Engineering Portfolio

2022-2023

Contents:

CRYPTIC

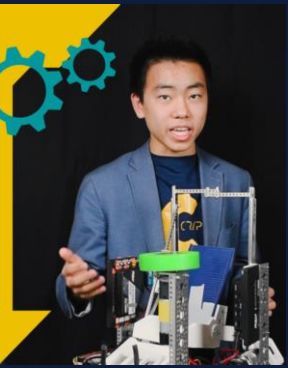
#20123

RAYAN ELIAS

Skill Development:

- Met with company boards for sponsorships; created LOI
- Maintained team website
- Organized team financials
- Presented at outreach events

BILL WANG



Skill Development:

- Designed pulley system for outtake
- Taught kids at CAD outreach
- 3D printed parts and designed components for the robot

JAMES LI

Skill Development:

- Taught students principles of design at outreach events
- Coordinated outreaches with local libraries
- Lead marketing team

JACOB ZHANG

Skill Development:

- Designed drivetrain in CAD
- Designed intake arm + claw
- Used CNC to make custom parts
- Mentored a rookie team at the library

ZHUOYU YANG

Skill Development:

- Implemented wire entanglement precautions
- Taught young children about engineering at library outreach
- Assembled chassis

ALINA LIU

Skill Development:

- Presented Rube Goldberg station at outreach events
- Helped program computer vision, outtake, and mecanum
- Developed autonomous path

ALLEN YANG

Skill Development:

- Programmed intake mechanism
- Managed code station at outreach events
- Planned autonomous paths

DAUD IDREES

Skill Development:

- Designed motor mount for intakeand the battery mount
- Mentored a rookie team at the library
- Helped render CAD model

ENOCH LI

Skill Development:

- Led stations at different outreaches
- Started HCLS subteam and mentored them for the FTC season

SUNNY YUAN

Skill Development:

- Managed team social media
- Operated the engineering lesson stations at outreaches
- Helped organize trifold board and physical presentations

Team Overview

ABOUT US

Team **Cryptic #20123** is a 2nd year FTC team based in Ellicott City, MD. Our members are all from Centennial High School and range from **freshmen** to **seniors**. Many of our members have previous experience in FTC, FLL, and even FRC. We gained immense traction from our **community outreach** events and recruited **5 new members** to our team. Despite our unique backgrounds, our love for robotics drives us to spread STEM throughout our community.

TEAM STRUCTURE

Captain: Rayan

Team Leads: Jacob, Bill, James

Team Members: Zhuoyu*, Enoch, Daud, Alina*, Allen*, Sunny*

**New members in FTC are denoted with an asterisk*

Our team is split into three main subgroups: building, programming, and marketing. All our members have multiple roles at some capacity, which leads to a higher level of **cooperation** and **communication**. We have three leads and one captain on the team, which offers members to both **collaboratively** learn through their **experiences** while finding the opportunities to take **initiative** in their respective subgroups.

OUR MISSION AND GOALS

Our mission is to encourage learning in all aspects of FTC through hands-on building, programming, and marketing, as we support students of various interests in collaboration. We also strive to provide outreach opportunities for our members to learn, while we engage and educate our local community in STEM.

Our primary goals for 2022-23 season:

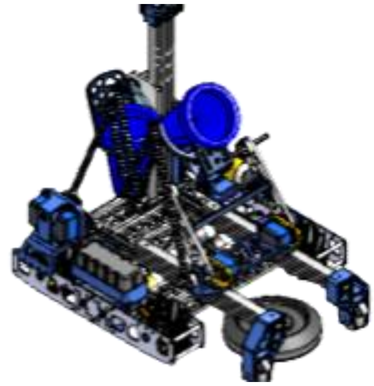
- Recruit new members
- Outreach to both kids and adults
- Acquire sustainable funding
- Collaborate with Other FTC teams
- Impact 100+ students in STEM
- Create a consistent & high-performance robot
- **Have fun!**

Organization

2022-23 MEETINGS & STRATEGY

We had 3 weekly team meetings [1 for builders, 1 for programmers, and 1 for marketers] in which members discussed plans:

- Builders focused on **CAD** and **design**, planning and modeling the design before physically building to minimize wasted parts.
- Programmers simultaneously created **code subsystems** while components were being designed.
- Marketers focused on organizing physical **outreaches**, planning and coordinating engaging STEM events in the community.



To collaborate online we took advantage of various platforms:

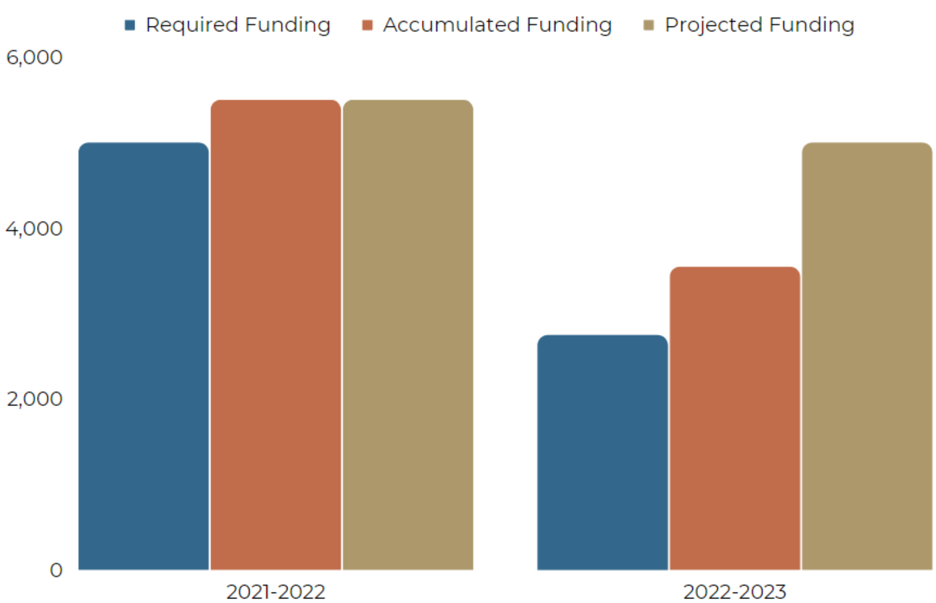
Communication/Meetings: Discord, Google Meet, Zoom

Files/Organization: Excel, Jamboard, Google Drive

Cloud-Based Version Control: Onshape, GitHub

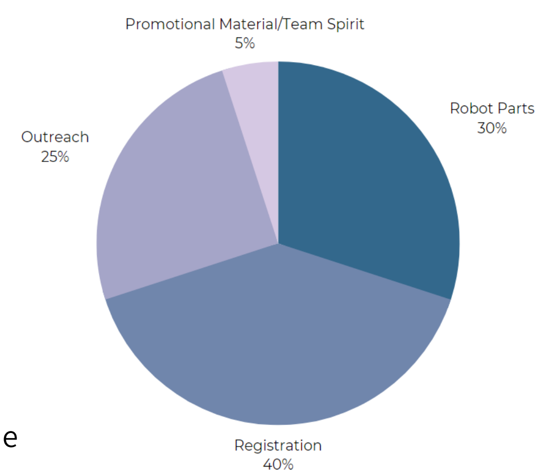
With these tools, we were able to collaborate together more efficiently and work together effectively during meetings.

FINANCIAL INFORMATION



In order to reach our fundraising goal of $2035, we sent **numerous** emails, proposals, and letters of inquiry to local tech companies and **grants**. Since our team runs **our own nonprofit** to operate, we are tax-deductible and can allocate some of the funding we get back to the **community**.

Fund Allocation



Sustainability: In order to continue our team for future seasons, it was imperative to save funds and **cut costs**. Our team created custom parts using **3D printing** and even created our own **CNC mill** to make our own side plates.

Outreach

Miller and Central Branch Library Outreach

In partnership with the **Howard County Library System**, Cryptic debuted the **“Taking Your FIRST Steps in STEM”** event at the Miller and Central Branch Library to reach new audiences in different parts of the county.

Some of the activities we coordinated:

- **Create Race Cars:** Participants are given different lego pieces to create cars that will race to travel down a ramp as far as possible that will simulate the **trial and error** process when building.
- **Learn to Code:** Participants will get an accurate feeling of how programmers try to solve **difficult problems** in different ways using block code.
- **Build a Rube Goldberg Machine:** Students created a Rube Goldberg Machine that transports a ping pong ball from the start point to the end point, teaching the **design process** taught by the design team.

Computer Aided Design Workshop: Summer Class

During the **preseason** of FTC, our team felt summer was one of the best times to **spread STEM** to the community. Our team members **organized** a CAD class in partnership with the **Howard County Library System** and hosted this class at the Miller Branch and Elkridge Branch libraries.

HOWARD COUNTY LIBRARY SYSTEM
Public Education for All

Our team members taught **two three-week long** classes that allowed participants to gain **hands-on experience** with our CAD software, **Onshape**. In the class, we taught the **fundamentals** of the software, including but not limited to: sketching, extruding, assemblies.

To successfully teach the skills of CAD, we created our own curriculum. We led participants through a **boat creating project**, teaching them all of the tools along the way. We also taught participants to customize their boats in their own **unique** ways. Parts of the boats included: Mast, Steering Wheel, Rotor.
At the end of the class, we **3D printed** all the boats for the participants so that they could keep their unique designs, inspiring them to use the skills learned to create their own projects.

FTC: HoCo Hazards 22742

Many participants from our outreaches wanted to participate in FTC, but members of our team found it **hard for them to get involved**. As a result, members of team Cryptic **created** FTC team HoCo Hazards #22742 in partnership with the Howard County Library System to give our **community** the opportunity to prepare for and compete in FTC.

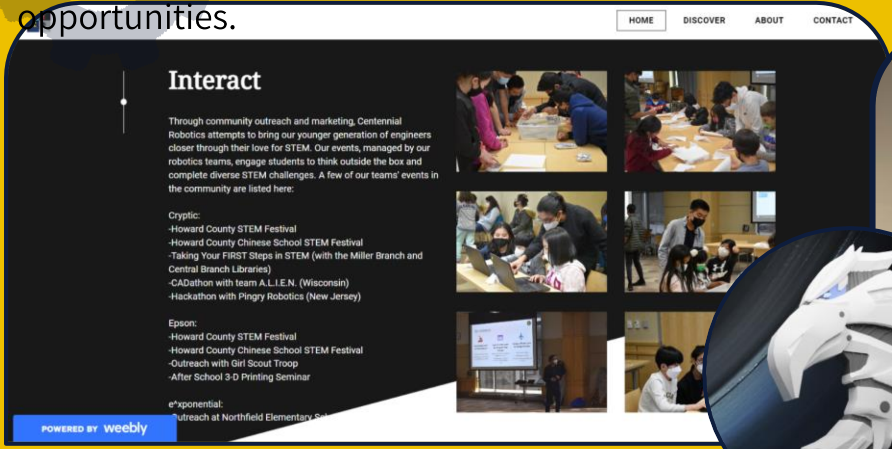
Through communication with the library system **President** and **teen curriculum director,** we were able to form a **completely free** public FTC team for our county. Through many meetings and resolutions, we were able to finalize the team and got them to participate in their first qualifier. We are **determined** to make an impact on the community by **sharing** STEM.

The Library System provided funds, and our members **dedicated** their extra time to **mentoring** and **leading** the team. The club quickly drew the **interest** of many people, and had over 40 people **apply** to join the team. Due to team sizing issues, we could only accept 15 people to the team.

Our team members organized **bi-weekly** meetings that focused on different **aspects** of FTC such as building and programming. We taught **inexperienced** members from **diverse** backgrounds that had no exposure to STEM before. Several children, along with their parents, have shown a large **interest** in FTC, and as a result, we are forming **three** robotic camps of FTC during the summer to further extend STEM in our community. We are also planning on creating **two** more FTC teams so we can accept more interested participants. We hope to be able to help students gain a **solid understanding** of robotics, programming, and design through the camps and teams.

Centennial Robotics Inc.

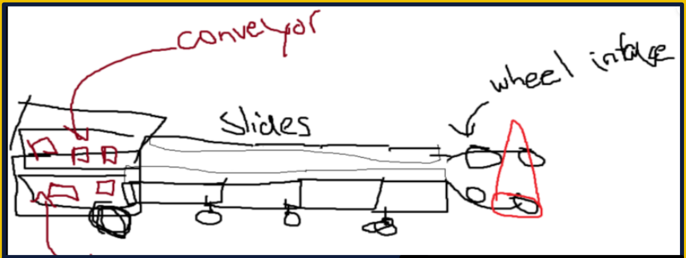
Originally, our veteran members competed in FTC through our **high school** robotics team. However, our school revised country legislation during the COVID-19 pandemic and **restricted** our ability to host **community outreaches**. As a result, we left all the sponsorship funding and parts we acquired over the years and started a **501(c)3 nonprofit organization** called Centennial Robotics Inc. The organization is **entirely student-operated** from managing company governance to managing finances. It was founded in 2022 and has continued to this year. We created this nonprofit to host **bigger** events and receive more **marketing** opportunities.

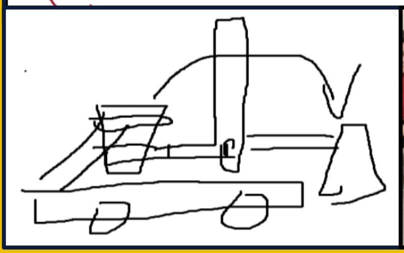


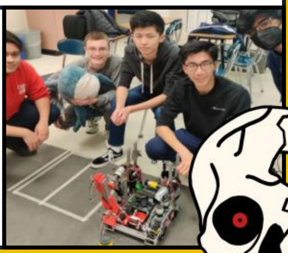
centennialroboticsinc.weebly.com

Our team presenting to the board of the Maryland Space Business Roundtable

Networking







Our **non-profit** organization hosted an Alumni day where we met with senior retired teams (Team **VIRUS** and **Exponential**) and their members provided us with guidance to gather ideas and tips for their robot design. We also met with other teams in **Maryland** and held a scrimmage with our local teams (**Epsilon** and **Robot in Pieces**) where we were able to find issues and further improve our robot design.

crypticrobotics.weebly.com

@crypticrobotics

NAC Conference 2022

During the preseason of FTC, our team also attended a three-day conference in **Washington, DC** to increase government spending in **Title IV, Part A**, of the Every Student Succeeds Act (**ESSA**).

Day One: Networking

Our team members were **introduced** to the buildings and areas in D.C., and we participated in activities to **bond** with other teams who were also **representing** Maryland to **advocate to our representatives** for **additional funding in STEM**. Some of these teams include:

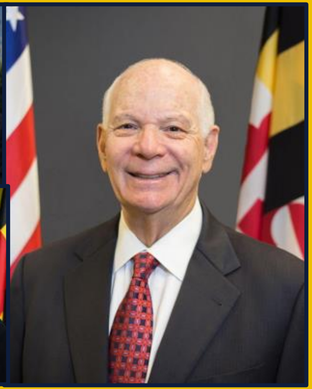
- FRC team **Robo-Lions**
- FRC team **Gladiators**
- FTC team **G-Force**

Day Two: Learning

On the second day of the conference, our team members were taught about funds relating to STEM, such as the Every Student Succeeds Act which **funds** STEM programs. We also learned about the **speaking process** with the senators and created topics to **discuss** with the senators. The conference taught our team members to take **initiative** in our own communities to **boost** STEM advocacy and involvement.

Day Three: Speaking

On day three of the conference, we met with the **senators** that represent Maryland in Congress: Senator **Ben Cardin** and Senator **Van Hollen.** Additionally, we also met with Representative **John Sarbanes**. We discussed the benefits of funding STEM programs, and convinced them to **continue support** in funding title IV, part A of the **Every Student Succeeds Act**. The additional funding in the Every Student Succeeds Act will allow the government to **allocate more funds into STEM programs**, including FIRST.



Future Plans

In the future, our team plans on **applying** the skills we learned at the National Advocacy Conference at the **local county level**. We will reach out to Howard County executive **Calvin Ball** as well as the Howard County Public Schools superintendent **Dr. Michael Martirano** for further support in STEM programs.

Design Brief

Background

Power and energy has been evolving rapidly ever since the beginning of civilization. From coal to oil all the way to solar and wind, the need to efficiently power civilization cleanly has been rapidly increasing. This year's FTC game Powerplay ***inspires*** future engineers to tackle the problem of renewable energy.

Criteria & Constraints

Criteria:

- **10+ cones** on the tallest pole rod
- Form a **circuit** at the end of the game
- Have the ability to stay in place and **cycle**
- High structural integrity
- Modular design for flexibility & low maintenance
- Scoring in high junction **consistently**
- Ensure all our members understand the tasks

Constraints:

- **Time limit - 2 mins and 30 seconds**
- **Avoid ground junction and poles on the field**
- **Physical robot constraints**
- **Rules and penalties in Game Manual 1&2**
- **Project period: 3 months**
- **Budget: $2,035**
- **Inexperienced members need to be trained with the appropriate skills they need**

Defining Problem

Create a robot capable of delivering cones with accuracy, efficiency, and reliability into the designated locations.

Brainstorm & Generate Concepts

Conduct research on the rules and scoring and generate possible strategies. Brainstorm potential Robot designs such as intake and outtake mechanism.

Select and develop a solution

Compile all the designs and make improvements and use a decision matrix to select the best robot design. Create a detailed plan for building and programming.

Test and evaluate

Test the robot and evaluate its performance. Gather data and make adjustments as needed to optimize the robots performance.

Robot Design

Explanation

Due to the many different obstacles present on the playing field this year, maneuvering around is very difficult. To combat this, we created a stationary robot with a set of horizontal slides and vertical slides.

The long horizontal slides allow us to intake from the alliance substation without having to move away from the junction, so we can repeatedly cycle through cones nonstop.

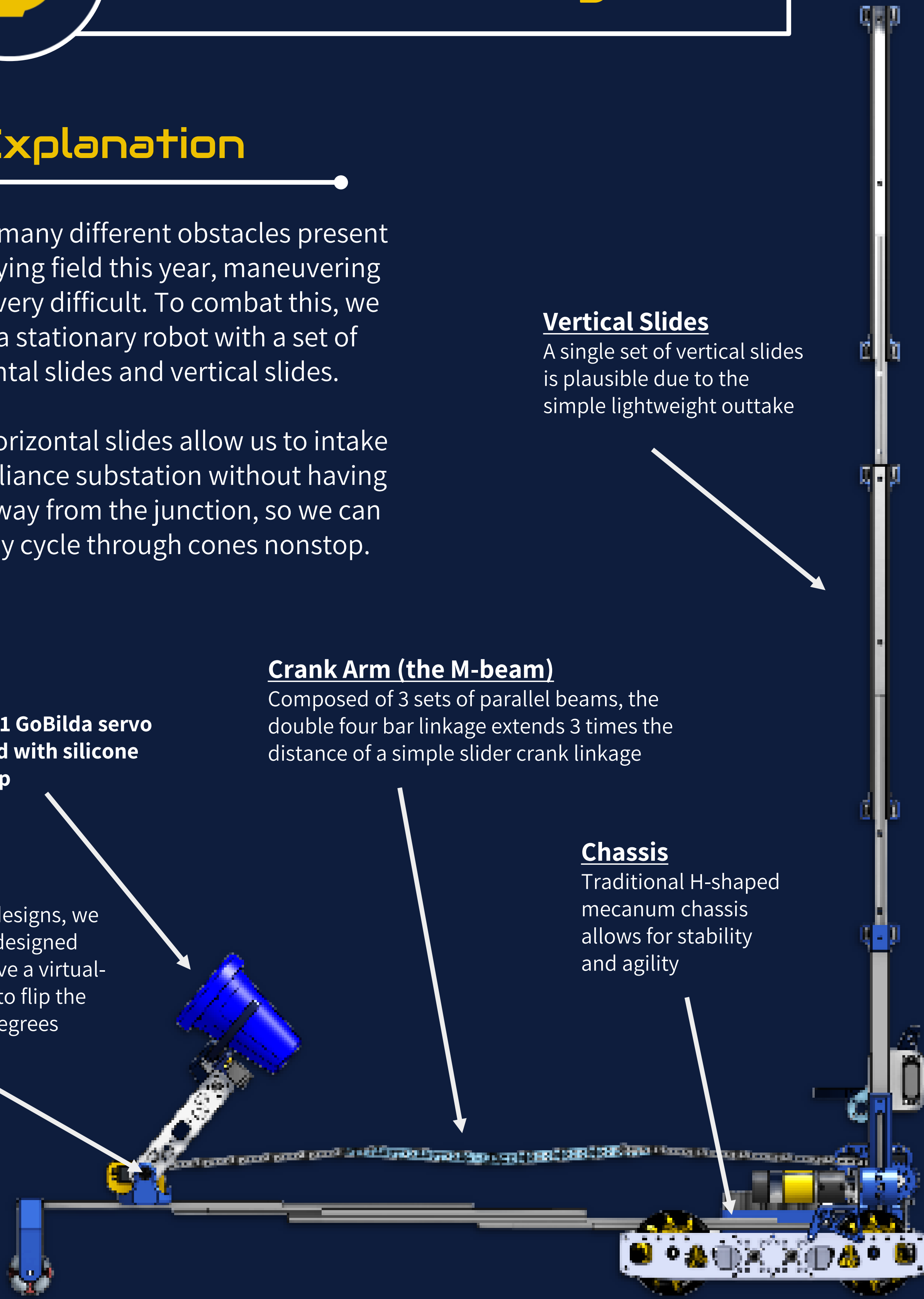
Vertical Slides
A single set of vertical slides is plausible due to the simple lightweight outtake

Crank Arm (the M-beam)
Composed of 3 sets of parallel beams, the double four bar linkage extends 3 times the distance of a simple slider crank linkage

Claw
Powered by 1 GoBilda servo and enforced with silicone tapes for grip

Pivot Arm
Unlike other designs, we purposefully designed arm to not have a virtual-4-bar linkage to flip the cone by 180 degrees upon intake

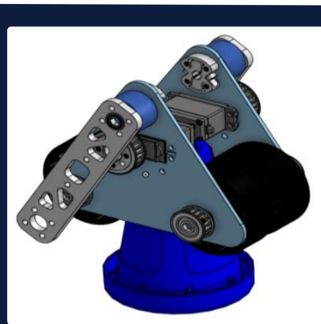
Chassis
Traditional H-shaped mecanum chassis allows for stability and agility

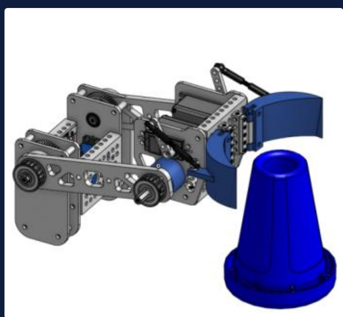


Intake

Preliminary Designs

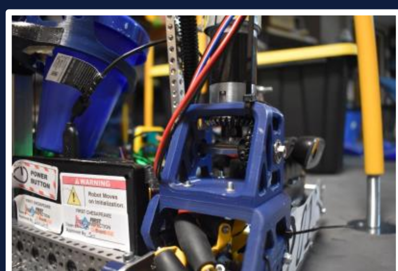
Idea 1: Vex Intake
Using two motors on either side with compliant to **“funnel”** a cone piece into the desired location.





Idea 2: V4b + claw
An arm with two joints controlled by two separate motors with our intake on the end.

The horizontal slides are powered by a **bevel gear** system transferring **rotational** movement from the motor to **linear** motion



Horizontal Slides

Brainstorming

We decided on some criteria that it should adhere to:

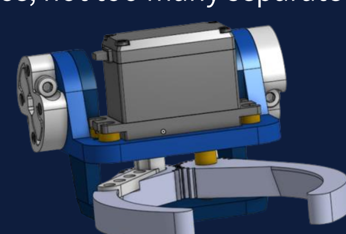
- **Efficient: Cycle and drop a cone in 3.5 seconds**
- **Fast: Stay near junction and extend into substation**
- **Reliable: Manual control if cycle automation fails**

Problems Encountered

Unstacking the cones was a major issue for intake. We went through **many** iterations of our intake such as using a **virtual four bar** and using an **arm** instead of slides. However, we eventually just decided to attach our intake to a set of arms controlled by **2 servos**. This allowed our robot to easily unstack and grip the cones. We also had problems with our intake not gripping the cone properly. To fix this, we used **silicone** to give the claw a better grip on the cones.

Horizontal Claw + 3D Printed Claw
We used some of the principles of **Idea 2** and mounted a smaller set of arms on a set of horizontal slides, which fixed the problem of unstacking and **drastically** increased the **range** of our intake. This made it possible for our robot to stay **stationary** while placing cones.
Some advantages of this design are:

+ Very high range
+ Quick and efficient.
+ Simple to build and integrate with other mechanisms
+ Reliable and consistent
+ One main piece, not too many separated parts



Outtake

Brainstorming

While discussing, we were inspired by past FIRST competition shooters and created some target criteria:

- **Quick: Can deposit cones onto poles in less than three seconds**
- **Accurate: Smallest chance of error when scoring points**
- **Compact: Able to maneuver between junctions and cones**

Preliminary Designs

Idea 1: Rotating Arm

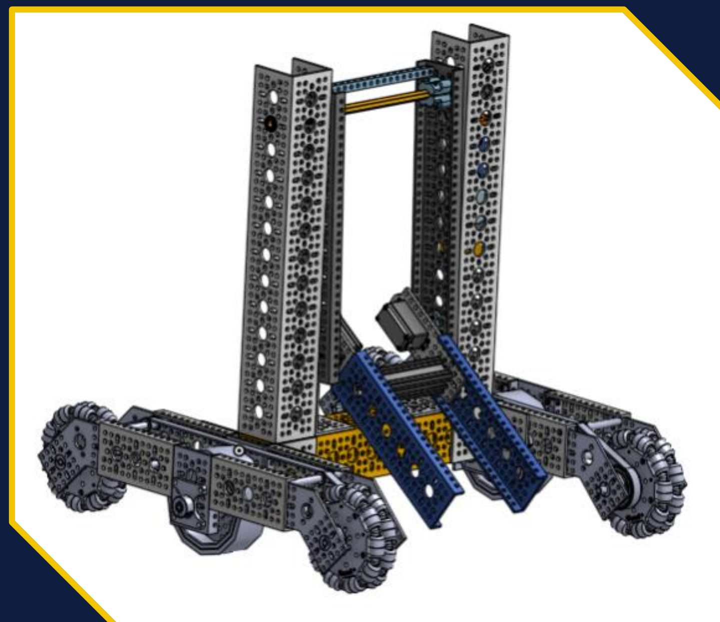
To test this design before ordering parts, we built a simple prototype using multiple U-channels and axles to demonstrate how the deposit would function and fix any complications that arose.

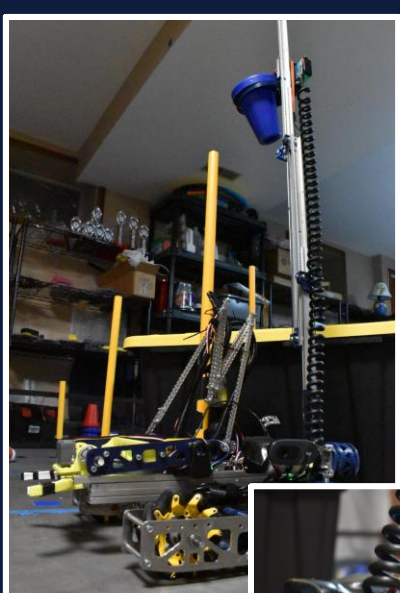
Advantages of this design are:

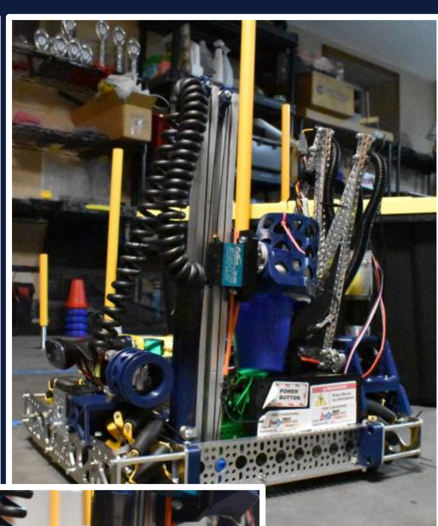
+ Intake also acts as outtake (lower complexity)

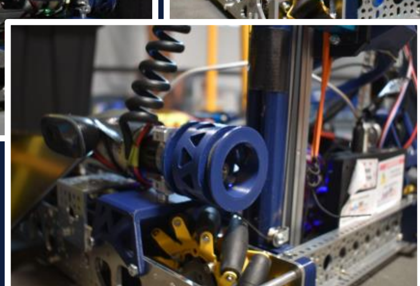
However:

- Many moving parts, which leads to high chance of error
- Too much strain on servos from weight of mechanism
- Easy to rock robot with high center of mass









Final: Simple Vertical Linear Slides

We wanted to develop simple and lightweight outtake so that it would be quick enough to score on the tallest poles efficiently. Originally, we had two sets of slides, but decided that it would be faster if we only used one set of slides with a lightweight outtake.

Advantages of this design are:

+ Increased height
+ Easily move game piece to different heights
+ More efficient transfer of cone from ground to pole

However:

- High center of mass
- Too much strain/wobbly due to height

Autonomous

Autonomous Paths

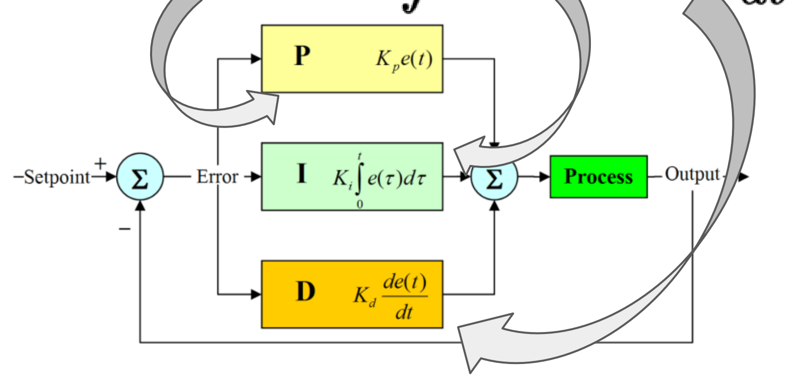
Path One Code

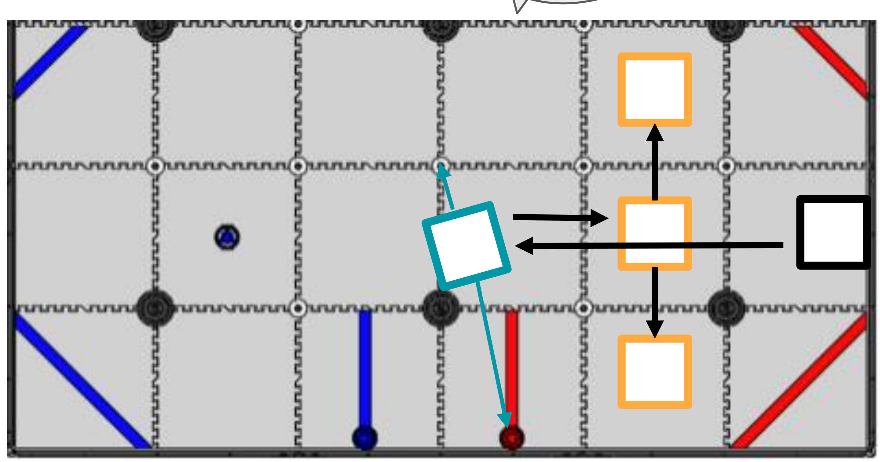
```java
// We want to start the bot at x: -12, y: 66, heading: 90 degrees
Pose2d startPose = new Pose2d(-12, 66, Math.toRadians(270));

drive.setPoseEstimate(startPose);

TrajectorySequence traj1 = drive.trajectorySequenceBuilder(startPose)
        // Robot drives straight forward to the shipping hub
        .lineTo(new Vector2d(-12, 36))
        .waitSeconds(3)
        // Robot drops the freight on the top row
        .addDisplacementMarker(() -> {
            robot.extensionServoLeft.setPosition(0.9);
            robot.extensionServoRight.setPosition(0.9);
            robot.outakeServo3.setPosition(0.722);
            robot.outakeServo4.setPosition(0.722);
        })
        .waitSeconds(3)
        // Robot resets outake to original position
        .addDisplacementMarker(() -> {
            robot.extensionServoLeft.setPosition(0);
            robot.extensionServoRight.setPosition(0);
            robot.outakeServo3.setPosition(0);
            robot.outakeServo4.setPosition(0);
        })
        .waitSeconds(3)
        // Robot drives back to the warehouse
        .lineTo(new Vector2d(-12, 52))
        .splineTo(new Vector2d(10, 66), Math.toRadians(0))
        .lineTo(new Vector2d(55, 66))
        .build();
waitForStart();
```

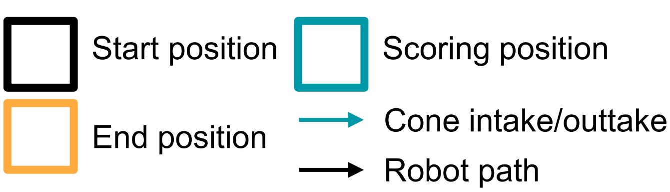
We programmed **many** autonomous paths. These paths utilize **PID**, **IMU**, and **waitsecond methods,** allowing us to have a quick and consistent autonomous. It is critical for us to implement **multiple paths** to accommodate our alliance team. If one of our paths interferes with our alliance team's autonomous path, we could choose a **different path**. This allows us to **maximize** points earned during the competition.

The robot will move forward and **rotate** so that the intake and outtake are **aligned** with the stack of cones and the tallest pole, respectively. After scoring the preloaded cone, the robot then scores all 5 stacked cones, and will move into the **parking** position corresponding to the signal **detected** at the start. In total, our autonomous is planned to score **80 points** on its own.

$$u(t) = K_p e(t) + K_i \int e(t)dt + K_p \frac{de}{dt}$$



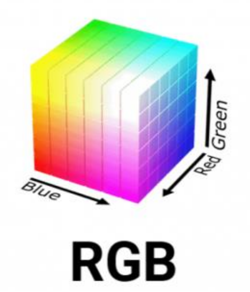


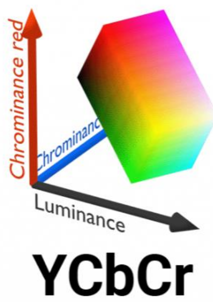


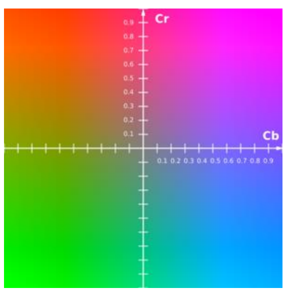
Autonomous

Vision Implementation

OpenCV Processing



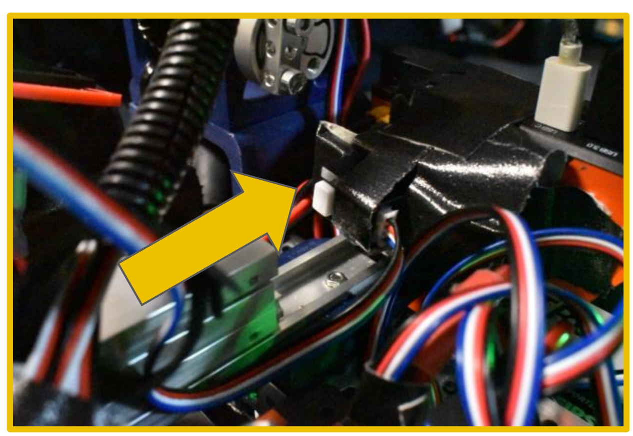




This year, our team integrated **computer vision** functionality to our robot in order to detect a custom signal sleeve that we created. Utilizing **OpenCV**, an open source computer vision library, our robot is able to analyze video feed from an **external camera**. Our OpenCV pipeline, the function which does the actual visual analysis, extracts colors from specific regions of our camera in order to **detect our custom signal sleeve**. Instead of using the standard RGB colorspace, our pipeline analyzes from a special **YCbCr colorspace** which prevents glare and variable lighting from interfering with our video analysis.

Limit Switch

Using a REV Touch Sensor, the robot **calibrates** itself each time the horizontal slides press the sensor and return to its original position. This allows us to **coordinate** our scoring cycle to have a **seamless** transition from intake to outtake. In addition, the limit switch allows our horizontal slides to **keep their position** when the robot is moving around rapidly around the field.



Controls

To keep code organized, we used **GitHub**, a version-control repository, for programmers to share and edit code. It was especially useful in helping us work **virtually** during the pandemic while keeping others **safe.**

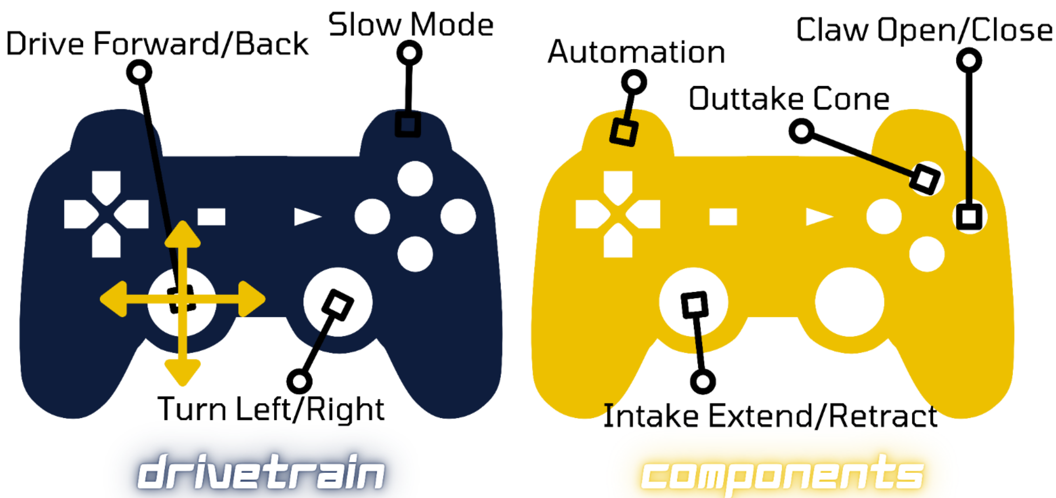
Automation in TeleOP

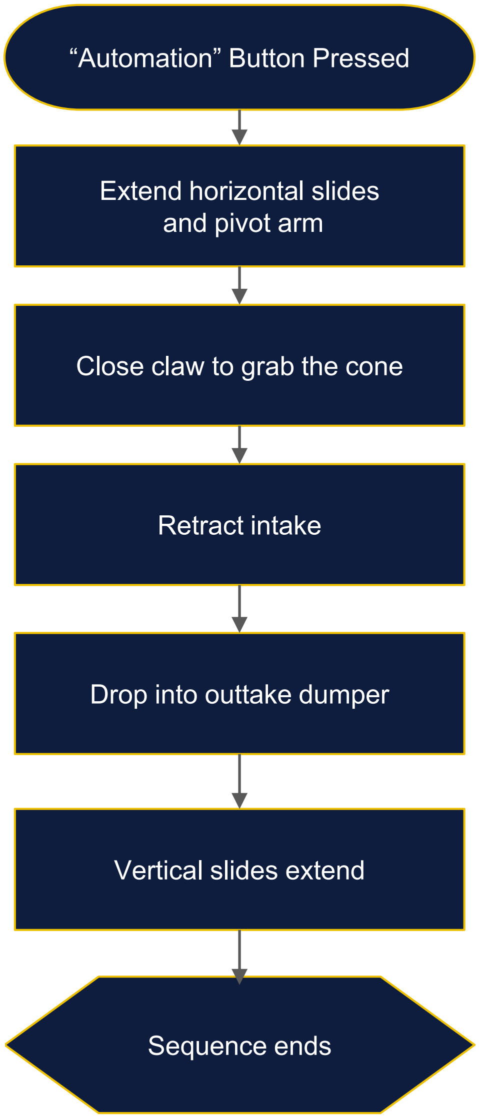
Automatic Scoring Sequence - *One Button to Rule Them All*

We **automated** the entire scoring process into an **"*everything button.*"** When pressed, it performs a series of tasks from grabbing the cone from substation all the way to scoring the cone onto a junction, simplifying the majority of the teleOP controls into the press of a single button. Doing so allows for both easier driving and faster cycle times.

Passive Slide Retraction System

While turning, the horizontal slides would fling out and hit obstacles, so we implemented a **passive** method that activates whenever the robot does a large movement. When **IMU** detects a change in the orientation of the robot, it **automatically** powers the servo and locks the horizontal slides.





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