



SPONTANEOUS CONSTRUCTION

FTC 14779

We are Spontaneous Construction! Our team is made up of 10th - 11th graders from Mounds View high school and this is our third year as an FTC team. We all came together after being parts of separate FLL teams with members ranging from 4-7 years as *FIRST* Students.



(Left to right) Ian, Henry, Aaron, Jackie, Leigha, Claire, Jamie

- Aaron - Member of our software team and also manages our website and social media pages
- Claire - Software team member and lead of sponsorship and newsletter
- Henry - Part of the software team and helps manage finances
- Ian - Member of hardware and CAD lead
- Jackie - Hardware team member, works on CADing, and lead of outreach
- Jamie - Member of hardware team, works on CADing, and the lead of fundraising
- Leigha - Hardware team member, works on CADing, and engineering notebook leader

Kaizen 改善

Our team uses the philosophy of Kaizen (Continuous Improvement). To continuously improve, we are constantly reviewing our work. For instance, we divide our season into Sprints (see EN section B3) which are designated chunks of time dedicated to getting certain goals accomplished. At the beginning of each Sprint we decide on goals for the Sprint. At the end of each Sprint, our team would get together to do a review of the Sprint. We call this process the Sprint Review. An example of our Sprint Reviews is included on the right.

In our Engineering Notebook (EN), at the bottom of each iteration, we have Peer Reviews. Two team members check over new entries and give feedback to improve the quality of the work. An example can be seen at the bottom of the image.

Sprint 1 Goals and Review

Date: MM/DD/YYYY

GOALS

This is where we create the objectives we want to accomplish during the Sprint for each subsystem.

Hardware: This is where the goals for Hardware go.

Software:

Outreach:

REVIEW

During the Sprint Reviews, we would go through important highlights that happened during the segment of time

Kudos:

- We give kudos to team members who did something outstanding during the Sprint.

Good:

- This is where we put the good things that happened during the Sprint.

Bad/Needs Improvement:

- This is where we put the things that didn't go so well and what needs to be improved upon.

Action Items:

- These statements would be things we would do to prevent the mishaps from happening again during the next Sprint. For example, if the team needed to get more work done on the robot, the action statement would be "Set up more meetings throughout the week".

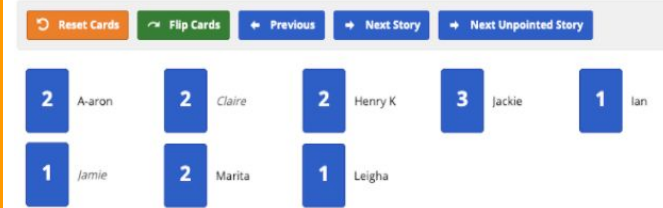
Reviewed by: Member 1, Member 2 Written by: Team Member

Game Strategy

Points:

Section	Scoring Action	Software	Hardware	Points
A	Wobble Goal in Correct Target Zone	10	2	15
A	Robot Parked over Launch Line	2	2	5
A	Ring Launched or Placed into Low Goal	7	60	3/ea
A	Ring Launched into Mid Goal	7	60	6/ea
A	Ring Launched into High Goal	7	68	12/ea
A	Power Shot Target Knocked Down	7	60	15/ea
T	Ring Launched or Placed into Low Goal	2	60	2/ea
T	Ring Launched into Mid Goal	2	60	4/ea
T	Ring Launched into High Goal	2	68	6/ea
E	Power Shot Target Knocked Down	2	60	15/ea
E	Return Wobble Goal to Start Line	2	2	5/ea
E	Each Ring Fully Supported by Wobble Goal	2	13	5/ea
E	Wobble Goal Dropped into Drop Zone	3	6	20/ea

In the beginning of each season, we analyze the new game and figure out what tasks we want to do (see EN page B1-4). In order to decide which missions to do, we set up a ranking system of difficulties on hardware and software for each mission, and then using a point scale, we voted on these difficulties. This allowed us to choose missions with the most amount of points scored and the least amount of difficulty points. We then highlighted the missions we wanted to focus on in green.

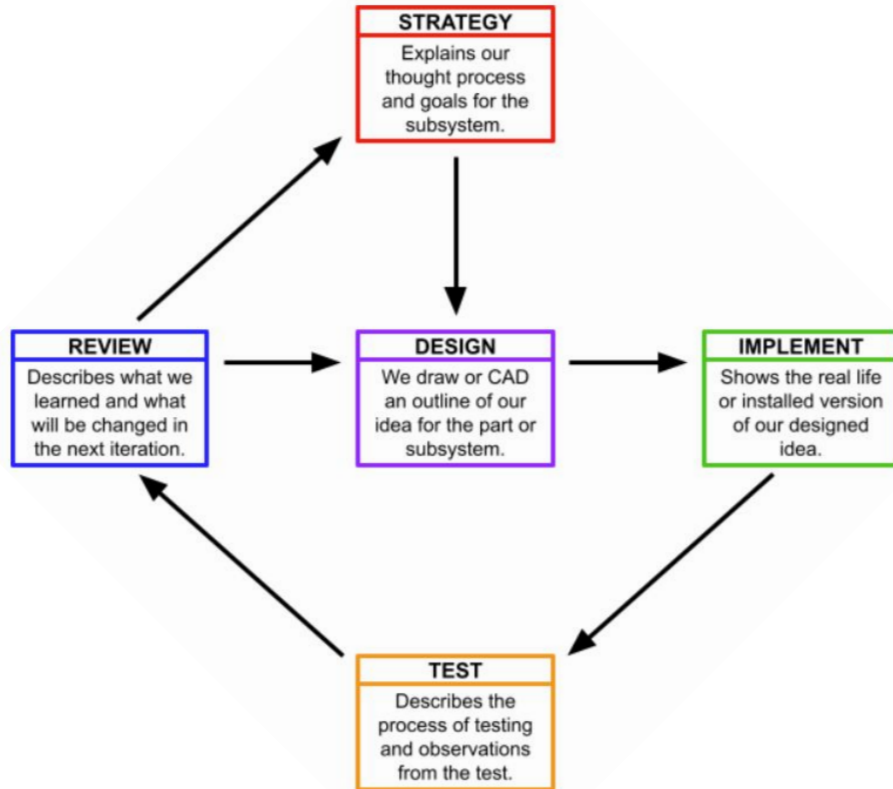


We used planningpoker.com to estimate hardware and software difficulty at the beginning of the season. It allowed each person to unbiasedly vote on each task's difficulty.

As a result of our estimates, we decided to pursue the Wobble Goal mission because it would be the easiest to do with the most amount of game points. But then we determined that we needed some sort of launcher to be able to score points in Teleop. We decided to go for the High Goal in Teleop because the same launcher could be used for any goal or even the Power Shot when aimed properly.

Engineering Process

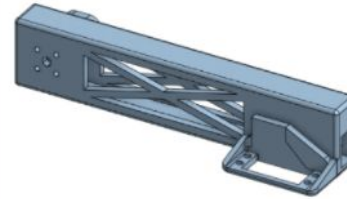
Our engineering process is below. Each step in the process is color-coded in our EN.



Iteration: Wobble Goal Arm #3

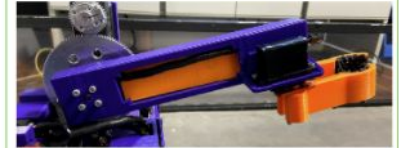
Date: 3/26/2021

DESIGN



The previous iteration of the Wobble Goal Arm was wider than it needed to be. We made the arm thinner and removed some of the material on the sides of the arm. This way we use less material and the arm is more aesthetically pleasing.

IMPLEMENT



We printed the arm and attached it to the post. The servo and claws were added to the arm.

TEST

We used the arm in some robot runs to see if it was strong enough to lift the Wobble Goal.

Success(es): The arm lifted the Wobble Goal easily, all parts fit onto the arm

Things to Improve: Some of the supports on the side of the arm broke off when we were removing supports from the print

REVIEW

The Wobble Goal Arm is working well and functioning as we want it to. We will be using the current model for our State competition. We would have reprinted the arm because the side supports broke off, but the arm was still stable and the supports were mostly decoration.

Outreach

Engineering Outreach - G1
Community Outreach - G2
Mentoring Outreach - G3
Volunteering Outreach - G4

Our team loves doing outreach and this year was no exception. We were able to reach **854 people** over **174 hours**. We did **25 different events** including engineering tours, community demos, and *FIRST* team mentoring.

High Tech Kids recognized our outreach efforts by awarding us with the Purple Gear Award. We were **1 of a 5 teams** that received the Purple Gear Award this season.

Outreach Impact and Hours					
Event name	Date	Hours	Adults	Kids	Attendees
		173.5	385	470	
Target Demo (HTK)	2/11/2020	10	51	6	~200
Target eXperience Center Tour	2/11/2020	6	-	-	-
FLL Jr. Expo Setup (HTK)	2/15/2020	7	-	-	-
FLL Jr. Expo Demo (HTK)	2/15/2020	12	65	106	~300
FLL Jr Expo Demo (HTK)	2/15/2020	6	35	88	~350
FLL State Volunteering (HTK)	2/21/2020	17	-	-	-
MVHS Steam/Career Fair	3/5/2020	6	12	-	12
LEGO Sorting	6/25/2020	18.5	-	-	-
Snail Lake YCARE Demo	7/7/2020	12.5	8	28	36
MV Community Center YCARE Demo	7/28/20	8	3	40	43
Island Lake YCARE Demo	7/31/2020	7.5	5	50	55
Mostly Operational Zoom Call	8/5/2020	4	-	2	2
Library Story Time Demo	8/6/2020	2	60	80	140
Meeting Remotely Presentation (HTK)	9/8/2020	5	-	60	60
Hack Factory Presentation	9/30/2020	8	2	-	2
Computer Vision Professor Mentorship	1/6/2021	5	1	-	1
Bind Demo	2/5/2021	6	107	-	107
Hypertherm Demo	2/26/2021	7	12	-	12
AAE Demo	2/26/2021	7	11	-	11
AGONY Team Mentorship	2/28/2021	6	1	3	4
AGONY Girls Mock Judging	3/14/2021	4	1	3	4
Mentorship with Mr. Sinarath	3/17/2021	3	1	-	1
Powderhorn Quantum Robotics Judgin	3/17/2021	2	1	4	5
Wire Managment with Nancy	3/18/2021	2	1	-	1
Highschool Showcase	3/18/2021	2	8	-	8

Purple Gear Award



Volunteering/Mentoring

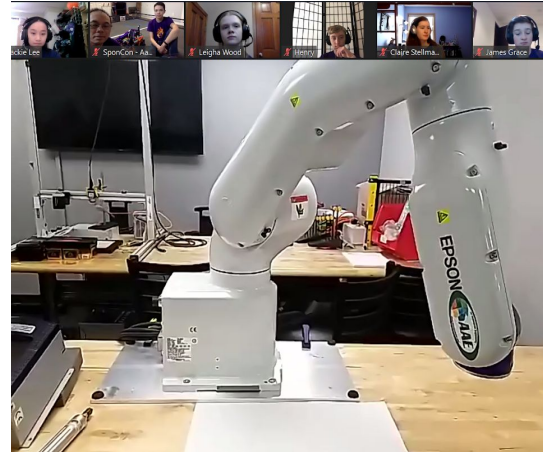
Before the pandemic our team volunteered at **3 FIRST tournaments** (see section G4) and one of our team member even emceed. We helped 2 FLL teams and 1 FTC team over **4 mentoring events** (G3).

Engineering Outreach

Descriptions of the events we attended can be found in section G1 of the Engineering Notebook:



Target Engineering Demo



Air Automations Engineering Demo

- Target Demo (see EN page G1-1)
- Target eXperience Center Tour (G1-2)
- High School Career Fair (G1-3)
- Twin Cities Maker Presentation (G1-4)
- Computer Vision Professor Mentorship (G1-5)
- Bind Benefits, Inc. (G1-6)
- Hypertherm Demo (G1-7)
- Air Automation Engineering Demo (G1-8)
- Mentorship with Mr. Sinirath (G1-9)
- Wiring Management with Nancy (G1-10)

At engineering events we showed engineers the opportunities in *FIRST* and demonstrated our robot. We have connected with **204 engineers** through **10 events** this season. These events are a great opportunity to gain connections with members of the engineering community who could be helpful to us down the road. An example of this is from our demo to Air Automation Engineering where we met an engineer who later mentored us on different writing strategies. Other things we learned include how machine vision works, how Target manufactures and tests products, and how water jet cutting is used in manufacturing.

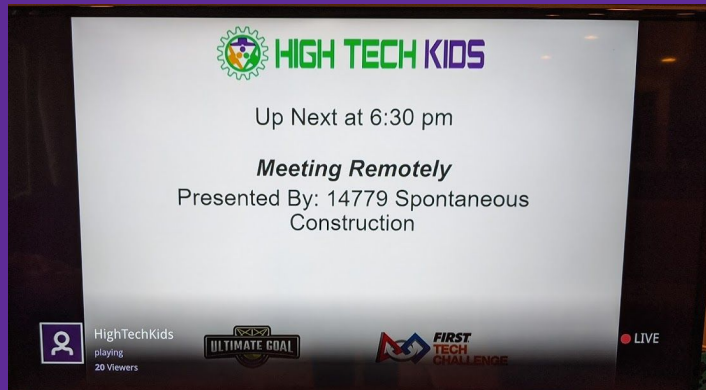
Community Outreach

All of our demos for this season were done either before the pandemic, during the pandemic with safety precautions, or through video conferences. This year our team had the opportunity to demo at **8 outreach events**:

- FLL Jr. Expo - morning (see EN page G2-1)
- FLL Jr. Expo - afternoon (G2-1)
- MV Community Center Y-Care Demo (G2-2)
- Snail Lake Y-Care Demo (G2-2)
- Island Lake Y-Care Demo (G2-2)
- Local Library's Story Time (G2-3)
- High Tech Kids Meeting Remotely Presentation (G2-4)
- High School Showcase (G2-5)

At community events we showed the public what *FIRST* programs offer and got kids interested in STEM. We were able to demonstrate our robot and let people experience driving it. Once a person finished driving the robot we gave them a robot driver's license which was a fun way for them to remember the demo. We enjoy spreading awareness of *FIRST* and connecting with people in our community, which so far included **184 adults** and **452 kids**. It's a lot of fun to teach people about *FIRST* and how everyone can participate.

During one of the Y-Care demos, we all talked about our involvement in *FIRST* and how many of the kids were on FLL teams and what their favorite part of the program was. Other kids told us about how even though they're not in the program, they enjoy STEM activities through engineering kits.



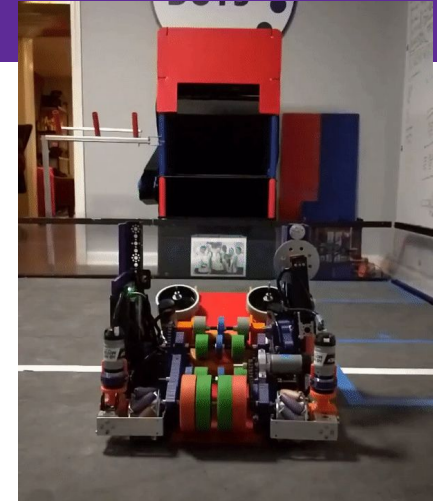
Demoing the robot for Y-care



Kids showing off their Robot Driver's Licenses

Experiments

We use experiments to determine what the best options are when developing subsystems for our robot. When we want to create an experiment we first outline what we want to test, then we define the variables and the definition of success (see EN section E1). Afterwards, we set up a process to test each experiment. Finally, we put the data we got into a table. We did **5 experiments** this season including, a Launcher Flywheel Motor Experiment (E1-3), a Wobble Goal Arm Gear Ratio Experiment (E1-1), and a Ring Spin Experiment (E1-5).



For the Ring Spin Experiment, we wanted to find the best power settings for the Launcher motors that will optimally spin a ring when launched. The reason we want to spin the rings is so that they can fly as straight as possible when launched. The table to the left shows our observations.

Power %	Straightness	Observations	# Made In Goal
100%	Pretty Straight	The rings wobble around in the air when shot out of the Launcher.	6 rings scored
95%	Far Left	There was no noticeable curving of the rings' trajectory.	6 rings scored
90%	Pretty Straight, Slight Curve	The 2 misses were human error.	5 out of 7 rings scored
85%	Very Straight	The rings have a noticeable spin.	5 rings scored
80%	Somewhat Straight	Since there's less power, more of the rings are going into the Middle Goal.	5 made middle, 1 made high, and 1 missed
70%	Straight	No wobble on the rings when they are in the air.	3 of 7 made it into the Middle Goal
60%	Straight	All of them are definitely spinning	All 7 made it into the Middle Goal
50%	Far Right	There is significantly less power than the 100%. The majority curved to the right.	7 of the 8 rings made it into the Middle Goal
40%	Far Right	The rings had quite a bit of spin to them with some of them making into the Middle Goal.	5 missed and 3 made it into the Middle Goal
0%	Very Far Right	The rings have a lot of spin to them.	All of them missed all the goals

Full Robot

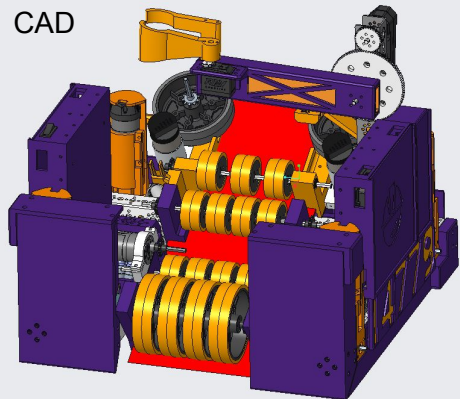
Weight Distribution and Calculations

Our robot had weight distribution problems after the Collector and Launcher were installed because the front was much heavier than the back. To solve this issue we created custom Ballast Mounts filled with concrete to even out the weight (see EN page C2-43). We did multiple calculations to find how much concrete we needed to even out the weight distribution (C2-40 and C2-41).

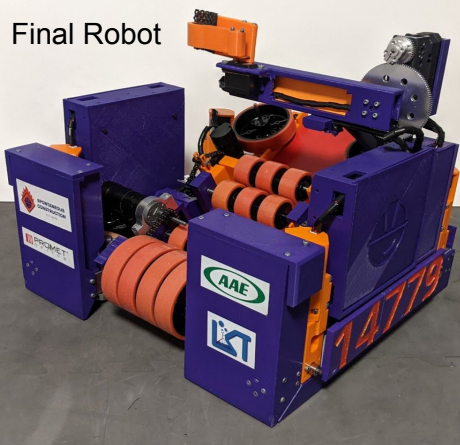
Wiring

Our robot has had wiring issues this season. To keep wires organized and secured, we designed a Wiring Box (C2-46). Each box holds the REV control or expansion hub and any extra wire length inside of it. This has cleaned up the robot and solved our disconnection issues.

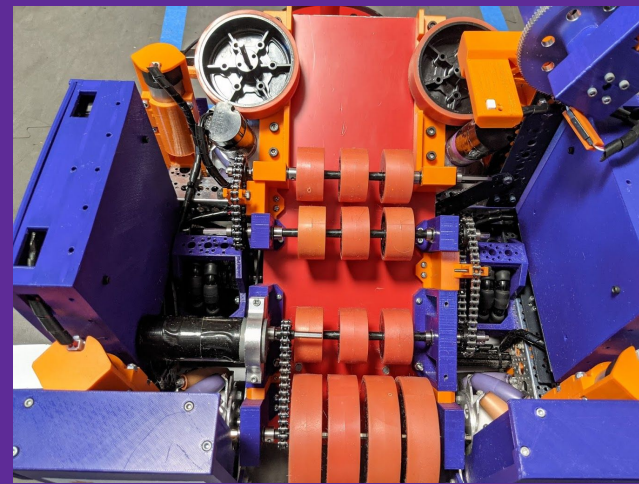
CAD



Final Robot



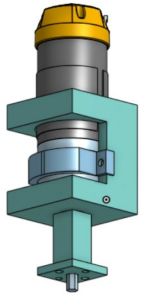
Before Wire Management



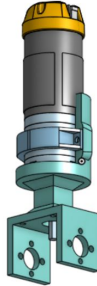
After Wire Management

Drivetrain

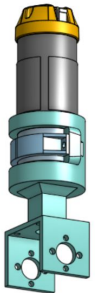
This year, we used bevel gears for our Drivetrain instead of a chain drive that we have used the previous years. To help the bevel gears work, we created **custom 3D printed Motor Mounts** (see below) that hold the motors in place. We spent all season perfecting this design by using the engineering process. **Eighteen other custom parts** were created for our drivetrain, two of which were machined in metal (C2-19 and C2-20) by one of our sponsors. We also wanted a clean wiring system so we got advice from a wiring engineer from our local sponsor, AAE, and a former member of the Ponytail Posse. We used their advice to create the Wiring Boxes (C2-46) currently on our robot.



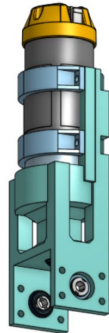
The 1st iteration of our Motor Mounts (C2-27) was designed to hold our motor vertically so we could use bevel gears for our drivetrain. The neck was too thin and there wasn't enough support on the U-channel.



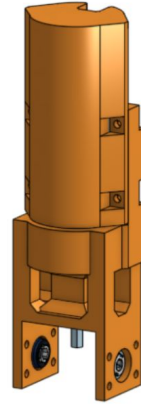
The 3rd iteration of our Motor Mount (C2-29) was much shorter so the motor shaft fit better into the bevel gear. The mount attaches more securely to the U-channel, but the motor wasn't being secured at the top.



On the 2nd iteration of our Motor Mounts (C2-28), we added side attachments to the U-channel and a round band to hold the motor. The neck was also made slightly thicker.



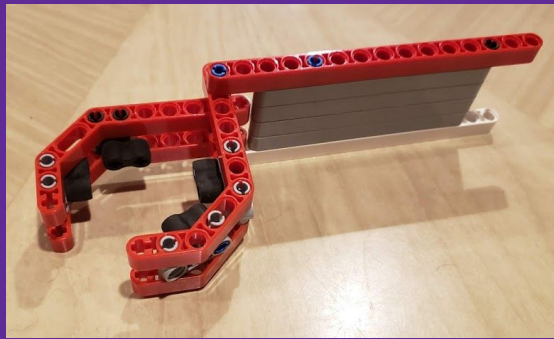
The 4th iteration of the Motor Mount (C2-30) was more secure with two brackets, but the motor would rise and turn in the mount when driving quickly. This was due to the stress on the wheels and bevel gears that translated to the motor.



For the 5th and final iteration of the Motor Mount (C2-31), we changed the bracket to prevent the motor from rising and turning. The motor and mount were both secure and the bevel gears are stable because of the added support.

Wobble Goal Arm

We decided to move the Wobble Goal because it gave us a lot of points for the amount of effort it would take to build the system. Our goals for this subsystem were to successfully and efficiently pick up the Wobble Goal, transport it around the field, and lift it up over the field wall. We decided we would make a claw and arm to grab the Wobble Goal.



This is the 1st iteration and prototype of the Wobble Goal Claw (see EN page C3-5). From this we decided that we wanted two halves of a claw that came together to grab the post.



This is the first 3D printed design we tested (C3-7). The claws didn't quite interlock and the curve was too wide.



The 1st iteration of our Wobble Goal Arm (C3-12) was made out of tetrix parts with an old 3D claw used in a previous season. The arm is powered by a hex motor and has a 3:1 gear ratio that we determined was best through our experiments (E1-1).



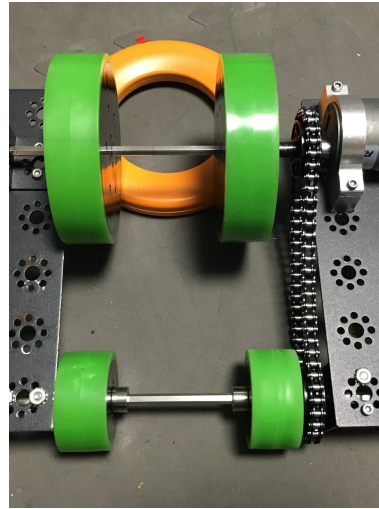
The 3rd and final iteration of our Wobble Goal Arm (C3-14) is completely 3D printed with printed claws as well. The servo mount is built-in along with the gear and axle attachment. The motor and gear ratio have stayed the same. The arm has been made longer to prevent the Wobble Goal from hitting the side of the robot.



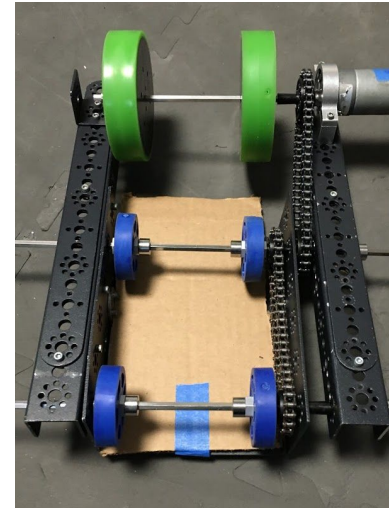
This is the final version of the claw we are using for state. This is the 7th iteration of the Wobble Goal Claws (C3-11). They are longer so the Wobble Goal Arm can allow for a greater margin of error.

Collector and Launcher

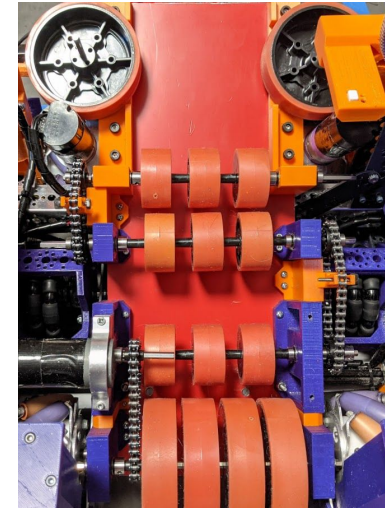
From the beginning of the season we understood that collecting and launching rings was a big part of this season's game. We knew that we needed an efficient Collection System (see EN section C5) that transferred easily to the Launching System. After testing the different Collector designs (C5-2 and C5-3), we decided that a wheel-based system would best fit our needs. It would attach to a base plate with our Launcher design and only needed one motor. We pursued this design and ended up creating **5 iterations**. This included 3 iterations of custom 3D printed axle mounts (C5-12) and 2 iterations of chain idlers (C5-14). The system is able to pick rings off the ground and transport them to the Launching System.



First Collection System Prototype



Third Collection System Prototype



Final Collection and Launching System

Our goal for the Launching System (EN section C4) was to launch consistently into the High Goal. We had several motors to choose from for the Launcher. To decide which motor and gearing combination to use, we ran a series of experiments (E1-3). After determining which motor to use we decided to create custom mounts to attach the motors to the acrylic. There were **3 iterations** of the Launching System including 4 iterations of the Launcher Structure (C4-11), 1 iteration of the Launcher Support (C4-12), and 2 iterations of the spring idler for the chains (C4-14).

Custom Parts

This season we created **35 custom 3D printed and metal parts** on our robot. We use these parts because of the versatility they give us, and because we are able to easily improve them. Everything on our robot that is purple or orange are parts we designed ourselves (see section D for DWG files).

We use PLA filament for most of our 3D prints. For the structural parts that are put under lots of stress we use PETG because it is stronger than PLA.

On the Drivetrain we have two custom parts made out of aluminum: Side Guards (C2-19) and Mecanum Wheel Adapters (C2-20). We designed them in CAD and they were machined for us by one of our sponsors, Conquest Engineering.

List of Custom Parts:

Drivetrain (C2):

- Odometry Pod (C2-15)
- Side Guard, metal (C2-19)
- Mecanum Wheel Adaptor, metal (C2-20)
- Battery Mount (C4-12)
- Motor Mount (C2-30)
- Motor Mount Bracket (C2-30)
- Left Plate (C2-37)
- Right Plate (C2-37)
- Center Plate (C2-37)
- Webcam Mount (C2-37)
- Ballast Mount (C2-41)
- Ballast Mount Hat
- Long Fender (C2-45)
- Fender Bit (C2-45)
- Wiring Box (C2-46)
- Wiring Box Cap (C2-46)
- Servo Power Module Box (C2-47)
- Servo Power Module Box Cap (C2-47)
- Number Plates

Wobble Goal Arm (C3):

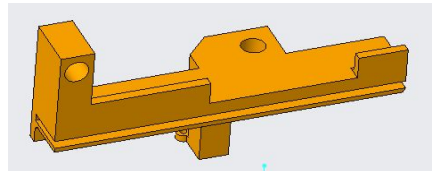
- Wobble Goal Servo Claw (C3-11)
- Wobble Goal C-Channel Claw (C3-11)
- Wobble Goal Arm (C3-14)
- Wobble Goal Arm Support (C3-23)
- Servo Cable Clip (C3-48)
- Wobble Goal Arm Backing

Launcher (C4):

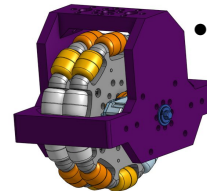
- Launcher Structure (C4-11)
- Launcher Support (C4-12)
- Spring Idler (C4-14)

Collection (C5):

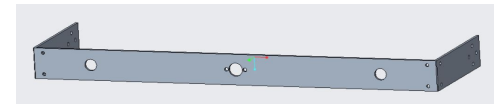
- Collector Support (C4-12)
- Extrusion Support (C4-12)
- Large Wheel Holder (C5-12)
- Small Wheel Mount (C5-12)
- Small Wheel Holder (C5-12)
- Spacer Idler (C5-14)
- Collector Spacer



Launcher Structure (C4-11)



Odometry Pod (C2-15)



Side Guard (C2-19)

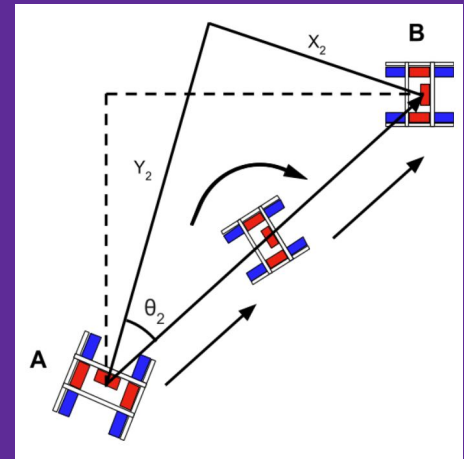
Sensors (Software)

Odometry Pods (C2-15): The Odometry Pods are one of the most complicated subsystems that software programmed this year. The physical system uses a pair of wheel encoders parallel to the drive wheels as well as one perpendicular to the drive wheels to determine the location of the robot on the field. We decided to base our code off of the Wizards.EXE Odometry spellbook. We used their online tutorial as guidelines for reading the encoder data, but **created our own custom method to move using the odometry outputs**. The code uses trigonometry to figure out the direction that the target position is in relative to the current position, then simulates a joystick on a controller to move in the direction of the target position. It also rotates at the same time, leading to clean movement directly from one point to the other while rotating. We're very proud of the fact that we were able to make the code for it! You can check out in more detail how the code works in the odometry section of the Engineering Notebook (see EN pages F1-9 to F1-12).

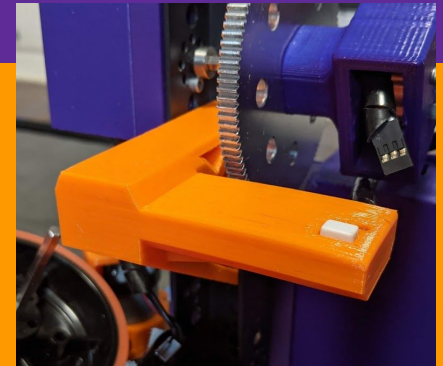
We have also **brought our moveToPosition() method into teleop** (F1-21) and use it to go to the right locations for launching rings. This is done by having the drivers tell the robot to save a location and then we can later tell the robot to go to that position.

Webcam: Along with knowing where on the field it is, the robot also needs to know about game pieces are to make decisions. For that, we have been using vision with a webcam on the front of our robot. The camera is used to detect the size of the ring stack at the beginning of the Autonomous period to determine which Target Zone the robot has to bring the Wobble Goal to.

Touch Sensor: We used to have problems when our autonomous didn't move the Wobble Goal Arm all the way back to its starting position because the encoder's zero position is based on where it is when teleop starts. When that happened, it broke our preset positions. So we added a touch sensor in our Wobble Goal Arm (C3-14) so that we can reset the arm's position whenever we need to



A diagram used in F1 demonstrating how odometry movement works.



The touch sensor used to reset the Wobble Goal Arm's zero position

Business Plan

The Business Plan is one way we reach out and introduce ourselves to sponsors. It contains an intro with information about our team, a description of *FIRST* and FTC, and explains this season's game. We detail our outreach events and give a summary of what we are currently doing on hardware and software. There is also information about our team budget and details about sponsorship. Our Business Plan can be found in EN section H1.

We raised money for our season by cold-calling companies during the off-season. Each family also contributed some money at the beginning of the season. The rest of the money we received from grants we applied for.

This was our team budget this year:

Categories	Item	Cost
Registration	<i>FIRST</i> Registration	\$275.00
	MN Registration	\$350.00
	State tournament registration	\$400.00
Season game pieces	FTC Field Kit	\$450.00
Robot	Electronics	\$1,000.00
	Extra parts	\$1,000.00
	Tools	\$225.00
Marketing	Uniforms (Polos and Sweatshirts)	\$1,000.00
	Buttons, Banners, Pit Display	\$700.00
Miscellaneous	Meals, Team Food	\$500.00
	3D Printer	\$1,000.00
	Other Parts	\$600.00
	Total:	\$7,500.00

Sustainability

To continue the legacy of *FIRST* we share it with as many people as we can. At our outreach events we demo our robot and talk to kids to interest them in FLL and FTC and encourage them to join teams. To pass on what we have learned, we reach out to and mentor FLL and FTC teams. During demos we recruit adults to volunteer at competitions and connect with interested mentors. Our team will continue our excitement and passion in *FIRST* even after we graduate through volunteering and mentoring.