Team #6417

Ultimate Goal | 2020-2021

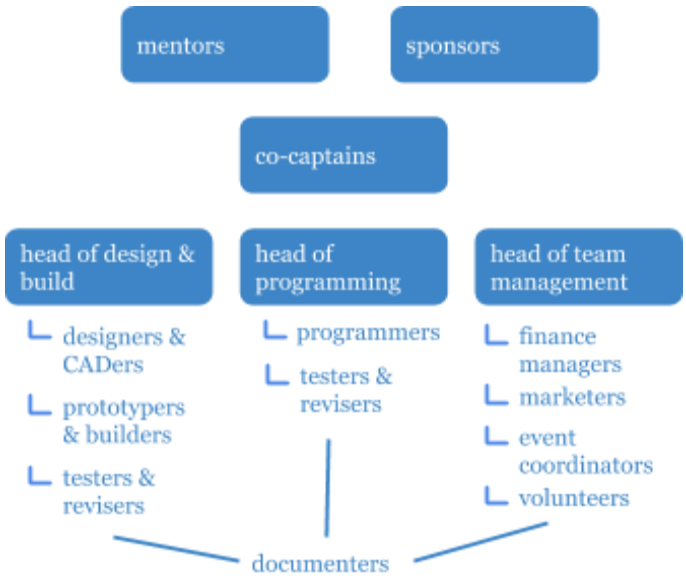
Engineering Portfolio

About the Blu Cru

The Blu Cru is part of the **Explorer Post 1010 organization**, based in **Rockville, Maryland** and founded by our mentor, Bob. Explorer Post 1010 is dedicated to offering students exciting hands-on opportunities to learn about engineering and STEM.

The Blu Cru made its debut in the FIRST Tech Challenge in 2012. The team has returned every year since, advancing to the state level of competition in almost all of its past seasons.

Why "Blu Cru"?
Gratitude and teamwork. We wear "blu" as a show of thanks to our sponsors, the Explorer Post 1010 & IBM. We embody our value of teamwork in every activity that our "cru" does together, working together respectfully and inclusively to achieve our goals.



Team Structure

To keep our team running efficiently every season, we elect a captain or two co-captains, a head of design & build, a head of programming, and a head of team management to oversee all sub-crus' activities and events. During the season, we divide into "sub-crus" to increase efficiency. Our main sub-crus are each focused on programming, building, and team management.

Team Relationships

Community: Our outreach is primarily focused on reaching out to the youth in the community because we want to inspire the next generation of FIRST, and future STEM workers and leaders. Over the seasons, we have also become heavily involved with the local libraries, hosting robot demonstrations and tutorials.

Other FIRST Teams: The Blu Cru embodies the spirit of coopertition as we interact with other teams. Our relationships with other teams are friendly rivalries, but off-the-gameboard-alliances first.

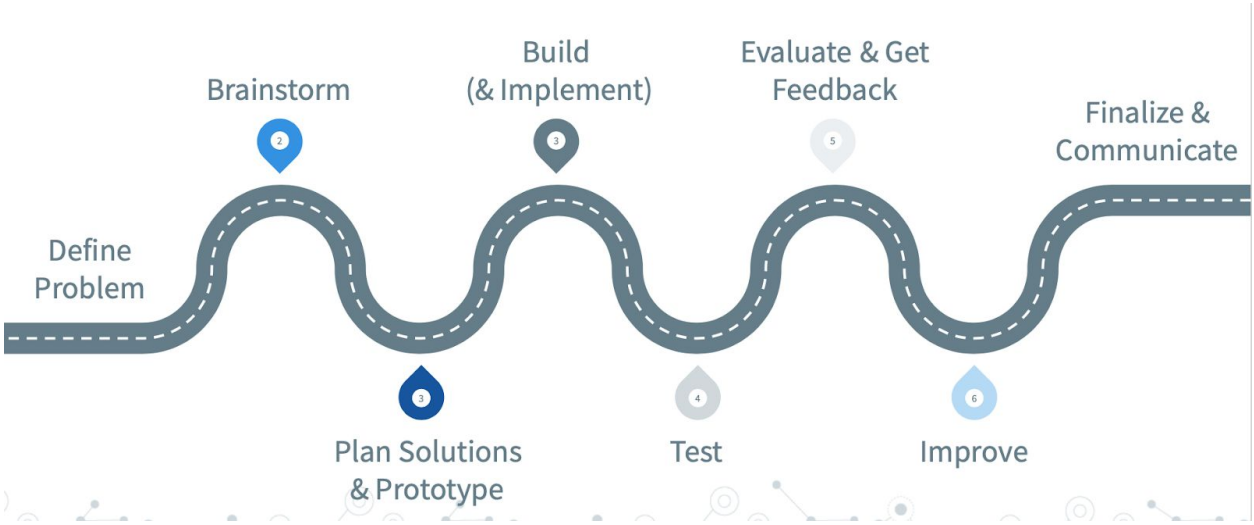
Sponsors: We are sponsored through the umbrella organization of the Explorer Post 1010 by the Rockville Science Center and IBM.
This year, we have maintained a strong relationship with our sponsors, but in a distanced setting. We keep our sponsors aware of our activities to maintain a personal connection with the organizations.

Above all, we are a united Cru. We come together to make important, group-scale decisions, like when we decide on autonomous strategy and group objectives. This season we've also decided that documentation should be done by the whole team not just individuals, because we believe that if everyone is involved, it will keep everyone informed of group activities and achievements.

Engineering Section

Engineering Design Process

Though it will be outlined in a chronological format, our engineering design process is anything but linear:



The step of the design process our Cru wants to pay special attention to this year is "plan solutions". With a condensed meeting schedule and fewer funds for parts than usual, we want to enter each meeting with clear objectives in mind. We plan to avoid mistakes on the robot by meticulously analyzing and CADing design solutions before we begin to build and implement them. We also aim to devote time to getting feedback from our mentors, who can offer valuable advice and insight on our robot.

Game Strategy

We chose which point-scoring activities to pursue based on a combination of our own capabilities and limitations:

- Experience level of team members
- Point values
- Available materials
- Feasibility (for first competition)
- Stricter time constraints
- Stricter in-person meeting protocols
- Strong alliance team choice (performing unique functions)

Below details our analysis of the points and our justifications for why or why not we don't plan to pursue them at competition. Point-scoring functions we're pursuing are indicated with a "✓" and those we're not with a "✗ ".

Activity	Points	Justification
Autonomous		
✓Deliver wobble to target zone	15	We combined this task with the task of transporting the wobble out of the field into one mechanism—an arm. This way, we were able to maximize our time and points.
✓Shoot rings into tower goal ✗Low ✓Middle ✗High	12 each	We aim to shoot two rings into the middle goal (for certain autonomous situations). The only thing that changes for each of the goals is the power that the ring needs to be shot at, which is easy to measure. Since the targets are roughly the same height as the middle goal, but shooting them earns significantly more points, we decided to build our non-adjustable ramp to aim for the middle goal and the target goals. Then, we can ensure more accuracy because the goal is larger. Since we can pre-load rings, this is not a majorly time-consuming activity for autonomous.
✓Park on white line	5	This is an easy way to score an extra 5 points, which can make a big difference when competing against evenly-matched teams.
✓ Knock down targets	15 each	Since we were able to stay on schedule, we had enough time to fine-tune autonomous to be able to knock down the targets. In some versions of autonomous, we shoot down two rings.
Driver-Controlled		
Shoot rings into tower goal ✗ Low ✓ Mid ✗ High	6 each	This is the only way to score points during tele-op. We knew we needed to build a mechanism to shoot rings, since in order to be a competitive team, we knew we'd need to at least score in the mid-high range. Since the area difference from the middle versus high goal is a factor of 2, we designed our robot to shoot into the middle goal so that we could ensure accuracy and consistency with the larger target.
End Game		
✓Deliver wobble to drop zone	20	This is the highest single point-scoring activity, so we wanted to pursue it. We use the arm from autonomous to accomplish this, saving time and materials by using one system to accomplish both.
✗ Deliver wobble to starting line	5	We prioritized delivering the wobble to the drop zone over this, since its 4x as many points.
✗ Wobble fully support ring	5 each	We decided this isn't feasible, as it requires a time-consuming amount of precision that's not worth pursuing for 5 points each in a short 30-second time period.
✓ Knock down targets	15 each	We aim to shoot down 2, as we have enough time during this period to try to aim before we deliver the wobble. Our drivers will be able to practice learning how to aim at the target, and we actually found a way to get consistent results by lining up our robot with the side wall.

Robot Design Evolution — Major Changes

Chassis

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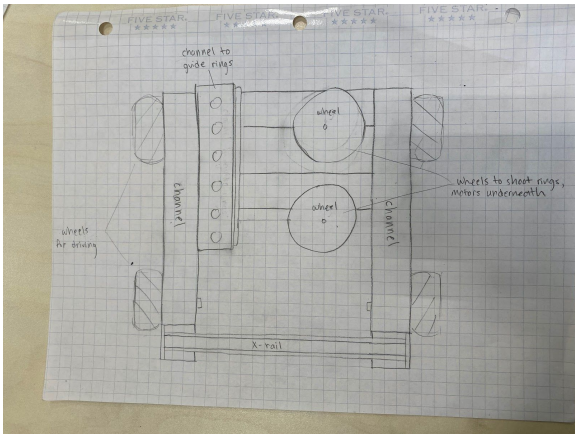

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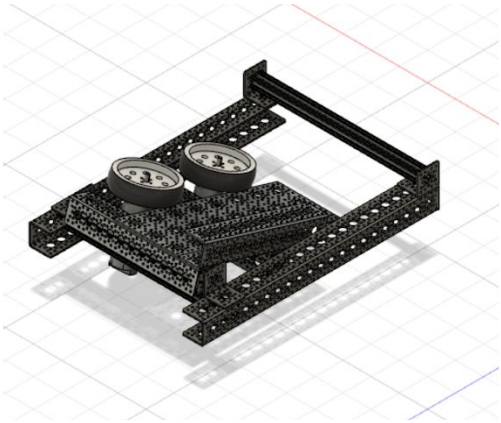

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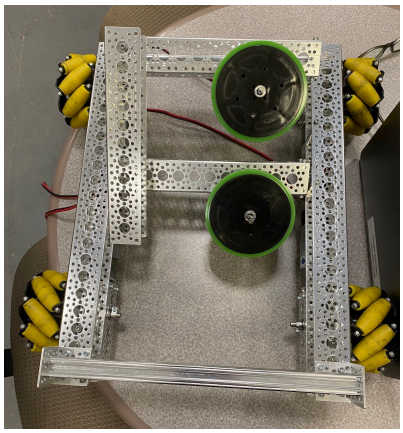

Our chassis has a higher center of mass than normal, which we chose to do to assist in launching rings to the higher goals. We used CAD to ensure that the appropriate launching angle we calculated was compatible with Actobotics parts. We have since attached more x-rails across the body of the chassis for support, as our chassis is very open. At the beginning, we planned on having the motors perpendicular to the Mecanum wheels, not needing bevel gears, but that would take up too much room within the chassis.

Intake and Launching

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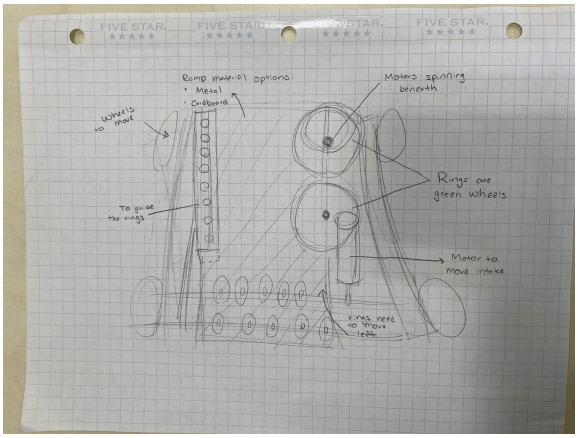

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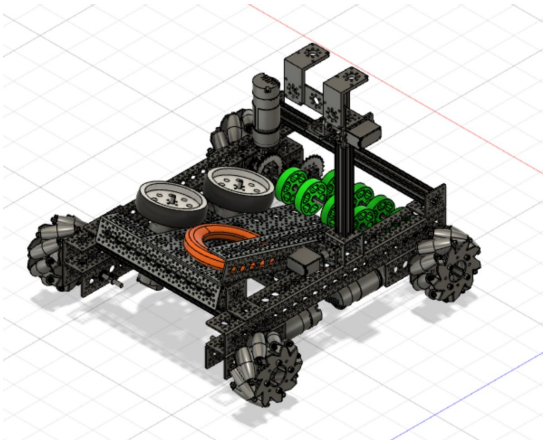
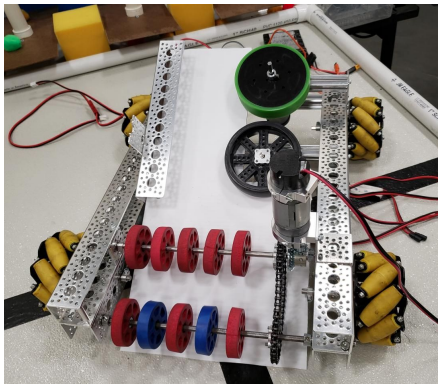
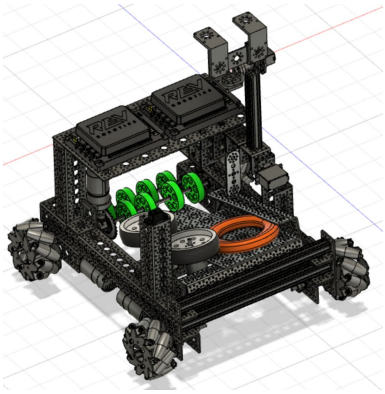
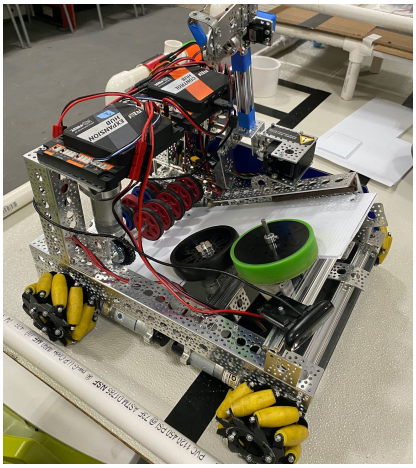
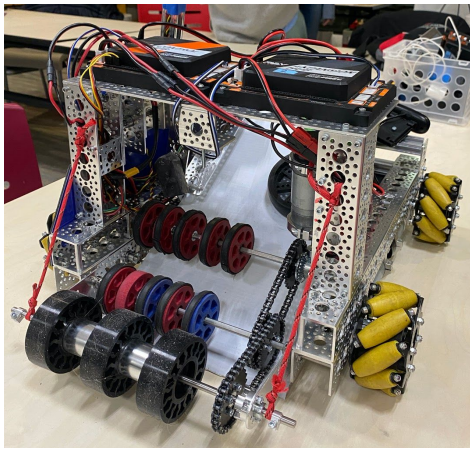


3. 

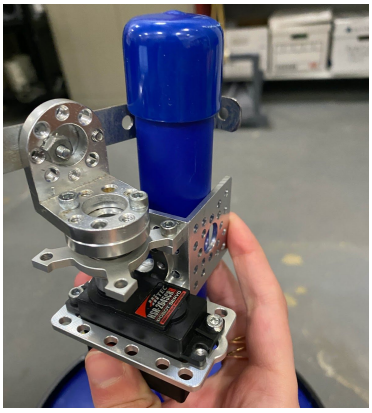
4. 

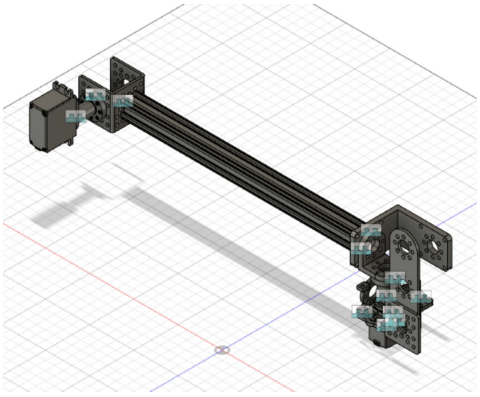
5. 

6. 

In our original plan, we planned on having 2 parallel sets of intake wheels and a conveyor belt that would bring the rings up to the shooter. As time went on we realized having a conveyor belt was unnecessarily complicated if we chose a low-friction ramp material instead, and would just be a waste of space, materials, and money. We settled on just having 2 sets of intake wheels, but after extensive testing found those could not reliably intake the rings. To counter this we added high-friction insulator strips to the wheels and a 3rd set of bigger wheels with more grip. This set can fold upwards so we are still within the size restrictions.

Robot Arm

1. 

2. 

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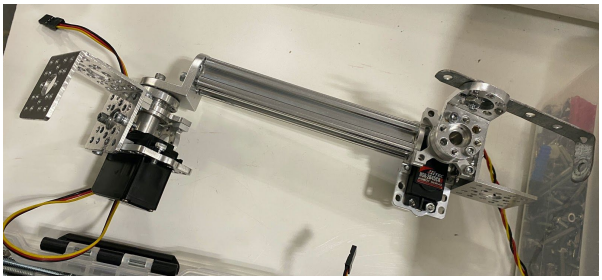

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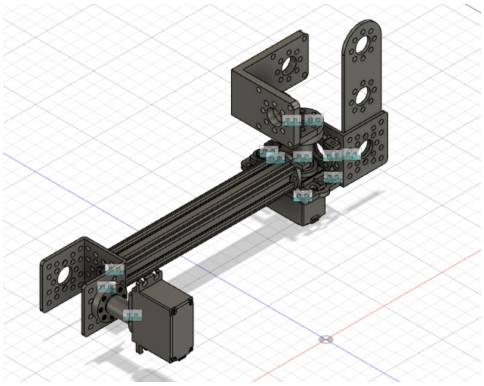

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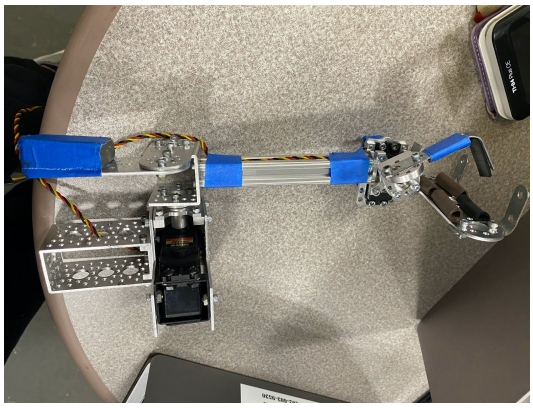


Originally we were planning on not having an arm. Our strategy was to just push the wobble goals into the zones in autonomous, without trying to lift the wobble goals over in endgame. Then, we decided to add an arm so we could get the wobble goals over the walls in the endgame. Our first prototype for the arm could not lift up the wobble goal at all. Adding rubber bands helped a little, allowing us to slightly lift the wobble goal off the ground, but it was still nowhere near high enough. We then shortened the arm, replaced the rubber bands with a weight, and replaced the arm servo with a bigger, more powerful one. This allowed us to lift the wobble goal high enough to drop over the wall.

Science & Mathematics

Overview

In science and math, the team has worked together to compile a collection of different applications of math and physics that was used in building our robot. These calculations ranged from using a video of our robot to use in a program to give us the speed of our robot, to manually calculating torque exerted when handling the wobble goal, to the projectile motion calculation you will see shortly. The team used a mix of prototyping and testing through science and math, to finalize our robot design.

Science & Math Extract

Projectile Motion (of the Rings)
Purpose: Not only is projectile motion relevant in terms of physics and kinematic motion, but by knowing the projectile motion of the rings we know the maximum height the rings can reach, how far they shoot, and how long it takes until the rings reach the ground. We can use this to determine how far away the robot should be positioned to score a goal.

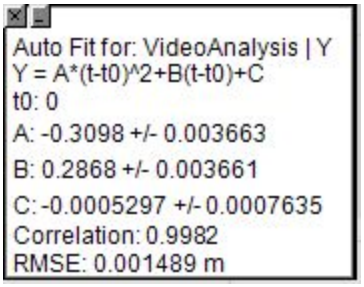
Calculations:

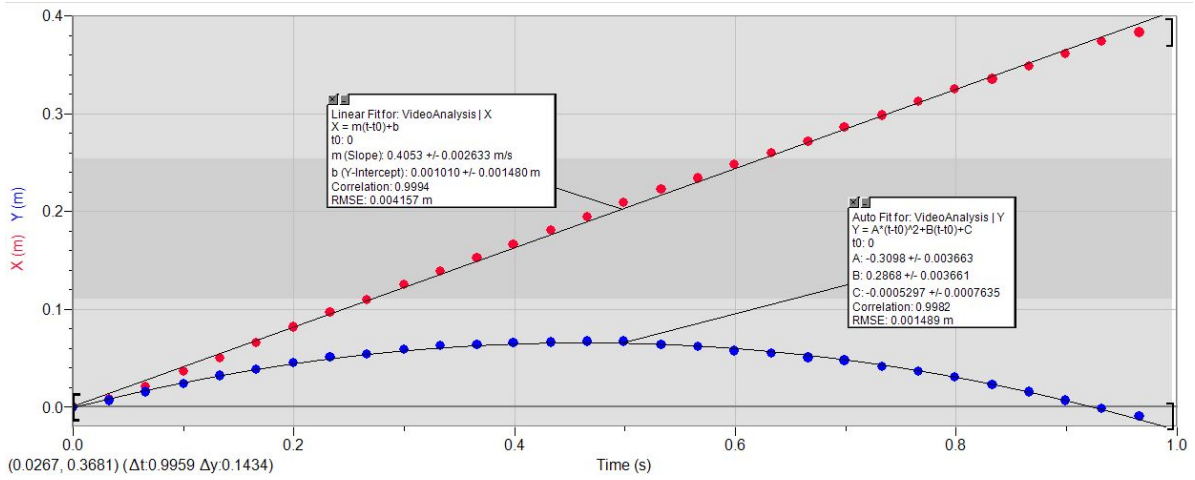
$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$$

$$v_x^2 = {v_{x0}}^2 + 2a_x (x - x_0)$$

v_x= final velocity
v_{xo}=initial velocity
a_x=linear acceleration
t=time

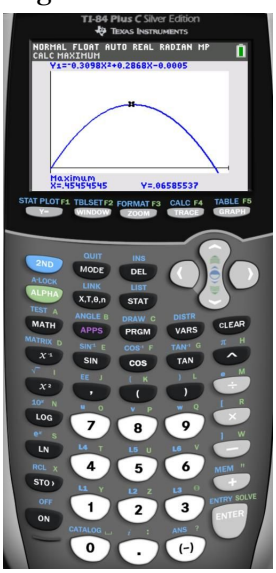


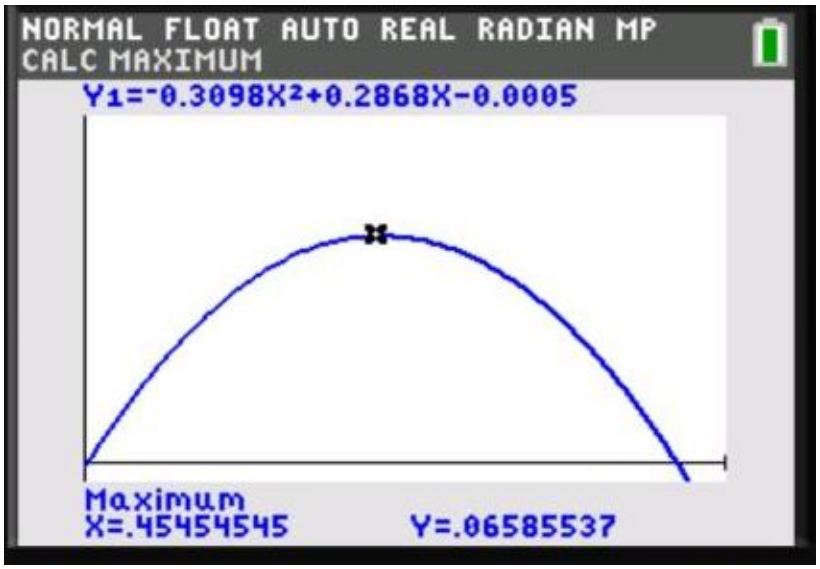


According to the video analysis using logger pro, the projectile motion of the rings being shot

from the robot could be represented by the equation(in the y-direction) $y=-0.3098x^2+0.2868x-0.00005$.

While this equation is useful and interesting, we can use this measurement to find the maximum height and what distance we want to shoot from to reach the maximum height the ring can reach.





Based off of this graph, the team can tell that the maximum height that the robot can shoot the projectile is 0.06 meters (not including the starting height it is at from after being fed through the intake system). Assuming we want to shoot at the maximum height, we should launch approximately 0.45 meters from the target.

Coding & Autonomous

Overview

We program our robot using Java in Android Studio. The three main modules in our robot's code are the **Hardware Map** which connects software to hardware based on the Control Hub's wiring, the **OpMode** which assigns inputs from the drivers' gamepads to actions on the robot, and the **Autonomous** segment which navigates the field to complete tasks without human input.

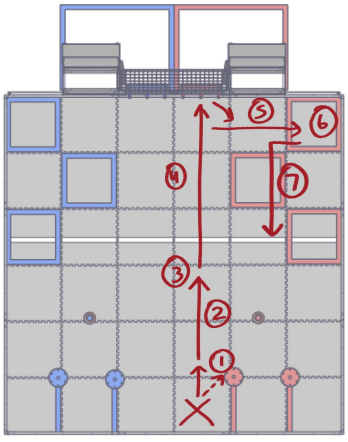
Sensing

The three main sensing techniques we use are:

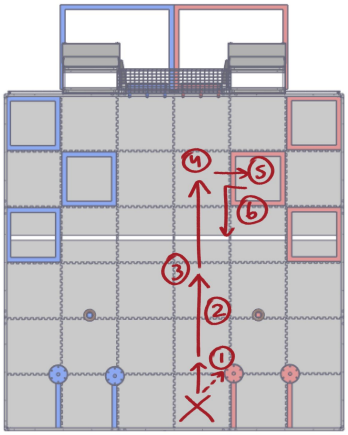
- **Encoders:** Sensing devices that detect the status of a motor based on electrical pulses. We can convert these pulses into revolutions of the wheel for our robot to travel specific distances on our field.
- **Inertial Measurement Unit (IMU):** An internal gyroscope built into the robot's Control Hubs. We use the IMU to detect the current orientation of the robot and rotate specific distances.
- **TensorFlow Object Detection:** A machine learning library that uses a pre-trained image recognition model to recognize objects through the webcam. We use this library to detect the number of rings on the field to determine which target zone to drop the wobble goal.

Autonomous Program Diagrams

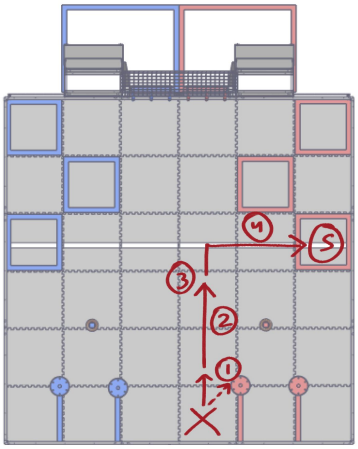
4 rings detected



1 ring detected



0 rings detected



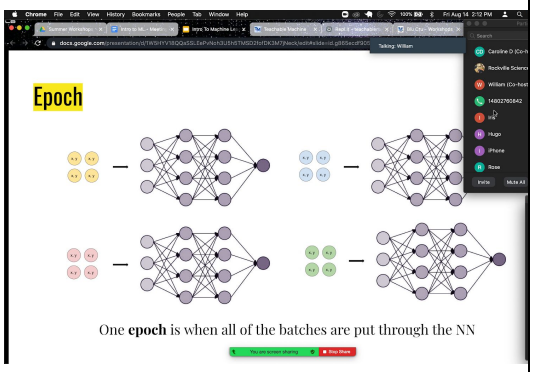
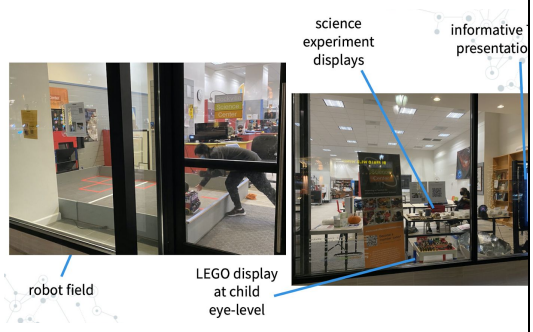
Autonomous Objectives:

Determine no. rings on field using TensorFlow
Shoot rings and knock down at least one Power Shot Target (+15)
Deposit 1 Wobble Goal into correct target zone (+15)
Park on white line (+5)

Business & Sustainability

Business & Sustainability Goals & Actions

Goal	Action(s)	Notes
Build sense of comradery	• We have engaged in remote meetings over Discord, which has helped us increase the frequency of our meetings. • We developed a game to play using this year's theme where we try to toss rings onto the wobble goals—it's a source of competitive fun for the team!	
Keep all team members updated and aware of responsibilities	• We have held regularly-scheduled business meetings for every member of our team to check in on the Cru's progress as a whole and the individual sub-crus. • We have used our Discord server as a way to recap each meeting at its conclusion for those who weren't there. Absent members also check our notebook for a more detailed account of what happened at each meeting.	This is an ongoing goal which is the responsibility of every team member. The co-captains are responsible for briefing the Explorer Post on the progress of our team. The head of team management is responsible for keeping everyone aware of upcoming business meetings and business-related deadlines.
Organize at least 2 online outreach events	• We hosted a series of Python programming workshops for beginners. Through the Rockville Science Center online seminar platform, we engaged over 50 attendees in how to	The Python programming workshops took place remotely over the summer. Our team conducted a series of Python programming workshops, led by our lead programmer Caroline. We virtually met with over 150 students over the course of five days, and our

	program at a beginner level, and even guided them on creating their own games! • We are currently organizing a series of seminars with local STEM professionals. Not only will we use this event to canvas for new mentors or sponsors, but we will post the seminars on our social media pages to educate our followers on different STEM fields.	curriculum ranged from the basics of programming to complex interactive projects. Our cru was able to strike a balance between fun and informative by incorporating games and graphics as well as vocabulary and complex concepts. We made sure to guide our attendees through follow-up questions and helpful suggestions, rather than simply tell them what to do. We wanted to model our coaches' teaching style, as it has been very effective with us. Overall, we believe we achieved our goal of spreading the wealth of computer science throughout our community with the limited time that we had. 
Coordinate volunteering positions at Rockville Science Center events	• A series of Arduino circuit workshops takes place every Saturday at our meeting venue. We have been rotating members to help out at this seminar.	This task falls on any member with experience in circuit building and Arduino. It is an ongoing effort.
Use storefront as form of team and STEM promotion	• We set up our playing field in front of the windows to invite interested passersby to look into the store. • We have lego displays, block towers, and STEM posters (including informative COVID-19 posters) in front of our store. We loop a presentation with upcoming STEM events on a TV.	

<table>
<tr><td>Increase presence on team social media accounts; increase number of teams that we are following to at least 40</td><td colspan="2">We have created a team Twitter account.
We have followed 53 teams on Instagram, which have in turn followed us back. We have direct-messaged several teams to keep each other updated on our teams.
We have followed well-known and engaging STEM-focused accounts, like those of Bill Nye and Neil deGrasse Tyson. THis provides us an alternative way of staying updated on science news, and also helps is
We have learned about the activities of other teams through their accounts, and they in turn have learned about ours.</td></tr>
<tr><td>Gain a minimum of 2-3 new members</td><td>With a majority of seniors on our team, we need to expand our membership so that the Blu Cru can continue to thrive next year. If we increase our membership this year, we can train the new recruits so they have valuable experience for next year. We set this goal of 2-3 new members because in combination with the 3 members that will return next year, the Cru will have a starting base of at least 5 members. We believe this is a good minimum number of experienced members for a team to successfully handle all the tasks that need to be completed.</td><td>We advertised FTC, the Blu Cru, and our open membership positions using the TV in the storefront to passersby.
We used an online “word-of-mouth” recruitment policy, in which our members informed people about our position openings using their social media accounts, like Instagram.
We used the Explorer Post 1010 and Rockville Science Center email chains to inform people about the openings on the team.
We successfully recruited 2 new members!</td></tr>
<tr><td rowspan="2">Train new members in CAD, building, programming</td><td>For the Blu Cru to be successful, the members who have gained experience after participating for at least one year share their knowledge and guidance with new members. This ensures that when the experienced members graduate, the newer members are equipped with the skills to carry on the Blu Cru’s legacy. This is why we devote time to training our new members on all sub-crus.</td><td>We took our new members on a “tour” around each of our sub crus, giving them an overview of each.
We held a CAD tutorial lesson for our new members using the Youtube tutorial developed by a Blu Cru alumnus (see our website). In these lessons, the new members learned the functions of CAD they would need for FTC, namely importing and using FIRST-specific parts and combining parts together to create an animated model for the robot.</td></tr>
<tr><td colspan="2">We involved new members in each of our brainstorming, designing, and braining activities, encouraging them to give their input during these stages. One of our new members has decided they enjoy the build team, so our build & design head has worked closely with her</td></tr>
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	to develop her skills in this focused area. • We showed our new members our test robot, and allowed them to tinker around with the bot to get familiar with the tools and the FTC-specific parts.	
Prepare current members for passing-on of leadership roles for the next season	This is a goal that we work towards achieving over time, as experienced members train newer ones. The heads of our sub crus aim to guide members who could fulfill leadership positions next year so that Blu Cru has smooth and successful transitions from year to year.	• The heads of our sub-crus have allowed our members to take the initiative on specific tasks. For example, the design of our wobble-grabbing arm was coordinated by our less-experienced members, who collaborated to build, attach, and test the arm. It was a success!
	• Our captains prepare experienced members to learn how to manage the various sub-crus. These members learn about what the other Crus are doing by "swapping" jobs for a few meetings to learn about tasks they don't typically focus on.	

Finances

This year demanded an unprecedented financial plan. We were unable to carry out our typical fundraising initiatives, which involve in-person activities, such as the annual Explorer Post Laser Tag game and Post 1010 picnic. Our budget will have to be adjusted. It is very apparent that this season is not an appropriate time to inquire about sponsorships from local business, most of which are in no financial position to divert resources to a sponsorship. We also know that our fundraising activities, which in previous years were entirely in person, would not be possible this year. In addition, IBM has changed the way it allocates grants for this year, meaning our grant will be of a smaller amount than usual.

2020-2021 Projected Income

Source	2019-2020 Amount	2020-2021 Projected Amount	Change from 2019-2020 season
Member dues	$2800	$1800	— $1000
Fundraisers/Community Donations • All-night laser tag • Post 1010 picnic • Bake sales at science events	$320 • $200 • $50 • $70	$0	— $320
Sponsors	$1500	$1500	—
IBM Grant	$500	$125	— $375

Total	$5120	$3425	— $1695

Luckily, our loss in expenses will be accompanied with a reduction in expenditures. Costs typically associated with competitions will be significantly reduced, and the transition from in-person outreach to virtual outreach will essentially eliminate outreach expenditures altogether.

Expenses

Category of Expense	Amount	Notes
FTC registration	$275	This is a required expense
FIRST Chesapeake Competition Fee	$300	This is a required expense
Field Costs	$450	This is a required expense
Robot parts ULTRAPLANETARY GEARBOX KIT & HD HEX MOTOR (x2) ULTRAPLANETARY LONG REACH MOUNTING BRACKET - 2 PACK (x1) Stealth Wheels (x2) 5202 Series Yellow Jacket Planetary Gear Motor (x4) 1206 Series Pattern Adaptor (x4) 1.00" OD 0.500" ID Smooth Hub Pulley (x6) 6mm to 6mm Set Screw Shaft Coupler (x4) Control hub	$621 $72 $5 $14 $160 $14 $36 $20 $300	We reused parts from last year, and only bought parts which we could not find adequate substitutes for
Additional competition expenses	$0	We do not have to print our notebook or provide other materials to present at competition (all online).
Rental of venue & other Explorer Post 1010 umbrella costs	—	These are covered by a portion of our membership dues.
Total	$1646	We are happy to have stayed on track with our budget!

As a result, we paid extra attention to being deliberate and sustainably-minded when it came to making purchases. In some ways, this unusual season prompted us to become more aware financial decision-makers.