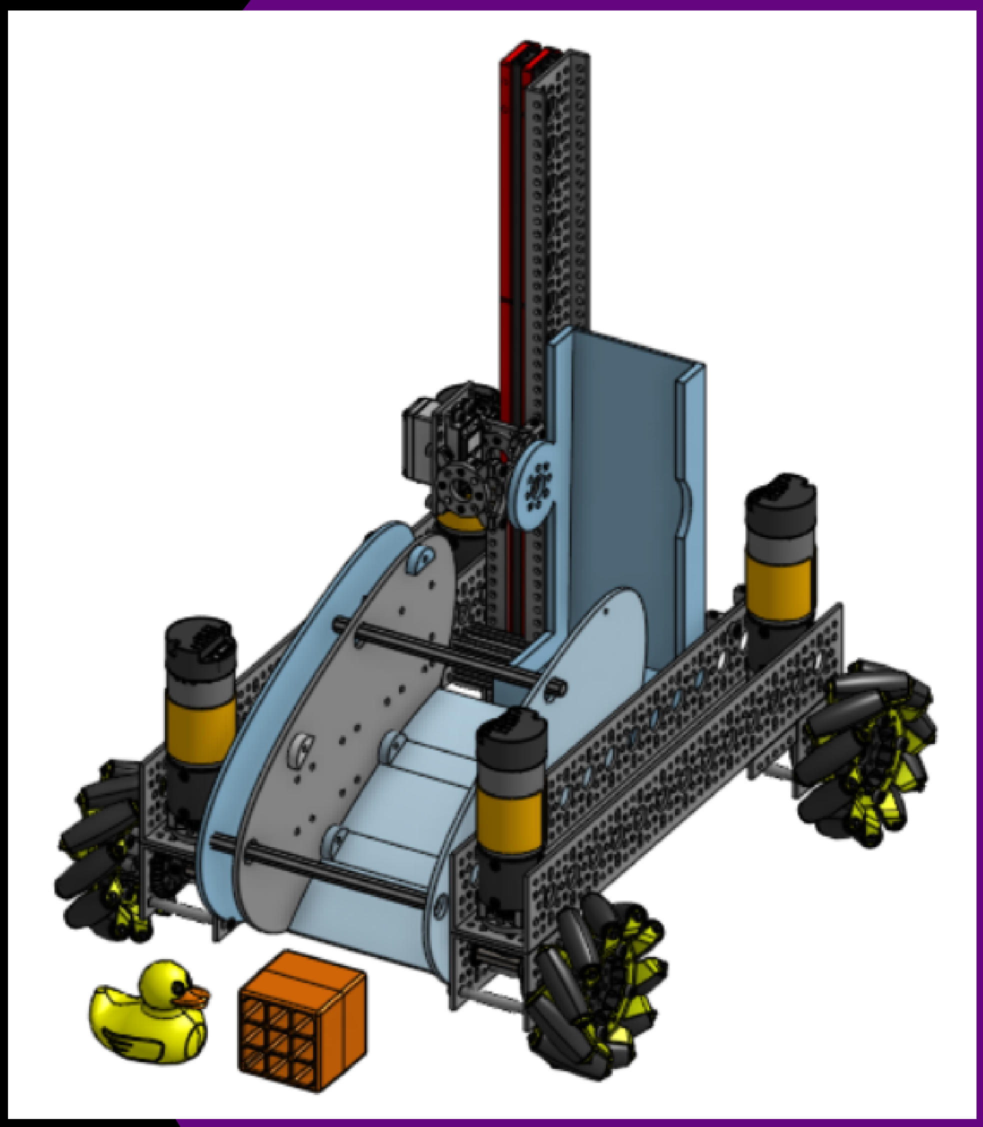
ROBOT 0

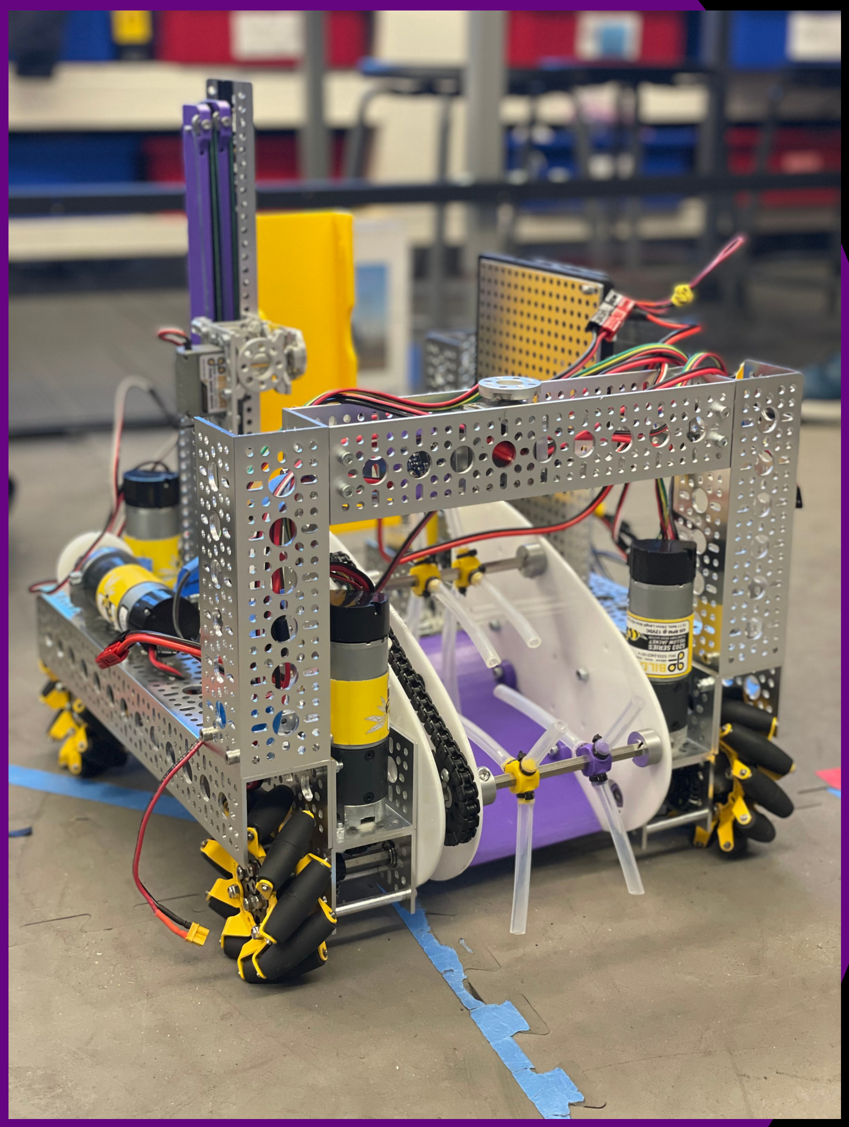




Our first design was Robot 0, made for early scrimmages and qualifiers, both of which were unfortunately cancelled. Our intent with this bot's design was to make a quick-to-assemble, simple, sturdy and reliable machine that we could use in the more urgently-approaching events. We plan on keeping this model assembled for future practices and presentations. The initial stage of this design was completed very early on, and we continued to iterate and improve its functionality over the entire season.

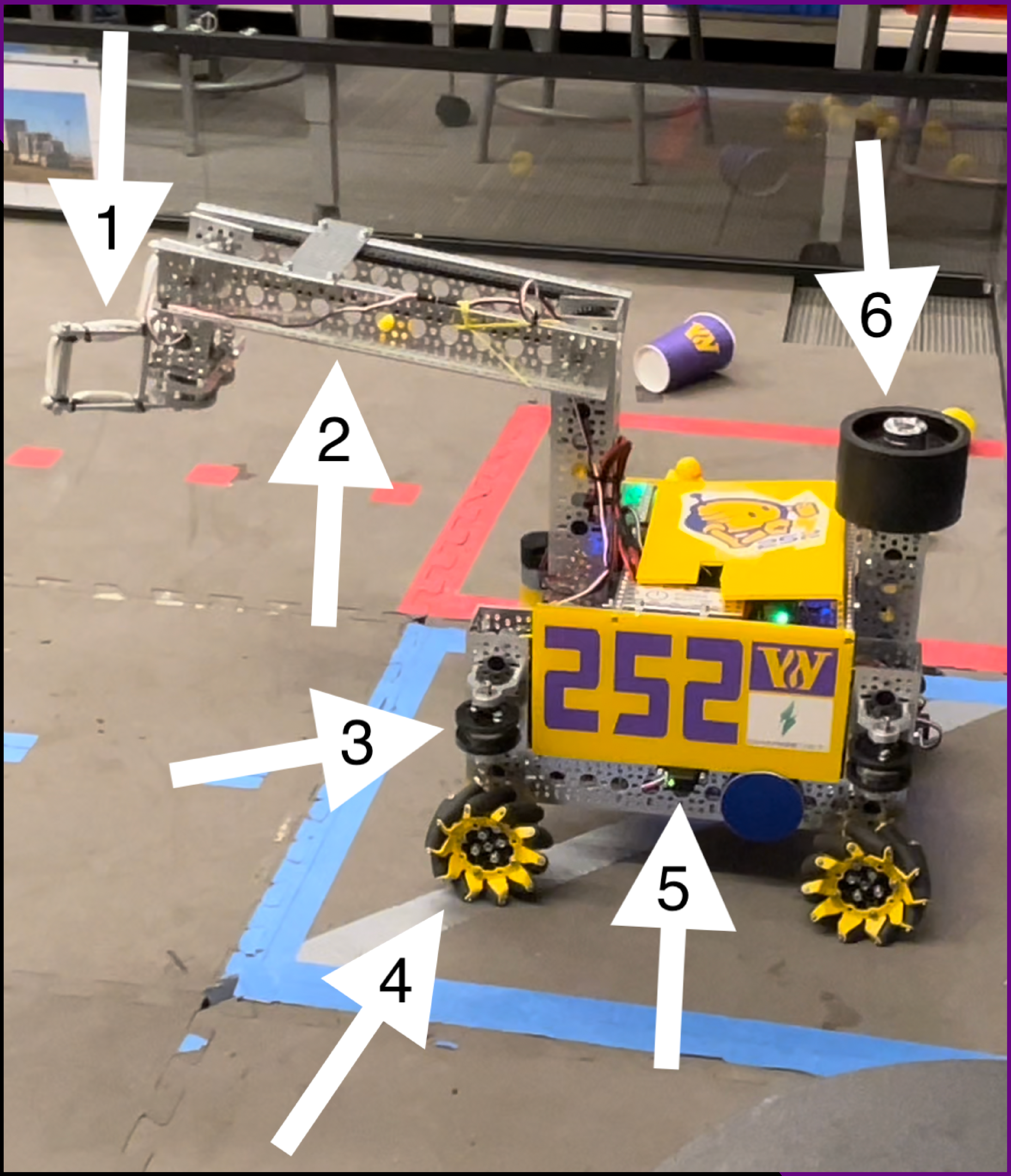
ROBOT 1





Building off of what we learned with Robot 0, Robot 1 was designed with more advanced engineering concepts in mind, and intended for a higher level of competition at the season's end. Our goal was to design a robot with a faster freight scoring cycle time and improved accuracy. We employed an active intake and linear slide and servo deposit mechanism for this goal.

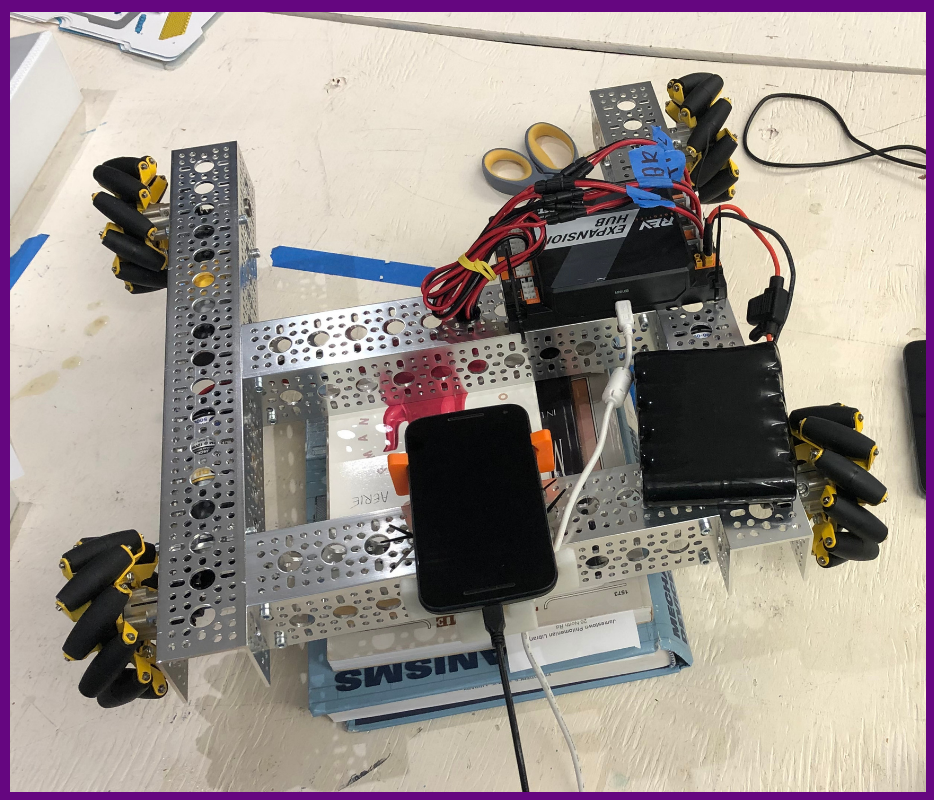
ROBOT 0 : OVERVIEW



Mechanical Design Highlights:

1. Our claw has a wide-sweep gripper that can grasp all game element types.
2. Our arm features a custom designed, virtual 4-bar linkage.
3. "Wall-ride" bumper wheels ensure smooth navigation between barriers.
4. Mecanum drivetrain features 4, 13.7:1 gearmotors (435 RPM @12V) for maximum speed and maneuverability.
5. Body-lift wheelbase design raises the chassis ride height 1" off the field, allowing the robot to traverse gamefield barriers. The chassis footprint (16" x 13.75") also allows us to easily navigate between gamefield barriers and wall, and aids in obstacle avoidance.
6. Carousel spinner designed with a single 19.2:1 gearmotor (312 RPM @12V) features 2 high-grip wheels for 2 inches of contact tolerance with the carousel.

ROBOT 0 : CHASSIS



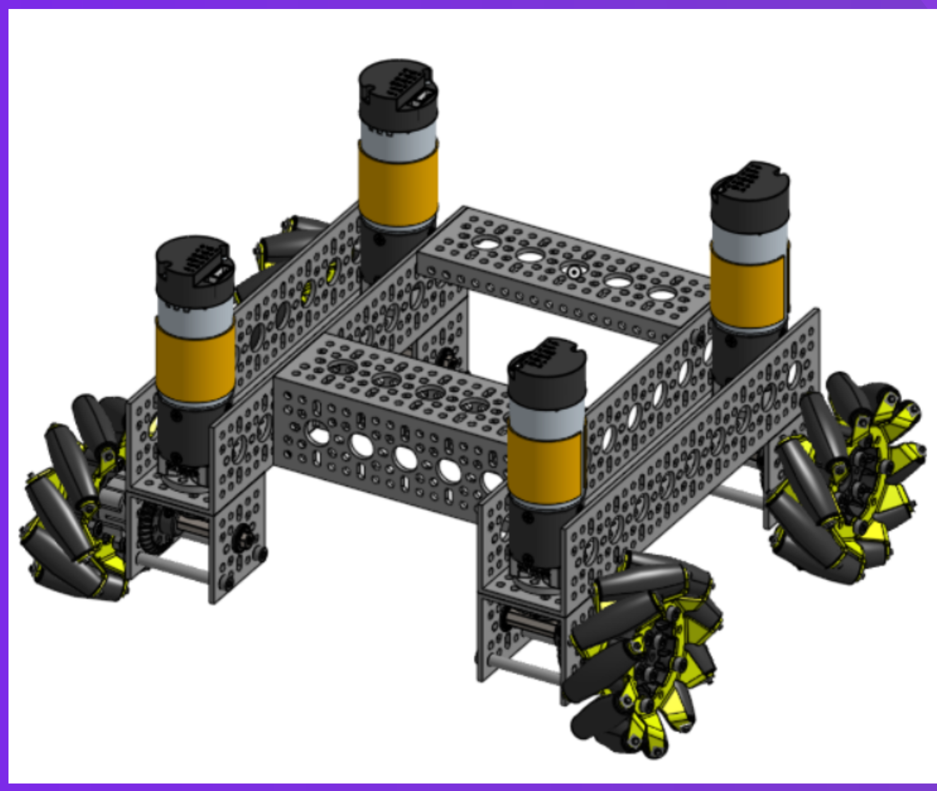
First chassis - *An efficient, open plan*

Strengths:

- Motors mounted inside channel to save space
- Plentiful mounting space for sub-systems and mechanisms

Weaknesses:

- Chassis footprint too wide to avoid the barrier 18" x 18"
- Wheelbase too low to drive over barrier



Second chassis - *A nimble, square base*

Improvements:

- Ultra-compact footprint - 13" x 13"
- Lightweight and fast
- Raised, body-lift wheelbase can scale the field barriers

Weaknesses:

- High-center of gravity: easy to tip over once arm and claw was attached
- Limited attachment points for electronics and mechanisms

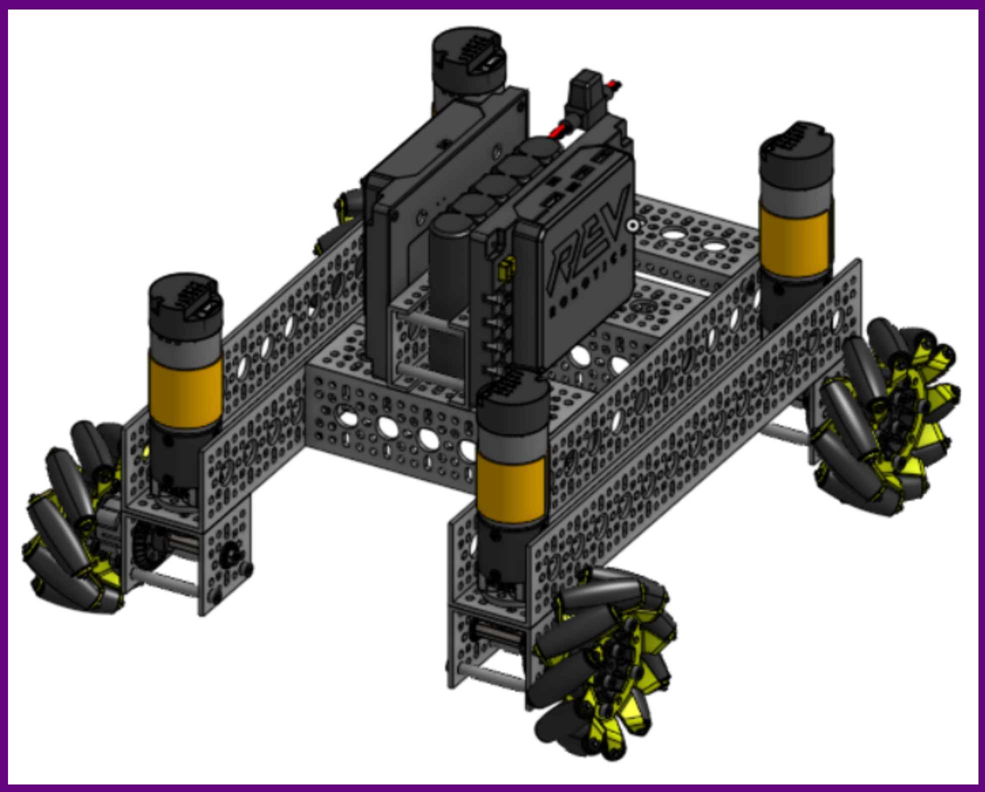
Third chassis - *A balanced, dual-threat alliance partner*

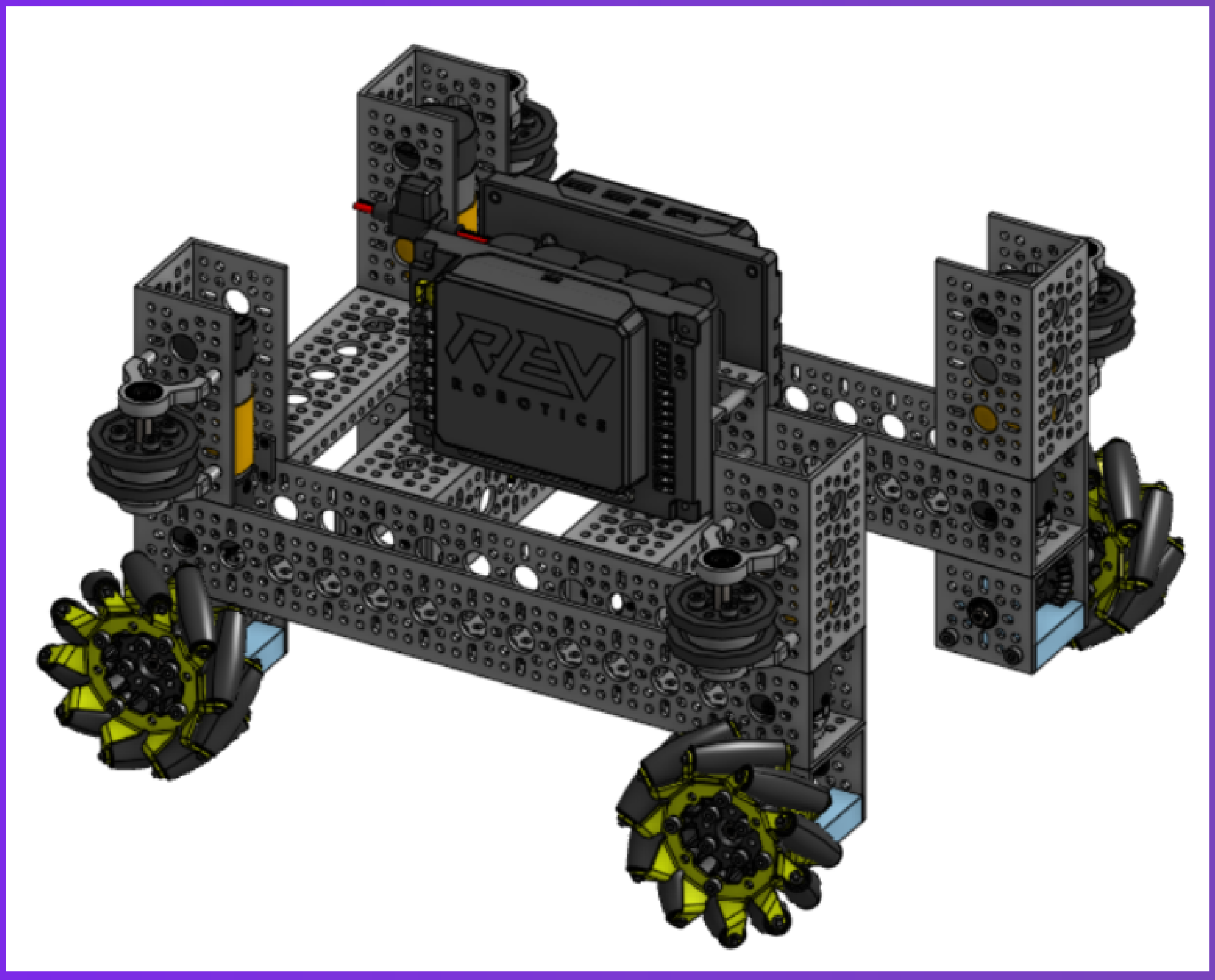
Improvements:

- Extended length 13" x 18" stabilizes center of gravity eliminating tip over
- Densely designed and centered control system and battery sub-assembly

Weaknesses:

- Unprotected mecanum wheels grind against the metal field perimeter
- Exposed drivetrain motors at risk of impact damage





Final chassis - *Our final revision*

Improvements:

- Shielded drivetrain motors
- Four, dual-48mm wall-ride wheels assemblies assist barrier avoidance at high speed
- Custom designed, 3D printed chassis end caps prevent the game field barrier anchor spikes from hooking into the robot

ROBOT 0 : ARM

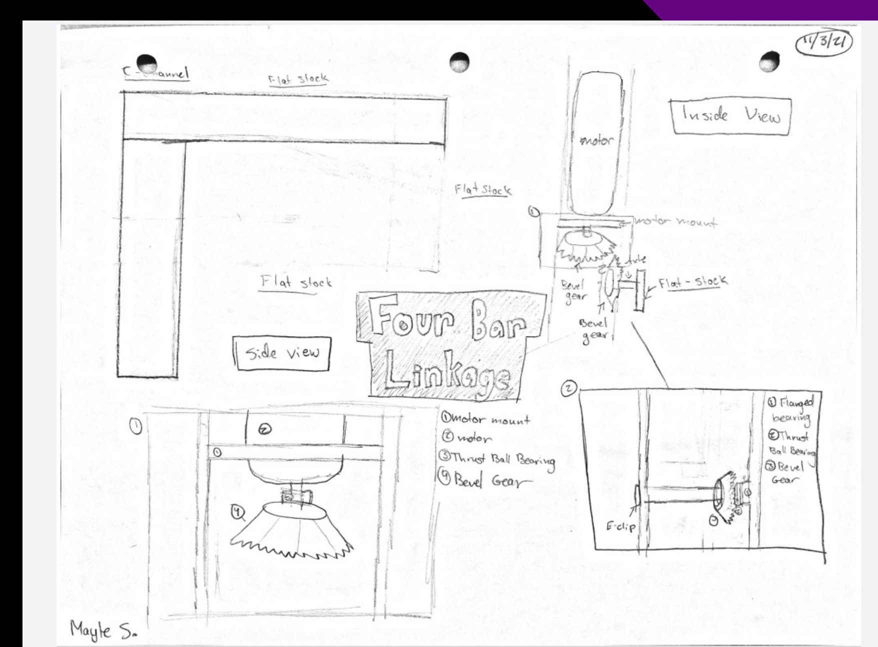
First Arm - *Traditional 4-Bar Linkage*

Strengths:

- 4-bar design ensures end effectors remain parallel to the floor at all times
- Prototyped with LEGO to explore design concept quickly

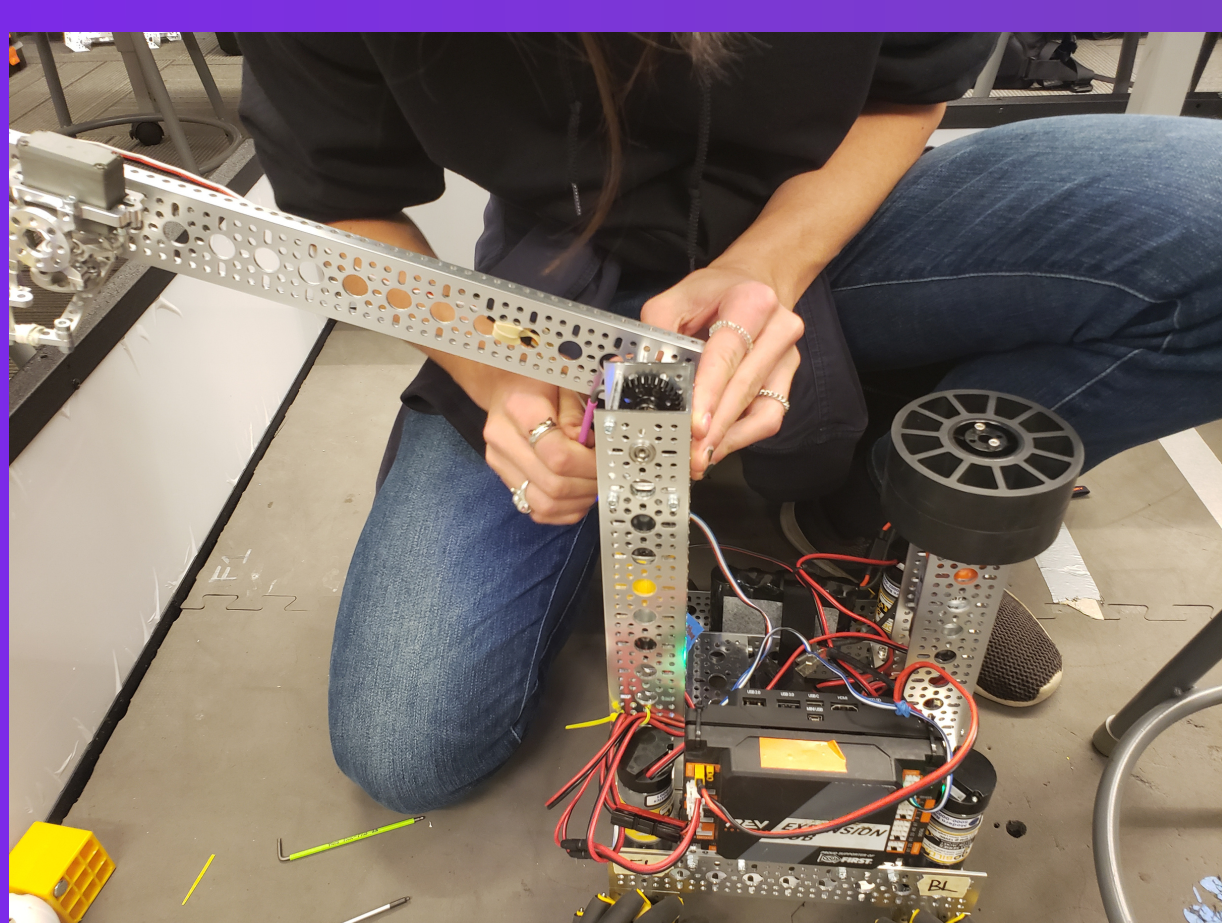
Weaknesses:

- Too bulky, risking an unbalanced robot



plan sketch

side view



Second Arm - *2-Bar Linkage*

Improvements:

- Designed for compact simplicity with single, high-torque gearmotor
- 2-bar design is lightweight

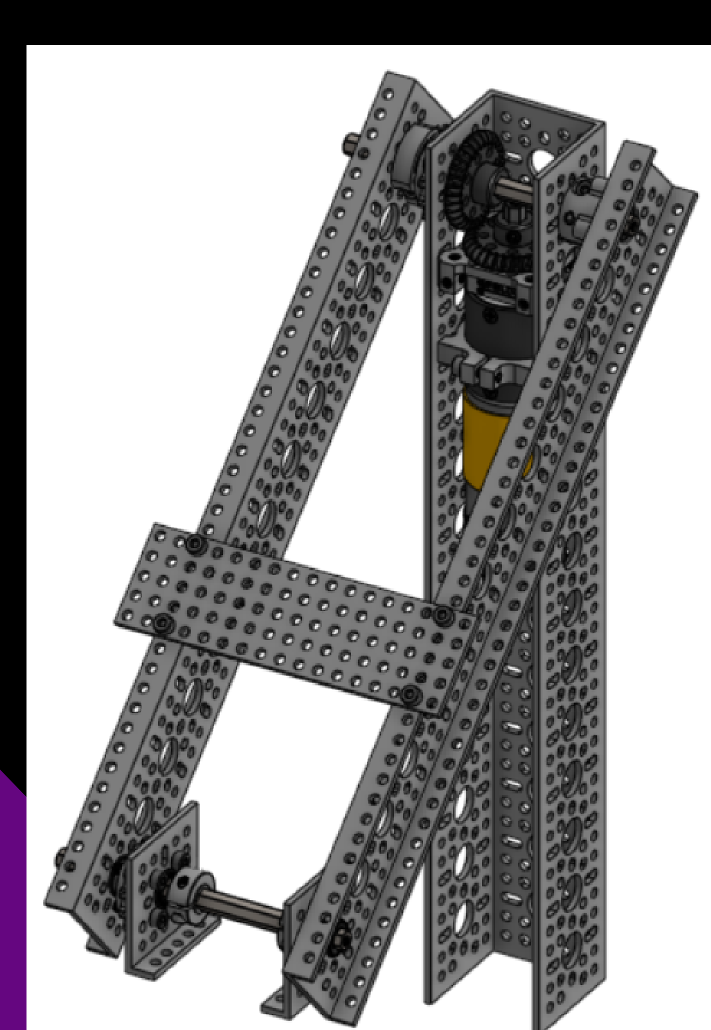
Weaknesses:

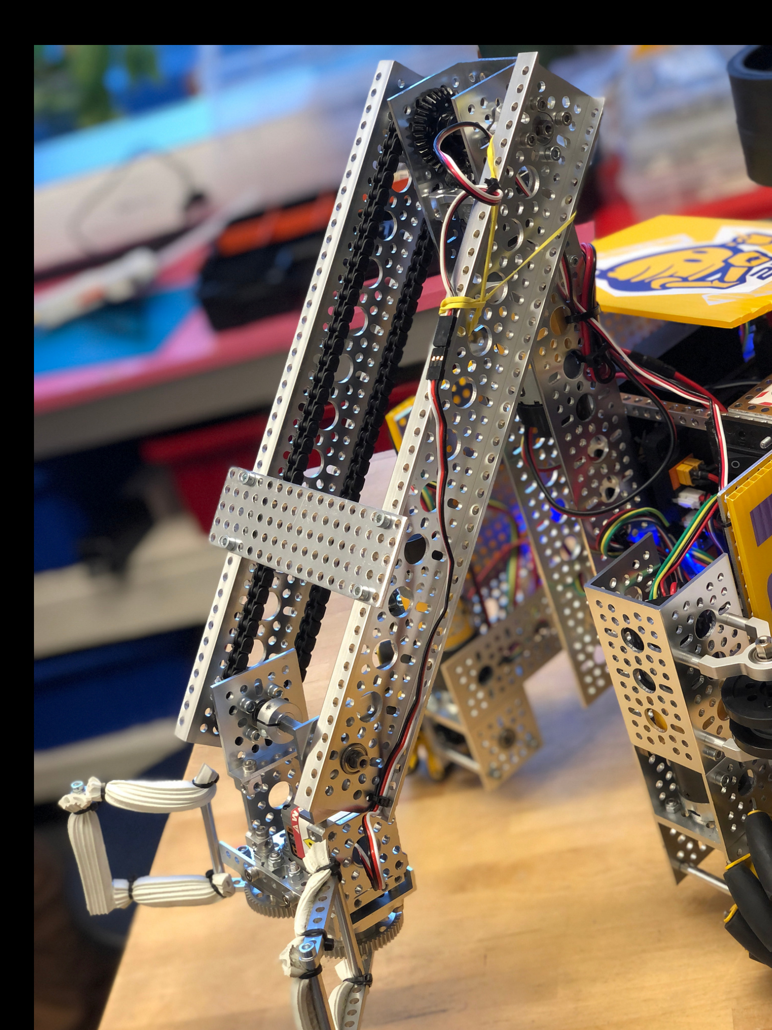
- Limited positional accuracy deemed to be ineffective
- Arm end often sunk into competition mat during driving
- End effector mounting is cantilevered, introducing a torsion risk upon impact

Final Arm - *Virtual 4-Bar Linkage*

Improvements:

- Custom, compact design employs a fixed sprocket and chain to ensure gripper intake is always level at any arm height
- Balanced 2-post mounting point for end effectors reduces torsion on gripper intake





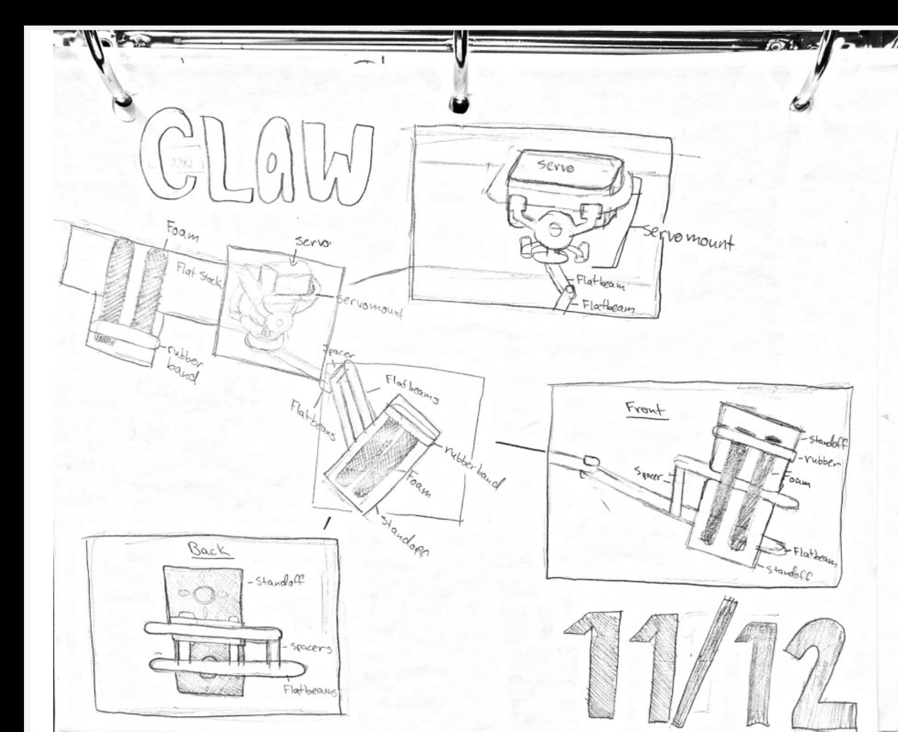
isometric view (CAD left, real arm right)

ROBOT 0 : GRIPPER

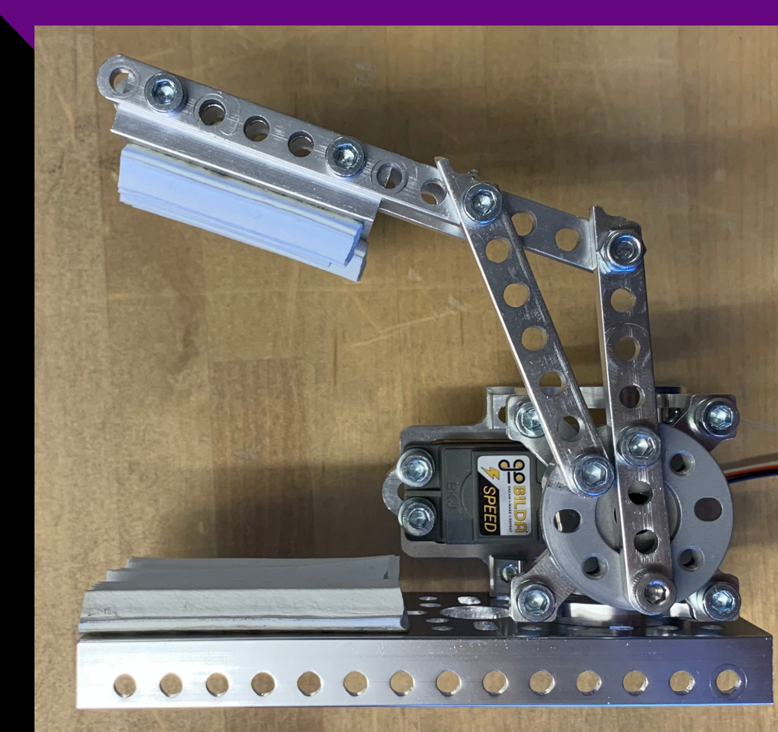
We pursued an elegant, passive intake solution for our initial robot design, knowing that a well-practiced drive team would perform very well under the single-piece-possession gameplay constraints of Freight Frenzy.

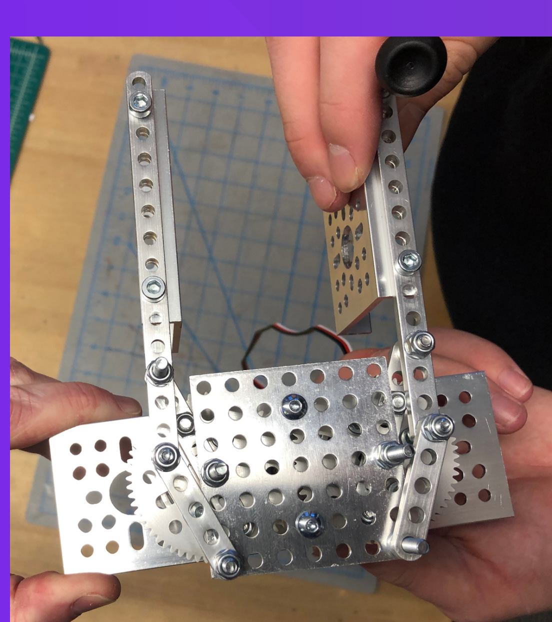
First Gripper

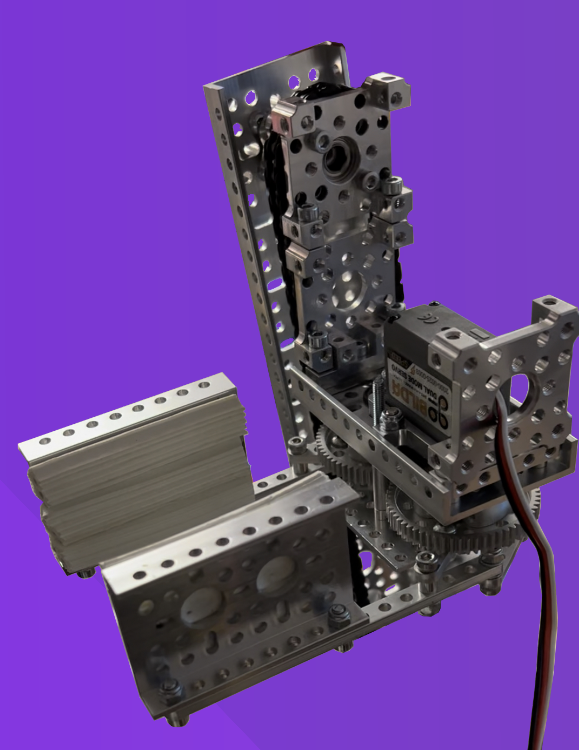
- Single jaw, servo-electric gripper
- Easy to get started, but ultimately limited at capturing variable game elements



plan sketch


side view


bottom view

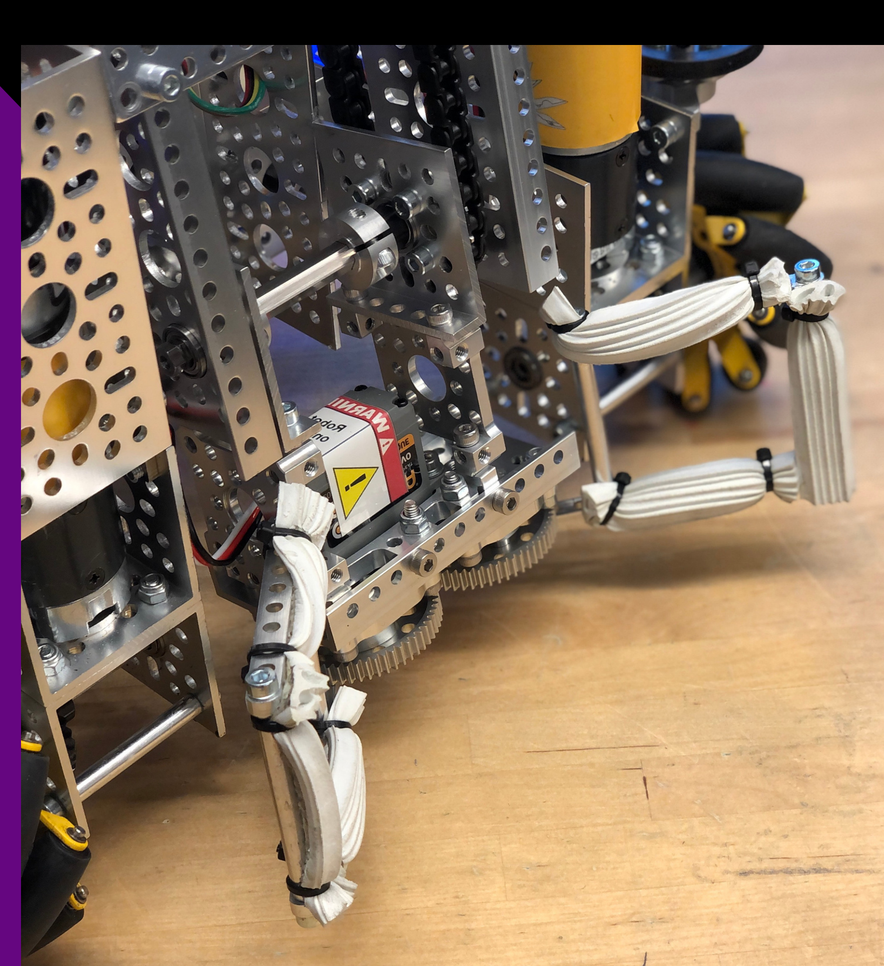

isometric view

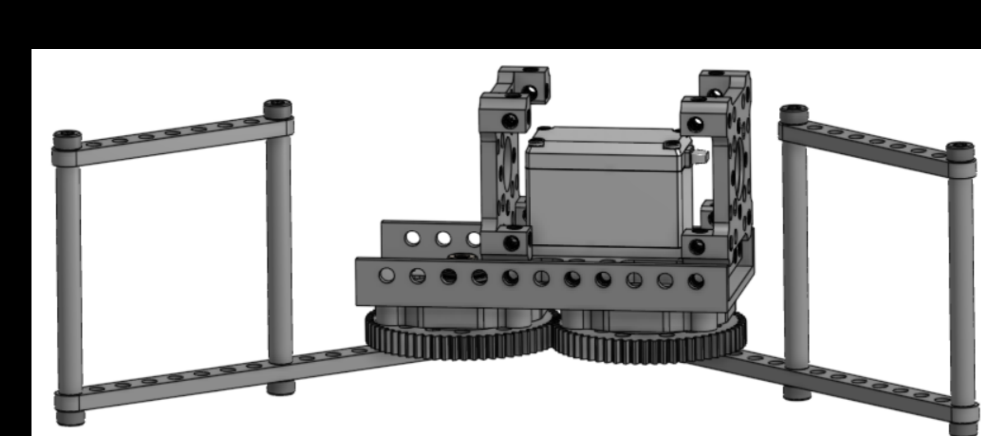
Second Gripper

- 4-Bar Linkage, parallel gripper with wide jaws
- A swift piercing, parallel action, but bulky and prone to lock up and skipping

Final Gripper

- Widest jaw sweep
- Padded, open frame captures highly variable game elements
- Fully bearing-constrained for maximum grip strength

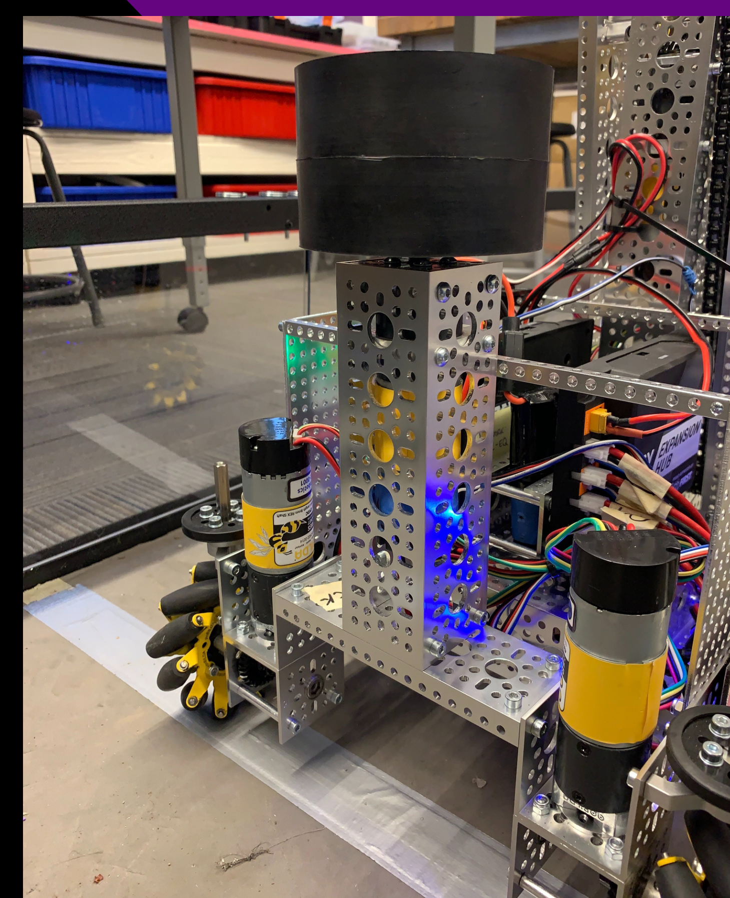

isometric view


front view

CAROUSEL SPINNER

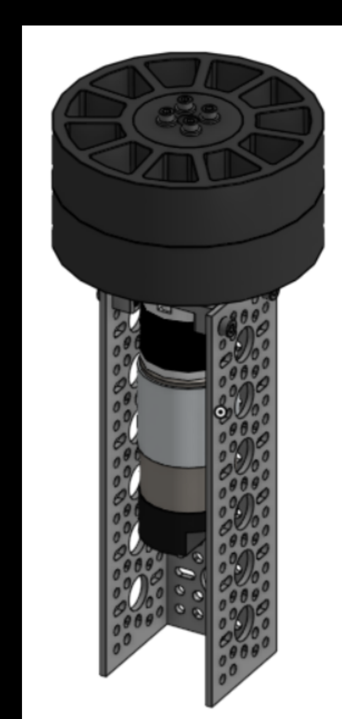
OVERVIEW

A stack of compliant wheels mounted on the back of Robot 0. It's one of the most efficient and effective ways of scoring ducks from the carousel during Endgame, and we haven't had to change it since its addition to the robot. Sometimes, simplicity is best.

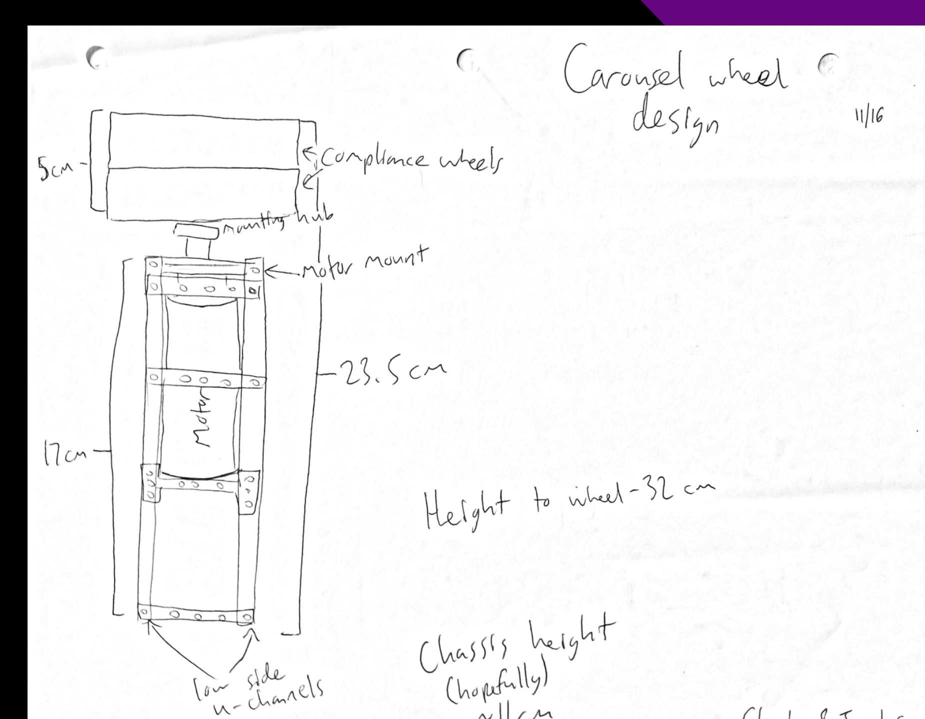


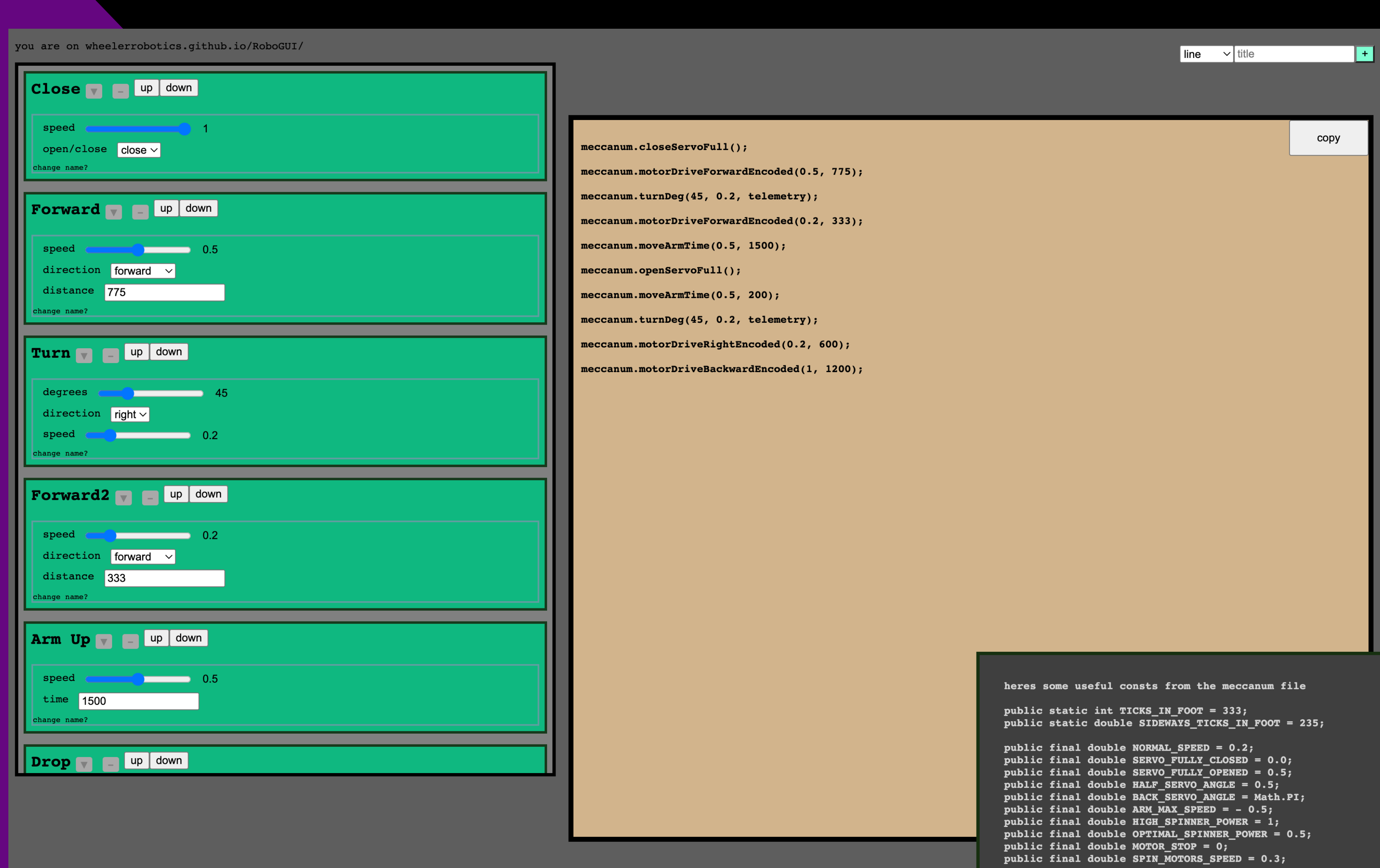
PROCESS

The simplicity of the carousel spinner also served another useful purpose: To introduce our newer members to the materials used in FTC, and give them a chance to try out the design process on their own for the first time.



isometric view





CUSTOM BLOCK CODING WORKSPACE

Feel free to stop by our table if you want to try this out!

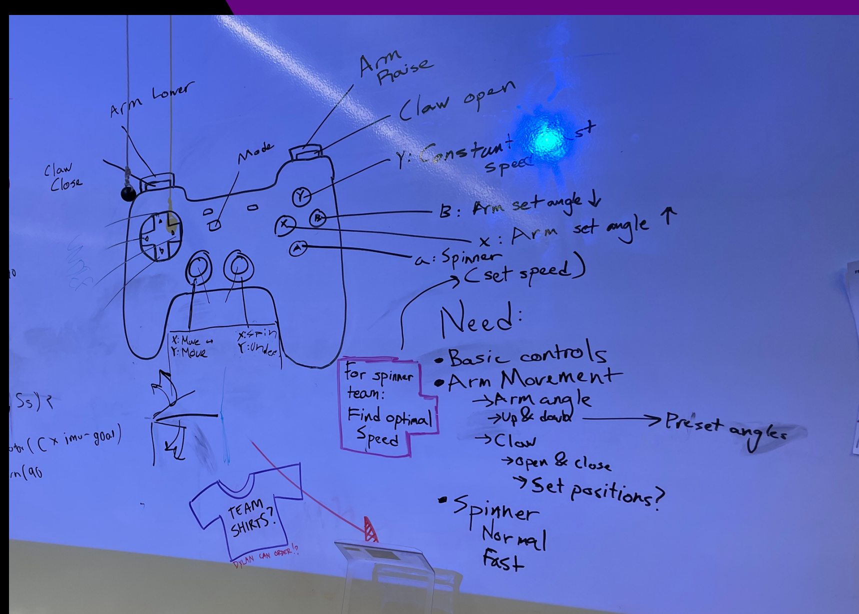
Program

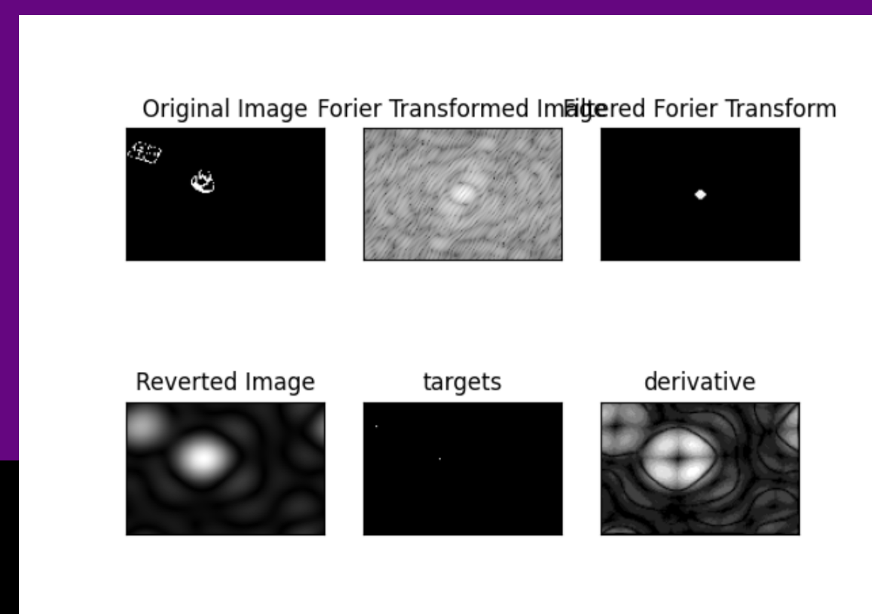
Using HTML, CSS, JavaScript and a Node.js webserver, we created a custom block coding environment, similar to MIT's Scratch, so that non-developers can create autonomous programs for the robot.

How To Use

First, select the movement in the top left of the window that you want (drive forward, turn, lift arm, etc), then add a title and click the add button. Then just adjust parameters such as speed or angle in the window to the left. You can then copy the generated code directly into the coding environment (Android Studio).

PROGRAMMING

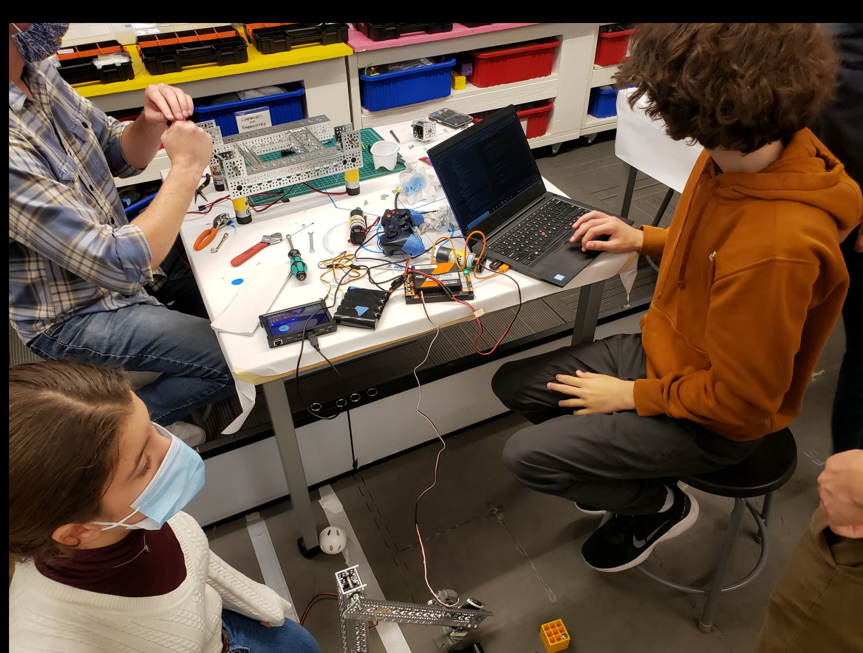

gamepad mapping



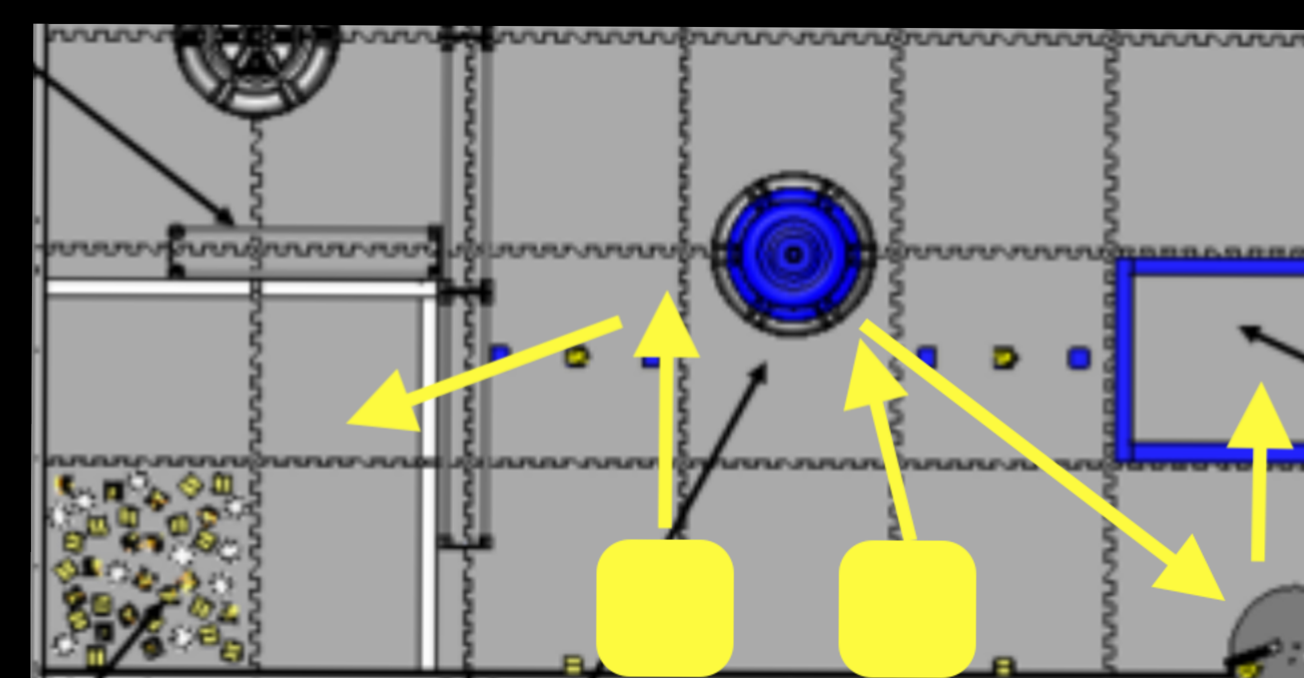
Python Fourier Transform testing

MAJOR PROGRAMMING PROJECTS

- Four autonomous algorithms
- Custom color detection
- Tensorflow object detection
- Python Fourier Transform testing
- Web application for driver automation
- Mixed sensor approach to navigation




Custom TSE color detection

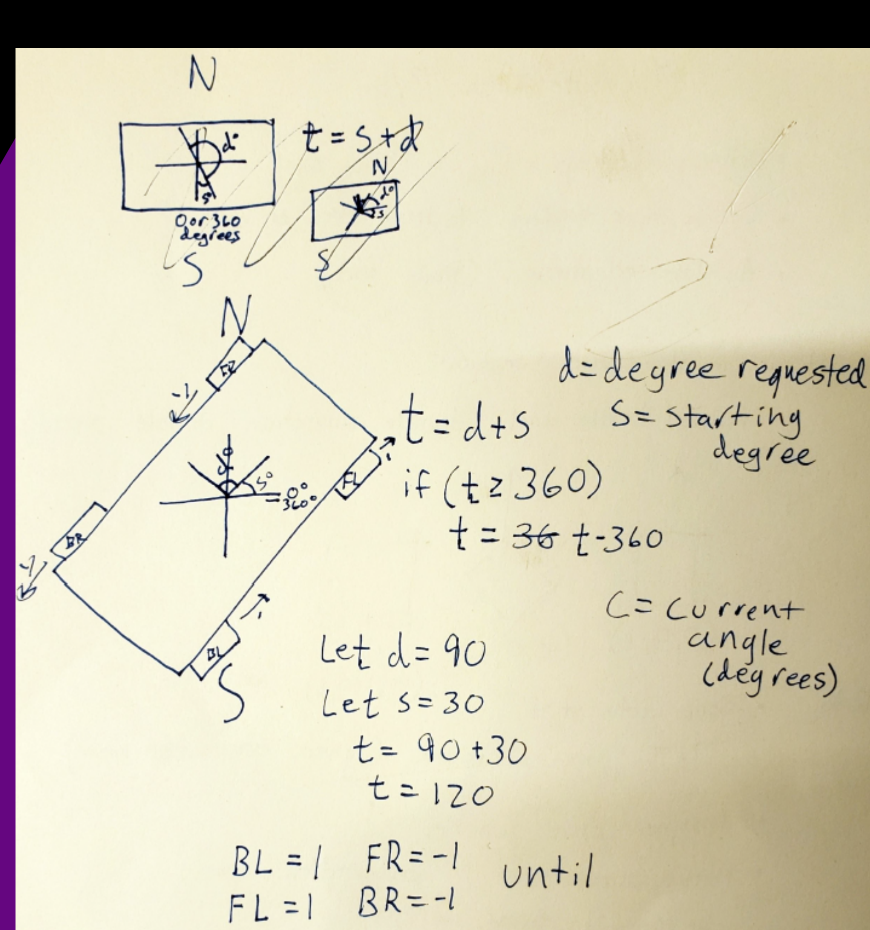

Autonomous drivepaths routes

This season we developed four autonomous op-modes, (one for each starting position) as well as 2 human-controlled tele-op op-modes (one for two drivers, and one for a single driver).

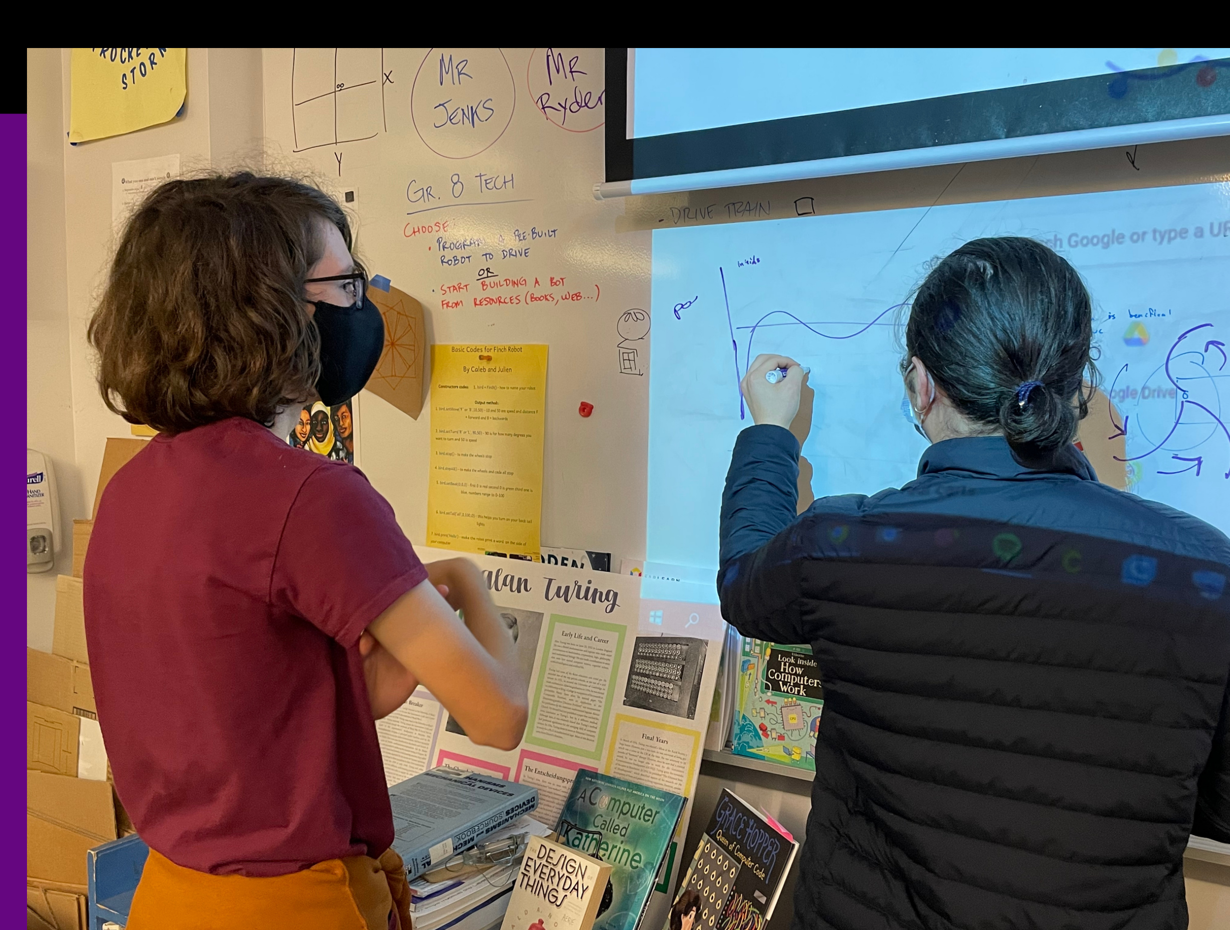
During the Autonomous Period, we use our webcam to detect the position of our team scoring element using a custom color detection algorithm. Once determining what level to place our pre-loaded block, our robot follows a predetermined path which incorporates encoder feedback and data from time-of flight IR sensors to accurately place our robot. With this code structure, we can reliably place our pre-loaded block on the level (of the shipping hub) indicated by our team scoring element. We then can reliably park in the warehouse, park in the storage area, and spin the carousel. We usually earn 36 points during autonomous. An image of our route is above.

Our controls during tele-op are split between two drivers. The first driver moves the robot in any direction, taking advantage of our mecanum drivetrain, and the second driver controls the arm, gripper, and carousel spinner.

We also experimented with computer vision techniques such as using a Fourier Transforms to detect shipping elements and their positions. We wrote this in Python but will be able to translate it to Java for future seasons.

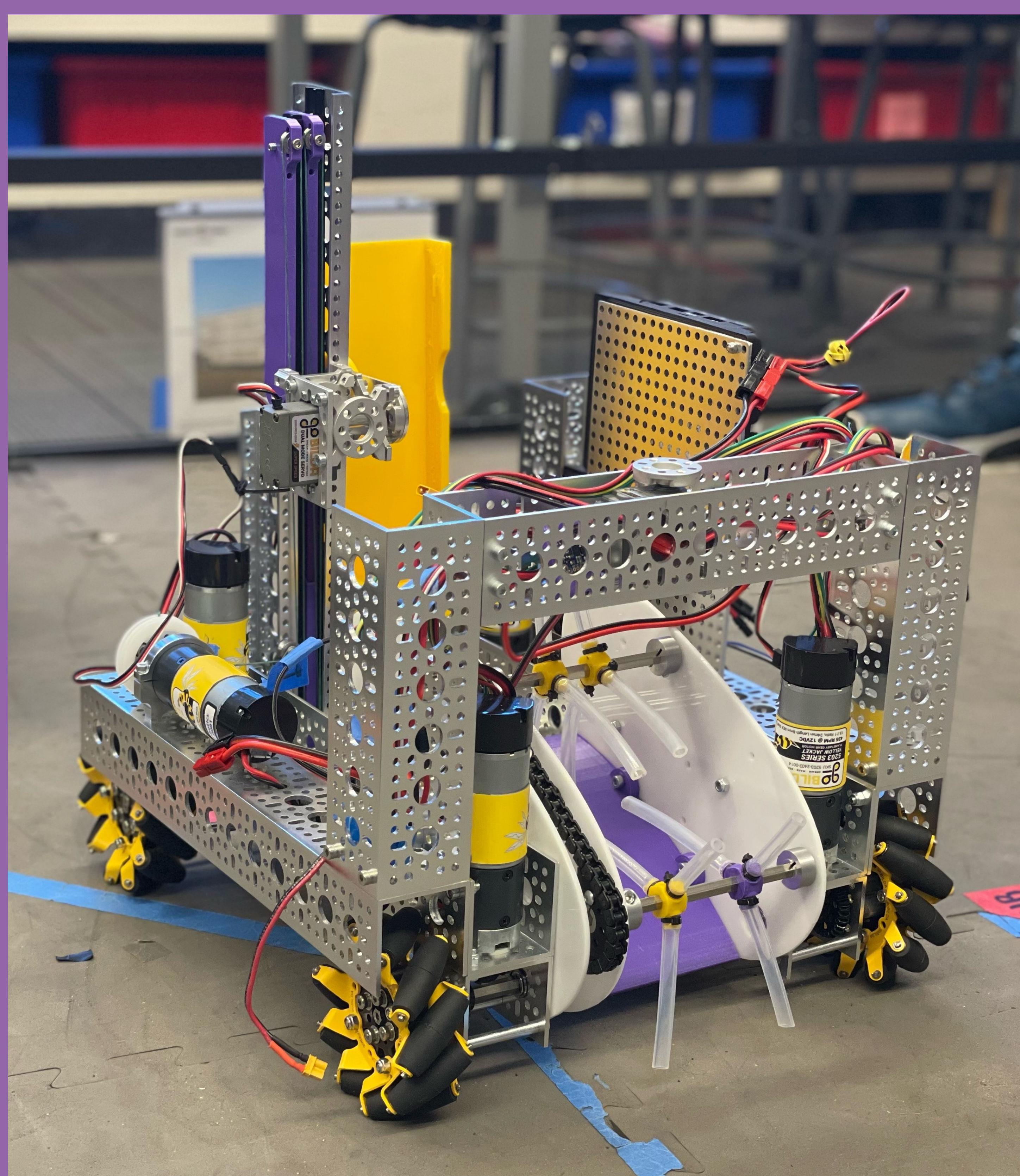


driving angle calculations



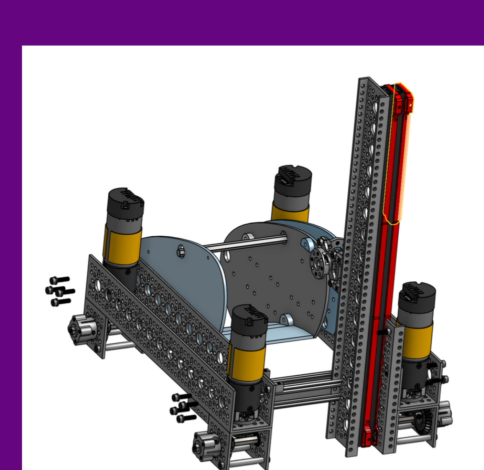
ROBOT 1 : OVERVIEW

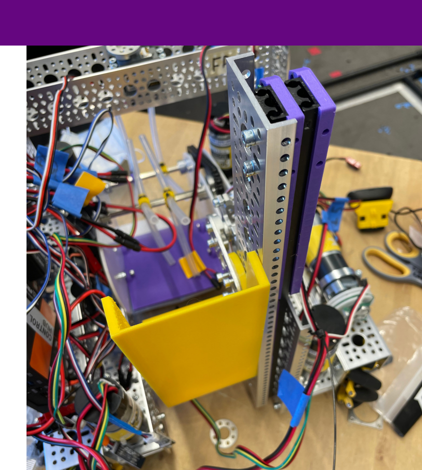
After finishing the bulk of our first robot, Robot 0, we began development of a second robot, Robot 1. Using what we learned from the first we have refined the design to optimize for maneuverability and ease of use. The main difference between our designs is that Robot 1 has an active intake which decreases the time it takes for us to pick up freight. We will not compete with this robot during the State Championship, but will continue to develop it after the event.



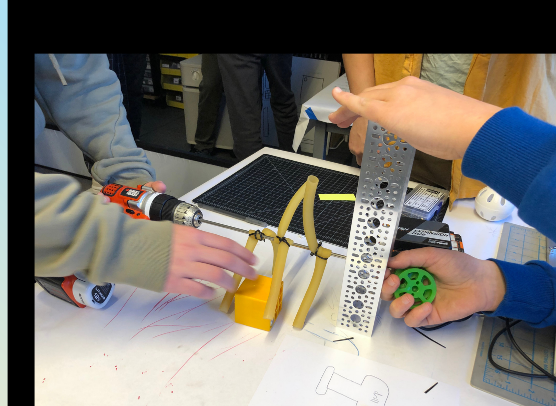
Custom 3D-Printed Freig Bucket:
To deposit freight onto the hubs, we designed a custom bucket which attaches directly to our servo.

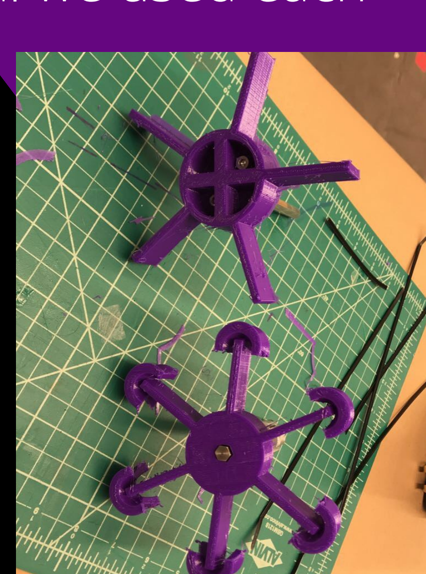
Linear Slide System:
Our linear slide system in conjunction with our custom Cargo Bucket was designed to cut down on scoring cycle-time.





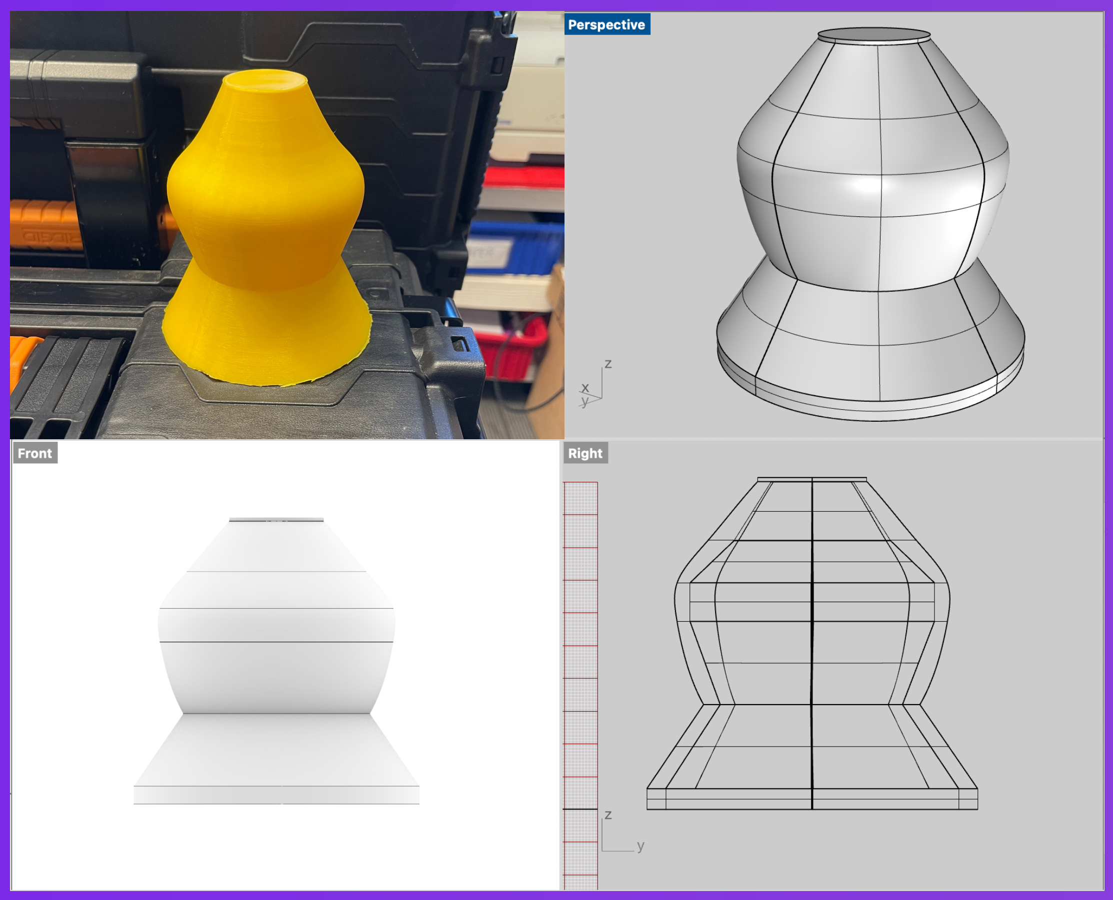
Active Intake:
While developing our intake, we tested many custom intake wheels, modifying the design and material we used each iteration.





DIGITAL FABRICATION

A large growth area for our team this year was the increase in our CAD and digital manufacturing skills. Team members used an array of tools including RHINO, Onshape, and Fusion360 to develop custom parts for our robots. Parts were fabricated with 3D printers and a laser cutter.

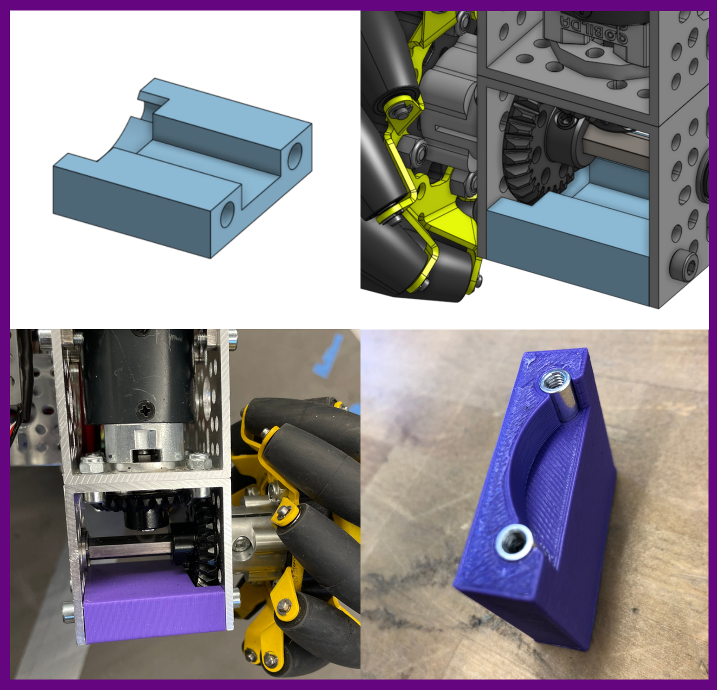


Team Shipping Element

- Our custom Team Shipping Element (TSE) allows us to double cap during the End Game portion of match play.
- The TSE was designed in RHINO and printed with PETG plastic for strength and rigidity.

Robot 0 & 1: Chassis End Caps

- We developed custom designed, 3D printed chassis end caps prevent the game field barrier anchor spikes from hooking into the robot.
- These were designed with Onshape to house two standoffs and nest around a bevel gear on each drive motor.
- End caps were printed with PETG plastic for resilience in the face of frequent impacts.



Robot 1: Custom Entraption Intake Wheels

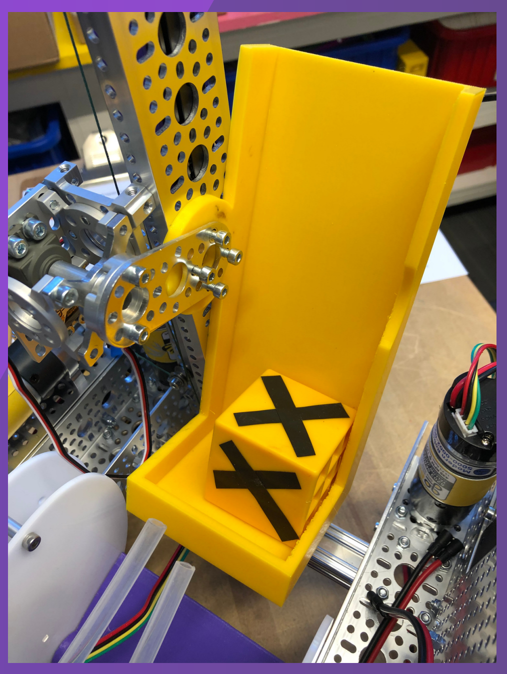
- We tested 5 original designs for custom entraption intake wheels for our active intake robot (Robot 1).
- The wheels were designed in Autodesk Fusion 360 to fit over 8mm hex shaft.
- All intakes were printed with TPU (flexible filament) to have strong but compliant flex.

Robot 1: Freight Pass-through

- Our active intake design features a custom travel path for freight.
- All 4 components were designed with Onshape.
- The 3 side-walls are laser cut Acrylic sheet, and the floor is PETG plastic.

Robot 1: Freight Deposit

- The freight-scoring deposit acts at the end of a linear slide mechanism.
- The deposit was designed with Onshape and printed with PETG plastic.



OUTREACH

Ben Hescott, professor & associate dean of undergraduate education at Northeastern.

We invited Mr. Hescott to present to our team and the broader Wheeler community on Dijkstra's Algorithm, an algorithm used for pathfinding.

Jon Schechter, Business Development Manager at AutoStore.

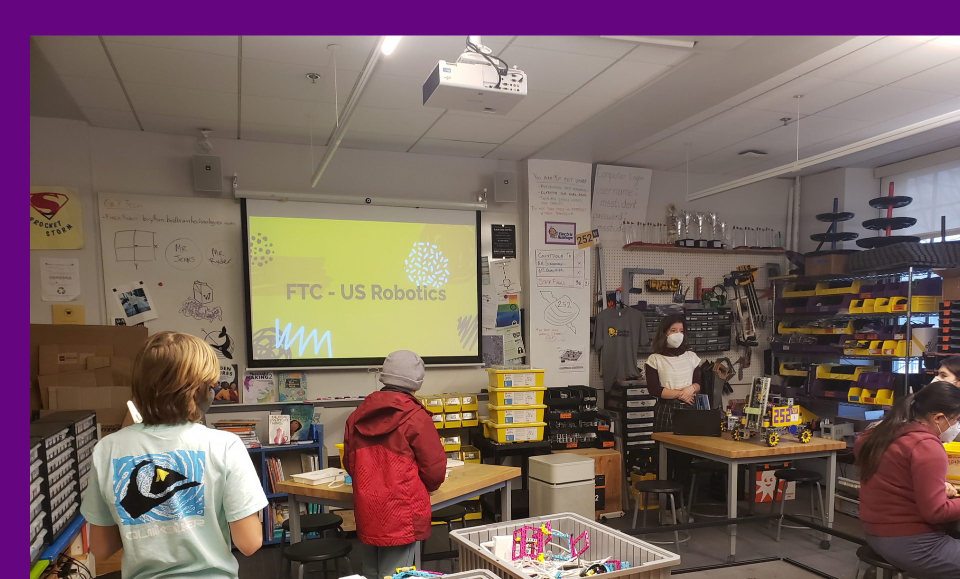
We Invited Mr. Schechter to present virtually on how robotics is being used in warehouses designed by AutoStore. He came back to our lab in person, to watch gameplay and give our team some design feedback.

The Wheeler School, Third Grade

We gave a brief demonstration of magnets (connecting to their Science curriculum) then demonstrated our robot's potential to use magnets for capping, and answered questions about the FTC robotics program.

FIRST Lego League

We presented on FIRST's FTC program to FLL team #1015 and answered questions about our engineering process and programming.



The Wheeler School, Upper School

Our leadership spoke to the entire upper school (400 students, some in person and others on Zoom Webinar) about our robotics program.

Open House

During our school's Open House, we presented our robotics program to prospective students. We shared our robots, process, and the FIRST program with over 180 families!