TECH NINJA TEAM

FTC#9929

ENGINEERING NOTEBOOK
2016-17 VELOCITY VORTEX

An Introduction to FTC Team #9929 "The Tech Ninja Team"

It all started in a basement with the Nelson family and the Matthews family. They were in the process of completing an overly complicated machine to, drum roll please, unzip a zipper. These two families had decided to complete the 2014 rube Goldberg machine challenge over a couple of weekends, for fun. After a few hours, one industrial shelf, and a ton of tape later, it finally worked. Then we went on hiatus for a few months before starting FLL. The team choose to "dominate" with education as LED (Lego Education Domination). The final robot didn't do so well but at least our name was cool.

Year two of our team's engineering adventure to becoming the Tech Ninja Team we are now brought some changes. A lot of changes. A few of the older team mates (Calvin, Kate, and Lauren) pushed the coaches to offer FTC after seeing the robots built for this competition online. They managed to convince the FLL coaches to start a FTC team. We unpackaged our first kit to build a robot in the basement of Coach Matthews. All of the team members were excited to begin building. Our team name came from a joke when we were unpacking the boxes of robot parts. We were all pretty excited about the cool parts that we unpacked and thought they were really cool, when someone said "Just wait until we unpack the ninjas". thus the Tech Ninja Team was born, along with a cool acronym (T.N.T). after beginning work on the robot we moved to coach Nelson's garage for more space. The name for our robot, Skittlebot, came from an exercise we did to better understand programing. Shortly before the team's first qualifier we got a new space to practice in at the to be Homewood Science Center. Little did the team know at the time how lucky we were to have the space. We would end up 11th place with a Control Award when the season was over.

During the off season we moved into our own room in the science center that is often referred to as the robot room. This space would allow us to expand more and start to learn more advanced techniques for building our robot. We also starting using Slack (a communication platform) and GitHub (a program storage platform) to better our team's communication. We researched prior seasons and worked on building mechanisms we noticed were used throughout the challenges. For kick-off we did some outreach and threw a kick-off celebration.

This year we used a lot more planning and critical thinking to bring a robot together. We communicate and keep our engineering notebook up to date using Slack, we plan tasks with a Kanban board, and we installed 33 feet of whiteboard in our workspace to use when brainstorming designs and working out programming algorithms.

This year's robot is much more advanced than last year and is taking us farther then our first robot. We are also competing in league play instead qualifiers, unlike last year. We prefer league play because the opportunity to iterate is more like engineering then a single qualifier. We hope that changes we made to the team will help us move farther.

Team Bios

Hannah Beezie
2nd year with FIRST
8th grade

I enjoy reading, drawing, and riding my bike in my spare time. I also enjoy going to our team meetings and practices.

I am primarily a part of the build team, but I also am the robot operator on one drive team.

I joined FIRST because I was interested in engineering and robotics, and wanted to learn more about STEM than I did in school.

Outside of robotics, I participate in Irish Step Dance and play classical guitar.

I am part of the programming team as well as a coach for a drive team.

I joined FIRST after I attended a STEM night at a local school featuring the team's previous robot. I immediately fell in love with the field of robotics and engineering and plan on pursuing it in college.

Caroline Madden
1st year with FIRST
Senior

Kate Nelson
3rd year with FIRST
8th grade

Outside of FTC, I play the violin. I enjoy playing music with Concert Orchestra in CYSO (Chicago Youth Symphony Orchestra)

I am a driver, as well as part of the programming team.

I joined FTC because I like the creativity of the game and enjoy driving our robot around the field.

I am Ian Barrow, I'm 13 years old and I joined FTC Robotics this year. My brother and I were told about it from our parents. I have one sport, Cross country to focus on and I felt like I could do something else. It would also help on many college applications. I knew some people at the Middle School Parker who did it. That is why I joined FTC this year

Ian Barrow
1st year with FIRST
8th grade

Lauren Matthews
3rd year with FIRST
8th grade

My name is Lauren Matthews. I am 14 and attend Parker Jr. High. I have participated in First as a whole for three years. For my first year I competed in FLL. After that season was over I, along with a few other team members, crossed over to the new FTC Team. I have always enjoyed engineering and have done other science related activities outside of FIRST. I also enjoy Olympic recurve archery, reading, art and crafts, and writing. I am on the programing team, have helped the build team occasionally, and am a coach for a drive team. I feel like the Tech Ninja Team has grown greatly from our first year as a rookie to now.

I'm an 8th grader at Parker Jr. High. This is my 3rd year with HF Robotics, second year in FTC. I really like the programming and driving/operating challenges that FTC gives me. In addition to robotics I play alto saxophone in the school jazz band and jazz combo. I would like to go into physics or computer sciences in the future. Science is savage!

Calvin Uecker
3rd year with FIRST
8th grade

Charlie McLean
1st year with FIRST
8th grade

Hello, my name is Charlie McLean. I am on the build team of team 9929, otherwise known as Team Tech Ninja. I got into robotics through an interest in a variety of topics. I really think robots are cool for one, but I also want to seriously pursue this. Those as well as a very large interest in robots and mechanic things in general led me to join. The other big thing I do is hockey. I've been playing for about ten years now. I play for the Orland Park Vikings NIHL Elite team. I also enjoy reading, art, and building custom Gundam models.

I am in Science Olympiad, I play soccer, and was in Gifted Art last quarter.

I am on the build team and a robot driver.

I joined FIRST after I went to a LEGO robot programming event and learned about FTC.

Taylor Washington
1st year with FIRST
8th grade

I am in track and field and I plan to attend the United States Air Force academy in CO, I play alto saxophone in band, and I am in Top Teens of America.

I am on the build team and I am one of the drivers during matches.

Jeremy Wesley
2nd year with FIRST
Freshman

My mom introduced me to FIRST one day and it was something I found special so I stuck with it because I love building and understanding how things work.

I play soccer, I'm on the school chess team, I am in the school band and I also play volleyball.

I am on the build team and I am also a coach during matches.

I joined FIRST because I enjoy a challenge and I enjoy being pushed, I also like how FIRST makes you think outside of the box.

Ashley White
2nd year with FIRST
8th grade

Kaylin Matthews
3rd year with FIRST
6th grade

I am the "intern" and mascot and I plan to officially join the team next season. This season for FTC I have done work on the robot and sat in on some of the programming team meetings.

I started FLL 3 years ago and am excited to continue with FIRST and graduate to FTC because I am very interested in robotics and STEM. I also am attracted to the FIRST community and how tight-knit everyone is.

When I am not at FTC meetings, I enjoy playing soccer and my flute.

Engineering

September 11, 2016 Season Kickoff

Members Present: Lauren Matthews, Hannah Beezie, Kate Nelson, Calvin Uecker, Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden, Jeremy

invited potential sponsors and important local figures to see the launch of the 2016-2017 FTC game. We began field assembly (beacons) and planned out this year's goals for challenge -- what we wanted to complete during autonomous, Tele-op, and end game along w/ order we would start working on them.

September 16, 2016

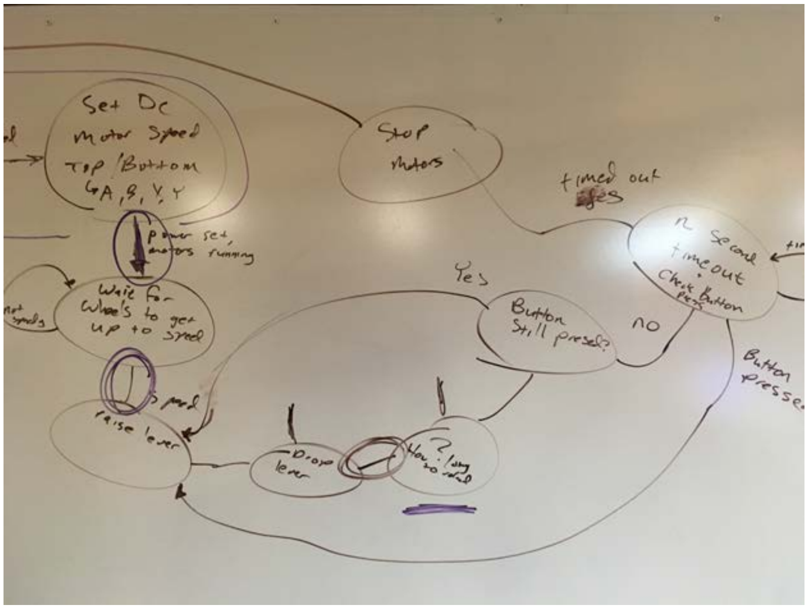
Members Present: Lauren Matthews, Hannah Beezie, Kate Nelson, Calvin Uecker, Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden

A few team members worked on completing the field setup we started at the season kickoff the week before. This consisted of painting the base of the center vortex and finishing the center vortexes. The red vortex went together with very few building complications but the same cannot be said for the blue vortex. We had issue with getting the cortex ramp to lay flat on the field. We tried many things to trouble shoot the issue bit found no solution. The plan is to continue to trouble shoot the blue vortex next week because of the inability to fix it in this meeting.

This week the build team continued to work on the new tank drive base. They worked on completing the second side of the new tank drive. To do so they added the motors and the wheels to the drive base.

September 23, 2016

Members Present: Lauren Matthews, Hannah Beezie, Kate Nelson, Calvin Uecker, Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden



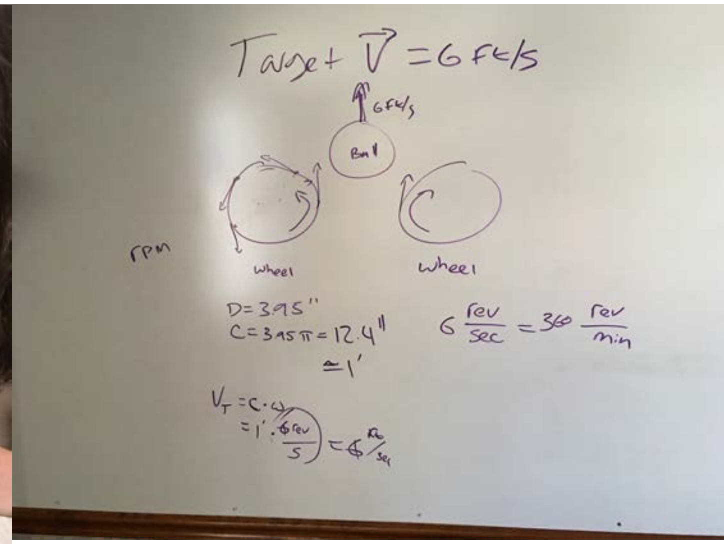
The programing team mapped out a state machine for the particle shooter. We then turned it into Java code ready to be tested once the particle shooter is completed.

The state machine code was created in such a way it can be reused in autonomous (in fact we plan to use this code to shoot particles during autonomous).

The corner vortex was still an issue during most of the practice. We eventually went online to see if any other FTC teams were having the same problem. We discovered that we had missed a step that many other teams had missed. The step of bending the L-brackets on the corner vortex was clearly shown in the instructional video but easy to miss in the written instructions.

September 30, 2016

Members Present: Lauren Matthews, Hannah Beezie, Kate Nelson, Calvin Uecker, Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden

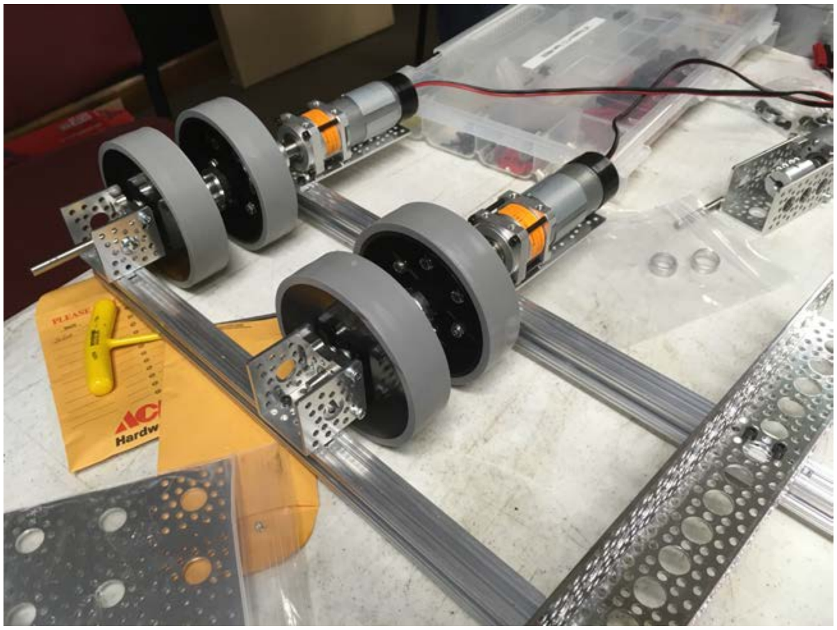


The build team calculated that our AndyMark motors used in our particle shooter would need a six to one or lower gear reduction to achieve required velocity. Members of the build team began to assemble the particle shooter by mounting wheels to axles and four to one gear boxes to our motors. Other build team members worked on the drive base mounting gears and motors for our west coast drive.

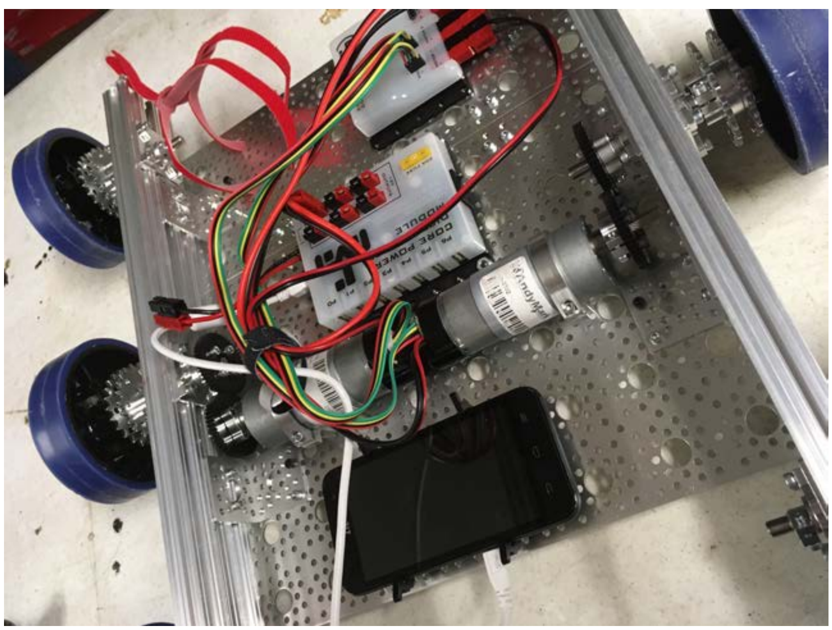
The programming team worked on finishing the servo city sponsorship essay by revising the text and taking the required picture. We managed to turn in the materials just before the dead line. The essay was what we want to improve on within our team. We forgot to add working on timing our priorities.

October 2, 2016

Members Present: Lauren Matthews, Hannah Beezie, Kate Nelson, Calvin Uecker, Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden



Basic particle launcher for the robot.



Basic robot drive base.

October 3, 2016

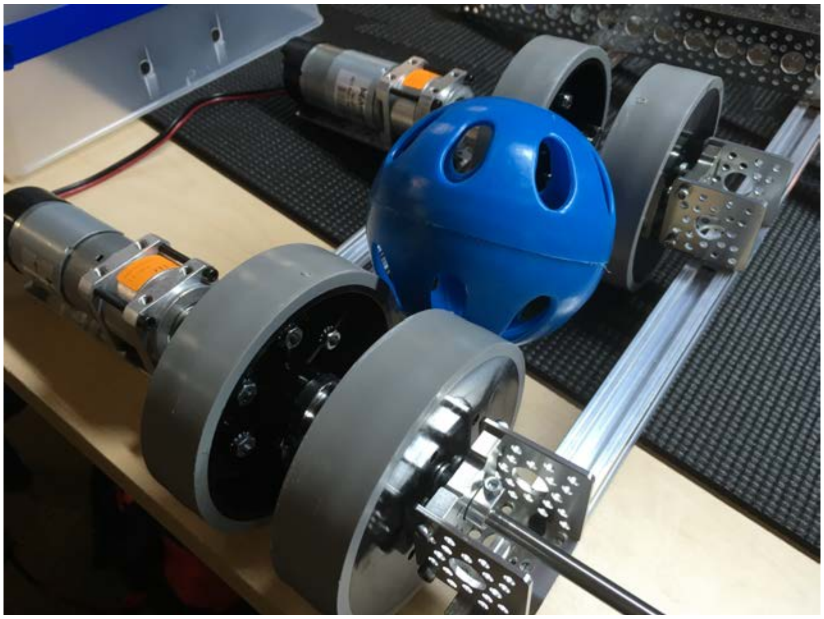
Members Present: Lauren Matthews, Hannah Beezie, Kate Nelson, Calvin Uecker, Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden

Using the drill press.

Helping out the BOOCbotics team from Dolton, IL.

October 7, 2016

Members Present: Lauren Matthews, Hannah Beezie, Kate Nelson, Calvin Uecker, Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden



Updating the launcher mechanism to fit the size of the game particles.

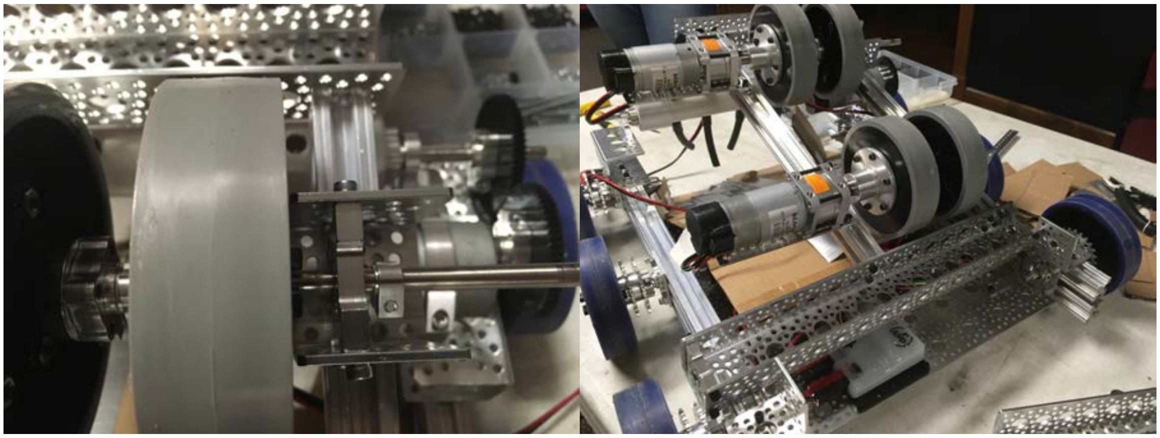
October 9, 2016

Members Present: Lauren Matthews, Taylor Washington, Jeremy Wesley

Testing a basic version of our robot.

October 10, 2016

Members Present: Ashley White, Charlie Mclean, Ian Barrow, Caroline Madden

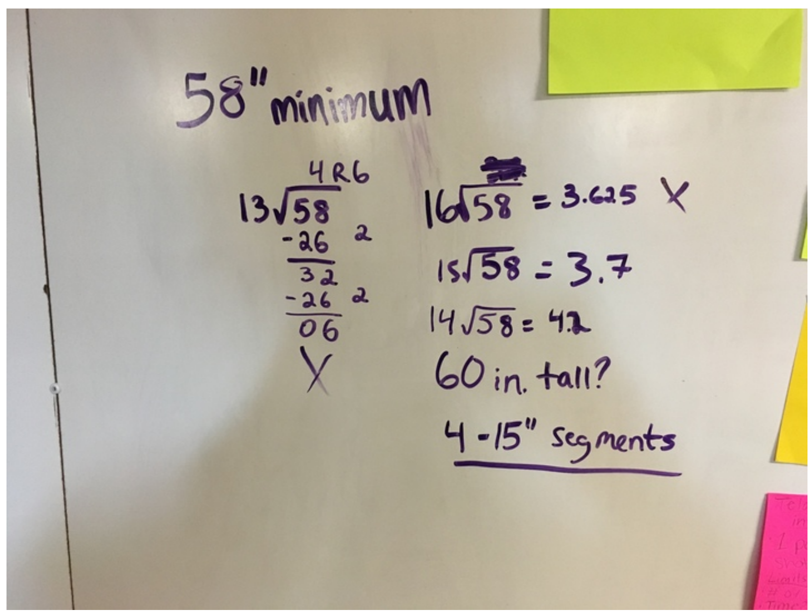


Preparing the robot for launching game particles into the center vortex.

October 12, 2016

Members present: Ashley White, Jeremy, Charlie Mclean, Hannah Beezie, Calvin Uecker, Kate Nelson

The majority of build team worked on a controller holder to hold the robots core motor controllers and Core Power Distribution Module. This version was made of Lexan and held four robot motor controllers and one Core Power Distribution Module. The picture to the left displays two members of the build team (To the far left, Jeremy and to the far right, Ashley) drilling holes into the Lexan for the robot controller holder.



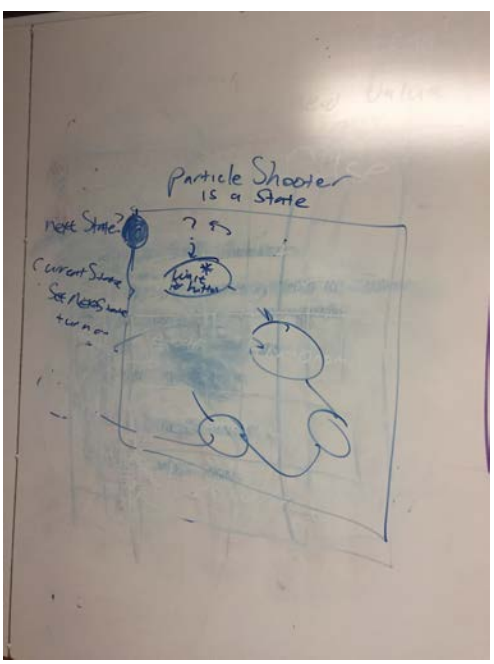
Hannah worked on calculation to help to decide the height of the ball lift, which we plan to use to lift and place the cap-ball onto the center vortex. It was known that the lift would have to reach 58" as a minimal total height. Hannah then calculated the number of segments need for four different segment of the ball lift, which is an elevator lift, to reach that height. Since she knew that she couldn't go above 18" she started with lengths that were under 18". She calculated how many segments were needed for a 13", 14",15", and 16" segments lengths. It was deduced that four, 15" inch, segments would be the most efficient way to build the lift.

The programming team wrote dual motor class, tank drive class, hardware map for controllers on robot.

October 16, 2016

Members present: Cal, Charlie, Hannah, Kate, Lauren, Taylor

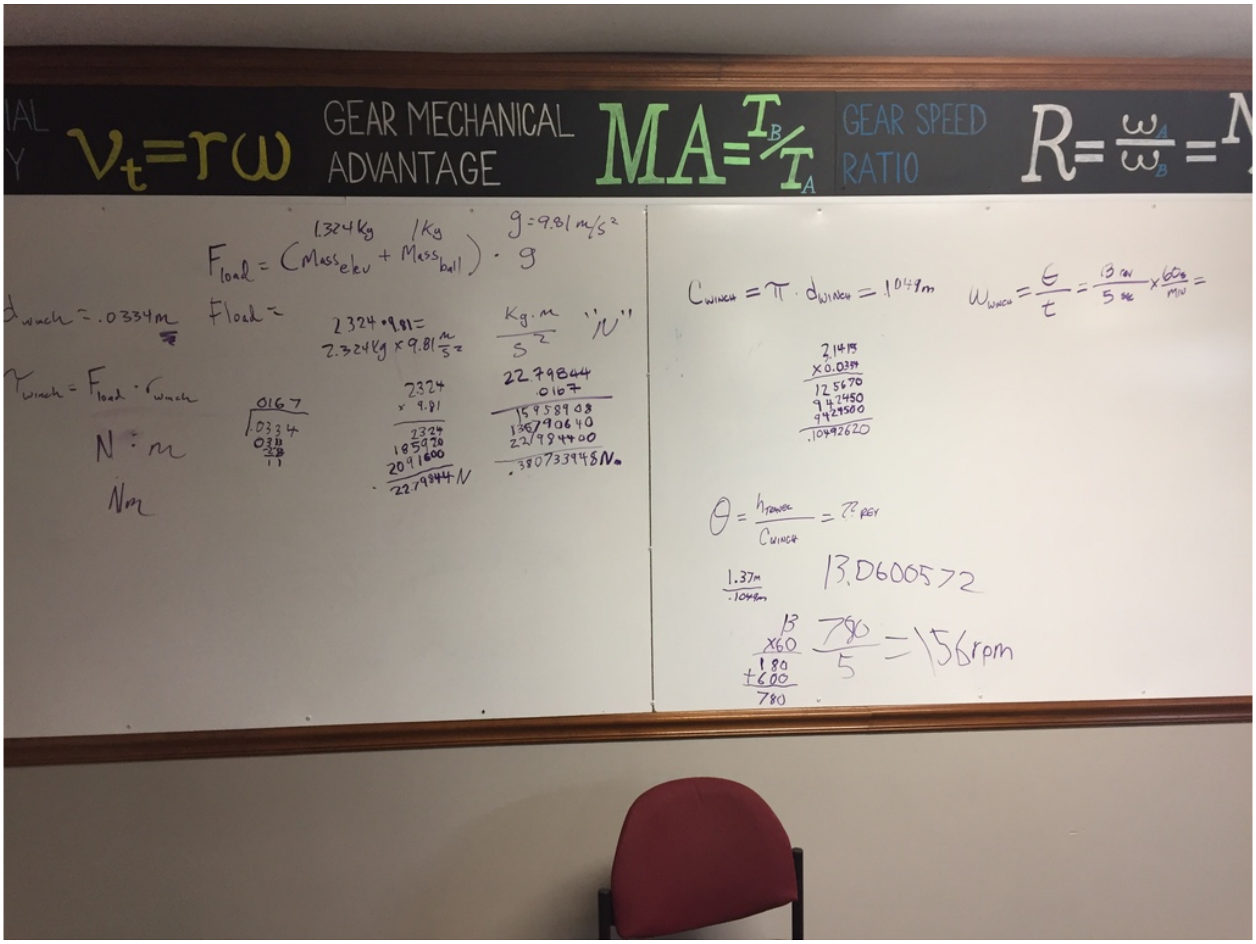
Elevator lift slides with side plates attached.



State machines discussion - both in Tele-op and Autonomous

October 21, 2016

Members Present: Cal, Charlie, Hannah, Kate, Lauren, Taylor



The main task this evening was to calculate the requirements for the winch to raise the cap ball lift. We have simplified some of the equations and assumptions. Namely, we have built a 4 stage lift. Assuming we're not yet lifting the cap ball - the winch does not experience the entire load of moving the lift's mass at one time, it lifts the first stage which is 25% of the mass, then the two stages together which is 50% of the mass, etc. (note that while we have a 4 stage lift, there are 5 sections that contribute to the mass that we weighed, but one is never lifted). We don't account for these differences, but we also don't think it will matter because we're not accounting for loss due to friction in all of the moving pieces, nor are we adding mass for whatever else we add to the lift to actually hold the ball. We're assuming that not accounting for these masses and friction will come out in the wash.

Deciding on a Performance Goal

The performance goal for this mechanism is the time to lift the cap ball. We reference the following game rules <***1.5.4.1***> *and* <**GS8**>, and how much time we believe is realistic that it will take to maneuver the cap ball into place and lower the lift, remembering that end game only lasts 30 seconds.

1.5.4 End Game

The last thirty seconds of the Driver-Controlled Period is called the End Game. During the End Game – and not before in the Driver-Controlled Period – Robots may raise the Cap Balls Completely Off the floor, or place the Cap Balls into the Center Vortex. Robots may continue to perform all of the other Driver-Controlled scoring activities during the End Game. Points are awarded for the following End Game achievements:

*1. **Cap Ball Off the Playing Field** – A Robot that raises the Cap Ball Completely Off of the Playing Field Floor and keeps it raised at the end of the Match, will receive points based on how high it is raised.*

***Low height** – The lowest point of the Cap Ball is lower than 76 cm (30 inches) – the approximate height of the Center Vortex crossbar – 10 points.*

***High height** – The lowest point of the Cap Ball is above 76 cm (30 inches) – the approximate height of the Center Vortex crossbar – 20 points.*

***Capping** – The Cap Ball is supported by an Alliance-specific Center Vortex and not in contact with a Robot on the corresponding Alliance – 40 points.*

***<GS8> Robot Height** – Robots may not extend higher than 29 inches (73.6 cm), the approximate clearance height of the Center Vortex Particle deflector, except during the End Game. An immediate Minor Penalty will be assessed per occurrence for violating this rule. Additional Minor Penalties will be assessed for each five second interval that this situation continues.*

Gathering and Converting Our Known Values into Useful Units

To solve for the motor power needed, and the speed, we must first convert all known values into metric: kg, meters and Newtons

Mass of the system to be lifted:

$Mass_{elevator} = 1.324kg$
$Mass_{ball} = 1kg$

The acceleration of gravity on earth: $g = 9.81\frac{m}{s^2}$

The load to be lifted by the winch:

$$F_{load} = (Mass_{elevator} + Mass_{ball}) \cdot g$$
$$F_{load} = (1.324kg + 1kg) \cdot 9.81 = 22.80 \frac{kg \cdot m}{s^2}$$

$\frac{kg \cdot m}{s^2}$ is the SI unit for force, also known as a "Newton", and abbreviated as "N"

d_{winch} = 3.34cm = .0334 m (the diameter of the 1" winch spool)
h_{travel} = 137cm = 1.37 m (the height of our lift when fully extended)

Turning the Performance Goal into Requirements

From this point on, we use what we know (things that can be measured) and things we want to have happen (the performance goal) to see if the performance goal can be met with parts available to use (namely DC Motors allowed in FTC).

First, we need to calculate the required rotational velocity of the winch.

We start with the circumference of the winch (which will give us how much cable is taken up by one rotation).

$$C_{winch} = .105m$$

Calculating the number of rotations to raise the elevator lift completely:

$$\theta = \frac{h_{travel}}{C_{winch}} = 13.05rev$$

Calculating the required rotational velocity required:

$$\omega_{winch} = \frac{\theta}{t} = \frac{13.05rev}{5s} \times \frac{60s}{min} = 156 \frac{rev}{min}$$

Calculating the load on the winch.

We note that the formula is the same as the one for a simple lever when the direction the force is applied is 90 degrees to the "lever" when dealing with torque. Imagine looking down the "spool" of our winch, there's an axle in the center, and the outer edge of the spool, from a mechanical point of view there is a lever that extends from the edge of the spool to the center axle, and the force (the cable pulling on the winch) is 90 degrees (tangentially) to that lever.

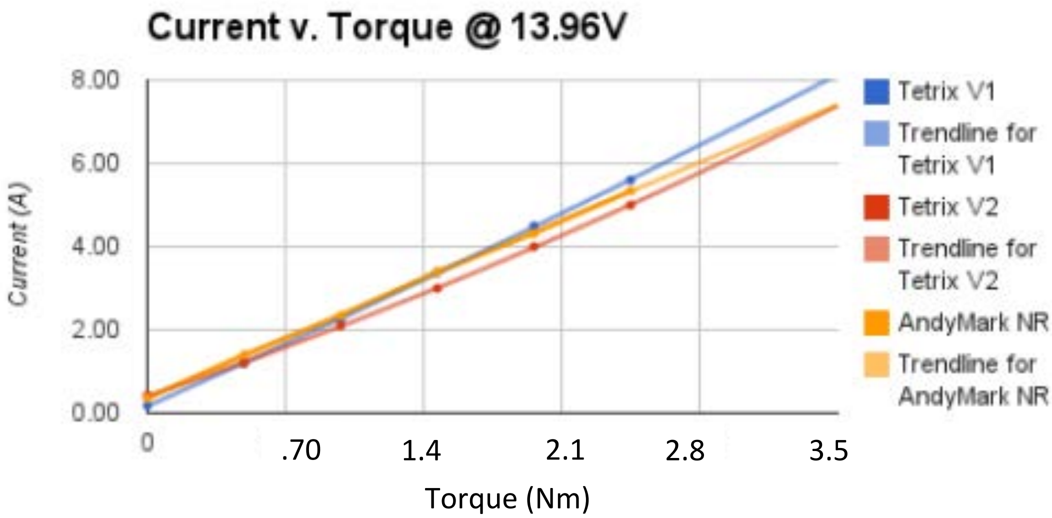
$$\tau_{winch} = F \times r = \frac{F_{load} \times d_{winch}}{2} = \frac{22.80 \frac{kg \cdot m}{s^2} \times .0334\, m}{2} = .38Nm$$

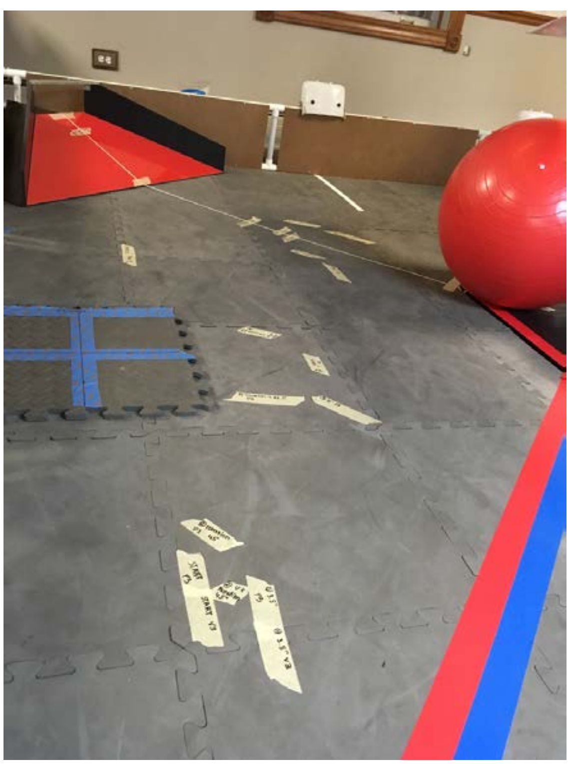
Selecting a Motor and Gear Train

We now have the required information to select a motor and gear train system (for now, there hopefully exists a motor that alone meets the requirement. The values needed for this selection are namely the torque the system must produce, and the revolutions-per-minute (rpm) required to raise the lift in the required amount of time. The easiest place to start is with this chart that shows torque vs. rpm for an AndyMark Neverest 40 gear motor:

On the above chart, we see that a point placed at .38 Nm and 156 RPM is within the data representing the measured performance of an AndyMark Neverest 40 DC motor). We may have to revisit the performance goal of 5 seconds to lift, but it appears our winch with a NR40 motor will perform acceptably.

Once we have a motor that is physically capable of raising the lift in the required amount of time, FTC motor controllers limit current draw to 5A per port (e.g. per motor), we must also check the following chart to ensure that at the given torque the motor will not draw more than 5A current:

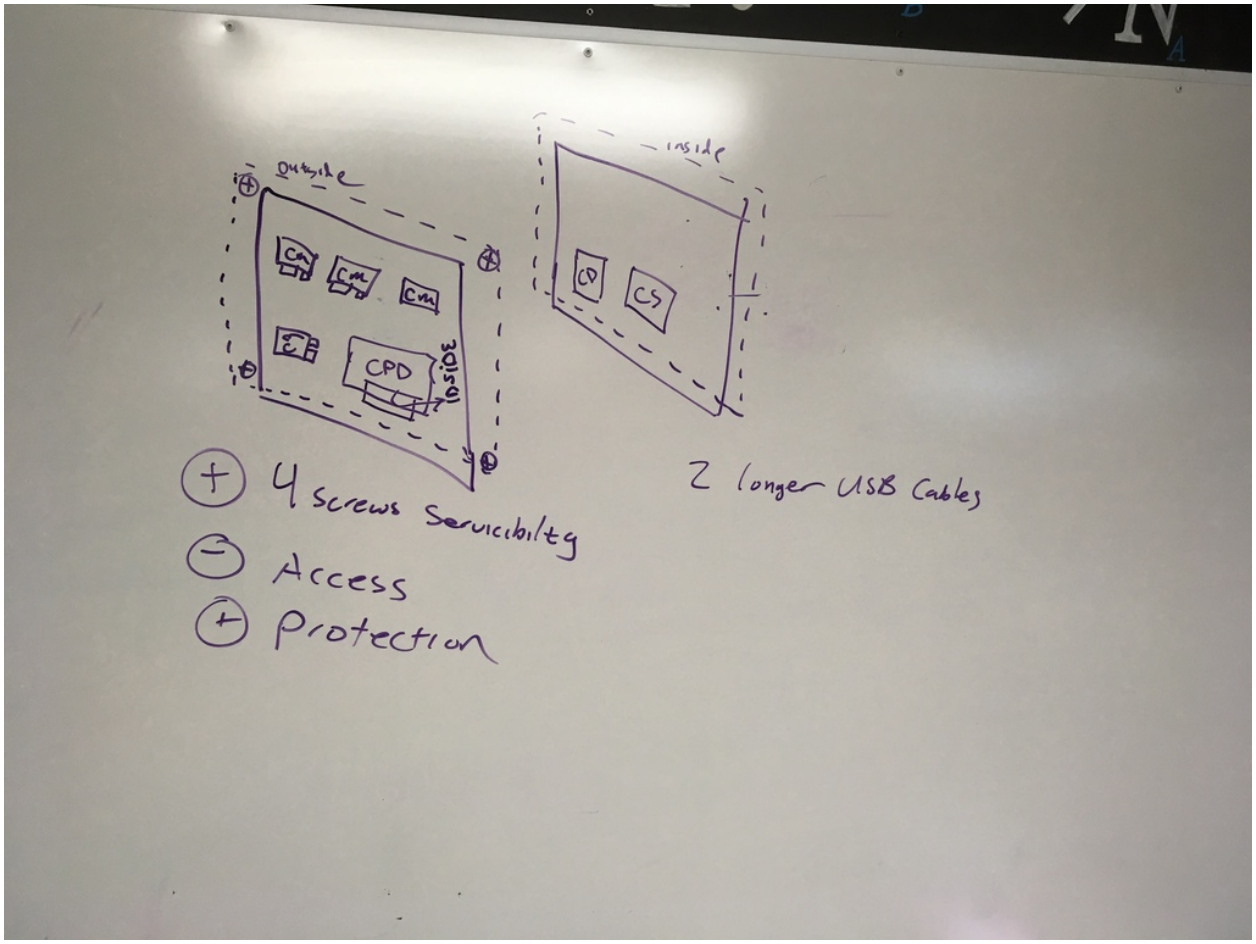




We also started to plan our autonomous OpMode routes. So the build team could have access to the robot we modeled the robot with a single 18 tile and laid out turns and distances from known starting points against the wall. These would later be entered into our code as separate states in a state machine (drive and turn states).

October 23, 2016

Members Present: Ashley



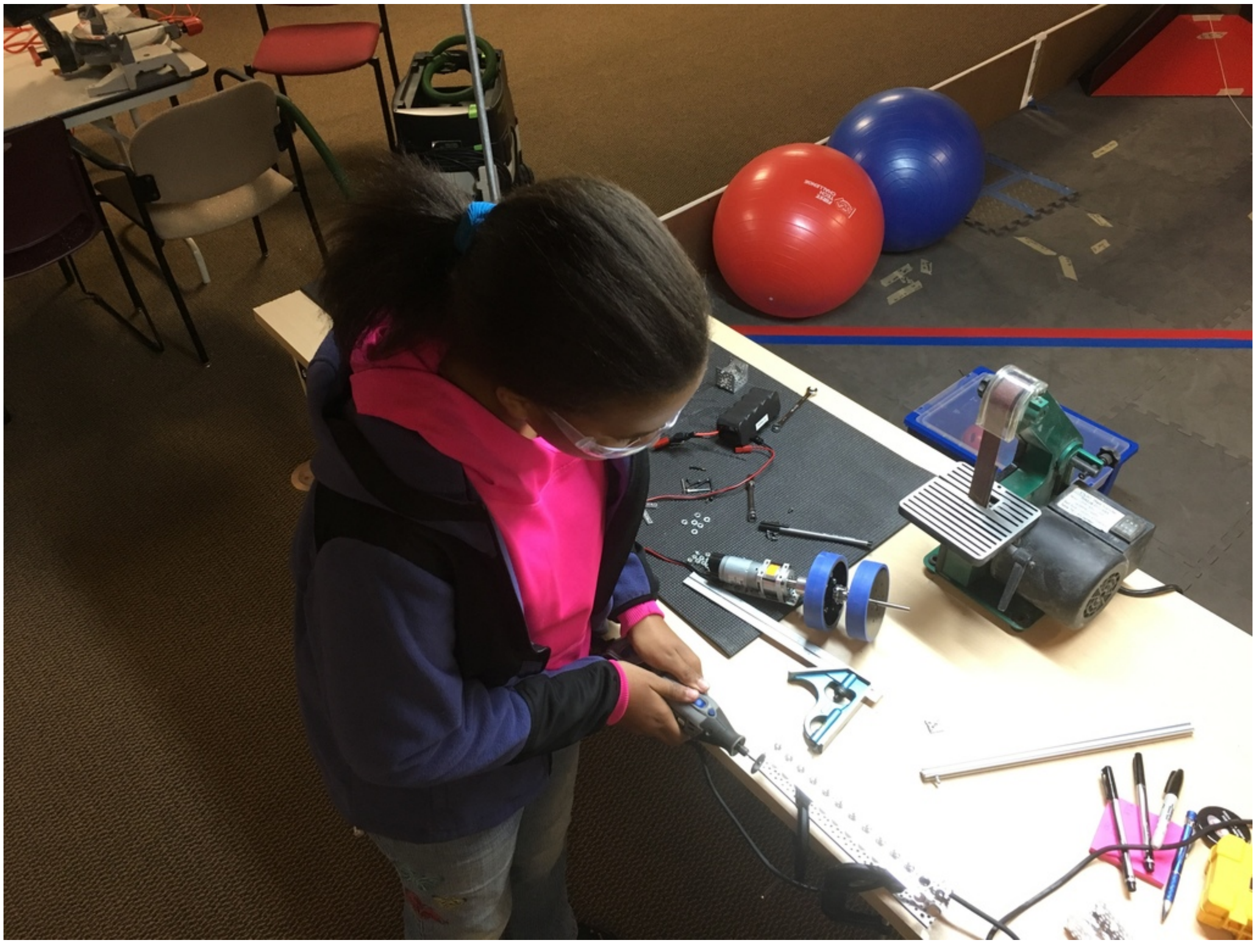
Electronics Mounting Plan, Core Power Distribution module is mounted reverse-facing, hole cut in inside panel to allow power leads to fit. All other control modules mounted facing out to see the power/connect LEDs. We'll use wingnuts and captured screws on the channel to make it easy to remove the outer protective Lexan panel to work on the modules.

Cut Lexan panels for mounting electronics, stiffening the frame and protecting the mounted electronics.

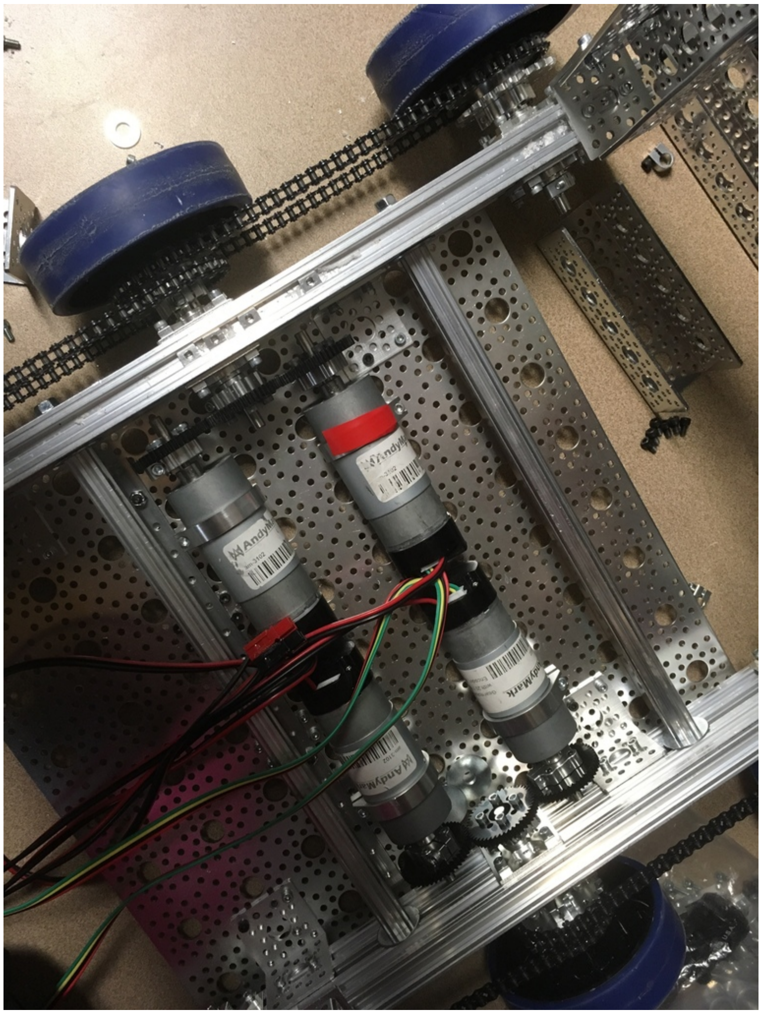
October 24, 2016
Members Present: Ashley

Disassembled the particle shooter to swap the wheels out for stickier ones (AndyMark Blue) and to shorten the X-rail to make more room for the cap ball elevator lift mechanism once it's on the robot.

October 25, 2016
Members Present: Hannah, Taylor



Cutting notches into the channel for the particle shooter for clearance of the elevator lift



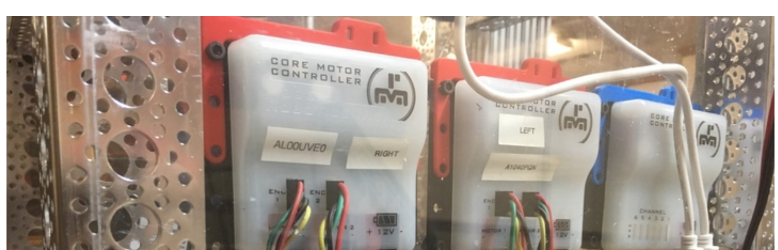
Churros (from last year's FirstResQ field kit!) installed to stiffen the robot chassis.

October 26, 2016
Members present: Hannah, Ashley, Jeremy, Ian

Increased clearance in shooter cross member for elevator lifts, cut more Lexan for panels, figured out standoffs for lift sides, cut wheel shafts shorter for clearance, planned controller layout

October 30, 2016
Members present: Hannah

Mounted particle collector including sweeper, sprockets and drive motor. Wired motor controllers for collector and particle shooter.



November 2, 2016
Members present: Lauren

Added ability to configure alliance, route and delay start from game pads to autonomous mode during init.

November 9, 2016
Members present: Caroline

Caroline got bottom ramp installed and continued work on launcher.

November 10, 2016
Members present: Ashley, Taylor

Taylor and Ashley nearly finished launcher conveyor, and installed much of the winch.

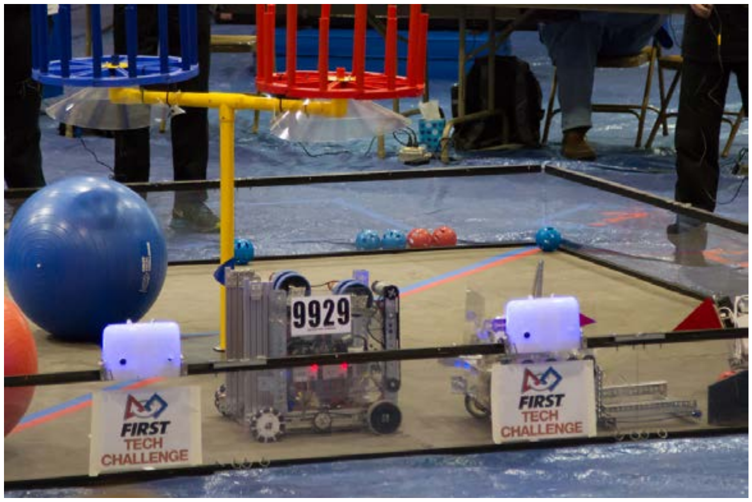
November 11, 2016
Members present: Everyone

Evening before first league meet. Went over strategy, drive teams. Practiced placing and starting autonomous opmodes. Double-checked robot for loose parts, packed up.

November 12, 2016 -- First League Match, Kankakee, IL
Members present: Everyone

Our first league meet was a great success. We went home ranked in 2nd place in our division and were pleased with the results, but also eager to improve.

Some of the team's drivers are hard at work in a match.



Getting ready to reclaim a beacon during a match.

Rank	Team	Event QP/RP/M	League R/QP/RP/M
1	10093	4/70/3	1:4/70/3
2	9929	4/35/2	2:4/35/2
3	9698	4/35/3	3:4/35/3
4	9342	4/30/2	4:4/30/2
5	9365	2/45/2	5:2/45/2
6	10421	2/35/2	6:2/35/2
7	7089	0/55/2	7:0/55/2
8	2923	0/45/2	8:0/45/2
9	10420	0/25/3	9:0/25/3

League Meet #1 Results (TNT 9929 is rank 2)

November 13, 2016

Members present: Hannah

Hannah and Mr. Beezie examined the robot for damage, loose screws, etc. We confirmed that a motor mount had in fact come loose and this was likely the cause of the grinding sound that Lauren and Charlie heard in the last match. We moved and re-secured the motor mount; the gears themselves appear to be fine. We also noted that one of the center wheels appears to be missing all of its outer screws where the bearing meets the x-rail. This will need to be repaired.

November 16, 2016

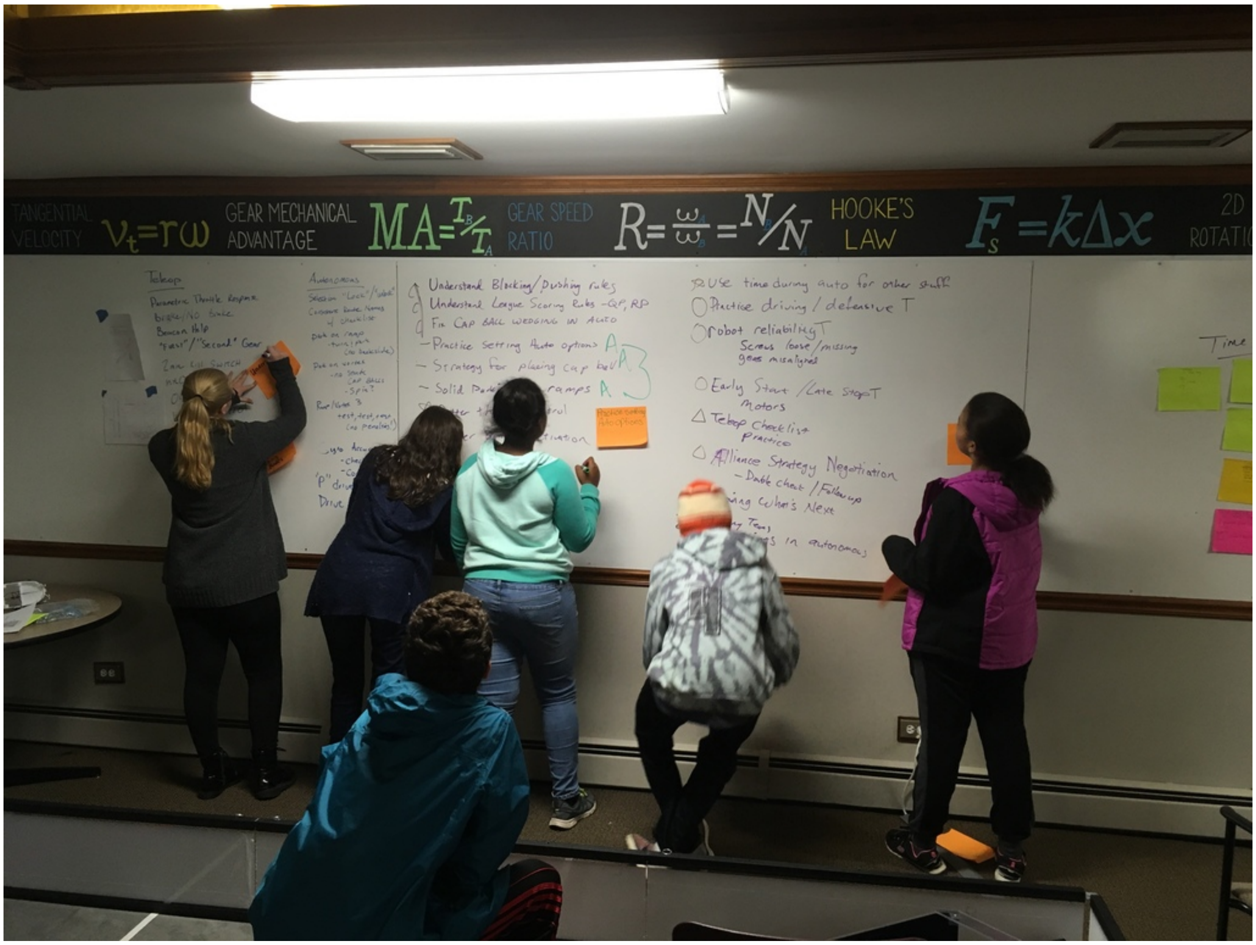
Members present: Ashley, Hannah, Jeremy

More work on getting the particle shooter working – "fingers" made with tape on the end of spear gun line, adding more spear gun line.

November 18, 2016

Members present: All

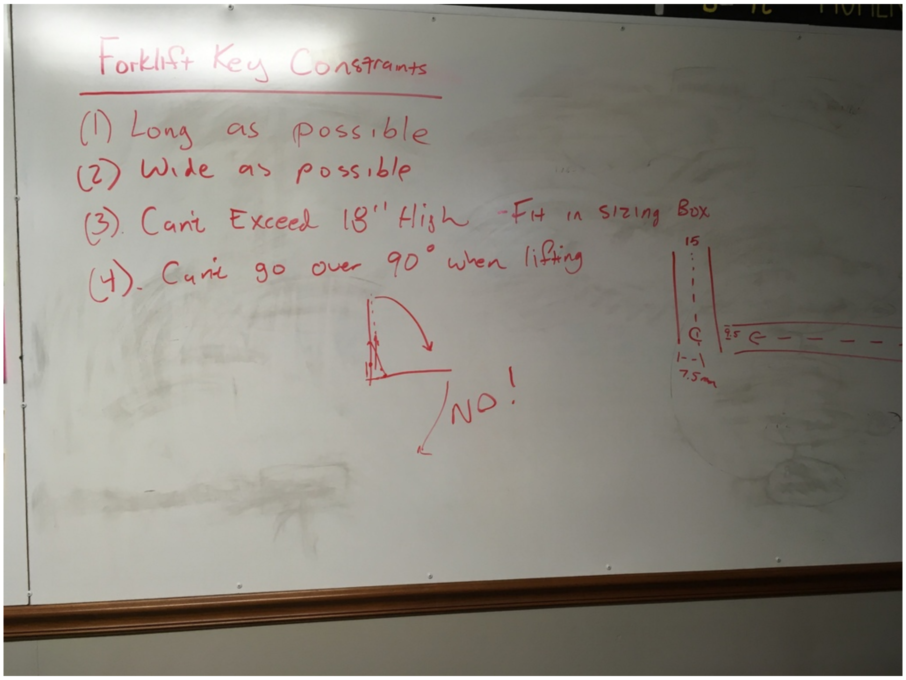
De-brief from first league match. Gathered input from team and mentors. Placed all ideas on post-its, and sorted/organized together to prioritize.

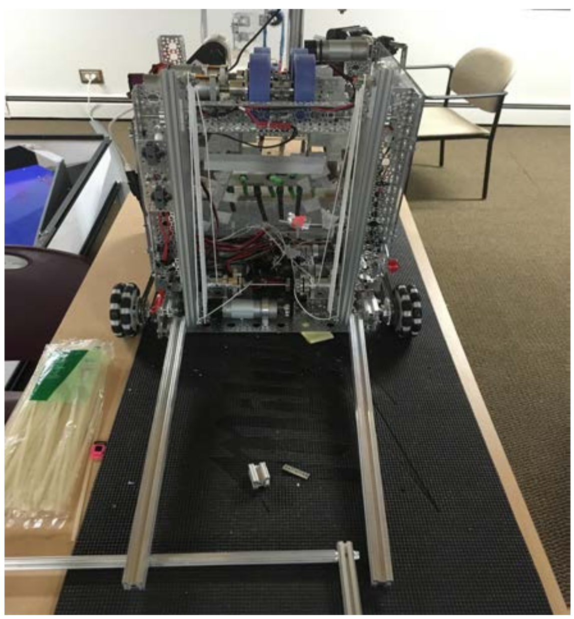


November 20, 2016

Members present: Ashley, Hannah, Lauren

Started building forks for cap ball lift.



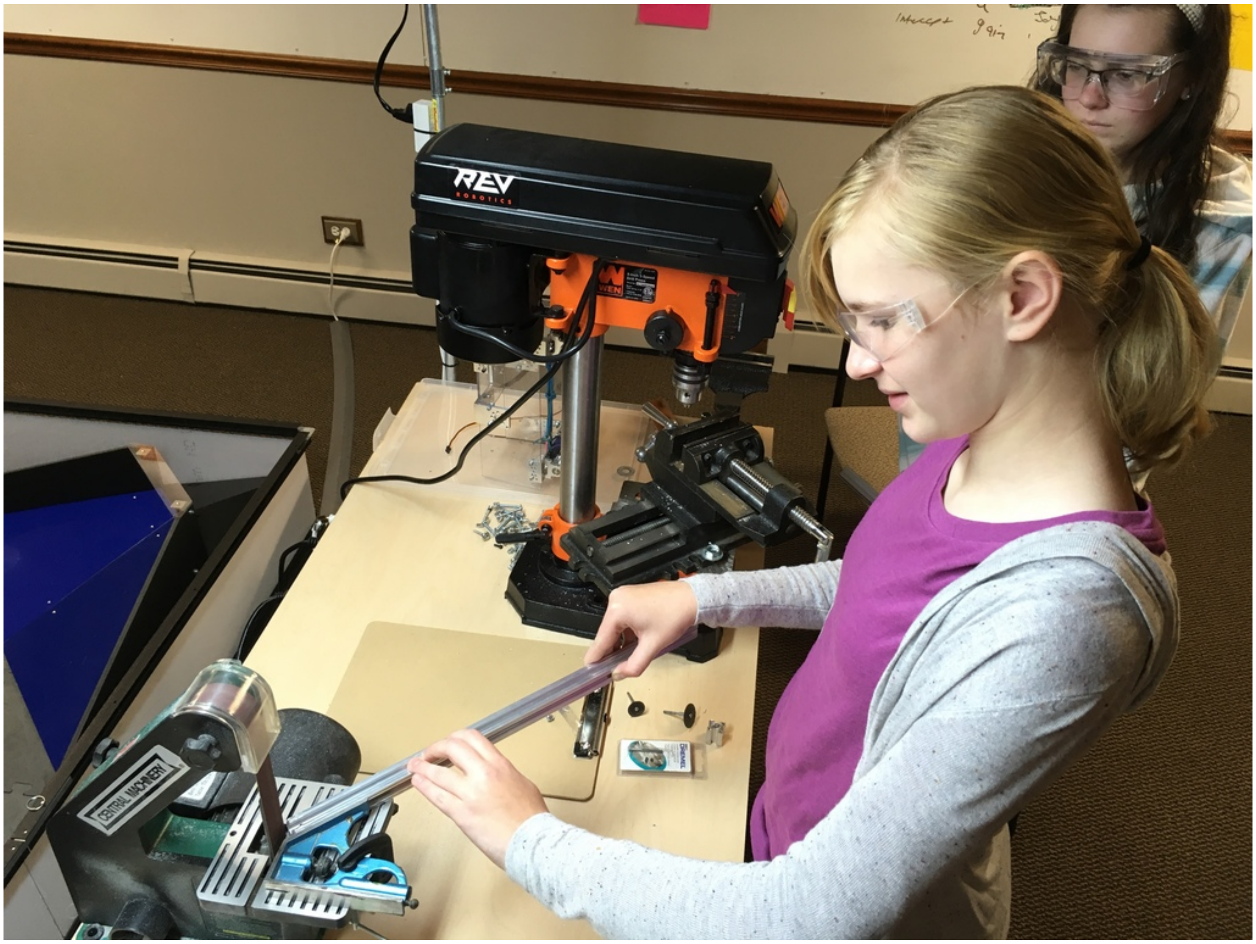


Adding lift forks to robot.

November 21, 2016

Members present: Calvin, Hannah, Kaylin

We lifted the cap ball for the first time! Testing the lift and forks – we need to add structure to keep lifts from twisting, re-rig spools to take up exact same amount of line, need line guides on outside of pulleys to keep line from derailing.



Sanding down the ends of lift forks for smooth surfaces that will not damage field equipment.

November 23, 2016
Members present: Caroline, Hannah, Taylor

Added and tested parametric throttle response (ask Coach Matthews for details to include). Added ½-speed mode for beacon pushing during tele-op. Hannah and Taylor made and installed cable guides.

Putting together the cable guides for the lift was challenging. However, we persevered and got it done!

November 27, 2016
Members present: Lauren, Ashley, Hannah, Jeremy

Lauren got autonomous configuration lock/unlock finished, removed support for conveyer, pulled collector forward/reverse/off into new methods to be used by autonomous modes, added route names that match the scouting sheet, started working with Hannah on improved scouting sheets, updated tele-op checklist diagram. Jeremy and Hannah removed film from new AndyMark wall panels, worked on lift. Jeremy and Ashley started construction of 2nd collector. Mark and Lauren repaired center sprocket bearing mounting on right side of robot.

November 28, 2016
Members present: Calvin, Hannah, Lauren

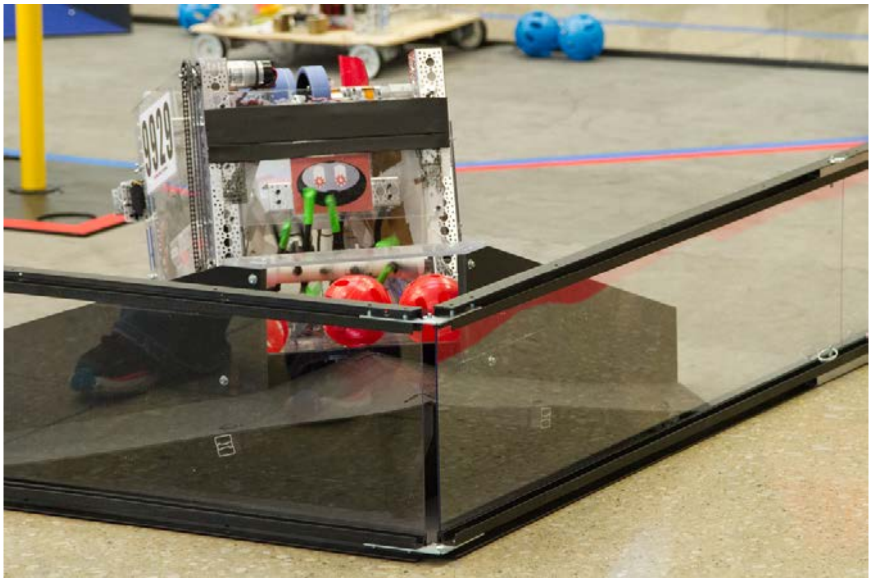
Worked on scouting/match plan sheet. Shortened lift forks, placed stops to keep Rev Robotics slides from pulling out. Added Lexan to keep forks from spreading. Tested lift (needs tilting mechanism).

November 29, 2016
Members present: Ashley, Calvin, Hannah, Ian, Lauren

Finalized rigging of cap ball lift, added Lexan panel on front of towers, fork tilt servo, fork unlock servo, wrote code to support both. Added Lexan for pushing beacons more reliably. Managed to pick up and lift cap ball! Drivers tested throttle response curve, settled on .3 gain level.

December 3, 2016 -- We Host 2nd League Meet -- Chicago Heights, IL
Members present: Everyone, plus Team Mascot

Getting ready for a match.

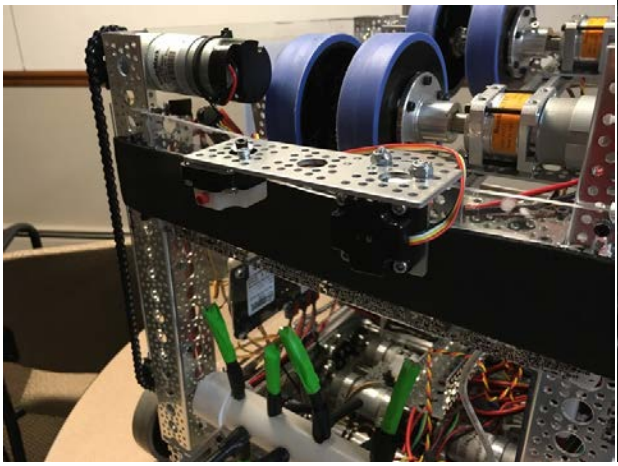


Scoring particles in the corner vortex.

We introduced our mascot to the other teams at this league meet. Everyone loved the new addition to the team!

December 12, 2016
Members present: Jeremy

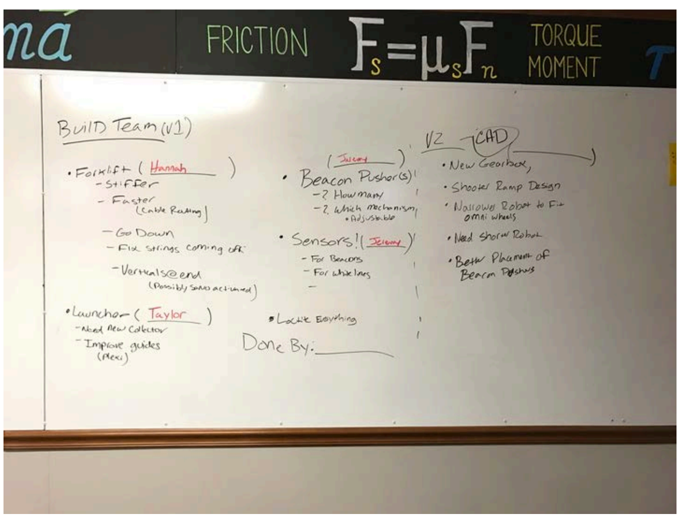
Designed, built and mounted a prototype sensor package for autonomous beacon pushing. Mounted the optical distance sensor for line following.




The sensors were safely hidden at times to prevent damage to them.

December 14, 2016

Members present: Lauren



Lauren added a state machine state to drive forward until the touch sensor is pressed, and another to detect blue and "press" (send message to DS via telemetry) the beacon button depending on alliance selection as a prototype for the entire autonomous program that will also line follow (using ODS) and slow the approach for a soft "landing" at the beacon (using range sensor, and perhaps encoders too)

December 16, 2016

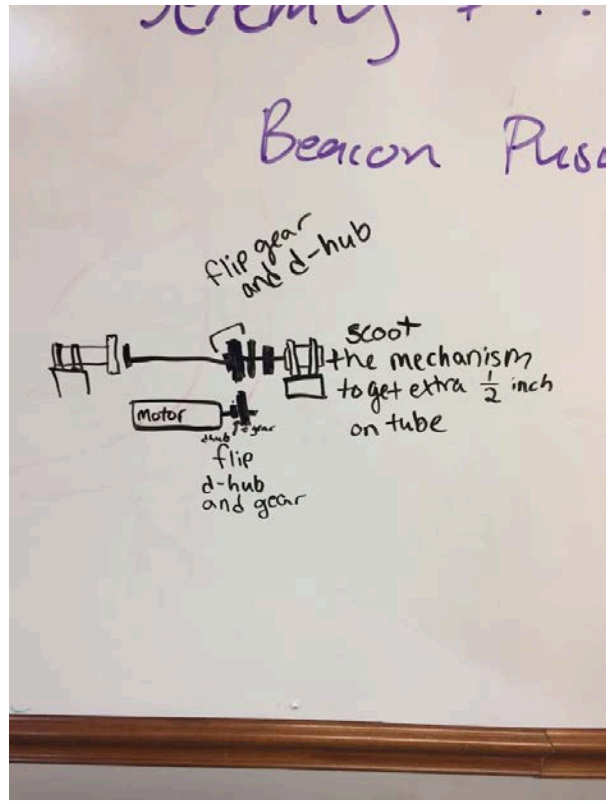
Members present: Ashley, Calvin, Hannah, Jeremy, Kaylin, Lauren

Ashley and Kaylin got bearings mounted for 2nd collector, Kaylin and Mrs. Matthews finished replacement of screws on drive train + Loctite. Hannah and Mr. Uecker fabricated pull-down line guides out of music wire (they won't allow the lift to be pulled all the way down, to clear the motor - but that is not a requirement the team thinks that is needed). Figured out that we need to extend the spools so they are two-sided for play-out, take-up (separate spools needed). Tested beacon detection autonomous code...Missed one side of logic (when we detected "not blue") ... fixed. Found touch sensor plugged into wrong port (needs to be digital, not analog). Code worked when color sensor worked - but failed when it didn't. Lauren knows a safety; we look for B >= 5 in RGBA. It should be something like B >=5 && B < 20-30 (so when color sensor is not working, 255 isn't read as "blue", because it's not). Calvin, Jeremy and Lauren looked into pusher mechanism options - servos + rack gear looks to be best, found places to mount them on intake side of robot (there's clearance). Lauren fabricated a potential pusher and tested it by hand.

December 18, 2016

Members present: Ashley, Calvin, Hannah, Kate

Fabricated second collector, practiced driving with the cap ball. Added detection of max slew rate during Tele-op, plan later to add an actual limiter. Added auto fork unlock code so that when drive team operator starts to move forks – if not yet unlocked will they will automatically be unlocked. Hannah worked out a plan to make room for dual spools for in/out spooling of lift lines.



Left: Collector mechanism in progress. Right: Idea for changing the cap ball lift motor setup.

Our “intern” Kaylin is rebuilding last year’s robot to be workable for scrimmage/practice. She started by tapping the new omniwheels from AndyMark to accept machine screws:

December 27, 2016

Members present: Hannah, Lauren

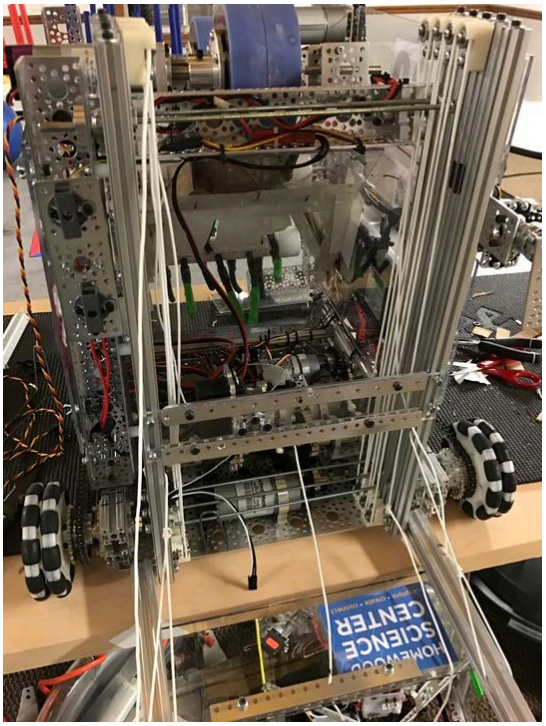
Hannah worked on ramp/guides to shooter. Moved wheels on front shooter motor together - observed more consistent trajectory. Low battery makes for a very inconsistent shooter. Things left to try - moving back wheels together, wrapping wheels with rubber bands, once trajectory is reached, especially without full power, programming team will use RUN_WITH_ENCODERS to attempt to maintain consistent speed.

Lauren worked on adjustable bars for each set of slides on the lift, pulled apart all lift sections, double-checked slides, measured, cut threaded rod to length, setup vise and drill press and through-drilled every slide at each end consistently. Installed threaded rod and reassembled lift and attached back to robot. It needs some adjustment particularly on the front sections, they probably need to be let out a bit wider because the fixed section on the robot was narrower than we originally assembled things. Lauren also notes that the Lexan on the front is now not mounted as square as it could be (given that the lift sections now sit more square to each other) so this probably needs adjusting as well. Lesson learned this evening…there wasn’t room to have a “strut” on the top of the 2nd-to-furthest out linear slide because the servo would hit it when it was being raised. Seems like we can live without it.

(Lauren and coach Mark think the slide needs adjustment **out** on the side of the robot where there’s more thread available - it’s obvious, it’s the right side when facing the robot … because when the lift sections were not on the robot it slid with little resistance and no binding - but once constrained to width on the robot it binds on one of the front sections)

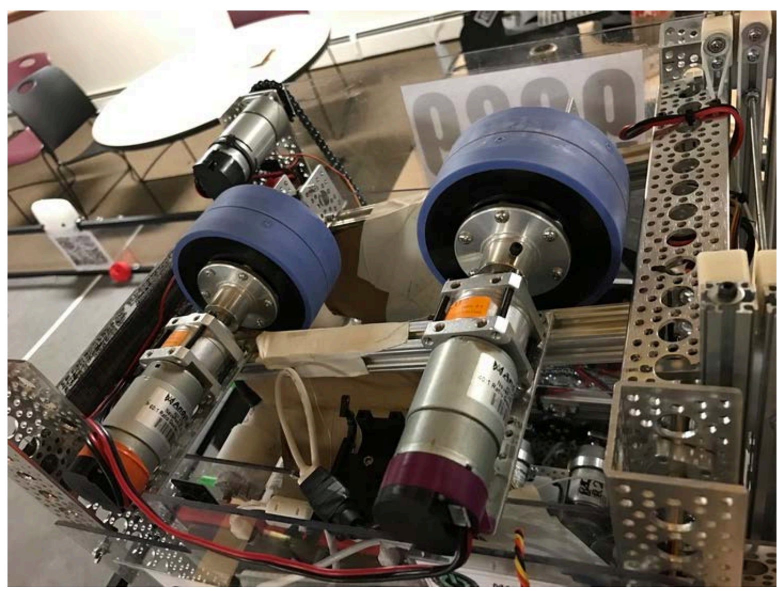
December 31, 2016

Members present: Ashley, Jeremy, Hannah, Taylor, and Kate



Installed 3D-printed cable guides on the lift, initial idea from FTC#7300 Guzzoline in Asheville, NC (who Kaylin, Lauren and Coach Mark visited while in Hendersonville, NC earlier in the week – see the Outreach section for more details) – printed by Mr. Brozek (community supporter). The pulley guides were a lot of work and not quite done by the end of the day. The new parts for the forklift winch were installed.

Moved top shooter wheels closer together to mirror bottom shooter wheels. Tested trajectory (more consistent, may still need gearing/sprockets to get even more speed for longer distances).



January 1, 2017
Members present: Calvin, Hannah, Jeremy and Kate

Continued to refine the movement of the forklift pulley. We added the "pull down" string and adjusted the winch. We had to reinstall the winch with stronger supports; it was bending the c-channel holding it up. Hannah, Jeremy, and Cal adjusted and tightened the threaded rod on the forklift. The team also worked to get a beacon pusher mechanism added to the robot, but ultimately put that aside. Hannah and Kate did some test driving of the robot. It appears to shoot consistently, though you have to be close to the goal to shoot. It also appears to handle the beacons fine. The forklift needs some cable re-routing.

January 4, 2017
Members present: Ashley, Calvin, Caroline, Charlie, Hannah, Jeremy, Kate, Taylor

Lessons learned from driver's practice:
1. It seems reasonable to hit 4 center goals in 90 seconds. 5 or 6 is possible, depending on how good a job we do of finding and picking up particles - there will be some luck involved. The team will also need to consider whether our alliance partner is also attempting to shoot particles, as two robots competing for 3 particles on the field could make things too slow.
2. All drivers need to improve their beacon times. We put some obstacles on the field and asked drivers to activate 4 beacons. The _best_ time we saw was over 60 seconds. Many attempts were almost 2 minutes. This further highlights the need to coordinate well with our alliance partners - it's likely that one robot will need to just focus on beacons.
3. We need a "shoot" macro (turn off collector 0.5s, turn on shooter 0.5 s, re-engage collector) to reduce the chance of operator error on shooting.
4. The shooter ramp needs regular attention to make sure that particles do not get stuck between the front shooter wheel and ramp. This results in weak shots.
5. Beacon smashing is still a problem. We should discuss with programming team whether we could have a "quarter speed" or even "10% speed" mode. The current robot configuration pushes beacon buttons a little better than last time.

January 5, 2017
Members present: Ashley, Calvin, Hannah, Ian, Jeremy, Lauren, Taylor
Packed toolbox, crates for league meet. Lauren ran some experiments with an o-scope and the servo tester to see how it all works pre-practice.

Cal and Lauren wrote the state machine to handle the shooter during Tele-op. (needs testing on Friday)

Hannah and Taylor and Ashley worked on the lift to get it all tuned and lifting more consistently. Ended up having to strengthen the "floor" because initial startup torque would cause flex and the gears would misalign.

(new rule, no gear trains held together by separate structures)

Driver/ops tested lifting and placing the cap ball... almost all attempts worked, but were slow…Not so slow that it can't be done on Saturday, but it's going to take some practice

January 6, 2017

Members present: Ashley, Calvin, Caroline, Charlie, Hannah, Ian, Jeremy, Kate, Kaylin, Lauren, Taylor

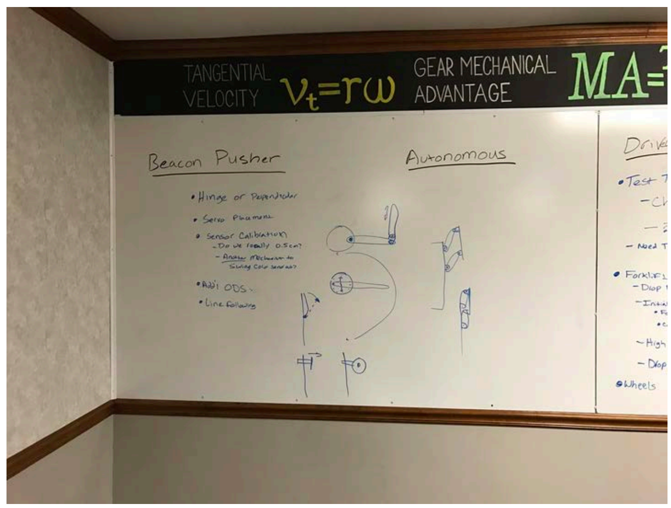
Set up field, etc. for the league meet we are hosting on the 7th. Drive team practice with the robot. Reworked our scouting sheets based on feedback from those on the team that are doing scouting.

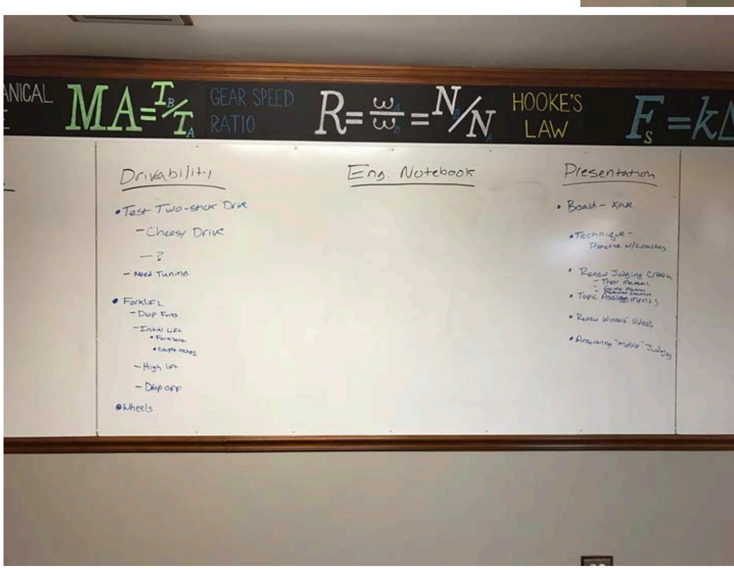
January 7, 2017 -- We Host 3rd League Meet -- Chicago Heights, IL

January 9, 2017

Members present: Ashley, Caroline, Hannah, Jeremy

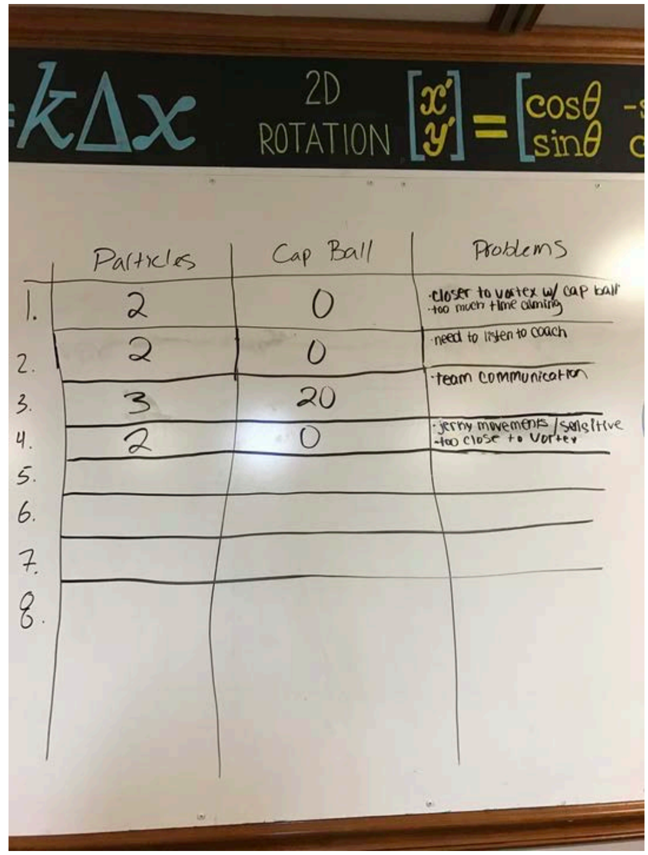
Today Hannah, Ashley, Jeremy and Caroline discussed what we need to do before qualifiers. We changed the wheel configuration on the robot and that made a _huge_ improvement in maneuverability. Caroline began looking at programming changes necessary to automate some of our cap ball lifting tasks. We experimented with "two stick" drive and discussed how we want that to work.



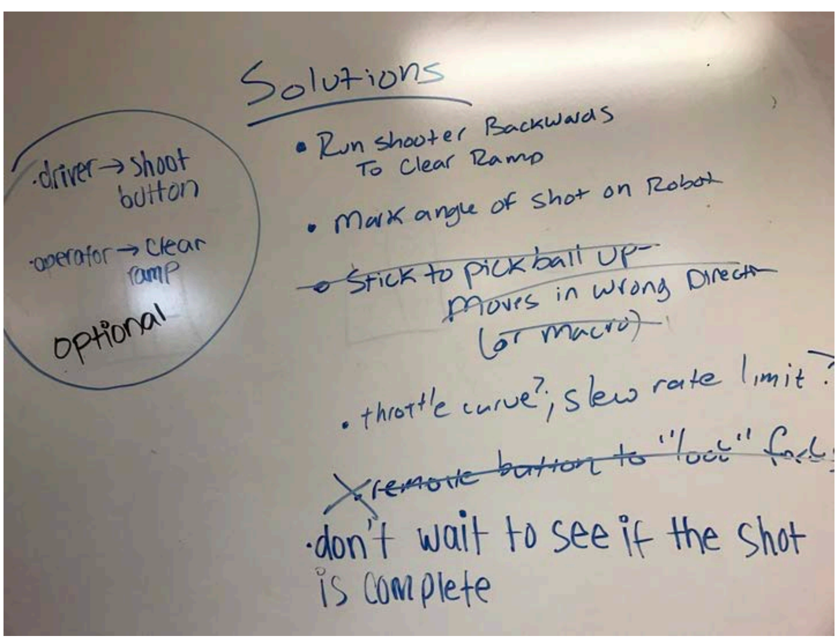


January 10, 2017
Members present: Caroline, Hannah, Kate, Taylor

Evaluated CheesyDrive (new 2-stick driving system), modified to base "quick turn" on dead throttle. Adjusted steering sensitivity (k) to 1.3. Caroline ported the scaling from our ArcadeDrive to CheesyDrive. Evaluated on throttle and steer, removed from steer. Practiced collecting and shooting particles with static obstacles and timer. Practiced end game. Hannah asked that the fork lift/drop stick direction be reversed. Also, we removed the ability to "lock" the forks from the controls so that it can't accidentally happen. Noticed that particles are often wedged against shooter wheel. Proposed that programming team reverse the shooter motors before spinning them the other direction for a fraction of a second at low power to "clear" them. (TBD). Need to add a "I MUST BE RESTOWED" tag or something to the lift servo cable.



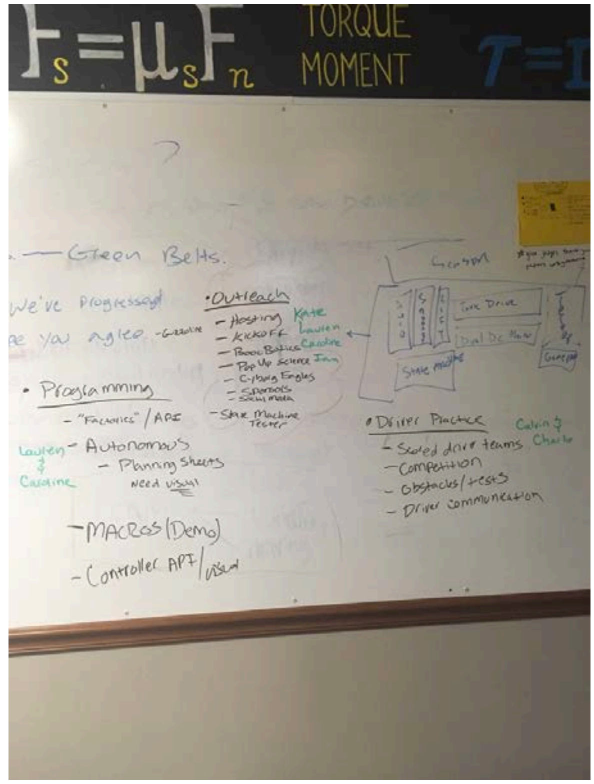
Taylor replaced our fully-functioning main power switch with an approved one. It probably needs some tweaking to be robust, but it's working for now.



January 13, 2017

Members present: Ian, Hannah, Taylor, Cal, Kate, Lauren, Jeremy

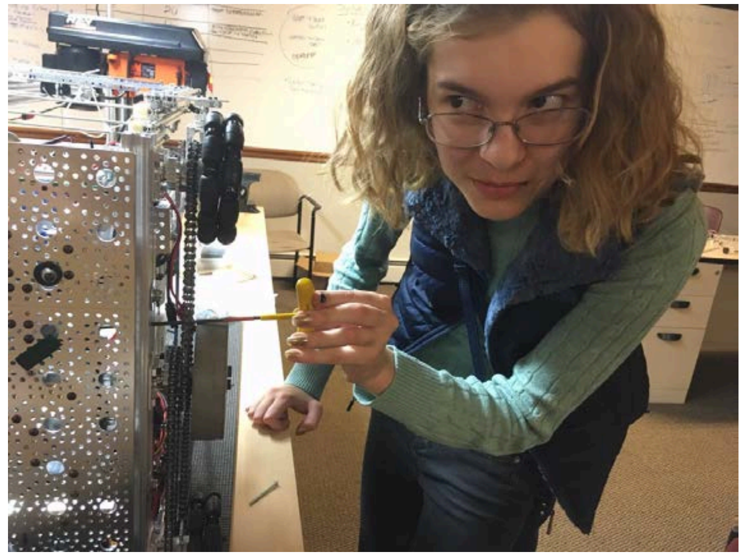
Replaced omni wheels with ones from ServoCity. Worked on top-level outline of topics for presentation and opening statement.



Drove the robot with new omni wheels, Kate noticed that it was veering slightly to one side.

It turned out to have a dead Neverest 20 motor. Replaced the motor and tore it down (broken gearbox). Validation that 2 motors per side makes for a robust drivetrain, however we are re-evaluating whether or not we need the speed of the 20s or if we can use 40's.

During rebuild noticed that other gears were loose, thought we needed to pull the gear or motor to get to it but Lauren noticed that all of our gears are reachable through the x-rail frame (another accidental design win!).



January 16, 2017

Members present: Hannah, Ashley, Kate and Caroline

We mounted the linear servos and beacon pushers. We made the beacon pushers out of Actobotics plates, then layered cardboard on top to make the surface flush with the mounting nut. The linear servos appear to be mounted securely, so long as the mounting straps hold. The beacon pushers will be subject to getting knocked out of position - they rotate around the servo nut rather easily. They also make changing batteries hard - we will either need to remove them, or create a battery-changing mode where they are extended. There is a color sensor mounted above the center pusher. We also mounted a range sensor on the side of the robot, and another range sensor on the front. These are not wired yet, and we will need to make sure that the wiring does not interfere with battery changing.

January 17, 2017

Members present: Present Kaylin, Hannah, Caroline, Cate, Calvin.

Kaylin moved the CDIM module so that the bulk of our sensors could reach it without extension cables. Hannah and Kaylin zip-tied loose cables and removed debris from the robot. Kate and Caroline learned to crimp servo cables and started making new and spare servo cables (6’) for the lift’s servos. Hannah tested the servos to determine what position would work for autonomous beacon pushing, we also used the SensorTestor OpMode to determine starting points for detecting red and green at that distance. Caroline coded up a proof-of-concept beacon pusher and we attempted to test it, but kept running into the MR Color Sensor returns garbage values issue that many other teams do..suspect low voltage, we’ll test later this week with a battery with more charge**.**

January 20, 2017

Members present: Hannah, Kate, Calvin, Lauren, Taylor

Calvin and Hannah laid out new auton. routes adding shooting and beacons. Lauren and Calvin added state machine for "grabbing" the cap ball off the floor. (not yet tested). Kate and Taylor removed the NR20 motors (some are failed and others are failing), and started replacing them with NR40s. Kate routed and dressed the motor power cables and encoder cables.

Lauren reworked sprockets on the collector drive to up the velocity of the collector bars.

January 22, 2017

Members present: Caroline, Calvin, Lauren

Designed and wrote proportional drive inches state Tested, precise but not accurate, we might be able to adjust for accuracy with some trim (edited). We had wrong values for encoder counts for full rev on nr40, fixed - Changed to NR40 motors in base hardware class. Noticing that robot slightly veers when driving (auto or tele-op), determined it's s mechanical problem through process of elimination. (Also drive chains are pretty loose on at least one wheel).

January 26, 2017

Members present: Hannah, Kate, Jeremy

We tackled the veering problem we were observing after changing the motors. One motor gear was pressing against bottom plate, we removed and repositioned it. We also tightened the chains on the collector-side wheels. They are much better. But when we tested the robot after these repairs, still significant veering. We identified some clamps on the wheel shafts which were too tight and fixed these, being careful to add shaft spacers. This substantially improved the veering but it's still there. We observed an omni wheel with wobble in it and reassembled it. It looks better, but veering is still (slightly) present. Notably, the veering problem is a "dragging" which occurs once per rotation, on one side of the robot. We ran out of time to chase this down further. The robot is fine for tele-op. For autonomous, some fudging of steering, or use of the gyro, may be necessary, but that should be minimal. Kate also worked on a cover page for the engineering notebook.

February 4, 2017
Members present: Lauren, Kaylin, Hannah, Calvin, Taylor

Finished chain guard, loctite on lift screws, tensioned lift lines, removed blocking cross pieces in lift (at motor and at stage near servo). Kaylin with Hannah's help organized our toolbox, especially all of the cables and sensors which are now in a grab and go case.

All worked on their presentation to judges, lauren continued work on her section of the notebook. Taylor Hannah and Cal had beacon, shooting and lift practice

NOTE WE NEED TO RETAPE THE LOW PART OF THE INTAKE, particles are jamming there!

February 6, 2017
Members present: Hannah, Taylor, Calvin

Plan - drivers' practice, fix some auton. issues with the beacon, remove not-used ODS, create scouting sheet ideas.

What we did - taylor and hannah had driving practice, shooting, beacons, cap ball. Re-tensioned cap ball lines. Hannah and Calvin had drivers' practice as well, had to lubricate the linear lift as well....Some attempts < 30 sec, good work. Still need to work on using concise words and precise directions.

Generated outline for scouting score sheets.

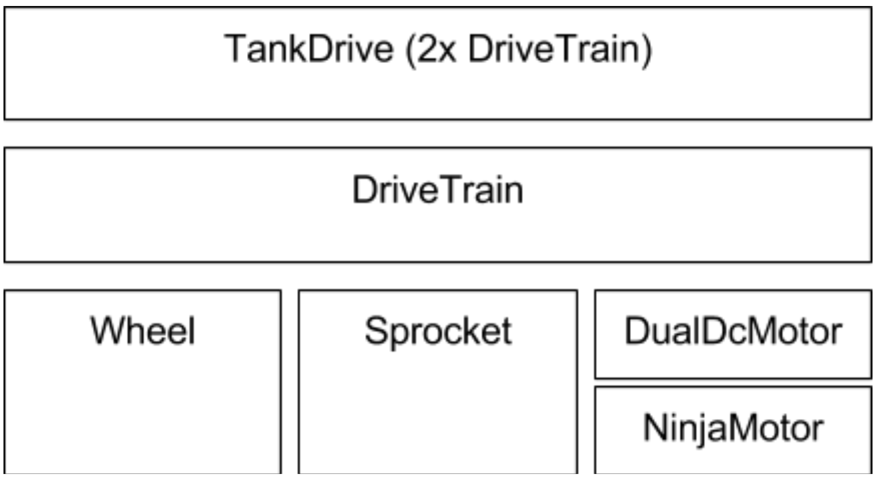
Hannah added in a 3 deg turn towards the wall after pushing the first beacon to hug the wall better. She also had the idea to slow down the ODS portion slightly to be more accurate (and it worked).

NOTE: Also, the far red beacon was not in position, which caused issues in testing autonomous because we weren't lining up correctly.

Controls, Software for Tele-Op and Autonomous

Key Functionality -- Drivetrain Class

We have many of what we call “factories” of code. The “factories” are sections of reusable code that we can call upon with simpler variables to create more complex things. We call them “factories” because they are sections of code in which we insert amounts for the code to compute into values we will use in the main code. They are separate areas of code so they don’t clutter up our main code but still gives us the needed functionality with relative ease. Sometimes (like in the DriveTrain class), the code uses simpler factories to create more complex ones (wheels, motors, gears turn are used to make a DriveTrain). The “factories” will be reused in our next season since they have been designed to be the platform for our future seasons’ robots.



A key class in this set of factories is the DriveTrain class. It hides the complexity of dealing with gear or sprocket train ratios, motor types with their encoder counts per revolution and rotation direction, and wheel diameter and thus circumference. By using the DriveTrain class, we are able to tell our robot to drive any amount of inches by calling one method with the direction and number of inches we want the robot to move. We had to switch motor types after our league meets because the Neverest 20 motors were not holding up, and all that was required to change in our autonomous code was to change the parameters to the motor factory to use a Neverest 40 (which happens to rotate in a different direction than a 20, and has different encoder counts). Nothing else in the code had to be changed.

Most of our state machine states use the DriveTrain class, You can read more about that in the next section.

Key Functionality -- State Machines in Autonomous and Tele-Op

Our robot's program is object oriented since it keeps data within each state, rather than stored throughout the OpMode code. Such data is the power of the motors while driving normally, current driving heading, required encoder counts to drive a distance, data sent or collected from the various sensors on the robot, and the power level used when in proportional drive. Our most used classes in this code are drive inches state, proportional drive inches state, and gyro turn state.

Our drive forward inches state allows us to set our robot to drive any amount of inches by only entering a few parameters as seen in the code below.

```
ProportionalDriveInchesState step1DriveState = new ProportionalDriveInchesState(
 State 1 - drive forward", drive, telemetry, 16 /* inches */,
 POWER_LEVEL /* power level*/, 15000 /* milliseconds to timeout */);
```

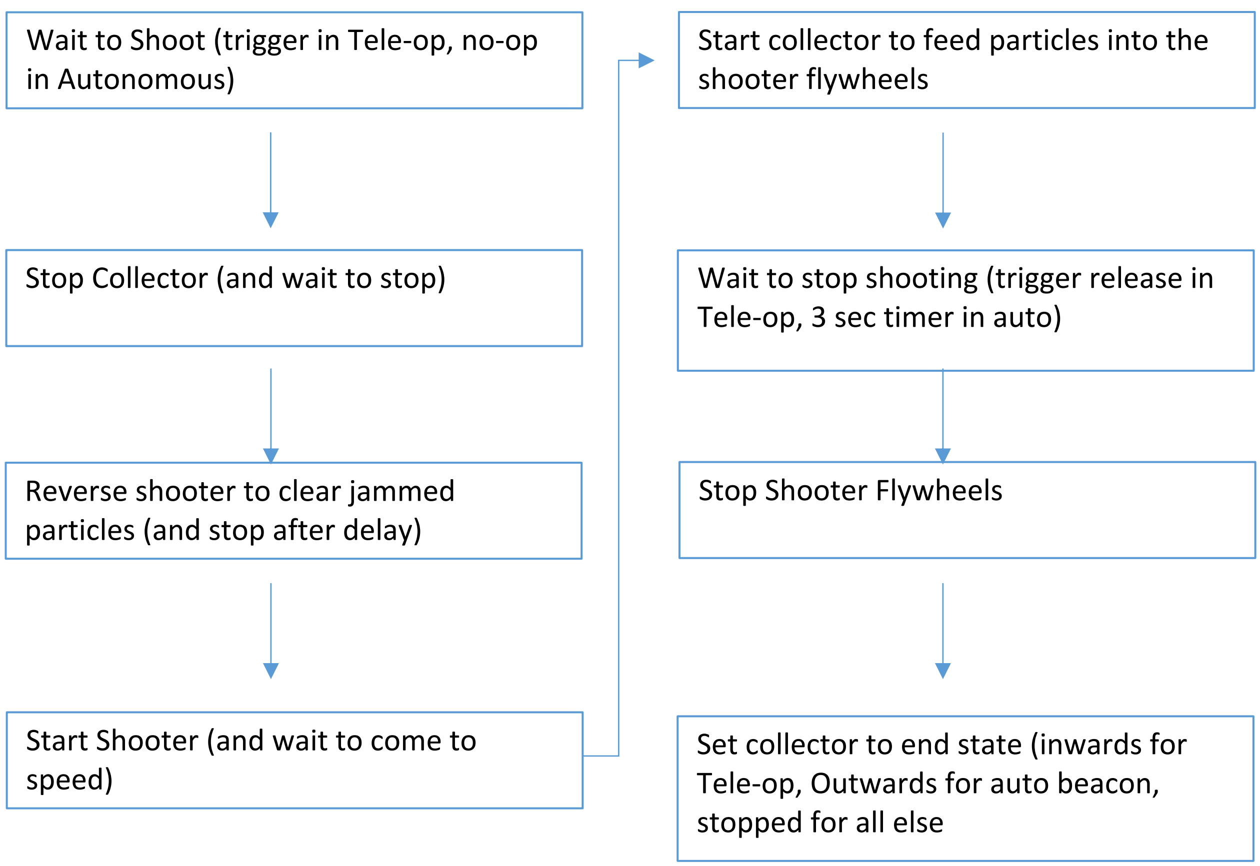
Because this state re-uses the DriveTrain class, it hides the complexity of dealing with gear or sprocket train ratios, motor types with their encoder counts per revolution and rotation direction, and wheel diameter and thus circumference. We are able to tell our robot to drive any amount of inches setting a value to a few variables within three lines of code. That code is reused throughout the robot's program by changing a few values to move the robot where we need it to go. This is easier for the coders and readers of the code to understand compared to 886 lines of code that would have had to been used if we had not made the code easy to call. Thus the few lines of code shown above pulls from “factories” of code hidden beneath our main programs.

Other states that use these “factory” codes are the gyro turn state, proportional drive state, and the delay state. The gyro turn state is a state that works with proportions. The proportions in the gyro turn state allow use to calculate the space left to turn and slow down the closer we get to the desired distance. Since we slow down the closer we get to the desired distance to turn it helps to prevent overshooting. Since we have cut overshooting in turning we are able to program complex autonomous modes without any or little line following.

We use a similar proportional feature in the proportional drive state. This state has a similar use to the gyro turn state. It prevents overshooting by slowing down. But instead of overshooting while turning it is used to prevent overshooting while driving in a straight line. The most notable use of this state is in our beacon claiming autonomous. We drive using our proportional drive state until we are around six inches from the beacon. We then switch to a constant speed drive state at a lower speed for the last six inches from the beacon. This makes it easier for the ODS sensor to find the white line in front of the center of the beacon while also preventing overshooting of the beacon.

One of the other states we commonly use the is the delay state. This state is used to have the robot wait for a set amount of time. One place we use this delay state is at the beginning of all our autonomous programs. We are able to change the length of the delay state before a match so we do not collide with our alliance partner during the match. While the robot is in this delay state it does not move. Another place we use this delay state is in our particle shooter state machine.

The particle shooter, although we use only one button to operate it in tele-op, is made up of many states. We start by waiting for the signal to start the shooter state with the shooter start state. In tele-op it is a button and in autonomous it is the end of whatever state was before the shooter start state. We then turn the particle collector off to ensure that no other particles are brought into the robot during the next few states. We then enter a delay state so we can wait for the collector to come to a stop. Once the delay state has come to an end we enter a state used to unjam the shooter. We do this by running our particle shooter backwards thus pushing the particles into the robot. We then have a delay to ensure the particles make it into the robot and are not jamming the shooter. After that state timeout is done we turn the particle shooter off. We then turn the shooter on in the forward direction and start a delay to wait for the shooter wheels to come up to speed. When this delay times out we turn the collector back on to draw the particles up to the shooter. We then have another delay state to wait for the particles to be shot. We then stop the shooter and reset all delays. Originally we had our drivers, during tele-op, press separate buttons for these states. It was made easier for our drivers when we condensed all the buttons into one state and thus one button:



Since state machines are such an important part of our program we have a few features that help us use our states to a fuller extent. One of these features is the state machine class. The state machine class allows us to reuse a set of states anywhere in our code. Our code is highly object oriented and, as we have mentioned earlier in the engineering notebook, we use many state machines multiple times within the code. The state machine class is thus extremely useful to the overall program.

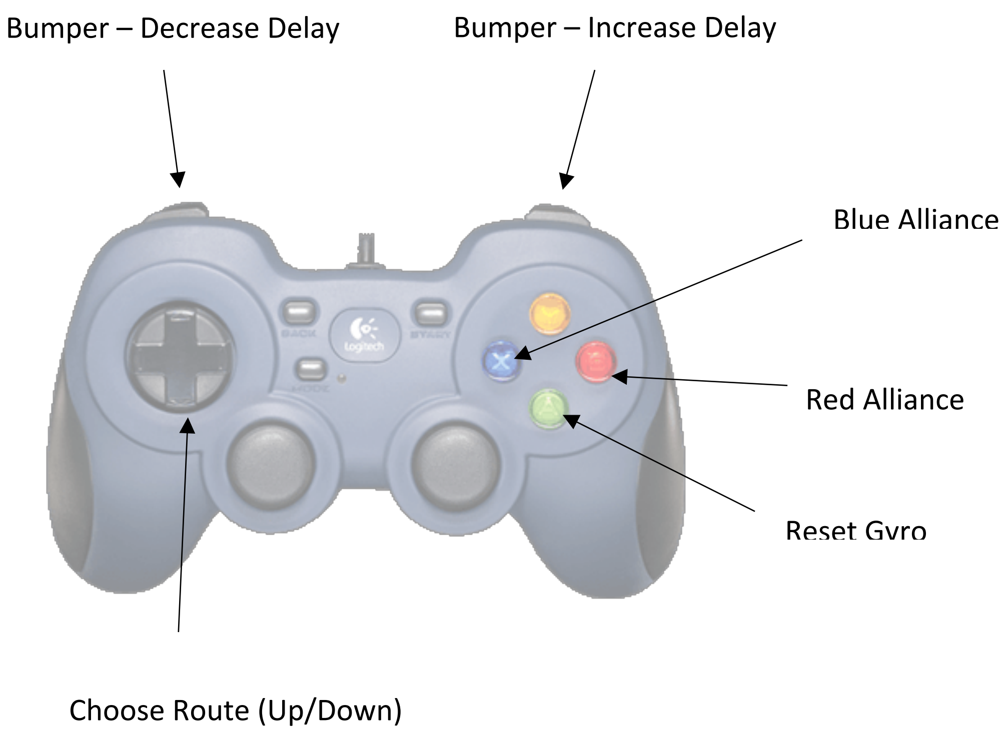
We also have the ability to use multiple state machines at one time. In tele-op we are able to shoot particles, drive and grab the cap ball at one time. This is a helpful tool because it enables us to perform twice or three times as more tasks than if we ran one state at a time. Since each match gives us limited time every second matters. If we can complete two tasks at the same time we are more efficient than if we could only complete one at a time.

Another important feature of our state machine class is our debugging mode. This is a mode that allows one to debug our robot's code, state by state from the driver's station. This code allows us to travel forward or backwards through states in the state machine. The debugging mode also allows us to alter variables within the state before they are run. This debugging mode saved us many hours of time by being able to repeat testing different values in the robot code without re-downloading the code each time. This made it easier and quicker to find the needed value of a variable in our code. Another use of the debugger is finding faulty code in the robot. Since you can go state to state you can see all the states at a pace in which you can observe them. Since you can then observe the states that last for a few seconds or less, it is easier to find broken or faulty code.

Key Functionality -- Configurable Autonomous Mode with Route Selection and Optional Delay

Our autonomous initialization stage holds another important feature of our code. We have our code set up in such a way that we can have multiple autonomous programs in one OpMode.

During init() mode, before we start autonomous, we have a menu of different autonomous programs. Our opmode allows the drive team to change between our different autonomous programs with the driver station dpad. We can also change the delay amount with the bumpers as well as change our alliance with the X (blue) and B (red) button. With the left stick we can lock the chosen configuration and with the right stick we can unlock the configuration.



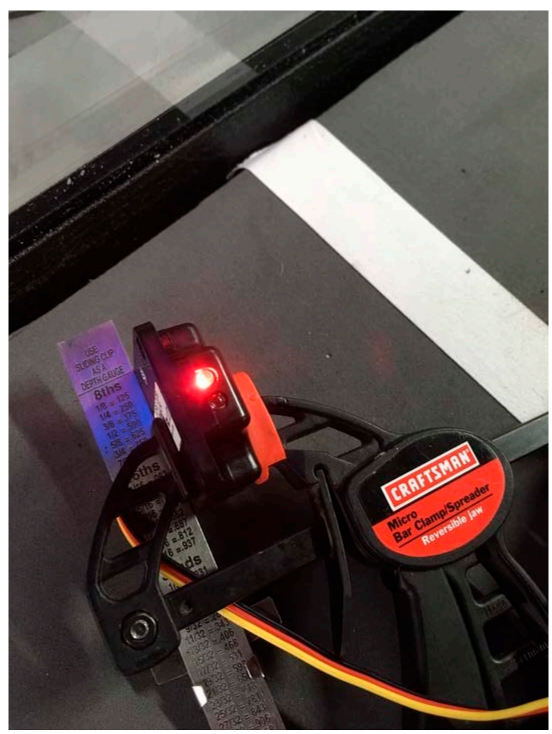
To make it possible to have such menus for our autonomous programs we had to create state machines made to fit this system, one for each possible major scoring opportunity (claim beacons, park on ramp (from 3 starting locations), park on vortex and dislodge cap ball (from 3 starting locations). We have a total of seven programs to select and each can be configured for the red or blue alliance. Changing alliances, for most programs, simply means reversing the turns in the program. We can then tell the robot to run of one of these programs and ignore the others before autonomous starts.

Another option that we can select is the delay. The delay is there to tell our robot to wait at the beginning of autonomous to ensure we don't run into the other team's robot. A few of our programs already have this delay built in. In all programs we can add a delay up to 15 seconds.

Key Functionality -- Beacon Detection and Pushing

Through the use of numerous sensors, we have successfully created an autonomous mode that can score two particles within the center vortex, as well as claim two beacons. Our robot contains a gyro in order to make precise calculated turns and encoders are used to drive measured distances. In order to claim the beacons in autonomous we have a range distance sensor, Optical Distance Sensor (ODS), and a color sensor. The range distance sensor is used to determine the distance the robot is from the wall and the beacons. The ODS is responsible for line sensing. This allows the robot to detect and follow the white line leading to the beacons. This also aligns the servos that are responsible for pushing the beacon. Finally, the color sensor is used in determining which side of the beacon needs to be claimed.

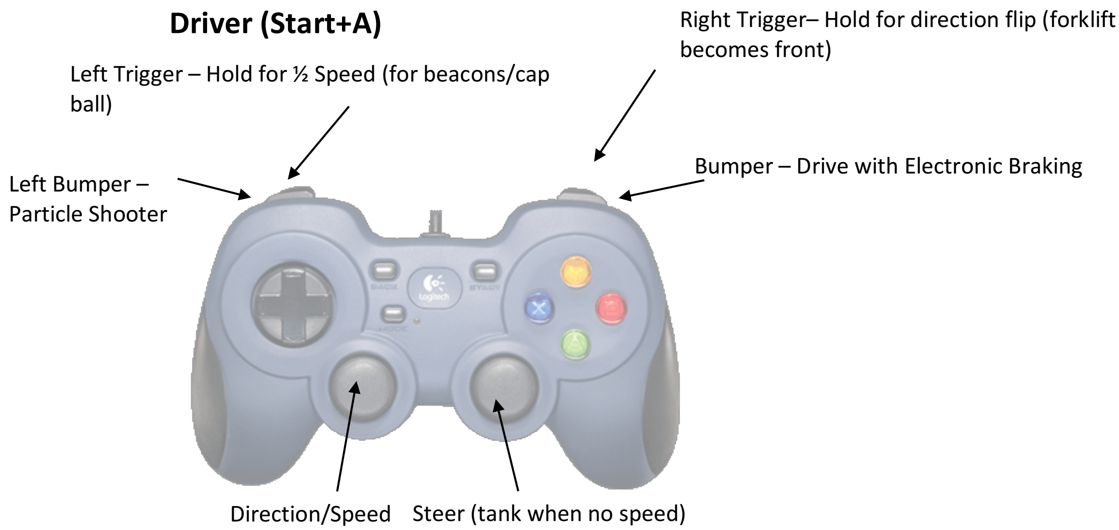
The first sensor we use is encoders when we drive with measured distances. This type of code is used in most of our robot's autonomous programs. We use the gyro to make the turn towards the beacon wall after shooting particles, and then start driving a measured distance. In this particular step of the program we also use the range sensor to sense the distance between the edge of the robot and the beacon wall. We do this to ensure that the robot ends up close enough to the beacon for our color sensor reading to be as accurate as possible. When we are close enough, we do another gyro turn to be parallel to the wall, and start driving forward a short measured distance. When we are close to the white tape line, we then use the ODS sensor to find the white line to align with the beacon. We have two ODS sensors to find the line, one called inboard ODS and the other outboard ODS. We use the two ODS sensors to align on the line in front of the beacon by stopping whichever side(s) of the drive are not sensing the white line. When both ODS sensors detect the white line the robot stops. If the robot drives for too long, we assume the white line has been missed and stop the robot. By squaring up on the white line we can be sure we are accurately positioned at each beacon. In fact the main reason we use sensors is to make our programs as accurate as possible. In order to have accurate sensor readings, we first needed to perform some experiments to see what distances the sensors could be from the value being sensed and still give good readings we used a bar clamp and scale to hold the sensor at varying distances and recorded the values from the sensor.



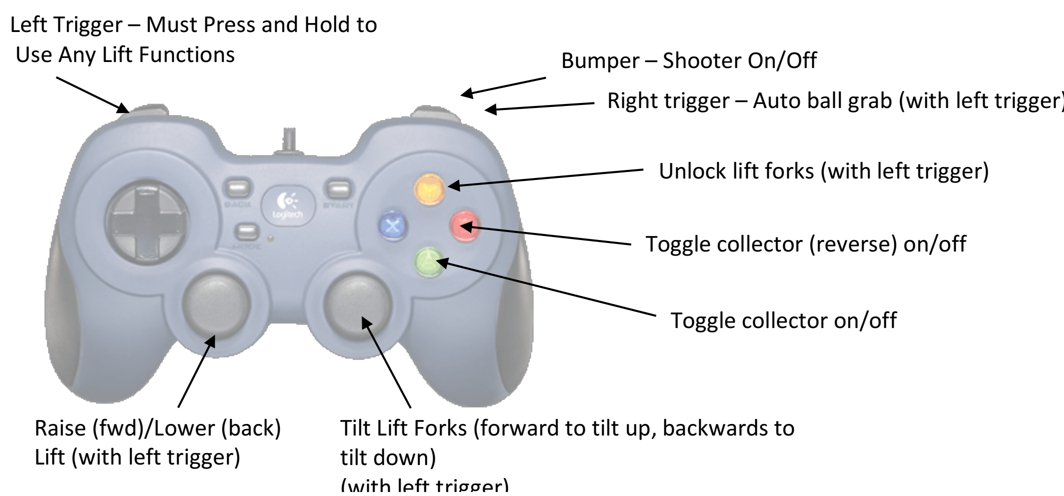
Since we only have one color sensor, we had to make a few adjustments within the code. For example, if we are the red alliance, the robot would detect the color red, and subsequently push the red side of the beacon. However, if we detect the opposing team's color (blue), the robot is programmed to assume the other side of the beacon is the correct color. Then it immediately presses the correct side of the beacon. At first, our color detecting was unreliable due to changes in light level as well as errors in the sensor calibration. However, we fixed this problem by adding a segment to our code that states, “if the color sensor senses red more than green and blue, then the color is red”. The same goes for blue, if more blue than red and more blue than green than it must be blue. We also recalibrated the color sensor so that the differences and strength of colors would be more apparent to the code.

Tele-Op -- Controls for Velocity Vortex

Driver (Start+A)

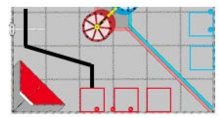
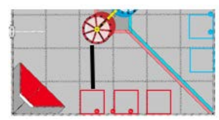
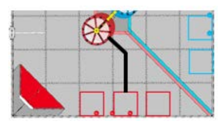
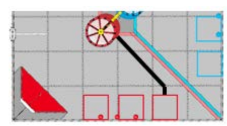
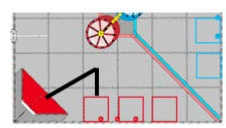
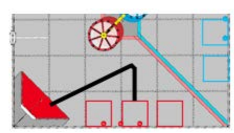
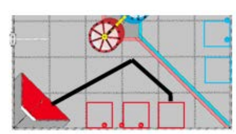


Operator (Start+B)



Autonomous -- Controls, Routes and Goals for Velocity Vortex

Our robot has 6 different autonomous "routes" allowing us to match well with alliance partners and still score the maximum amount of points for the alliance during the autonomous period. This table is from our "match planning sheet" we use to discuss and organize with our alliance partners prior to the match. As detailed in the "State Machines" section of this chapter, the selected "route" and delay are configured during init() pre-match.

Shoot and Claim Beacons – (2x15pt (particle), 2x30pt (beacons) + 2 extra particles)	
Park on center vortex 1 -- (2x15pt (particle), 5pt, +5 cap ball) Delay:____	
Park on center vortex 2 -- (2x15pt (particle), 5pt, +5 cap ball) Delay:_____	
Park on center vortex 3 -- (2x15pt (particle), 5pt, +5 cap ball) Delay:____	
Park on ramp 1 – shoot particles (5pt, 2x15pt (particle)) Delay:____	
Park on ramp 2 – shoot particles (5pt, 2x15pt (particle)) Delay:____	
Park on ramp 3 – shoot particles (5pt, 2x15pt (particle)) Delay:____	

Outreach

Social Media

Facebook – We have our own Facebook "Page", used more to reach local audiences (upcoming events, news). We have 120+ followers that are primarily within the state of IL, or are family and friends of the team members.

Twitter – We are @FTC9929 on Twitter. Here is where we tend to keep up with other FTC teams, sharing our successes (and experiments that don't quite work out). We have nearly 300 followers, and we enjoy seeing how teams around the world are having fun with robots and STEM. Twitter is where we met a veteran FTC team that shared some parts designs with us -- some of us visited them in-person in Asheville, NC over the winter break (more details in this section of our notebook).

YouTube – we've produced our first "tech tips" video, which is "Say No to KEP Nuts" advising build teams to use nylock nuts instead. We're looking forward to producing more videos in the off-season around engineering and programming topics.

GitHub – We share all our robot code with the world as we write it. We've structured our program such that much of it is reusable season-to-season and we're hoping that it may be a jumping off point for teams that need help in this area.

July 16, 2016 HSC Pop Up Science -- Anatomy of an Emergency

The anatomy of an emergency was an event we participated in through the Homewood Science Center on July 16. The theme of the event was what happens at an emergency that is science related. We were there to help describe how robots are used in emergencies when it is too dangerous for a human to complete a task. We also did outreach by letting people drive the robot we had at the time, all though it was only a drive base. One of the tasks involved using a GoPro mounted on the robot to read a sign in a cardboard tunnel and doing something based on the sign to demonstrate remote sensing. We allowed participants to get “robot driver’s licenses” during this event since the age group was mostly younger kids. Our goal at this event was to interest younger age groups in FIRST and meet potential sponsors at the event.

August 30, 2016 HSC STEM Network Open House

The STEM Network Open House was an event done through the Homewood Science Center aimed at local STEM educators as well as potential sponsors for both the Science Center and our team. We displayed our robot's current skill set at the time as well as talked about our past season. This event helped us to reach out to potential sponsors in a different setting as well as allowing us to demonstrate our robot's skills with more accuracy. Overall the event was a success as many potential sponsors saw our team and we were able to tell our story to a lot of STEM educators.

September 11, 2016 Season Kickoff

As a team, we wanted to get the community in on the excitement of this season, as well as do something where they could learn about FIRST, FTC and robots. We invited the families of our FTC team, the kids and families of the FLL teams from our parent organization, our teachers and school administrators, and the mayors of our two towns to the Homewood Science Center to be part of our 2016/2017 season kick-off.

Our mentors and team members spoke at the beginning about FIRST and FTC, the history of our team, and encouraged everyone to become part of our team's season – working with us to assemble the Velocity Vortex game elements, working with us "unpacking" the game rules and deciding how we were going to approach this season's game.

We had dozens of attendees and lots of participation. There were conversations that started at this event that have continued on between the team, our parents and our school administrators around collaboration with our schools or even starting their own FIRST teams.

Hosting League Meets and Helping Other Teams

We believe that in order to be successful as a team, outreach to both the community and competing teams is necessary. We have grown particularly close to two area FTC teams, the BoocBotics (FTC#7074) and the Cyborg Eagles (FTC#7089). Last year during our very first qualifier, BoocBotics picked us as an alliance partner during an elimination match. This year, we invited the BoocBotics team over to our workshop in the Homewood Science Center on two different occasions, in which we provided them with tools, mentors, and a full practice field.

In prior years, there has never been any FTC competitions held within the South Suburbs. However, this year we managed to host two league meets with the help of a local high school -- Marian Catholic in Chicago Heights. These two meets In combination with a league meet hosted by the multiple teams at Kankakee Junior High School has made travel to competitions more reasonable for many teams, as well community spectators. For example, school administrators from our school district have attended some competitions, which has inspired the creation of more STEM-oriented clubs and activities within the district.

During the second league meet we hosted, many robots had technical issues that prevented them from competing. One team, the Cyborg Eagles had either faulty motor controllers or a faulty core power module. They had no spares, but we did so we invited them back to our workshop and loaned them some spare Modern Robotics controllers to assist them in repairing their robot so they could continue to work on it while they waited for replacement parts.

December 29, 2016 Visit to FTC Team #7300 "Guzzoline" in Asheville, NC

We were introduced to FTC team #7300 "Guzzoline" through our social media outreach efforts on Twitter. We noticed that they were using a similar lift mechanism and had designed some 3-D printed parts that help keep the lift lines on the pulleys. When we heard they were willing to share the .STEP files, we asked, and they very graciously sent us the design.

Soon after, we found out that they were from Asheville, NC and that they had been at FTC for some time and even went to Worlds last season! Lauren, Kaylin and Mr. Matthews were going to be near Asheville, NC after Christmas, so Mr. Matthews wrote their mentor to see if we could drop by one of their build meetings, and they were more than happy to accommodate us.

We brought "the mascot", and some swag to exchange as well as an eagerness to learn what we could from a veteran, successful team. We learned many things from them during our short visit:

- Be organized with the engineering notebook, have a consistent message, have it reflect in your pit display
- Coroplast is a flexible material option
- Sprocket and chain is more forgiving than gears
- Mecanum wheels are good for combining omni + tank capabilities
- Have the team sign blank thank you cards whenever they are present so you can be gracious to those that help you along the way

It wasn't a one-way street, we introduced them to our new favorite tool, the "Dark Soul" chain breaker, which is a great tool for sprocket chains because it breaks and assembles chains without master links! Lauren and their lead programmer also discussed many ideas of how they are approaching the autonomous tasks.

Most importantly we learned that their team felt and looked an awful lot like ours, they've just had more experience to iterate on how to build their robots and go through competitions – and they were willing to share those experiences with us!

We have been invited to drop by any time we are in town, and we will. It will be fun to compare our Velocity Vortex seasons, and see what both teams learned along the way. Certainly, we will keep the conversation going over Twitter, it's fun to see how our seasons are going (they've qualified for NC State, waiting to see if they move on to Worlds!).

Business/Sustainability

This year we have been extremely fortunate to have had generous in-kind donations of practice space and opportunities for outreach through the Homewood Science Center. We will be receiving a batch of computers from ComEd via the center later this year, which should help with the adoption of CAD by our team. Many of our team members are involved with volunteering with the center outside of FTC activities bringing STEM education to the community at large. We have also had generous contributions from individuals in the community. We've applied for, and been awarded grants from FIRST. At the beginning of the season we did put together a sponsorship plan, and started to approach potential sponsors (it is attached to this section). After the Velocity Vortex season ends we look forward to being able to devote more time to working to find sponsorships, both for funds, and for potential mentorship opportunities like tours, talks, etc.