TEAM X #23512

teamx@ignitepathways.org

Engineering Portfolio

INTO THE DEEP 2024-2025

PRESENTED BY RTX

Portfolio Outline

Meet the Team

We are **TEAM X**, a community team based out of Dublin, CA. We have been a team since 2018: five years in FLL, second year of FTC.

Our Mission: *Solve real-world problems using Robotics & Electronics, while having fun!*

Ronav Gupta

Captain

Arnav Jain

Hardware

Samar Bhowmick

Outreach

Yajat Sunkara

Operations

Arjun Mahajan

Software

Rajeev Gupta

Lead Coach 1

Neeraj Juneja

Lead Coach 2

Shivang Patwa

Design Mentor

Suhani Gupta

Youth Mentor

Roles & Responsibilities

Driving Success Through Teamwork and Leadership

Success is built on **focus**, **accountability**, and **collaboration**. At TEAM X, we prioritize clear roles and shared accountability. Each member takes ownership of their designated leadership area, ensuring that tasks are completed with excellence. At the same time, we foster a supportive environment where everyone contributes to the success of the team as a whole. By working together and staying committed to our collective goals, we strive to innovate, grow, and perform at our best.

RONAV GUPTA, *Quarry Lane School* ***Team Captain, Design Lead***

Ronav, our Captain and Design Lead, is a CAD and 3D printing enthusiast known for his innovative designs and strategic vision. Proficient in OnShape, he shares his expertise by teaching CAD and contributing to the FTC community, inspiring creativity and excellence both within and outside the team.

ARNAV JAIN, *Dublin High School* ***Hardware Lead***

Arnav leads the hardware development for TEAM X, ensuring the robot's structural integrity and mechanical performance. With a keen eye for detail and a passion for engineering, he focuses on creating robust, efficient, and innovative designs that align with the team's strategic goals.

ARJUN MAHAJAN, *Emerald High School* ***Software Lead***

Arjun, our Software Lead, is passionate about the convergence of technology and innovation in robotics. His expertise drives the development of efficient and precise code, enabling the team's robot to perform at its best during every challenge.

SAMAR BHOWMICK, *Quarry Lane School* ***Outreach Lead***

Samar, our Outreach Lead, combines a passion for coding and public speaking to drive the team's outreach and community involvement. Responsible for outreach, and engagement, Samar hosts free coding camps for kids, teaching Python, HTML, and CSS, while fostering excitement for technology and robotics within the community.

YAJAT SUNKARA, *Fallon Middle School* ***Operations Lead***

Yajat, Operations Lead, is the youngest member of the team and a true team player. With a hands-on approach and a passion for tinkering, he contributes across all areas, ensuring smooth operations and bringing fresh energy to every project.

Design Strategy

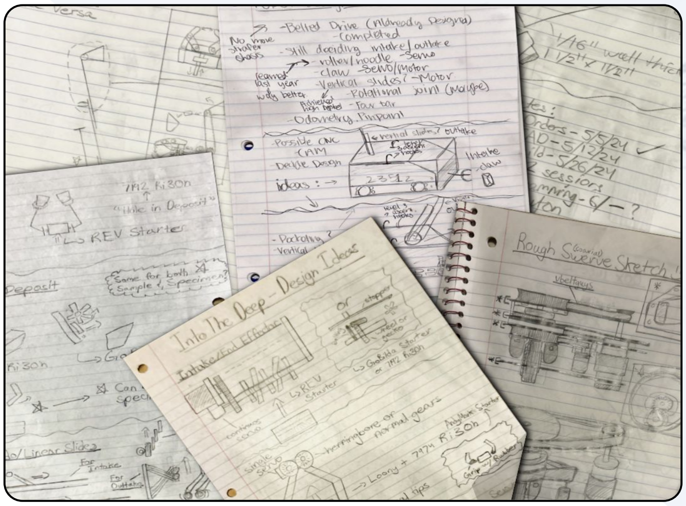
The Blueprint Behind Our Success

Our design strategy reflects our commitment to **innovation**, **collaboration**, and **iterative improvement**. With a focus on solving challenges effectively and efficiently, we prioritize robustness, adaptability, and precision in our robot's design. This strategy guides our development process, ensuring alignment with competition goals and the FTC's Core Values.

KEY PRINCIPLES

Problem-Driven Design	**Modular Approach**	**Simplicity & Efficiency**

DESIGN WORKFLOW



Conceptualization

We begin by analyzing the game to figure out what's most important—scoring, mobility, and other key tasks. Then, we brainstorm ideas, **sketch** them out, and build **CAD** models to bring them to life. Once we have a list of options, we use a decision matrix to choose the best design.

Prototyping

Next, we turn our ideas into working prototypes. This is where we test things out, see what works, and uncover any challenges. It's all about experimenting and improving as we go.

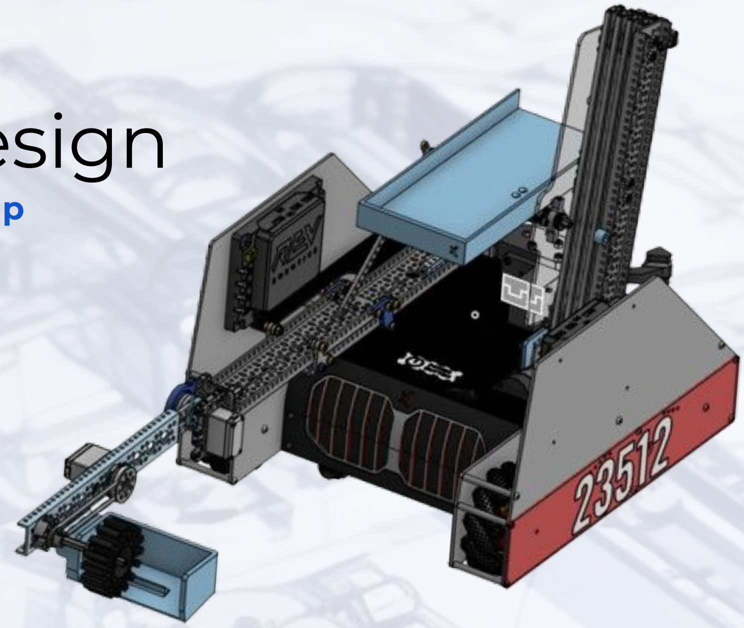
Iterations

We then focus on design iterations based on feedback from our prototypes, ensuring a balance between form and function. We evaluate what worked, what didn't, and refine each element to enhance both performance and aesthetics.

Final Design

Finally, we put everything together into the finished robot. We run it through rigorous testing to make sure it's durable, reliable, and ready for competition.

Custom Robot Design



Crafting Innovation from the Ground Up

One of our key goals this season is to create a custom robot. This goal pushes us beyond the convenience of off-the-shelf parts, challenging us to **innovate**, **engineer**, and **build** a robot that showcases our creativity, skills, and understanding of robotics.

WHY CUSTOM DESIGN?

Building a custom robot allows us to address unique challenges with tailored solutions. Instead of adapting to pre-made parts, we design components that fit our strategy and objectives perfectly.

Mechanism	Features	Advantages	Performance outcomes
Belted Drivetrain	• Belts and pulleys to transfer power from motors to wheels • Lightweight and low-friction design	• Smooth & efficient power transmission • Quieter operation compared to chain drive	• Reliable and precise movement • Improved speed and agility during matches
Servo Claw	• Servos for controlled gripping and releasing of objects • Compact and precise design	• Accurate and repeatable object manipulation. • Lightweight and low energy consumption	• Improved performance in specimen pick up • Effective for picking up and placing samples
Passive Bucket	• Mounted for collecting or depositing objects. • No servo or motor • Gravity-assisted mechanisms	• Simple and efficient • No wiring / clutter • Less electronics, less software bugs	• Fast and reliable scoring in baskets or observation zones • Simple and effective
Extendo	• Four Bar Linkage • Compliant wheels • Operated by 3 servos, 1 for the four bar, 1 for the elbow, and 1 for the roller	• Little to no precision needed • Compact and Simple	• Greater versatility in gameplay • Ability to score and pick up in distant locations

Design & Performance

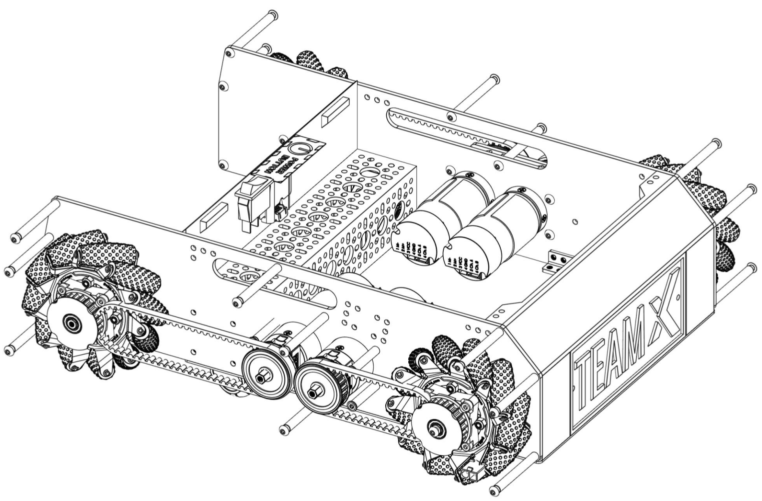
Enhancing Excellence Through Customization

Great design drives exceptional performance. By focusing on **custom robot** design this season, we've unlocked new opportunities to optimize our robot's capabilities and address challenges with tailored solutions. Custom components not only elevate the robot's functionality but also reflect our commitment to engineering excellence.

CUSTOM DESIGN ENHANCES PERFORMANCE

Precision and Optimization

Custom-designed components allow us to fine-tune every aspect of our robot's performance. By creating parts specifically for tasks like scoring, mobility, or object manipulation, we can achieve a higher level of precision and efficiency compared to generic, off-the-shelf solutions.



Seamless Integration

With custom design, each part is created to fit perfectly into the overall system. This integration reduces unnecessary weight, minimizes mechanical complexity, and ensures that every component works in harmony, boosting the robot's reliability and effectiveness.

Innovation and Adaptability

Custom parts empower us to think creatively and develop innovative solutions for unique challenges. They also allow for adaptability, enabling us to modify designs as we refine our strategy or encounter unexpected obstacles.

Competitive Edge

By designing and building our own components, we gain a deeper understanding of our robot's capabilities and limitations. This hands-on approach gives us an edge in competition, as we can troubleshoot, adjust, and improve more effectively.

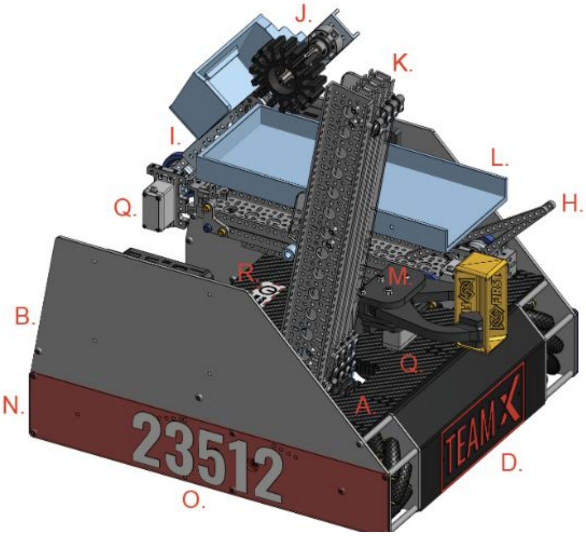
CAD, CAM and CNC

Turning Ideas into Precision Engineering

Instead of free-building, we rely on a structured process of design iterations and CAD modeling to bring our ideas to life. By combining CAD with CAM and CNC fabrication, we create custom parts that elevate our robot's performance and showcase the power of precision engineering.

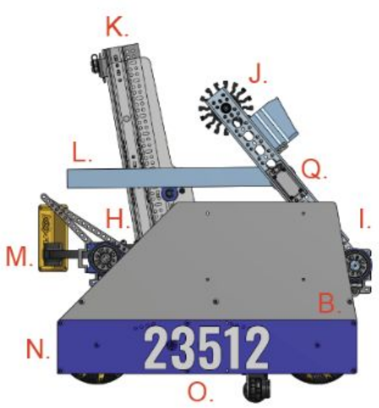
CAD (Onshape) **as the Foundation**

Every component we build begins in CAD, where we create detailed **digital models** to visualize and refine our ideas. This allows us to explore multiple iterations, test the feasibility of our designs, and ensure every part serves its purpose efficiently. By starting with CAD, we ensure that **form**, **function**, and **performance** are balanced from the very first step.

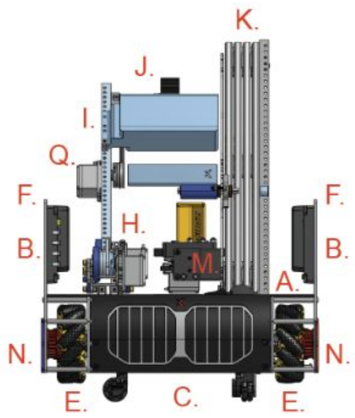


From Design to Reality: CAM and CNC

Once our designs are finalized, we use CAM (**Computer-Aided Manufacturing**) to translate them into precise instructions for CNC machines. **CNC fabrication** allows us to create custom parts with unparalleled accuracy and consistency. This process ensures that every component is tailor-made for our robot's needs, enhancing both its performance and reliability.



LEFT SIDE VIEW



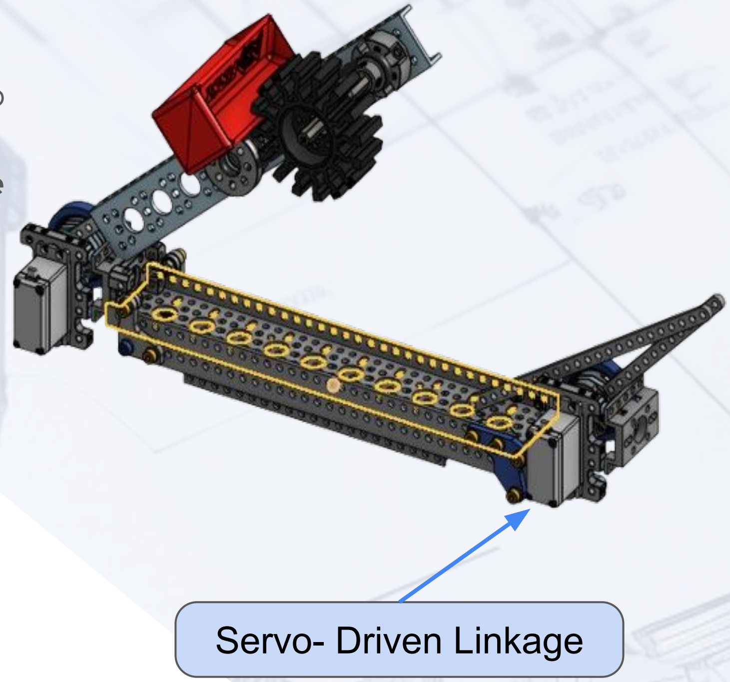
FRONT VIEW

- A. Top Plate
- B. Side Plate
- C. Front Grill
- D. License Plate
- E. Belted Drive Train
- F. Control Hub
- G. Battery
- H. Extendo (Arm)
- I. Movable Elbow
- J. Active Intake
- K. Viper Slide
- L. Bucket
- M. Servo Claw
- N. Alliance Marker
- O. Team Number
- P. Motor
- Q. Servo
- R. Power Switch

Extendo

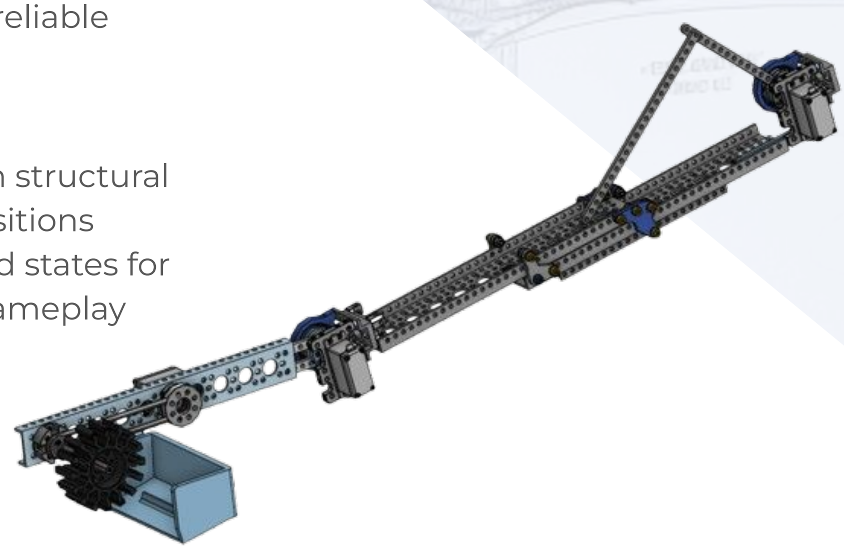
After several iterations, our team ended up with this amazing extendo, which is sleek and delivers high performance via it's **core design** and **automation**.

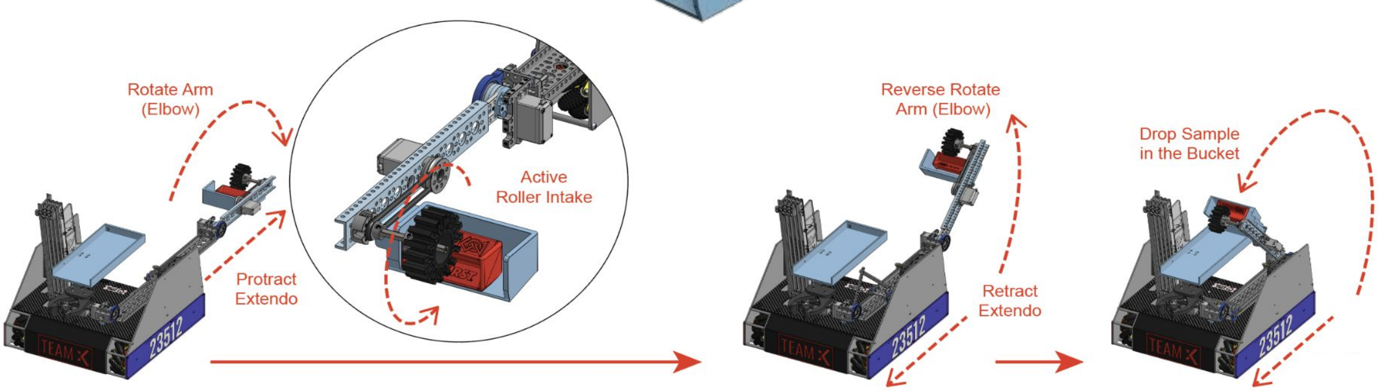
Extended Reach
Utilizes a servo driven linkage and elbow system to achieve significant extension, allowing the robot to access distant or elevated areas on the field like the submersible.



Object Acquisition
The roller mechanism at the end is designed to efficiently intake and secure samples, ensuring smooth and reliable collection during gameplay.

Versatile Deployment
Combines precision control with structural flexibility, enabling smooth transitions between retracted and extended states for efficient space utilization and gameplay adaptability.

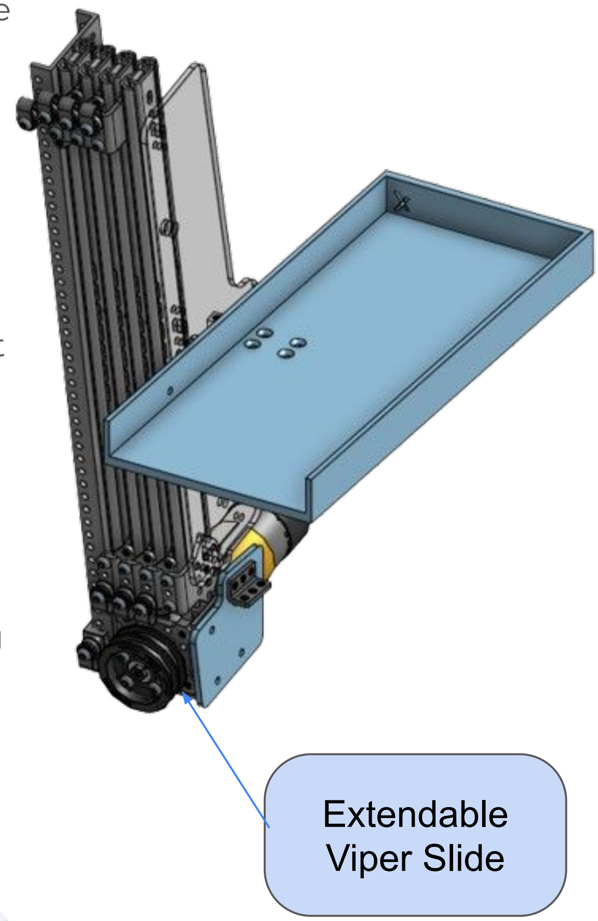




SAMPLE INTAKE - EXTENDO | ACTIVE ROLLER INTAKE

Passive Bucket

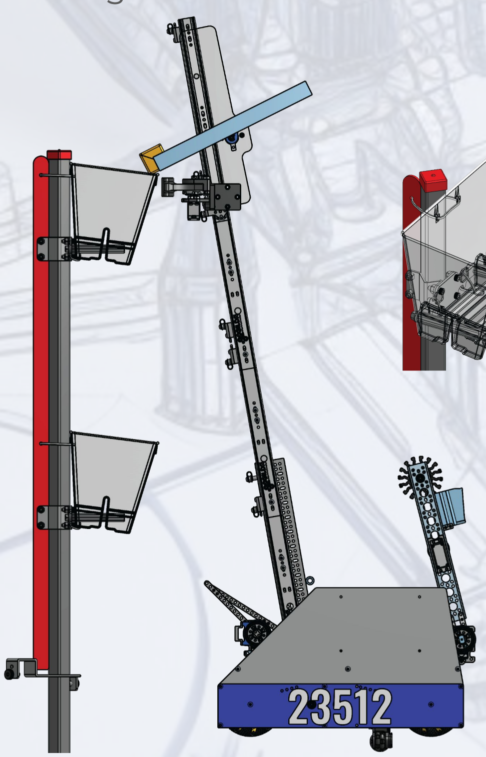
The passive bucket leverages gravity and simple mechanisms to deposit samples efficiently, offering reliability, energy efficiency, and reduced complexity without the need for motorization.

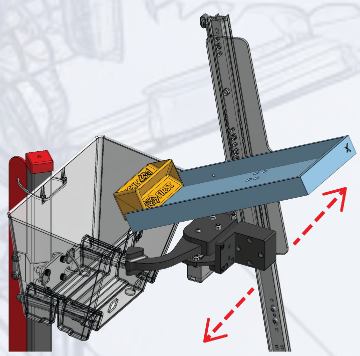


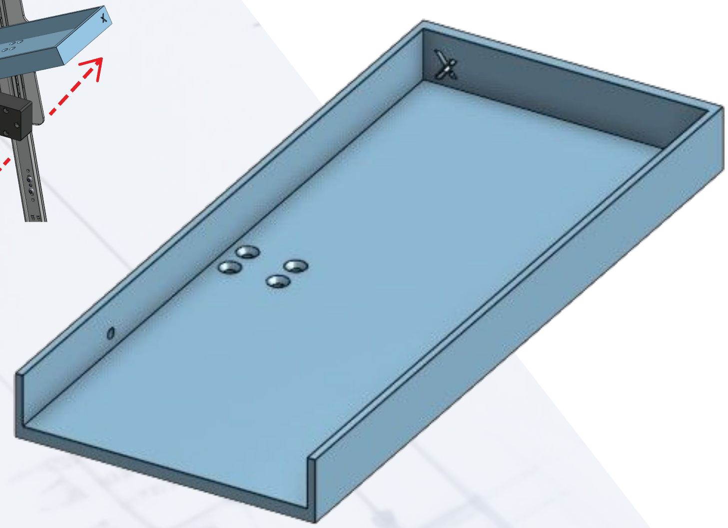
Sample Transfer
Acts as an intermediary system to receive sample objects from the Extendo and transport them to specific scoring locations or storage zones on the field.

Vertical Mobility
Utilizes a Viper Slide to move the bucket vertically with precision, ensuring smooth handling of samples at different heights during gameplay.

Stable Sample Containment
Features a sturdy design with a flat bucket platform, ensuring that samples remain secure during transfer and vertical motion.



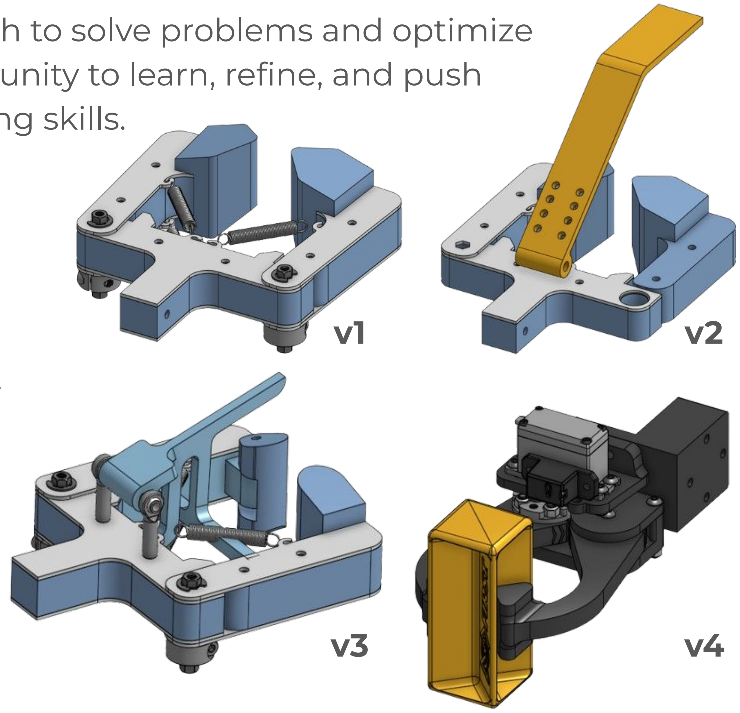




Iterations and Problem Solving

Driving Continuous Improvement

We embrace an iterative design approach to solve problems and optimize performance. Each iteration is an opportunity to learn, refine, and push the limits of our creativity and engineering skills.



Custom Specimen Claw

The custom specimen claw evolved through a careful iterative process.

- **V1** featured a basic passive design,
- **V2** added reinforcements for stability.
- **V3** introduced a lever mechanism improve performance
- **V4** transitioned to motorized automation, improving precision

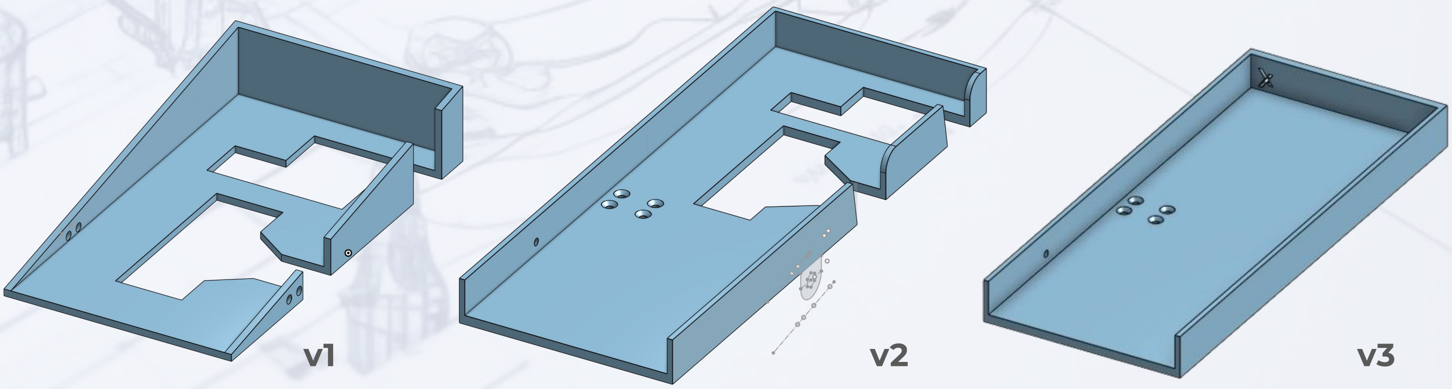
Each iteration built on testing insights, resulting in a highly optimized design.

Passive Bucket

The passive bucket **leverages gravity** and simple mechanisms to deposit samples efficiently, offering reliability, energy efficiency, and reduced complexity without the need for motorization.

The bucket evolved to improve functionality and manufacturability. Starting as an open structure in **Version V1,** it gained reinforcing features in **Version V2** for better strength and assembly. **Version V3** simplified the design into a fully enclosed shape, enhancing rigidity and reducing material use.

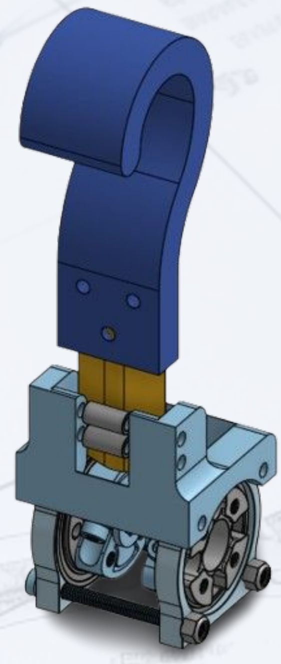
Each iteration refined its **durability** and **efficiency**.



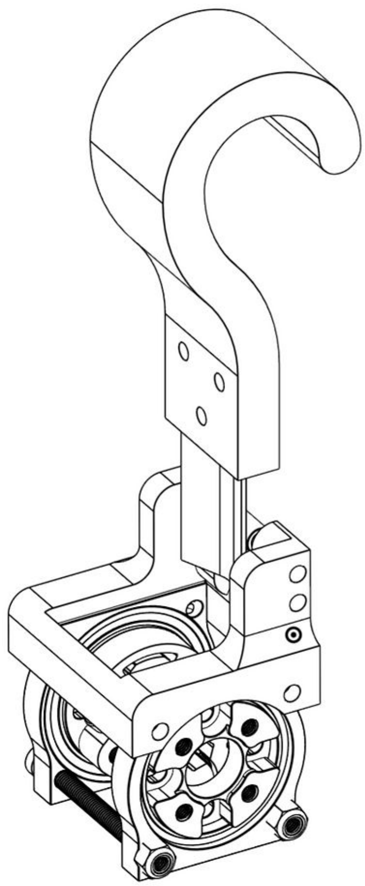
Innovating Level 3 Ascent

Innovating Ascent with Tape Measure

During a brainstorming session for FTC's INTO THE DEEP challenge, we explored countless mechanisms for the Level 3 Ascent, from **hooks** to **winches**. None felt right—until inspiration struck with an everyday tool: **a tape measure.** Initially dismissed as impractical, the idea grew on us as we realized its potential. Compact, lightweight, and precise, it offered a unique way to tackle the challenge.



Our final design uses two tape measure mechanisms, each equipped with a **3D-printed hook** for stability and durability. A motorized system allows the tape measures to extend and retract efficiently, enabling the robot to hang securely from the high rung, earning **30 points.** The system's compact design keeps the robot streamlined while maintaining strength and reliability.



DESIGN ITERATIONS & TESTING

Prototype Development: We started by modifying standard tape measures with metal hooks and GoBILDA Sonic Hubs. Initial tests revealed the need for alignment guides to ensure smooth operation.

Weight Testing: Using a 25-pound dumbbell, we confirmed the its ability to support our robot without bending or twisting.

Final Refinements: Updates included reinforced 3D-printed hooks and enhanced integration onto the robot

The tape measure solution transformed an everyday tool into a high-performance ascent system, blending innovation with simplicity. Compact, reliable, and efficient, it exemplifies TEAM X's commitment to creative problem-solving.

Software Strategy

The Brain Behind the Bot's Precision and Performance

Our software strategy is designed to create a seamless integration between the robot's hardware and its operational capabilities. We focus on two main areas: **Autonomous** and **TeleOp**, supported by **engineering best practices**.

AUTONOMOUS STRATEGY

For Autonomous, we need to make sure the robot always knows its **exact location** on the field. To achieve this, we utilize GoBILDA Pinpoint odometry, which provides precise tracking of the robot's movement.

To translate this position data into reliable movement, we implement **PID control.** PID dynamically corrects the robot's path in real-time, ensuring precise navigation and alignment with field elements.

TELEOP STRATEGY

For TeleOp, we take a **customer-centric approach**, where our drivers—our 'customers'—define the controls that work best for them.

Through collaborative feedback, we design software with intuitive keybindings, sensitivity adjustments, and driver-assist features like automated scoring mechanisms. This approach enhances the drivers' instincts and efficiency during matches.

ENGINEERING BEST PRACTICES

To ensure reliability and scalability, we adhere to following engineering best practices:

- **Test Driven Development:** Using **Meep Meep**, a virtual simulation tool, we design and test our autonomous paths before running them on the robot. This allows us to identify and resolve potential issues early, saving time and ensuring a more reliable Autonomous mode.
- **Version Control:** Using Git to track changes and maintain code integrity.
- **Peer Code Reviews:** Ensuring quality and consistency through feedback.
- **Clear Documentation:** Keeping detailed records of code functionality and system design for future reference and easy collaboration.

These practices ensure our software remains robust, maintainable, and ready for continuous improvement.

Odometry and Road Runner

Navigating with Precision: Odometry and Path Planning

ROAD RUNNER

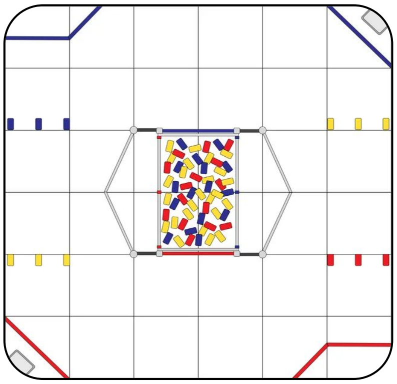
We use Road Runner, a motion planning library, written for the FTC robotics competition. This helped us in designing complex path following while maintaining control of velocity & acceleration during the autonomous time period.

4-BAR ODOMETRY & ENCODERS

We use 4-bar odometry configuration to keep record of our robots position and heading (Pose) at any time. Using two parallel odometry wheels to calculate heading is more accurate and higher performance while also incorporating an external IMU from the GoBILDA pinpoint computer.

DEAD WHEELS

A small unpowered wheel that tracks the distance the robot has traveled through the encoder attached to the wheel's axle. Generally, odometry wheels are sprung so that the wheel is in contact with the floor tiles at all times to ensure accuracy.



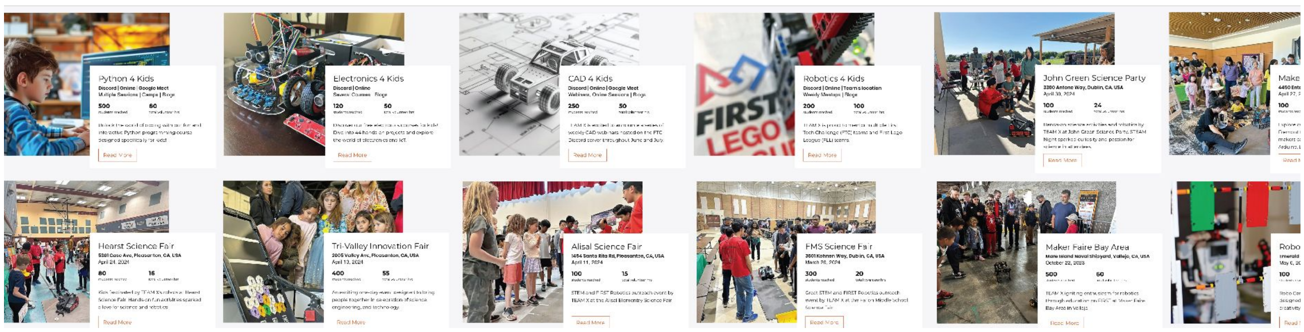
MEEP MEEP

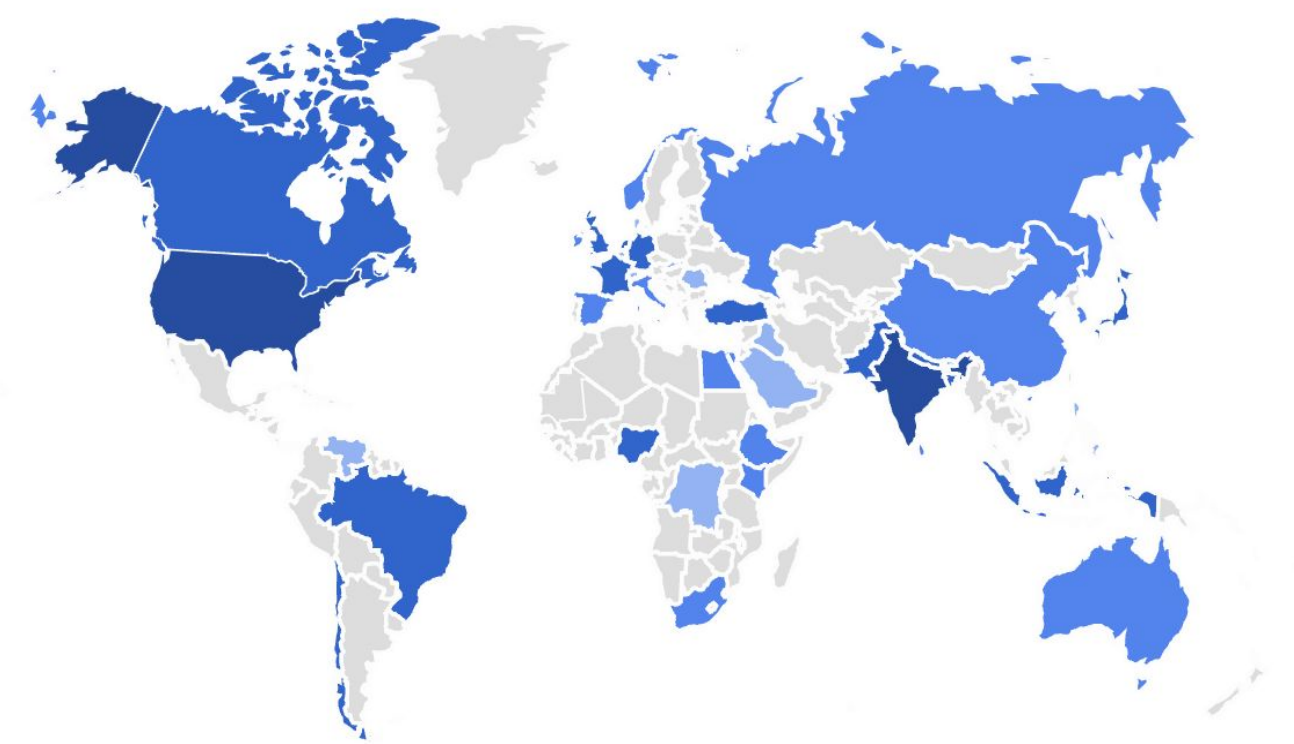
We use Meep Meep to build and test **trajectories** before coding our Auto. It allows us to simulate the robot's movements without requiring a physical field. This sped up out autonomous programming process as we are able to determine the most efficient paths.

Global Outreach

Impact by the numbers

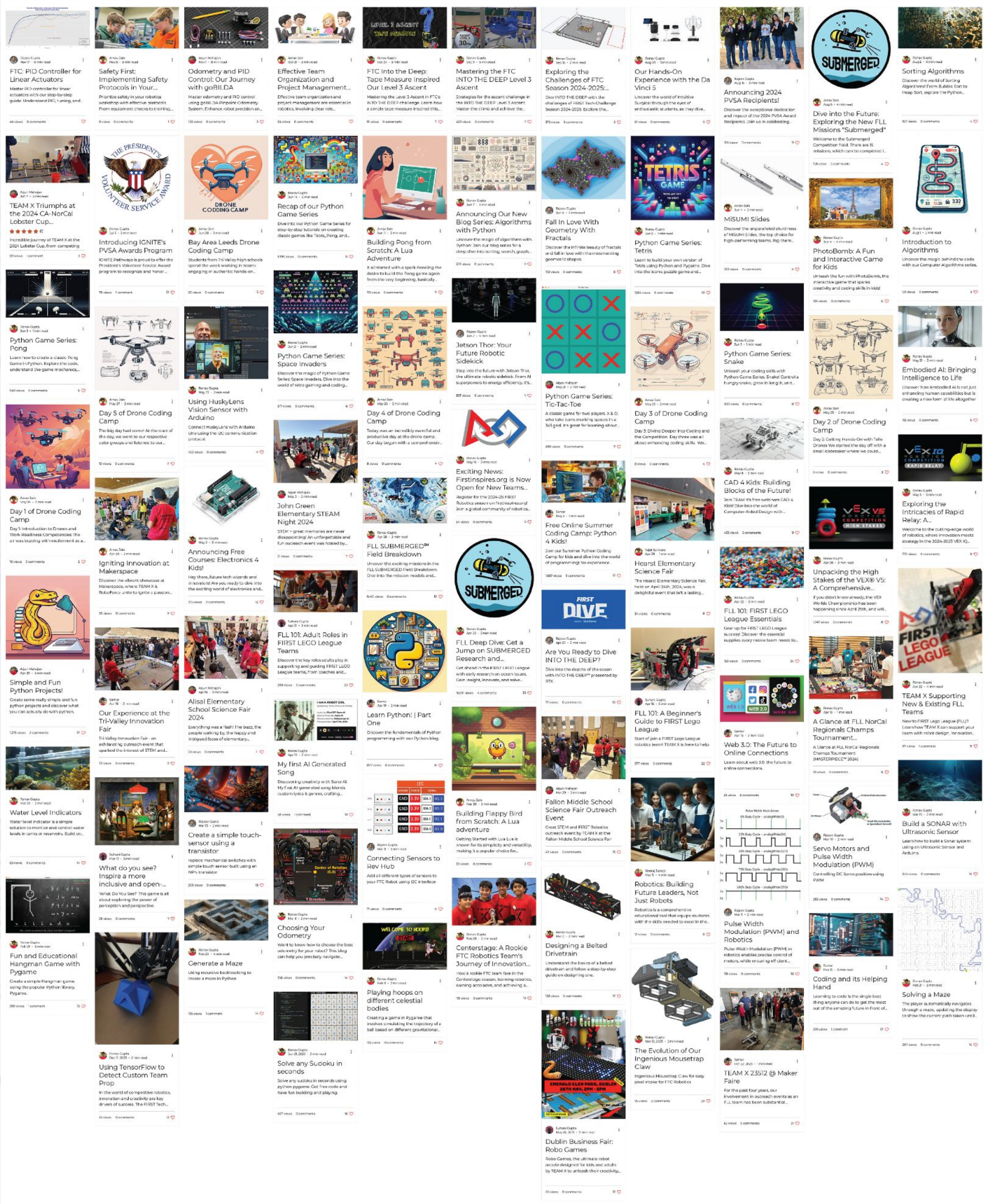
Outreach Events [24]





Online Outreach

Online Blogs, Articles, Newsletters, and Camps (CAD & Programming)

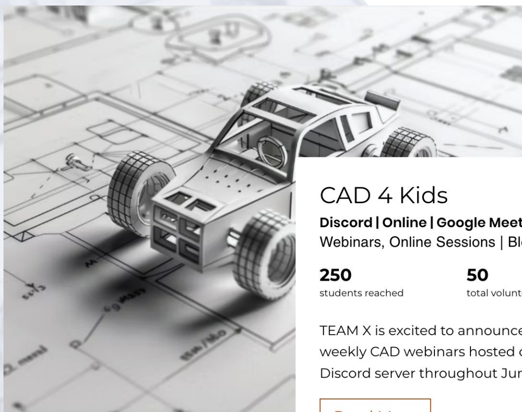


Technical Outreach

Empowering the Next Generation

We are passionate about **sharing** our knowledge and inspiring others to explore the exciting world of STEM. Through our technical outreach programs, we aim to empower young minds by providing accessible, hands-on learning opportunities in engineering, programming, and robotics. These initiatives reflect our commitment to fostering creativity and innovation within the community.

SUMMER CAMPS and ONLINE SESSIONS



CAD 4 Kids

Discord | Online | Google Meet
Webinars, Online Sessions | Blogs

250 students reached
50 total volunteer hrs

TEAM X is excited to announce a series of weekly CAD webinars hosted on the FTC Discord server throughout June and July.

Read More

Python 4 Kids

Discord | Online | Google Meet
Multiple Sessions | Camps | Blogs

500 students reached
80 total volunteer hrs

Unlock the world of coding with our fun and interactive Python programming course designed specifically for kids!

Read More

MENTORING FTC and FLL TEAMS

We are deeply committed to fostering growth within the FIRST community by mentoring multiple FTC and FLL teams. Through regular guidance, technical support, and encouragement, we help these teams achieve their goals while promoting the values of FIRST. Our mentorship efforts include:

- **FLL Team Terrace Tech Titans (#65169)** - California
- **FTC Team Glitch (#23836)** - California
- **FTC Team Rapid Fire (#25442)** - California
- **FTC Team Solar Flare (#25707)** – New York
- **FTC Team Black Frogs (#6134)** - Michigan
- **FTC Team Smart Cluster (#19071)** - Romania

By mentoring these teams, we share our expertise in design, programming, and strategy while encouraging teamwork, creativity, and resilience. Seeing these teams grow and succeed is one of the most rewarding aspects of our outreach efforts.

Special Thanks To Our **Sponsors** & **Grantors!**

PLATINUM

opkey

GOLD

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TRI-VALLEY VENTURES

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SILVER

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QUANTUM ROBOTICS

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DUBLIN CALIFORNIA

SOUSOU TEAM

Breeze

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