# 1002 CIRCUITRUNNERS
SURGE

ENGINEERING PORTFOLIO
2021 - 22

CR CIRCUITRUNNERS ROBOTICS

We are FTC 1002 CircuitRunners Surge!
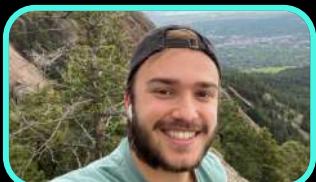
August	Aidan	Kazi "Rokib"	Richard	Rohan	Kavin	Jason
4th Season	3rd Season	2nd Season	1st Season	1st Season	1st Season	1st Season
Team Lead Design Lead Build	Build Lead Design	Build Marketing	Build Design	Marketing Outreach	Build Design	Build Design

Nelitha	Ryan	Saahas	Aarush	Samarth
4th Season	3rd Season	2nd Season	1st Season	1st Season
Outreach Lead Drive Coach	Coding Lead Drive Team	Coding Drive Team	Coding	Build Design

Each 1002 member works with their respective teams (Build, Design, Marketing, Outreach, Coding)

These teams then work in conjunction with each other: such as the Build team making an Outreach robot.
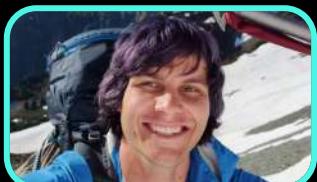
Mentors

Cameron Huggins	Zachary Cloud	Mr. Mars Berwanger	Varun Vedula
How Acquired: CircuitRunners Alumni	**How Acquired:** CircuitRunners Alumni	**How Acquired:** Engineering teacher and club sponsor	**How Acquired:** Connection through Zachary Cloud; Alumni of FTC #8813;
New Knowledge Gained: > Manufactures parts > Game strategy and robot design > Outreach at Chick-Fil-A	**New Knowledge Gained:** > Club and Project Management, finance > Industrial Design Techniques	**New Knowledge Gained:** > Event logistics > Teamwork and Communication	**New Knowledge Gained:** > Portfolio and Presentation skills

Team Plan

We've reached over **2200** people through our many outreach initiatives and marketing efforts!

Our robot's high score is **236!**

Team Goals
- 95% rookie member retention
- Reach out to 4,000 people to spread STEM & FIRST's values throughout our local community
- Expand member knowledge by reaching out to 10 STEM Professionals in our community
- **Worlds or Bust!**

WHEELER HIGH SCHOOL ROBOTICS TEAM QUALIFIES FOR WORLD CHAMPIONSHIPS

Mar 9, 2022 | Lifestyle | ★★★★★

EastCobber News Headline of our Team

MARKETING
> We love creating content that shows our team culture, and showcases events where we impact the community.
> We've created media **such as the FTC League Meet video montages.**
> We've come up with creative ways to market ourselves, such as a **CircuitRunners Bulletin Board** in our school, and **custom made videos/images for social media posts.**
> We've communicated with local new organizations such as the East Cobbler, Marietta Daily Journal, and 11Alive, to speak about our advancement to the World Championship and our fundraising efforts.

FUNDRAISING
> **We fundraise through corporate sponsorships, member dues, and concessions at hosted events**
> Ran fundraising at events, such as FLL Regionals and Super Regionals, through concessions.
> Pursued new sponsorships such as R.W Smith Contractors
> We apply for grants, such as receiving the NCR Team Impact Grant
> To pay for Worlds we created a GoFundMe and shared it with our community and local news organizations

Sponsors
Parker 3D Prints

StartProto

sevaa group

Chick-fil-A

LOCKHEED MARTIN

RW SMITH COMPANY GENERAL CONTRACTOR

Summarized Budget

Item	Expense/Income
Student Dues	$ 3,750.00
Sponsors	$ 2,500.00
FLL Qualifier Stipend	$ 550.00
FLL Super Regional Stipend	$ 650.00
Concessions	$ 500.00
World's Fundraising	$ 6,300.00
World's Student Dues	$ 4,280
Total Income	$ 16,250.00
FTC Registration	- $ 275.00
League Registration	- $ 300.00
States Registration	- $ 600.00
Worlds Registration	- $ 2000.00
Worlds Transportation + Housing	- $ 8,580.00
General Expenses	- $ 3,349.00
Total Expenses	- $ 15,104.00

Member Development

GOAL

Since we gained 9 rookies this season, we needed a **member development plan to fully integrate new members** into our team.

Stage 1: FTC BOOTCAMP

Initial Goals: Teach prospective members the basic skills needed for FTC in 2 weeks.

Steps Taken:
> We went over basic Java programming skills and how to program motors, servers, and Op-Modes for 5 days.
> Members were taught shop safety and first aid and how to use tools such as band saws and drills.
> Presentations about EDP and design philosophy and an introduction to common build systems.
> Members learned the basics of marketing and outreach
> Members designed, built, and programmed a simple outreach robot
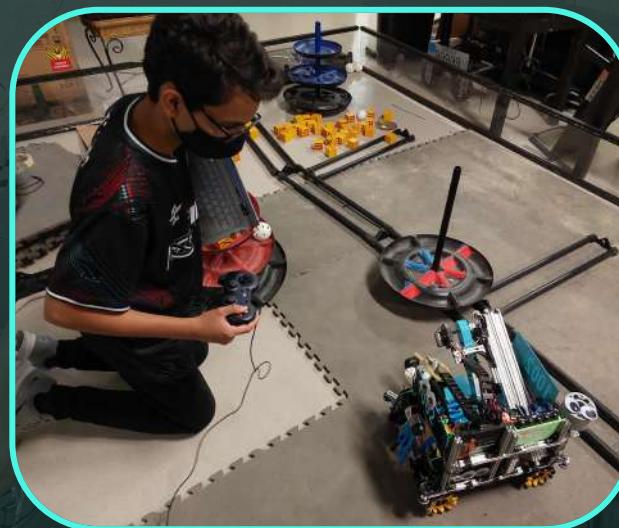
Nelitha and Ryan teach new members how to properly use a drill

Stage 2: APPLICATION OF BASIC CONCEPTS

Initial Goals: Start to integrate rookies into the team by giving basic tasks based on their chosen team role. This way they are not overwhelmed by the transition.

Steps Taken:
> Members participated in hosting FTC and FLL events.
> Members helped mount simple parts
> Rookies helped gather material and tools to get used to the shop environment
> Rookies assembled mechanisms under supervision from mentors and veterans
> Rookies tuned drivebase code to understand basic programming skills
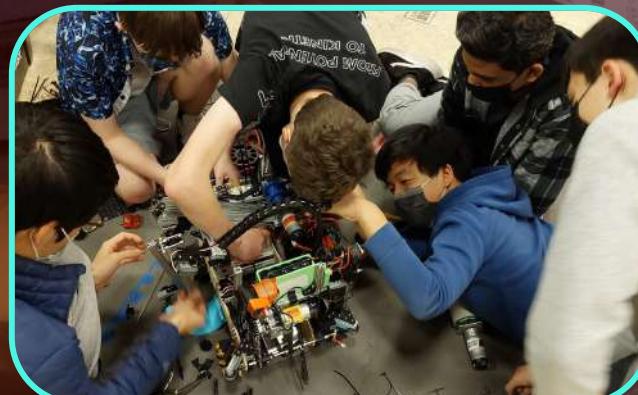
Aarush testing his TeleOp code

Stage 3: INTEGRATION

Initial Goals: Rookies start to take on more active roles in the team and gain lead roles in designing, building, and programming with less supervision
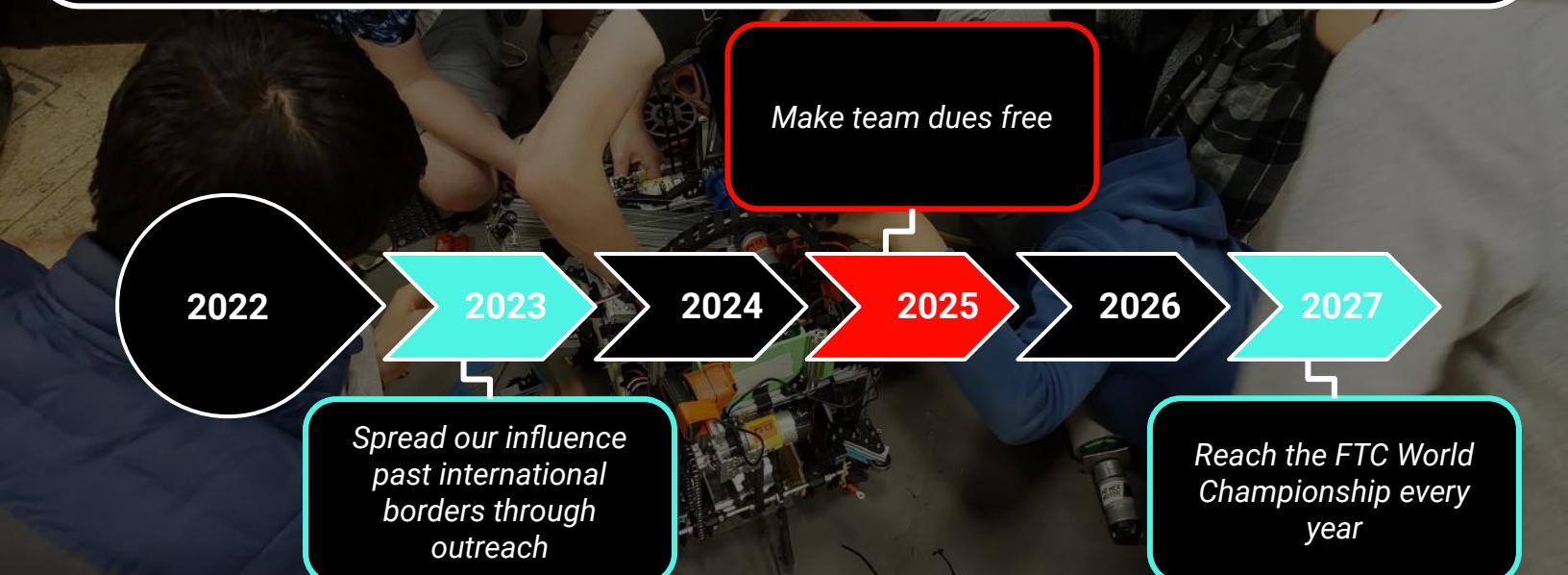
Steps Taken:
> Members worked on more important tasks such as designing parts for the dual intake and outake system.
> Members have helped research contacts and write email drafts to people such as STEM speakers/professionals and FLL teams.
> Members have been involved in programming the teleop and autonomous.

Working on the robot together!

Future Goals & Team Mission

> *"The Wheeler High School **CircuitRunners** seeks to instill the values of **engineering and business to the surrounding community and across the world**. By providing the **foundation** for students to engage themselves in STEM and **leadership**, our organization will **inspire and create the future leaders** that are necessary for advancing society."*

Make team dues free

2022 → **2023** → **2024** → **2025** → **2026** → **2027**

Spread our influence past international borders through outreach

Reach the FTC World Championship every year

2023

> Our goal is to be able to spread our impact through outreach past the US borders.
> We are currently working on mentoring teams through FIRST global in preparation for next season.
> Our mentor Cameron is helping us contact team Malaysia for mentoring.

2025

> CircuitRunners robotics should be a place where anyone can come to learn about STEM and robotics.
> We aim to eliminate the club dues so that anyone can participate in FIRST.
> We are looking for more sponsorship opportunities to support our team.

2027

> Our goal is to advance to worlds every year which requires a flow of knowledge from veteran to rookie.
> We are setting up more formal member development programs to make this possible.
> Additionally with the help of our mentors we reach out to CR alumni to teach our team.

SUSTAINABILITY

> **Worked to recruit new members into the club by:**
> Presenting at Wildcat Days and other events where clubs introduce themselves to prospective students.
> Creating videos to showcase robotics for events like Open House and Prospective Student Night.
> Holding informational nights to give info about our organization.
> Working with feeder schools such as helping Sedalia Park Elementary School's FLL team.
> Conducting demonstrations at FLL Events to inspire students to pursue FIRST robotics in high school.
> Keep member dues as low as possible, so robotics is more accessible.
> **Member development allows experience to be transferred to rookies from veterans, allowing the club to thrive for years to come.**

Outreach Overview

Supported Society of Women Engineers CAD Workshop
April 5 - 9; Reached 40 people

Assisted FTC 19987
All Season; Reached 15 people

Ran CT Hackathon and Code Workshop
April 5 - 18; Reached 15 people

Ran CAD Summer Camp
July 12 - 16; Reached 30 people

Participated in Wildcat Dayz
July 20; Reached 150 people
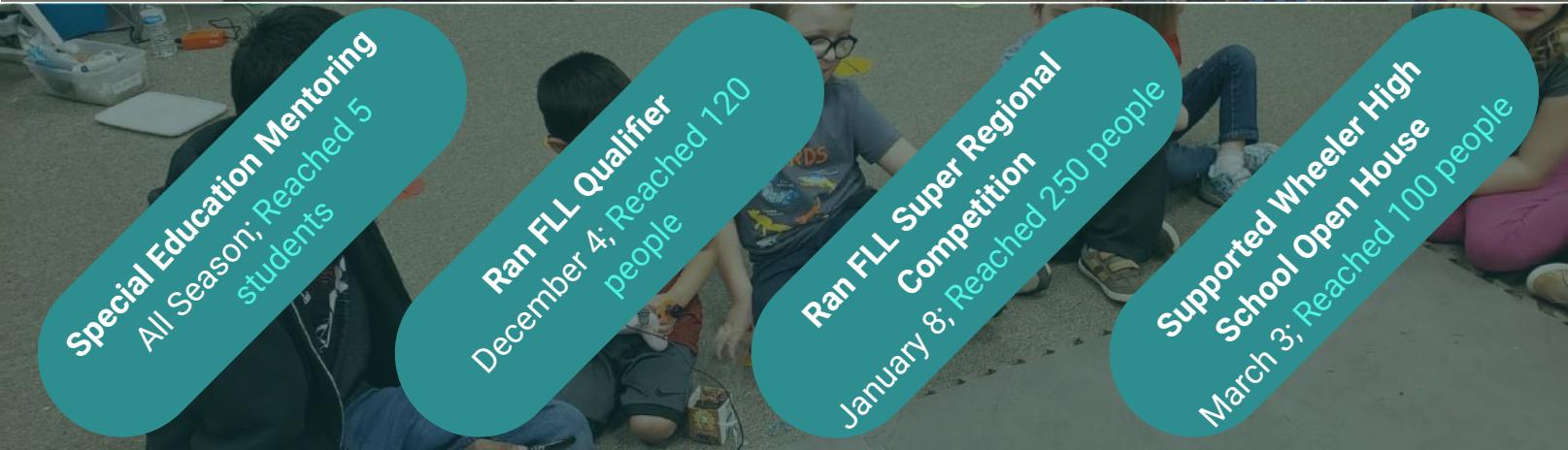
Hosted Speaker Series
All Season; Reached 60 people

Ran FLL Workshop
October 9; Reached 45 people

Host FTC Marietta League Meets
Oct 30 - Jan 15; Reached 16 FTC teams

Special Education Mentoring
All Season; Reached 5 students

Ran FLL Qualifier
December 4; Reached 120 people

Ran FLL Super Regional Competition
January 8; Reached 250 people

Supported Wheeler High School Open House
March 3; Reached 100 people

Supported Addison Elementary Demo
March 24; Reached 150 people

Hosted FTC Scrimmage
April 2; Reached 3 FTC teams

Inclusivity Initiative and LGBTQ+ of FIRST Partnership
All Season; Reached 200 people

Total outreach impact of 1300 people!

Special Education Mentoring

> Introduced STEM concepts to our school's special education students through weekly activities and lessons, since they don't get the opportunity to learn STEM in their curriculum.

> Met with FRC 1002 members every week to design lesson plans and simple STEM activities, such as "Teaching Buoyancy through Tin Foil Boats".

> Worked through these activities with the special education students every Monday.

*Rohan walks the students through a Tin Foil Boat activity that demonstrates buoyancy principles.*

Assisting FTC 19987

> Assist rookie team FTC 19987 Black Screen of Death 1.0 in preparing for and succeeding in their first season.

> Guided them through team creation and various onboarding tasks.

> Helped them get set up by teaching them basic CAD and programming skills.

Working with Other Clubs at Our School

> Spread STEM and the mission of FIRST with the help of other clubs at Wheeler.

> Mentored our school's Society of Women Engineers in creating and marketing a CAD Workshop.

> Worked with the GSA(Gay-Straight Alliance) to help spread inclusivity within our own club and school through presentations and anonymous threads.

> Partnered with volunteer organizations like the National Honour Society and Helping Hands to staff larger events such as our FLL tournaments.

A screenshot from a meeting with Wheeler's GSA

Partnering with the LGBTQ+ of FIRST

> Reaffirm our commitment to making FIRST robotics a place for everyone.

> The 3 CircuitRunners teams (FTC 1002, FTC 11347, FRC 1002) are the first and only teams in Georgia to become a partner of the LGBTQ+ of FIRST organization.

> Held club-wide informational meetings, and anonymous discussion threads.

> Pledged to be an ally and distribute LGBTQ+ of FIRST promotional materials/pins at our events and competitions, so everyone and anyone can feel comfortable in robotics.

LGBTQ+ of *FIRST*
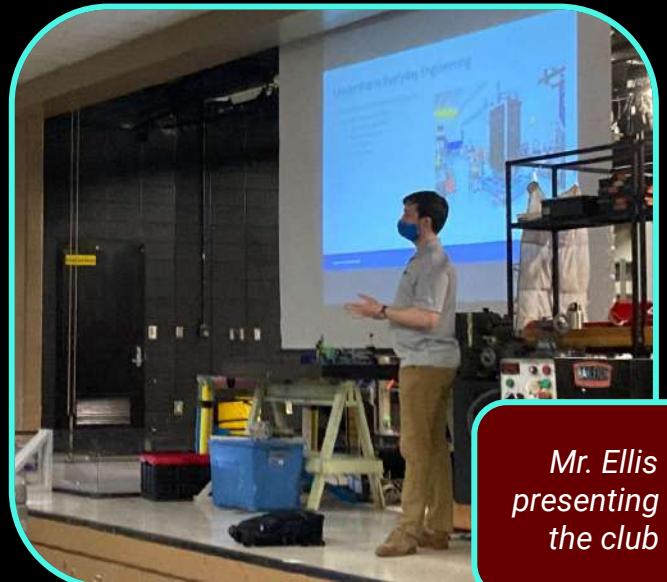
Working with Local Partners

> Spreading STEM and FIRST means working with our community to benefit both our team and the community.

> Work with Parker 3D Prints to print custom parts for our robot.

> Partnered with Legomatics to staff robotics themed summer camps, birthdays, etc.

Speaker Series

> Provide club members with an understanding of STEM careers and how STEM is applied in the real-world. We've reached out to 3 professionals in the STEM field, and plan to reach out to 7 more by April.

> Reached out to Mr. Connor Ellis of Lockheed Martin. As a Wheeler Alumni himself, he was able to give us valuable insight into how he went from a Wheeler Graduate to a professional in the field.

> Spoke with Mr. Tyler Peterson and Mrs. Sarah Hall from General Mills. It was eye-opening to see how wide the variety of career opportunities are in STEM.

> Plan to reach out to other engineers such as a consulting engineer from Coca-Cola, and Mr. Daniel Dobry Jr, a civil engineer from Croy Engineering.

Mr. Ellis presenting to the club

Contacting Former Ambassador John Rakolta

> Initiate action to be taken to assist the Afghan Girls Robotics team escape the country after the Taliban took over in August 2021.

> With FTC 11347 and FRC 1002, we wrote to Ambassador John Rakolta, the former ambassador to the UAE, to see if he could help them out of the country.

> We choose Mr. Rakolta because we felt his connections might allow him to better bring light to the issue, as well as the fact that he was a friend of an uncle of a CiruitRunners member.

> While we don't know if our efforts aided in the rescue of the team, they were evacuated successfully and safely!

CircuitRunners CAD Camp

> Host an intro-level, week long, CAD Summer Camp for middle school students.

> Marketed event to local middle schools and the incoming freshman class at Wheeler.

> Added more activities and improved lessons based on last year's feedback.

> Made pre-recorded tutorial videos for people to view if they missed lessons, or wanted to go back and rewatch explanations.

> Covered the engineering design process, 2D sketching, 3D extruding, and Assemblies

A screenshot from CAD Camp
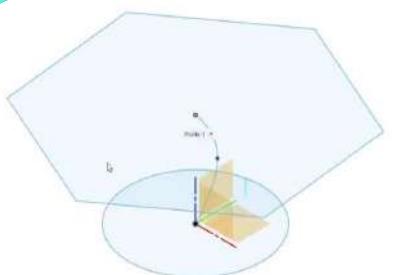
FTC Scrimmage

> Give opportunity for GA's Worlds teams to practice together before Worlds.

> Invited Georgia's Head Referee Ms. Lori O'Neal to lead strategy discussions.

> Practiced various in-game defense scenarios.

Hosting FTC Marietta League Meets

> Spend the day before and day of competitions working to pack up equipment and set up fields, pit tables, A/V equipment, etc.

**>** Scheduled meets to be paced out across the season
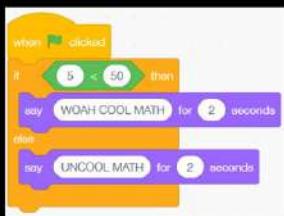
CT Hackathon

> Host a workshop for middle school students to learn basic programming through Scratch (block code), and allow them to apply their skills in a hackathon.
> Partnered with the Techno Titans (FRC 1683) and FTC 11347 to plan the event.
> Week long workshop with activities and lessons. Covered pseudocode and each type of Scratch block
> Hackathon submissions sorted by prior coding experience, and graded on: Program Sophistication, Aesthetic, Gameplay/Creativity, and Code Quality

A slide on If Else statements in Scratch

If Else Statements

If-Else statements are used in everywhere, and are a super useful programming concept.

Programming Outreach

> Assisted teams' programming efforts across the world
> Providing devices like control hubs and phones
> Giving example code and other resources
> Teaching concepts like setting up OpenCV pipelines
> Ryan makes contributions to Open Source Libraries, and is one of 22 contributors of the FTCLib Project

Teams Helped:

FTC Team 14275 Ctrl-Alt-Design (Katy, Texas, USA)	FTC 11347 CircuitRunners Blackout (Marietta, Georgia, USA)
FTC Team 14318 BioBots (Fremont, California, USA)	International FTC Team 20945 (Bangalore, KA, India)
FTC Team 14413 Trinity Tigers (New York City, New York, USA)	FTC Team 16131 Pebblebrook Rookies (Mableton, Georgia, USA)

Hosting FLL Events and Competitions

> Host a workshop to prepare FLL teams for their season, and host the FLL Qualifier and Super Regional Competitions
> We worked with FTC 11347 and FRC 1002 to host an FLL Workshop to help teams prepare for their competitions. We discussed Game Strategy, Robot Design, Judging Overview, Programming, Core Values, and advice from personal experience.
> Hosted the FLL Qualifier (with help from FTC 11347 and FRC 1002), with Nelitha serving as the event's Volunteer Coordinator. Additionally, Ryan hosted an FTC robot demo at the event!
> Hosted the FLL Super Regional Competition (with help from FTC 11347 and FRC 1002), with Nelitha again serving as the event's Volunteer Coordinator. Our team members served in a variety of roles, including judging, refereeing, and robot-game queueing.

Saahas teaching programming concepts at the FLL Workshop

Ryan shows our robot to an FLL team at the FLL Qualifier

Being an Ambassador for FIRST

> Our many outreach events and initiatives offer us the opportunity to bring knowledge of FIRST, FIRST Tech Challenge, and our team to the community.

> At events and whenever we interact with people outside of the club – STEM professionals for the speaker series, potential mentors, potential sponsors, legislators – we give a short introduction about CircuitRunners and FIRST.

> We host robot demonstrations at events to show people what we do as a high school robotics team.

> We work to ensure that FIRST is a place for everyone, regardless of race, gender, national origin, or economic status. Some ways we do this is by promoting LGBTQ+ Inclusivity and **bringing STEM to groups that typically don't receive much exposure to it** and tend to get pushed to the wayside, such as special education students and students of refugee backgrounds.

Who We Are

We are CircuitRunners Robotics!

- Nonprofit FIRST robotics organization based out of Wheeler HS.
- Our mission is to provide STEM-based learning opportunities to students and the community.
- We were established in 2002 with the start of FRC 1002
- ~55 Active Members!

CIRCUITRUNNERS ROBOTICS

CircuitRunnners Informational Slide from virtual events.
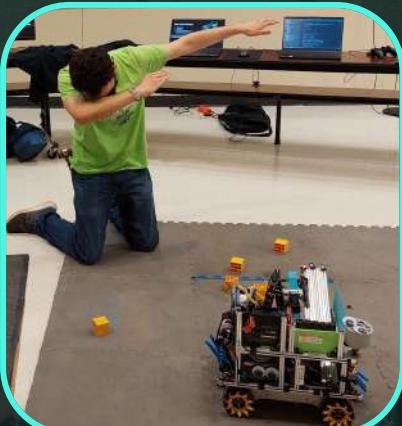
Sharing Portfolio and Advice

> Apply our own experience to help teams create a successful, winning, portfolio.

> After winning 1st Inspire at the Georgia State Championship, many teams came to us for advice on a successful portfolio.

> We shared with them our own portfolio for reference.

> We offered to review their portfolio using our own lessons learned.

Teams Helped:
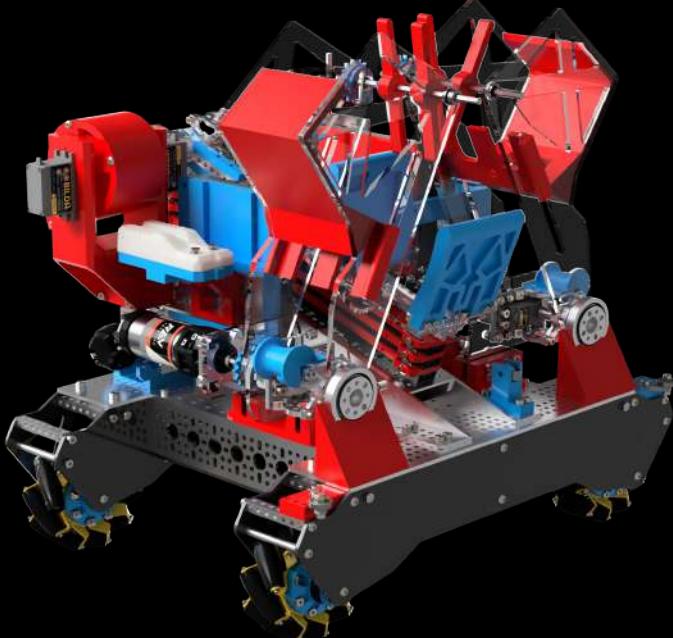
FTC Team 12762 Tech Titans (Alpharetta, GA, USA)	FTC Team 4221 Smíða Syndicate (Macon, GA, USA)
FTC Team 14473 Future (Fremont, CA, USA)	FTC Team 11212 The Clueless (San Diego, CA, USA)
FTC Team 12533 Inception (Austin, TX, USA)	FTC Team 12887 Devolt Phobos (Chihuahua, CHH, Mexico)

Wheeler High School Open House

> Reach out to incoming students of our school and show them CircuitRunners and FIRST Robotics.

> Gave demo of robot and let incoming students drive it.

> Answered parent and student questions.

> Displayed presentation on team information.

Having fun at the Wheeler Open House!

Addison Elementary Demo

> Demonstrate robot and show CircuitRunners and FIRST Robotics.

> Gave demo of robot and let kids drive the robot.

> Answered parent and student questions.

Nelitha demonstrating the robot at Addison Elementary.

Robot Overview

THE CHEESE GRATER
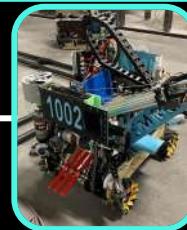
> Fully custom-designed drive base!
> **Unique side outtake for fast cycle times with limited movement.**
> 2.3" clearance crosses pipes, the spike, and freight!
> **Dual intakes to intake from both sides.**
> Corner mounted radial bearings for wall alignment.
> **Small Track-Width to pass through gap.**
> Gear reduction of 15.36:1 gives a free speed of over **70 inches/sec!**
> CNC-ed 1/8" Aluminum Plates.
> **Multitude of 3D-Printed parts using PLA, PETG, and TPU.**
> Machined 3/16" Polycarbonate Plates.

Robot Iterations

Tank Drive (Meet 1)

Mecanum Bot (Meet 2 - 3)

Smol Bot (Meet 4 - States)

GAME STRATEGY

General Strategy: Our robot cycles freight through the warehouse gap with minimal adjustments using our unique dual intake and side outtake design.

Autonomous

Cycle Auto

We scan and score the preload freight. We cycle to and from the warehouse into the top level

Driver Controlled

Alliance Hub

We will cycle to and from the warehouse gap into the top level of the Alliance Hub

Shared Hub

We will cycle to and from the warehouse gap in order to tip the shared shipping hub.

Endgame

Ducks

We score all the ducks and full park

Capping
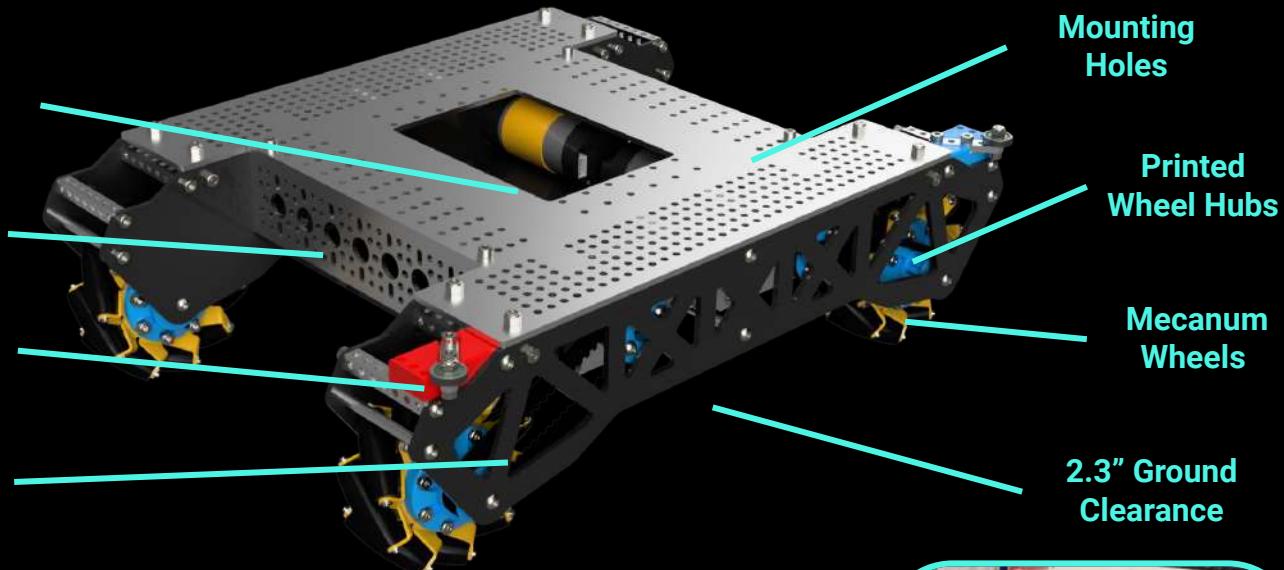
We cap our team shipping element and full park

Drive Base

Compact Wire Management Sections

12.5" Track-width

Corner Mounted Bearings

Custom CNC-cut Drive Plates

Mounting Holes

Printed Wheel Hubs

**Mecanum Wheels**

2.3" Ground Clearance
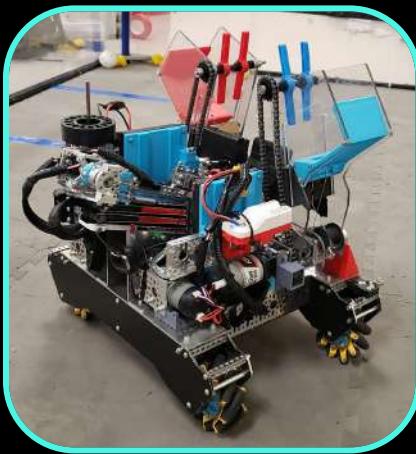
INNOVATIVE FEATURES

> **Small total width of just 12.5"** allows passage through the Warehouse and Shared Shipping Hub gap.

> **High chassis clearance** allows for passage over the **pipes, the spike, and cubes!**

> 3D Printed wheel hubs gives custom pulley sizes for a **15.36:1 gear reduction.**

> Theoretical **maximum velocity of 5.83 ft/s.**

> 1/8" Aluminum Side Panels.

> **Come see prototypes and examples of wheel hubs and plates in our pit!**

Calculating track width and wheel placement

Completed Robot

Lessons Learned: Using experience accumulated from previous iterations results in a design that is reliable and consistent.

Drive Base Progression Timeline

Tank Drive

Problem: *Mecanum Bot had difficulty maneuvering the field and could not fit through the gap*

Smol Bot
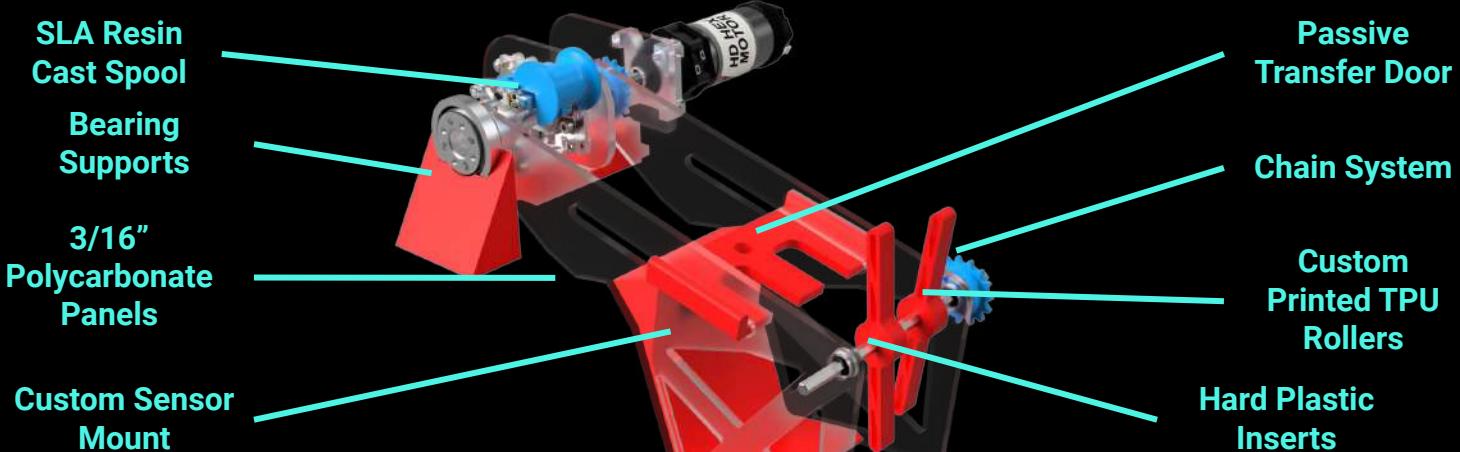
Problem: *Tank drive base was extremely slow and unwieldy*
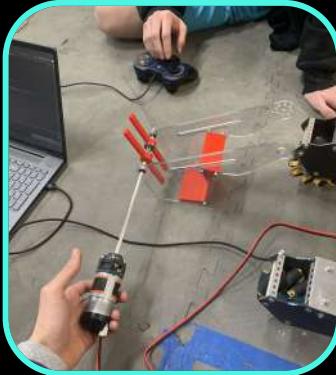
Mecanum Bot

Problem: *This drivebase was structured around ramp intakes which did not fit our new strategy*

Dual Intake

SLA Resin Cast Spool

Bearing Supports

3/16" Polycarbonate Panels

Custom Sensor Mount

Passive Transfer Door

Chain System

Custom Printed TPU Rollers

Hard Plastic Inserts

Four iterations of TPU intake flaps

Calculating intake speed
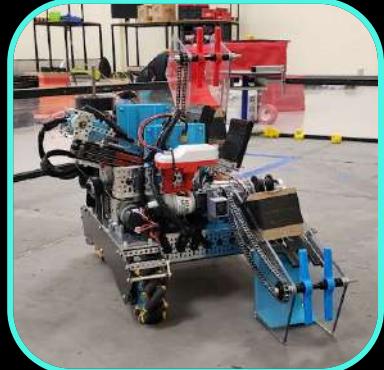
INNOVATIVE FEATURES

> Intake motors run at **470 RPM** with a freight intake time of **0.3 seconds!**
> **Accurate pivot** to quickly pass freight into the bucket.
> Passive Transfer Flap prevents launching.
> Door counter strung with **Resin-Cast Spool.**
> CNC-ed **polycarbonate side panels** for extreme durability and to reduce weight.
> **Custom 3D printed TPU elastic rollers** pocketed to reduce bending stress, with PETG inserts.
> Several types of intake rollers tested.
> **Come see roller iterations in our pit!**

Intake Testing

Lessons Learned: Prototyping and testing is as integral to the design process as the design phase.

Current Intake
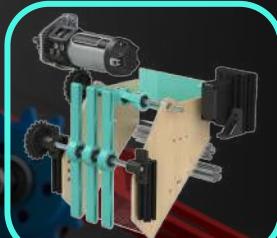
Intake Progression Timeline

Initial Claw

Problem: Rover Ruckus inspired intake was flimsy, prone to damage, and added additional complexity.

Ramp intake
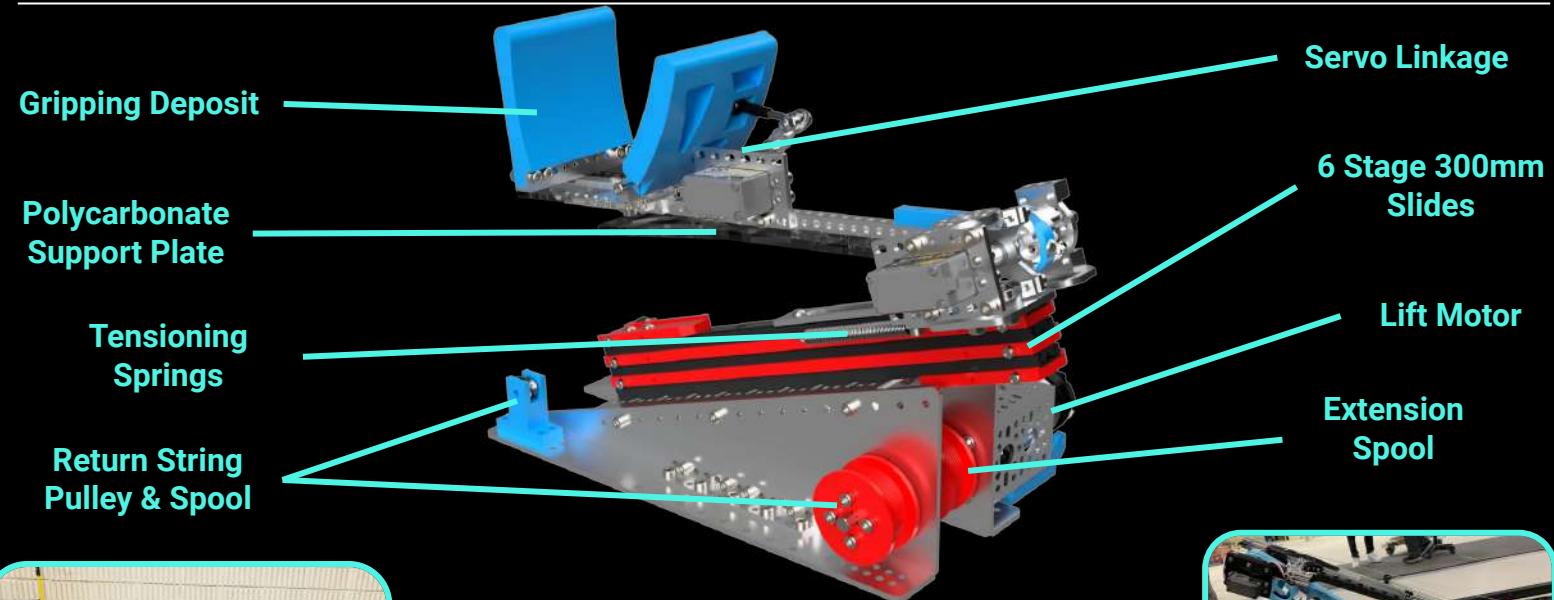
Problem: Claw is extremely precise and slow.

Flip Out

Problem: Intake could hold multiple freight.

Outtake and Deposit Scoring System

Gripping Deposit

Servo Linkage

Polycarbonate Support Plate

6 Stage 300mm Slides

Tensioning Springs

Lift Motor

Return String Pulley & Spool

Extension Spool
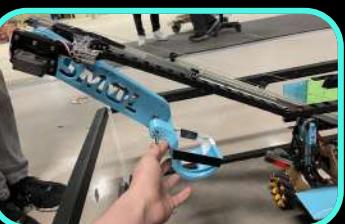
INNOVATIVE FEATURES
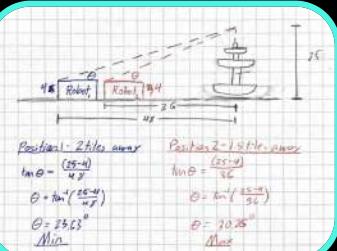
> **Side outtake can score without turning the robot!**
> Arm on end of lift for 12" of extra reach and scoring on all hub levels!
> **Shallow 18 degree angle allows scoring from the side wall.**
> Extension and return strings sprung to keep tension.
> Linear speed of **42.8 in/sec,** fully extends in **0.8 seconds.**
> Gripping deposit provides precision placement.
> Utilizes 6 stages of Long Robotics 300mm slides.
> **Come to our pit to see our lift in action!**

Calculating the lift angle

Lessons Learned: Taking the time to plan out a design reduces unforeseen mistakes and increases efficiency.

Completed lift and arm scoring system

Calculating the ideal motor gearing for lift speed

Outtake and Deposit Progression Timeline

Claw Deposit

Side Outtake V1

Problem: Our space constraints didn't allow for a fast enough lift system.

Problem: Claw was slow and too precise for a competitive game plan
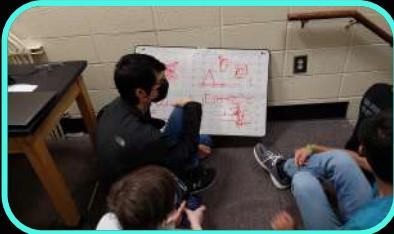
Back Outtake

*Problem: Arm was unbalanced and slide orientation created excessive leaning.*

Engineering Design Process

This is the **Engineering Design Process** we use throughout the season.
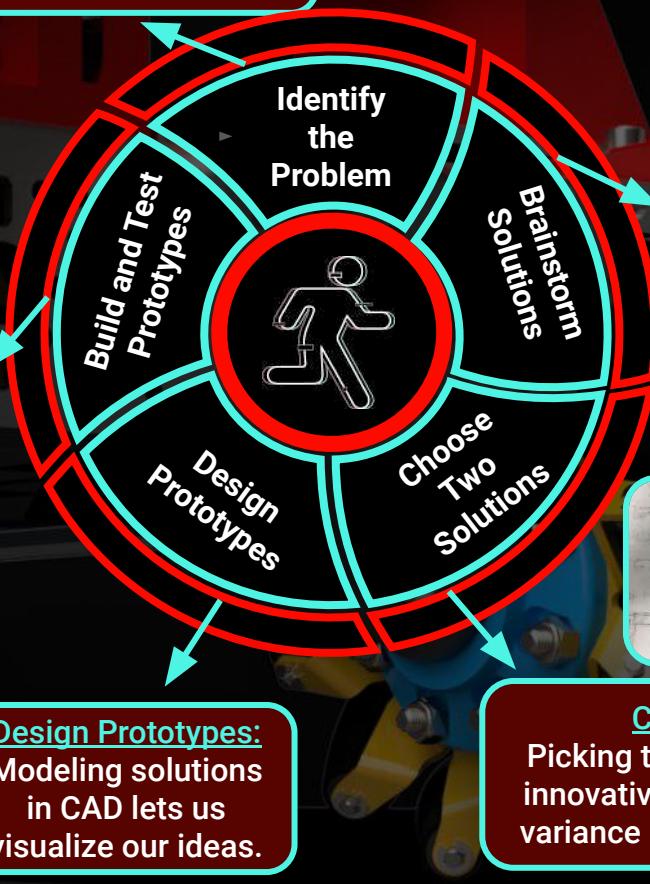
Identify the problem:
Identify the problem at hand.

Brainstorm Solutions:
Brainstorming as a group allows us to combine our individual skills and ideas to create an even better solution while involving the entire team.
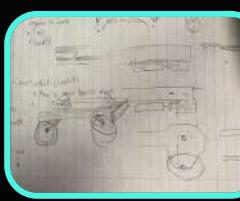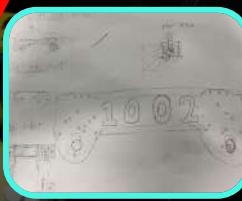
Build & Test:
Thorough testing can reveal potential problems with designs.

Identify the Problem

Brainstorm Solutions

Build and Test Prototypes

Design Prototypes

Choose Two Solutions

Choose Two Solutions:
Picking two solutions allows for more innovative and creative designs as the variance increases chance of success.

Design Prototypes:
Modeling solutions in CAD lets us visualize our ideas.

Field-Centric Drive

Forward   Forward

> **Instead of using traditional driving controls, we used field-centric drive to rotate the controls.**

> This control method works with the holonomic nature of our mecanum drive base to make the robot's forward direction always relative to the driver.
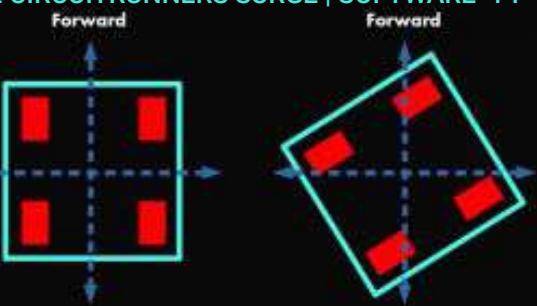
> This means that wherever the robot is pointed, if the joystick is pushed forward, the robot will go the same direction.

> How to convert:

> > Convert the translational controls to a vector, And find the heading of it.

> > Add the robot's current heading to the heading value of the vector
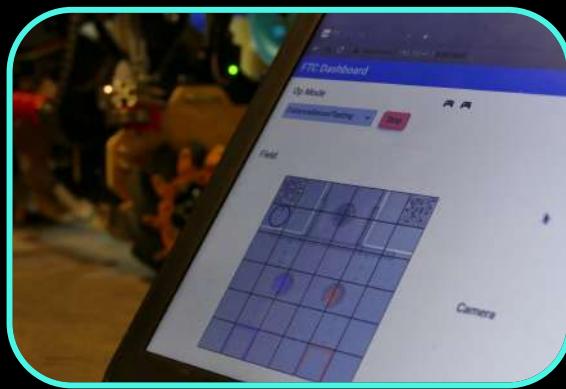
> > Then convert the new vector back to Cartesian, and pass on the new x and y as normal inputs.

Driving the robot with field-centric controls means the robot moves relative to the driver's view of the field
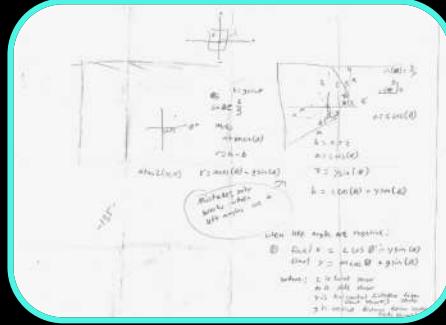
Distance Sensor Localization

One of our main goals this season was to be able to cycle consistently in the autonomous period. **One of the biggest initial points of failure we had with this was our localization.** Our drive encoder localization builds up drift over high speeds and sharp turns. **We used forward and side facing distance sensors to periodically localize in autonomous.** We used trigonometry to incorporate the robot's heading and calculate the position of our robot on the field.

Our initial ideas for the trigonometry math
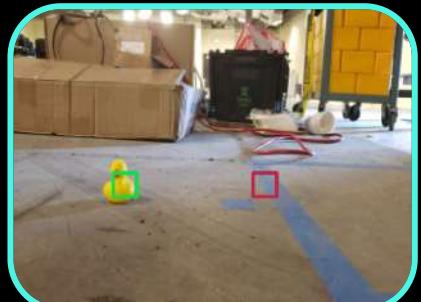
Full localization test of the distance sensors

We wrote an I2C driver to interface with an ultrasonic sensor

Marker Detection With April Tags
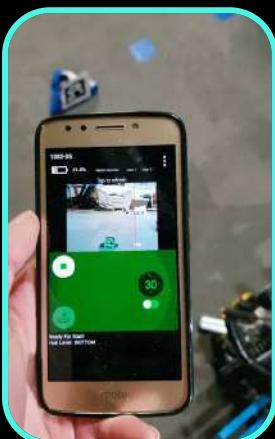
One of our autonomous goals is to consistently score the preload freight into the proper level. **We used an April Tag to detect our team marker at the start of autonomous.** This is a new vision strategy that emerged this season, and we decided to try it using a community plugin in the EasyOpenCv library.

Advantages of April Tags
> The robot will recognize the April Tag regardless of orientation.
> We have brought it seamlessly into many different lighting conditions.
> These factors allow it to be a very consistent way of marker detection.
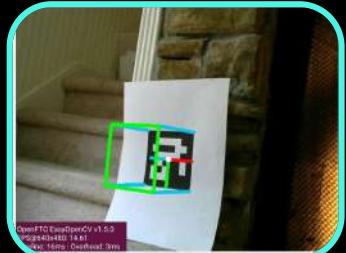
Our previous detection utilized sample regions that measured the average color values

Test of the April Tag detection on our team marker

April tag mounted on the marker

Initial testing of the detector