ENGINEERING PORTFOLIO

MEGIDDO LIONS 18833

Science Technology Education

MEGIDDO LIONS

Power Play 2022-2023

Opening

ABOUT US

We are team Megiddo Lions #18833 from Israel. We are the official team of the Megiddo regional council. Our team is made of 13 students in grades 10-12 coming from 6 different small towns (kibbutz) around our council. Most of us are in the FTC program for many years but some of us are new to the program and to FIRST. We are sharing our workshop with our younger FTC team #12797, we mentor them and help them with everything they need using the knowledge we acquired through experience.

Our goal is to challenge ourselves and get better every year. To implement our goal this year we built a unique robot that had many iterations until the final product. This year we designed, machined, built, and programmed our robot all by ourselves in our workshop. With high-level software which contributes to our robot, we are certain our robot will perform well.

This year we had a 2nd goal as well - expose as many people from various populations to science and technology. We achieved our goal by building and conducting various projects and activities with various populations, from informal educational centers in our community to kids with disabilities and at-risk children.

After all of the hard work that went into this season and all previous seasons, This year we won the Inspire award at the 2023 Israel championship and got to represent our regional council and our country at the 2023 FIRST Championship

TABLE OF CONTENTS

"A winner is a dreamer who never gives up"

Nelson Mandela

Science Technology Education
MEGIDDO LIONS

GOALS

- Work independently without the need to rely on external support
- Maintain our knowledge for our team's future
- Raise our next generation by exposing children to STEM
- Contribute to weakened communities through science and STEM
- Write a reliable and consistent code
- Get the most out of our robot using software
- Make the programming process easier and clearer
- Learn from our mistakes in previous seasons.
- Make a unique and complicated robot that will oppose us a challenge.
- ENJOY THE PROCESS AND LEARN FROM IT!

SUSTAINABILITY PLAN

To sustain our team and knowledge over the years we have a 6-year plan for FTC in our robotics club. Our club is made of 2 teams, one for grades 7-9 and one for grades 10-12, this way students have the opportunity to acquire more knowledge and to share their knowledge with younger students.

"Megiddo Lions" exists for 10 years and over the years we have successfully sustained and developed our team's knowledge.

We believe in the importance of making STEM more popular and accessible to everyone and because of this, we are trying to recruit students to our team and expand our reach in our community. This season we spread STEM to new communities.

Outreach

This year our goal was to reach and teach as many people as we could.

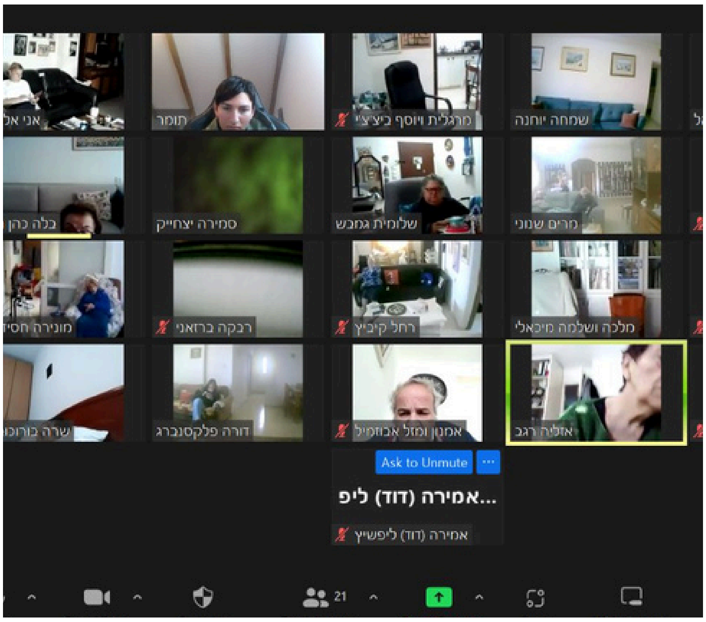
- We have built an activity that introduces kids with diverse backgrounds to robotics and STEM. We have had this activity for over 350 kids during the past two years.
- We have had weekly online meetings for a group of 30 people from the elderly community.
- We have had over 50 meetings since the end of last season.
- We taught people about the world of science and engineering at the events we had.

Outreach Data

~50	~1250	13
Intergenerational activities	People we reached in our community	STEM workshops for children

INTERGENERATIONAL MEETINGS

Since last year, we have had meetings with a group of 30 people from the elderly community. We had conversations about; science, engineering, current affairs and life as a whole. We believe these meetings have had a great impact on those who participated both socially and educationally. Our meetings were incredibly joyful, both for our friends of old age and us.



HOSTING A SCRIMMAGE

This year (2023) we hosted and arranged Israel's third FTC scrimmage competition of the year, where 34 teams competed.

Science Technology Education
MEGIDDO LIONS

STEM HOUR

We have built a robotics and applied-physics activity, we refer to it as “STEM HOUR”. The goal of “STEM HOUR” was to give kids a taste of what it is like to be an engineer. In the activity the kids got to experience:

- Physics - a construction of a vehicle which demonstrates the way mass affects acceleration.
- Sensors - an exercise with lego robotics which teaches sensors and their uses.
- Robotics - an introduction to robotics through a demonstration of our in-house robot, as well as letting them drive it.

This year we ran “STEM Hour” for a wider variety of kids, and in the past two years we have conducted it for a total of 350 kids. We had it for three groups of kids who live close to us, for children with special needs, and for two groups of children at risk.

“**Wings of Krembo”** (a youth movement for kids with and without special needs) - We held an activity there for 12 kids with special needs and 20 tutors. These are kids that don’t often meet the world of science and robotics so we’re happy we got to meet them and introduce them to something new.

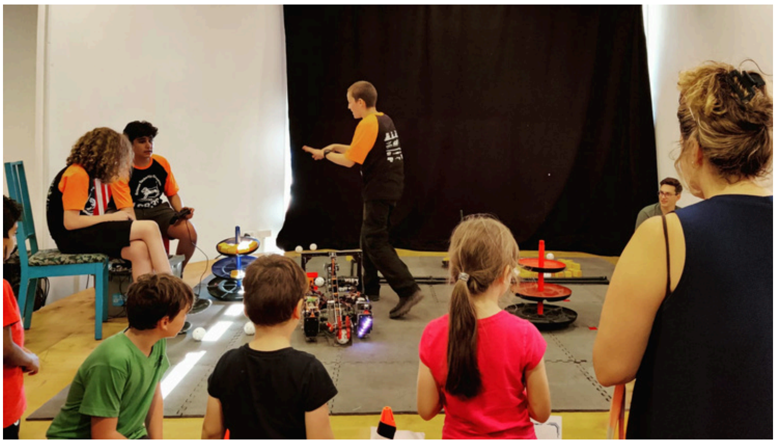
“Merhavim” (informal educational centers in our region) - this year we continued to conduct our “STEM HOUR” activities at the “Merhavim” across our regional council. So far we conducted 3 activities in 2 different Kibbutzim.

At-risk child care facilities - We have had “STEM HOUR” for two at-risk child care facilities each with more than 15 kids. These are kids that don’t often have extra-curricular activities and we are glad to have given them this experience.

Outreach

STEM FESTIVALS

We operated 4 STEM festivals in our regional council in association with MegidoTech (a technological center in our region). At those festivals, we presented our robots and conducted different activities.



ACTIVITY AT ELEMENTARY SCHOOL

We visited “Plagim” elementary school and had an activity for the kids who took part in the school’s robotics program. The kids showed us their creations out of WeDo Lego kits, explained how they worked, explained how they liked working as a team, what they learned and what part of the creation process they liked most.

Additional outreach activities:

- Contribution to our school’s fencing team - we have helped them maintain their electrical gear.
- Jewish South African delegation visit - we have introduced them to our team and the technical development in our regional council.
- Climate march- members of the team attended the “climate march” in Tel Aviv, we find protecting the environment valuable and important.

Fundraising & finance

#18833

"STEM HOUR" FUNDRAISING

In order to fund our participation at FIRST championship, we used our STEM HOUR activity that we have been conducting voluntarily for the last two years and conducted it for a symbolic price. By doing this we continued to expose kids to STEM and partially fund our trip. We did the activity 5 times and had a lot of fun doing so.

FUNDRAISING from LOCAL COMPANIES and COMMUNITY

In order to fund our participation at FIRST championship, we reached out to local companies and our local community. We created a short video that explained who we are and our journey this season and invited them to help us fund our trip.

INCOME and OTHER RESOURCES

*Our income and other resources are for us and our sister team

Regular income and other resources:

- Tama - a local company and our main sponsor
- Members participation fee
- Free dinners - Kibbutz Ein Hashofet

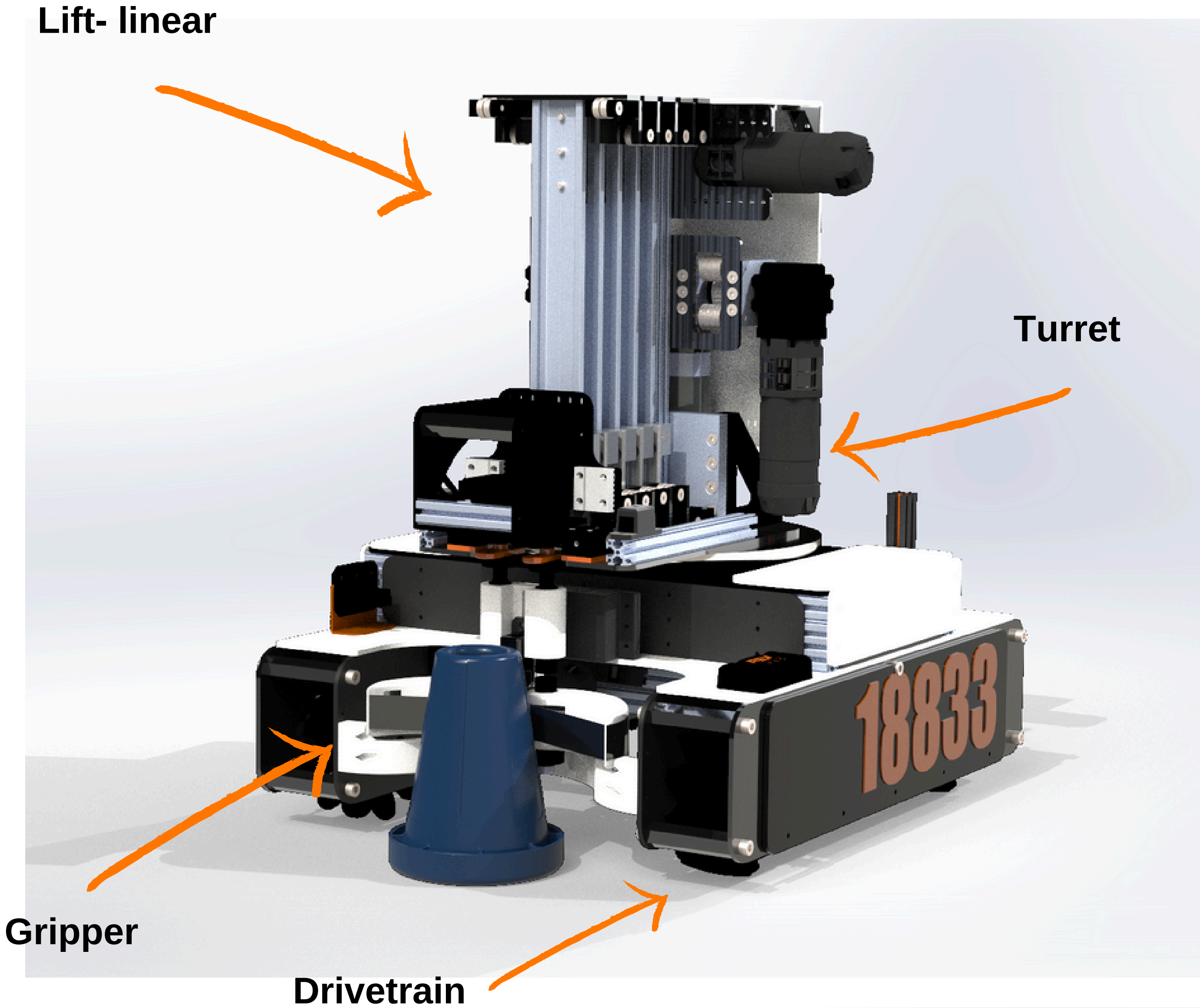
Additional income for FIRST championship:

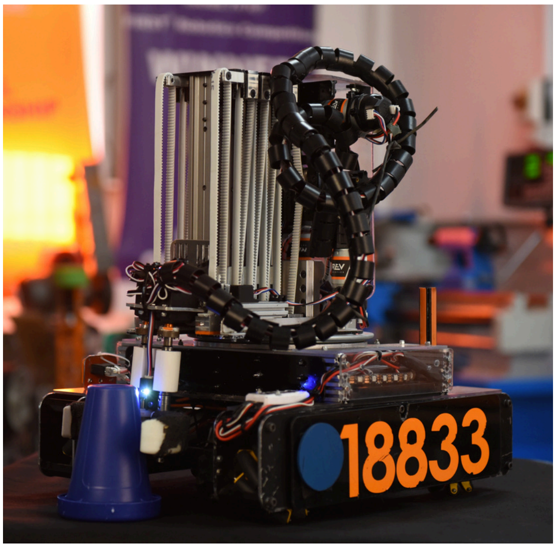
- Tama - a local company and our main sponsor
- Megiddo regional council
- ARAD - a local company
- Donors
- Members travel cost participation

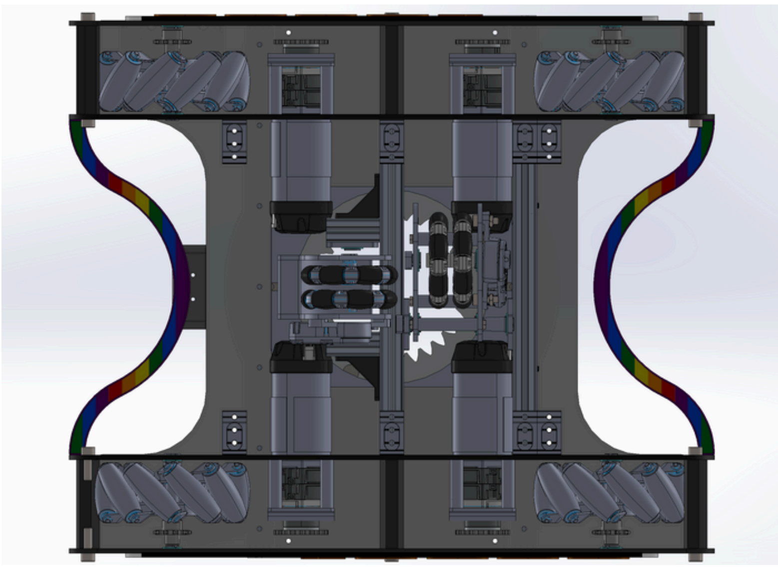
EXPENSES

- Robot parts
- Mentors’ salary
- Registration fee
- Field and game element
- Travels and accommodation
- Hosting a scrimmage
- Others (team shirts, merchandise, prints)

Our Robot







Design Process

DESIGN PROCESS

The design process allows us to choose the strategy and robot that fit the game best, thus maximizing our robot capabilities.

The design process includes the following steps:

- Watching the season's game video, reviewing the game manual, and fully understanding the rules of the game.
- Prioritizing missions within the game.
- Choosing a strategy.
- Brainstorming concepts for the robot’s mechanisms and ruling them out by their feasibility.
- Building and checking our concepts' feasibility and choosing our robot’s mechanisms.
- Creating a CAD module for our robot, machining, and building it.
- Fixing and improving the robot’s mechanisms.
- reaching the final design.

OUR GAME PRIORITIES

the robot should be able to:

- Park in the terminal that corresponds to the signal image.
- Collect cones from the substation.
- Score cones.
- Maneuver with ease.
- Prevent cones from entering the chassis.
- Collect cones from a cone stack.
- Collect and score the beacon.
- Score in each junction.
- Go over the ground junctions.
- Collect a cone and the beacon simultaneously.

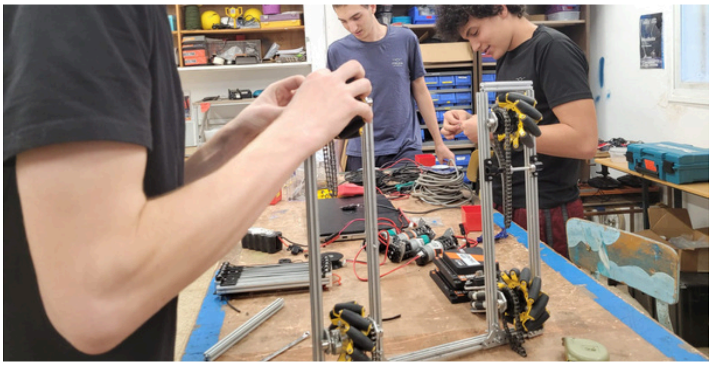
THE CHOSEN STRATGY

Our strategy is to be able to perform any mission on the playing field but to mainly focus on spreading cones to complete a circuit when understanding that the number of cones in the field is limited and that they will run out. We want to score them in the most score effective way.

In addition, we figured that we want to navigate in the most efficient way around the field. We achieved that by trying to move only forward and backward, our turret system rotates to the right angle and saves us valuable time.

THE SIMPLEST ROBOT

during our design process we realized that even the simplest robot- one with only a drivetrain, a gripper, and a lift can perform just as well. To test this we built concepts. In the end, we decided to challenge ourselves and build a more complex robot.



Choosing a Concept

#18833

Our goal is to build a robot that fulfills our game strategy in the best way possible. We do it by brainstorming different concepts we think will play along with our initial strategy and consider them heavily. This year 2 main concepts reached our final cut. We built our 1st robot according to our 1st chosen idea but unfortunately, we needed to change our choice because it made many troubles.

CONCEPT B

This concept consists of a mecanum drivetrain, two lifts, one on each side of the robot and a gripper which moves horizontally.

concept characteristics:

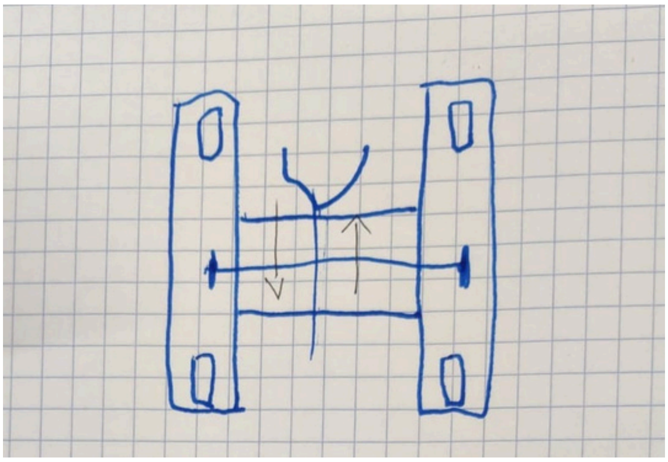
- Has the ability to gather and score cones from both sides.
- We have experience with mecanum drivetrains.
- A more standard design.

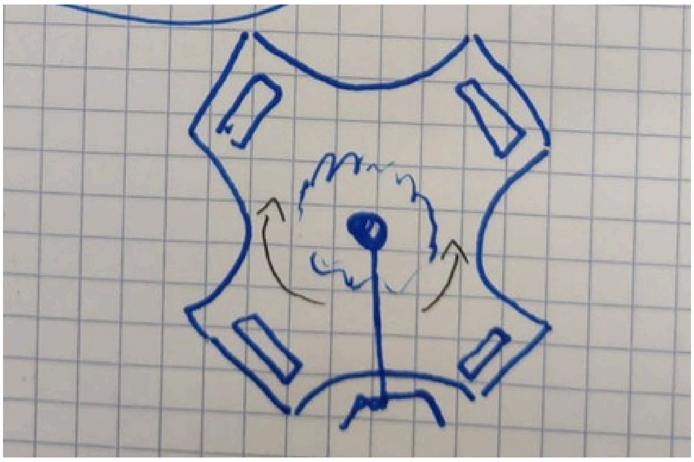
CONCEPT A

This concept consists of an omni in an “x” pattern drivetrain and a lift connected to a turret.

Concept characteristics:

- Efficient movement of the robot because of its smaller size and ability to travel with the same velocity on both x and y axes.
- Saving time with the ability to gather and score cones from 4 different directions.
- The arcs allow the robot to position easily in front of cones and junctions.
- Relatively challenging to design.





The chosen concept is concept A. This concept was chosen because we concluded it would be more efficient and because we wanted to try out building a robot which has unique mechanisms we are not familiar with, and which will inspire other teams.

Designing and Machining

REACHING OUR FINAL ROBOT- PROCESS

This year we made many changes to our robot during a very short period. After choosing the first concept, designing and building it to compilation, we came across unexpected difficulties which gave us no choice but to design and build different mechanisms just a few days before our competitions. This season we built 4 different lifts and 2 completely different chassis. These iterations led us to our final robot.

Building and Manufacturing

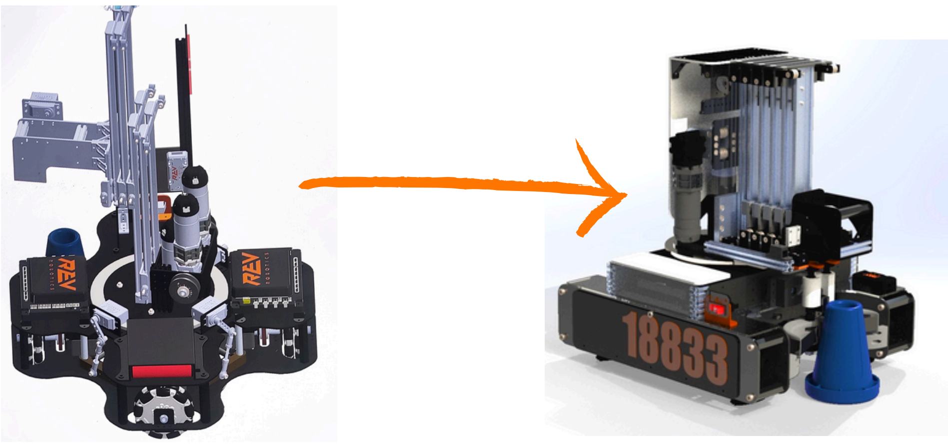
Our robot was entirely manufactured by us at our workshop. It was created with a variety of tools and machines.

- CNC router
- Laith
- Router
- 3D Printer
- Hydraulic bender
- Manual tools

CAD

After our design process in which we decided what type of robot we would like to build we advanced to modeling our robot in SolidWorks (a 3D modeling software).

The purpose of using the software is to confirm that our ideas are eligible before wasting time building and testing them. In addition, it allows us to reach high precision and to machine our parts in our 3D printer and CNC router. Our robot was modeled completely before being manufactured.

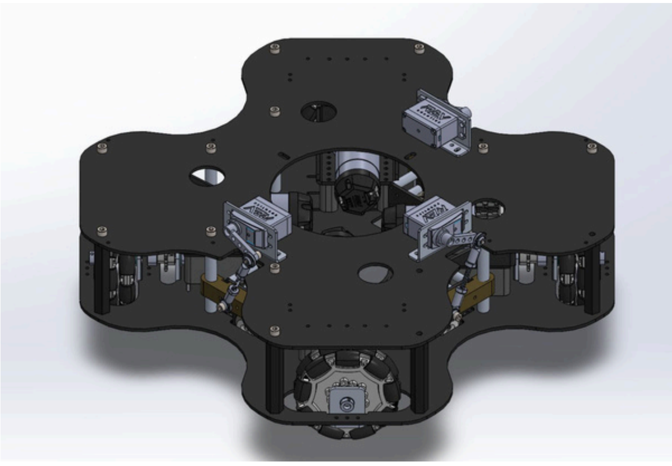


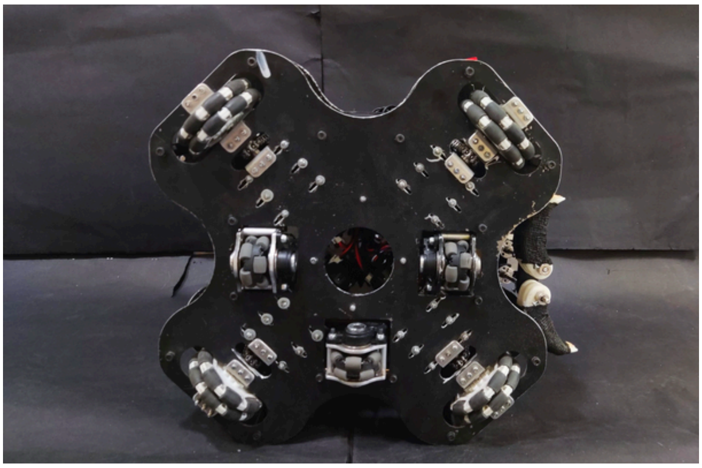
Drivetrain

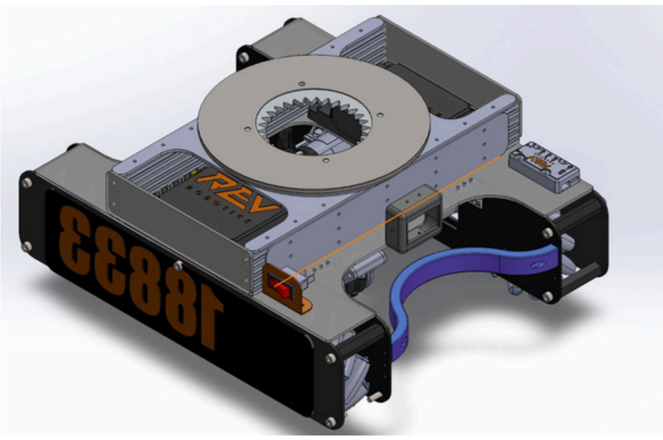
#18833

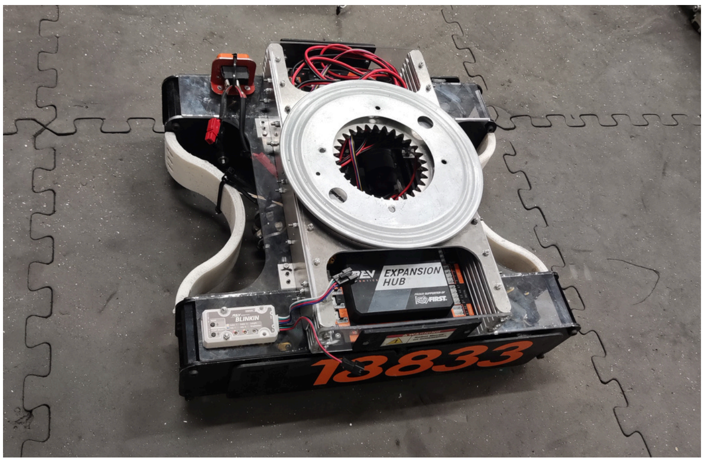
Our drivetrain consists of four 96-millimeter mecanum wheels, driven by four 1:20 gear ratio motors. This drivetrain allows for quick and holonomic movement.

The original concept of our robot included a drivetrain with 4 omni wheels in an “X” pattern, this concept allowed us to move in every direction at an equal speed. The drivetrain was relatively compact and had 4 arches that allowed us to position in front of the cones and junctions with ease.
In this drivetrain, we ran into a severe problem - the robot wouldn't drive straight and because of that we needed to replace it. The problem occurred because each wheel was suppose to rotate in a specific direction and in a combination of all 4 of them the robot should be able to move in every direction. Our drivetrain was not built in an optimal way so we had a lot of troubles getting the wheels to align in order to move in a straight line. After many days of testing and attempts to fix it, we came to the conclusion we had no choice but .to change it to a different concept, this happened a week before our scrimmage





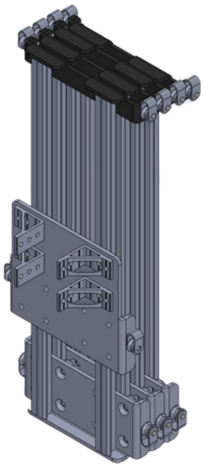




Lift

We went through 4 different lifts this season, 3 of them were wire-based, where a wire and a pulley system make the elevator rise, and the 4th and final one is timing belts based, where belts are pulling the lift up and down.

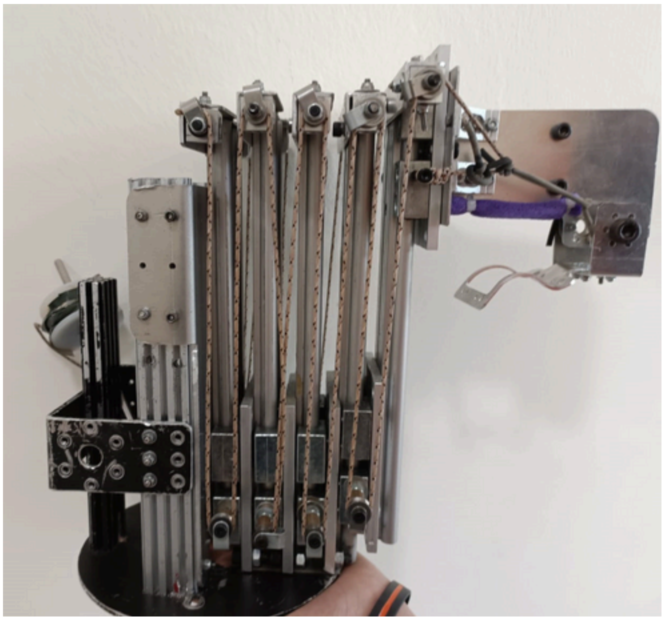
MECHANISM A
The 1st idea was based on rails with “V” bearings. The bearings were screwed to the rails but we needed to replace the lift because the bearings had a lot of free movement and the threads broke.

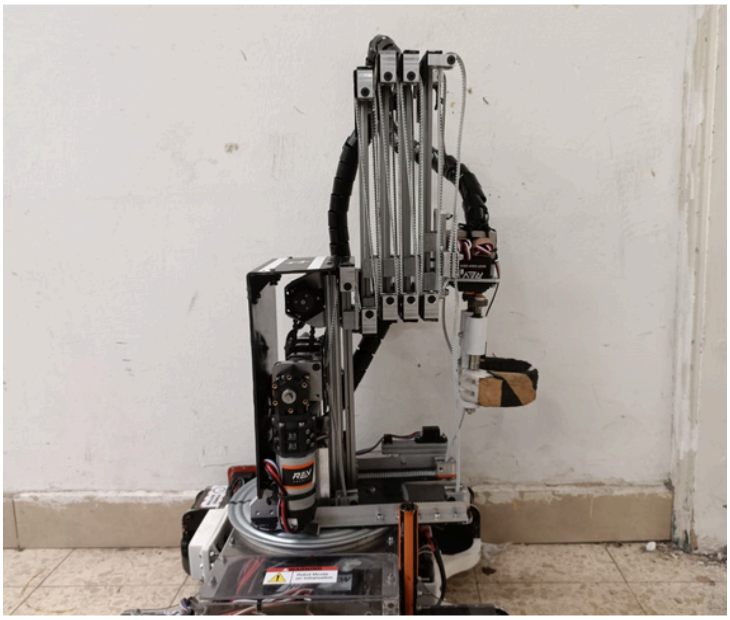


MECHANISM B
Was based on a REV Robotics elevator in addition to our lift from the 2020 FTC season. This elevator wasn’t smooth enough and didn’t close down well. In addition, the V bearings were too small and it was difficult to find a wire small enough to fit.

MECHANISM C
An IGUS-based lift with customized parts. This lift is very smooth but also very heavy and bulky. It is very consistent but unfortunately, it requires 3 motors.

FINAL MECHANISM
A timing belt-based lift, this lift is very smooth, efficient, and reliable and gives us great results in the game. This lift requires 3 motors but with a gear ratio of 1:9, it’s both fast and strong.

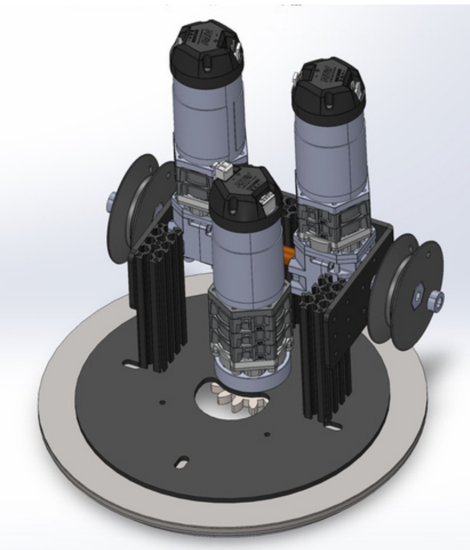


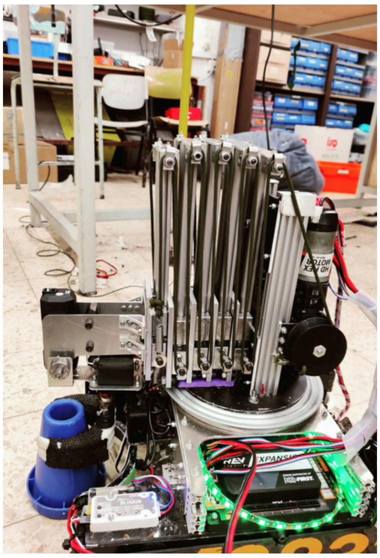


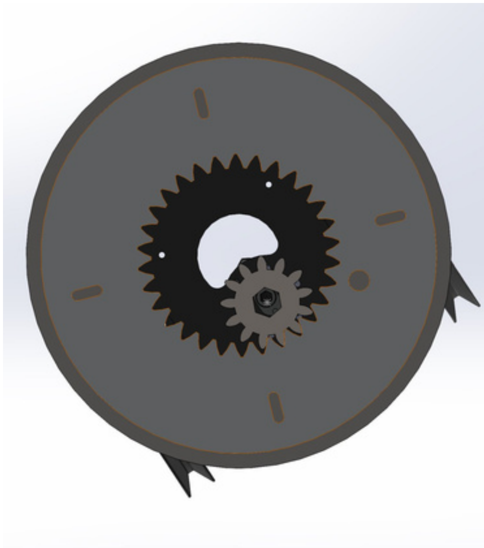
Turret + Gripper

TURRET

At the middle of our robot is our turret mechanism, it’s purpose is to allow us to gather and score cones from different directions. The turret consists of a large bearing connected to the outer gear wheel while the inner gear wheel is rotated by a motor. The turret didn't go through much change from the original design.

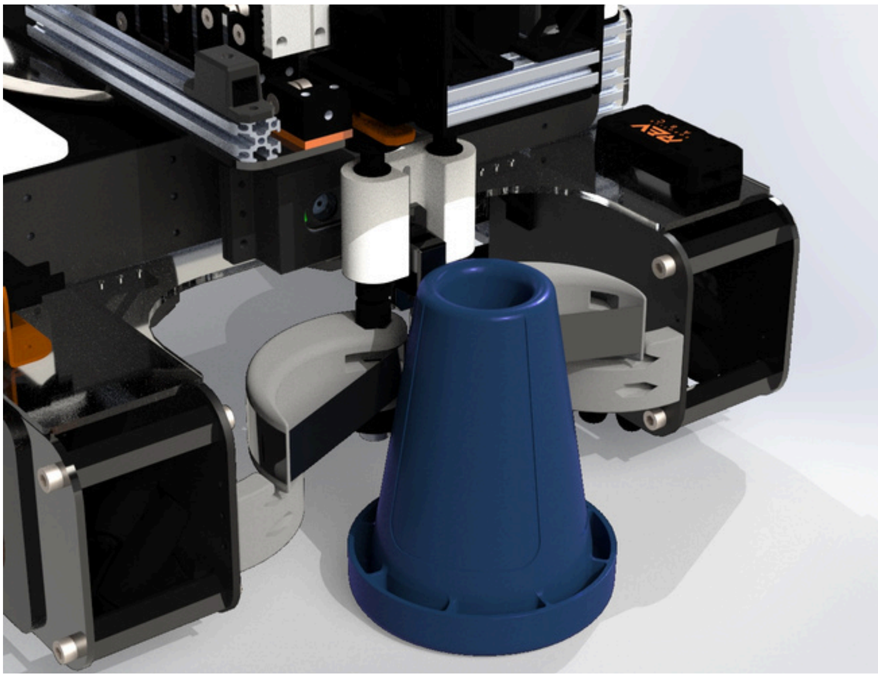




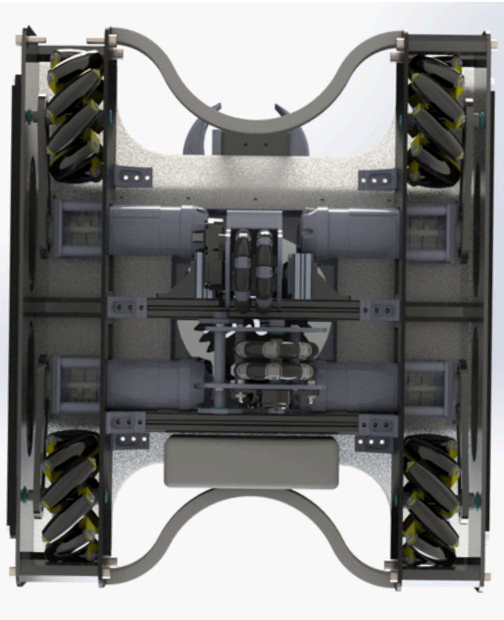


GRIPPER

Our gripper is built out of two 3D printed claws each connected to a servo. The claws are wrapped in elastic bandage to provide good grip. The gripper itself didn't go through many changes from the original design, still we changed it’s measurements to adapt it to the different lifts we used.



In this season we focused on writing our software in the best way possible in order to get the most out of our robot and simultaneously make our driver's job easier. We kept in mind that the less complicated the driver's work, the chance of mistakes decreases.
In our software, we use 8 DC motors, 2 smart robot servos, 4 internal encoder sensors, 2 external encoder sensors, and the built-in IMU sensor. We use all of these to maximize the accuracy of each of our robot's actions.
In addition to those sensors, we use a limit switch to detect when the lift system is in the lowest position to avoid situations when the software tries to lower the lift too much which could harm the timing belts in the lift.
During the autonomous period, we use a camera to run custom image-processing algorithms we programmed ourselves in order to find the correct place to park.



DEAD WHEEL ODOMETRY

For a few years now we have been using "dead wheel odometry" to determine the robot's position accurately during the autonomous period. We didn't invent the concept but we are among the first teams who implemented the concept in the FTC field in Israel with a custom design that improves from one year to the next depending on the field and robot needs.
The system is made of 2 Omni wheels that can spin freely on the field's floor. We connect an encoder to each wheel and with mathematical equations, we can calculate the robot's position, this way we can detect errors in the robot's movement (for example if we collide with another robot) and correct these errors in real-time and overall achieve more accurate autonomous.

COMPUTER VISION

In order to detect the right place to park our robot at the end of the autonomous period, we use a sleeve with easily detectable colors (Red, Green, Blue) then we use Image Processing using OpenCV (an Industry standard library for Computer Vision) with custom filters to find the side of the sleeve directed at the robot.

Programming without the need to install the software:
Last season we encountered a problem, the time it took to deploy the robot code was up to two minutes, which caused the development of our autonomous to be inefficient, because every small fix took a few minutes to implement. And for writing an autonomous program which is basically a lot of small changes, that was a big deal.
In order to explain the solution we chose we first need to explain the way we write our code, because it's uncommon among FTC teams.
We implement each of the robot's actions as a command, which we can chain to form more complicated actions. Each of the commands is represented as an object in code, thats means that instead of hard coding our programs we can dynamically create the command objects and run them. The only problem was how to dynamically load the commands from a file. We utilized past experiences of our team members with creating custom interpreters and the Android operating system. We designed a custom programing language to be both simple and easy to write, and simple to interpret. So now, we hard code only the available commands, and our autonomous is fully loaded from a text file we can upload to the robot filesystem using ADB (Android Debug Bridge) in mere milliseconds.

ROBOT'S AUTOMATIONS:
In order to make our robots actions more accurate and reliable during teleop we use a variety of automated actions:
- Our turret rotates autonomously to 4 pre-determened spots using an encoder sensor, thus allowing the driver to change positions quickly and efficiently. Additienly we can adjust it manually for specific angels during the match.
- Our lift rises to pre-determined hights using an encoder sensor. Every time the lift closes a magnetic limit switch is activated and the hight resets in the software. This is how we know the exact height of our lift at every given moment.
- Our turret returns to a “zero” position in a push of a button no matter in what orientation it is. This helps our drivers to make quick and efficient cycles.
- We have a distance sensor inside our gripper which knows when we are trying to grip a cone, when a cone enters rhe gripper it closes automatically.
- We have a LED strip on our robot which changes light (green, orange,red, rainbow) acorddind to the games timer. This way our drivers can know the time without looking at the clock. We also use this system for additinal information like visually indicate when a cone is collected.