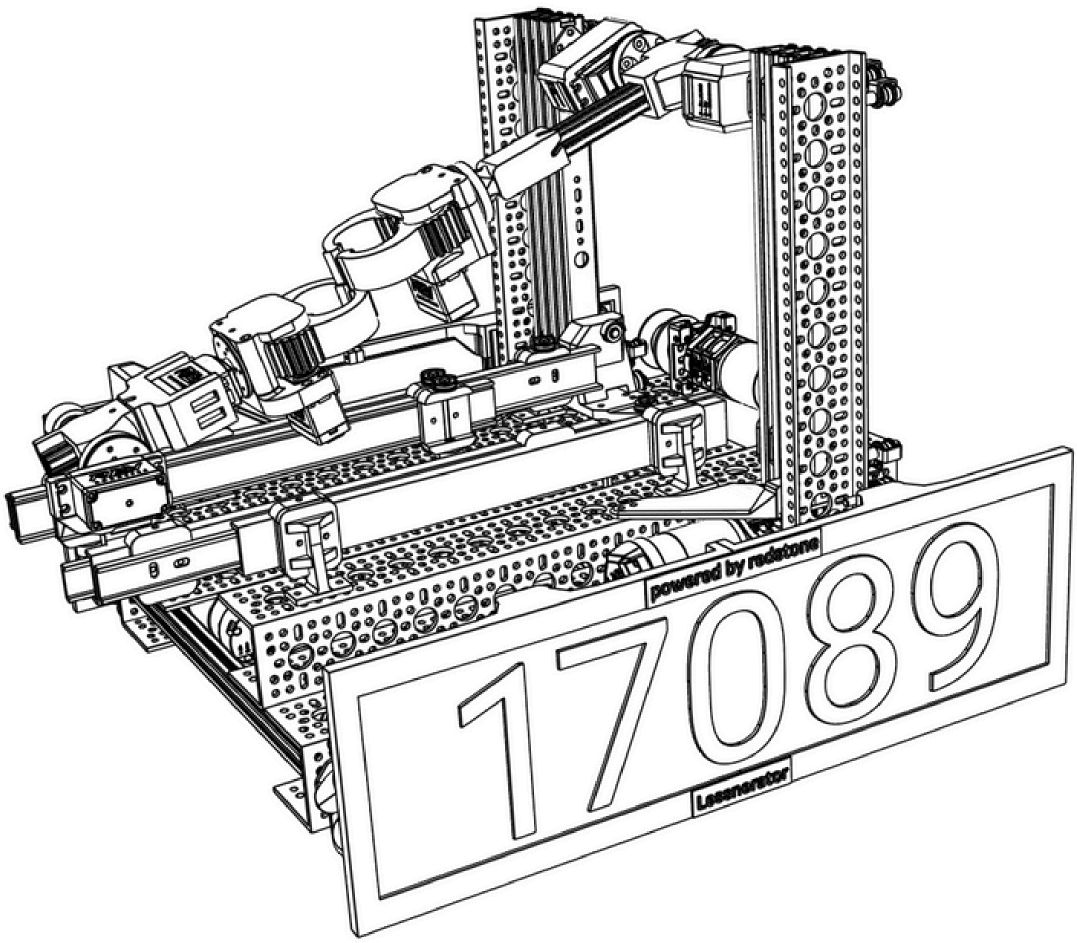
Powered by

Redstone

2024/2025 season



Open Gate School

FIRST TECH CHALLENGE

INTO THE DEEP

PRESENTED BY RTX

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1. Meet the team

Our student-led team has operated with minimal guidance from Mr. Lessner since 2019. He offered suggestions and insights without taking control, allowing us to lead every step of robot development - from brainstorming and designing CAD models to full-on testing. Our hands-on approach throughout the season helped us push our creative and technical limits, providing an invaluable learning experiences in engineering, programming and teamwork.

Dr. Lessner *Mentor*

I am Dr. Lessner, the team mentor and Computer Science teacher. Iguide the team by keeping them focused on their goals, balancing work and school, and occasionally suggesting design improvements, while supporting their growth in engineering and programming

Rosťa *Team Leader*

Hello, my name is Rosťa and I am the team leader for this season. I have spent most of my holidays and evenings in our IT class designing, 3D printing and installing the parts. I also try to make our team cooperate in an effective way and bring new members into the team.

Jenda *Head of Programming*

My name is Jenda, I am a part of the team since last season and I have the role of head of programming. I started programming around five years ago and I can do small projects with an arduino and a raspberry pi.

Tom *Head of Engineering*

My name is Tomas. I have been an engineer in our team since 2021. Currently, I am the head of engineering and am responsible for key design choices, and most importantly the drivetrain.

Ernest *Programmer, Java Nemesis*

My name is Ernest, one of the team's two programmers. I focus on developing autonomous OpModes and occasionally assist with refactoring and rewriting driver-side code.

David *Engineer, Quartermaster*

Hi, I'm David from the engineering team. This season, I worked on horizontal linear actuators and side plates and serve as the team's human player.

Christian *Engineer, Mechanic*

Hi, I'm Christian from engineering. I led the vertical sliders on this robot and mentor our Junior Robotics team to ease their transition to Powered by Redstone.

Jan Pavel Škoda *Master service man*

Hi, I'm Honza, a new member focusing on organization and logistics. I'm excited to join the engineering team soon.

Viki *Engineer, Public Relations*

Hello, I'm Viki, a new team member working in PR. I enjoy the club and look forward to focusing on engineering.

Calista *Engineer, mechanic*

Hello, I'm Calista, a new member in engineering this year. I'm excited to be part of the robotics team and contribute to our projects.

Eliška *Design*

Hi, I'm Eliška, and I work on design. I enjoy creating and contributing to the team's visual and functional elements.

2. Outreach

2.1 Maker Faire Prague

In May of 2024, we took part at the Prague Maker Faire event. This event includes all sorts of creative hobbies and areas, where everyone has the place to present their own making skills. Our goal of attending this fair was to find out new partnerships both technology-wise and sponsor-wise. We were put into the young-makers pavilion. During the event, we interacted with other robotics groups such as the FRC teams Robul #9585 and RUR #5996, and the KeplerGo team from FLL. The latter team was particularly interested in connecting with us, as they wanted to participate in the 2024 FTC season for the first time. Together, all of us that participated in a presentation of our respective First events. Along with presenting the FTC competition, we also had an interactive element of our stall, where we had a small corner of the 2023 Centerstage playing field with that seasons' robot to show the visitors how each part works and to inspire more people to become interested in robotics. Along with helping KeplerGo start with their FTC endeavour (this year in FTC as #26838), we also got a contact for another Prague-based FTC team, Falcontech #11041, with whom we plan on having shared practice sessions and building days.

2.2 School STEM Fair

To inspire our fellow schoolmates to join our team, we organised our own school STEM fair. The target of this activity was to showcase what interesting activities one can do within the STEM environment. There were three main attractions within the fair. The first was a presentation about biology, organised by our classmate, who talked who her internship at a biochemical reasearch institute. The second part of the fair was the showcase of our team member's home-made wind tunnel, which he used to conduct research for his school diploma essay. The last, and most important part of the fair was a demonstration of our robotics team. We wanted to show our school, that FTC is not just about engineering and programming, but that it is almsot equally important to have a good public relations team and a design department. Our demonstration composed of letting pairs of people race the robot around a short circuit while being timed, completing tasks that use the game elements from the 2023 Centerstage season. Letting the students have a hands on experience with the robot helped people become more interested in helping with our project. Since then, we have accumulated almost double the amount of team members which helped a lot with our team efficiency.

2.3 School presentation

At the beginning of each school year, we have a school-wide assembly, during which we introduce many of the school's projects. This year, we had the opportunity to present our robotics team. Since last year, we have recieved more support from our school due to our success in the Romanian competition the previous year. A few days before the presentation, the new 2024 game was unveiled. During our presentation, we introduced this year's game to everyone. Along with presenting our FTC team, we also presented about our junior robotics club, which serves as an entryway into the FTC robotics programme. The students of the junior robotics club build with Fischer construction sets and build simple mechanisms and robots. Most of our current engineering team came from the junior robotics team.

2.4 Building day with Falcontech robotics

Since making contact with Falcontech robotics at the Maker Faire event in Prague, we have been trying to organise a shared event between our teams. In January, we managed to meet up at their school for a building day, during which we would share tips and tricks and help eachother solve engineering and programming issues. Since we already had a robot that participated in events, we were mostly refining our existing designs. We gave our friends a lot of tips, since we have already functioned within the current season. In the last couple of years, we were aspiring to enhance the local FTC community, to be able to organise our own full events with at least 4 teams. Including Falcontech, we now know of 2 other teams from our proximity, which will allow us to have more shared practice sessions in the future.

2.5 Cooperation with KeplerGO

We met KeplerGO during the Maker Faire in Prague. At the time, they only competed in FLL. With our help, they managed to create an FTC team this year, with which we have a close collaboration. We have had multiple meetings, during which we discussed our strategies, designs, and most importantly for us, orders of new components. In the past, an immense problem of ours was the shipping fees on orders from the US. By being able to split the shipping prices between our two teams, we will be able to save a lot of money when ordering new components. Along with Falcontech, KeplerGO is another team with which we want to organise our local practices and matches, which will bring more experience to both of our teams.

3. Game Strategy

In the First Tech Challenge a well-trained and adaptive game strategy is crucial to levitave the strengths of the robot. 150 seconds is not huge amount of time and the robot needs to effectively cooperate with their alliance partner. This year the robots can score in two ways - with sample or specimen. After the first scrimmage, where our robot was able to score only specimen, we realized that it is not the right path for us to take. In order to be attractive alliance partners, our robot needs to be able to score in both ways efficiently. This is a bigger challenge than just focusing on one way of scoring. By this way we avoid a situation when we block our alliance partners when trying to score in the same way.

Therefore we have designed two linear sliders with joint and a grabber, one horizontal and one vertical. The role of the linear slider is to pick up from the submersible. We are then able to transfer the sample from the horizontal slider to the vertical slider and score on the higher rang or higher basket. This transfer is fully automatized, so it leaves no room for human error.

Driving practice is an underrated part of the preparation for the tournament. We have been able to build the robot few weeks before the robot, so our drivers had time to practice. But we wanted to minimize the work of the driver, because from our experience driver error is very common, which leads to a loss of time. Thus, we wanted to imply as much automatization as possible. This is for the transfer and positions for hanging specimens and placing samples.

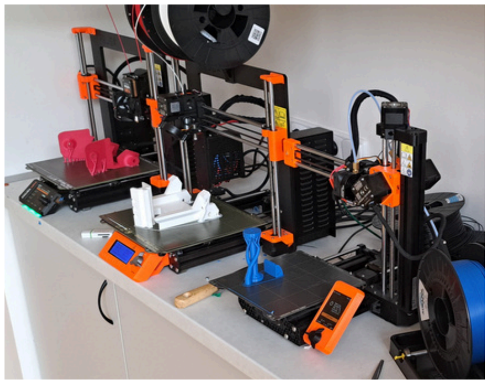
We analyzed how many points we can score on average in a specimen run, so firstly we took samples from the submersible and give it to the human player. When all of the samples we wanted to score are with the human player, we pick them up as specimens and hang them on the higher rang. For this situation we trained our human player, who knows exactly where to place the specimens.

From our driving practice and results, we have decided to score mainly specimens. This is also because most of the teams aim to score samples. However, if our alliance partner is not able to score samples and only specimens, we will score samples.

4. Engineering

4.1 Introduction

Our engineering approach has always emphasized creativity and problem-solving. While we have access to various manufacturing technologies at our school—such as 3D printing and, more recently, laser CNC machining—which allow us to design custom-fitted components, we often rely on older, previously used parts due to budget constraints. Administrative hurdles and high shipping costs further limit our ability to purchase new off-the-shelf components. As a result, our work primarily involves integrating parts from past seasons with custom 3D-printed solutions.

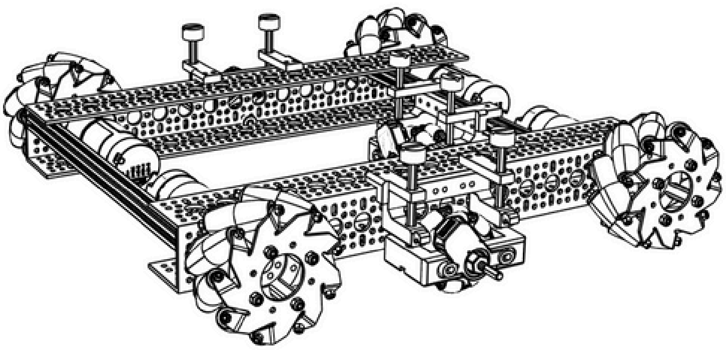


This year, we have strategically prioritized the key aspects of our robot design by allocating our limited funding toward new motors for increased speed and GoBilda Viper slides to ensure a rigid and reliable framework. These components provide a level of resilience and performance that cannot be easily matched by 3D printing. Focusing resources on creating such a complex system in-house would be inefficient, as these robust off-the-shelf solutions allow us to direct our efforts toward other systems that cannot be readily purchased.

4.2 Drivetrain

In the beginning of the year we began with a limited amount of resources, that have been used since the founding of our team. For our first event, our robot had a square mecanum wheel chassis. Four REV corehex motors were installed in the back of the robot with the intention of moving the center of mass opposite to the vertical scoring mechanism. This would allow the whole assembly to be more stable and balanced. The motors were attached to the wheels through belts that were hidden in a tetrix u-profile. In november, our new supplies arrived from Gobilda. This meant that we were equipped with new yellowjacket 312rpm motors, that have a much higher rpm, than the REV motors that we used before. Through our testing of the shifted center of mass design, we realised that the advantage that it gives is not enough to outweigh the disadvantage of having more weakpoints in the assembly. So we decided to install the four motors directly to the wheels. We use our own designed wheel hubs 3D printed from ABS, which is a plastic that has a higher structural integrity. Though we have had some issues with the hubs poorly gripping onto the 8mm rod.

A key feature of our drivetrain is our own custom-built odometry assembly. We use REV through bore encoders that have a set of omni wheels which register movement in either x/y direction. The lower assembly of the odometry is free to move vertically, but is pushed down using rubber bands to provide with a consistent contact with the ground.



Define

The first step of EDP is certainly to define the problems to which we try to find solutions.

Imagine

Often, the most challenging part. It is when creativity is the most valued and you have to think of all the possible design solutions for the specified problem

Plan

For us, this usually means taking the necessary dimensions that have to be respected in the final design. We also make sketches since the basic ideas are often better seen on paper than in CAD software.

Create

For us, this usually meant 3D designing in OnShape. We often used the Derived and In-context features to enable us to make the parts as tangible as possible even in the digital form.

Experiment

Prototyping of parts, how they work and how they fit with REV supplied parts and the rest of the robot.

Improve

Often, after you have the parts physically in hands, many new ideas arise. Sometime certain limitations show which were not evident

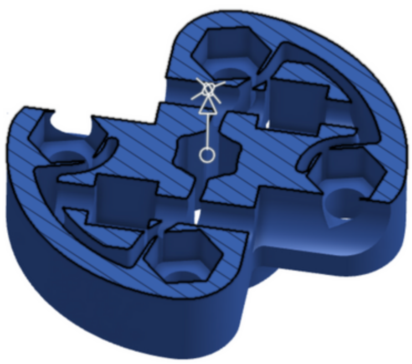
In EDP we identify these steps. However we also realise how interconnected they are and that they cannot always be separated into discrete steps.

Design Principles for 3D Printed Parts

Course completed

As mentioned previously, 3D printing is our primary mode of manufacturing parts. However, there still was (and is) a lot to improve with 3D printing. It is very important to understand a manufacturing process down to the smallest details to be able to create the best parts possible. That is, I believe, one of the most prominent features of engineering, understanding the structural concepts available to you and adopting them accordingly. In order to do so, Prusa Academy courses proved to be very useful, and few techniques presented in them were used to make better designs.

Or this course encouraged print in place of nuts and magnets. which was used for ABS wheel hubs, with nuts in both vertical and horizontal orientation being printed into the component.
These nuances significantly enhanced our work in certain scenarios, further emphasising the importance of understanding the challenges and advantages of a manufacture method.



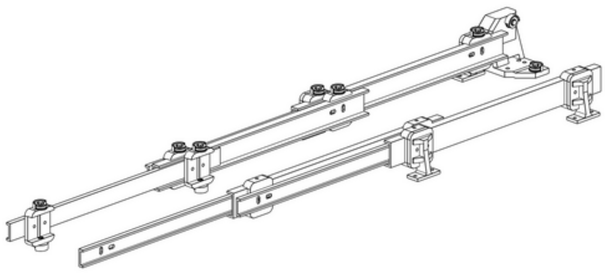
4.3 Linear Actuators

Linear actuators have been the backbone of our game element scoring system since the inception of our current robot design, The massive reach that they offer enabled our vision of a dual linear slider scoring system. On top of this versatility, they are also suprisingly compact allowing our engineers to fit 4 seperate sliders into a frame so small. Our scoring ystem incorporates 2 different, independently controled, slider subsystems, the horizontal subsystem and the vertical subsystem both consisting of 2 sliders each.

4.3.1 Horizontal Linear Actuator

The horizontal linear actuator is a custom-built, in-house solution integrated into a larger assembly. It is specifically designed to reach deep into the submersible, a task that would be impossible to achieve with a conventional arm.

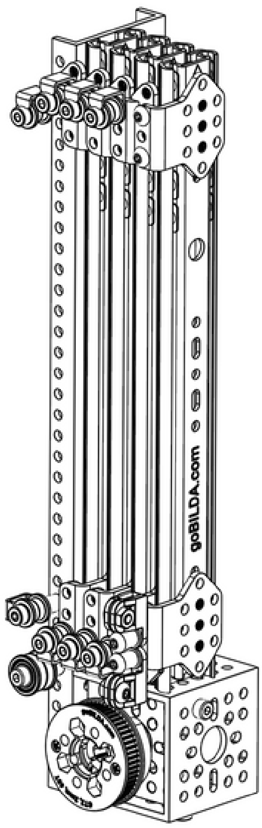
The development of this design was particularly challenging since conventional vertical linear sliders benefit from gravity. In contrast, with this purely horizontal setup, we had to address the complexities of both extending and retracting the slider. which had to be solved by a single motor.



After many iterations, we developed a string-based double spool solution. Previously, we relied on a complex wiring system for the sliders, which proved inefficient for retracting the slider. Through this process, we learned that the simplest solution is often the most effective. Instead of employing intricate wiring, we designed a straightforward string guide that seamlessly weaves the string directly into the spool.

4.3.2 Vertical Linear Actuator

For our vertical slider solution we chose the GoBilda 4 stage viper slide kits (240mm), for many reasons, but especially for their incredible reliability, making them the perfect solution for this seasons especially vertical tasks. We specifically chose the smaller 240mm sliders because of the shorter profile that they have as opposed to their 336mm counterparts. These parts however had many issues during robot development some of which persist today. One of the first issues we encountered was the fact that the official assembly guides only support a single direction of assembly, this meant that our engineers had to modify some parts of the slider to be construct able while mirrored. Another problem we faced was, surprisingly, the structural reliability of the sliders, this was caused solely by our error though as due to the admittedly rushed first version of our concept the slider was improperly constructed, which caused rapid unscheduled disassembly during one of our tests, this was however, a very simple fix only requiring a reassembly.
Other than these simple problems though, the viper sliders have been functioning perfectly, making them the right choice for this seasons and others to come.



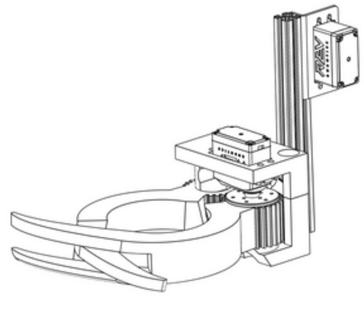
4.4.1 Compact gripper

The story of the gripper is an engineering adventure combining the ability to “recycle” past prototypes with the desire to create the best version of a product.

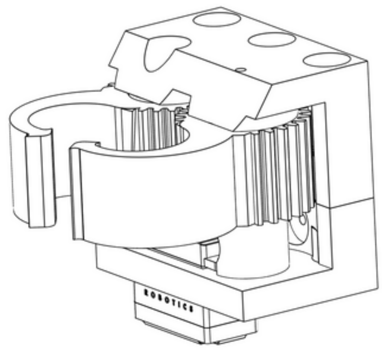
Upon the design strategy of servo-driven claw was approved, we required a quick and reliable solution. In thermoplastic additive manufacturing, which is our primary manufacturing method, it is the most difficult to accurately dimension tolerances. For that, we reached out for a solution from Power Play which we have intensively tested in the past. With slighly adjusted claws for this year’s game elements, which worked as the V1 of our gripper.

Naturally, the goal of engineering is not to make things work but rather to make them work the best. We were aware that the current solution is voluminous and weighty. To achieve superb results, we knew that we needed a radical change, we cannot get dragged back by endlessly optimising a deficient design. On that account we only retained on the leassons learned from V1 and started from scratch. With this approach, we were able to achieve the significant volume reduction shown (isometrically to scale) on the right figure. As print time was not a concern for the compact gripper, we were free to focus on the size constraint hence we introduced print-in-place nuts amongst other elegant features.

our Power Play Claw



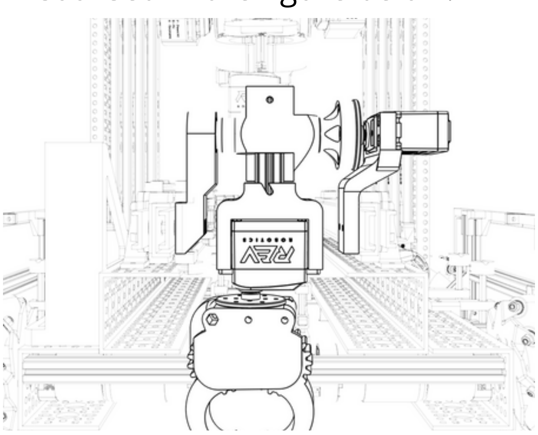
V1 Gripper



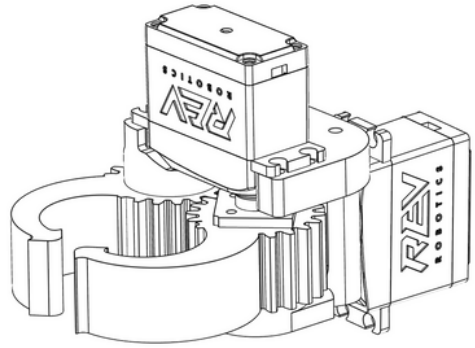
4.4.2 Horizontal gripper unit

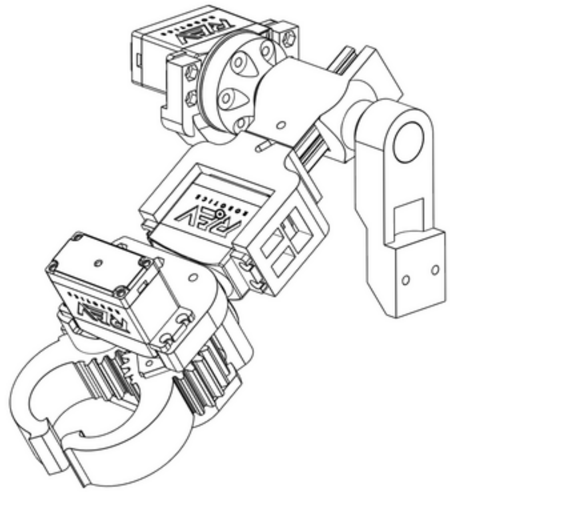
The horizontal gripper unit is a crucial component of the pickup system of samples. This system is attached to the horizontal slider. We wanted to cut the amount of servos to the least possible and leave only the most important motions.

The system needs to rotate from the ground to the body of the robot to transfer the sample or specimen to the vertical gripper unit to perform handover. The distance of the gripper unit above the ground is bounded by the horizontal slider position but thanks to the extrusion prototyping of desired length can be readily performed. Custom brackets were designed to nicely fit the tight space in the horizontal slider asembly visualised in the figure below.

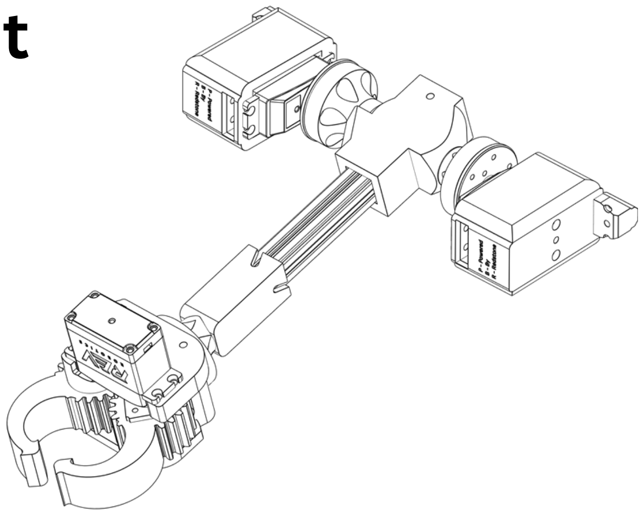


(V2) Compact Gripper



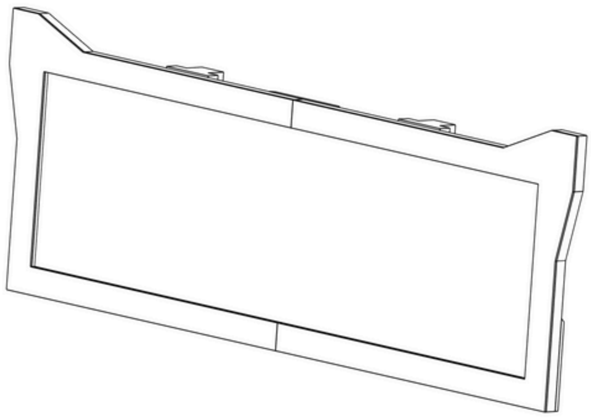


4.4.3 Vertical gripper unit



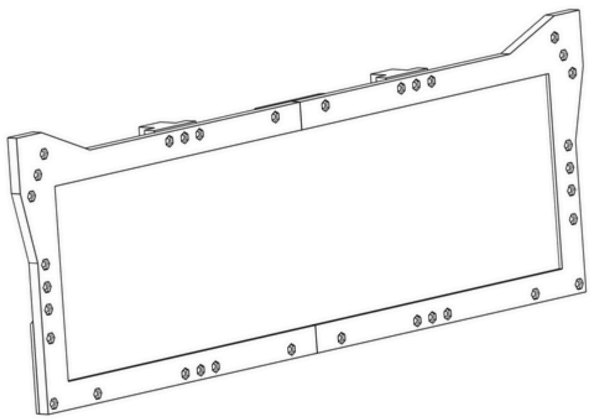
For the vertical subsystem we largely utilised the parts of the horizontal version as it included similar requirements on degrees of freedom. However some iteration were still made to match the desired purpose to the greatest extend possible. Two servos were necessary to achieve sufficient torque to hook samples. While the servo adjacent to gripper was replaced by a fixed part as it became superfluous since we can position the samples before the handover.

4.5 Robot side plates

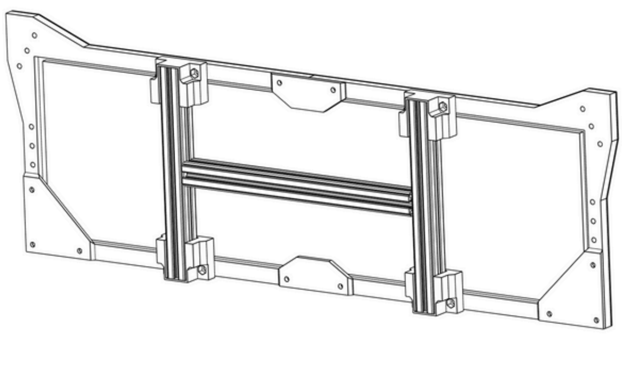


Thanks to 3D printing, we can iterate designs rapidly. Last year, we faced a challenge with the replaceability of side plates, as it took around half an hour to replace a broken one. Additionally, we aimed to create something different—something more distinctive and elegant—that would stand out.

However, these plans came with many challenges. Since we had never attempted something similar before, we relied on rapid design and prototyping. This approach led us through approximately seven iterations of the side plate design, with each version improving upon the last as we meticulously optimized every small feature to perfection.



At the start, we weren't entirely sure what we wanted, so we opted for fully 3D-printed side plates. However, we quickly realized this approach was impractical due to the significant time required to print plates at the scale we envisioned—covering an entire side of the robot, approximately 450mm x 200mm. This led us to explore CNC machining, where we chose a fully wooden middle section. While this design was a substantial improvement over its predecessor, it fell short of our sturdiness requirements. Ultimately, we developed 3D-printed covers combined with brackets for metal extrusion, creating a sturdy backbone for the side plates. This design has proven highly effective, even withstanding full-speed collisions.



5. Programming

5.1 Introduction and Goals

Last season, the entirety of the previous programming team members just graduated and had therefore left the team. We were tasked with reconstructing core concepts from the old codebase and reverse engineering components such as position tracking with odometry and movement using the mecanum wheel base with barely any documentation. As we were FTC rookies, we didn't know any common frameworks or libraries we could implement, so we decided to make all the code from scratch without utilising any other tools. This proved to be very much of a challenge, however, as we soon realised that we were spending too much time debugging our core logic instead of tweaking and fine-tuning the control themselves.

At last year's competition, we tried getting advice from other teams and they were all very surprised we hadn't used any libraries. Therefore, our main goal this season was to gather as much experience, knowledge and tips from other teams and online discussions/forums. We have since discovered tools like FTCLib and Roadrunner that we have adopted and that have greatly aided us in making our code more readable, reliable and, most importantly, easier to change on the fly.

Furthermore, a clear goal remains not to leave the next generation of programmers in the same position that we had found ourselves in last year and we are constantly updating a section of a shared document with tutorials, references as well as tips and tricks that we found out along the way and spent too long debugging ourselves. We hope we are building a strong foundation which will be reusable in many coming years and that will be easy to build on top of.

5.2 Code Philosophy and Structure

After trying a couple of different options, in the end we settled on using two libraries - Roadrunner for autonomous opmodes and FTClib for advanced motor/servo control and driver-side automatizations. Of course this came with an issue - we were writing a large amount of the code two times - one time as an action for use with Roadrunner and the other as a command for use in FTClib. Luckily, both libraries had similar approaches to overall code structure, which we of course adopted.

Since Java inherently uses the Object Oriented paradigm with no way of using functional programming, the structure of subsystems and commands is very logical. A subsystem represents a collection of robot hardware and packages it together with simple functions, abstracting it from the rest of the robot code as well as restricting access to it. This allows changes to the specific details of the implementation to be isolated from the rest of robot code, making it far easier to make changes.

The previously stated problem with using multiple libraries was solved in the following way: the subsystems are simple java classes with only basic java methods (thus they are the same for both). Then, we have classes for the actions, which build on the subsystems (or other actions). They contain two subclasses (an Action for Roadrunner and Command for FTClib) and thus use the same constants defined in the class which we can very quickly change from the FTCDashboard and most importantly only have to update it a single place.

5.3 Game Phases and Work Division

Since out programming team is composed of exactly two people, the division was pretty simple. One took the autonomous period and the other the driver period. Of course, the subsystems and commands were a collborative effort, since both opmodes had different requirements. This division of labour allowed increased specialization between the two of us as well as many less merge conflicts while using our version control. We will discuss both of the opmodes in more detail in the following two sections.

5.3.1 Autonomous period

This season's autonomous code is fundamentally different from the one from last season. I previously aimed to achieve all components of a successful autonomous period by myself, which I found out is an extremely complex task.

Last season I made a fatal mistake that stalled the progress of autonomous development and led me to question my entire approach. When we started out last season, I simply had the engineering portfolio from the previous team members to guide me on developing a working odometry position tracker. The equations and the explanations were correct, so I began to implement them in my own code for autonomous movement. What I was not toldm, however, was that the algorithm did not account for the robot strafing and rotating simultaneously and would produce extremely incorrect values as a result. I ended up finding out about FTC Roadrunner and its implementation of the IMU built into the REV Control hub to correct for these errors and immediately began research on implementing it and its actions model for our own code.

5.3.2 Driver period

We tried to automate all of the repetitive tasks that the driver has to perform. A large priority this year was to fully automate the sequence of pickup, retract horizontal slider, transfer and prepare to place either to the bar or the basket, which we managed to do. Now the only thing the driver has to worry about is lining up for the pickup and then placing - essentially only using three buttons at a time along with some modifiers. An example of a modifier is holding L1 or R1 while extending the horizontal slider and preparing for pickup which rotates the yaw of the claw in paralel with the slider to increase speed during cycling.

As mentioned, we used the mecanum wheels as the drive base and used the yaw sensor in the control hub paired with our odometry to have field-centric drive.