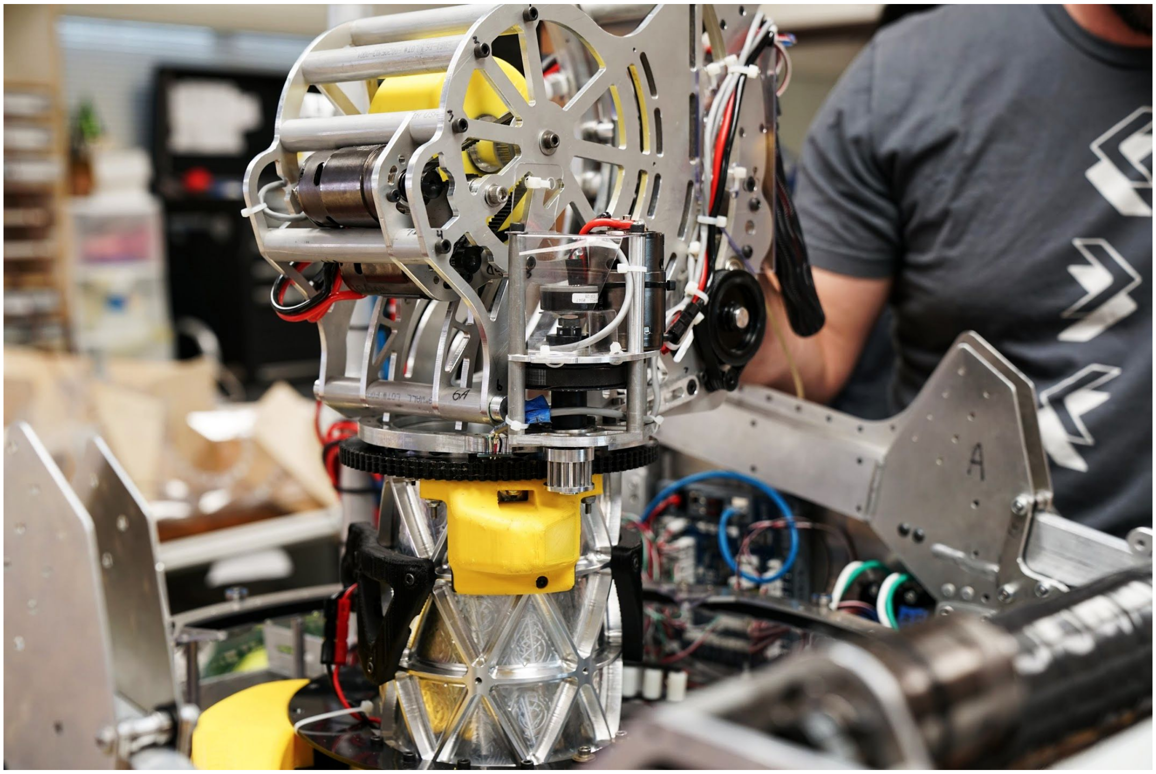
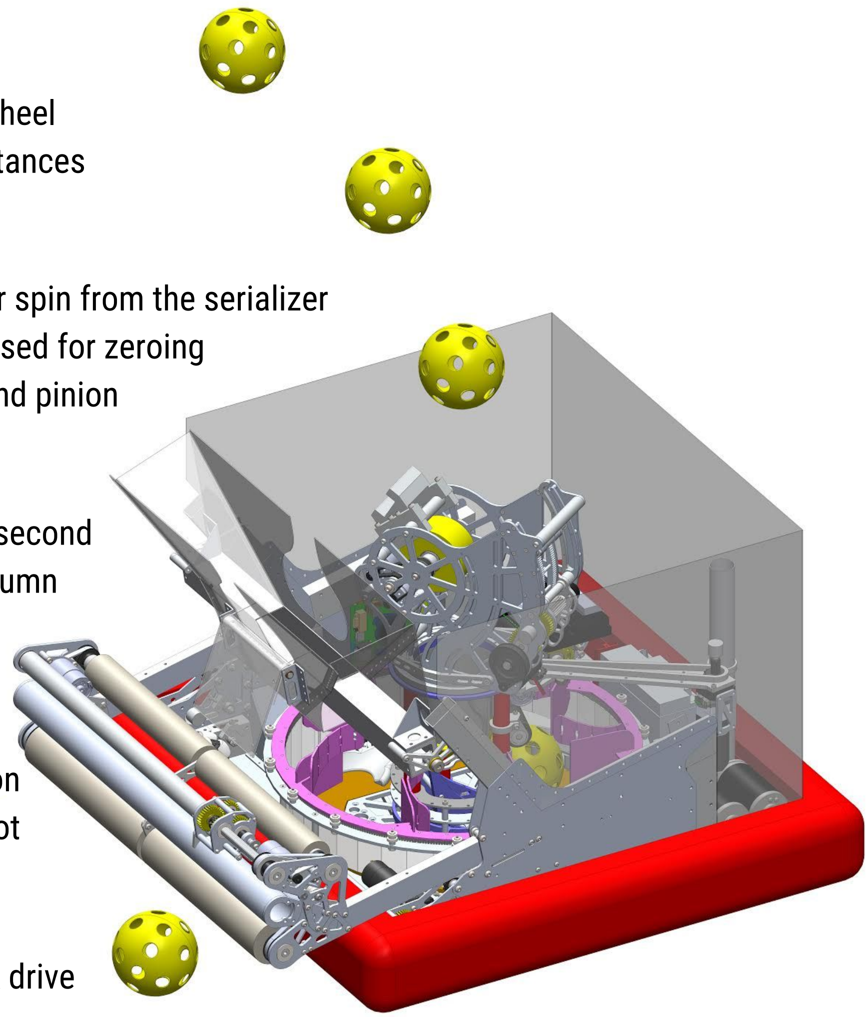
SPARTAN ROBOTICS

FRC 971



Technical Documentation 2017

971 Robot Overview



Shooter

- 4" diameter shooter wheel
- Hybrid Kalman Filter to control the shooter wheel
- Hood mechanism allows for varying shot distances

Turret

- 4 state-space controllers oppose the counter spin from the serializer
- WCP Hall Effect Sensor, developed by 971, used for zeroing
- Custom designed epicycloidal gear profile and pinion

Serializer

- Maximum speed is geared for 30+ balls per second
- Counter rotating outside cage and inside column
- "Dolphin" clears balls out in case of jams

Gear Mechanism

- Collects gears from the human loading station
- Allows Pilot to pull the gear out from the robot

Hanger

- One way bearing and a ratchet prevents back drive
- Driven off of two 775pro motors in the intake
- Velcro roller

Intake

- Over the bumper system
- Foam rollers with silicon self-sealing tape
- Abrasion-Resistant neoprene bumpers

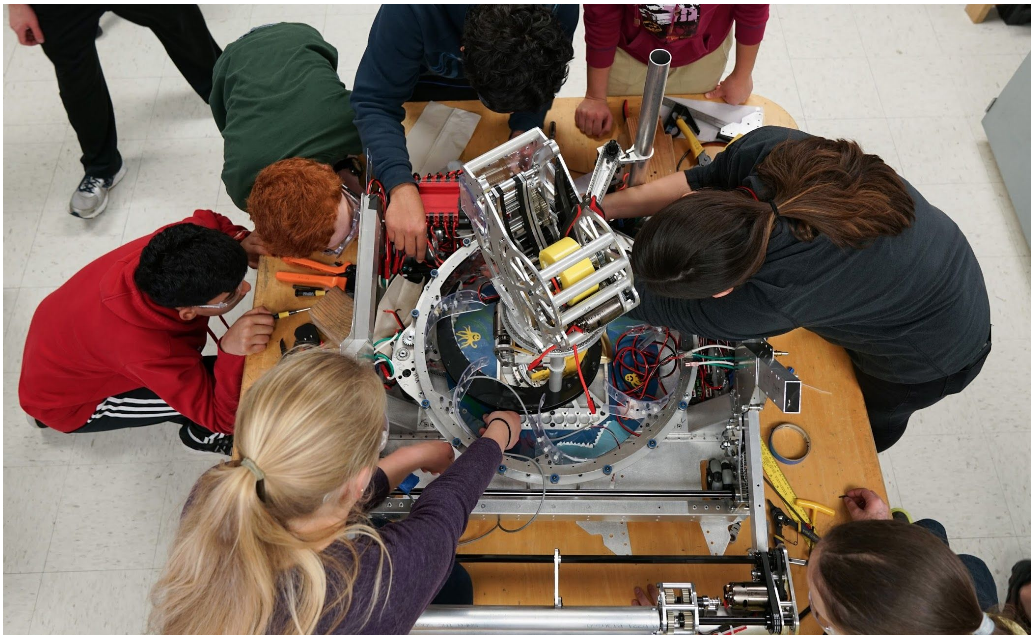
Drivetrain

- 15.6 ft/sec, single speed transmission
- 3.5" omni wheels on the front axle
- 3 of 3.5" Colson wheels on the back axle

971 ON DESIGN

On Spartan Robotics, we believe that engineering is the process of optimizing a solution to perform its task as efficiently as the laws of physics allow. Our goal is the develop the highest quality robot possible and relentlessly chase perfection.

Design Process



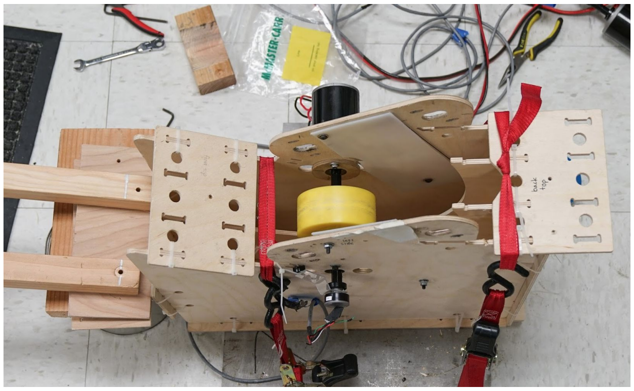
1. Identify necessary functions.
2. Determine assemblies and allocate the necessary functions.
    - Prototype subassemblies.
    - Use CAD to determine geometry and prototype to confirm feasible geometry.
3. Use CAD to design the robot and produce drawings for manufacturing.
4. Integrate subsystems with code. Use state feedback control to make the robot run at peak performance reliably and consistently.

Robot Function Objectives

- Shoot Fuel at 30 balls per second with 95% accuracy.
- Intake Fuel off the ground.
    - “Touch it, own it.”
- Maneuverable and light drivetrain to avoid defense.
- Collect Gear from human player station and allow pilot to retrieve it from robot.
- Hang quickly and consistently at the end of the match.

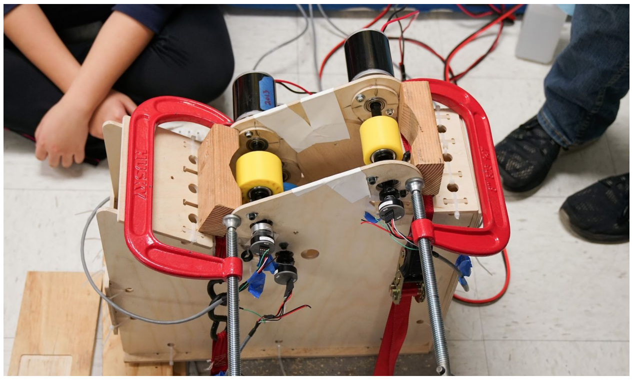
Prototyping

Shooter



Single Wheel

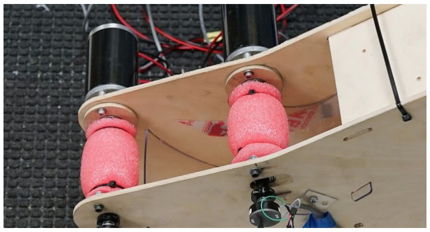
- Easier to implement
- Balls are in contact with the wheel for a longer period of time, allowing for more acceleration and more stable shot



Double Wheel

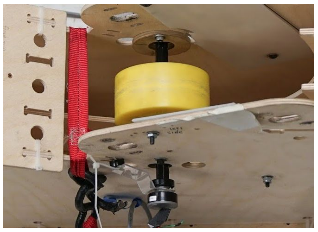
- Two shooter wheels allows for more control over the spin in the ball. However, our prototyping shows that it did not make a significant difference, so we went with a single wheel instead.

Wheel Selection

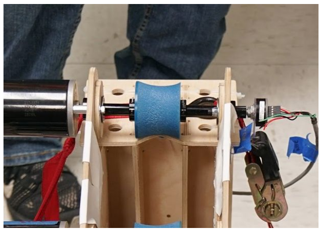


Since the wiffle ball shape is inconsistent, we tried using pool noodles, which had compression. We got surprisingly good results; however, we did not use these in our final design because pool noodles are not durable and would likely need to be constantly replaced during competition.

We added rubberizing spray to the pool noodles to help with durability, but our shot accuracy ended up being worse.

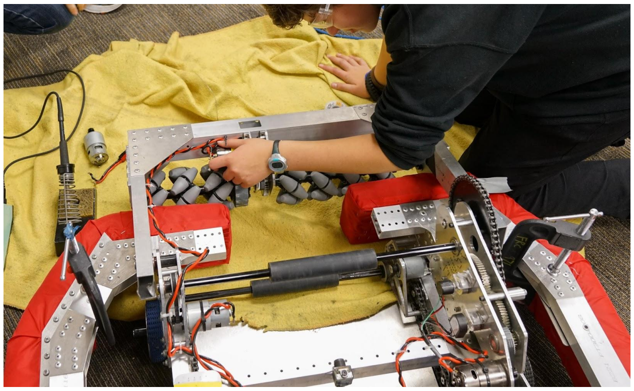


The Fairlane urethane single wheeled shooter proved to be the most accurate out of all the wheels we tested. Our trials showed that, with tuning, this wheel had about 95% accuracy.



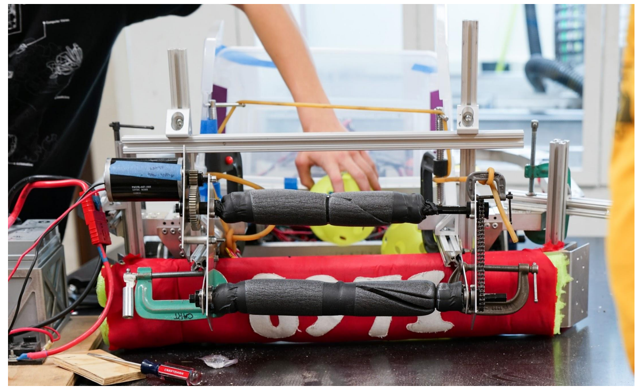
We also tried this modified wheel, which had a curvature in it equal to to the radius of the ball. However, it was not as accurate as the wheel that we used in our final design.

Intake



Through the Bumper

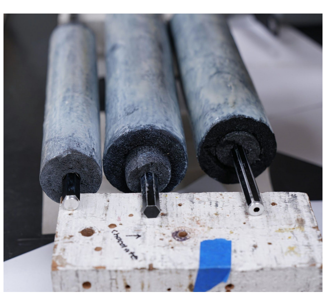
- **Pros:** Vectored intake wheels allowed balls to be funneled inwards towards the opening in the bumper.
- **Cons:** An opening in the bumpers weakens the front of the drivetrain. There were also jam positions with the vectored intake wheels and the holes in the balls.

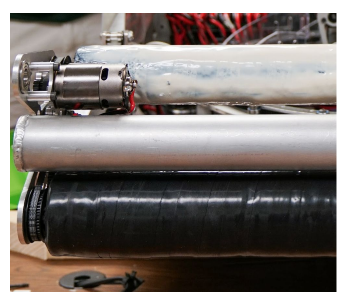


Over the Bumper

- **Pros:** Didn't have to split the drivetrain in front. It also allowed us to intake balls across the entire front bumper.
- **Cons:** It was a more complicated design. Since the balls don't compress very well, there is one part of the ball path where the robot wasn't in control. We solved this problem by applying polyurethane numbers and logos to our bumper.

Experimenting with polyurethane rollers and bumpers:

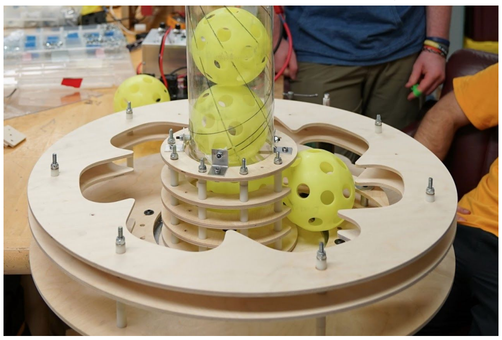




Abrasion-Resistant Natural Rubber

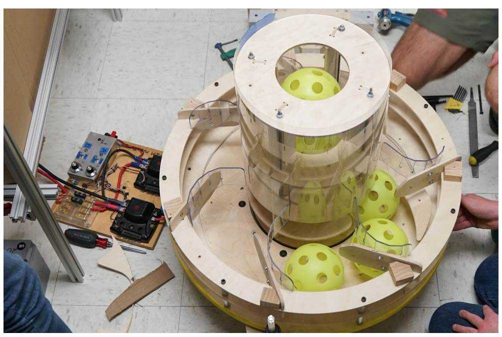
Serializer

Inspiration: Paintball Dye Rotor Serializer



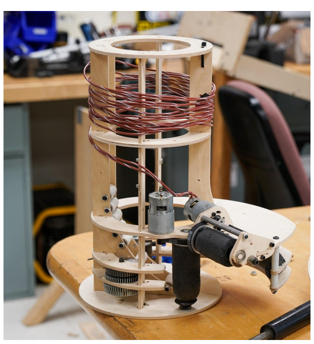
First Iteration

Outer protrusions were meant to sort balls as they were funnelled upwards, but ended up just causing jamming issues.



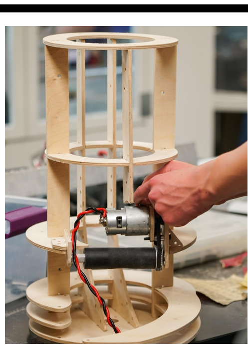
Second Iteration

Smaller, more flexible “fins” were used in place of the outer protrusions. Another benefit was that opening up the pockets left more room for balls to fall in. We also added a more graceful curve in the middle so that the balls could ramp up better.



Third Iteration

Two active rollers were meant to help funnel balls into the center column and then upwards, in place of the large hook. We kept the same “fins” that are pictured above. The rollers did a good job resolving jams, but it wasn’t sweeping up the balls as fast as the original hook.



Final Iteration

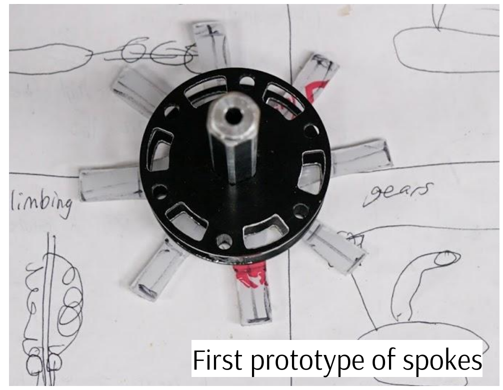
We combined the last two iterations and ended with a hook with small passive rollers, along with another single active roller mounted on the center column to help suck and push balls upwards. By combining the active roller from the third iteration and the speed of the hook from the second iteration, we were able to get the best of both worlds!

Hanger

Spokes Design

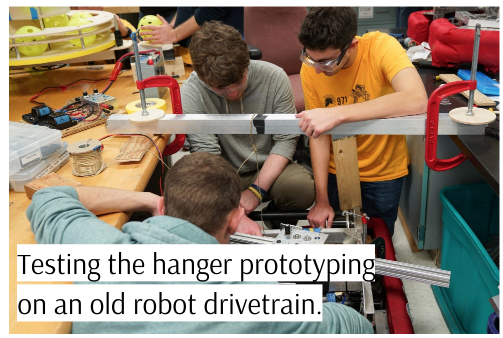
Spokes were designed to capture a knot at the end of the rope. Once the rope was captured, we would continue to spin the gearbox and climb the rest of the rope.

- **Cons:** It is harder to line up with the bottom of the rope during matches. This design also didn't package easily into the robot general design.



First prototype of spokes

More refined spoke designs right after they were cut on the CNC Router



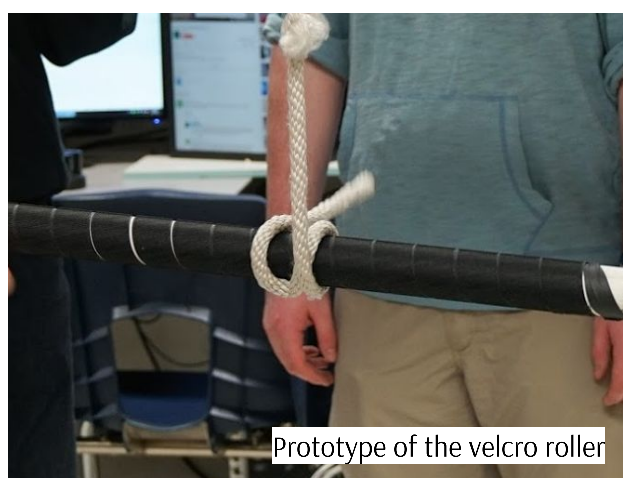
Testing the hanger prototyping on an old robot drivetrain.

Velcro Roller Design

A velcro lined roller runs into the rope, capturing it and then continues to winch the robot up.

- **Pros:** Easier to capture the rope during the match. This design also integrated nicely with the intake mechanism and saved a lot of space.

Velcro testing

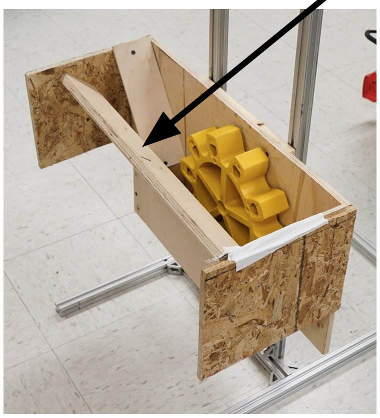


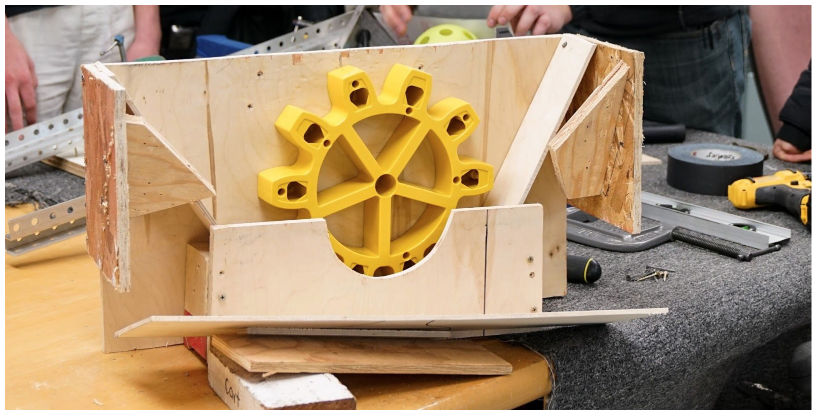
Prototype of the velcro roller

Gear Mechanism

Initial Design for Human Player Pickup

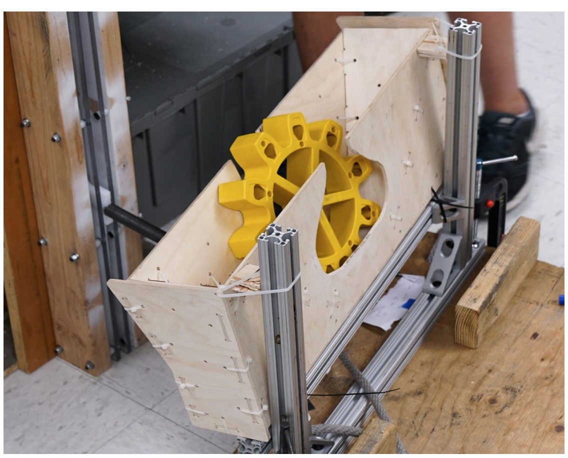
- The diagonal funnel wood pieces are for centering the gear once the human player drops it through the slot. It also gives the robot driver more room to line up with the human player slot.
- We also added a diagonal piece up front to help catch the gear from the human player slot.





Final Design

- Once robot geometry was laid out in CAD, we realized that the gear mechanism would have to be about 5 inches higher than the spring. So, we added a ramp that would funnel the spring into the bottom of the gear.
- The final design was also made with polycarbonate, which is lighter and more durable, but we maintained the same geometry.
- We attached our final prototype to a cart in order to test it.



Ramping mechanism

In-House Manufacturing

CNC Router

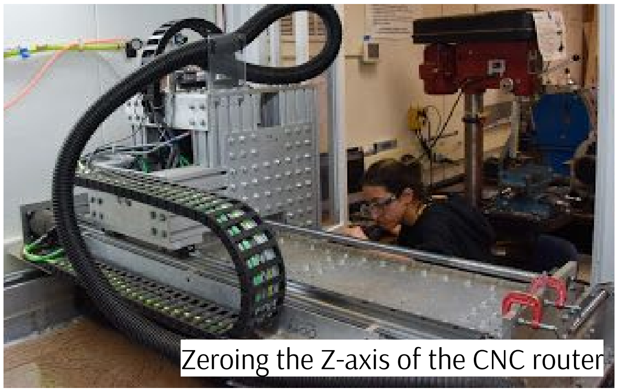

Creating a sheet layout

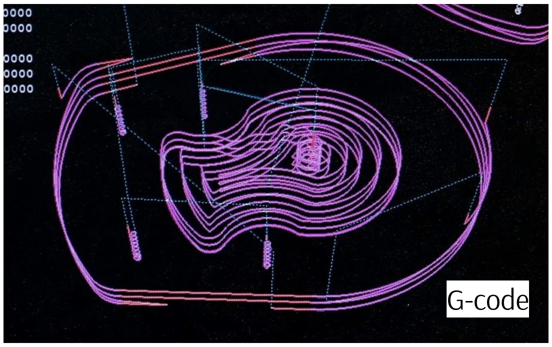

Loading and zeroing a sheet

Custom sprockets machined in-house!


Not enough coolant!


Tube fixture for machining tube stock


Zeroing the Z-axis of the CNC router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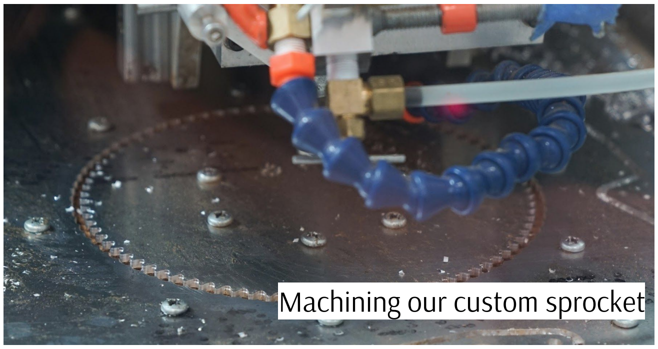
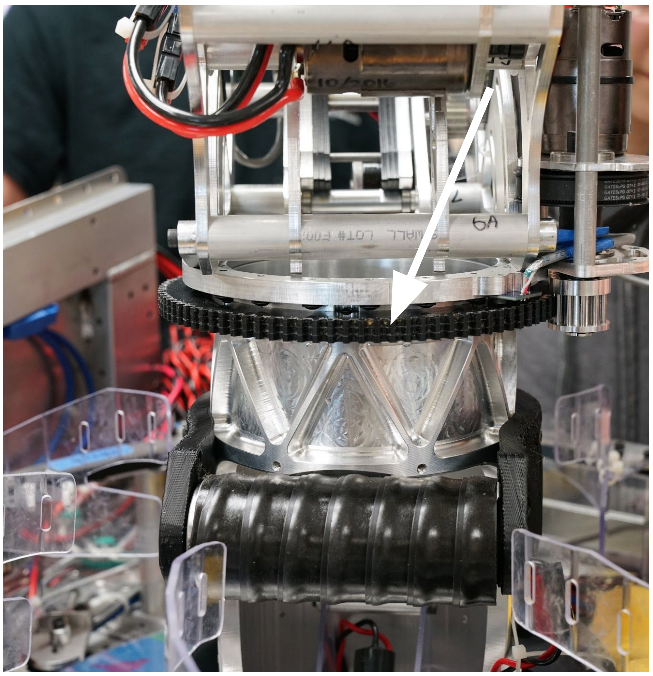

Machining our custom sprocket

Other Fun Things!



Epicycloidal Gear

We designed a custom gear profile for our counter-rotating turret system. Since this was a last minute design modification, we needed to be able to machine the large diameter gear on the CNC router we have in-house. We decided to use a pinion with 1/8" diameter pins because the smallest sized endmill we have has an 1/8" diameter. We designed the profile of the gear by using an epicycloid equation driven curve in Solidworks.

$$x(\theta) = (R+r)\cos\theta - r\cos\left(\frac{R+r}{r}\theta\right)$$
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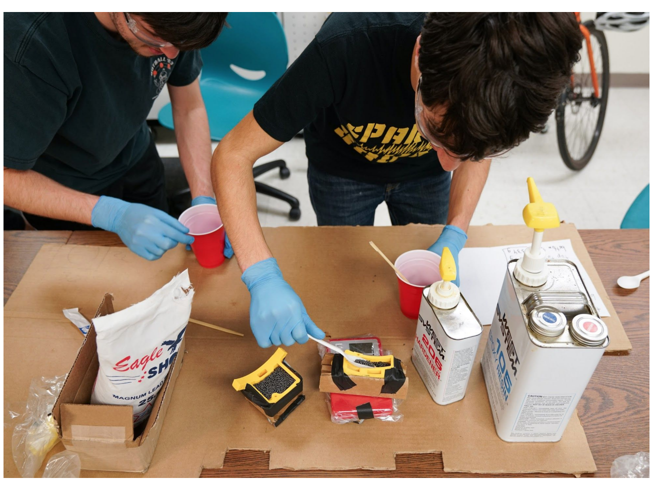

Lead Shot Counterweights

Since our center column spins at high speeds, it became necessary to center our mass and align our principal moment of inertia to improve the stability of our shooter, which sits on top. We solved this problem by moving models of lead shot counterweights in SolidWorks until they were centered. Then, we created 3D printed parts and filled them with the required amount of weight. In order to seal the lead shot for safety reasons, we sealed it in with epoxy.

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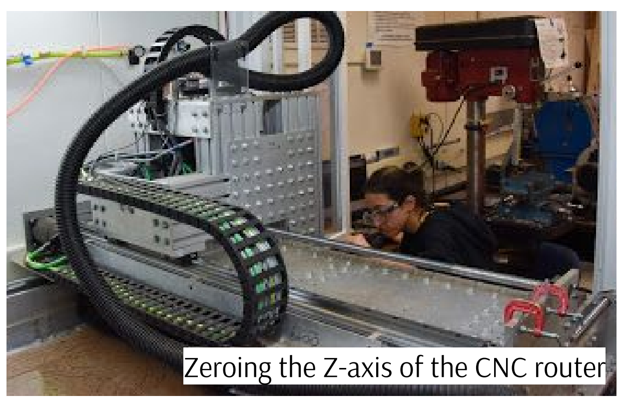
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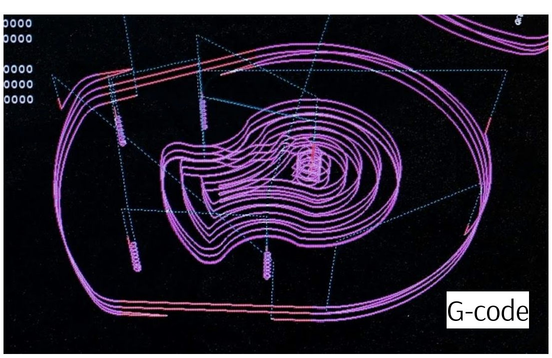
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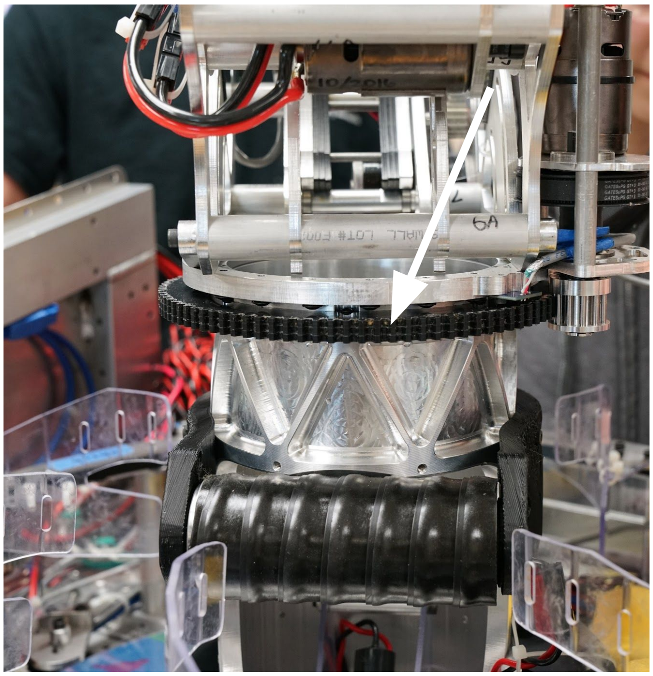

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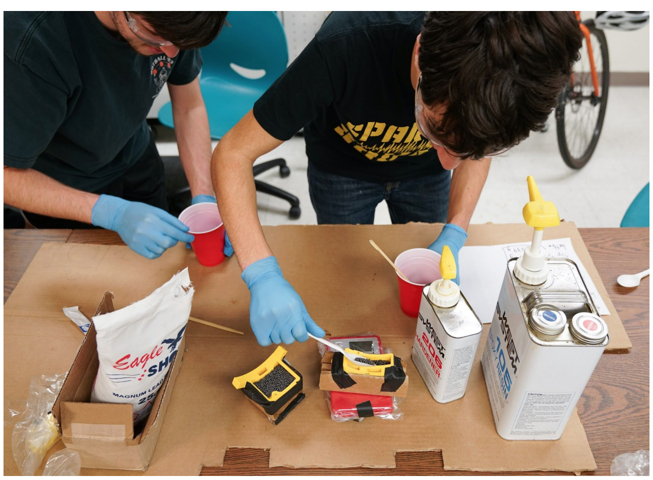

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