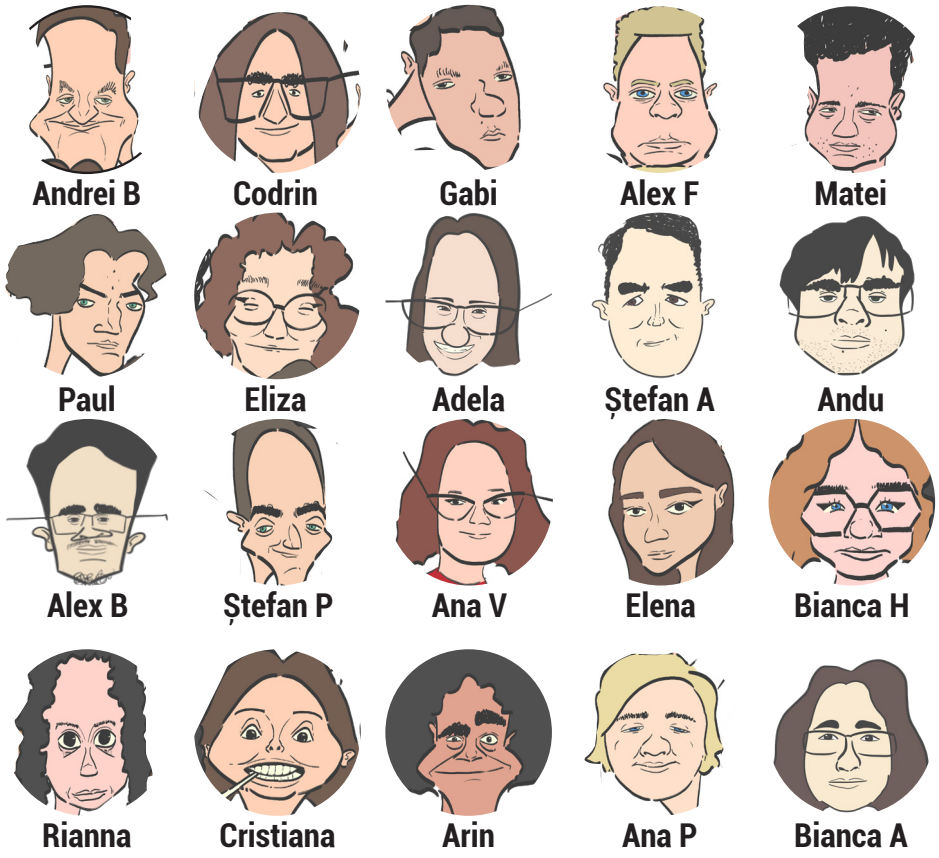
We are **team Peppers #19044 from the Computer Science High School "Grigore Moisil" Iași, Romania.** We have been part of the FTC community for four years, focusing our attention on **spreading the FIRST Core Values** and on implementing a strong sustainability plan and mentoring strategy. We have **15 members, 6 volunteers, 4 peer mentors and 7 mentors.**

GROWTH INDICATORS

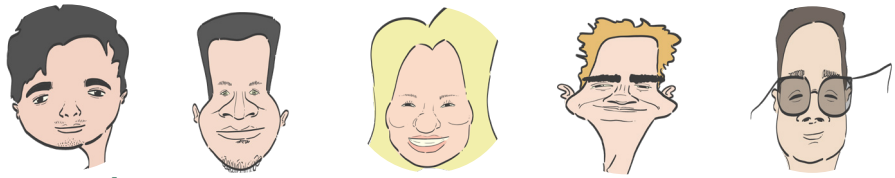
- **Team** - **over 90 members** and **12 leaders** flourished in the last 4 years
- **Impact** - We **have spread the FTC values** to **over 2700 teens** in our community, three times as many as last year;
- **Sustainability evolution** - **9 events**, **14** times **the financial resources** and a more **efficient distribution** of them;
- **Adaptability** - **growth rate of 442% in our social media presence**.



OUR MISSION

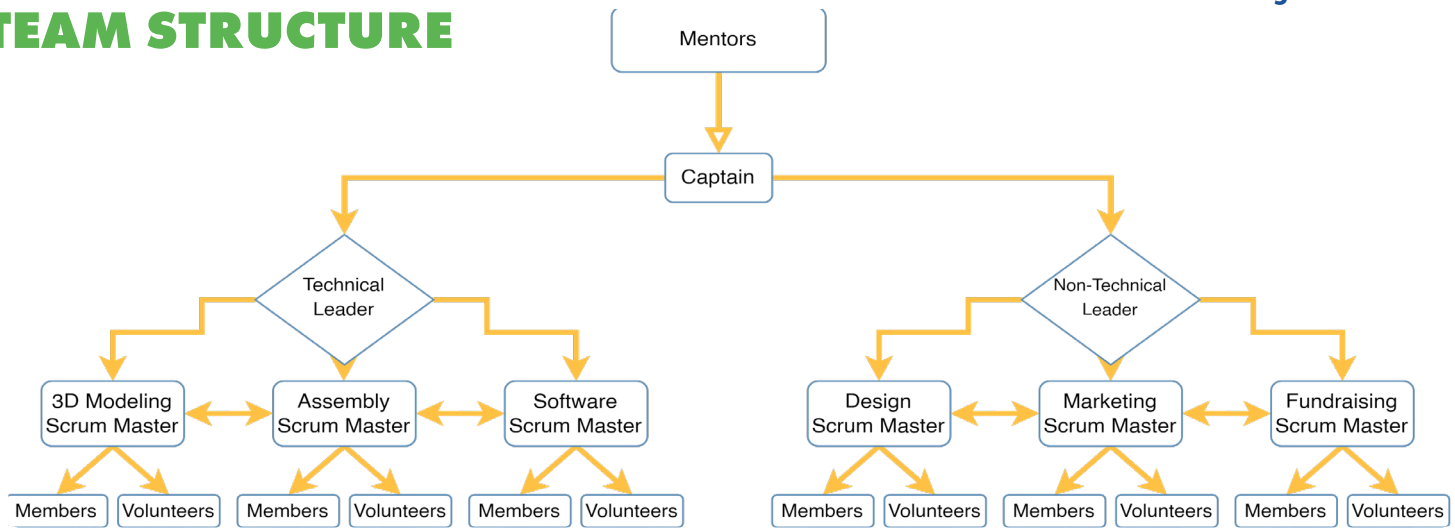
We aspire to become a STEM Hub for our local community and promote FIRST on a national level. This mission comes from the impact that hands-on learning had on us as individuals; we planned on achieving this by organizing and participating in events, mentoring and through outreach activities.

OUR PEER MENTORS



OUR MENTORS

TEAM STRUCTURE



TEAM VALUES

• **Discovery** - Our focus this season has been on **peer-to-peer education,** and we've made connections with **over 40 teams from around the world.** Through a range of activities, such as our **podcast, PeppTalks, scrimmages, events, and presentations,** we've been able to **discover and share new information.**

• **Impact** - Over the course of our initiative, we have **successfully promoted STEM through 9 events** that attracted **more than 2700 participants**. This effort was **built onto the foundation provided to us by our alumni** and received **invaluable support from our mentors, other teams and IT companies**. Furthermore, we had the privilege of **mentoring 50 children** in primary and middle school, through **two FIRST Lego League programs: Challenge and Explore.**

• **Innovation** - We aspire to be creative and to come up with **original ideas** which are showcased through our **robot design and building process**, as well as **our final robot design**.

• **Inclusion** - We actively **recruit people from the entire city**, not just from our school, while also focusing on potential rather than current skill level. We also aim to **integrate children from underpriviledged backgrounds into STEM** through the event **Gift a Robot**.

• **Teamwork** - We discovered that **strong bonds and effective communication between team members** are key elements to achieve our goals. Our **team structure** is well thought out, so that **every member gets to collaborate with people from other departments** and **learn bits of knowledge** from each of them.

• **Fun** - We take pride in enjoying every task we acomplish, while maintaining a great work-life balance.We also make sure to **spend time together in informal environments** by **celebrating birthdays together, organizing teambuildings, and discussing about each others' passions.**

THIS SEASON

GOALS	ACTIONS	RESULTS
•Increase our impact in STEM and FIRST comunities	•organized **4 major and 5 minor events** •**participated in 20+ events** •**posted constantly** on social media •held presentations and colaborations with **local NGOs**	•**2700 participants** at our events •followers number increased by **70%** on social media platforms compared to last season •**20,000 people reached** on social media in the **last 3 months**
•Involve ourselves in the learning process of children	•mentored **over 50 student**s for First Lego League competitions; •Peppers Christmas Special event •Gift a Robot event	• First Lego League awards: **Challenge Solution award & Coding Award** • **800+** children at Peppers Christmas Special • **200+** children at Gift a Robot
•Connect with robotics teams and STEM professionals from all around the world	•PeppTalks (other teams and STEM professionals) •participated in scrimmages and events organized by other teams and the community •reached out to companies	•connected with university professors •connected with **40+ teams** from all over the world •received trainings from IT professionalsmentoring from STEM related companies (Mobil Service, Heaven Solutions, WinMENTOR)

IN THE FUTURE

HOW WE PLAN ON ACHIEVING THEM

• **Recruit new members and start their training** - To be achieved by August 2023	• focusing on the **recruitment process on students in 9th grade** so that they can pass on our traditions and values, following our strategy and plan
• **Mentor First Carol Generation and CyberCarol for NextLab** - To be achieved by June 2023	• organizing **meetings with them 1-2 times per week** in order to monitor their activity and give them valuable advice
• **Revisit Schools from Gift a robot** - To be achieved by July 2023	• building **strong connections with the children** from those schools **through presentations**, therefore establishing a **greater learning environment** for them

TIMELINES

SEPTEMBER

- 5th - Disassemble last season's robot
- 10th - Kickathon robot
- 13th - Meeting FR
- 22th - First Bobot prototype
- 27th - Meeting marketing
- 28th - First Bobot Code

OCTOBER

- 6th - Heaven Solution visit
- 13th - Pepptalks meeting
- 16th - Peppween event
- 17th - Peppween event
- 19th - First robot CAD

NOVEMBER

- 3rd - Bobot upgrade & First autonomus
- First virtual four-bar prototype &
- 4th - PeppTalks F.R.O.G.
- 13th - First scrimmage
- 14th - Engineering meeting
- 16th - First robot prototype
- 18th - Second scrimmage
- 21st - FLL mentoring start
- Meeting Peppers
- 21st - Christmas Special
- 23rd - PeppTalks IT professional
- 24th - First odometry pods
- 25th - First 4 cone autonomy
- 26th - Third scrimmage

TIMELINES

DECEMBER

- 3rd - PeppTalks Matrix
- 8th - Moisil++ event
- 9th - Brainstorming and teambuilding
- 11th - Fourth scrimmage
- 17th - Fifth scrimmage
- 19th - Peppers Christmas Special event start
- 21st - First extendo prototype
- 28th - First 5 cone autonomus
- 29th - Marketing meeting

JANUARY

- 3rd - Robot rebuild
- 4th - Meetings engineering & general
- 5th - Field rebuild
- 8th - Sixth scrimmage
- 12th - Robot disassemble
- 13th - First pole guide & open odometry
- 15th - Finishing the robot for Regionals
- 23rd - Peppers++ meeting
- 27th - Peppers++ event

FEBRUARY

- 7th - Meeting for Regionals
- 13th - Regionals
- 18th - Meeting for Nationals
- 22nd - Meeting FR
- 26th - General meeting

MARCH

- 3rd - Nationals
- 7th - Meeting FR
- 13th - Meeting engineering
- 15th - Meeting for pit
- 19th - Quantum Championship
- 23rd - Teambuilding

APRIL

- 3rd - FLL Preparations for NextLab
- 6th - Team S.T.A.T.I.C #18996 meeting
- 8th - Robokings #12993 meeting
- 9th - The Inventors #20131 meeting
- 11th - Wolfpack Machina #18438 & KookyBotz #16379 meetings
- 12th - Java the Hutts #14725 meeting

--> non-technical timeline
--> technical timeline

THE PEPPERS BRAND

Our **team's brand** started with the **CyLiis Peppers** name, but in order to **better individualize** our identity within the **FTC community** we changed it to **Peppers.** Our approach when it comes to **teamwork** is based on using the **FIRST core values,** both **internally through our recruitment process and peer-to-peer mentoring,** as well as **externally through community events and outreach initiatives.**By showcasing the detailed work we've done, our accomplishments, and future objectives, we've established a **reputation of dependability among students, other FTC teams, local and national companies.** This has led to **financial support, mentorship**, and the **spread of our mission** on a national and international level.As a result, we managed to achieve great numbers on social media, at our events, and also in the competitions we participated in.

CyLiis PEPPERS → Peppers

OUR MASCOT PEPPIE

NON-TECHNICAL

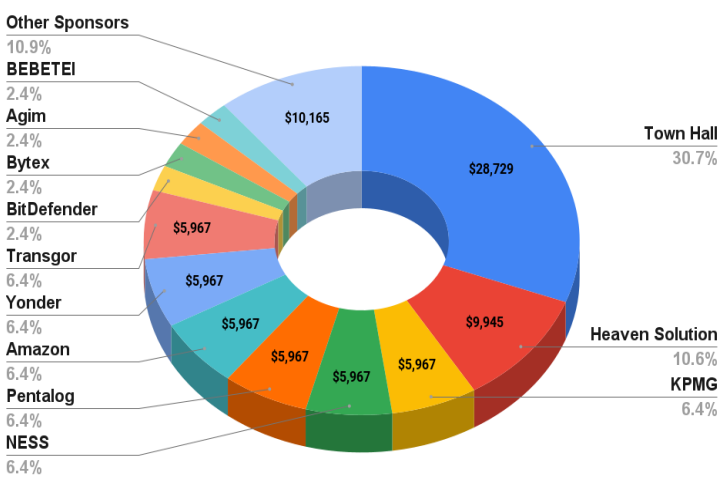
- 20,000+ people engaged
- 70% more followers
- 1700 followers on Instagram
- 442% rate of growth
- 8,700+ people from events we participated in

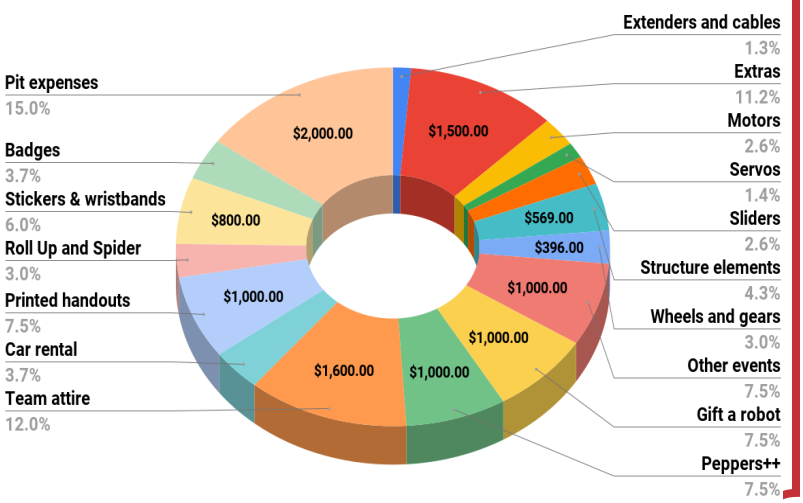
TECHNICAL

- 151.2 OPR at Nationals
- 252 solo points (with 1+5 auto)
- 75s full field completion
- 0.6s deposit time on low&mid junctions
- 1s deposit time on high

FUNDRAISING

This season, our goal was to raise all the funds needed by our team to compete. We raised a total of $106,354 throughout this season. From this amount, $93,454 were raised for the Worlds, from which we spent $73,336 ($20k on accommodation, $40k on transportation and $13,336 on team purchases) and remained with $20,118 to cover expenses while in the USA.





MENTORSHIP AND SUSTAINABILITY

FROM MENTEES...

TEACHER MENTORS

Mirela, our Computer-Science teacher, has been **guiding and supporting** us since the inception of our team. She not only taught us about the **coordination of team activities** and **events** but also about **planning and managing tasks and timelines** efficiently, enabling our members to develop valuable organizational skills.

Adina, the headmaster of our school, has been instrumental in providing us with **valuable fundraising knowledge**. She has been particularly helpful in **training** new members on how to **approach sponsors** and **create sponsorship packages** that offer something in return for financial support.

ALUMNI

Our team has also received support from **5 alumni** who continue to assist us. **Andrei** and **Cătălin** are our primary technical mentors, who have provided us with **valuable insights into physics concepts** to enhance our **robot design** and make it more robust. **Adia, George,** and **Radu,** on the other hand, guided us through the steps of the **team's organizational structure** and have initiated some of our team traditions such as **Peppers++** and **Peppers Christmas Special**. Their involvement helps us **maintain the team's purpose** while promoting our events to achieve our goals.

IT COMPANIES

To further expand our knowledge and expertise in IT, we have been seeking support from mentors with a background in this field. One such company we recently met with is **Mobil Service,** which has offered a range of **innovative ideas** to make our systems, including the claw, lift, and transfer, **faster and more efficient**. From **Heaven Solutions** we received **constant trainings** about **marketing, graphic design, team management** and **public speaking**.

TO MENTORS

This year, along with team CyLiis #19043, we created and mentored **3 First Lego League Teams**: **2 Explore** teams composed of **primary school students** and **1 Challenge** team with **middle school students**.

FIRST Lego League Challenge

We opened a First Lego League Challenge team, **Avocado Robotics,** composed of **13 members** divided into technical and non-technical departments. Coaches from our team and CyLiis#19043 guided the members in various tasks and offered emotional support. Although the team didn't make it to the national stage, they **gained valuable knowledge and experience**, leaving them **motivated** for the upcoming season.

CHILDREN MENTORED: 50

Achievements

The FLL Explore teams worked hard to bring to life the components of their board using Lego pieces for the national championship.

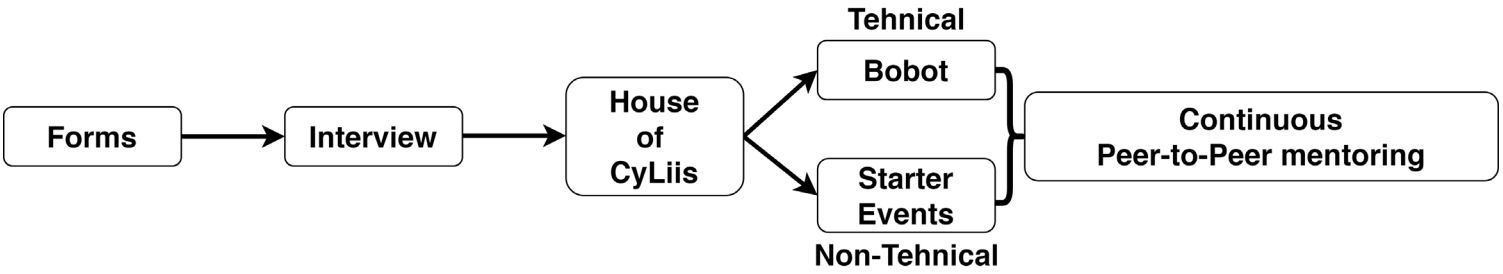
- **First Carol Generation** won the **Challenge Solution award** for their innovative eco-energy project;
- **Cyber Carol** won the **Coding award** for their impressive coding skills.

The experience opened the children's eyes to the **endless possibilities in FIRST program** and they are excited to continue the activity in the next seasons.

FIRST Lego League Explore

At the outset of our work with the 2 Explore teams, we encountered some unexpected challenges, due to our lack of experience. However, with the passage of time, the children began to show **increasing interest** in the information we were imparting. Currently, they are **actively engaged** in creating **two distinct projects** aimed at implementing green energy solutions within their school.

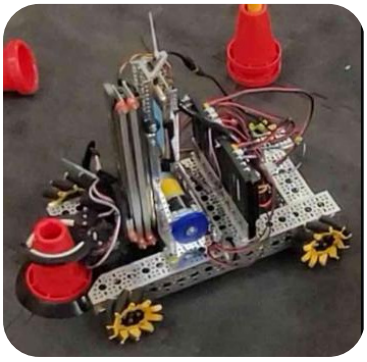
FOR NEW MEMBERS



We implemented a selection process that **ensures development**. We give the aspirant members the opportunity to sign up and join our team.
Over half of this year's members are rookies in this competition, so we needed to ensure that each and every member is **well-prepared and knowledgeable** in their field of work. We did this through an **interview-based selection process** followed by an event, organized for the third year in a row, **House of CyLiis.** After that, the new members receive **continuous training** depending on the department: **starter events for non-technical** and **Bobot for technical members**.

House of CyLiis

House of CyLiis is a **two-week long bootcamp** through which we **train the new members** interested in our activity as a team. We taught all the participants the **essential knowledge** we have collectively acquired with the help of our mentors and from the last editions of the event.



Members' trainings

Starter events

New members, primarily from non-technical departments, organize „starter events" with the **help and guidance of the older members and alumni.** During this time, they receive **training** on design principles, marketing, and fundraising strategies, with a particular focus on how our team is going to use them.

Bobot - rookie's robot

At the beginning of the season, the new members of the technical departments built their **first robot by themselves with guidance from older members and mentors,** which they named "Bobot". Throughout the building process, they were able to pick up new knowledge, practice and find solutions to their problems as a team.

Continuous peer-to-peer mentoring

Through our **mentoring meetings**, our members have learned **practical skills** related to working under pressure and with the need of great concentration. On the non-technical side, they have **discovered** the steps necessary to create a **brand identity**, from designing a logo to **creating** social media posts and promotional materials. On the technical side, they got to **develop** their 3D modelling, assembly and programming skills by first following the steps taken by the older members and understanding them. At that point, by **managing** to do them by themselves, they could focus more on finding **better solutions** for the problems the team encountered without the worry of not knowing how to do certain steps.

FOR NEW MENTORS

Our team's oldest members often become **alumni** after graduating high school because they want to stay **involved** in the program and **give back** to the new members of the team. Mentoring allows them to **share their knowledge and experience**, helping to develop the next generation of innovators and problem solvers. All this information can be used then in the **members' future careers.**
To attract new mentors, we **reached out** to local organizations, used social media, and hosted events to **showcase our work** and provide opportunities to meet **new mentors.** We participated in many such events during both **off-season and season** periods.

STARTER EVENTS

ECOPEPP

December 2022

To support the **sustainability** and well-being of the environment, we set out to organize an activity called EcoPepp. **5 robotics teams** from Romania created short videos presenting **their way of recycling.** We then posted all of them on our social media accounts.

Ecopepp

PEPPWEEN

October 2022

We organized a Halloween drawing contest with portraits of famous people in STEM thematically dressed up. This offered all the participants passionate about art the opportunity to **promote their artwork** on all the social media accounts we manage.

STEM EVENTS

PEPPERS CHRISTMAS SPECIAL

20-23th of December 2022

Peppers Christmas Special is an event organized right before the Holidays, with the intention of **promoting STEM education** among students in **primary and middle school.**

WHY?

We organized this event so we could take part in **younger students' development** through games and experiments, sparking their interest in STEM.

WHAT DID WE DO?

We prepared a presentation about the meaning of STEM, sharing with them interesting information about each field.

SCHOOLS: 4
CLASSES: 25
STUDENTS REACHED: 800+

Pepper Christma Special
Promoting STEM education

PEPPERS++

27-29th of January 2023

Peppers++ is a national **mathematics, physics** and **computer science contest** for middle schoolers. This year we held the **third edition.**

PURPOSE:

Prepare middle-school students to excel in STEM subjects.

REACH:
300+ students
800+ students since the start of the project
students from 53+ cities

PEPPTALKS

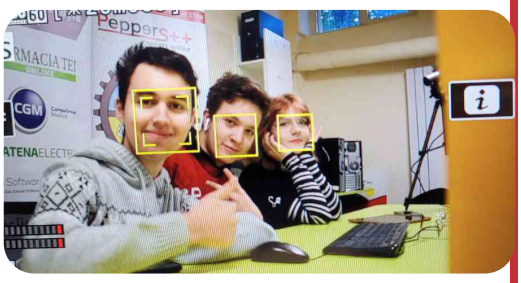
With the goal of **spreading the FIRST values** and **interacting with teams** from all over the world in mind, we decided to create a podcast through which we could **exchange ideas and experiences** with both international and local teams.

An IT professional's experience

We had the opportunity to talk to Mrs. Carmen, a **professional in IT**, who guided us and gave us valuable advice on how to **improve our public speaclallabking skills**, how to **give effective feedback** and **master assertive communication.**

WHAT DID WE LEARN?

Through this event we were able to both **share our knowledge and experiences** with the other teams, but also **pick up valuable pieces of information** that we later got to integrate in our **team management and workflow.** For example, from team **F.R.O.G. #10183** we understood that **taking the necessary breaks to build bonds and establish effective ways of communicating within the team** are the one key elements in achieving our goals.



REACH: 350+ people
COLLABS: 9 teams from 6 different countries
90,000+ minutes listened to

GIFT A ROBOT

February-April 2023

In the **unprivileged areas of Romania**, schools lack financial support, resulting in **poor education**, forcing students to move or commute to neglected state institutions. Our mission is to **empower** underprivileged children in isolated zones of our county by **providing access to technology**, **inspiring and motivating** them to reach their full potential, and introducing them to the **STEM community** through robotics. By **mentoring** these clubs we **spread FIRST values.**

Why?

THE RATE OF SCHOOL DROPOUT IN THE LAST 10 YEARS: 15%

THE RATE OF FUNCTIONAL ILLITERACY AMONG CHILDREN UNDER 15 YEARS: BETWEEN 45-50%

Source: PISA (Programme for International Student Assessment) - 2021

200+ children taught
7 schools visited this season
13 schools in total
3 schools opening robotics labs
1 school implementing robotics as optional classes

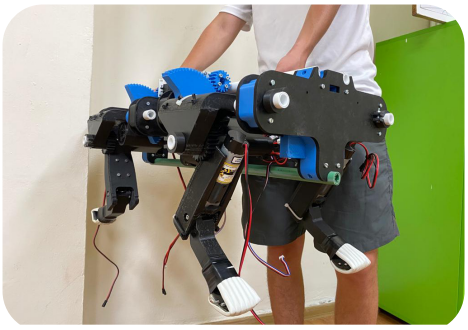
EVENTS WE PARTICIPATED IN

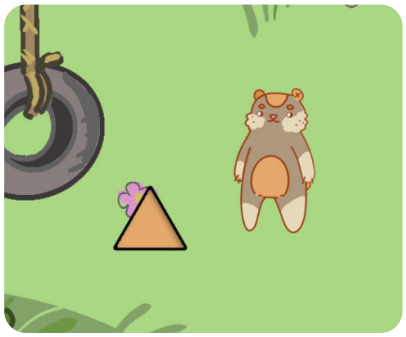
FTC Events
- Kick-Off
- Kickathon
- XeoTalks
- RoboFest
- Quantum League Iasi
- Zilele Roboticii
- Focșani Tech Challange Game of Robots
- Demo BraveBots x Hypercube
- Quantum League Cluj
- Quantum League Bucuresti
- 4Challenge Transilvania
- and other events

TOTAL : 20+

INFOEDUCAȚIE

We participated in the **Digital Innovation and Creativity Olympiad** with a robotic dog and an app that helps children learn about outer space through easy and fun games.



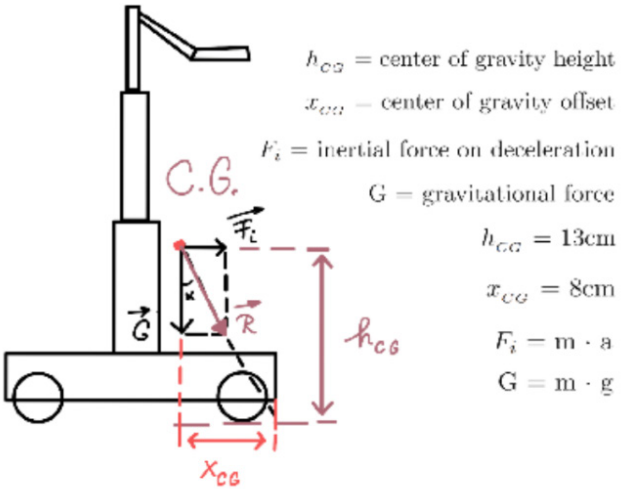


4IT50

4IT50 was an event in which a team needed to develop an app for **helping children with mental deficiencies** learn about **STEM.** Our app is called Geometry Hunt and its main goal was to introduce them in the world of geometry.

BRAINSTORMING AND ANALYSIS

At the beginning of our design process we discussed several ideas, taking into account effectiveness, part count, and price. We also made sure to conduct engineering analysis using theoretical physics to approximate the robot's maximum performance. For instance we used calculation similar to those attached in order to estimate the maximum acceleration and deceleration for our robot without it tipping over. We used the same process to figure out the best gear ratios for powering our drivetrain and lift.



h_{CG} = center of gravity height

x_{CG} = center of gravity offset

F_i = inertial force on deceleration

G = gravitational force

$h_{CG} = 13\text{cm}$

$x_{CG} = 8\text{cm}$

$F_i = \text{m} \cdot \text{a}$

$\text{G} = \text{m} \cdot \text{g}$

$$\text{tg}\alpha = \frac{F_i}{G} \leq \frac{x_{CG}}{h_{CG}} \Longrightarrow \frac{m_a}{m_g} \leq \frac{x_{CG}}{h_{CG}} \Longrightarrow \text{a} \leq \frac{x_{CG}}{h_{CG}} \cdot \text{g}$$

$$\Longrightarrow \text{a} \leq \frac{8}{13} \cdot 9.81 \frac{m}{s^2} \Longrightarrow \text{a} \leq 6 \frac{m}{s^2}$$

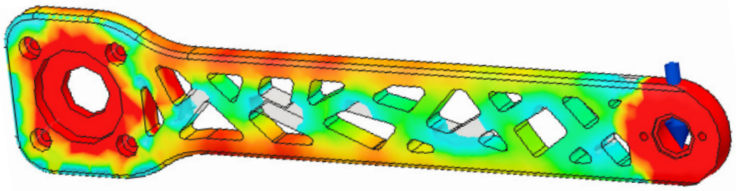
MODULARIZED CODE

Splitting up classes in Android Studio by hardware components. **Finite State Machines** allow us to **optimize all modules separately** and then integrate them into a larger system with ease, also helping us introduce **driver macros and automation**.

HARDWARE

RAPID PROTOTYPING

We use Computer-Aided Design (Fusion 360) to create digital prototypes. Our robot is mainly comprised of 3D printed parts and goBilda components to ensure modularity. Our 3D printers allow for fast iteration and testing of our designs. We used Fusion 360's Material Analysis function to test the design of our final parts.
This allowed us to calculate the **best weight to durability ratio, print orientation, and infill density for optimal strength.**



SOFTWARE

OPTIMISED FOR RELIABILITY

We used a well-known reliable library called RoadRunner for our autonomous trajectory generation, which we modified to work in conjunction with our **Finite-State Machines.**

GAME STRATEGY

- We built a **small, fast, and maneuverable robot** to get as many ownership points as possible.
- Our goal was to be able to **score on all poles with ease**.
- Ability to **traverse over the ground junction** to **maximize flexibility** in movement.
- We coded a **fast and reliable autonomus** to ensure a high TBP.
- We **automated almost all subsystems** in our robot to reduce human error.

PROGRESS

POWER PLAY KICK-OFF

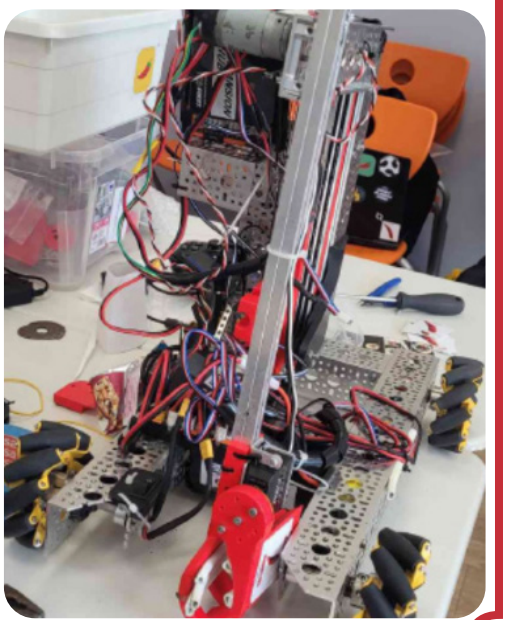
We started our Kick-Off at Quantum Kickathon, a Hackathon-style event where we needed to **build a robot in 16 hours** to compete in a scrimmage at the end. To minimize build time, we used our Chassis from Freight Frenzy, which featured 312 RPM Motors and a 2-stage lift with a motor that moved an arm. For picking up the cones we used a 3D-printed hand-like arm powered by one servo.

STRENGTHS:

- The robot's reduced width (13.5 in) increased its maneuverability;
- Our cone-lifting assembly was modular and smooth because it used linear slides and a pulley system.

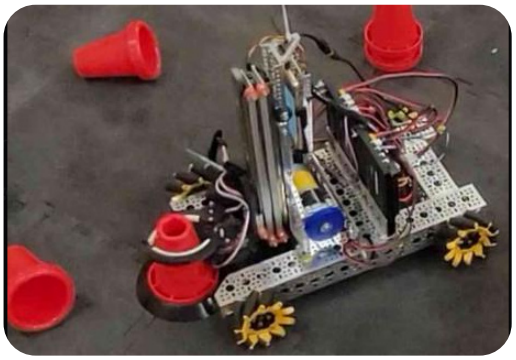
WEAKNESSES:

- Our chassis was too long to easily fit in tight spaces;
- The lift was slow and unstable at maximum height;
- Our inefficient claw design meant we would knock down many cones;
- A lot of unnecessary movement was needed because or robot picked up and delivered cones on the same side.



BOBOT POWER PLAY

The "Bobot" is the prototype built by **this year's recruits** so we could teach them **our main robot design process**. They learned how to use hand tools, 3D printers, Fusion360, Android Studio, and standard FTC parts. The initial version of the Bobot featured the same chassis used in the Quantum Kickathon, plus a more robust 3-stage lift that solved the need for an additional arm to reach the high pole. The claw at the end was 3D printed and controlled by two servos.



STRENGTHS:

- The design was minimalistic, allowing for further shrinking and shortening;
- The improved claw design gripped cones firmly, reducing drop rates.

WEAKNESSES:

- The claw had synchronization issues because it used 2 servos to open and close;
- The lift wobbled too much and got stuck often;
- The length of the robot remained a problem for navigating around junctions, even after eliminating the cone-grabbing arm.

BOBOT V2

For the improved version of the "Bobot", we replaced the steel linear slides in the lift with aluminum Misumi SAR-230s, which were **lighter and more rigid.** We also shortened the chassis for better maneuverability, so the final chassis dimensions became 13.5 x 13.5 inches.

STRENGTHS:

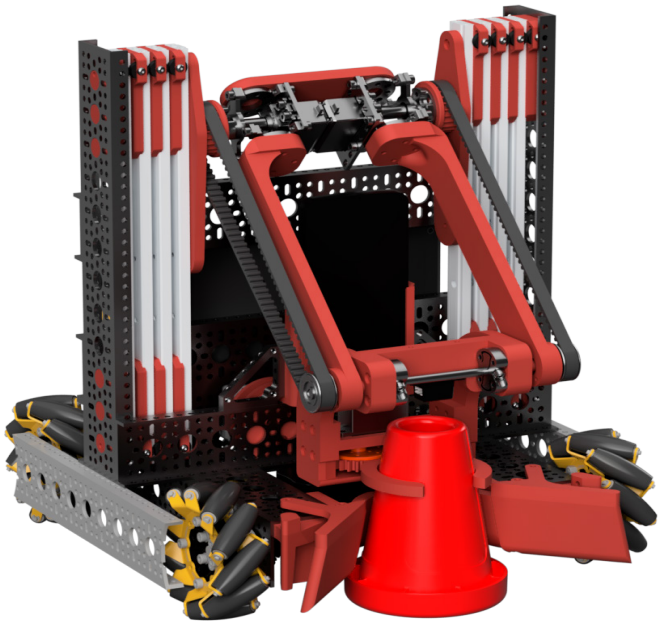
- The shorter wheelbase provided great agility and precise movement;
- The higher-quality slides did not get stuck, increasing reliability even during robot-to-robot contact.

WEAKNESSES:

- The robot did not have any localization, making it largely unable to score during the autonomous period;
- The absence of a retraction string limited the speed of the lift;
- The single stacked-slider design continued to be unstable and still used the same side of the robot to pick up and deliver cones.

ROBOT V1

For the first iteration of our main robot, we modified the lift to feature a **Virtual Four-Bar (V4B)** so we could **pick up cones on one side** of the robot and **deliver them on the opposite side**. This eliminated the need to spin our robot 180 degrees for cone scoring, significantly **increasing our speed**. We also implemented most of our **autonomous functions** and assists at this stage.



STRENGTHS:

- Scoring became **easier and faster**, as we no longer needed to turn 180° between cone pick-up and delivery;
- By attaching the lift to the chassis on two sides, we significantly **increased its strength and reduced its wobble**;
- The **speed of the lift increased**, as it was equipped with a retraction string.

WEAKNESSES:

- The robot could tip over due to inadequate weight distribution;
- The software was not optimized and ran inefficiently, limiting scoring potential;
- The wheels got stuck in fallen cones.

ROBOT V2

For our second prototype, we added 3 odometry modules, each containing an omnidirectional wheel and a REV magnetic encoder. These were used to localize our robot during the autonomous period.

STRENGTHS:

• The robot could independently locate itself within the field, increasing the reliability of autonomous operation;

WEAKNESSES:

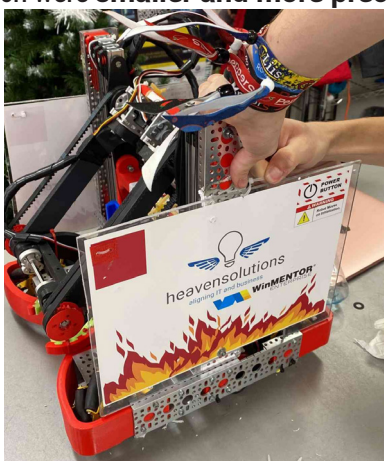
• The transition from auto to teleop had software problems;

• The odometry modules could get stuck in the ground junctions;

• The 3D-printed omni wheel mounts had a lot of play, thereby diminishing positional accuracy;

ROBOT V3

The third prototype featured an **improved cone intake funnel** that was integrated into the front wheel bumpers. We also added plexiglass sidewalls, on which we displayed our team numbers, alliance markers, sponsors, etc. The new walls gave us more protection for the REV Expansion Hubs. We also installed redesigned odometry modules, which were **smaller and more precise**.



STRENGTHS:

• The teleop mode was very optimized, as it was equipped with many **driving assists**, and the **robot transitioned smoothly** from **autonomous to teleop operation**;

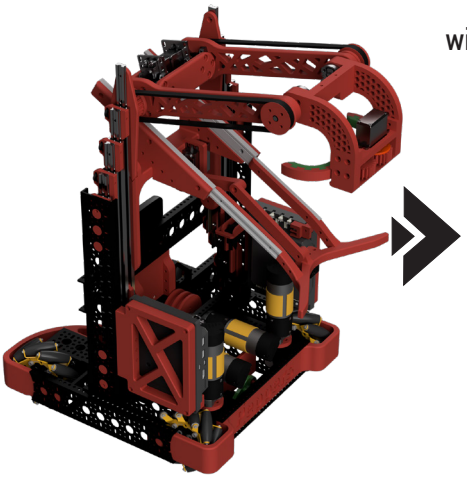
• The robot was **very agile and reliable**, and, due to the new bumpers, it could no longer get stuck in fallen cones;

WEAKNESSES:

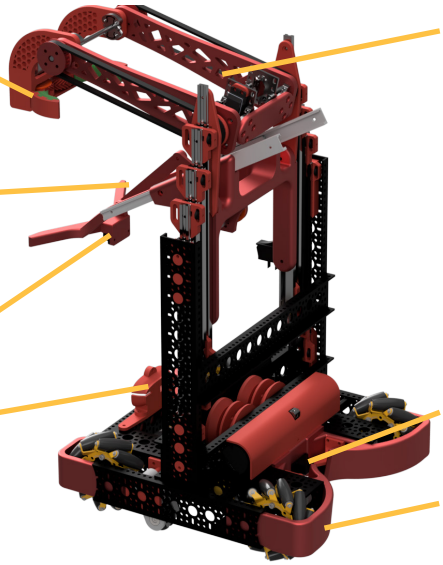
• The improved odometry was yet to be tuned, so autonomous scoring was highly dependent on the starting position and angle;

• The robot needed to avoid going over ground junctions because the odometry could get caught in them.

ROBOT V4



ROBOT V5



CLAW
with a custom silicone mold

POLE FUNNEL
aligns the junctions with the robot

COLOR SENSOR
detects the junctions

WEBCAM
front camera for object detection

VIRTUAL FOUR-BAR
with a skeletonized robot arm and speed servos

DISTANCE SENSOR
to detect incoming cones

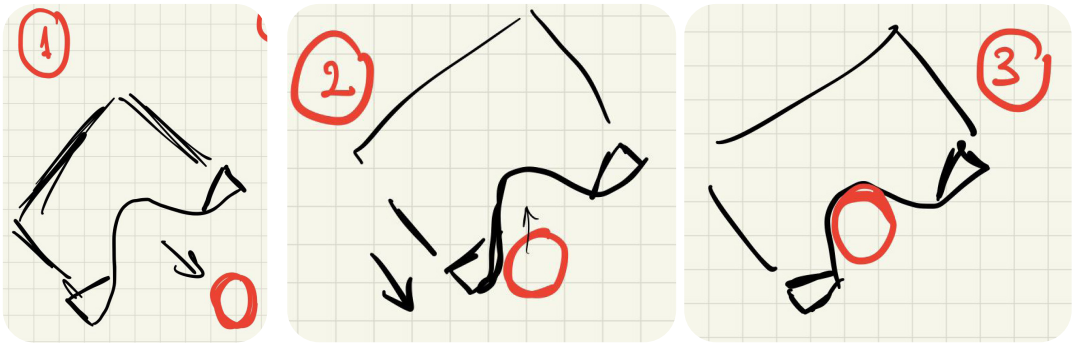
FUNNEL
to guide the cones

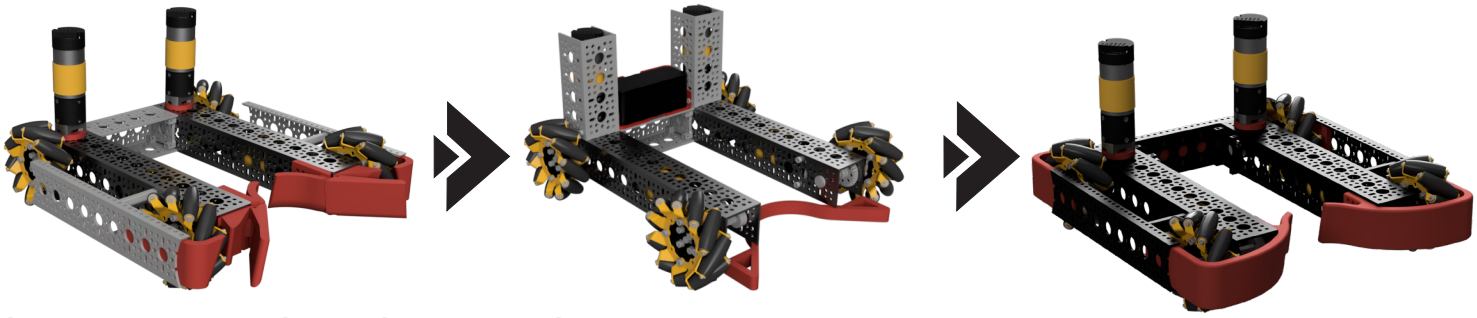
For the Worlds we wanted to **make our robot even more reliable**. Thats why we moved our motors under the chassis, helping us relocate our center of mass. One more thing that was improved is the change to using a **Control Hub.** This helped us use only 2 odometry wheels, because the Control Hub IMU is much faster than the Expansion Hub IMU. The Control Hub is also much faster at running our code, **improving our time between the actions**.

CHASSIS

Our chassis is made of standard goBilda elements complemented by 3D-printed bumpers and a cone funnel to intake the game elements without making them fall over. We used mecanum wheels which are powered by 435 RPM motors for maneuverability around the junctions, giving us a theoretical **top speed of 2.18 m/s**.

CHASSIS- concept drawing





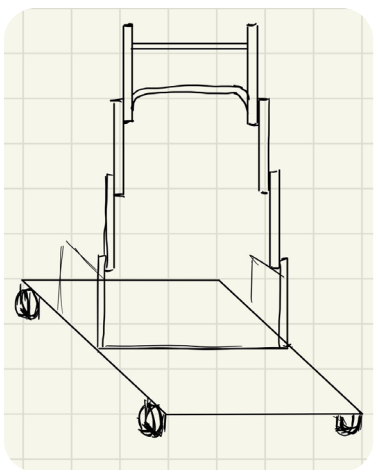
CLAW - TOUCH IT OWN IT

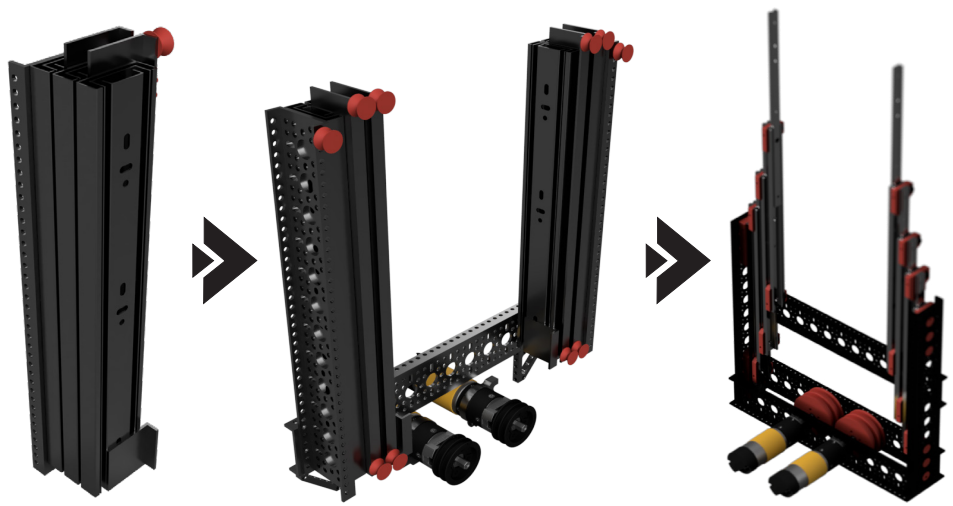
Our claw is one of our **most iterated-on mechanisms**. It is directly driven by a Speed servo, using 1:1 gearing to ensure synchronous, symmetric operation of its fingers. We used two custom made **silicone molds** to **strengthen the grip** of our claw. The 3D-printed part and the silicone are connected by a jigsaw joints. We also skeletonized the side plates of our claw assembly to make the lift lighter. Under the claw, we have a **proximity sensor** that detects when a cone enters the robot and **automates the pickup process.**

ELEVATOR

Our elevator consists of two modules, each containing 4 Misumi SAR230 slides with 3D-printed inserts that hold them together and provide mounting points for the string pulleys. The string is attached to a 45 mm winch pulley which is powered by 435 RPM motors, giving us a theoretical **extension top speed of 1 m/s**.

concept drawing

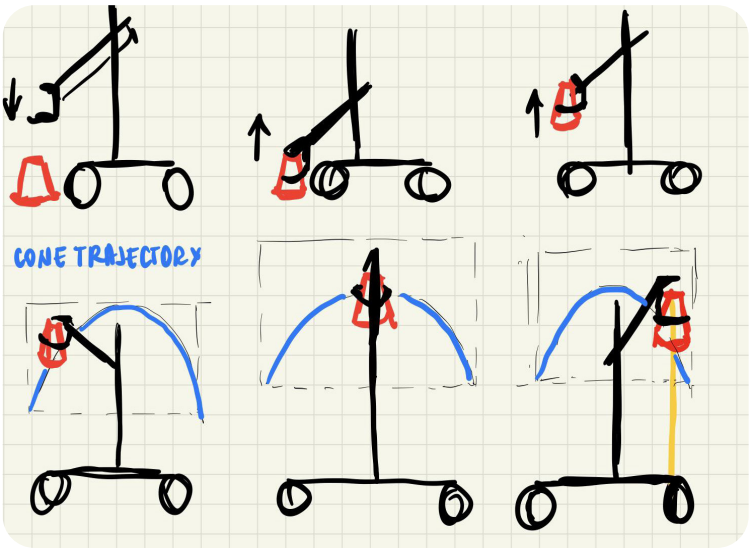




ARM- THE TRANSFER

Our arm is composed of a virtual four-bar that is powered by two servos. We use the virtual four-bar to **keep the cone parallel to the ground at all times**. The virtual four-bar works by creating a virtual parallelogram with the belts and pulleys. As a result, its opposite sides will always be parallel. The body of the arm is also **skeletonized** to maintain a **low weight**, enabling it to reach its "release" position in **less than a second**. We also use **surgical tubes** to **tension the arm** and **decrease the required servo effort**.

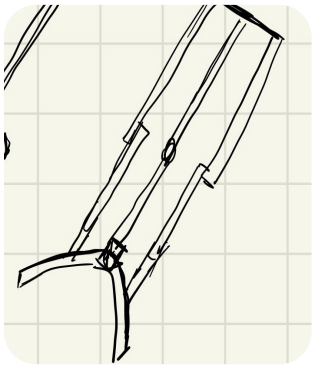
concept drawing

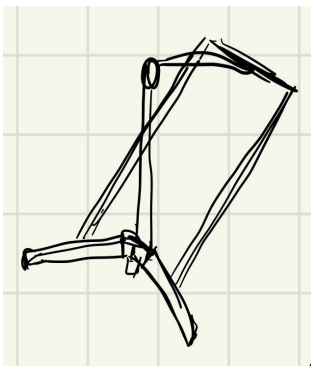


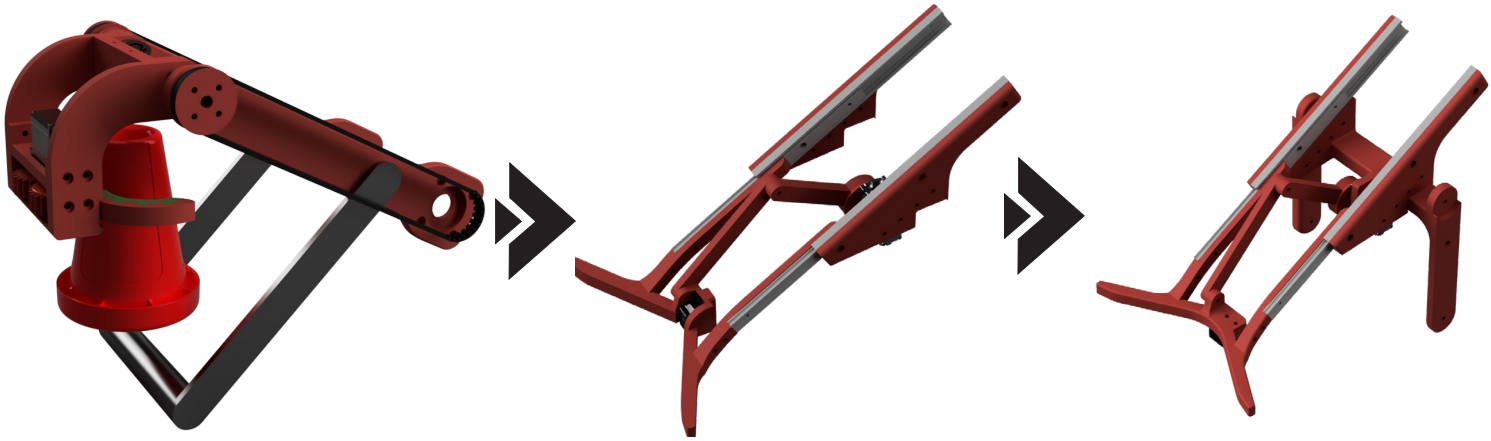
POLE FUNNEL

concept drawing

The pole funnel, or, as we like to call it, the "Aim assist", is a 3D-printed funnel that we use to **align our robot with the junction**. The funnel is mounted on two Misumi SAR 220 slides that we extend via a **linkage**. At the end of the funnel, we use a **proximity sensor** to **detect the pole** and further assist the driver with scoring cones.

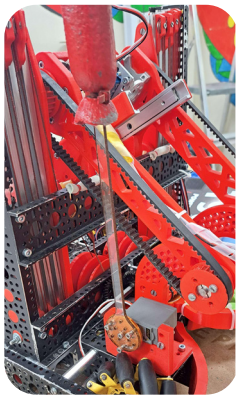




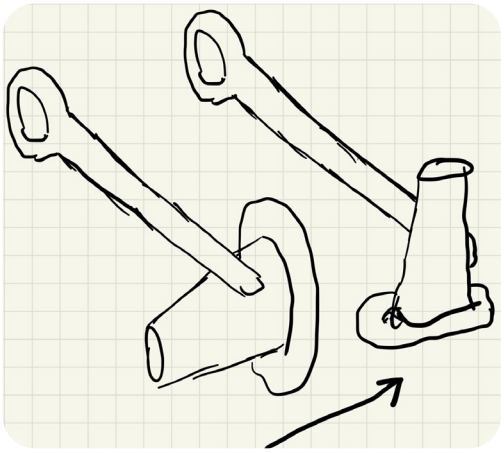


CONE REVIVAL SYSTEM (C.R.S.)

Although our drivers are very precise, it is almost inevitable that they, or our alliance partners, will tip over some cones, preventing us from scoring them. This is an issue because our robot alone can score **all the cones in under 2 mins**. To regain access to tipped-over cones, we came up with the C.R.S., an innovative polycarbonate arm covered with a soft sponge connected to a servo. It is **flexible, fast, and reliable** in repositioning cones, and we can lift it up when it is not in use.



concept drawing



IT'S NOT A BUG IT'S A FEATURE

AUTOMATISATIONS

To increase the number of points we are able to score during a match, we have automated almost all processes, besides deciding when the cones are released, the height at which the lift is raised, and driving the robot around the field.

TELEOP

A **colour sensor** placed **under the claw** detects a cone's presence and **automatically picks it up**. Finite-State Machine computations clearly define the state of each robot mechanism, allowing the robot to drive the elevator, pole guide, and virtual four-bar simultaneously. A proximity sensor at the end of our pole guide detects contact with the junction and facilitates pole-to-cone alignment.

AUTO

The two odometry modules measure movement in the XY plane and continuously calculate the robot's location and orientation, alongside with the Control Hub's gyroscope, enabling it to pick up and deliver all the cones. We've developed a **custom Pure-Pursuit** algorithm that enables the robot to follow efficient trajectories by independently adjusting its heading and speed vector via three custom PID controllers.

AUTO OBJECTIVE

This year our autonomous objective was to make a **very consistent auto**, while also trying to reach the **highest score possible**.

Problems encountered:
- the **size of the odometry pods** as they were to big for our chassis
- had issues **determining the heading** with just the wheels, their wrong placement would cause the atonomy to fail

Sollution:
- replacing the old odometry wheels with **new, smaller ones**
- using the **Control Hub's gyroscope**, to measure the robot's turning angle

NEW AUTONOMY

Due to the problems encountered with the old autonomous, we reprogrammed the robot to score five cones on the high pole closer to the alliance station and one on a middle pole.

Old auto problems:

- Encountering other robots at the center line
- Robot moved the stack

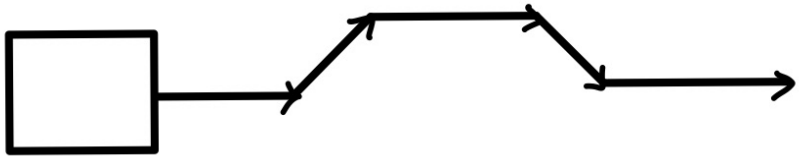
Problems encountered while reprogramming the autonomous:

- Odometry prone to drift
- We couldn't integrate the sensors into RoadRunner
- Inconsistent realignment speeds

Solutions:

- We used our own custom auto code alongside RoadRunner
- We used two color sensors to align with the line under the cone stack
- Inconsistent realignment speeds

PURE-PURSUIT



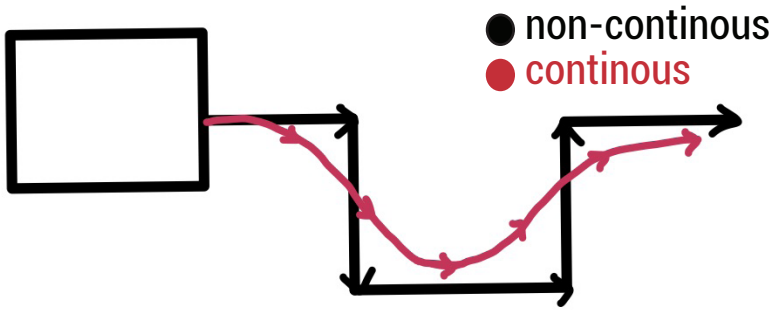
PROBLEM

Lacks continuity.

GOAL

Create a path following algorithm for better customization during the autonomous period.

Sollution: a path-following algorithm called pure-pursuit that takes in a non-continuous path as input and creates a simple continuous path.



The **spline** is made by creating a **circle** from the **center of the robot** and computing where it intersects the **path** and then making the **robot drive toward that point**. The calculations have to be redone at **every control loop**.

$$\left.\begin{aligned} y &= m \cdot x + n \\ y^2 &= r^2 - x^2 \end{aligned}\right\} \Rightarrow \begin{aligned} m^2 \cdot x^2 + 2 \cdot m \cdot n \cdot x + n^2 &= r^2 - x^2 \\ x^2 \cdot (m-1) + x \cdot (2 \cdot m \cdot n) + n^2 - r^2 &= 0 \end{aligned}$$

$$\Delta = 4 \cdot m^2 \cdot n^2 - 4 \cdot (n^2 - r^2) \cdot (m^2 - 1)$$

$$x = \frac{-m \cdot n \pm \sqrt{\Delta}}{2 \cdot (m^2 - 1)}$$

=> LINE DOESN'T INTERESECT THE CIRCLE (ERROR)	=> LINE INTERSECTS THE CIRCLE IN 1 POINT	=> LINE INTERSECTS THE CIRCLE IN 2 POINTS

After we find the **intersection** of the **circle and the path** we calculate the **necessary motor power** needed to drive in that direction. For this, we **first translate the coordinates to be robot centric**.

ROBOT CENTRIC COORDINATES

$$x_{error} = (x - x_{robot}) \cdot \cos\alpha + (y - y_{robot}) \cdot \sin\alpha$$

$$y_{error} = (y - y_{robot}) \cdot \cos\alpha + (x - x_{robot}) \cdot \sin\alpha$$

To control our **holonomic** drivetrain we have **three** coefficients: **drive** (how fast the robot needs to drive forward), **strafe** (how fast the robot needs to strafe right), and **heading** (how fast the robot needs to turn).
For every **coefficient**, we have a custom **PID controller** to get to the target point as **efficiently** as possible. The formulas for them will be:

$$\text{drive} = k_{p1} \cdot e_x(t) + k_{i1} \cdot \int_0^t e_x(t) + k_{d1} \cdot \frac{d}{dt} e_x(t)$$

$$\text{strafe} = k_{p2} \cdot e_y(t) + k_{i2} \cdot \int_0^t e_y(t) + k_{d2} \cdot \frac{d}{dt} e_y(t)$$

$$\text{heading} = k_{p3} \cdot e_h(t) + k_{i3} \cdot \int_0^t e_h(t) + k_{d3} \cdot \frac{d}{dt} e_h(t)$$

$k_p, k_i, k_d \implies$ Coefficients in PID

These values are good, but because the **voltage** sent to the motors from the Expansion Hub is a **fraction of the battery's total voltage**, motor speeds will not be **consistent** in **different** matches.
For this, we use **voltage compensation** on the motor **powers** to make sure the robot runs at the **same speed** no matter what **voltage** it gets from the **battery**.

NAIVE POWER OF THE MOTORS

$$\text{frontLeftMotorPower} = \text{drive} + \text{strafe} + \text{heading}$$

$$\text{frontRightMotorPower} = \text{drive} - \text{strafe} - \text{heading}$$

$$\text{backLeftMotorPower} = \text{drive} - \text{strafe} + \text{heading}$$

$$\text{backRightMotorPower} = \text{drive} + \text{strafe} - \text{heading}$$

OUR IMPLEMENTATION

$$motorPower = \frac{(drive + strafe + heading) \cdot 12}{batteryVoltage}$$