2024-2025 SEASON

ROBOAS

NATIONAL COLLEGE "ANDREI ȘAGUNA"
BRAȘOV

Inovation Design Creativity Impact Problem-solving STEM Build

INTO THE DEEP

RO_009

#19082

Meet the Team

Engineering


Vlad


Robi


Rareș


Anne


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Programming


Daria


Alex


Tea

Marketing & PR


Alexa


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Rebecca


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Mentors: Sorina Marton, Radu Mesa, Bogdan Fodor, Claudia Puia, Irina Aupici

Our goals for this season:

Our Season Goals and Achievements:
We set two main goals for this season. First, those of us returning from last year aimed to achieve the best possible performance. We focused on building and programming a robot that is unique, high-performing, and reliable. Second, with only four members remaining from last season, we set out to mentor the next generation of team members who will hopefully lead the team next year.
How We Achieved Our Goals:
We began designing the robot at the start of the season, forming partnerships with companies like Autoliv and 3Ddot, which specialize in prototyping and manufacturing. We dedicated countless hours to iterating designs and programming automated systems to maximize performance. To ensure the team's future, we recruited nine new members from our high school, covering all departments from engineering to programming. They are currently working on a second robot as a learning platform, while we actively mentor them, passing on the skills and knowledge we gained last season.

The budget:

Before the National Championship this season, our main funding came from Round Table Brașov, through a summer fundraising event, and from companies like Autoliv, who helped us purchase additional parts. After nationals, we connected with companies like nVent, who gladly supported our trip to Eindhoven.

Before National Championship:
Sponsorships: 8120€
Robot costs: 5400€
Transport and hotels: 2100€
PR and merch: 620€

After National Championship:
Spunsorships: 15000€
Robot upgrade costs: 2000€
Hotel Eindhoven: 5000€
Plane tickets: 6000€
PR and marketing: 1000€

Autoliv partnership:

Autoliv, a global leader in car safety systems, has a factory in Brașov and supported us throughout the season. Their engineers were impressed by our work and provided both components and guidance.
We toured their factory, learned about industrial robotics, and built our first lift prototype there using shape-pressed steel sheets. They also ordered key parts and manufactured aluminum plates—contributions that played a major role in our success.

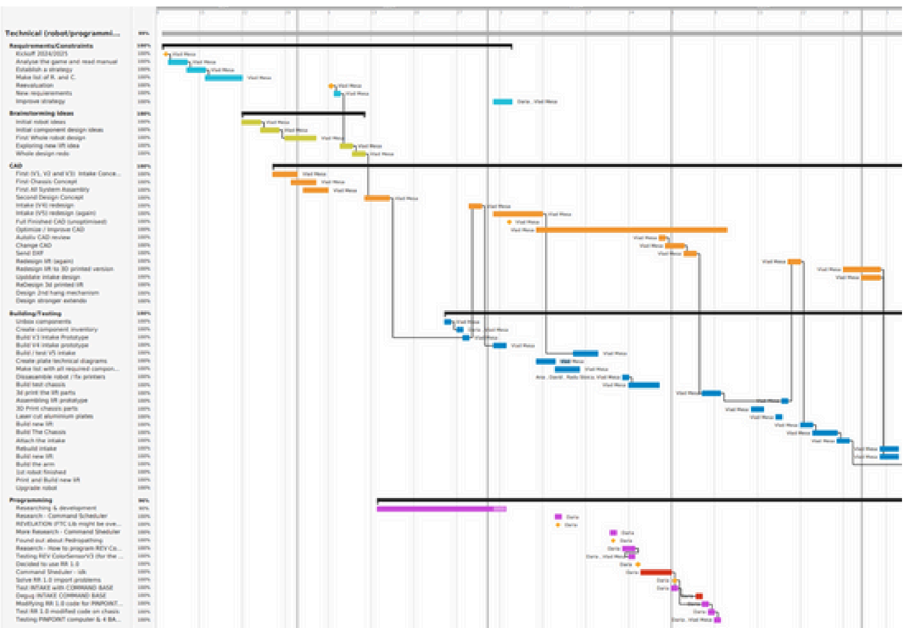
3Ddot parthnership:

3Ddot, a Brașov-based 3D printing company, invited us to a major tech event where we shared a stand and promoted FTC and our team.
They mentored us on printing materials and their properties, helping us choose the best option to reinforce our lift. They also provided materials and print time, playing a key role in our design process.

nVent partnership:

nVent, a leading manufacturer of sheet metal electrical products, sponsored our trip to Eindhoven and supported us with essential components. They also laser-cut our chassis plates and gave us a factory tour, showcasing real automation and manufacturing processes, an experience that helped us better understand industrial production and engineering at scale.

Team organisation

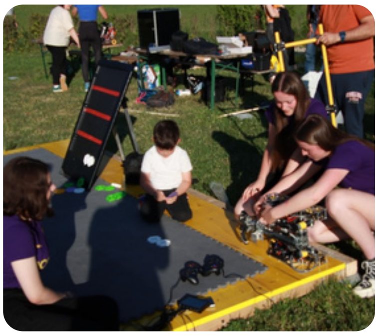


Efficiently managing an FTC team while building a robot is no small task. To stay organized, we used TeamGantt, a professional project management tool that generously offered us a free €500 subscription.
With it, we assigned tasks, tracked progress, and adjusted timelines dynamically. Each completed task was documented with notes on our process and challenges, creating a detailed record accessible to the whole team.
The Gantt chart here outlines the engineering team's workflow—from defining requirements to brainstorming, CAD, building, and programming—mapped over time for a clear visual overview.

Team events

1. Avioane de Hârtie ("Paper Aeroplanes") 2024&2025

"Avioane de Hârtie" is a major annual event we organize with Kronbot and local volunteers to both fundraise for Brașov's robotics teams and promote FIRST and STEM in our city.
The paper airplane competition draws kids of all ages, creating the perfect opportunity to showcase our robots and run practice matches, sparking curiosity and inspiring the next generation of programmers and engineers.



2. Intek Brașov Tech Fair 2025

In April, we joined 3Ddot at Brașov's largest tech event, presenting our robot to dozens of companies and university professors to encourage support for FTC teams nationwide.
Our focus on the educational impact of FIRST impressed many attendees and led to an invitation, after the FPEEU, to present our work to the General Association of Engineers of Romania (AGIR), engaging directly with leaders in the national engineering community.

3. The High School Fair

At Brașov's annual High School Fair, where local schools present themselves to graduating 8th graders, we represented our high school by showcasing our FTC team. We introduced students to robotics, PR, and marketing—giving future 9th graders a full view of what being part of our team means and encouraging them to join both our school and the FIRST community.

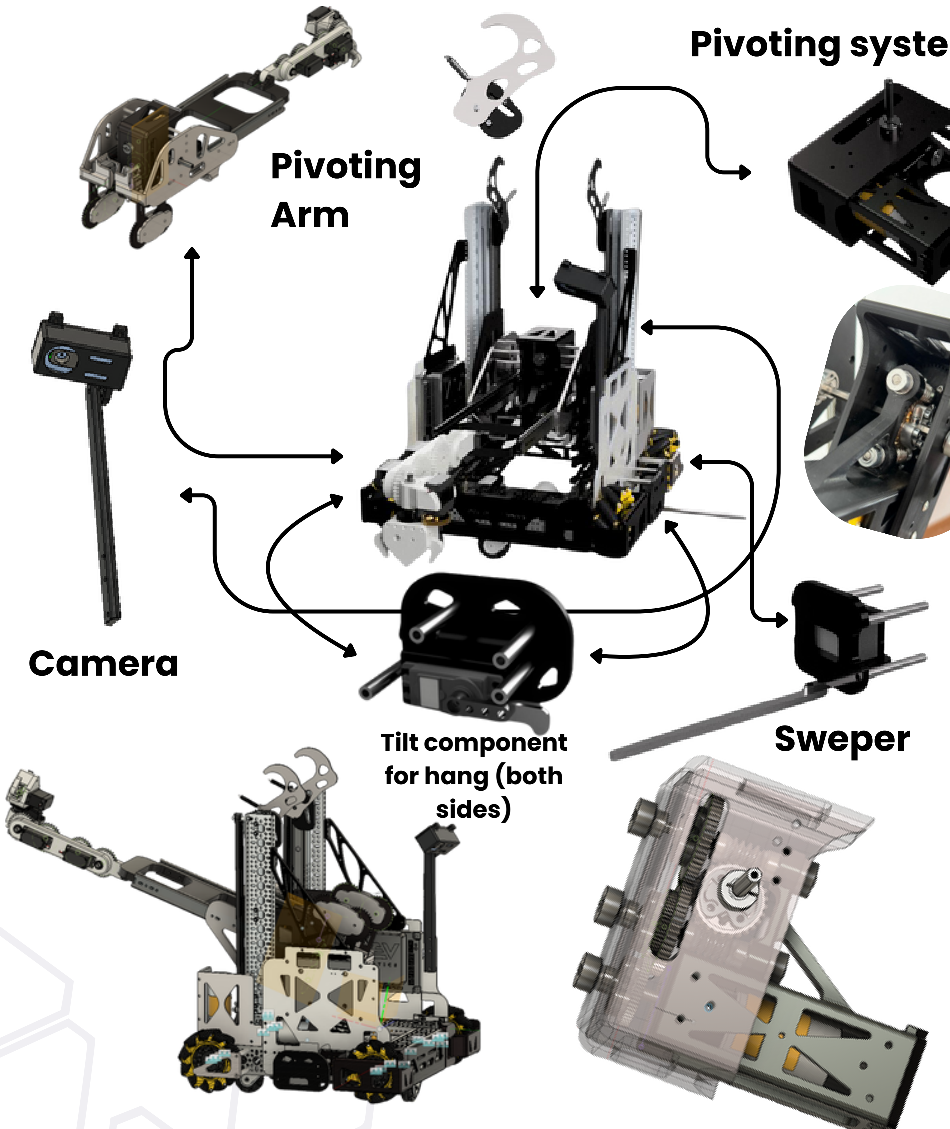
4. Radio Interview

To raise awareness about FIRST and STEM, our team's three leaders were invited to speak on a local radio program in Brașov. They shared insights about the competition, the impact of robotics on youth development, and how FIRST inspires innovation and teamwork.
The broadcast reached a wide audience, helping promote STEM education across the community. After the FPEEU, we were invited back for a second appearance, continuing our mission to represent FIRST and expand its presence in Romania.

Keeping the legacy alive

This season, only four experienced members remained, so it was clear we needed to grow. We recruited 11 new students at the start of the season; although three later chose a different path, nine stayed—ready to carry the team's legacy forward. With guidance from the experienced members, the new engineering and programming departments worked independently on their own robot, as a learning platform to experiment on. Here's what they accomplished:

Introducing Little Genesis:



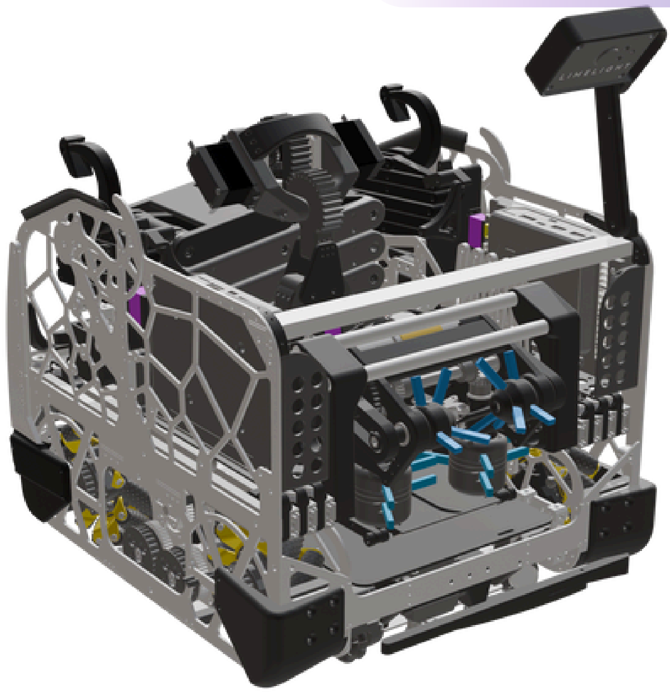
*This is not our final design

As first-year participants in FTC, we dove headfirst into Into the Deep with open minds and a shared drive to learn. We built not one, but two functioning robots—one entirely from spare parts—demonstrating our creativity, perseverance, and ability to overcome challenges. Along the way, we taught ourselves Fusion 360, mastered 3D printing, and experienced the thrill of turning digital designs into real, moving parts. Every step was a learning moment, filled with teamwork, laughter, and quotes like "I think it's working" quickly followed by "I think I broke it."

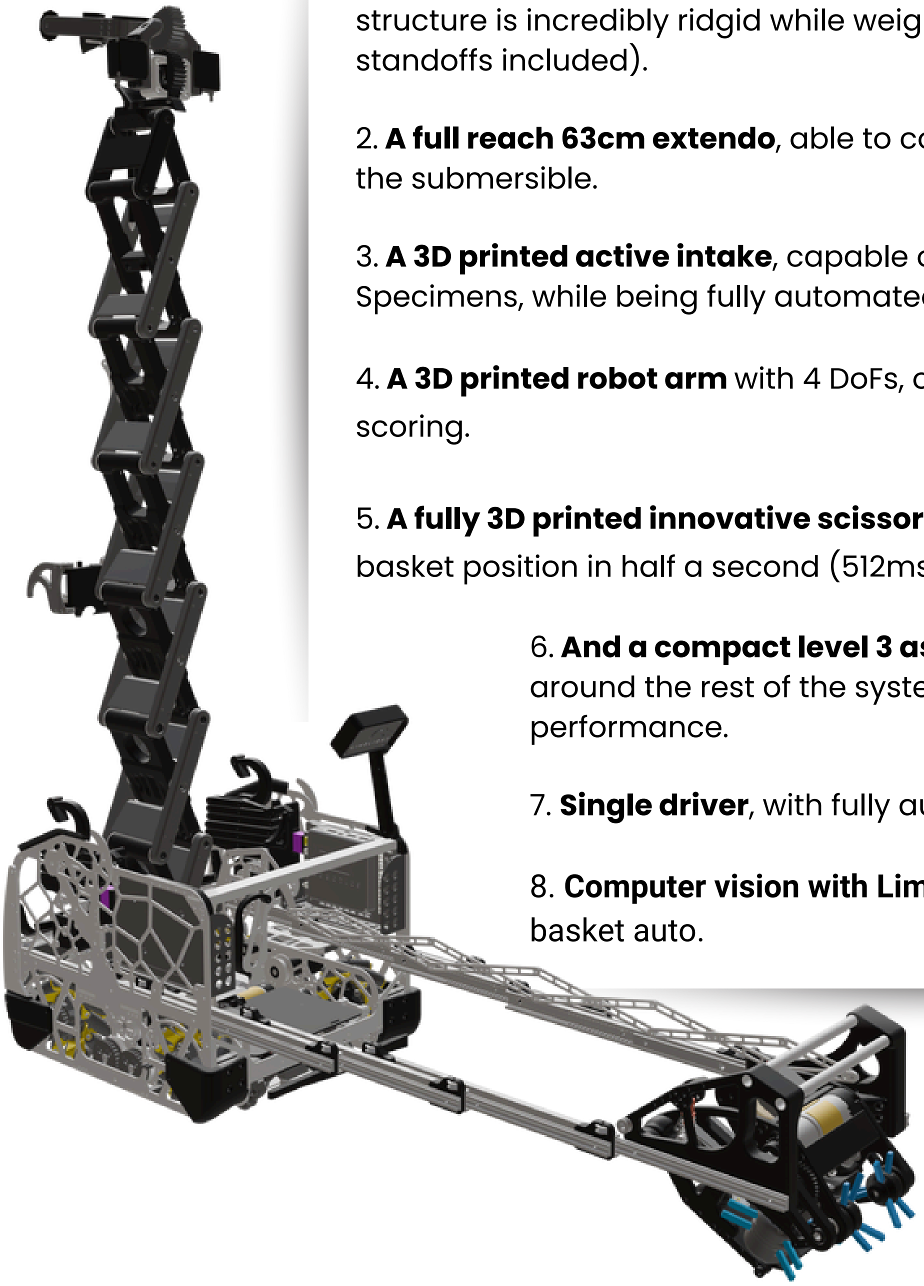
We didn't just grow as builders, we grew as thinkers, coders, and collaborators. We programmed our robot and webcam system to auto-align with field elements, pushing ourselves to tackle autonomous strategies from scratch. Beyond the robot, we explored graphic design, team branding, and documentation, understanding that strong presentation is as vital as strong performance. Most importantly, we learned how to support each other, solve problems together, and stay motivated through every setback. This season wasn't just about competing, it was about becoming a real team, ready to innovate, inspire, and carry the spirit of FIRST forward.

Robot overview: (Genesis)

Specs:
- 6 second sample cycle time
- 7 sample auto
- 5 specimen auto
- Autonomous specimen scoring in teleop.
- Over 10 innteligent failsafes
- Compact: 35cm x 32cm x 27cm
- 10 second level 3 ascent
- > 270 points basket solo
- > 210 points specimen solo



Genesis is a high performance robot featuring:



1. A **puzzle like costum aluminum chassis,** which due to it's advanced structure is incredibly ridgid while weighing only 1200 grams (with screws and standoffs included).

2. **A full reach 63cm extendo**, able to collect samples from the entire area of the submersible.

3. **A 3D printed active intake**, capable of manipulating both Samples and Specimens, while being fully automated.

4. **A 3D printed robot arm** with 4 DoFs, optimized to be light weight for fast scoring.

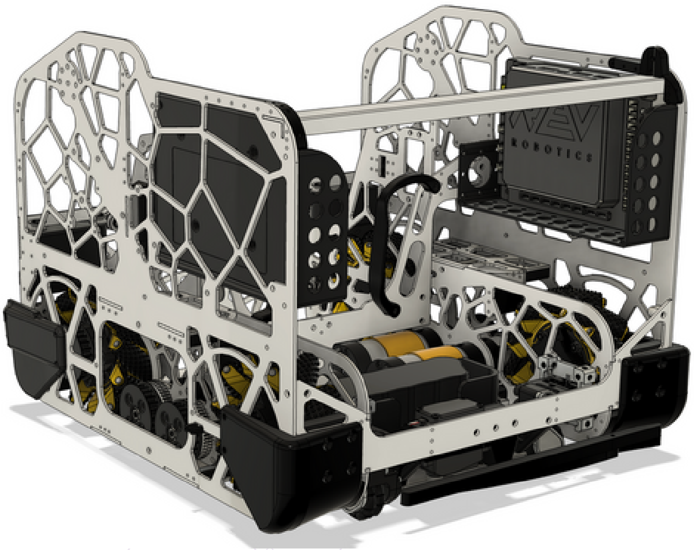
5. **A fully 3D printed innovative scissor lift,** capable of reaching the high basket position in half a second (512ms).

6. **And a compact level 3 ascent mechanism**, designed to work around the rest of the systems as to not impact scoring performance.

7. **Single driver**, with fully automated scoring sequences.

8. **Computer vision with Limelight**, for precise sample targeting in basket auto.

The Chassis

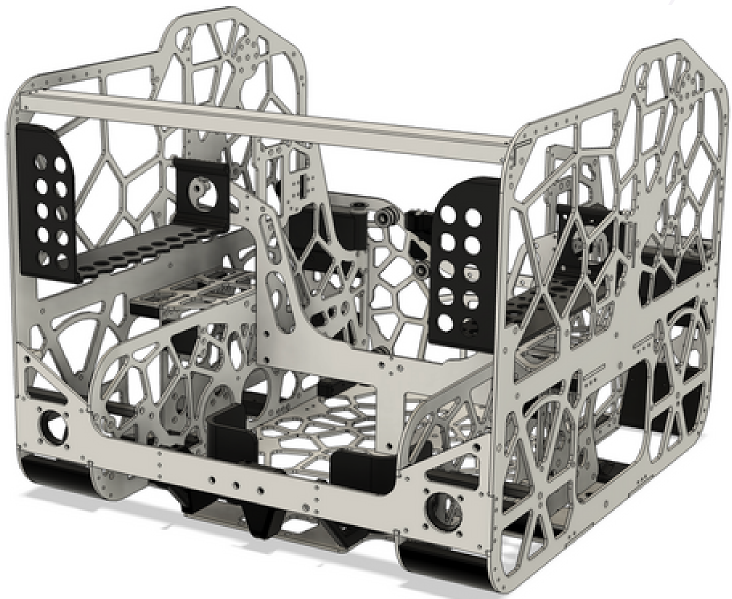


Chassis Highlights

- **Drivetrain**: Optimized for belt-driven mecanum with GoBilda GripForce wheels.
- **Lightweight**: Boosts acceleration and reduces power use during ascent.
- **Rigid & Durable**: Even stress distribution for impact resistance.
- **Integrated Design**: Houses extendo, motors, and electronics with clean cable routing.
- **Compact & Stable**: Easy to maneuver, with a low center of mass for better stability.
- **P.T.O.**: Couples ascent mechanism with drivetrain for efficient power transfer.

Chassis Design & Material Choice

To meet all requirements, we initially considered using carbon fiber plates for the chassis. However, a cost-benefit analysis revealed that spending 500 euros for a mere 500g weight reduction was not justifiable. Therefore, we revised the design to use 2mm aluminum plates instead.
This structure fulfills all requirements, measuring just **35cm x 32cm x 27cm and weighing only 1.2 kg**. It accommodates all systems while positioning the motors and battery close to the ground for a low center of mass. Additionally, the interlocking design of the plates ensures exceptional rigidity despite the thin 2mm construction.



Interlocking Plate Design:

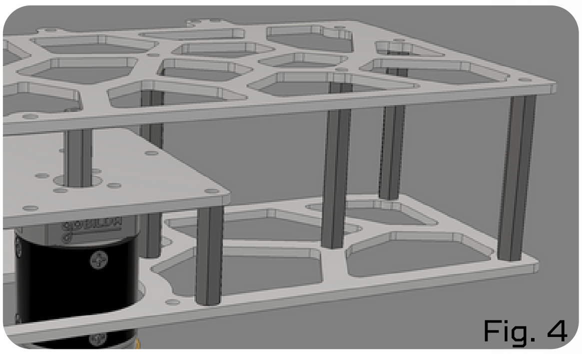


Fig. 4

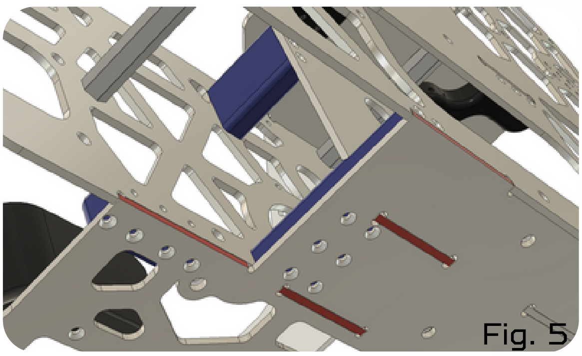


Fig. 5

To reduce weight, we analyzed standard chassis designs and found that much of the weight comes from poor structural design, which requires thick 3mm plates, heavy steel standoffs, and M4 screws for rigidity (as seen in last year's design in Fig. 4). Our design eliminates 90% of the metal standoffs and M4 screws by using **interlocking plates** that brace each other across all three dimensions, making this chassis **30% lighter** then a standard chassis. These plates feature integrated tabs that fit together like puzzle pieces, distributing load and impact evenly across the entire structure while maintaining exceptional rigidity.
The chassis is so structurally sound that it can hold itself together without any screws. :)
To secure everything in place, we use **lightweight 3D-printed brackets and small 2mm self-tapping screws**. Since the plates bear all the structural load, no stress is placed on the screws, unlike the Fig. 4 design that relies on the strength of standoffs. Fig. 5 shows a close-up of the interlocking tabs (in red) and plastic brackets (in blue).

The Intake

Extendo Mechanism Design

The intake system has two main parts: the intake and the extendo. The extendo uses four Misumi slider modules in series, extending up to 65 cm. A reinforced structure with a scissor-style cable holder protects the intake and connects the modules. The design ensures continued operation even if one cable fails.
Cables are routed through pulleys with compact 3D-printed guards to minimize interference (see Fig. 7).

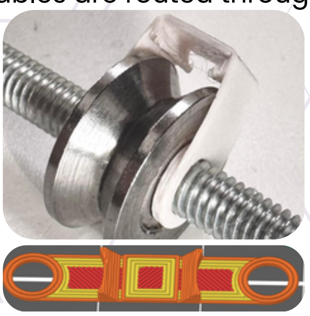
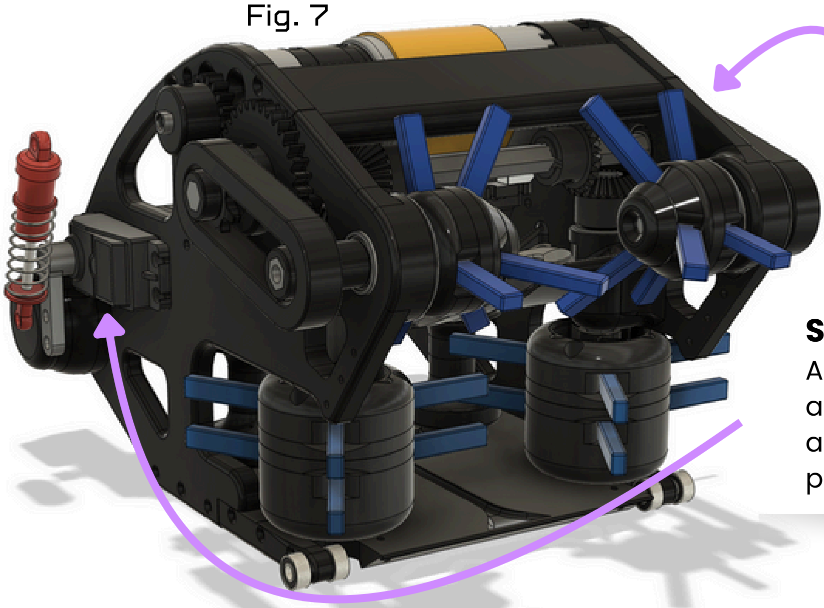


Fig. 7

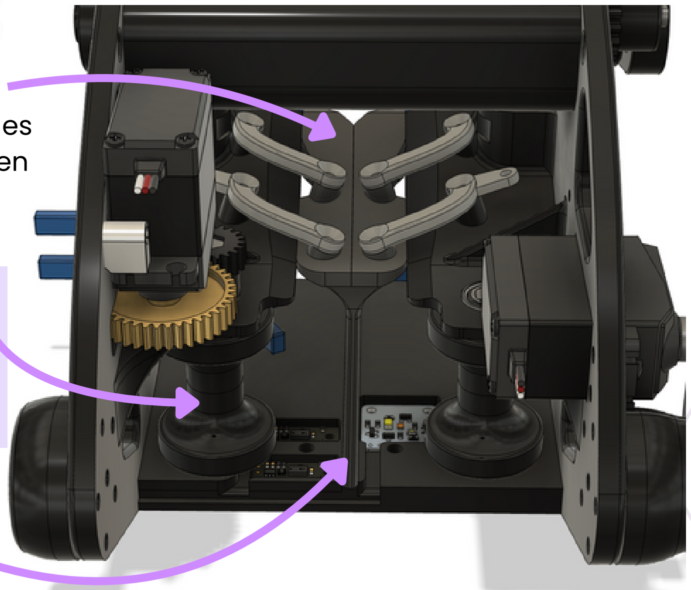


The Brushes:

The active intake uses four spinning brushes to grab, align, and pull in samples efficiently. Their orientation **handles both samples and specimens** with ease. Each brush has rubber bristles in a PLA mount with a soft TPU core for flexibility.
They are powered by a DC motor through a series of chains and bevel gears.

Suspension mechanism:

A servo lowers the intake using a miniature shock absorber, allowing it to press down gently. If it meets a raised sample, the suspension compresses, preventing strain and enabling smooth entry.



Shape-Shifting Guide Doors:

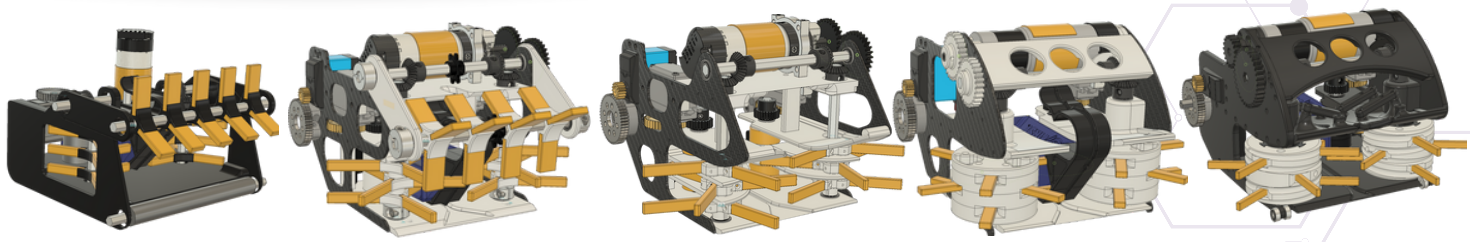
Mounted on a spring-loaded four-bar linkage, these guides position samples correctly during intake. When a specimen clip hits them, they retract to allow it through, enabling reliable handling of both samples and specimens.

TPU Control Rollers

Driven by a continuous rotation servo with a built-in encoder, the TPU rollers with grip tape align, secure, and precisely eject samples forward or backward as needed.

Sensors

A digital proximity sensor detects when a sample enters the intake, while a color sensor identifies its color to trigger the appropriate action automatically.



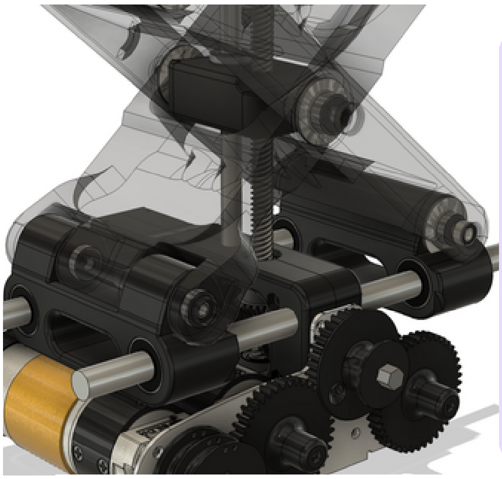
Iterations:

To achieve maximum reliability and functionality for handling both samples and specimens, multiple design iterations were necessary, as shown in the photos above.

The Lift

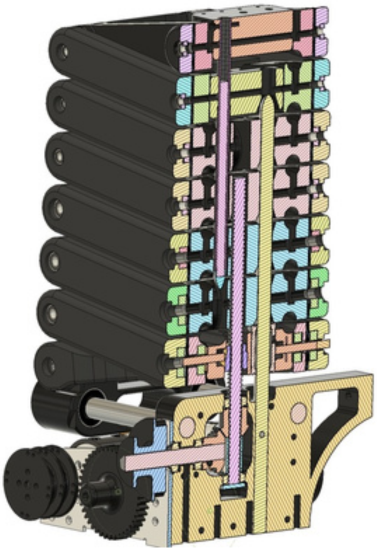
Lift Mechanism Design Approach:

Initially, we considered using a set of sliders similar to those on the extendo. However, having worked extensively with Misumi sliders last season, we were eager to explore a more unique and innovative solution. That solution, is this scissor lift!



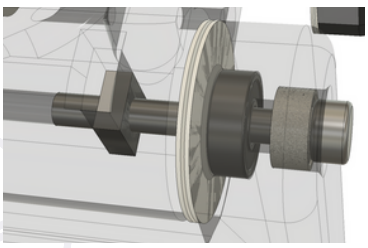
How It Works:

The mechanism is simple in principle but required fine-tuning for reliable performance.
To lift, two 1150 RPM motors drive a system of spur gears, bevel gears, and a lead screw, converting rotational motion into 800 N of linear force.
The gear ratio was calculated to perfectly balance torque and speed for optimal lift performance, archiving full height in 0.52 seconds.
The scissor mechanism is stabilized on three axes using 8 mm polished steel beams with linear bearings.



Scissor Mechanism:

Made from 3D-printed parts, the inner modules use rPLA and the outer ones CF-PET. Each module includes channels and cutouts for rails, springs, and a telescopic top stabilizer. The complex geometry ensures clearance in both open and closed states while maintaining high rigidity. Strong springs between modules counterbalance gravity to maximize lift speed.



Engineering Details

- **Fasteners**: Metric screws (M5–M3) with embedded square nuts for secure, space-efficient joints.
- **Bearings**: Specialized bearing configurations tailored to each joint for optimal motion.
- **Low-Friction Washers**: Custom CNC-machined PTFE (Teflon) washers reduce friction without lubrication.
- **3D Printing Optimization**: Varying infill, shell, and layer settings maximize rigidity while reducing weight higher up the lift, where less force is applied. Though not visible, print parameters significantly impact performance.
- **Telescopic stabilizer**: A carbon fiber telescopic beam maintains vertical alignment of the top mount within tight space constraints.

Design & Development Process

The system went through several iterations. We initially planned to use carbon fiber but switched to stainless steel for budget reasons—only to find it too flexible and flawed. A fully 3D-printed design followed, with the second version successfully meeting all requirements.

The Arm

The Arm Design:

This robotic arm transfers the sample or specimen from the intake to the high basket or rung. Its low weight enables fast lift speeds and quick pivoting—rotating 60° in just 0.12 s using motion profiling, all without overloading the servos or requiring a power module.

Differential:

The middle gear is fixed to the base, while the side gears connect to servo axles (see Fig. 9), enabling two-axis movement for precise alignment using the gyroscope. It also combines both servos' power for backward pivoting, delivering full functionality with just two servos instead of three.

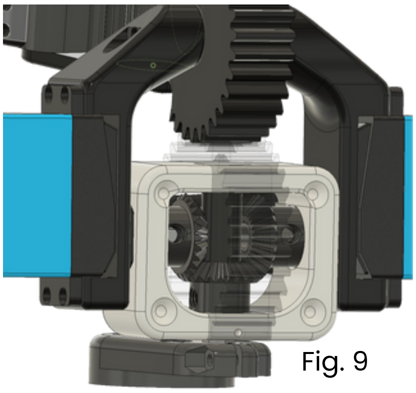
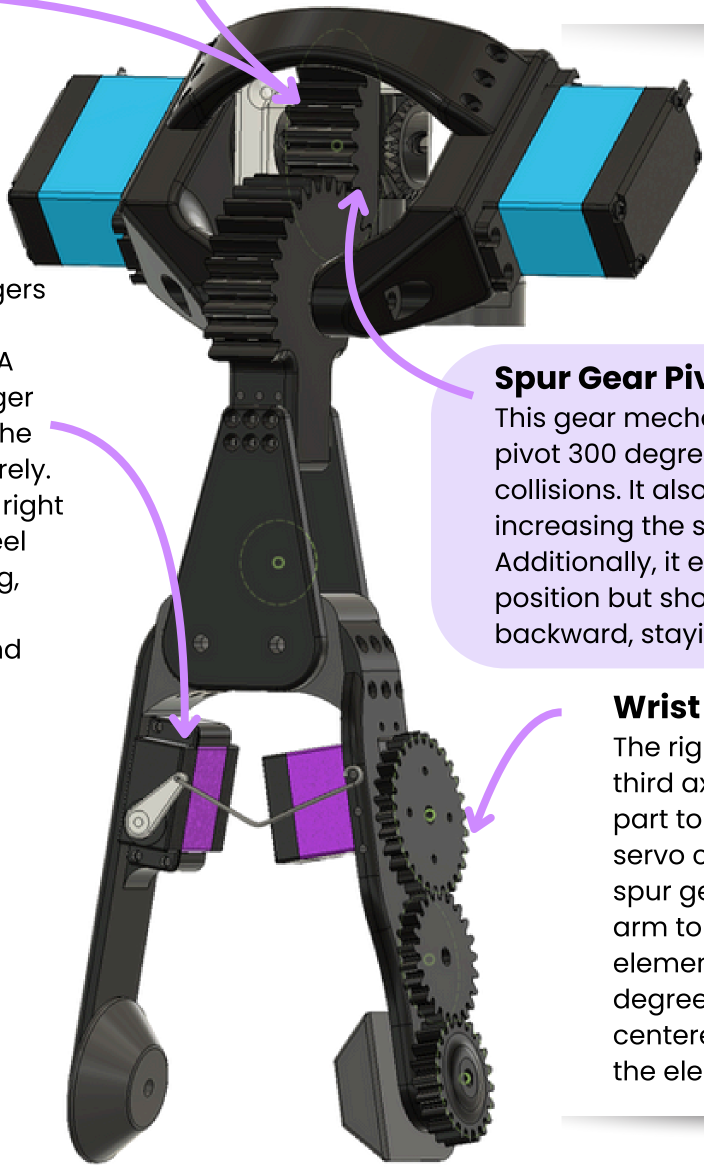


Fig. 9



Claw Mechanism:

The claw has two long fingers linked by spur gears for synchronized movement. A micro servo on the left finger closes the claw, gripping the sample or specimen securely. The servo connects to the right finger with a bent 1mm steel beam that acts as a spring, ensuring firm grip while preventing servo stress and overheating.

Spur Gear Pivot:

This gear mechanism enables the arm to pivot 300 degrees around the lift, avoiding collisions. It also provides a 1:2 ratio, increasing the servos' speed and range. Additionally, it extends the arm in the idle position but shortens it when pivoted backward, staying within extension limits.

Wrist Mechanism:

The right finger doubles as a third axis, allowing the gripping part to pivot using a micro servo connected through three spur gears. This enables the arm to adjust the scoring element's orientation up to 230 degrees, with the pivot point centered through the middle of the element.

Fig. 10

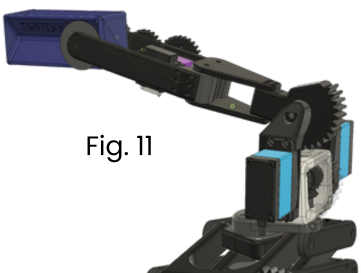


Fig. 11

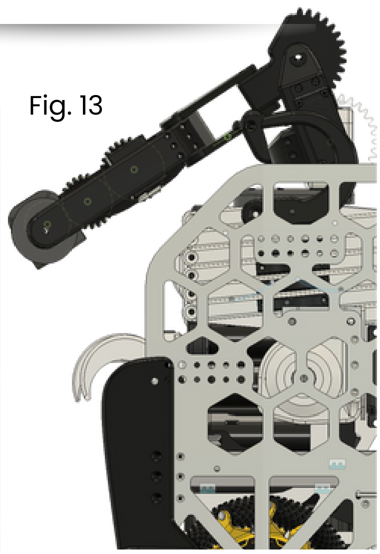
Fig. 12

Arm Positions:

The arm has four main positions:

- Idle Position (Fig. 10): Waiting to grab a scoring element from the intake.
- Basket Position (Fig. 11): Used for scoring in the high and low baskets.
- Specimen Scoring Position (Fig. 12): Endures the highest stress, positioned at the sharpest angle for maximum stability.
- Although specimens are primarily collected with the intake, the arm has a backup position for picking specimens off the wall, as shown in Fig. 13.

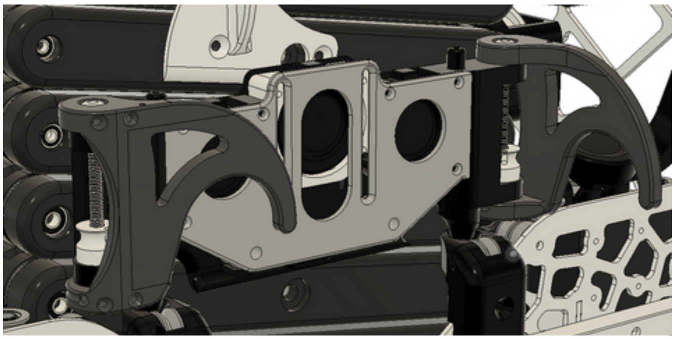
Fig. 13



The Level 3 Ascent

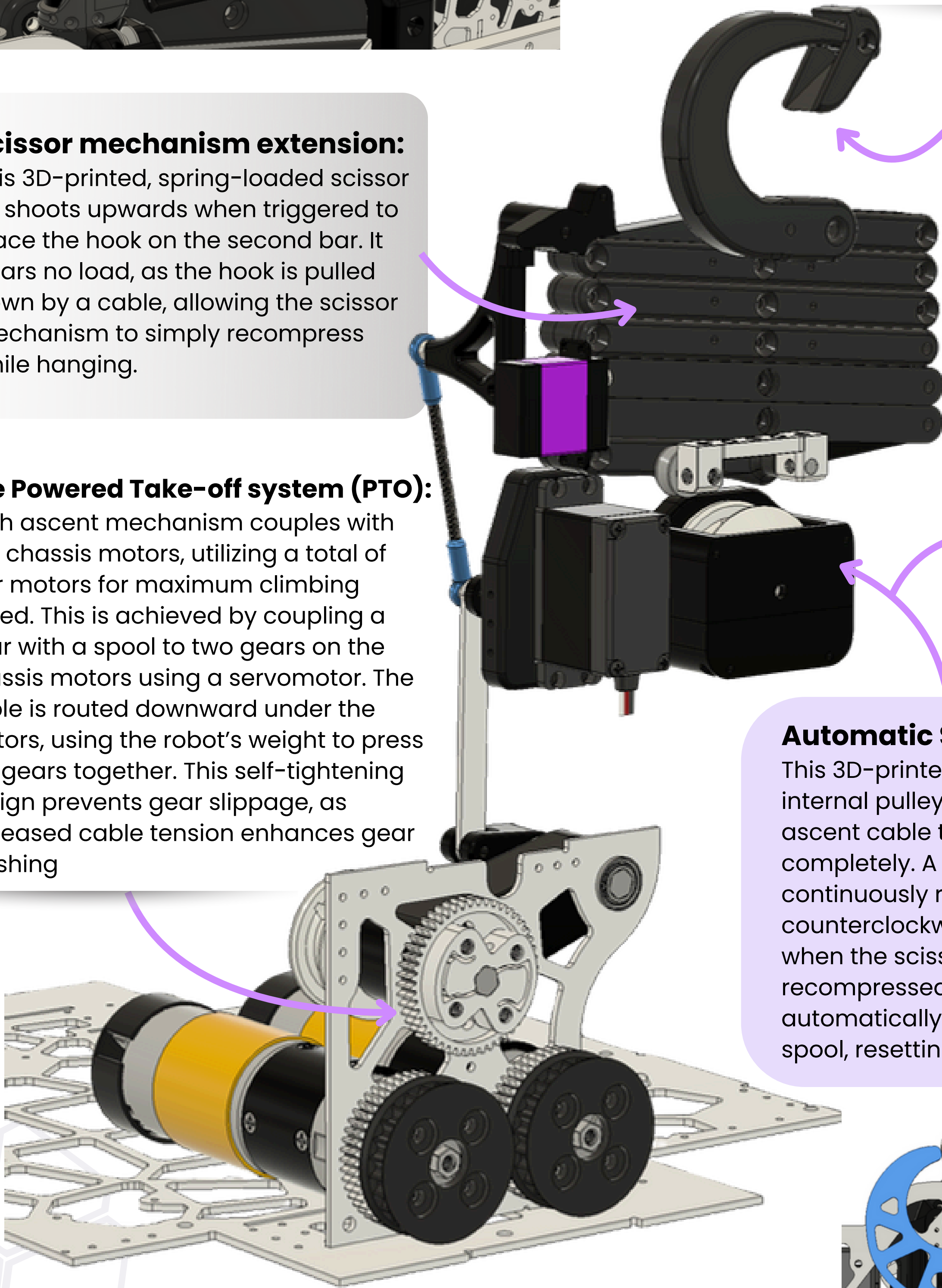
How it works:

The robot first lifts itself to the first bar using a hook on the lift. Then, two spring-loaded scissor mechanisms snap onto the second bar. From there, all four chassis motors power the final climb to complete the level 3 ascent.



The level 2 ascent:

A floating hook, pulled down by the lift motors via strings, enables the level 2 ascent. It stays closed below a certain height to avoid interfering with specimen scoring, then deploys at full extension. When engaged, it lifts the robot from the rear, hanging it face-down from the first bar.



The Hook:

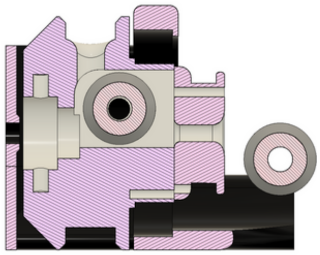
The hook is a 3D-printed part with a spring-loaded locking clip that secures it to the bar during the hang.

Scissor mechanism extension:

This 3D-printed, spring-loaded scissor lift shoots upwards when triggered to place the hook on the second bar. It bears no load, as the hook is pulled down by a cable, allowing the scissor mechanism to simply recompress while hanging.

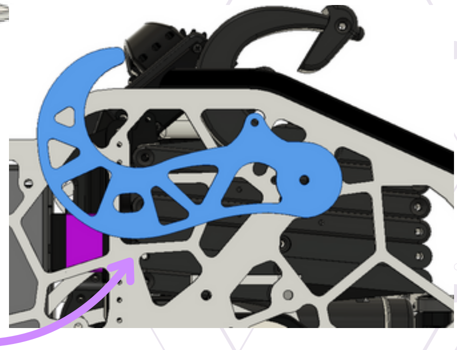
The Powered Take-off system (PTO):

Each ascent mechanism couples with two chassis motors, utilizing a total of four motors for maximum climbing speed. This is achieved by coupling a gear with a spool to two gears on the chassis motors using a servomotor. The cable is routed downward under the motors, using the robot's weight to press the gears together. This self-tightening design prevents gear slippage, as increased cable tension enhances gear meshing



Automatic String Reloader:

This 3D-printed spool features an internal pulley that allows the ascent cable to pass through it completely. A weak spring continuously rotates the spool counterclockwise. After an ascent, when the scissor extension is recompressed, the extra cable is automatically wound onto the spool, resetting it for the next hang.



Safety Hooks:

To ensure the robot stays mounted after ascent, even when powered off, two aluminum hooks deploy and lock it securely onto the bar.

Tele-Op

One Driver to Rule Them All

A single driver operates the robot

This season we chose a single driver software design approach because it offers faster operation of the robot and better coordination on the field. Even with a single driver, the robot is very easy to control because the button logic is well-structured and intuitive, and the robot performs multiple automated actions throughout the match. Additionally, we implemented multiple control systems so the mechanisms perform controlled and smooth movements, as well as multiple fail-safes so that we are backed up no matter what may go wrong on the field.

The Art of Automation

Fully automated Intake and Outtake mechanisms

Using **Command-Based Programming**, we developed automated robot actions for the Intake and Outtake mechanisms, as well as for the transfer between them. With this design pattern, the robot executes groups of commands completely independently, without requiring multiple driver inputs, making it very easy to operate.

Intake

Equipped with proximity and color sensors, the Intake detects both the presence and color (red, blue, or yellow) of a sample. Once a sample is intaked, if it is an opponent alliance sample, it is automatically ejected, and if it is a desired sample, it is retained for further processing.

Transfer

If the desired sample is yellow, it is directly transferred to the Outtake, where the claw of the Arm closes to prepare for scoring. If the desired sample is alliance-specific color, the driver may choose whether to pass it to the Outtake for scoring or eject it to the human player for conversion into a specimen.

Outtake

With a single button press, all the sub-mechanisms of the Outtake (Lift, Arm, and Wrist) are positioned for scoring. For basket scoring, immediately after the sample is released into the basket, the Outtake automatically returns to the initial position.

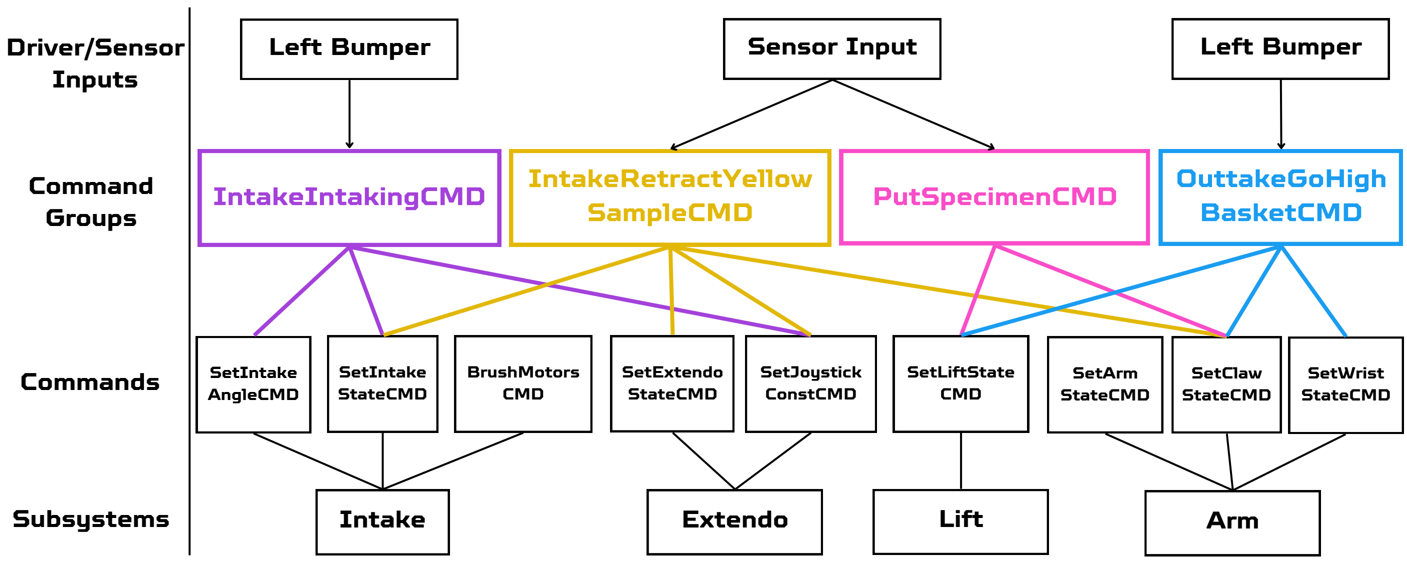
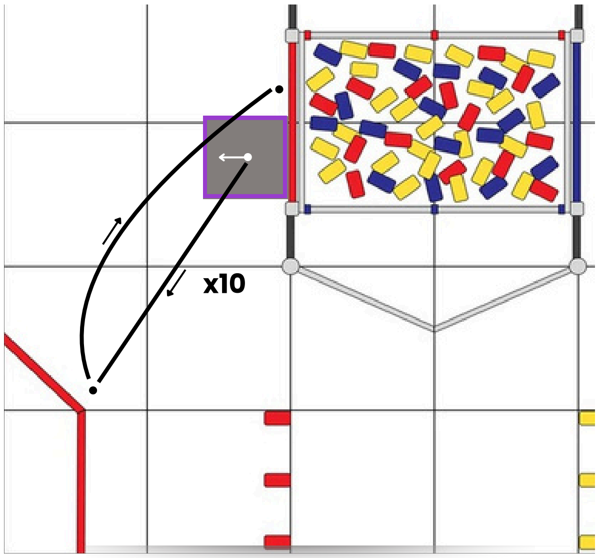


Diagram – Brief explanation of how we implemented Command-Based programming on our robot

Autonomous Scoring in TeleOp

Fully autonomous specimen scoring cycles

Just like in a normal autonomous routine, our robot is capable of scoring reliably up to 10 specimens on the High Rung in under 40 seconds. This leaves no space for human error while performing repetitive cycles, which tremendously improves our scoring performance during TeleOp. Additionally, this approach allows the driver to focus more on practicing the non-repetitive, strategic aspects of the match, such as selecting specific samples, delivering them to the human player, high-performance basket scoring, hang positioning, defense etc.



Power is nothing without Control

All about PIDs, Motion Profiling and control enhancement

PID Controllers

A PID Controller is a feedback control system used to achieve precise and stable control of a mechanism by continuously adjusting its output based on the error between the desired and actual position. We use them for Lift, Extendo, and Ascent mechanisms.

The controller's output is calculated using the following formula:

$$Output = K_p \cdot Error + K_i \cdot \int Error + K_d \cdot \frac{d(Error)}{dt}$$

where: K_p, K_i, K_d are tuning constants

Motion Profiling

Motion profiling is a technique used in robotics to generate smooth, controlled motion by carefully planning a mechanism's velocity and acceleration over time. While not a control loop itself, it works effectively alongside control systems like PID controllers to improve movement precision and stability.

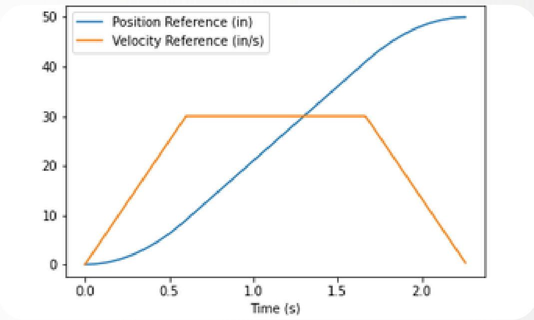
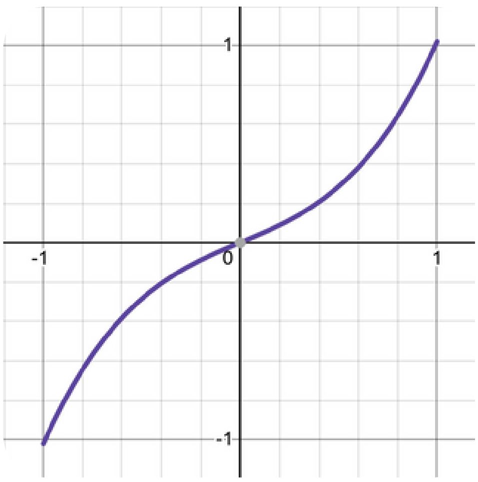


Image source: CTRL ALT FTC Control Theory guide

We implemented Trapezoidal Motion Profiling for the Lift, Extendo and Arm mechanisms because relying solely on PID control (even when well-tuned) and raw power signal, resulted in movements that were too abrupt. These sudden accelerations placed unnecessary mechanical stress on the mechanisms . By incorporating Motion Profiling, we regulated maximum velocity and acceleration, achieving smoother motion, reducing mechanical strain, and improving long-term durability.

Non-linear Power Adjustement



To achieve smoother, more precise control of the Extendo and Chassis mechanisms, their speeds are adjusted using the following cubic polynomial function:

$$f(x) = (x^3 + 0.7x) \times 0.6 \quad \text{where } x \text{ represents the joystick input}$$

Unlike a linear control approach, where motor power is directly proportional to joystick input, this function improves precision by creating a smoother transition between low and high speeds. Small joystick movements correspond to finer, more controlled adjustments, while higher speeds are only reached with more significant joystick input.

Failure is Not an Option... But We Planned for It Anyway

The most interesting TeleOp Fail-Safes

Blocked Samples Fail-Safe

To prevent multiple samples from entering the Intake at once and jamming the mechanism, we implemented an automated eject fail-safe. This system monitors the current draw of the Intake brushes motor via the control hub's **voltage sensor** and activates if the current exceeds 2.75 AMPS, which indicates a blockage. The fail-safe ejects the samples immediately, clearing the intake before the jam affects robot operation. This is especially useful when the submersible is full, as the risk of jamming is higher. By acting instantly, it saves precious time compared to relying on the driver to notice and react manually.

Unresponsive Color Sensor Fail-Safe

The Color Sensor is a single point of failure, meaning that if it crashes we will no longer be able to transfer samples to the Outtake. To avoid that, we continuously monitor the Color Sensor during intake actions. If a sample is intaked and the sensor fails to detect its color for more than 3 seconds, we automatically declare it as DISABLED. From that moment, the robot relies only on the Proximity Sensor to handle the intaked samples.

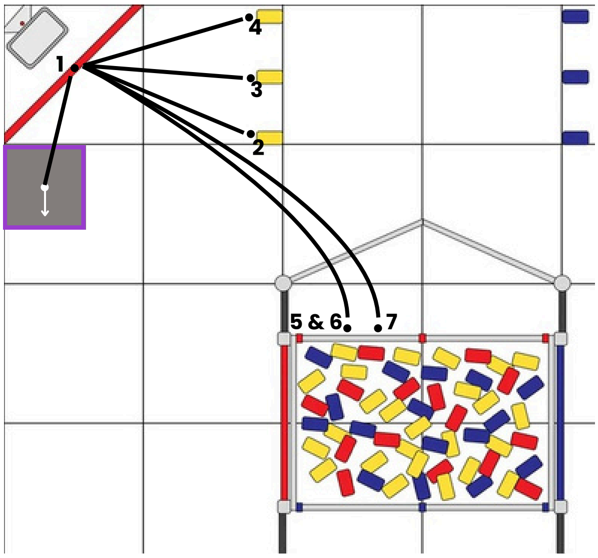
While this means we lose automatic handling for yellow samples and opponent allience samples, the robot remains operational and can still collect and score, ensuring we stay competitive during the match.

Autonomous

Strategy

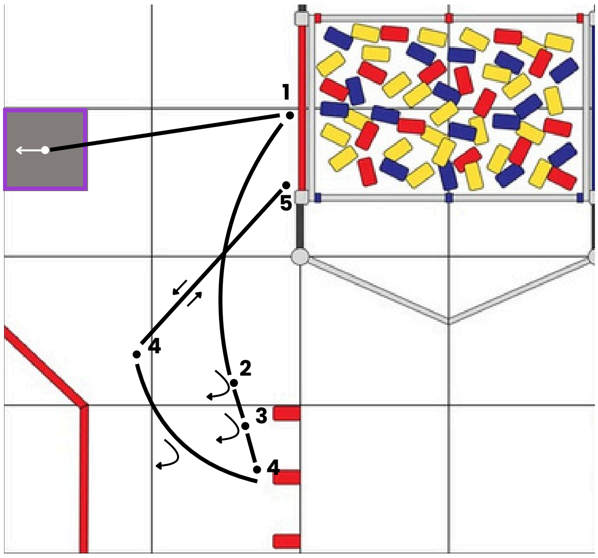
7 Samples Basket Autonomous

The robot first scores the preload sample, followed by the 3 preset samples. It then cycles between the submersible and the basket, intaking and depositing up to 3 additional samples.



5 Specimens Autonomous

The robot scores the preload sample, then uses the Intake to grab the 3 preset samples and bring them to the human player. It then cycles between the human player and the high chamber for scoring 4 additional specimens.



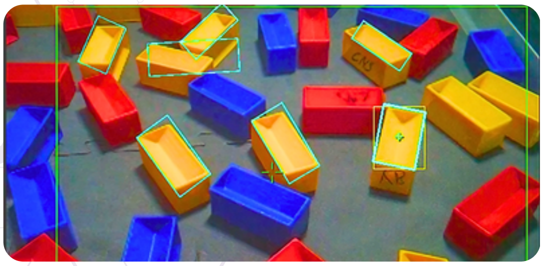
For our autonomous code, we evaluated whether to develop a custom pathing system or use an existing third-party library. Given our time constraints and the need for a highly performant and consistent autonomous program, we chose Pedro Pathing, a library developed by the mentor and alumni of FTC Team 10158 (Georgia, USA). This allowed us to focus on refining our autonomous strategy rather than building a pathing system from scratch. Additionally, we implemented fail-safes to handle field imperfections, human error, and scoring elements bloackages.

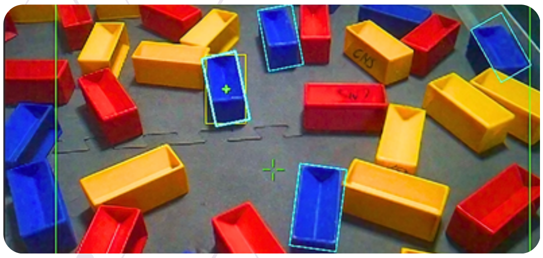
Why Pedro Pathing?

Pedro Pathing stood out due to its Bézier curve generation, which enables smoother, faster, and more efficient trajectories than other methods. Unlike many pathing libraries, such as Road Runner, which rely on purely kinematic models and spline-based trajectory planning, Pedro Pathing optimizes for real-time corrections and fluid motion, making it a superior choice for our robot.

Sample Detection with Computer Vision

Our robot uses a Limelight 3A camera with a **custom Python Snapscript pipeline** to detect and choose samples during Basket autonomous. The camera feed is processed using OpenCV to isolate 3 colors: yellow (most favorable), opponent alliance samples (to avoid), and allience specific samples(less favorable but still valid).





How does the camera choose the target sample?

1st priority: Yellow samples that have empty space directly below them (to ensure a clean pickup). The closest such sample is targeted.

2nd priority: If no good yellow is found, we check for similarly isolated allience specific samples.

3rd priority: If no sample meets the previous criteria, they are all ranked based on proximity to opponent alliance samples (bad), proximity to other yellows (good), and allience specific samples(not bad). The highest ranked sample is chosen.

last resort: If all else fails, we target the sample in the biggest cluster, assuming it's safer to intake

The Math behind Robot Motion

The Limelight camera gives 2 outputs:

- **Tx** How far up or down the target is (degrees)
- **Ty** How far left or right the target is (degrees)

We can use the Tx and Ty values to calculate how much the robot needs to rotate towards the detected sample and how much the Extendo needs to extend to reach it.

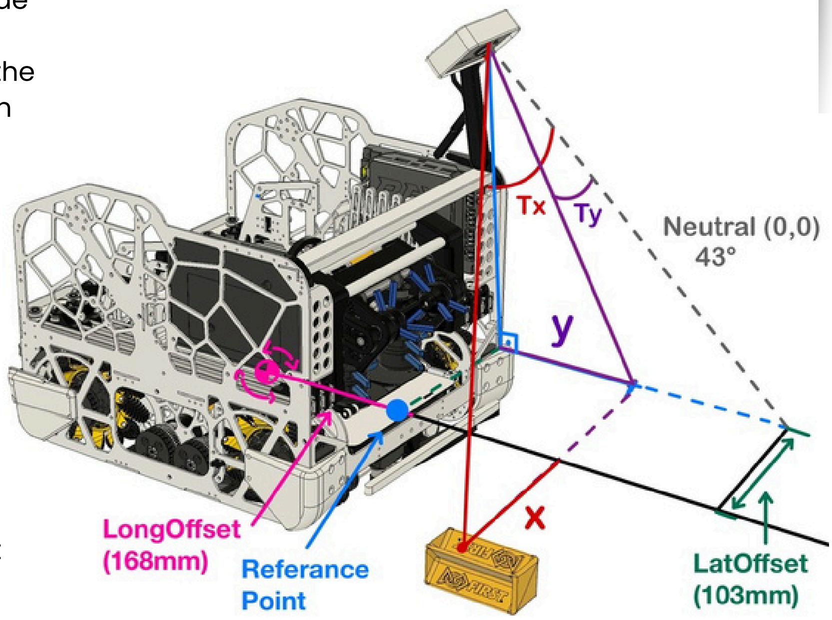
First, we need to determine the forward distance (y) and the lateral distance (x) between the robot and the sample. We chose the center of the Intake mechanism as the reference point to simplify the calculations.

As shown in purple on the diagram, the forward **distance(y)** can be represented as the bottom side the triangle formed by the camera's **Ty value**, the **camera angle**, and the **camera height**. Knowing the height and angle, we can use the tangent function to find **y**:

$$y = \tan(T_y + cameraAngle) \times height$$

Similarly, the lateral **distance (x)** can be represented as the bottom side of the triangle situated on a plane parallel to the line formed by **Ty**, as shown in the diagram. By knowing the **Tx angle**, finding the length of the line formed by Ty, and using the tangent function, we can find the lateral distance relative to the camera. By subtracting the distance from the reference point to the camera(the Lateral Offset), we get the final x value:

$$x = \tan(T_x) \times \sqrt{\text{height}^2 + y^2} - \text{lateralOffset}$$

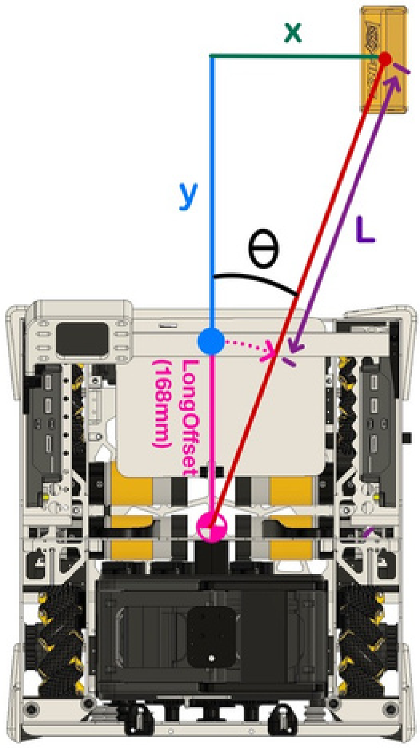


To determine the rotation of the robot we use another triangle, formed between the **robot's center of rotation,** the **forward** and **lateral distances**. We apply the arctangent function to find the angle of rotation, taking into account the distance between our reference point and the robot's center of rotation (the Longitudinal Offset).

$$\theta = \arctan\left(\frac{x}{y + \text{longitudinalOffset}}\right)$$

For determining the length of the Extendo, we calculate the hypotenuse of this triangle and subtract the offset from the Intake to the center of rotation. After that, we multiply the result by 1.81 to convert from millimeters to motor ticks, as this is the tick-to-millimeter ratio of our Extendo mechanism.

$$L = \left(\sqrt{(y + \text{longitudinalOffset})^2 + x^2} - \text{longitudinalOffset}\right) \times 1.81$$



Failure is Not an Option...
But We Planned for It Anyway (again)

The most interesting Auto Fail-Safes

Basket Autonomous	**Specimen Autonomous**

Preset Samples Fail-Safe

If minor field imperfections prevent the robot from grabbing a preset sample on the first attempt, the Extendo extends slightly more for a second try. If the sample is still not intaked after the second attempt, the scoring trajectory to the basket is canceled, and the robot proceeds directly to the next preset sample.

Limelight Targeting Fail-Safe (no sample intaked)
During each cycle to the submersible, the robot can attempt to intake a sample up to 3 times. If the 1st attempt fails, the Extendo slightly retracts and then extends a bit further to retry intaking the same sample.
If the robot also misses the 2nd and 3rd attempts, the Extendo fully retracts, the robot realigns to its original target position, and then searches for a new sample to collect.

Limelight Targeting Fail-Safe (wrong sample)
If an opposing alliance sample is accidentally intaked, the robot automatically ejects it and then resumes its targeting attempts as described above.

Misplaced Specimen by Human Player
If the human player misplaces a specimen and it is puched away by the Intake, the robot attempts to intake it for 1.5 seconds. If no specimen is detected by the proximity sensor, the extendo retracts for 2 seconds to allow repositioning, then retries to intake. This process repeats for all 4 specimens.

Specimen Blockage in Intake
Although blockages were very rare during testing, we wanted to ensure we are prepared in case one occurs during a match. If a specimen is physically stuck in the Intake, a current spike is detected due to increased current draw. We monitor this via the control hub's voltage sensor. If the voltage exceeds 1.5 AMPS, the robot ejects the specimen, retracts the Extendo for 2 seconds, and retries the intake.

If you are interested in our code and/or our CAD model, they are all open source on our website!

ROBOAS