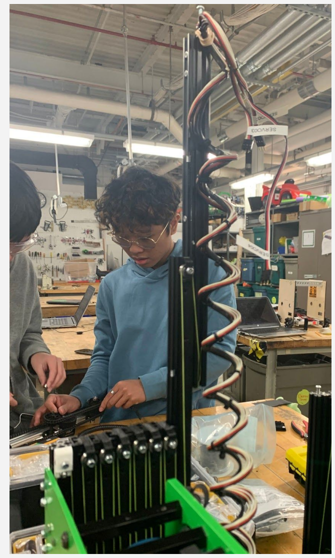
FABRICATE AND INTEGRATE: VERTICAL WIRE EXTENSION

The newly installed lift on our robot extends 68 inches. In order for the wire to extend and retract to reach the servos at the top of the lift, the mechanical team added longer coiled wires that make the robot appear cleaner and more organized, as well as easily connected to the future servos.



Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: SLIDE TESTING

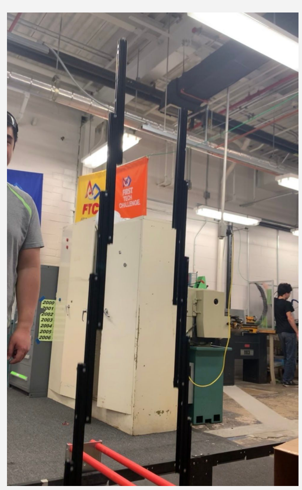
We wanted to see how high the lift can actually stack because we calculated that it can stack 16.25. We saw that it can only actually stack 15 high because the height of the nub interferes with the next stack.

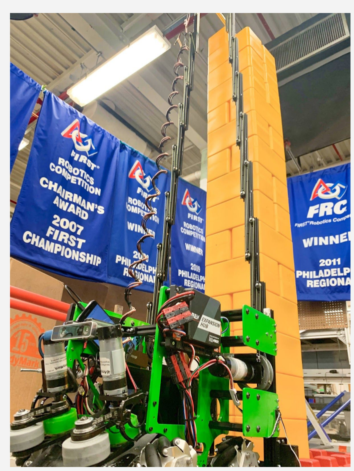
We also tested how the slides would run at a lower power because our motor tester only ran it at max power. We clearly saw that the slides were running at completely different rates.

When asking the internet for help, someone who is running slides a lot faster than we are said to just make the connection so rigid that it is physically impossible for the two slides to be at different heights.

We thought that tensioners would help with strings falling off, but two teams that are very experienced in slides said that they use an extension string and a retraction string with no tensioners at all.

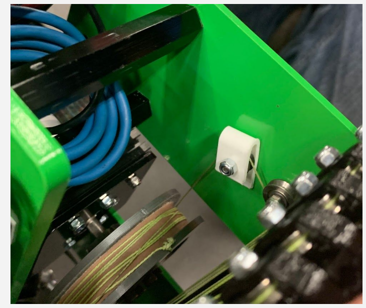
We are highly considering using a retraction string because it will not be too hard to implement.





FABRICATE AND INTEGRATE: PULLEY GUARD

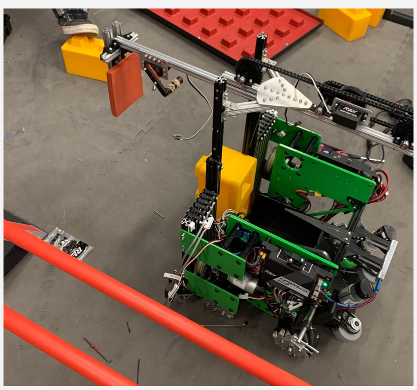
After constantly having to restring the pulleys, we added the pulley guard to one of the slide plate pulleys. The string still sometimes falls off of the motor pulley. We think that a retraction may help with the inertia problem because a team online runs the motors a lot faster and does not have the problem.



Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

SCORING STONES

FABRICATE AND INTEGRATE: OUTTAKE MOUNTING



We made a bracket to mount REV extrusion to a 45 degree angle. We then cut the angled REV so that the distance between the ends is the same as the distance between the two REV Extrusions. This mounting has some play between the two slides so we need another cross beam to support the two sides together. We can fit one at the button, and one that is perpendicular to the outtake.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

DELIVERING STONES

TWEAK & EVALUATE: DELIVERING STONES

While testing the new ramp and edited code for the robot’s harvester, the ramp that the stone travels on while being harvested cracked and split into two pieces. When the robot travels underneath the neutral sky bridge, the ramp gets caught on the raised platform under the bridge. This will create problems in the future as avoiding the middle raised platform will increase the amount of time needed to transport stones. Because of this issue, the mechanical team evaluated ways to avoid ramp problems and possible designs for a more convenient ramp.

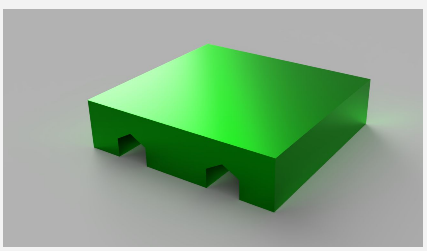
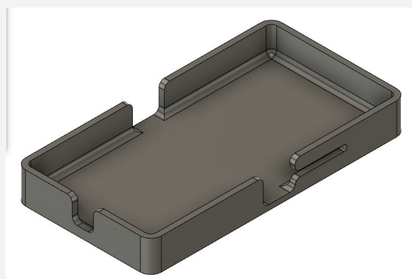
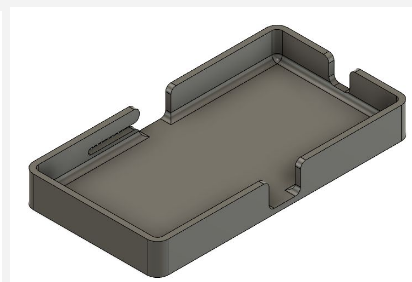
If we use aluminum, it might not comply to the stone when intaking. This might be problematic because the rigidity can cause the stone not to funnel into the tray. We think that a servo powered ramp should help going over the neutral bridge platform.

Define Problem	Generate Concepts	**Develop a Solution**	Construct & Test a Prototype	Fabricate and Integrate	Tweak & Evaluate

PHONE MOUNTING

DEVELOP A SOLUTION: PHONE MOUNT

The new phone mount consists of two parts which will be glued together: The redesigned phone case and the part that attaches to the top of the robot. Ian designed one part and Connor designed the other. Then, Ian started 3D printing both parts as well as the battery mount. The print will not finish during this meeting and should be reevaluated during the following meeting.

Define Problem	Generate Concepts	**Develop a Solution**	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

BATTERY HOLDER

DEVELOP A SOLUTION: BATTERY HOLDER

For the new robot, we needed a new battery holder to hold the robot battery on the robot securely. This battery holder had to shorter than the length of the battery to easily take the battery out. So, Ian took the battery holder he Caded and 3D printed for the previous version of this year's robot and modified it in CAD to fit the needs for this robot. He shorted the height of the battery holder to make it easier to take it out. So, he shorted it from being 4 in high to 2.5 in. Then, he made the base of the older battery holder into the backside of the battery holder and made a 1 in. high piece that the top of the battery can be supported by. The next thing he did was to decrease the width of the battery holder to give it less wiggle room to move back and forth. The last thing he did was to curve the sharp 90 degree edges with the filet tool to make the edges stronger. After that, I got Zach, Andrew and Bryan's Approval.

CONSTRUCT & TEST A PROTOTYPE: BATTERY HOLDER

After getting the Cad of the battery holder approved, Ian put the Cad files of the Battery Holder with the two phone mount pieces into the slicer software to 3D print them.

- The slicer setting for this 3D print of the 3 pieces are:
    - Perimeters/Walls : 3
    - Infill: 15%
    - Layer height: 0.3 mm
    - Supports: On

Then, Ian sliced the three models to see how they would look while printing and then turned it into a .gcode file. After that, he turns on the 3D printer and put the temperature of the printer hotend and heated bed to heat them up the right temperature for the Black Petg filament. After that, the printer calibrated the mesh bed leveling and then started printing the 3 pieces. This print will not finish in this meeting but will be ready for the next meeting on Saturday, January 4, 2020.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

SLIDE TESTING

CONSTRUCT & TEST A PROTOTYPE: SLIDE TESTING

We made an Op Mode where we can test the Slides individually and also run them together using the gamepad controllers. Now, we can run tests on the slides using varied motor power, and also in the future, we can try using encoders and PIDs.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

CONFIG

FABRICATE AND INTEGRATE: CHANGED CONFIG

After the electronics were done, we changed the config so that the new names were assigned to the correct ports. We followed the same naming system as before doing XXX(M/S)HP
Where the X's is a 3 character abbreviation for what the port is for, and then whether it is a motor or a servo, and then the hub number and finally the port number
For example the front left drive motor is FLDM12 because it is the Front Left Drive Motor, and it is a Motor, and it is on Hub 1 Port 2.
The Right Foundation Grabber is named RFGS20 because it is the Right Foundation Grabber, it is a

Servo, and it is plugged into Hub 2 Port 0.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

BATTERBOT

FABRICATE AND INTEGRATE: DRIVE CODE IN BLOCKS

Karthik helped Helen create the program for the new batterbot outreach robot. The robot is able to drive and strafe, as well as turn and hit wiffle balls off a tee based off of commands inputted by the controller. This process was helpful, as it both prepared the batterbot for future outreaches coming up in January and helped introduce Helen to programming for the actual SkyStone competition robot. At outreaches, the younger students and their parents will be able to drive the batterbot safely with the two driver controllers (one that will be used by a MOE member to terminate dangerous robot movements). The new batterbot will be used in a month for the next outreach.

NON-TECHNICAL DISCUSSION

- **Helen continued to organize the Black History Month outreach.**

On February 1, MOE members will attend the Black History Month outreach at the Walnut Street YMCA and demonstrate our new batterbot for a variety of event attendees.

MEETING SUMMARY

- Mount SLAM camera
- Intake/Drive Test
- Lift Test
- Lift Extension Wires

THURSDAY, JANUARY 2, 2020 [EXTRA] MEETING

DATE & TIME: 1/2/20 | 5:15 PM - 8:45 PM

STUDENTS: Patrick, Bryan, Karthik

MENTORS: Jennifer The'

AGENDA
Fix Drivetrain Belt
Work on Positional PID

TIMELINE REVIEW

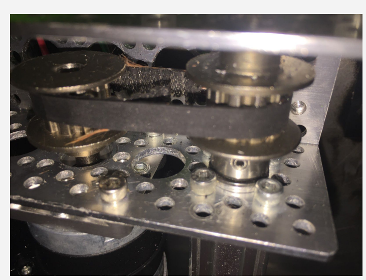
Programming	Finish Autonomous for upcoming competitions
Upcoming Competitions	Dover High School meet on January 10 and Pennsylvania Qualifier on January 19
Possible Competitions	Waitlisted for New Jersey Meet on January 12 and Maryland Qualifier on January 25
Upcoming Outreaches	Hagley STEMtastic Museum Maker Fest Outreach on January 20

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

CHASSIS

TWEAK & EVALUATE: FIX DRIVETRAIN BELTS



While Karthik had the robot home, one of the belts shredded. After doing some research, we found that we could not do much to help this because our belts are already correctly tensioned and we use high quality belts. We already had spare belts, but we ordered more just in case this problem arises again.

Also, one of the pulleys lost both of its sets screws (one in a meeting and another at Karthik's house). Also, one of the set screw holes got stripped. We chose to completely replace that pulley. We added medium loctite to keep the set screws in place.

Define Problem	Generate Concepts	**Develop a Solution**	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: RETRACTION STRINGING

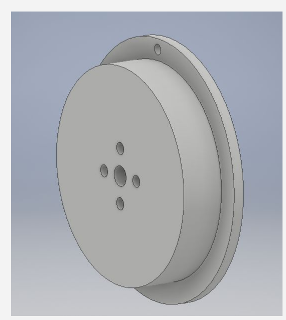
Currently, our robot uses a gravity retraction system. We noticed many problems with it.
First, the string has trouble staying onto the spool. It is not properly tensioned and it can easily fall off. A solution to this is to control the acceleration and speed of the lift so the string does not jump off. However, we cannot use this solution because our lift has to fall down quickly to completely retract because the last few stages have problems overcoming friction at slow speeds.

Our first thought was to use a tensioner, but we discussed with well established teams online to get some opinions.
World Champion Team Gluten Free #11115 says that they have used an extension and retraction string with no tensioners on every single lift/extension they've made after Relic Recovery.
JirachiKid on Reddit also uses an extension and retraction string with no tensioners this year, and there lift runs a lot faster than ours. We were struggling using something geared 1.6 times slower, but also at four-tenths of the power, while they were running theirs at very high speeds with no problem.

This leads us to believe that a retraction string will be the best solution for our lift..

DEVELOP A SOLUTION: RETRACTION SPOOL

While at the meeting, we measured that we had a little over 1.4 inches of space to fit two spools. The current spool is a two part print that is .75 inches total. For the retraction string, the print will be the same inner width of the two part print combined. To do this, we just got the two part print and removed one of the walls.



Define Problem	Generate Concepts	**Develop a Solution**	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

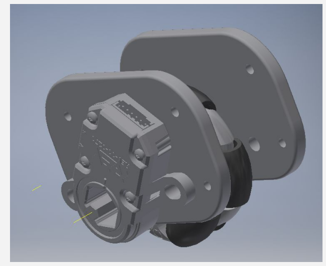
ODOMETRY

DEVELOP A SOLUTION: ODOMETRY V7 CAD

We wanted odometry ready to test at the NJ meet. Unfortunately, the REV Through Bore Encoders won't arrive until afterwards, but we still designed the odometry wheels.

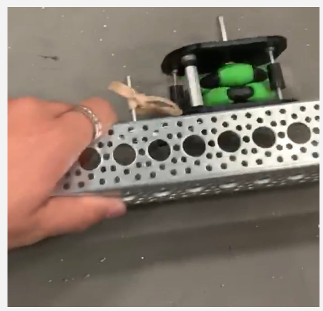
It is a two plate prints held together by screws. It is made to be easy to assemble and easily adjustable. Everything is also using a hex axle, meaning it will rotate a lot more accurately than the D-axle.

This is one of the main reasons we chose the REV Through Bore Encoders over other encoders.
Other reasons are that it is cheap, it plugs directly into an encoder port, and it counts continuously.
There is space for a rubber-band so it can springload against the ground, and we will use a screw head as a hard-stop.
This design is made to be much, much smaller. It fits between the two Nexus wheels, and also right behind the slides. We were able to make our print compatible with the Actobotics Channel and the REV extrusion.



DEVELOP A SOLUTION: ODOMETRY V7 TESTING

Jonas printed the odometry prints using his home 3D printer. Since he could not come to the meeting, Karthik picked them up. Bryan assembled them and mounted them on a spare Actobotics channel to see if he has to redesign it. His revised fabrication will have thicker walls so that they do not break. We may make this out of aluminum with weight saving holes in the future because it is a simple plate design.



PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

POSITIONAL PID

CONSTRUCT & TEST A PROTOTYPE: PID TUNING

Karthik brought the robot home on the Saturday meeting to start tuning the PID. He made sure to run it at low powers, but one of the belts got shredded in the middle of his testing.
After replacing the belts, he tested the turn PID and it was able to cleanly rotate 180 and 90 degrees.
When testing the Forward PID, we noticed that the robot was trying to turn counterclockwise 359 degrees when the angle was reading 359 degrees but its target angle was 0 degrees. This means it is trying to go the long way, and our wrap around is incorrect.
We fixed this so that the turn will always be on the minor arc, wrapping around 0 and 360.
Karthik is bringing the robot home again to do more tuning and start the Autonomous Pathing

NON-TECHNICAL DISCUSSION

- A day before this meeting, Patrick finished all of the meeting entries and updated the Table of Contents so the notebook will be ready for the upcoming qualifiers
- We chose to meet today because Karthik was able to bring the robot home, but it needed maintenance.

MEETING SUMMARY

- Positional PID Tuning
- Vertical Lift Retraction Spool CAD
- Odometry V7 CAD & Testing

SATURDAY, JANUARY 4, 2020 MEETING

DATE & TIME: 01/04/20 | 9:00 AM - 3:00 PM

STUDENTS: Ian, Aidan, Helen, Connor, Karthik, Jonas, Bryan, Patrick, Paige, Katy, Clare

MENTORS: Andrew, Zach

AGENDA
Review scheduling
Replace drivetrain belts
Make MOE buttons

TIMELINE REVIEW

January 10	Dover High School Meet
January 12	New Jersey Meet
January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

STACKING STONES

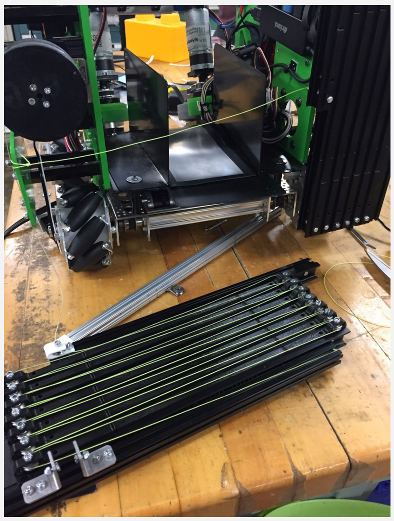
FABRICATE & INTEGRATE: 3D PRINTED SPOOLS

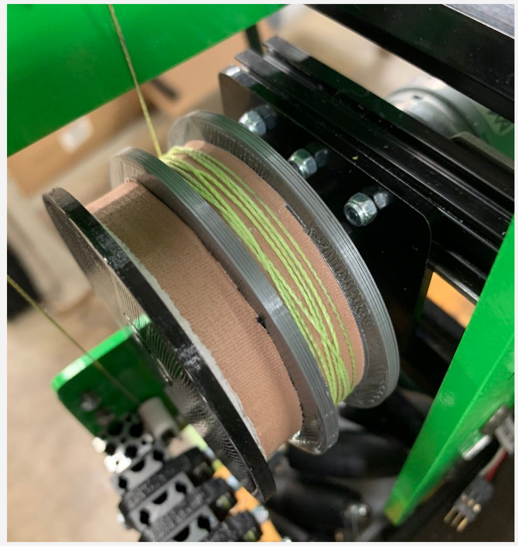
Ian used Bryan's CAD files to 3D print the spools. The sizing was incorrect so we needed to lathe down parts of the print.
Also, the screw heads made up a significant part of the width of the spool, so we put a counterbore on the pulley prints so that the screw head can fit flush with the spool.
We printed another set of pulleys that is a quarter inch shorter, so we do not need to lathe it down the next time.

FABRICATE & INTEGRATE: RETRACTION STRINGING

We found in our previous runs that the lift does not go down by itself very well. We used the 3D printed spool and attached it to the spool already on the lift motors. Now, we can run a string running in the opposite direction that pulls it down.

This process required us to take off the slides which took more time than expected. The foundation grabber and the ramp were in the way of the slides, but we did not want to take off the ramp.
We took off the foundation grabbers and saw that a pulley was in the way. We removed the pulley and decided that the bottom crossbeam needed to be taken off.
We now see that it is faster to just take the bottom crossbeam off first, and then take it out from the top instead of doing it the way that we did.





FABRICATE & INTEGRATE: TENSIONING STRING

We decided to string the retraction onto the outtake, but since it was not mounted, we just mounted it to where the outtake mounts. Because the retractions string mounts direction to the lift without a secondary pulley, the string releases at different rates depending on the height of the lift.
To remedy this problem, we attach a spring to keep it tensioned. This way, if the string releases too much, the spring will keep it taut.
We can now raise the slides by hand because the retraction string will spin the motor spool causing the release of the extension string.

TWEAK & EVALUATE: SPOOL SIZES

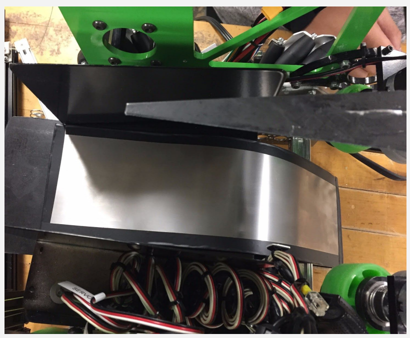
Even after lathing the spools down, the lift still do not reach max extension because the screw heads on the lift hit the spool. Because we already started the next print a quarter inch shorter, we will soon change to those pulleys.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	**Tweak & Evaluate**

DELIVERING STONES

FABRICATE & INTEGRATE: RAMP FABRICATION

After the failure of the plastic ramp, we definitely wanted to make it more durable. Coming into the meeting, we did not know what material to make the ramp out of.
Bryan was tasked to find a new material, but was reluctant to use metal because it was too stiff to pick up the stone at a steep angle.
He found a very thin sheet of metal, thinner than previous aluminum that we tried. This gives us the durable we are looking for, with the compliance we got with the plastic ramp.
Because it was very thin, Bryan surrounded the metal with electrical tape before mounting it to the inner tray in the robot.




TWEAK & EVALUATE: RAMP TESTING

Through testing we saw that the compliance definitely helped with intaking the stones. One minor problem we saw through testing was that small crashes would cause the angled portion of the ramp to untape itself from the chassis and spring flat. This would render the ramp unusable, but it did not happen often and it is easily fixable between matches until a better solution is found.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

ODOMETRY

FABRICATE & INTEGRATE: DEAD-WHEEL ODOMETRY BUILD

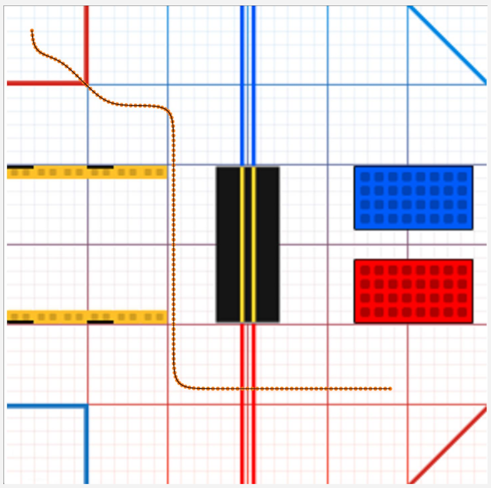
This odometry wheel used thicker walls than the prototype design. Because the prototype was built in the meeting prior to this, we did not have any problems with the fabrication of this finalized version.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

PURE PURSUIT

TWEAK & EVALUATE: PURE PURSUIT SIMULATIONS



The programming team modified the pure pursuit algorithm from the 2018-2019 season in order to run simulations that are smoother and more efficient. Karthik edited the values and variables used in pure pursuit so the path given in the simulation allows the robot to drive in a more natural and realistic way. The rounded corners in the picture on the left show a more natural driving path for the robot in the simulation.

Then, we did an initial Autonomous pathing using this simulation.

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	**Tweak & Evaluate**

POSITIONAL PID

CONSTRUCT & TEST A PROTOTYPE: POSITIONAL PID INITIAL POSITION

Currently, the camera initializes with at (0,0,0) assuming the coordinate system (x, y, theta), where x and y is the position on the field, and theta is the direction that the camera is facing.

We need to change it so that the robot can initialize in any position and use that starting value plus the position and angle that the camera returns to find out its actual position.

For example if it started at (10,10, 45 degrees), the camera would still think it is at (0,0, 0 degrees). If it moves forward 10 units, then its actual position would be (10 + 10/sqrt(2), 10 + 10/sqrt(2), 45 degrees), but the camera would still read (0, 10, 0 degrees).

To fix this, we need to rotate and translate the points so that it lines up with the actual initialization point. We had the idea of using polar coordinates for this calculation because the movement is based on a radius. In the previous example, both what the camera reads and what actually happened has an r value of 10, but a different theta value. Also, the change in angle would be the same.

Now, we need to use this idea and 6 values: the 3 positional values of the camera's initial position, and the 3 positional values that the camera returns.
We will call this the initial camera position and the raw camera position, respectively.
We will solve for camera position
The camera angle is simply the initial camera angle + the raw camera angle because the actual angle is offset by the angle the camera started at

To solve for camera's x and y, we need to add the initial x and y to the distance traveled in the x and y directions, respectively. We got the square root of the sum of the raw camera x squared and y squared values. This is the hypotenuse and the conversion from Cartesian to Polar. We multiplied that by sin(atan(x raw/y raw plus the initial angle). This whole thing is essentially a Cartesian to Polar conversion then a Polar to Cartesian conversion with the initial angle of the robot added.

We changed the sin and cos, and also flipped the inside of the atan function to adjust the polar system to more intuitive angles. Polar starts with theta = 0 on the x axis with positive angles going counter-clockwise. Our coordinate system assumes theta = 0 is on the y axis, with positive angles going clockwise.

The equations written out:

$$\theta_{camera} = \theta_{initial} + \theta_{raw}$$
$$x_{camera} = x_{initial} + \sqrt{x_{raw}^2 + y_{raw}^2} * sin(tan^{-1}(x_{raw}/y_{raw}) + \theta_{initial})$$
$$y_{camera} = y_{initial} + \sqrt{x_{raw}^2 + y_{raw}^2} * cos(tan^{-1}(x_{raw}/y_{raw}) + \theta_{initial})$$

CONSTRUCT & TEST A PROTOTYPE: POSITIONAL PID ROBOT LOCATION

Now that we found out how to start the camera's position anywhere, we want to solve for how to start the robot's position anywhere, and also how to solve for the robots current position where the camera is located on the robot.

We used polar values again it is easier to deal with the rotation of the robot. If the robot rotates along its center, then the x and y values of the camera change. If it's in polar, the r value stays constant but the theta changes. The math is very similar to the previous math. We will call the position of the camera on the robot, the "relative position" it is shorter because we measured the relative position in polar already so we do not need to convert cartesian to polar; we just need to convert polar to cartesian.

The equations written out:

$$\theta_{robot} = \theta_{camera} - \theta_{relative}$$
$$x_{robot} = x_{camera} + r_{relative} * sin(\theta_{camera} + \theta_{relative})$$
$$y_{robot} = y_{camera} + r_{relative} * cos(\theta_{camera} + \theta_{relative})$$

Now, we also want to initialize the position based on the robot instead of setting the initial position of the camera. To do this, we will solve the camera initial position using the robots initial position

$$\theta_{camera\ initial} = \theta_{robot\ initial} + \theta_{relative}$$
$$x_{camera\ initial} = x_{robot\ initial} + r_{relative} * sin(\theta_{robot\ initial} + \theta_{relative})$$
$$y_{camera\ initial} = y_{robot\ initial} + r_{relative} * cos(\theta_{robot\ initial} + \theta_{relative})$$

NON-TECHNICAL DISCUSSION

- **Paige looked at designing team pins/buttons.**

Mrs. Ho had the idea to hand out MOE pins and buttons at future outreaches to help promote the team in a fun way. In the past, MOE handed out pins at meets and competitions. Paige started brainstorming designs for pins/buttons and making buttons.

Then, Connor, Paige, and Ian made some basic MOE buttons so that we can always have some on hand to give out.

- **Mrs. Ho and Helen discussed upcoming outreaches.**

Mrs. Ho and Helen made a list of the team roles and materials needed for the Hagley outreach. To help make outreaches more interactive, they decided to bring parts to the Hagley outreach as conversation pieces to introduce robotics to the children at the outreach. In addition, Helen decided to start making a trifold to display information about MOE and a slideshow to display pictures of the team at outreaches.

- **Katy created an updated logo design for our team.**

MOE 365

- **Helen created a slideshow of pictures for future MOE outreaches.**

MEETING SUMMARY

- Vertical Lift stringing/testing
- Intake Ramp
- Odometry Fabrication
- Positional PID Testing
- SLAM Camera Positioning Math
- Pure Pursuit Simulations

TUESDAY, JANUARY 7, 2020 MEETING

DATE & TIME: 01/07/20 | 6:00 PM - 8:30 PM

STUDENTS: Karthik, Helen, Bryan, Patrick, Clare, Rohan, Aidan

MENTORS: Andrew, Nick

AGENDA
Review upcoming competitions/outreaches
Set priority lists
Finalize judging presentation

TIMELINE REVIEW

January 10	Dover High School Meet
January 12	New Jersey Meet
January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

ODOMETRY

FABRICATE AND INTEGRATE: REV ENCODER MOUNTING

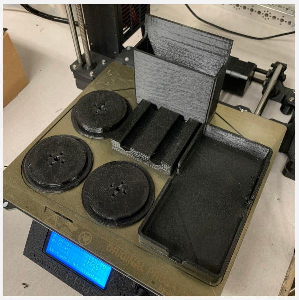
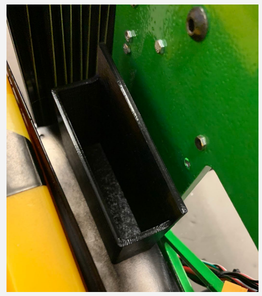
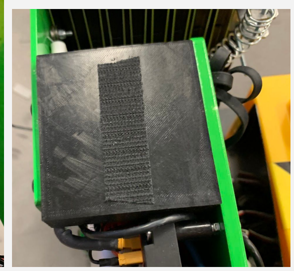
The REV Encoders came in today, so we can mount them to to odometry wheel. The inserts that came with the encoders work perfectly, but there is no space for a nut on one of the screws. It's not a major issue because just one nut can keep the encoder in place while the other screw with no nut keeps it from rotating. It is also supported by the axle. They are ready to mount once the mechanical team has enough time with the robot.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

BATTERY MOUNT & PHONE MOUNT

FABRICATE AND INTEGRATE: BATTERY & PHONE MOUNT PRINTS

We 3D printed our battery mount and our phone mount. The case portion of the phone mount did not fit under the 14” skybridge, so we opted to just use the hex-mount section with velcro.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

AUTONOMOUS CODE

TWEAK & EVALUATE: AUTON

The programming team continued to edit the code for the autonomous period of each match. In addition to the autonomous template provided by FIRST, Rohan included elements of autonomous that are specific to the MOEbot. One of these elements is code for the SLAM Intel RealSense T265 camera, which can aid in robot localization and positional calculations used later during the match.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

LIFT

TWEAK & EVALUATE: LIFT PID

After the mechanical team attached the two sets of linear slides on the robot, the programming team started programming the motors of the lift. While initially simple to code, one difficulty that arose was programming the motors so that both sides of the lift rose and dropped at the same time. Since there is nothing currently connecting the two sets of slides, it becomes crucial to have both motors controlling the two sides equally.

First, we tested using the built-in motor PID using the motor encoders.
This worked out perfectly for us; It stayed in relatively the same position, when we increased and decreases the height of the lift.

NON-TECHNICAL DISCUSSION

- **The team discussed the upcoming competition and outreach schedule.**
- **Each subteam created a list of priorities to address before this weekend's competitions.**

MECHANICAL/ELECTRICAL	PROGRAMMING	JUDGING/OUTREACH/DRIVE PRACTICE
1. Test Outtake 2. Spool (retraction) 3. Intake Claw (transfer) 4. Limit Switch 5. Attach Odometry	1. Auton (1 stone) 2. Lift/limit switch testing (Assisted TeleOp) 3. Auton (2 stone)	1. Finalize judging presentation/practice 2. Finish mentor bios 3. Create scouting sheet 4. Promote Video

- **We set autonomous as the main priority for the meeting to prepare for the DE and NJ Meets.**
- **Clare and Helen added final edits to the judging presentation.**

In order to ensure that MOE is ready for judging by the Pennsylvania qualifier on January 19, we set time constraints on each section of the judging presentation and finalized the images/information provided.

- **Helen collected pictures of the MOE team from the past couple of years.**

With these images, we will be able to create and display a slideshow of images that help introduce our team. This slideshow can be projected on a television during outreaches or competitions.

- **Clare and Helen discussed ideas for a trifold.**

After examining trifolds and posters from previous seasons, Clare and Helen decided to create a new trifold for the SkyStone season that summarizes the goals and outreach aspirations of our team. This can be used as a supplement to outreach team introductions or to our judging presentations.

- **Clare finished the team bios.**

MEETING SUMMARY

- Odometry Fabrication
- Battery & Phone Mounts
- Discuss priorities for competition preparation
- Lift PID
- Edit autonomous code
- Finalize judging presentation

THURSDAY, JANUARY 9, 2020 [EXTRA] MEETING

DATE & TIME: 01/09/20 | 4:30 PM - 8:30 PM

STUDENTS: Karthik, Helen, Bryan, Patrick, Rohan

MENTORS: Jennifer The', Andrew

AGENDA
Test positional PID
Mount outtake
Mount odometry
Pack for tomorrow's meet at Dover High School

TIMELINE REVIEW

January 10	Dover High School Meet
January 12	New Jersey Meet
January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	**Tweak & Evaluate**

SCORING STONES

TWEAK & EVALUATE: CLAW DEADZONE

One problem that the grabber faces is that it cannot completely reach the stone if it is too far away.

There is a "deadzone" where neither the intake or the grabber has mechanical control of the Stone. To fix this problem, we pushed the claw further back and made it grab the back of the stone. Although it has more reach, it does not completely eliminate the dead zone.

FABRICATE AND INTEGRATE: OUTTAKE INTEGRATION

After testing and evaluating the linear slides, we mounted the claw outtake component constructed in meetings around late December 2019 onto the robot in preparation for our upcoming competitions this coming weekend.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

ODOMETRY

FABRICATE AND INTEGRATE: ODOMETRY INTEGRATION

As the programming team debated with the idea of replacing odometry with the new SLAM cameras for this season, the mechanical team continued with the fabrication of the odometry pods for the robot as a backup for localization. Bryan and Patrick mounted three odometry pods to the redesigned robot in a similar fashion as the previously mounted odometry pods (one on each side of the robot facing in the forward/backward direction and one between REV beams on the robot facing in the sideways direction). As explained in previous meetings, the use of the third odometry wheel allows the robot to receive input regarding the turning motions without increasing the amount of distance travelled by the robot.

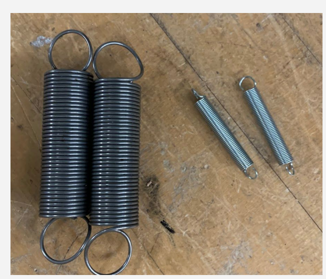
As of today's meeting, we decided that we will use the mounted odometry pods solely for receiving values rather than localization.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	**Tweak & Evaluate**

STACKING STONES

FABRICATE AND INTEGRATE: CLAW

We saw that the springs we used were too weak and too large, causing it to hit the slides. This eventually caused the deformation of the spring. We looked for more springs in the "tool crib" where only Mr. Perrotto has access to. There were a variety of springs to choose from, but we opted for ones that were a lot smaller than the previous one we used.



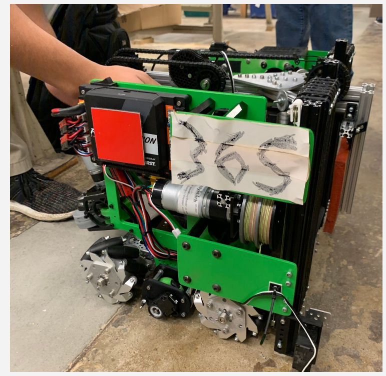
Because we did not have enough time to finish everything, Patrick and Bryan brought the robot home to restring the lift.
We got tested different tensions of the springs to see which one would work the best. We only had 3 different types so we mixed and matched them. We found that string is a hassle to work with, and we are hoping that maintenance will not be too bad at competition.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

CHASSIS

FABRICATE AND INTEGRATE: ROBOT LEGALITY

We made a quick team number on the side of the robot, and added velcro on top of the REV Hub to mount our Alliance Marker on to make our robot legal in matches.



PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

SLAM CAMERA

TWEAK & EVALUATE: SLAM CAMERA

In order to ensure that the SLAM camera is ready for the Dover meet tomorrow and the New Jersey meet on Sunday, we tested the code for localization and pathfinding. Because the mechanical subteam worked on the robot to mount the claw component, the programming team used a separate SLAM camera for testing. By hand moving the SLAM camera to different locations around the room, we were able to simulate the camera that is attached to the robot.

Since the SLAM camera uses a separate set of axes to return values, Rohan and Karthik worked to convert these values into unit values that our code uses in calculations and to guide the robot's movements.

NON-TECHNICAL DISCUSSION

- **Patrick and Helen continued to add final edits to the judging presentation.**

- **Helen reached out to the Western YMCA childcare program.**

The childcare program at the Western YMCA would offer MOE a good audience for future outreaches as we would be able to introduce younger students to robotics, which may be their first interaction with a STEM subject. We look forward to hearing back from the YMCA and are excited to reach out to an organization that we have not met with before.

MEETING SUMMARY

- Outtake Integration
- Debug and edit SLAM camera code
- Odometry Integration
- Pack for the Dover meet

SATURDAY, JANUARY 11, 2020 MEETING

DATE & TIME: 01/11/20 | 9:00 AM - 2:30 PM

STUDENTS: Connor, Bryan, Patrick, Rohan, Karthik, Paige, Aidan, Isha

MENTORS: Andrew, Zach

AGENDA
Autonomous Testing

TIMELINE REVIEW

January 12	New Jersey Meet
January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	**Tweak & Evaluate**

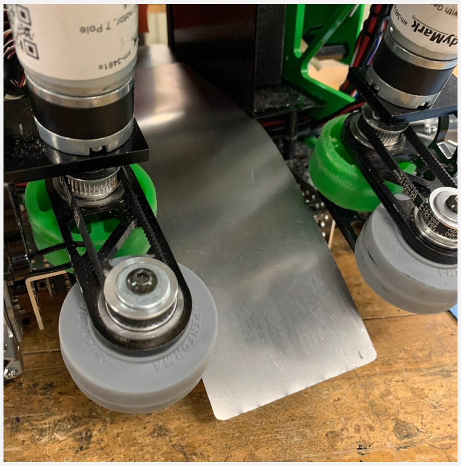
DELIVERING STONES

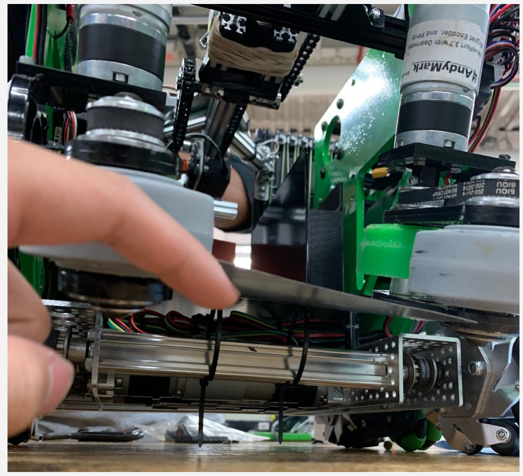
TWEAK & EVALUATE: TAPED RAMP PROBLEM

We were pretty unsatisfied with the performance of the ramp at the Dover Delaware meet. The electrical tape border created too much friction that blocks were more likely to rotate about the lip of the ramp than it was to slide smoothly in. The tape that held the ramp at an angle also needed a more permanent solution, not only because it didn't hold the ramp well but also because it held the ramp at too steep of an angle.

FABRICATE AND INTEGRATE: RAMP SOLUTION

The first thing we did was take off the electrical tape to create a smoother surface for the block to slide on. We used the belt sander to smooth out the sharp edges. Then, we took off the ramp to slide it further forward, giving it a less steep angle. Our solution to keeping the ramp at an angle was to put adhesive-backed zip tie mounts to the bottom of the ramp to keep it bent down on the chassis. Using zip ties, the static position of the ramp is easily adjustable while still giving a springy compliance for blocks to go up the ramp with ease.





PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

SLAM CAMERA

TWEAK & EVALUATE: DEBUG SLAM CAMERA MATH

We spent most of the day trying to make fix the math for the SLAM camera to handle rotations and initial position. Patrick already tested the math at home, but it didn't work so Rohan tried a different method to handle the initial positions. This did not work, but we just used the assumption that the robot started at 0,0 and ran it several times.
Very little progress was made because the math we were using was not working.
We struggled making the SLAM camera work with initial values, so we could not start writing autonomous yet.

NON-TECHNICAL DISCUSSION

- More buttons were made: MOE logo, Karl, Unikesha, and MOE dew button designs
- This is the day before the New Jersey Meet, a highly competitive and important competition. To score competitively, we need to have a reliable autonomous, so most of the focus today will be on autonomous.

MEETING SUMMARY

- Intake Ramp
- Debug SLAM Camera Math

TUESDAY, JANUARY 14, 2020 [EXTENDED] MEETING

DATE & TIME: 1/14/20 | 1:00 PM - 9:00 PM

STUDENTS: Patrick, Bryan, Connor, Helen, Karthik, Jonas, Clare, Aidan

MENTORS: Arnav, Nick, Andrew

AGENDA
Discuss last weekend's meets
Assign priorities for the next few weeks

TIMELINE REVIEW

January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

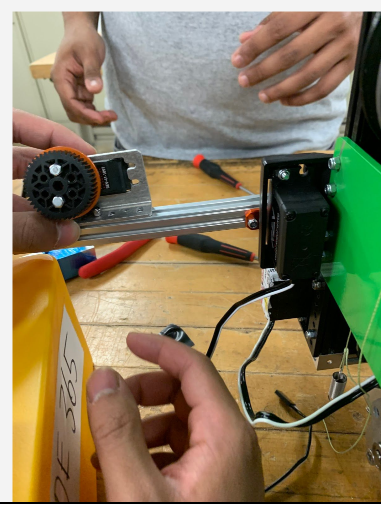
MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

SCORING STONES

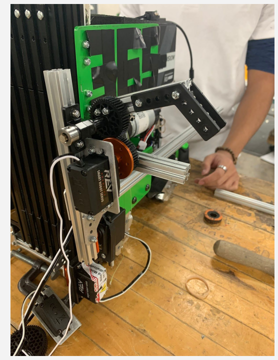
CONSTRUCT & TEST A PROTOTYPE: AUTONOMOUS SCORING ARM

Based off of our performance at New Jersey States, we clearly saw that autonomous should be a high, high priority. We noticed that our intake would not be consistent enough for scoring in autonomous, so we wanted a separate arm for autonomous.



To prototype this idea, we used a scrap REV extrusion for the arm and a gear-based claw. The main idea is to have one servo rotate the claw out and then use two gears with fingers attached that rotated in opposite directions in a pinching motion. We also needed another claw on an opposing side or else we wouldn't be able to reach the stones that are against the wall all of the time. We tried doing this by attaching a beam attached to the rotation that ran along the side of the chassis.

Overall, we spent almost all of the meeting trying to create a prototype, but none of the designs fit within the size restrictions of the robot.

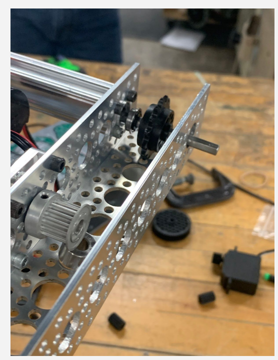


We decided we'd try again tomorrow. Our plan is to at least fit one arm, and to try and make it detachable and mirrorable to account for all cases of skystone arrangement.

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

CHASSIS

CONSTRUCT & TEST A PROTOTYPE: CHAIN DRIVETRAIN TEST



To fix our issues with shredding belts, we tried looking at chain as an alternative. Our initial thought was that it'd be easy because we came to a revelation that the REV kit sold sprockets with the same pitch as TETRIX, meaning our wheel and our motors would be directly compatible. Unfortunately, the smallest size we had was 15 teeth, and those did not fit. We ordered 10 tooth sprockets because they would fit, with the plan of boring out the 5mm hex hole into a 6mm round hole. We think that the chain will be able to handle the slop that comes from the worn down drive chassis, and we plan to mount the last odometry wheel while the pulleys are off and the mounting hole is more accessible.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

POSITIONAL PID

TWEAK & EVALUATE: SLAM INITIAL ROTATION

Patrick used a different way to handle initial position. He tested the idea of rotating the axes first and then adding that to the initial angle. When searching for the rotation of axes formula, he saw that it was just a derivation of a polar to cartesian transformation, which was the original

$$x = x' \cos\theta - y' \sin\theta$$
$$y = x' \sin\theta + y' \cos\theta, \text{[9]}$$

method that Patrick used. Now, the code is cleaner because it simply rotates the axes depending on the how the robot started and its current angle and position

TWEAK & EVALUATE: PID TESTING

After our position system worked, we tested using a Linear Opmode for our PID. All of our previous testing had been in Iterative Op Modes that can constantly run the PID. We made it travel 2 tiles forward, but set up the robot to see if what the camera sees affects its accuracy. We saw major inconsistencies depending on what the camera saw. We noticed that the closer the camera is to what it sees, it tends to be more inaccurate. We have to do more testing to see if it is competition ready.

NON-TECHNICAL DISCUSSION

- **Patrick and Bryan wanted to start the meeting early in order to have time to create the autonomous arm**
- **The team discussed the successes and failures of the past two meets.**

Over the past weekend, MOE participated in two meets: Dover High school meet and New Jersey Southern County meet. Throughout both of these competitions, we continued to face issues with the drivetrain belt of the robot, as the belts on the robot were continuously getting shredded. In addition, the scoring elements of our robot proved to be inconsistent, which we will keep in mind for the Pennsylvania qualifier this upcoming Sunday.

- **We outlined the goals and priorities for this week.**

MECHANICAL/ELECTRICAL	PROGRAMMING	JUDGING/DRIVE PRACTICE
• Sprocket and chain • Lift pulley • Outtake length • Arm grab (autonomous) and delivery/capstone	• Moving foundation • Detecting skystone • Arm control autonomous	• Notebook entries (finish the remaining four) • Control document • Edit business plan

- **The team made plans regarding judging at the Pennsylvania qualifier.**

To make the judging presentation more efficient and effective, we decided that we will bring the leads of each subteam into the judging room (Rohan, Karthik, Bryan, Patrick, and Clare). We hope to bring some of the new members into the judging room so that they will be exposed to how judging presentations function.

- **Clare created a flyer for MOE to hand out during outreaches.**

In order to spread information about our team and how students can participate in robotics, the marketing team decided to design flyers to hand out during future outreach events.

MEETING SUMMARY

- Set new priorities for the Pennsylvania qualifier
- Prepare for the Hagley outreach and judging presentation
- Autonomous Arm Prototyping
- Positional PID Testing

- Intake Ramp Evaluation
- Test Chain and Sprocket Drivetrain

WEDNESDAY, JANUARY 15, 2020 [EXTRA] MEETING

DATE & TIME: 1/15/20 | 10:00 AM - 8:30 PM

STUDENTS: Patrick, Bryan, Karthik

MENTORS: Arnav

AGENDA
SLAM Autonomous
Autonomous Arm Fabrication

TIMELINE REVIEW

January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	**Fabricate and Integrate**	Tweak & Evaluate

SCORING STONES

CONSTRUCT & TEST A PROTOTYPE: AUTON ARM PROTOTYPING

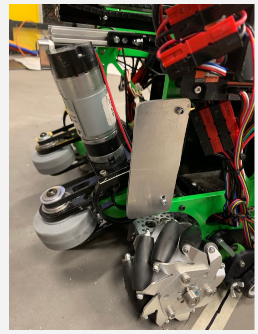
We were still trying to think of designs that would fit on the robot. One idea was to have a linkage similar to a small, horizontal double reverse 4 bar, but it would have been too complex.
We finally thought of an idea similar to yesterday's idea, but instead of a claw, it was only one finger clamping the block against the hard mount. This design was folded up better as the finger folded to be in-line with the arm.
This design was good because it could fit right next to the harvester. It would not poke out much further than the extremes of the robot, so we would not increase in size.

Furthermore, there were two mounting holes for an aluminum plate to mount the autonomous arms on.
Also, since we would not increase in size, was space to fit two auton arms.
Overall, this solution fixed all the problems we were having yesterday.

FABRICATE AND INTEGRATE: AUTON ARM FABRICATION

We were pretty satisfied with the performance of our prototype, so we cut black extrusion to make a more finalized version of the arm.

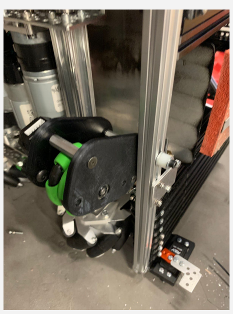
We also created a plate that we could tape the servo on to that used extra holes in the side panel.



Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

ODOMETRY

FABRICATE AND INTEGRATE: STRAFE ODOMETRY MOUNT



After running some autonomous testing, we decided that the SLAM camera alone was not robust enough for consistent autonomous movement and that we needed odometry wheels to assist it. They were already built beforehand, so all we had to do was mount it to the REV Extrusion. We tried to fit the strafe odometry wheel where it was planned to be but it was a few millimeters too thick. We were eventually able to fit it by using one of the thinner variations of the odometry pods, countersinking the holes for the screws, and drilling a hole through the REV extrusion for the axial screw. After it fit, the odometry pod worked, mechanically, as expected.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

AUTONOMOUS

TWEAK & EVALUATE: POSITIONAL PID TESTING

Now that we have the ability to use the positional PID in a linear opMode, we began programming autonomous.
We set the robot’s initial point so that it can start against the wall, then we tested how well it handled going forward close to the stones, turning, and then moving forward all the way to the foundation

It was inconsistent in all three of these cases. Sometimes, it moved too far and would hit the stones out of the way. Sometimes, the robot would move too far when going towards the foundation.

Also, a simple turn was inconsistent too. Sometimes, it would try to turn, and right before it completed it, it would drift away in a random direction.

Through this testing, we decided that we had to use dead wheel odometry for any sort of consistency.

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	**Fabricate and Integrate**	Tweak & Evaluate

ODOMETRY

CONSTRUCT & TEST A PROTOTYPE: ODOMETRY CONFIG

Although we already have the math for 3-wheel odometry set up, we did not have the code for 2-wheel odometry. While the mechanical team was adding the second odometry wheel, we worked on creating a constructor for odometry wheels.
We made an odometry system class that holds both odometry wheels, and a config for each odometry wheel.
In the config, we set inputs for the ticks per revolution and the wheel diameter. This is used to calculate the distance traveled using the circumference equation and a proportion.

Distance = encoderPosition/ticksPerRevolution * wheeldiameter * pi

Next, each wheel needs a turn correction value, because we do not want to make the encoder wheel count the position when rotating. Like last year, we will graph the function of the encoder value with respect to the angle, and get that slope to find the turn correction.

FABRICATE AND INTEGRATE: ANGLE WRAPPER

Currently, the angles that we get are from 0 to 360, where it restarts back to 0 after hitting 360. These values will not work for the turn correction because the angles need to add up past 360 so it can keep subtracting off the correct values.

To actually get these turn correction values, we would need to spin the robot and track those values. We made a class that stores those values in a text file so we can make them into a google sheets graph when we have the robot.

NON-TECHNICAL DISCUSSION

- We had this extra meeting because we have a lot to do for the very important Pennsylvania qualifier.
- The spools for the slides will not print until tomorrow and the arm for autonomous is very high on our priority list.

MEETING SUMMARY

- Autonomous Arm Fabrication
- Odometry Wheel Integration
- SLAM Positional PID Auton
- 2 Wheel Odometry Code

THURSDAY, JANUARY 16, 2020 [EXTRA] MEETING

DATE & TIME: 1/16/20 | 12:00 PM - 4:30 PM

STUDENTS: Patrick

MENTORS: Arnav

AGENDA
Replace Vertical Lift Spool
Assemble Auton Arms
Test Odometry

TIMELINE REVIEW

January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

STACKING STONES

FABRICATE AND INTEGRATE: REPLACING LIFT SPOOLS

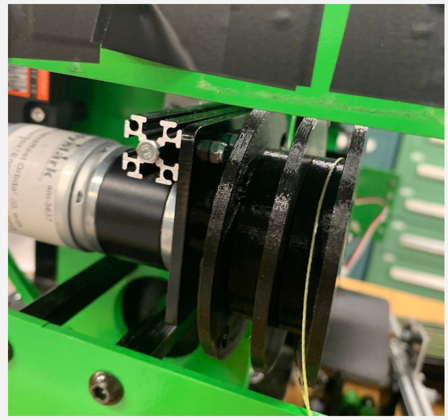
Because of the lift performance in New Jersey, we printed new spools that had twice the flange size. This is a good trade off because it doubles the flange size, but only decreases the speed by 80% (because of the change in inner diameter. Furthermore, we were only using the lift at 70% power so now we can run it at a higher power, meaning we would have more torque.

This was not a huge priority because autonomous needs to be programmed, so we decided to do it at an extra meeting.

We created counter bores for both the axle hub to fit in and the screw heads to fit in so the overall design will be a lot smaller. We also bored out the center of two of the pulley prints so that the motor can go through it. Stringing the lift was tedious and time consuming because both the extension and retraction string needed to be taken care of. Also, the lift needs to come off for the pulleys to come on, so the whole process took a very long time, another reason for having an extra meeting

We also added another set of pulleys at the bottom crossbeam of the linear slides. This is so the retraction string can spool out without changing that rate when the lift raises. We decided to not use that because it does not have a pulley guard, so it wouldn't be reliable in a match.

Sadly, while restringing the lift, we dropped heavy counterweights onto the robot from 5 feet high. It landed right on the crossbeam, leaving a nasty dent, but it does not affect functionality so we will change it when we have the time.



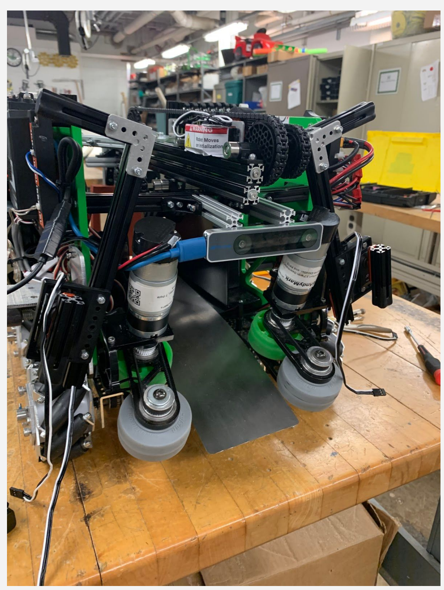
Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

SCORING STONES

FABRICATE AND INTEGRATE: AUTONOMOUS ARMS

First, to add rubberized grip to the claw, we used plasti-dip. "Plasti Dip is a multipurpose, air dry, specialty rubber coating. It can be easily applied by dipping, brushing or spraying"
We dipped our REV extrusion into black plasti-dip to keep the aesthetic. The rubber coating made it much grippier.

Also, we found our Black VHB Tape, which is our strongest double sided tape, so we mounted the autonomous arms today as well

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ODOMETRY

TWEAK & EVALUATE: ODOMETRY VALUES

We tested the odometry code as soon as we finished the restringing the lift. The odometry values were exactly correct!
This was very exciting news because now we have a positioning system for quick autonomous pathing.

There was no time to conduct the turn corrections test, but that can easily be done tomorrow. Also, the odometry wheels need to be field centric in order to accurately path, but that does not work as well. Patrick will look at the code at home so he has math prepared when retesting odometry tomorrow.

NON-TECHNICAL DISCUSSION

- We had this extra meeting because we knew the linear slides would take a long time to replace. We need this out of the way because the chains for the new drivetrain will not come until tomorrow, so there would be no other time to do them.

MEETING SUMMARY

- Vertical Lift Spool Replacement
- Autonomous Arm Integration
- Autonomous Testing

FRIDAY, JANUARY 17, 2020 [EXTRA] MEETING

DATE & TIME: 1/1720 | 8:30 AM - 2:30 PM

STUDENTS: Patrick, Bryan, Karthik

MENTORS: Arnav

AGENDA
Change Drive Train
Mount Autonomous Arms
Test Odometry

TIMELINE REVIEW

January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

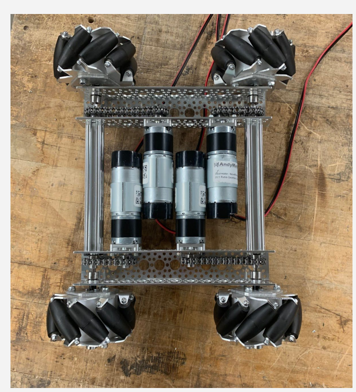
MECHANICAL ACCOMPLISHMENTS

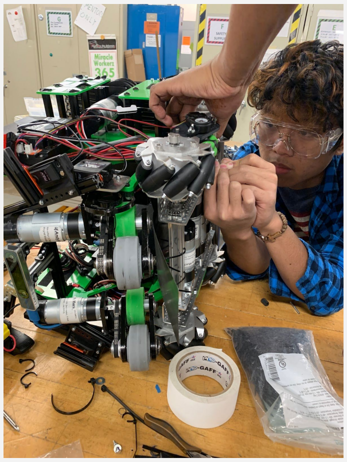
Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

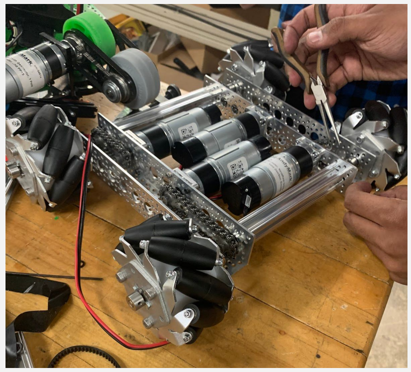
CHASSIS

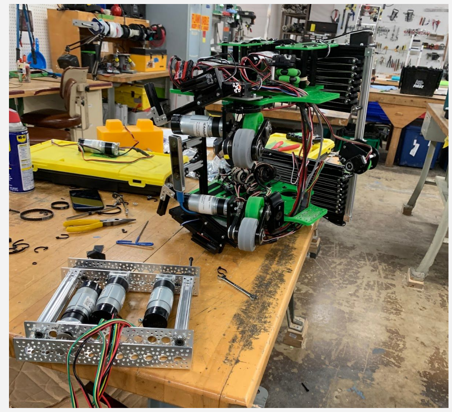
FABRICATE AND INTEGRATE: CHAIN AND SPROCKET DRIVETRAIN

The sprockets came in last night, so we have everything to replace the drive train. We began taking apart the power transfer, and we realized that the motor shafts were so beat up that it was impossible to take some of the pulleys off. We made the decision to detach the old drivetrain from the side panels and replace it with our spare drive train. Now we have a new channel, new motors, new axles, and new bearings in addition to our new chains which were supposed to work even with old hardware. The entire replacement process was long and tedious, but nothing was out of the ordinary. We just had to bore out the motor sprockets, slide in the new drivetrain, build the drive train to be identical to our previous one except with chain, and tighten everything back together.









PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

ODOMETRY

FABRICATE AND INTEGRATE: ODOMETRY TESTING

Getting the normal values worked the last meeting, but now we have to test turn corrections and then field centric.

First thing we tested is whether those values updated in a loop. They both did, so we spun the robot and then used the logs to calculate distance traveled per angle traveled for the turn correction.

We inputted the turn corrections for the respective wheels and ran the turn test again. The values appeared to be correct!

Next, we did the field centric math. The first math did not work so we just adjusted the inputs and the trig functions depending on what the calculation errors were. For example, if the values were moving in the wrong direction, we flipped the signs.

After some flipping of values, field centric also worked!

We ran the same Positional PID test as yesterday, but it sadly did not work. Then we ran just a normal teleOp and saw that the drivetrain did not even move correctly. We think this is due to the drivetrain change, but it should be an easy fix tomorrow.

NON-TECHNICAL DISCUSSION

- Since the new sprockets did not arrive until yesterday night, we had to have this extra meeting to finish up any major, time-consuming mechanical changes. This was the last major mechanical thing on the list, so Saturday is free for fixing mistakes, autonomous, and judging.

MEETING SUMMARY

- Chain & Sprocket Drivetrain Replacement
- Odometry Code

SATURDAY, JANUARY 18, 2020 MEETING

DATE & TIME: 01/18/20 | 9:00 AM - 5:00 PM

STUDENTS: Helen, Paige, Karthik, Ian, Jonas, Patrick, Bryan, Rohan, Katy, Suraj

MENTORS: Arnav, Andrew, Zach

AGENDA
Practice Judging
Drive Practice
Pack for Pennsylvania Qualifier and Hagley Outreach

TIMELINE REVIEW

January 19	Pennsylvania Qualifier
January 20	Hagley STEMtastic Museum Maker Fest Outreach
January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: SEALING SPOOL CRACKS

Because the spools for the vertical lift are a three-part print, there is a tiny gap between the two outer spool parts and the plate in the middle. When Patrick and Bryan tested the lift and their house, they saw that the string got stuck in that crack. It was impossible to pull out, so they decided to completely disassemble the lift and redo the spool by sealing the crack. Because the string had to be cut, Patrick restrung one entire set of slides because the old string was not long enough. Bryan used hot glue to seal the cracks in both spools.

This was a problem in the first spool print, so we should have addressed it earlier so we did not have to completely disassemble the lift. Thankfully, because of the robot's serviceability, we were able to redo the spool without messing up the rest of the robot. Hopefully we learn from our mistakes and continue to seal spool cracks when needed.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	**Tweak & Evaluate**

ODOMETRY

FABRICATE AND INTEGRATE: ODOMETRY POSITIONAL PATHING

To prepare for the qualifier tomorrow, we had a heavy focus on autonomous. In attempt to maximize the number of points we get, we wanted to finish our odometry system so that we could simply plot points for the robot to follow. Our Positional PID was already tuned from when we used SLAM, so we just needed to finish the math for odometry.

After putting the relevant math in, there were still major bugs. It was not going in the right direction. We changed our rotation of axes math to counter this and it worked!

We got the robot able to go to a point, but it seemed to be unreliable. It would do a certain run consistently, but fail when the robot has to go in a different direction. We do not know if this is a mechanical problem or a programming issue, but we decided to attempt to use this for autonomous and find the problem by analyzing the outcomes from autonomous coding.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

AUTONOMOUS

FABRICATE AND INTEGRATE: AUTONOMOUS PATHING

After the odometry positional pathing code was usable, we started the pathing for autonomous. Since we did not have much time, we wanted to jump straight into a 1 or 2 stone autonomous with the foundation moved and then a park. We did not want to just do foundation because it does not score many points, and we did not want to do skystone because it triples the number of paths required.

It was able to strafe to the stones with reasonable consistency. Then we made it drive to the foundation but it kept veering to the left. This did not make sense because the x value plotted is the same in the code.

We looked at the odometry wheel movements and saw that the strafe wheel was rotating even when it was not strafing. We also noticed that this should not have affected the position as much as it should have. We believe that these small errors possibly compounded with the field-centric code making it add up the distances incorrectly.

We were stuck with not many solutions left. We did not know why the odometry wheels were being inaccurate because the code got very complex, without proper unit testing to analyze errors beforehand. Next time, we will run better tests by isolating certain changes so we find and solve our problems.

For the Pennsylvania Qualifier, we only had the parking autonomous to use because of our high ambitions. We hope a strong tele-op will get us picked for elims even if we do not do well in the qualification matches.

3D Printer

- Ian upgraded the software to the Prusa MK2.5 3D Printer,
- He then did a first layer test to make sure the z offset height and layers are printing right.

NON-TECHNICAL DISCUSSION

- **Paige, Katy, and Helen continued making buttons for the meet/outreach.**
- **Patrick printed the entire notebook.**
    - At home, Patrick and Bryan finished up the rest of the notebook meeting entries so that the notebook would be completely updated. They also worked on getting pictures and details for the Design Document
    - Patrick made a summary page based off of last year's summary page. It described what can be found in the important sections.
    - Helen finished the team and mentor bios.
    - Patrick, Helen, and Jonas worked on finishing up the design document by finding page numbers to reference the design process steps of each design
    - Rohan wrote the control document.
    - The first printout we did in November came out with bad ink so we changed out the toner
    - The last few dozen pages started losing ink quality
    - We ran out of pre-holepunched paper, so Patrick took the notebook home to hole punch the rest.
    - Patrick also taped the section covers.
- **Helen made a trifold for the MOE pit and outreach.xt**
- **Patrick, Clare, Bryan, and Rohan did judging practice**
    - To prepare for the PA Qualifier, we ran through the judging presentation to get some input from our mentors. We learned to have more of a purpose when we speak. A lot of the content we said seemed to just be a bunch of facts. We reorganized the structure and tried to strongly conclude each idea with a purpose. This overall made for a stronger and more engaging presentation.

MEETING SUMMARY

- Preparation for PA Blue and White Qualifier
- Programming Autonomous
- Judging Practice

TUESDAY, JANUARY 21, 2020 MEETING

DATE & TIME: 01/21/20 | 6:00 PM - 8:30 PM

STUDENTS: Jonas, Bryan, Clare, Patrick, Aidan, Helen, Karthik, Rohan

MENTORS: Andrew, Nick, Arnav

AGENDA
Priorities
Retrospective on PA Qualifier
Hagley outreach - reflection

TIMELINE REVIEW

January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: RETRACTION EXTRA PULLEY

At the PA Qualifier, we saw that the string still kept getting unspooled, even with the larger spool walls. Patrick believes that the major tension inconsistencies caused the problem. This is because the retraction spool goes directly from the motor spool to the lift. As the lift increases in height, the rate at which the string pulls the lift also increases. This is because the angle from the spool to the lift changes.

To fix this, we added a pulley right below the last stage of the lift. Now, the spool goes to that pulley and then to the lift. This angle does not change as the lift increases height, so the tensioning will be consistent.

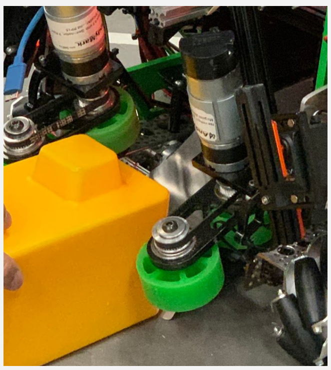
When running with this change at the Hagley STEMtastic Weekend outreach, we saw major consistency improvements!

We only had to restring it twice during its continuous use, and the first time was due to the screw for the pulley guard being too lose.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

DELIVERING STONES

TWEAK & EVALUATE: WHEELED INTAKE MATERIAL



To improve the intake, we looked at changing the front colson wheels to compliant wheels. We originally did not do this because we did not have them available, but we saw that this would either improve the design or not have any effect on it.

After changing to this, we saw a huge improvement with intaking. It was able to intake stones that were at an angle with more consistency than it used to.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ODOMETRY

TWEAK & EVALUATE: 3RD ODOMETRY WHEEL & STRAFE WHEEL

The strafe odometry wheel got cracked when accidentally driving over the neutral bridge. It also wasn't contacting the ground very well because the 3D-printed mount hit the ground first.
To fix this, we drilled into the REV extrusion to create a better mount for the strafe wheel. Now it contacts the floor better.

We also added a 3rd odometry wheel. This is to get better turn values for our odometry positioning system.

TWEAK & EVALUATE: SPRINGING

Our old suspension system used rubber bands. To increase the consistency of it, we found springs to use. This made the odometry wheels touch the ground better, while also increasing the elasticity over time. The rubber bands constantly needed to be changed, so this should help.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

ODOMETRY

CONSTRUCT & TEST A PROTOTYPE: 3-WHEEL ODOMETRY

For more accurate positioning in autonomous, we switched to 3-wheel odometry. The math behind the wheels is slightly different from 2-wheel odometry so we rewrote the code.

We started from scratch because our 2-wheel odometry code was riddled with bugs. We reviewed our math and compared it to the math that Team #9794 Wizards.EXE used for their odometry. We saw that ours was very similar, so we figured we were on the right track.

We also switched our metrics from half-inches to inches so that the numbers would not be as confusing. Overall, because the math was so similar, we were able to finish this new 3-wheel system.

We scheduled an extra meeting on Friday to finish plotting the positions in autonomous.

NON-TECHNICAL DISCUSSION

PA Qualifier
- What went right
    - Stacking in practice
    - Drive practice
    - Judging
    - Chain drive vs. timing belt
    - Lift was inconsistent until pulley guard added at Hagley

- What went wrong
    - Autonomous
    - Unlucky match schedule
    - Did not meet expectations

- Lessons learned
    - **Judging**
        - **More content**
        - **How to sell the team**
        - **Show progression**

Hagley Museum Outreach
- Issue with wire management
- Outreach robot ran well - needs some maintenance
- Padua team - had trouble with batteries, we lent them one
- Good way of providing information about FIRST (better process)

- Less traffic, made it more manageable
- Good to have competition robot
- Lots of drive practice
    - Better cycle strategies
    - Transfer
    - Park better
- Had fun… great overall experience

The College School Talent Show

- Aidan's school presentation
- Success!

Priorities

- Autonomous
- Judging
- Drive Practice

- We did a large Judging Presentation review
    - We decided to place an emphasis on story-telling instead of just stating facts in order to draw in the judges attention
    - We added more detail on things that set us apart from other teams.
    - We emphasized the design process a lot more because it is crucial to how we run.
    - We also wanted to stress our "serviceability" using an actual story.
    - We added a greater focus to our outreach section to emphasize our goals.

MEETING SUMMARY

- PA Qualifier & Hagley Outreach Retrospective
- Judging Practice
- Small Intake & Lift Improvements
- Autonomous

FRIDAY, JANUARY 24, 2020 [EXTRA] MEETING

DATE & TIME: 1/24/20 | 3:00 AM - 9:30 PM

STUDENTS: Clare, Patrick, Bryan, Karthik

MENTORS: Arnav, Zach

AGENDA
Preparation for PG County Maryland Qualifier
Judging Practice
Autonomous

TIMELINE REVIEW

January 25	Maryland Qualifier

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

CHASSIS

TWEAK & EVALUATE: DRIVETRAIN BEARINGS

Even after switching to chain, we still had to do constant maintenance and PA Quals. We saw that the sprockets kept moving even after we applied loc-tite.

Looking at the acto c-channel that holds the chassis together, we saw that the holes where the bearing sat got bored out. This means that the bearings did not fit well in the channel and the constant use just degraded it faster over time.

This was very strange because we replaced the channel right before the competition. One of the alumni, Zach, suggested to reinforce it using two bearings. This means that we would have to completely replace the drivetrain again. Because of the serviceability, we were able to finish it in that meeting and still have time to work on autonomous. Karthik did this with Zach while everyone else was doing judging practice

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

AUTONOMOUS

FABRICATE AND INTEGRATE: POSITIONAL PATHING WITH ODOMETRY

We spent the rest of the night working with odometry and positioning. We struggled with consistency errors like before. Some things would work and some things would not. We did not have time for a well-formed testing plan and everything was rushed.

Each test came with an unexplainable result, so we had to keep checking our values for each wheel.

We saw that the turn value was wrong because the gyro was not calibrated. After fixing this, the robot still did not move where it was supposed to go.

Towards the end of the meeting, we decided to try using time, but we did not have enough time to create anything. This was very upsetting, but now we know to have better fall back plans instead of being too ambitious.

NON-TECHNICAL DISCUSSION

- Arnav and Mr. Chrystel helped with judging
    - We decided to go with a longer format, even though it extends past the 5 minute mark. We seemed to be rushing past material and did not have many conclusive points
        - We rewrote our scripts to add more detail where needed and to end with strong conclusion. This sounded a lot more effective
        - We improved our ability to answer questions
        - We spent a good amount of time on refining everything about the judging practice, going through multiple run-throughs and taking notes.
- Updated Summary Page
    - We pointed to specific pages for the judges to go to and highlighted key ideas that we wanted them to know about
    - We included the section titles so the judges know what the letters on the side mean without having to flip to that page
- We added the Hagley Entry
    - We thought it would be too much to add the other meeting entries and we did not want to rush it.
- We were still relatively well-packed from last week's competition, so it was simple to pack up again.

MEETING SUMMARY

- Replaced Chassis
- Judging Practice
- Autonomous

TUESDAY, JANUARY 28, 2020 MEETING

DATE & TIME: 01/28/20 | 6:00 PM - 8:30 PM

STUDENTS: Clare, Karthik, Bryan, Ian, Connor, Helen, Suraj, Rohan, Isha, Aidan

MENTORS: Andrew, Arnav, Mr. Buckingham

AGENDA
Reflection from Maryland Qualifier
Set priorities for February
Create plan to improve programming

TIMELINE REVIEW

February 1	Black History Month Outreach (Walnut St. YMCA)
February 18	Padua Meet
February 19	Boeing E-Week Outreach

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	**Tweak & Evaluate**

SCORING CAPSTONE

TWEAK & EVALUATE: CAPSTONE CHANGES

Jonas made a Capstone for the competition in Maryland. It was a simple design that just attached to the lift but was able to come off when the lift went down on the stone. It was attached to a REV L-bracket so it was easy to add to the robot.

Jonas made a bigger hole for the stone nub to go through and also made it more structural where it mounted so it wouldn't break like it did at the competition.

CONSTRUCT & TEST A PROTOTYPE: CAPSTONE

Ian got the capstone model that Jonas made in Cad. Then, he put the Capstone CAD object into PrusaSlicer to prepare it for 3D printing. The settings that, he put for the models are:

- Parameter/walls: 4

- Infill: 30%
- Layer height: 0.30 mm
- Supports: Off

Then, I turned the cad object with the setting I choose into a .gcode file for the 3D printer to use to print the object. He then turned on the 3D printer and then he cleaned the bed with Isopropyl Alcohol. After that, he told the 3D printer to heat the extruder and print bed to the temperatures for petg. The 3D printer then calibrated itself by doing the mesh bed calibration. After that, it started to print the capstone. It printed the first layer and it printed the well.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

ODOMETRY

FABRICATE AND INTEGRATE: ODOMETRY ANALYSIS

In accordance with our priorities for the next month, the robot was immediately handed to the programming team. We started by testing odometry for mechanical faults for a two hour time block, as seen in the table in Non-Technical Discussion.

One problem with our testing was that we were jumping from test to test too much instead of running the same test and recording data. This means that our results were not significant enough to draw conclusions from. Arnav suggested using a test sheet to document everything: the purpose of a test, the data from the trials, and conclusions made from the trials.

We could also write down any mechanical rig or device we need to perform certain tests. With this clear communication, we would be able to run more conclusive tests.

NON-TECHNICAL DISCUSSION

- **Set new priorities for the month of February.**

After the Maryland Qualifier on this past Saturday, we decided to set new priorities for each section of the team to improve as efficiently as possible before the Maryland state competition on March 1.

Mechanical	Programming	Judging/Drive Practice
- Wire guide - Longer wall on grabber - Servo for capstone	- Moving foundation - Detecting skystone - Arm control autonomous - PID	- Notebook entries - Design - Make edits to judging presentation - Train non-drive team

		members for pit judging - Pit display

- **The programming team set new goals.**

Action Item	Time Management
1. Test odometry for mechanical faults 2. Test odometry logic: angles/field centric 3. PID	1. 2 hours 2. 2 hours (simultaneous to mech. faults)

- **Clare and Helen looked into outreach opportunities.**

After getting the second place Inspire award at the Maryland qualifier, the marketing subteam decided to increase outreaches to further connect to the FTC and local community.

- **Outreach opportunities:**
  - Black History Month Kickoff: Feb 1 at Walnut St. YMCA
  - Juliette's Revenge: Feb 1 visit to DuPont lab
  - (possible) FLL Qualifier: Feb 8 at Greater Dover Boys & Girls Club in Dover, DE
  - (possible) FLL Qualifier: Feb 15 at Las Américas ASPIRA Academy in Newark, DE
  - Padua Meet: Feb 18 at 5:00
  - Boeing E-Week: Feb 19
  - STEM Expo: Feb 22 at the Delaware Children's Museum

- **Clare wrote the Maryland PG County Qualifier outreach entry.**
- **Helen updated the MOE website with pictures from our recent events.**

MEETING SUMMARY

- Maryland Qualifier Reflection
- Setting February Priorities
- February Outreach Opportunities
- Odometry Analysis

SATURDAY, FEBRUARY 1, 2020 MEETING

DATE & TIME: 02/01/20 | 9:00 AM - 2:30 PM

STUDENTS: Connor, Karthik, Jonas, Helen, Ian, Suraj, Rohan, Bryan, Patrick, Isha, Paige

MENTORS: Andrew, Arnav, Zach

AGENDA
Outreach day!
Juliette's Revenge visit (9 am - 11 am)
Black History Month Kickoff Outreach (10 am - 1 pm)
Work on autonomous testing

TIMELINE REVIEW

February 1	Black History Month Outreach (Walnut St. YMCA)
February 18	Padua Meet
February 19	Boeing E-Week Outreach

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

SCORING CAPSTONE

CONSTRUCT & TEST A PROTOTYPE: CAPSTONE

The capstone 3D print that Ian started on Tuesday's meeting got stopped by the filament sensor. He started the print back up but when it was doing the infill of the piece, the filament sensor keeps stopping the print for some reason only while printing the infill and a few times that the printer stopped, he turned off the filament sensor and the 3D printer was printing smoothly and with pausing.

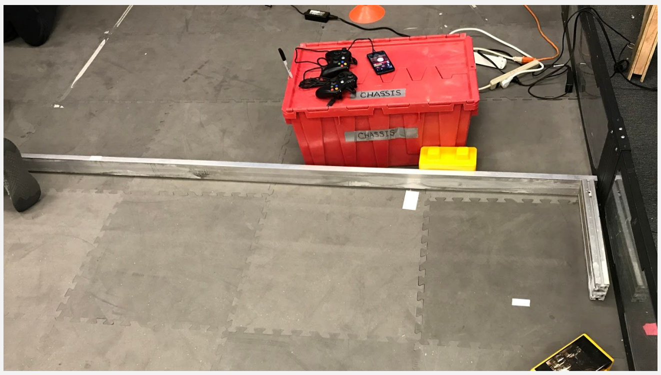
We hope to get more iterations of the capstone design, so we can have one that performs the best at future qualifiers. Our first iteration of this type of capstone performed pretty well during Maryland, but we hope that we can add more structural support and compliance when placing.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

ODOMETRY

CONSTRUCT & TEST A PROTOTYPE: ODOMETRY WHEEL TEST



The programming team decided to run a few tests on the three odometry wheel systems on the competition robot. These tests aimed to determine if the two forward facing odometry wheels were calibrated. The mechanical team constructed a rail in the game field to run the robot along in these tests. They also created a chart that kept track of the values that they collected during these tests.

This straight path combined with the output of the odometry means we can properly test the performance of the wheels with minimal human/driving/robot error. It is important to minimize confounding variables in these tests because we are trying to determine the accuracy of the odometry wheels.

After completing a series of tests on the odometry wheels, the programming team made a graph of the right and left odometry wheels and their performance while strafing.

Trial	Right Forward Wheel	Left Forward Wheel	Strafe Wheel	Error (Right-Left)	% (RIGHT-LEFT)/(LEFT)	
1 (Left)	-664	-4111	-146587	-3447	0.8385	
2 (Left)	831	-1674	-146382	-843	0.5036	0.5638
3 (Left)	153	-2212	-146101	-2059	0.9308	0.5529983162
AVG LEFT	106.6666667	-2665.666667	-146356.6667			
STD DEV LEFT	748.5762041	1280.27432	243.9883877			
4 (Right)	-171	89	147507	82	0.9213	
5 (Right)	-578	925	147639	-347	-0.3751	
6 (Right)	-1772	1188	147703	584		
AVG RIGHT	-840.3333333	734	147616.3333			
STD DEV RIGHT	832.1143752	573.8562538	99.94665244			

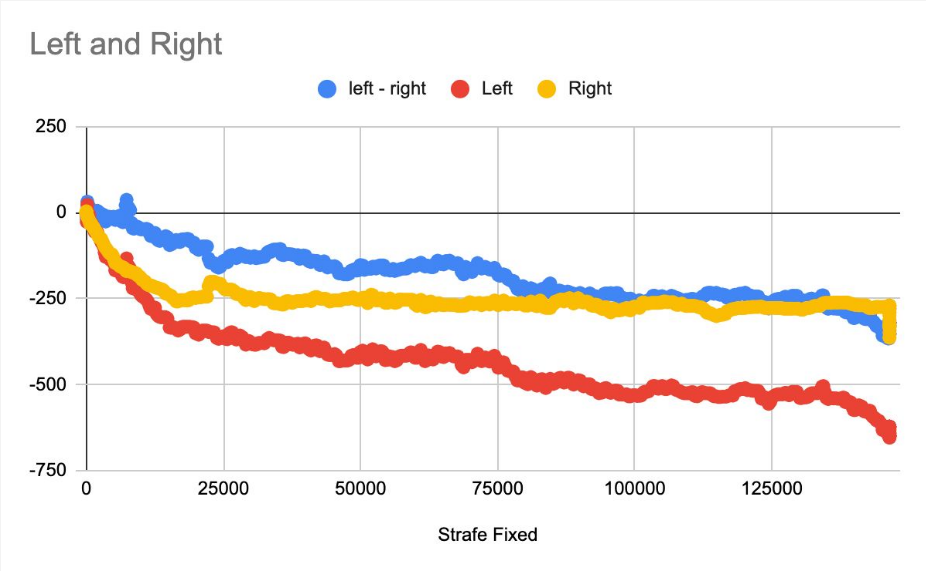
The strafe test represented in the graph above can be represented in this table as well. This table showed the amount of encoder ticks that the two forward facing odometry wheels tracked while the robot is strafing. We saw a large amount of error from this test. The error was also not very repeatable, so the problem was inconsistent (not proportional or due to certain locations on the field).

Due to this error, the programming team decided to discard use of the Positional PID until the mechanical team is able to find a feasible solution to fix this error in the odometry wheels.

Trial	Right Forward Wheel	Left Forward Wheel	Strafe Wheel	Error (Right-Left)	% (RIGHT-LEFT)/(LEFT)	
1	148070	146413	-125	1657	0.0113	
2	148228	146425	1616	1803	0.0123	0.0120
3	148441	146461	-33	1980	0.0135	0.001057932218
4	148172	146595	1190	1577	0.0108	
5	148300	146504	426	1796	0.0123	
	148242.2	146479.6				
	139.3240826	73.61249894				

The final test that was conducted today tested the amount of error in encoder ticks that the strafing odometry wheel experienced as the robot drove forward and backwards. This test also examined the difference in measurement between the two forward facing odometry wheels. This difference will be used in the future to help calibrate the two forward facing odometry wheels. The error between these two odometry wheels is not extreme, making the forward facing odometry wheels more reliable as compared to the sideways strafe odometry wheel.

The graph on the right shows the fixed strafe and the number of encoder ticks (as shown on the y-axis). This graph represents the strafe testing and how much error in movement the forward facing odometry wheels have. As shown, the odometry wheels experienced around 750 encoder ticks, which is roughly equivalent to half an inch of movement. This test showed that the odometry wheels are fairly stationary while the robot is strafing.



With these conclusions, the programming team decided to go with a more simpler odometry approach for the next competition. We hope to improve the mechanical design of odometry so we can use our more complex positioning system later in the season.

NON–TECHNICAL DISCUSSION

- **Half the team went to the Black History Month outreach event at the YMCA from 10:00 to 1:00.**

Helen, Paige, and Mrs. Ho met many students and families at this event celebrating the start of Black History Month and famous African American inventors. More information can be found in Section E under *Black History Month Kickoff*

- **The other half of the team stayed in the lab and helped Juliette's Revenge (#14851).**

Patrick and Andrew helped Juliette's Revenge work on their robot to help them start harvesting stones. It was educational to see them progress through the season! More information can be found in Section E under *Juliette's Revenge Meeting #2*

MEETING SUMMARY

- Help Juliette's Revenge
- Black History Month Kickoff Outreach
- Test Odometry Wheel Outputs

TUESDAY, FEBRUARY 4, 2020 MEETING

DATE & TIME: 02/04/30 | 6:00 PM - 8:30 PM

STUDENTS: Connor, Ian, Bryan, Patrick, Helen, Karthik, Jonas, Clare, Aidan, Rohan, Isha

MENTORS: Arnav, Andrew, Nick

AGENDA
Discuss Priorities for February
Meeting with RobAUKtics #395
Work on Autonomous
Brainstorm Promote Video Ideas

TIMELINE REVIEW

February 18	Padua Meet
February 19	Boeing E-Week Outreach
February 22	STEM Expo at the Delaware Children's Museum

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

ODOMETRY

CONSTRUCT & TEST A PROTOTYPE: TURNING PID

The programming team decided to create a new method in the autonomous program that would allow the robot to correct its turning while it is moving forward. This will help the robot maintain its direction while moving during autonomous, as the drive team will be unable to redirect the robot during this period of time. By doing so, we can make the autonomous movement more consistent and reliable. In order to accomodate for the new turn-correcting method, the programming team also decided to tune the turning PID to ensure that the turning PID will account for turn corrections made by this new method.

To tune the PID, we made the robot do turns while changing the constants based off of the performance of the turn. If it turned too fast, we dampened it with the kD constant. The PID still slightly overshoots but the performance is very good. We decided to continue with movement tests for forwards and backwards movement and tune more if needed.

CONSTRUCT & TEST A PROTOTYPE: MOVEMENT TESTS

After deciding to implement the simpler odometry system for discrete, linear movements, the programming team conducted a series of tests using the odometry wheels. The series of tests that were conducted determined the number of encoder ticks per inch and ensured that we had a consistent, correct number for this rate before starting work on the autonomous program. Afterwards, we decided to start conducting strafe tests to aid in determining the number of encoder ticks per inch. By taking the averages from these tests, we were able to figure out the most accurate number that can simplify unit conversions in the autonomous code. We saw that the movement was very inconsistent, even when doing one movement at a time, but we could not do much better without replacing the odometry system.

The robot overshoots its target because it is not run by a PID anymore (for translational movement). We will just run autonomous at lower speeds to lower the effect of the overshoot.

NON-TECHNICAL DISCUSSION

- **Jess from Archmere RobAUKtics #395 visited.**
  - Jess was told to not bring the robot to the meeting because her mentors said that they did not want the robot and the phones out of the school. Fortunately, she had a video of her robot, and we could assess the design from the video.
  - We also showed her our notebook and what we have done to organize our meeting entries.
- Helen and Mrs. Ho told us about the MLK outreach at the Walnut Street YMCA.
- Patrick talked about Juliette's Revenge meeting.

- Andrew talked about the Boeing Outreach
- Clare brainstormed ideas for the Promote Award. She wanted to do a video, possibly at the Padua meet where there are many other people to be in the video. Her main idea was to get post-it notes on how FIRST has changed everyone and the colors of the post it note can spell out FIRST.
- Opportunity for FLL Qualifier Outreach
  - Bring competition robot and field for drive practice
  - Volunteer opportunity
  - Expose younger FIRST students to next step - FTC

Mechanical Priorities (all after autonomous)	
Wire guide	Active work on the robot
Longer wall on grabber	Can be done off the robot
Servo for capstone	Active work on the robot (30 minutes)

MEETING SUMMARY

- Set new priorities to prepare for state championships
- Work on autonomous
- Meet with RobAUKtics #395

SATURDAY, FEBRUARY 8, 2020 MEETING

DATE & TIME: 02/08/20 | 9:00 AM - 2:30 PM

STUDENTS: Connor, Ian, Jonas, Karthik, Helen, Paige, Clare, Rohan, Aidan

MENTORS: Andrew, Arnav, Mr. Prettyman

AGENDA
Brainstorm Ideas for Pit Presentation
Work on Autonomous
Organize Promote Video
Discuss Upcoming Outreaches

TIMELINE REVIEW

February 15	FLL Qualifier (Outreach)
February 18	Padua Meet
February 19	Boeing E-Week Outreach
February 22	STEM Expo at the Delaware Children's Museum

PROGRAMMING ACCOMPLISHMENTS

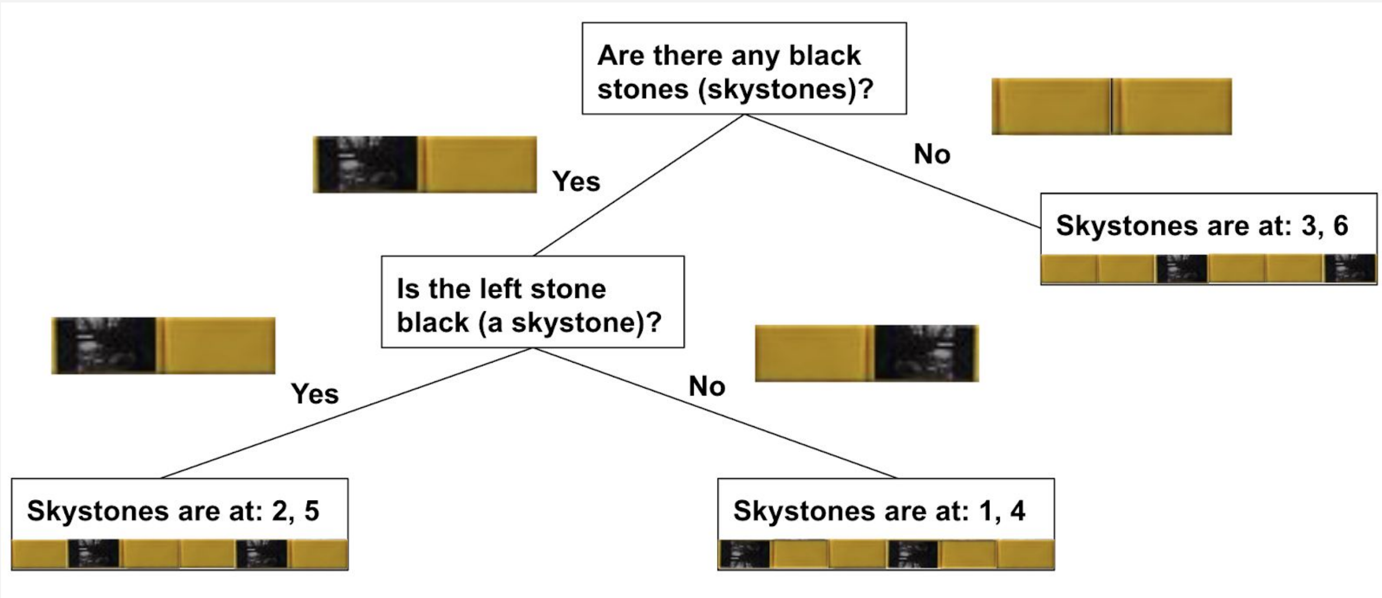
Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

SKYSTONE DETECTION

CONSTRUCT & TEST A PROTOTYPE: SKYSTONE ALGORITHM

The programming team worked on the autonomous program of the robot, specifically with regards to detecting the skystones.

As of this point, the autonomous program starts the robot on the side of the field. The programming team tested to see if the robot is able to select the skystone out of a row of stones. First, the robot's camera takes a picture of the row of stones. Using the designed skystone algorithm, the robot examines each stone to find the skystone (whether it is centered or off to the right/left side). The process of the skystone detection algorithm is shown below.



We made classes to access this camera data during autonomous by making an object for its location. They can either be LEFT, MIDDLE, or RIGHT. Using these values, we can make conditional statements for the robots movement.

NON-TECHNICAL DISCUSSION

- **Helen and Clare looked at t-shirt designs.**
- **Aidan and Paige made more MOE buttons/pins for our upcoming events.**
- **Connor worked on CAD renders of the robot and mechanisms.**
- **Helen and Clare examined trifolds from past seasons.**

We decided to create two trifolds that will include information about our robot and outreaches. These will be used at future outreaches including the FLL Qualifier next week and in the MOE pit at competitions.

MEETING SUMMARY

- Work on Skystone detection algorithm
- Prepare promote materials for outreaches and competitions
- Brainstorm ideas for promote video

TUESDAY, FEBRUARY 11, 2020 MEETING

DATE & TIME: 02/11/20 | 6:00 PM - 8:30 PM

STUDENTS: Aidan, Ian, Jonas, Bryan, Patrick, Clare, Karthik, Helen, Rohan

MENTORS: Arnav, Andrew, Nick

AGENDA
Judging Practice - 7:00
Introduce Mr. Steve Rhodes
Meet NCS visitors
More Autonomous Work

TIMELINE REVIEW

February 15	FLL Qualifier (Outreach)
February 18	Padua Meet
February 19	Boeing E-Week Outreach
February 22	STEM Expo at the Delaware Children's Museum

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

SKYSTONE DETECTION

FABRICATE AND INTEGRATE: SELECTING A SKYSTONE

After testing out the different cameras, the programming team decided to use the webcam to detect the Skystone. In order to simplify the process of creating the program, Rohan and Karthik chose to code an autonomous program that would pick up one Skystone. After finishing this, the programming team will then adapt the code to be able to select both Skystones in the autonomous period. During this meeting, the programming team worked on coding the webcam to detect a Skystone based on color detection by following the flowchart that was created during the last meeting. This was effective, and the robot was able to correctly select the first Skystone after testing during this meeting. However, the robot was not able to deliver and place the Skystone on the foundation after selecting it, which the programmers will work on in the next meeting.

NON-TECHNICAL DISCUSSION

- **Discuss meeting plans for the next couple of weeks**
- **Members of the team talked to Mr. Steve Rhodes and a NCS student.**
    - The NCS Student, Kevin, came in to watch how the robotics program worked because 4 members of the team go to Newark Charter with him. He was interested in how the program operated, so we showed him around the lab and how the robot worked.
    - Mr. Steve Rhodes is a local robotics mentor that wants to start engaging in the FIRST Robotics program. We were able to help him learn more about how to access coding (starting with block-based programming) and combine it with the mechanical aspects of the robots.
        - Mr. Rhodes used to do VEX Robotics, but he liked what the FIRST program offered to students. He wants to try FTC and expand the FIRST Community in the local area.

- **Judging Practice:**

Rohan, Bryan, Patrick, Clare, and Helen worked on editing and practicing the judging presentation. After going through the presentation, the MOE mentors gave feedback about each focus of the presentation, allowing us to make the slideshow more cohesive. Some of the feedback that we received is organized in the list below:

- Create a call to action on each slide (what message should the audience receive?)
- Use a stronger conclusion to summarize the entire presentation
    - Give each slide a purpose
- Implement more cohesive transitions between sections

MEETING SUMMARY

- Practice judging
- Meet with Mr. Steve Rhodes and NCS students
- Autonomous programming

SATURDAY, FEBRUARY 22, 2020 MEETING

DATE & TIME: 02/22/20 | 9:00 AM - 3:00 PM

STUDENTS: Bryan, Patrick, Ian, Helen, Aidan, Karthik, Suraj

MENTORS: Andrew, Zach

AGENDA
Edit Judging Presentation
Work on Autonomous
DCM Outreach
Finish Promote Video

TIMELINE REVIEW

February 22	STEM Expo at the Delaware Children's Museum
March 1	Maryland State Championship
March 14	Delaware State Championship

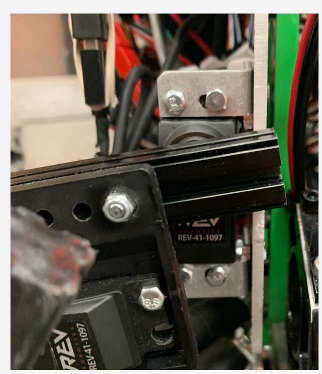
MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

SCORING STONES

TWEAK & EVALUATE: SERVO ARMS

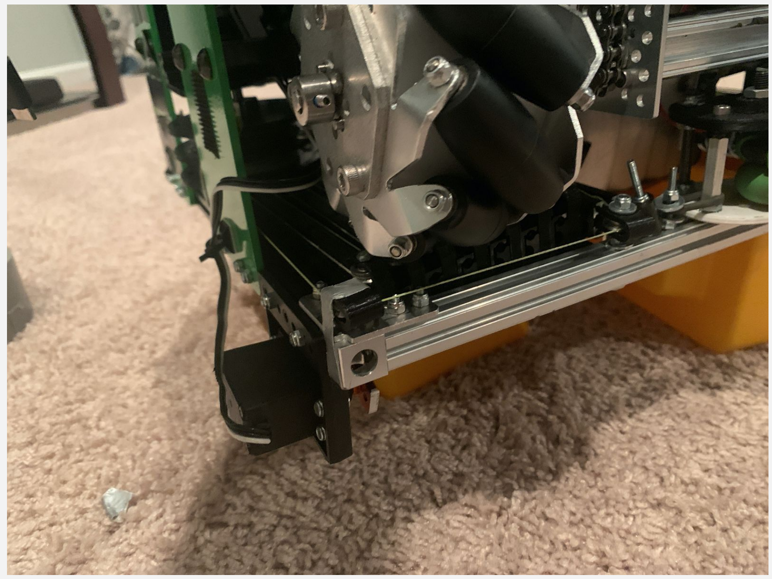
As an alternative to using tape to attach the servos, we decided to use the mill to modify an L-bracket in order to use it as a mounting bracket for REV servos. Although this was more difficult to accomplish, this was a good opportunity to teach Suraj (one of our new mechanical team members) the basics of using the mill. After learning with other members of the mechanical team, Suraj will be able to know the full capabilities of the mill for future design.



Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: PULLEY SYSTEM



The mechanical team had to improve our pulley system because the screws of the pulley system ripped out of the extrusion at the FLL outreach and Padua meet. This was because of too much torque on the screw. The solution to this problem was to use a mounting strategy where the screw went through the entire REV extrusion instead of being mounted on the face of the extrusion.

When we assembled the pulley system again, the new screw was not long enough to mount the pulley with the same amount of spacing that was previously used. To fix this, we decided to add two other pulleys in the corner of the robot so the pulley string can go around the slides that were in place. Because we used to more pulleys, the torque is distributed across the two pulleys so each individual pulley will take half of the total force. Since the perpendicular distance of the line of action of force from the axis of rotation is smaller, there is less torque acting on the screw.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

ASSISTED TELE-OP

FABRICATE AND INTEGRATE: LIFT CONTROLS

Patrick added code to the lift for two reasons:

1) To make the lift run smoother
2) To make the lift easier to drive

Patrick hypothesized that the that lift ran very jittery because the PID was not able to run effectively because of how the positions were set. They incremented as you moved the joystick instead of being set to a certain point. This means that the Proportion control of the PID would not work effectively because the the target position is not a set distance away from the current positon.

He wanted height control in order to choose the height of the stone. This means that the driver does not have to play with the joystick to get the correct height, he can just pressed a button to make it move a stone up and a stone down. This will also help the proportion controller because the distance will be set.

Patrick also added memory control. This was mainly so that the lift can be set to the bottom position very quickly. This means the proportional controller will also make the lift go down faster, which it struggled with before

After implementing these changes, we saw major improvements on the lift's movements. Not only did it move with less jitter, but it was also a lot faster. This will help us stack more stones in competition

Finally, Patrick added an intake assistance where the lift automatically raises a little to make sure the Stone goes all the way through to the front of the robot. Previously, the stone would hit the servo of the lift and only make it half way and the driver would have to fiddle with the lift in order to grab the Stone.

Adding these changes will greatly improve our cycle time because it increases intake speed and lift speed. It will also decrease the amount that the drivers need to think and control because they will get assistance with the software.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

SKYSTONE DETECTION

FABRICATE AND INTEGRATE: DELIVERING A SKYSTONE

Karthik continued to work on the Skystone autonomous program from the February 11, 2020 meeting to select one Skystone. During this meeting, the programming team was able to write code for the robot to be able to deliver the Skystone after detecting and selecting it using code from the last meeting. This code will be adapted so that the robot can detect, select, and deliver both Skystones in the upcoming week's meetings. He only created a single path for the skystone LEFT case and will finish up the MIDDLE and RIGHT cases in later meetings.

NON-TECHNICAL DISCUSSION

- **With the Maryland State Competition coming up, we set some milestones for the next week.**

Mechanical	Programming	Judging/Outreach
- Mount autonomous arms (Bryan and Zach) - Redo slides and pulley string (Bryan and Patrick) - Extension wiring → remove rubber bands? (Andrew and Bryan)	- First stage auton: 1 skystone, foundation, park (Karthik) - Lift control (Patrick) - Second stage auton: 2 skystone, foundation, park (Rohan and Karthik)	- Outline - Judging practice - Promote video - Drive practice - Print notebook

Saturday 2/22	DCM outreach, mount autonomous arms, extension wiring, autonomous (1 skystone), outline judging, work on promote video
Monday 2/24	Programming, drive practice, mechanical tweaks
Tuesday 2/25	Padua visit, drive (delivery) practice, judging practice
Saturday 2/29	Judging practice, drive practice, packing
Sunday 3/1	Maryland State Championship

- **The team made a purchasing list for notebook tweaks.**
  - Toner
  - Three-hole punch paper
  - Binder (2 inch)

- **Clare and Patrick worked on the new team shirt design.**
  They sent each other designs back and forth to refine an idea. Examples of the progressions are below:

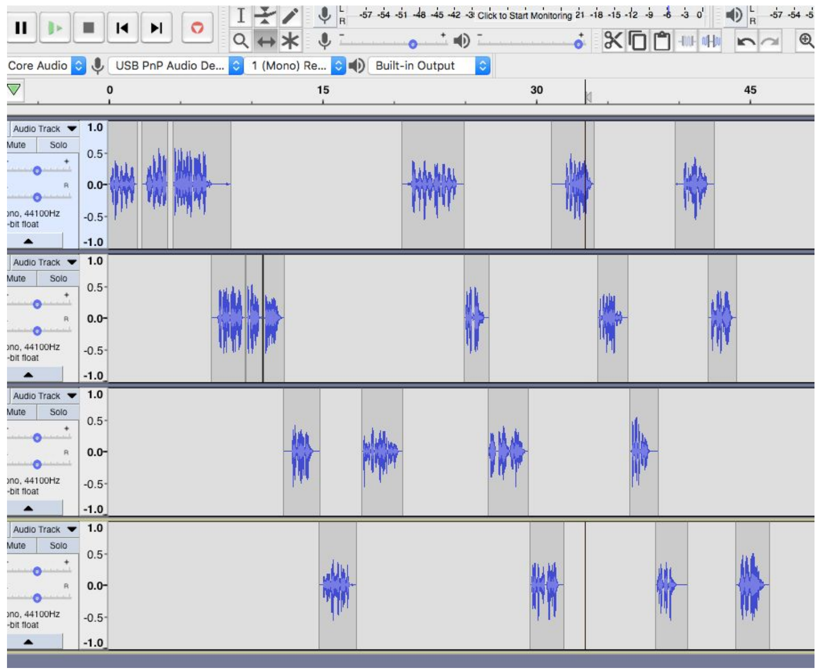
- **Patrick and Helen created a new judging outline.**

After receiving feedback from the mentors about the current judging presentation, we decided to outline the key points that are needed in each section of the presentation based off of mentor advice. This will help us keep track of and focus on the most important information about our team.

- **Helen and Mrs. Ho attended the DCM outreach.**

The Delaware Children's Museum hosted a STEM Expo and members of our team attended this outreach with the batterbot. More information about this event can be found in the Team Section under *Delaware Children's Museum.*

- **Patrick and Clare worked on the promote video.**
    - After Clare and Helen collected the visual time lapses of the “How has FIRST changed me?” sticky note answers, Patrick gathered audio files from MOE members that answer this question as well. Helen gathered audio files from members of FLL teams during the Aspira Academy qualifier that can also be used to create the promote video.
    - Patrick used an audio editing software to enhance the quality of the recordings. By using this software, Patrick was able to run noise cancellation and then enhance the quality by using a compressor.
        - A compressor lowers the volume of the audio if it passes a certain volume level. This can enhance the the volume of the quieter sounds and even everything out. Then he mixed the audio so they would all be around the same audio level.



MEETING SUMMARY

- Discuss robot tweaks needed after Padua Academy meet
- Set milestones for each subteam
- Edit judging presentation
- DCM outreach

MONDAY, FEBRUARY 24, 2020 MEETING

DATE & TIME: 02/24/20 | 3:00 PM - 8:00 PM

STUDENTS: Karthik, Patrick, Bryan, Jonas

MENTORS: Jennifer The’

AGENDA
Make Mechanical Adjustments
Start 2 Stone Autonomous
Drive Practice

TIMELINE REVIEW

February 25	Meeting with Padua (X^2 Factor)
March 1	Maryland State Championship
March 14	Delaware State Championship

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

SCORING STONES

TWEAK & EVALUATE: AUTONOMOUS GRABBER

After starting to run the autonomous program, the mechanical team realized that the current autonomous claws for the Skystone intake were inconsistent and inefficient when picking up the Skystones. Jonas designed and 3-D printed an additional block to put on the end of each autonomous claw. In doing so, the autonomous claws will have an extended reach. At the same time, the blocks will increase the surface area that the claws are able to grab onto for each stone. These changes will make it easier for the robot to gain a hold on the Skystones and make the transport of the stones more secure. In the picture on the right, the added pieces form a 90 degree angle with the rest of the arm and can be seen at the top of the image.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

AUTONOMOUS

TWEAK & EVALUATE: WORK ON BLUE AUTONOMOUS

Our original schedule called for doing 1 skystone, then foundation, and then park for both red and blue autonomous. After analyzing the paths, we saw that 2 skystone and then a park would result in 4 points MORE than the original plan AND it would be easier because the pathing is relatively forwards and backwards. Also, it is a lot easier to add a foundation and then a park at the end of 2 skystones compared to adding a skystone in the middle of a 1 skystone and foundation autonomous.

We ran tests, changing between the 3 possible cases and changed the strafe and forwards movements using Guess and Check. For every run, we lowered values when they overshot and increased them when they undershot. We cannot use measurements in our autonomous due to the inconsistency of the wheels, so this process is lengthy, but at the end of the meeting, The first skystone in all three cases were fairly consistent, and it was able to get to the location of the second skystone without grabbing it.

TWEAK & EVALUATE: TURNING PID

We have turn corrections implemented in our autonomous, but it takes up a significant portion of our time due to its low tolerances. We need to fix this because we will not have enough time to get the second skystone and then park. In order to fix this, we tuned the PID to be more accurate. We increased the D value by a lot to stop it from over shooting and we increased our P gain to lower the steady-state error.

This was able to cut our turn times from 3 seconds to .7 seconds at some points because we were able to turn using higher power.

NON-TECHNICAL DISCUSSION

- Drive Practice Session
    - This meeting was mainly made for autonomous, but we had a little period of drive practice to teach Jonas the new and improved assisted Tele-Op controls.
    - We timed the cycle, but the lift unfortunately got unstrung 1 minute and 20 seconds in. We were able to get 5 stones on our first attempt.

MEETING SUMMARY

- Autonomous grabber extension
- Autonomous
- Drive Practice

TUESDAY, FEBRUARY 25, 2020 MEETING

DATE & TIME: 02/25/20 | 3:00 PM - 8:30 PM

STUDENTS: Bryan, Patrick, Paige, Helen, Clare, Jonas

MENTORS: Nick, Arnav, Andrew

AGENDA
Autonomous Programming
Outreach with Padua (X^2 Factor)
Judging Practice
Prepare for Maryland State Competition

TIMELINE REVIEW

March 1	Maryland State Championship
March 14	Delaware State Championship

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

SCORING STONES

TWEAK & EVALUATE: AUTON ARMS

We quickly rubber dipped our auton arms for increased grip (and to keep the black aesthetic)

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

SCORING STONES

TWEAK & EVALUATE: RED VS. BLUE SKYSTONE DETECTION

After successfully coding the majority of the Skystone detection/delivery program for the robot when it starts on the blue side of the field, the programming team wanted to start coding the program for the red side of the field. Although this seemed to be a simple task in the beginning, we soon realized that the Skystone detection code will have to be edited for the red side since the webcam is not centered on the robot. Currently, the camera crops images taken during autonomous to isolate the first stones in the quarry and determine the locations of the Skystones. Because the webcam is offset to the left of the robot, the camera will not crop the correct stones to determine the Skystone locations. The head programmers were absent from this meeting, so the rest of the programming team decided to wait for more experienced programmers to assist in working with the camera.

The programmers at this meeting then decided to focus on tweaking and fixing small problems in the existing autonomous code designated for the robot when it starts on the blue side of the game field. These edits can help make the autonomous program more reliable and can be used to code the autonomous program for the red side of the field as well.

NON-TECHNICAL DISCUSSION

- **Paige and Helen made more MOE buttons for the upcoming Maryland State competition.**
- **Padua Academy's FTC team visited the lab (X^2 Factor #4200)**
  With the Delaware state competition coming up in mid-March, Padua's team visited the MOE lab for drive practice and brainstormed game strategy ideas with MOE.
  - **X^2 Factor and MOE Drive Practice**
    While they were over at our lab, we practiced game strategy and driving on our field. They showed some connection issues, and we quickly followed suit. We were not able to get our robot back running for the rest of the meeting, so we went to judging practice.
  - **X^2 Factor and MOE worked on our judging presentations.**
    To receive external feedback from another team, we decided to practice our judging presentation and give the Padua team an opportunity to receive external feedback as well.

MEETING SUMMARY

- Drive Practice
- Brainstorming with Padua
- More Autonomous Work

THURSDAY, FEBRUARY 27, 2020 MEETING

DATE & TIME: 02/27/20 | 3:30 PM - 8:30 PM

STUDENTS: Bryan, Patrick, Helen, Jonas

MENTORS: Jennifer The'

AGENDA
Fix Connection Issues
Finish Autonomous Program
Edit Past Notebook Entries
Drive Practice
Debug Code

TIMELINE REVIEW

March 1	Maryland State Championship
March 14	Delaware State Championship
March 20	Maker Madness Outreach (DCM)

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

CONNECTION ISSUES

TWEAK & EVALUATE: USB HUB

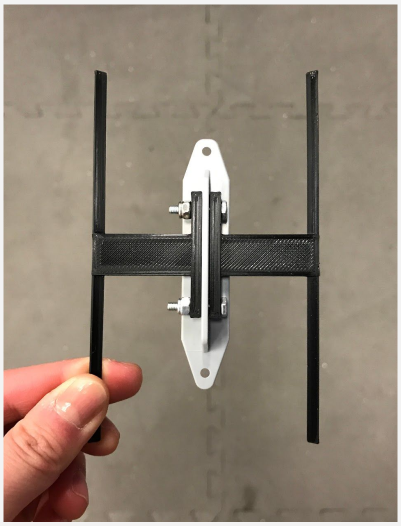
Patrick noticed that one of the wires in the USB hub was continuously getting disconnected despite being connected to the hub. When this happened, the program would crash and the robot would stop running after only a couple of seconds. This connection problem proved to be different than the issues that we faced early in the season, as the wires appeared to be connected even though the robot interpreted them to be disconnected. In order to fix this, Karthik recommended that the mechanical team should replace the entire USB hub to prevent future disconnections and ensure that the robot will not disconnect randomly during a match. After replacing the USB hub, the connection errors were solved and the robot was able to continue running as normal.

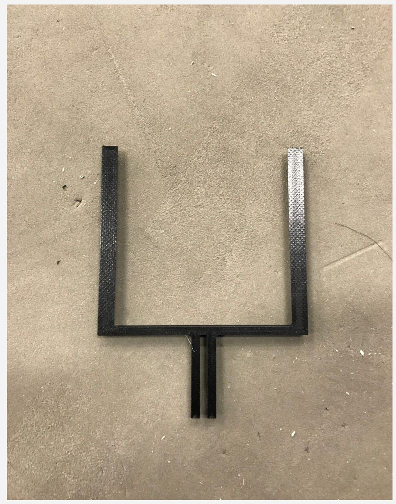
Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

SCORING CAPSTONE

CONSTRUCT & TEST A PROTOTYPE: REDESIGNED CAPSTONE

Jonas created new designs for the capstone in order to make it easier to manipulate and place on the tower during Endgame. By using smaller and flatter designs, the capstone will save space when loaded onto our robot and be easier to move around. The designs shown below will use zip ties to connect the parts to be placed on top of the stones. Since the space between the sides of the capstones is so wide, it will be easy to place the capstone on the top of the tower.





Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

SCORING STONES

TWEAK & EVALUATE: AUTONOMOUS SERVOS

Due to the high torque that the servos have to handle with autonomous code, the internal gearing of the servos broke under stress. This required a lengthy mechanical fix that involved removing the autonomous arms from the robot and detaching the servos from the mount as well. To fix this problem at this point in the design process, the mechanical team had to replace the servos for the autonomous arms completely, since the internal gearing of the servos was unsalvageable.

The mechanical team realized that the best way to fix this problem is to use servo blocks to prevent too much torque from being applied to the servos. This will save the internal gearing of the servos and remove the need to replace servos throughout the season. Since the servos have already been damaged in this season, using servo blocks is not an option for the mechanical team at this point. However, we will keep this solution in mind as the mechanical team progresses through the years to save time, effort, and materials in future seasons.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

AUTONOMOUS

TWEAK & EVALUATE: SKYSTONE MOVEMENT

Patrick tweaked the program for autonomous Skystone detection. The programming team encountered some difficulties while trying to get exact positioning of the robot to place the Skystones on the foundation. One of these problems was over-strafing the robot when returning to the quarry to pick up the second Skystone. At the same time, the robot constantly missed the second Skystone after dropping off the first Skystone. In order to fix this, Patrick made a series of edits to the autonomous code that made changes to the robot movement. With these code edits, the robot started to intake and deliver both Skystones during the autonomous period (although it was inconsistent at this point).

To test this autonomous code, we set up the Skystones in each of the three possible locations in the randomizing period. Based off of these cases, we were able to make more edits and debug the code so the autonomous program will remain consistent in every possible case. We did not have the foundations during this meeting, so we utilized available resources and created a foundation substitute using tape on the field.

NON-TECHNICAL DISCUSSION

- **Helen updated the February notebook entries.**

Although the team is generally more consistent with updating the notebook after each meeting, the large number of outreaches that we had this month caused some disorganization with the notebook as parts of the team would work on the outreach instead of adding to the notebook.

MEETING SUMMARY

- Fix USB hub connection issues
- Tweak autonomous code
- Update old notebook entries

SATURDAY, FEBRUARY 29, 2020 MEETING

DATE & TIME: 02/29/20 | 9:00 AM - 3:00 PM

STUDENTS: Clare, Helen, Patrick, Bryan, Karthik, Jonas, Rohan

MENTORS: Arnav, Andrew

AGENDA
Code the Red Side Autonomous
Make Final Mechanical and Programming Tweaks
Finish Organizing Notebook
Drive Practice
Judging Practice
Pack for Maryland States

TIMELINE REVIEW

March 1	Maryland State Championship
March 14	Delaware State Championship
March 20	Maker Madness Outreach (DCM)

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: RESTRING LIFT

After constantly tying and untying the string of the vertical lift, it started to fray and weaken. We wanted to ensure that the string would not break at the competition, so Patrick and Bryan brought the robot home in order to restring it.

Although this is a fairly simple concept, running a string through our many stages is still quite a lengthy process. We did come up with a novel idea to zip tie the knot on the pulley end for faster maintenance. This has cut our string maintenance time in half.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	**Develop a Solution**	Construct & Test a Prototype	**Fabricate and Integrate**	Tweak & Evaluate

AUTONOMOUS

DEVELOP A SOLUTION: MOVEMENT ALGORITHM

In order to have more comprehensive code, we restructured our movement function to accept a direction object, and three magnitudes that are dependant on the location of the skystone. When first implemented, the robot moved slower than it did with the previous method.

Because it was slower, this messed up the already written blue autonomous as well as glitching the PID in some instances. After a lot of debugging, we saw that there were errors in our conditional statements, causing the robot to slow down when the old method was passed through the new method.

FABRICATE AND INTEGRATE: RED AUTONOMOUS

Because we already had blue autonomous written, the red autonomous will already be somewhat correct after some minor changes. Because the autonomous is mirrored, our turns need to be flipped 180 degrees and our left strafes need to be converted into right strafes. Also, the “left skystone case” is now the 4th skystone position instead of the 6th, so the left and right skystone cases need to be swapped.

Another thing that needed to change was our computer vision algorithm. Because our camera is not centered on the robot, and the skystone positions are mirrored, the cropping of the camera needs to be different. In order to set this up for two different op modes, we need to create a config class to make a different crop for each skystone. By analyzing pixel data given back from the camera, we were able to make the correct crop for the red auton.

The aforementioned movement algorithm was not working, causing the progress for red autonomous to be significantly slowed down. We were not able to test it again after fixing the movement algorithm, so our red side autonomous will be fairly inaccurate.

NON-TECHNICAL DISCUSSION

- **Patrick, Clare, and Helen worked on organizing the notebook.**

To prepare for the Maryland State Competition tomorrow, we wrote new entries for the social media activities from this season. In addition, we caught up each of the notebook sections and added page numbers to have a complete notebook.

- **The judging team made final tweaks to the presentation.**

We practiced the judging presentation for the last time before the Maryland State Championship tomorrow and practiced answering judge questions as well.

- **The drive team practiced playing the game.**

MEETING SUMMARY

- Drive and judging practice
- Finish notebook
- Make autonomous and mechanical fixes
- Pack for Maryland competition

TUESDAY, MARCH 3, 2020 MEETING

DATE & TIME: 03/03/20 | 6:00 PM - 8:30 PM

STUDENTS: Patrick, Bryan, Ian, Isha, Rohan, Clare

MENTORS:

AGENDA
Reflect on MD States competition
Set goals for March 14 - DE States
Timeline - programming plan to fix disconnect issues, schedule extra meetings if possible
Set plans for judging practice

TIMELINE REVIEW

Today: Programming	Fix connection issues, plan for autonomous fixes
Friday 3/13	Drive practice meeting, judging

3D Printing

- Ian showed Byran the 365 numbers with the platforms that he made on Saturday the 22 of February to see what he thought of it.
  - He liked it but he suggested taking off the platforms on the support or attachment beam because he did not know if the where screw head in those places on the plate the numbers would go on.
- Ian made these changes and then put the object into the PrusaSlicer Slicing software
- The settings he used for this print are:
  - Layer height. 0.20 mms
  - Parameters: 3
  - Infill: 20%
  - Top and Bottom solid layers: 5
  - Supports: On
- Then, he turned the object with the setting into a .gcode file and then turned on the 3D printer and set the extruder and heat bed to Petg temperatures.

- Then, the 3D printer mesh bed level and then started printing the team numbers for putting on the robot.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	**Construct & Test a Prototype**	Fabricate and Integrate	Tweak & Evaluate

CONNECTION ISSUES

DESIGN PROCESS STEP: SUBTITLE

We were very disappointed because of the connection issues of the robot in the Maryland Championship. This was a high priority item because we will not be able to score points if our robot does not run.
One team at Maryland States told us to use powered USB Hubs; they claimed to be having a similar problem until they used an external battery to power their camera.

Through testing with the REV Ultra Hubs, which draw power from the 12V REV Battery, we found that this may be the solution. We plan to integrate these into our electronics the next meeting.

We were also able to prevent initialization problems by using OpenCV to take pictures instead of Vuforia. Furthermore, we added an exception so that the opMode would not time out during initialization, which would cause the robot to restart and delay our start.

NON-TECHNICAL DISCUSSION

- **We planned for the Delaware State Championship.**

The Delaware State Championship is on March 14, which is only a couple of weeks away. With this in mind, we created a new set of priorities for us to focus on in the next 2 weeks. This list is shown below:

- Replace USB hub
- Create red side autonomous program
- Judging practice

- **The judging team made presentation editing plans.**

At the Maryland State Championship, our judging presentation went over the 5 minute time limit, which condensed the amount of time the judges had to ask us questions. We decided to shorten the prepared portion of our judging presentation so the judges will have more time to ask us questions about topics that they want to hear more about.

MEETING SUMMARY

- Fix connection issues
- 3D print new team numbers
- Set new goals

SATURDAY, MARCH 7, 2020 MEETING

DATE & TIME: 03/07/20 | 9:00 AM - 2:30 PM

STUDENTS: Ian, Paige, Connor, Helen, Rohan, Marcus, Karthik, Aidan, Suraj, Bryan, Patrick

MENTORS: Andrew, Mr. Prettyman, Arnav, Zach

AGENDA
Replace USB hub
Drive Practice
Autonomous Tweaks

TIMELINE REVIEW

Friday 3/13	Drive practice meeting, judging
Saturday 3/14	Delaware State Championship
Friday 3/20?	DCM Maker Madness Outreach

MECHANICAL ACCOMPLISHMENTS

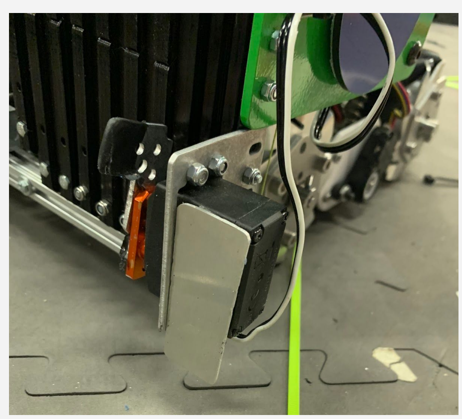
Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

MOVING FOUNDATION

TWEAK & EVALUATE: METAL SERVO MOUNTS

During drive practice, one of the foundation servo mounts snapped off. We replaced both mounts with a metal servo bracket. Also, we added metal guard rails so that our servo would not get caught on the foundation when moving.

We hope that these add-ons will increase the durability of our foundation servos.

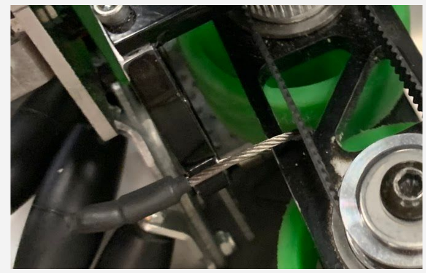


Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

DELIVERING STONES

TWEAK & EVALUATE: GALVANIZED AIRCRAFT CABLE STOPPER

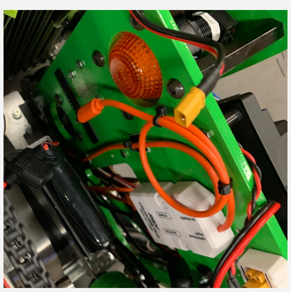
Whenever our intake hits a wall at a high speed, the zip tie that acts as a hard stop snaps. This is because of the high tension under a short time that the zip tie is experiencing. This is not good because losing one zip-tie decreases the our intake efficiency by a lot, and losing both zipties makes the intake almost unusable. To eliminate this issue, we remade the hard stop using aircraft cable. This material is EXTREMELY durable. We tied it together by crimping them and then shrink wrapping them for added safety.



Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ELECTRONICS

TWEAK & EVALUATE: CONNECTION ISSUES



To fix our connection issues, we decided to implement the REV Ultra Hubs. We 3M-taped them to both sides of our side panels and rewired our expansion hub, cameras, and phone to this ultrahub.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

DELIVERING STONES

TWEAK & EVALUATE: GALVANIZED AIRCRAFT CABLE STOPPER

We redesigned the team number using a 3D print for a more aesthetic design. More detail about the print below.

3D Printing

- The print with the 2 team numbers with platforms on the back came out really well.
- Bryan and Ian put them on the robot number plates with tape and the one for the left side plate stuck well bet the one for the right side plate did not because the screws are in different places for the platforms to go around or mirrored.
- For one of the side plates, the screws are mirrored to the other plate, so the platforms on the back had to be changed.
    - Bryan gave Ian a newly drawn diagram for him to change the locations of the platform on the back of the numbers.
- Ian CADed the changes the platforms to the new locations on the back of the numbers so it can fit on the plate on the robot with the screws.
- He then put the new team number object with a platform into PrusaSlicer and kept the setting like the other team number with platforms object 3D printed the Tuesday the 3rd meeting, which were:
    - Layer height. 0.20 mm
    - Parameters: 3
    - Infill: 20%
    - Top and Bottom solid layers: 5
    - Supports: On
- Then, he turned the model with the slicer settings into a .gcode file.
- He got the 3D printer ready by turning it on and then setting the 3D printer's extruder and heated bed to petg temperatures and let it heat them up to these temperatures
- Then, Ian started the print on the print and then the 3D printer did a mesh bed leveling calibration to level the bed digitally.
- After that, the printer started to print the team number print.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

AUTONOMOUS

TWEAK & EVALUATE: RED SIDE AUTONOMOUS

After running through the blue side autonomous program multiple times, the programming team was able to ensure that the autonomous code worked reliably and consistently. The blue side autonomous program detects and delivers the two Skystones and parks underneath the Skybridge.

Although most of the code between blue and red remains the same, the programming team faced some problems with the camera. Since the webcam on the robot is off-center, the image that is taken and cropped during autonomous to find the locations of the Skystones is also off. In order to fix this, the programming team looked at the blue side autonomous code and changed the cropping area of the image taken by the webcam. This proved to be effective and resolved the issues that arose with mirroring the autonomous code to the red side.

We know that the left and right strafing might not be exactly the same, so we will continue to test the red side autonomous and tweak the values in order to get correct measurements.

NON-TECHNICAL DISCUSSION

- **Paige and Helen made more buttons.**
- **Patrick and Bryan taught Suraj the basics of driving.**

Since Jonas, the secondary driver on the drive team, was not at today's meeting, Patrick needed another person to test drive the robot with. This was beneficial as we need new drive team members for future seasons with the graduating seniors.

- **The drive team ran several practice matches.**

After the programming team tested the autonomous code, the drive team ran several individual matches in order to obtain an estimate of our point-scoring range. Since the drive team had to teach Suraj how to drive as the secondary driver, our point-scoring capability did not reach its full potential. In these practice matches, our total game scores ranged from 39 to 68 points.

- **Helen looked at team banners.**

At the Maryland State Championship, Helen noticed that some of the teams used large banners on stands in their pit display to present information about their robot, team, and outreach program. The marketing team decided that this is an effective way of giving passerbys information about our team, so Helen looked into the possibility of printing our own team banners.

- **We created a new schedule for the next week.**

In order to meet all of our priorities for the Delaware State Championship,

Sunday March 8	1 - 5	Full match run-throughs: autonomous/drive practice
Tuesday March 10	3 - 8:30	Autonomous tweaks, judging practice
Wednesday March 11	6 - 8:30	Packing, judging practice, print notebook

MEETING SUMMARY

- Tweak autonomous
- Replace USB hubs
- Drive practice
- Tweaks to foundation grabber and intake

SUNDAY, MARCH 8, 2020 [EXTRA] MEETING

DATE & TIME: 03/08/20 | 1:00 PM - 5:00 PM

STUDENTS: Bryan, Patrick, Karthik, Jonas

MENTORS:

AGENDA
Program Red Side Autonomous
Drive Practice

TIMELINE REVIEW

Friday 3/13	Drive practice meeting, judging
Saturday 3/14	Delaware State Championship
Friday 3/20	DCM Maker Madness Outreach

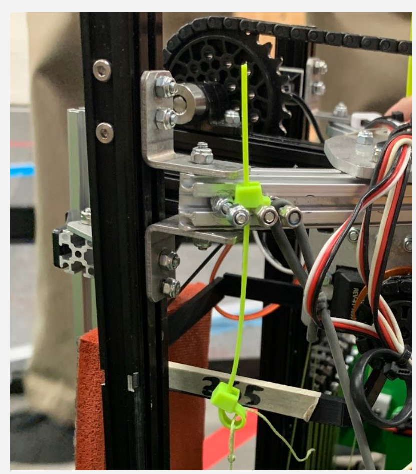
MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: STRING TENSION

Many of the teams with fast lifts told us that they do not use springs to tension their lift. Instead, their string is already very tight. This idea sounds appealing because it may solve our problem of the string hopping off pulleys. Instead of tying the string very tightly, we used a zip tie in order to tune the tension of the string.



We are worried of the slight possibility that the zip tie may snap due to major tension, but we will run the lift during drive practice and evaluate its performance:

We saw that the lift ran a lot smoother when using the fine controls. This is most likely due to the high tension.

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ASSISTED TELEOP

TWEAK & EVALUATE: VOLTAGE DROP FIX

Through drive practice we saw a major issue: the grabber servo was not working when the lift was very low. Through testing, we saw that if the PID set the lift position to below zero, it would draw too much voltage, causing weird behavior with servos. It causes our grabber to not close all the way, and it sometimes also randomly activates the payload servo.

To fix this, we added a conditional statement that the lift will slow down if the position is below 0. This way, the lift does not draw too much voltage when trying to close. This has fixed our problem so far.

TWEAK & EVALUATE: UPDATED DRIVING CONTROLS

One problem with moving the foundation is that the driver cannot move backwards and turn at the same time. This is because it causes one of the foundation servos to slip from the foundation and leaves the second servo to handle the rest of the load. We saw that turning independently from moving backwards does not cause this issue. To prevent the driver from moving backwards and turn, we limit the forwards power to always be above 0 when the turning power is above .1 and when the foundation grabbers are down. We saw that the foundation grabbers no longer slip after this fix.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ASSISTED TELEOP

TWEAK & EVALUATE: VOLTAGE DROP FIX

We spent the last half of the meeting tweaking the values for the red side autonomous. We wanted to do one skystone case at a time, so we started with the right case.

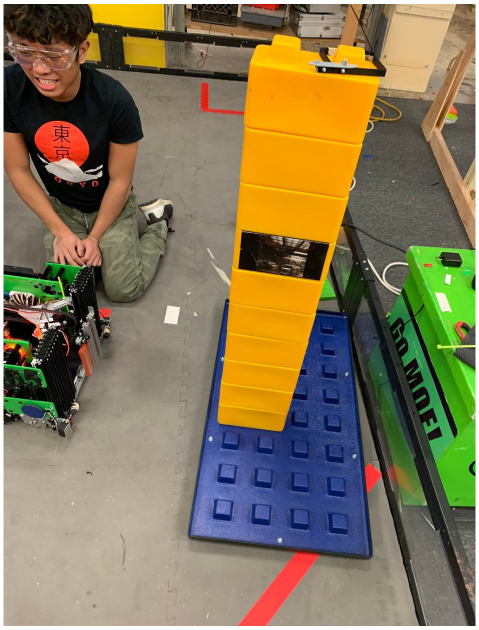
By the end of the meeting, the right case consistently got two skystones. We hope to finish up with the middle case and left case in the next two meetings.

NON-TECHNICAL DISCUSSION

- We conducted some drive practice at this meeting:
    - We practiced our communication and cohesiveness as a drive team
    - We found ways to implement programming to improve our performance
    - We saw that our mechanisms are very robust and can run under long periods of time.

MEETING SUMMARY

- Drive Practice
- Assisted Teleop
- Red Autonomous Programming
- Lift Tension Tweak



TUESDAY, MARCH 10, 2020 [EXTENDED] MEETING

DATE & TIME: 03/10/20 | 4:00 PM - 8:30 PM

STUDENTS: Bryan, Patrick, Karthik, Connor, Rohan, Jonas, Helen, Ian, Paige, Claire, Aidan

MENTORS: Andrew, Arnav, Mr. Prettyman

AGENDA
Judging Practice
Drive Practice
Red Autonomous
Start Packing

TIMELINE REVIEW

Friday 3/13	Drive practice meeting, judging
Saturday 3/14	Delaware State Championship
Friday 3/20	DCM Maker Madness Outreach

PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

AUTONOMOUS

TWEAK & EVALUATE: RED SIDE AUTONOMOUS

We met early in order to get more autonomous done. We were able to tweak the left-case enough to get a reliable 2 skystone and park autonomous, and we started to do the middle case.
One fix that we added was that the skystone kept hitting the skybridge. We noticed the left autonomous arm was mounted higher than the right autonomous arm, causing the stone to hit the bridge when doing red-side autonomous.

To fix this, we did not raise the arm as high after grabbing it. This seemed to fix our problem

When running middle case, we saw that the auton arm stopped grabbing very well. One time, one of the claw ends got bent upwards and then it hit the skybridge. This tore the pinion off of the servo. We are meeting tomorrow to fix this problem and then keep working on autonomous.

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ASSISTED TELE-OP

TWEAK & EVALUATE: ASSISTED TELE-OP

We saw that in many of our matches, stones get pushed away if we do not line up with the stone in a certain way. We wanted to see how to mitigate this problem so we tested how drive speed and intake speed affect the intake of the stone. We saw that at slow intake and drive speeds, the stone consistently went inside the robot, but at the expense of not completely transitioning to the grabber consistently. We saw that we definitely wanted to keep running the intake at high speeds, but slow down the movement of the robot. We did not want to add an additional slow down when intaking because this will make the slow controls even slower. Instead, we opted to disable the fast mode when intaking. This way we can efficiently travel from our building zone to the depot and slow down when we intake the stone.

NON-TECHNICAL DISCUSSION

- **The judging team made final tweaks to the judging presentation.**

In order to prepare for the Delaware State Championship, our judging team ran through the judging presentation a couple of times and received last pieces of feedback from our mentors and member parents. This version of the judging presentation is shorter than the previous versions, as we realized that we were going over the presentation time limit. We also practiced answering judge questions.

- **The team started packing for the Delaware State Championship.**
- **Members not in the drive team prepared for pit judging.**

Since many head members of the subteams are also on the drive team, we practiced answering questions that could come up during pit judging. This was beneficial as it allowed us to teach new members how to answer judging questions.

- **The drive team practiced running matches.**

This helped the drive team prepare for the competition and practice driving. We were able to refine and practice our game strategy for the most efficient match runs.

MEETING SUMMARY

- Drive and judging practice
- Red side autonomous

SUNDAY, MARCH 8, 2020 [EXTRA] MEETING

DATE & TIME: 03/08/20 | 1:00 PM - 5:00 PM

STUDENTS: Bryan, Patrick, Karthik, Jonas

MENTORS:

AGENDA
Program Red Side Autonomous
Drive Practice

TIMELINE REVIEW

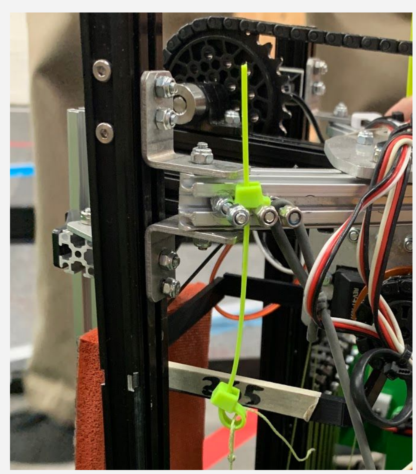
Friday 3/13	Drive practice meeting, judging
Saturday 3/14	Delaware State Championship
Friday 3/20	DCM Maker Madness Outreach

MECHANICAL ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

STACKING STONES

TWEAK & EVALUATE: STRING TENSION



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PROGRAMMING ACCOMPLISHMENTS

Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ASSISTED TELEOP

TWEAK & EVALUATE: VOLTAGE DROP FIX

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Define Problem	Generate Concepts	Develop a Solution	Construct & Test a Prototype	Fabricate and Integrate	**Tweak & Evaluate**

ASSISTED TELEOP

TWEAK & EVALUATE: VOLTAGE DROP FIX

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MEETING SUMMARY

- Drive Practice
- Assisted Teleop
- Red Autonomous Programming
- Lift Tension Tweak