MECHROMANCERS

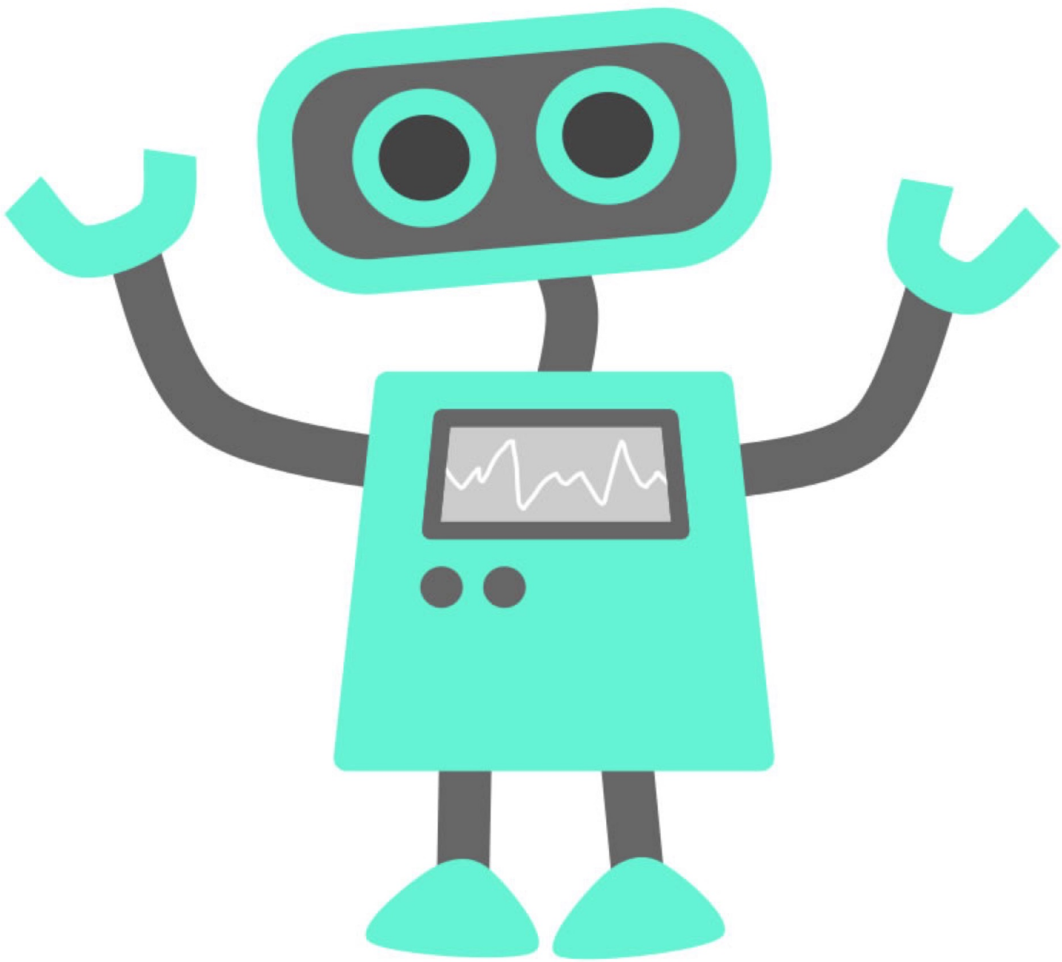
Hagerty High School

4717 Mechromancers

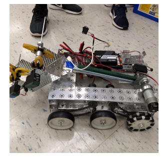
February 28, 2022

Contents

Design Overview

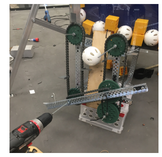


8.30.18 — Begins Creo Cad design of drive train to get head start



9.16.18 — RI3D is built as robot base and sub assemblies are finalized

10.02.18 — Rough PID algorithm is created is used to reduce programming errors

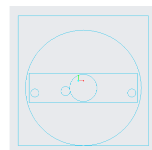


10.16.18 — Shooter is tested at different angles to determine accuracy

10.22.18 — The backplate design started to be assembled

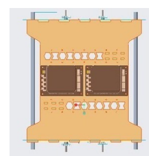
10.25.18 — The mechanism plates are cut at UCF Innovation Lab

11.05.18 — the conveyor side plate is designed in CAD through mapping T-slots

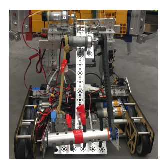


11.07.18 — Hang mechanism is assembled for meet

11.15.18 — Motor gear ratio and driven gear size are calculated to determine the robot's RPM use that data for final specs11.19.18

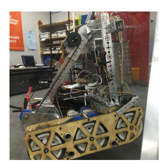


11.25.18 — Treads are added to wheels to avoid field damage



12.02.18 — Determined REV PID has a fast reaction time than other potential PIDs

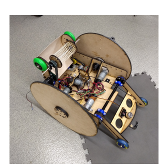
12.06.18 — Arm assembly finished



12.11.18 — Gear train in arm mechanism is replaced with a new chain and sprocket

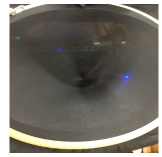
12.27.18 — New phone case designed to keep the phone secured during matches

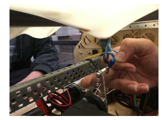
12.28.18 — A new motor is added to maintain control over Bullseye's arm system

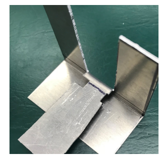


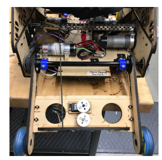
12.31.18 — Notches are cut out of Bullseye's wheels to better scale the crater

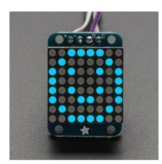
- **1.05.19** — Began creating our "Blackhole" shooting mechanism to collect silver only silver minerals
- **1.14.19** — An aluminum stand is created for our camera so it is never blocked by our current hang mechanism
- **1.19.19** — Our original design of belts in pulleys is replaced by a chain and sprockets in the front arm.
- **1.21.19** — An optical interrupter is added
- **1.25.19** — More tread was added to the wheels to prevent Bullseye from slipping when it drives over the crater.
- **1.26.19** — A camera is added to determine the position of the gold mineral when sampling in Autonomous
- **2.04.19** — LED matrix is added as visual programming feature
- **2.08.19** — A state machine is implemented to prevent the "black hole" shooter mechanism from pulling past the intended position
- **2.09.19** — Conveyor system is added to collect minerals- door for wheels is added to fix software problem
- **2.10.19** — Initial velocity of the shooter is calculated though physics team
- **2.15.19** — Mechanism is added to pan web camera
- **2.17.19** — Doors are added to the wheels to fix software problem
- **2.20.19** — PID controller is adjusted to prevent an autonomous fail

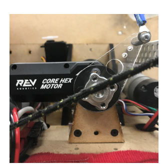












Gamepad Controls

Coach: Ben Steinebronn
Driver 1: Shey Naik
Backup: Jonathan Valentin

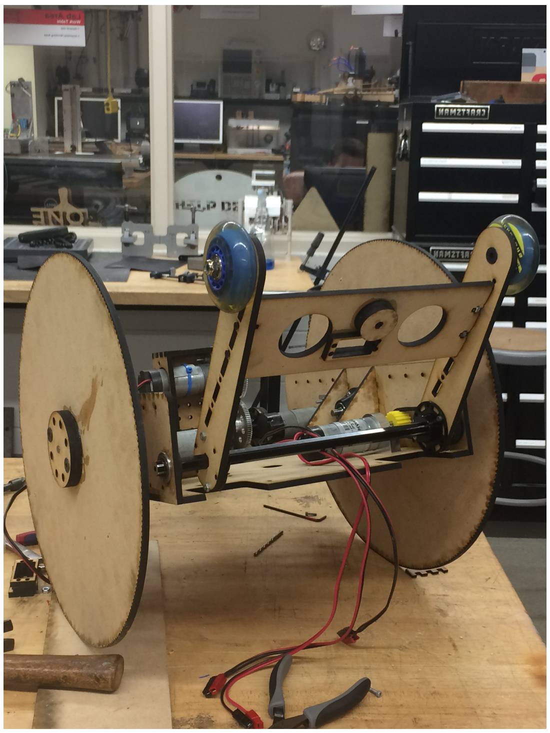
Figure 1.1: Driver - Gamepad 1 Controls

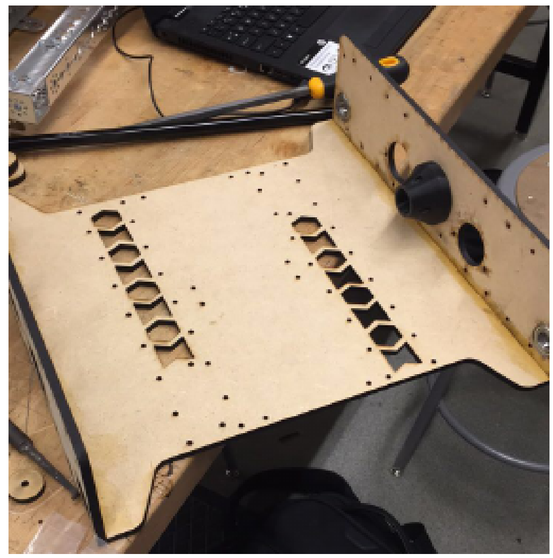
Driver 2: Jolie Miller
Backup: Austin English

Figure 1.2: Operator - Gamepad 2 Controls

Drivetrain

Goal: Create a stable drivetrain that can scale the crater to recover minerals quickly and effectively





Core Materials

0.25" Medium Density Fiberboard, Aluminum, ABS Plastic, Steel, Retaining Rings

Manufacturing Processes

Laser Cutting, 3D Printing, CNC Milling, Lathe

How it Works

The drivetrain is composed of two modules connected by a center chassis where the motors are built on. Each module has two 20:1 BaneBots planetary gearboxes which spin a driver gear. This gear is meshed in a 1:4 ratio to the gear attached to each wheel. Each 16" wheel has a notch cut in it to allow us to go over the crater. The wheel assemblies ride on bearings that are fixed onto custom 3D printed pieces in the wood.

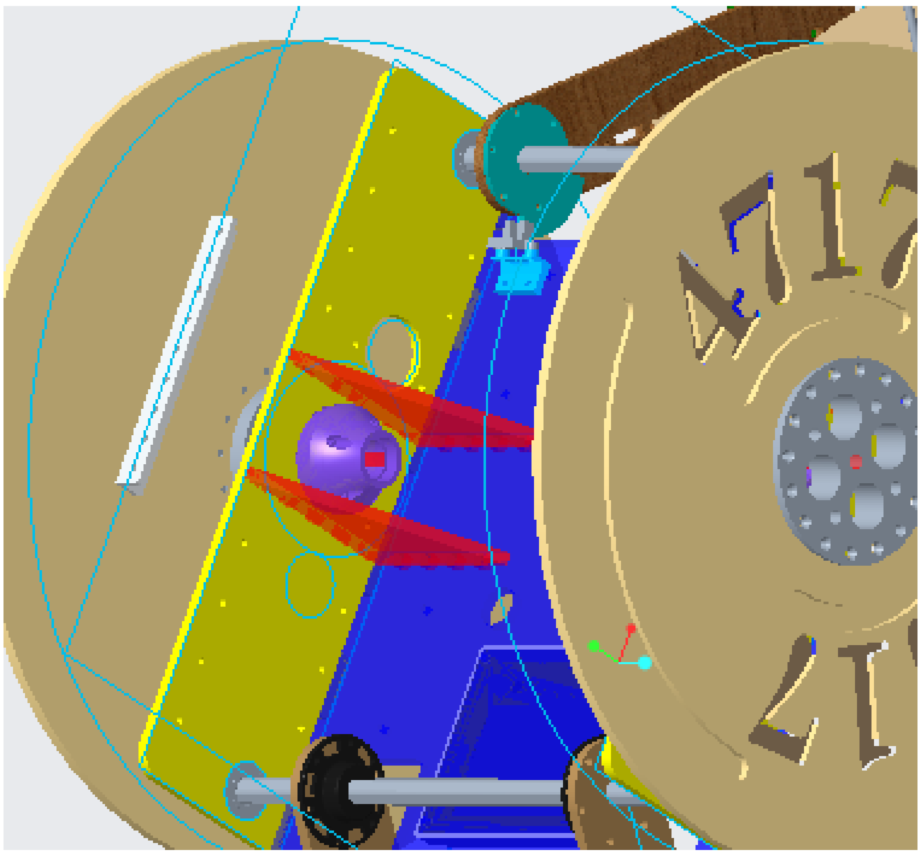


Figure 1.3: Another look at the CAD of our Drivetrain

Iterations

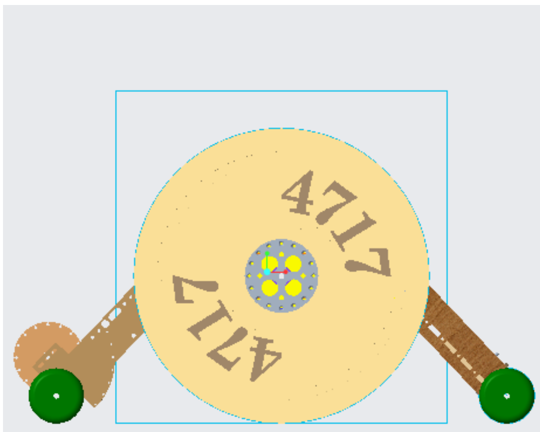
In prior years, our team utilized belts and pulleys to power our drive train. We found that for this game, going over the crater is essential and bigger wheels would make that task much easier than having a low profile drive train with belts and pulleys. Our first prototype consisted of four 40:1 motors with a 40T driver gear actuating a 120T gear on the output shaft. However, given that the stabilization arms required another two motors, we tried something new by only using one motor to power each side. This worked fairly well for the team, as we didn't compromise on speed or efficiency. In addition, we had to make some changes to provide some horizontal support.

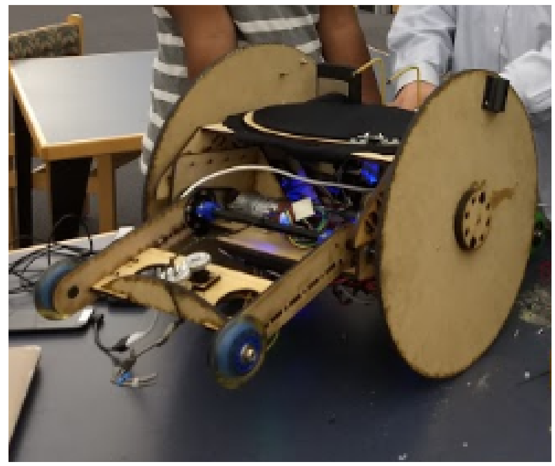
Mechanism Accomplishments

- It can drive up the crater
- It can quickly traverse the field, going from the crater to the lander
- Its design allows for more space to add more components

Chassis Stabilization Arms

Goal: Stabilize the chassis and set to numerous positions for various teleop objectives





Core Materials

.25" Medium Density Fiberboard, Aluminum Shafting, PLA Plastic, Steel 1/2" Radial Bearings

Manufacturing Processes

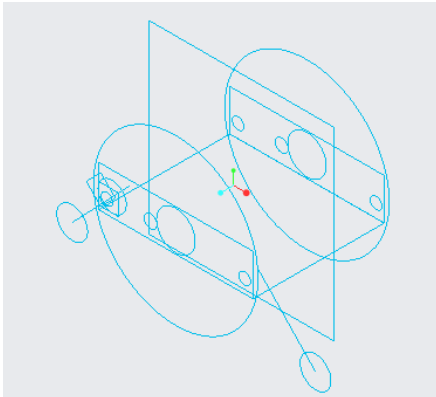
Laser Cutting, 3D Printing, Lathe work, CNC Milling

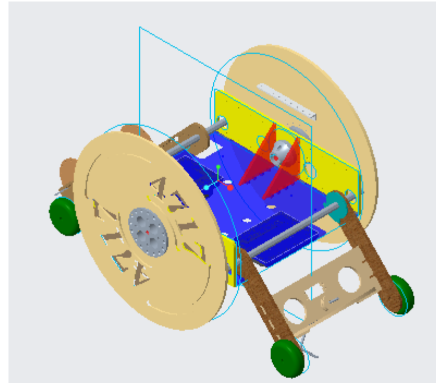
How it Works

40:1 Torquenado motors actuate the arms using chain and sprocket with a 1:2 gear ratio. Each side features two 8" arms with skateboard wheels. Zeroed perpendicular to the chassis, the arms set to a natural stabilization position during autonomous, keeping Bullseye's floating chassis level as it drives. During crater scaling, the arms are programmed to actuate in accordance with the gyroscope, moving to keep the chassis balanced. Another arm set position readies the robot for shooting. Photointerruptors on each side ensure that the arms can find it's position during teleop in case of emergency.

Modelling & Simulation

When designing the chassis stabilization arms, we established a body skeleton of the robot in PTC Creo, which was a basic sketch of the whole robot with set axes and coordinate systems. Then, we created motion skeletons for the individual arms. From there, we could build our parts around the skeleton, and attach them to the moving bodies. We could then simulate the movement within the motion skeleton. These skeletons not only helped us define the geometry and joints of the arms with several sketches, but they made major part modification simple since they're referenced to a base sketch, thus allowing us to change the arm design with ease.





Iterations

Originally, our prototype chassis stabilization was done with primitive integration of the 4" Tetrix Omni Wheels and a short arm length. Not only did this haphazardous assembly fail to integrate well, with several wood spacers used to distance the bronze bushing to install the wheels, but the skinny wheel also made travel on the tiles much more difficult. We replaced the omnis with skateboard wheels, which made integration simple as it only required an 8mm screw with a washer and a nut. Another significant iteration we made was in regards to the arms' actuation. At first, we'd used HTD belts and 3D printed nylon pulleys with the same 1:2 ratio, yet we quickly recognized that the belt required incredible tension to run smoothly without skipping, which was so strong that it would twist the motor out of place, causing the belt to be loose yet again and causing it to skip. Realizing that a chain and sprocket system would be much more robust and less vulnerable to skipping, we replaced our pulleys with 16T to 32T VexPro sprockets with chain.

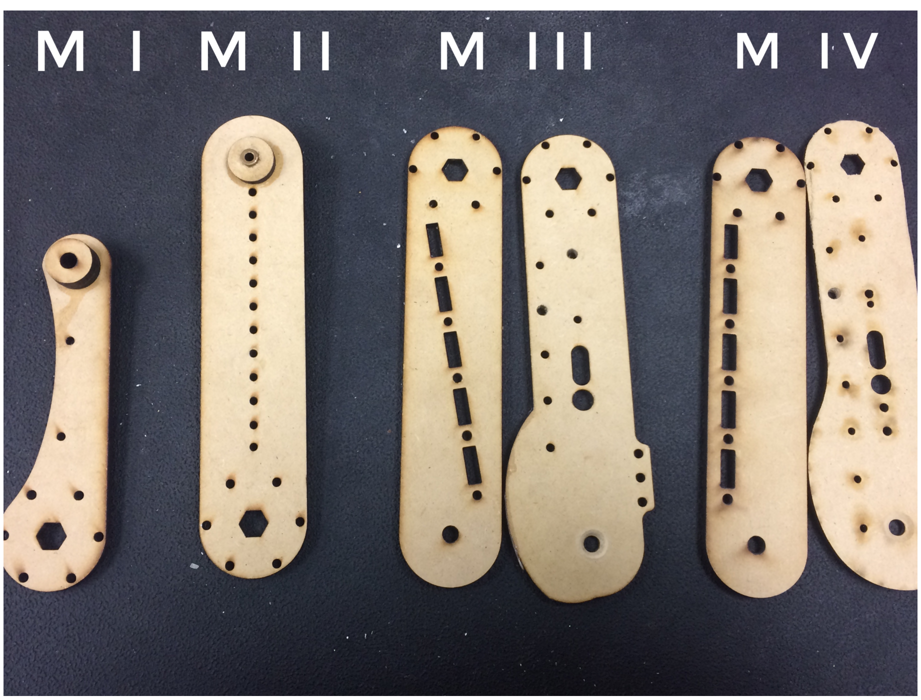
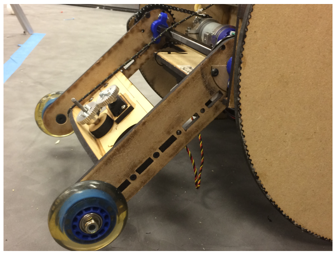


Figure 1.4: Design Iteration of the Stabilization Arms, Mark I to IV



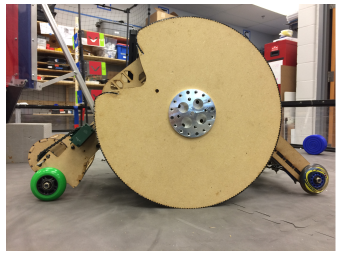
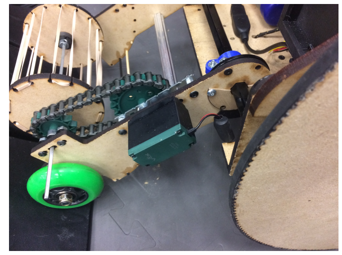


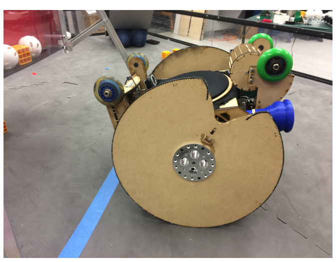
Figure 1.5: Final Stabilization Arms, Mark V

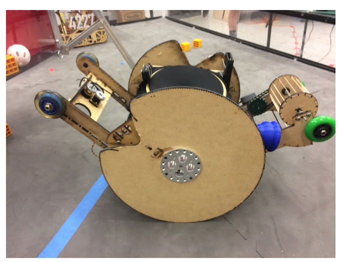


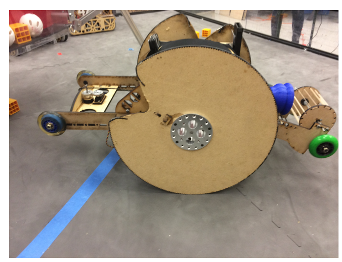
Sensors and Control

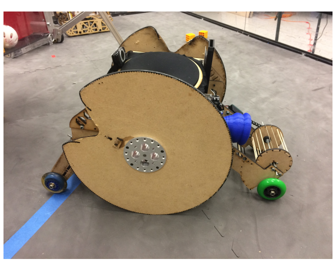
Two photointerruptors, one on each side, are used for emergency recalibration of the arms at their natural position. Two laser cut wooden flanges on each arm break the light beam of the photointerruptor, setting a known position for the arm. However, understanding that the encoders aren't perfect, and given the backlash of the chain, we understood that we had to come back up and return slower in order to calibrate at exactly the right position for driving smoothly. In addition, we use the internal PID on the REV Expansion Hub for stabilization, and utilize preestablished angles for various telemetry operations, such as intaking minerals, shooting into the lander, or hanging on the latch. For determining level driving angles for the arms, our physics division determined a formula to calculate the angle at which one arm would have to be in relation to the other.

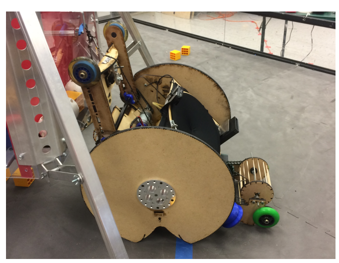
Different Arm Preset Positions: *Various Preset Positions for the Stabilizing Arms*

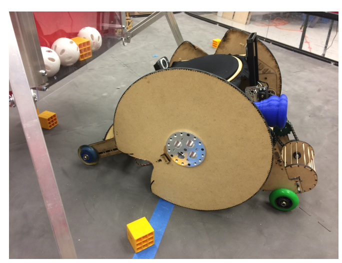












Chassis Stabilization and Level Driving Angles:

The goal is to maintain ground contact of both stabilization arms in order to drive smoothly.

$$\phi_{front} = \arccos(\frac{sin(\theta) + 6.7 + 6.5}{8.0} - 90 + \theta) \tag{1.1}$$

$$\phi_{back} = \arccos(\frac{-sin(\theta) + 6.7 + 6.5}{8.0} + 90 + \theta) \quad (1.2)$$

Equation Analysis

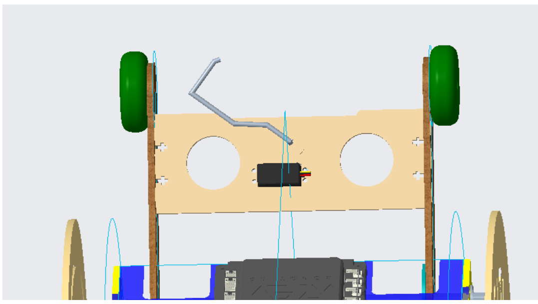
With the use of one of the angles, we can calculate the angle of the other arm to be stable; Refer to the January 20th entry to learn more about how these equations work, and how we created them.

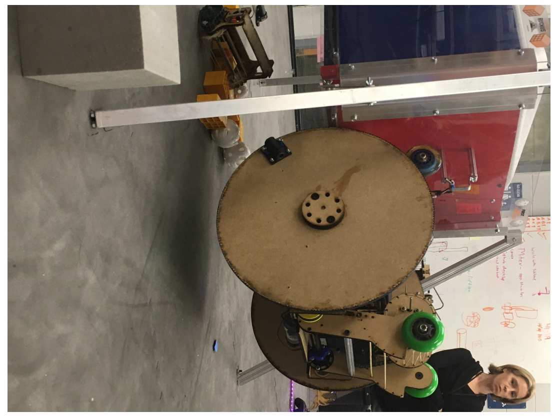
Mechanism Accomplishments

- Uniformly stabilize the chassis, maintain ground contact to ensure smooth driving
- Set to the prepositioned intake angle to pick up minerals
- Set to the prepositioned shooter angle for mineral deposit
- Set to the prepositioned hang angles for the endgame in TeleOp

Hang Winch

Goal: **Create a fast, reliable hang mechanism to latch and de-latch in both autonomous and endgame**





Core Materials

Steel rods, Duracord, Surgical Tubing, Aluminum

Manufacturing Processes

Laser Cutting, CNC Milling, Metal Bending

How it Works

The hang mechanism works by attaching a hook onto the end of the front arm. This hook has a winch connected to it that runs through the robot and to the underside where a 40:1 motor turns, lifting the robot. The claw gets to the latch by tilting the robot so that the front arm sticks up in the air. The claw than rotates due to a small servo on the arm to put the hook into the latch when the winch motor pulls the robot up. In autonomous, the winch motor spins the opposite way to lower the robot and unhooks by tilting the robot to push up.

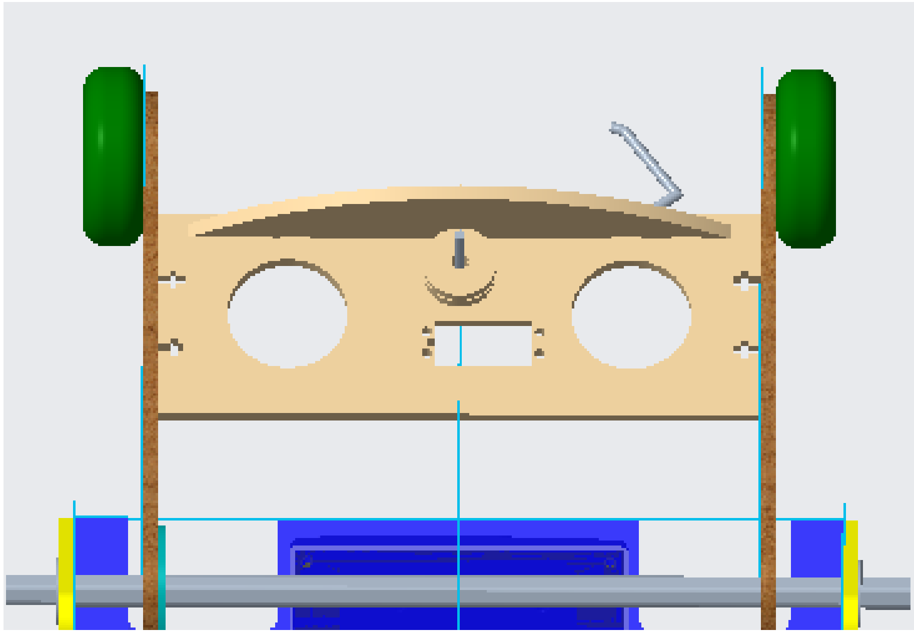


Figure 1.6: Hang Top Pic

Modelling & Simulation

Modelling the hang mechanism involved minimal design challenges. The only thing we originally struggled with was how the arms would line up with the lander. In order to model this, we used body and motion skeletons to see the distance to the latch as well as how far in it would reach. However, issues were primarily resolved through design iteration, as you'll see below.

Iteration

Initially,we angled the hang plate that held the hook, believing that that would allow for the hook to be well within the latch. However, after testing, we determined that a straight hang plate worked much better. We also made several iterations of a winch box that would rest at the back of the chassis, yet after struggling with space issues we realized that we could simply mount the motor directly on the underbelly of the chassis with a hole to guide the winch string.

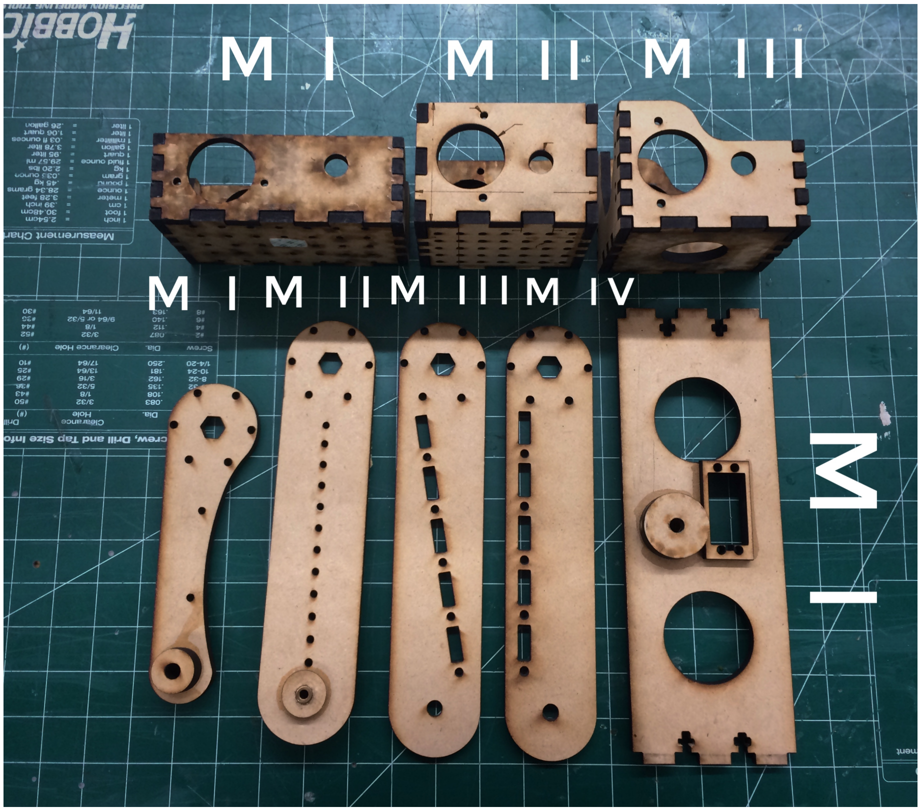
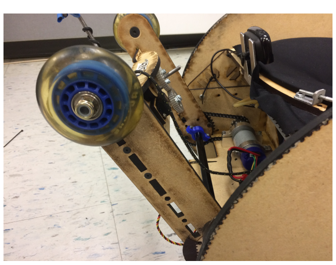


Figure 1.7: Design Iteration of the Hang, Mark I to Mark IV



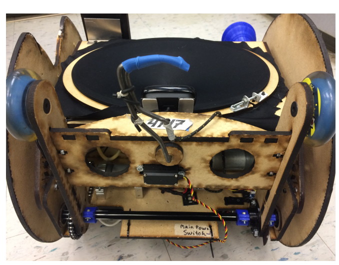
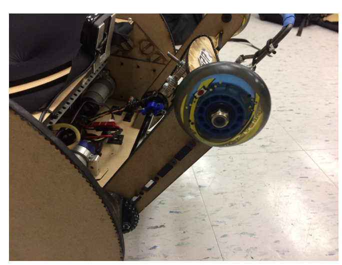


Figure 1.8: Final Hang Mechanism, Mark V

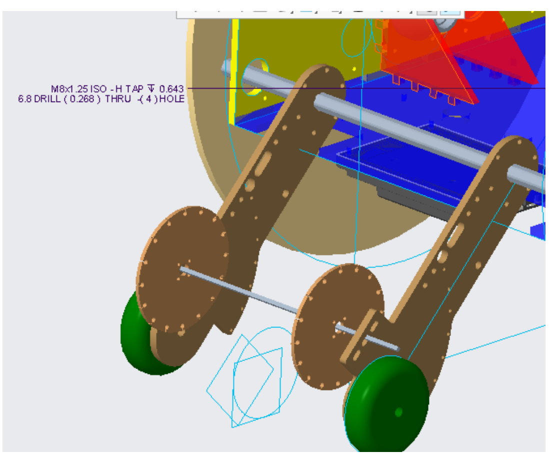


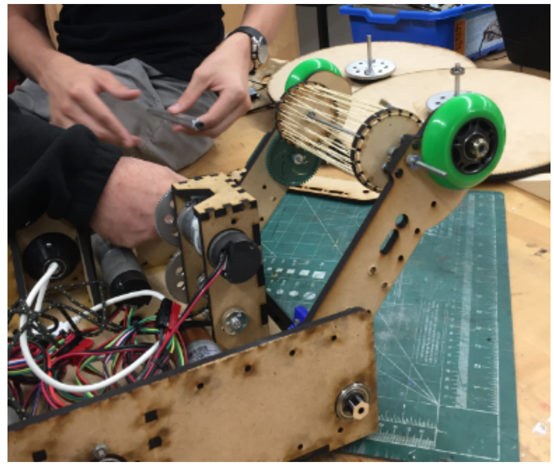
Sensors and Control

The winch motor uses encoder PID to hold the hang position during autonomous. In addition, we use two buttons for autonomous setup, with the buttons controlling winching up or winching down. Wanting to determine the power of the motor, our physics team developed a formula to determine the amount of torque that the motor needs to pull the horn down. These equations are described below.

Intake Mechanism

Goal: Drive into the crater and intake silver minerals; sort out the gold minerals





Core Materials

0.25" Medium Density Fiberboard, Rubber Bands, VEX chain, Aluminum, ABS Plastic, Carbon Fiber, Skewers

Manufacturing Processes

Laser Cutting, 3D Printing

How it Works

Our intake mechanism features laser cut sprockers with rubber bands in between the teeth. The intake spins due to a chain and sprocket powered by a VEX motor. The minerals are fed into the intake and roll up strategically placed dowels to sort the minerals. The gold mineral, being smaller in size, goes through the intake and falls out the back of the dowels. The silver mineral, being larger, gets stuck in the intake and waits for the transfer mechanism. Refer to Figure **??** for an image of this passive sorter.

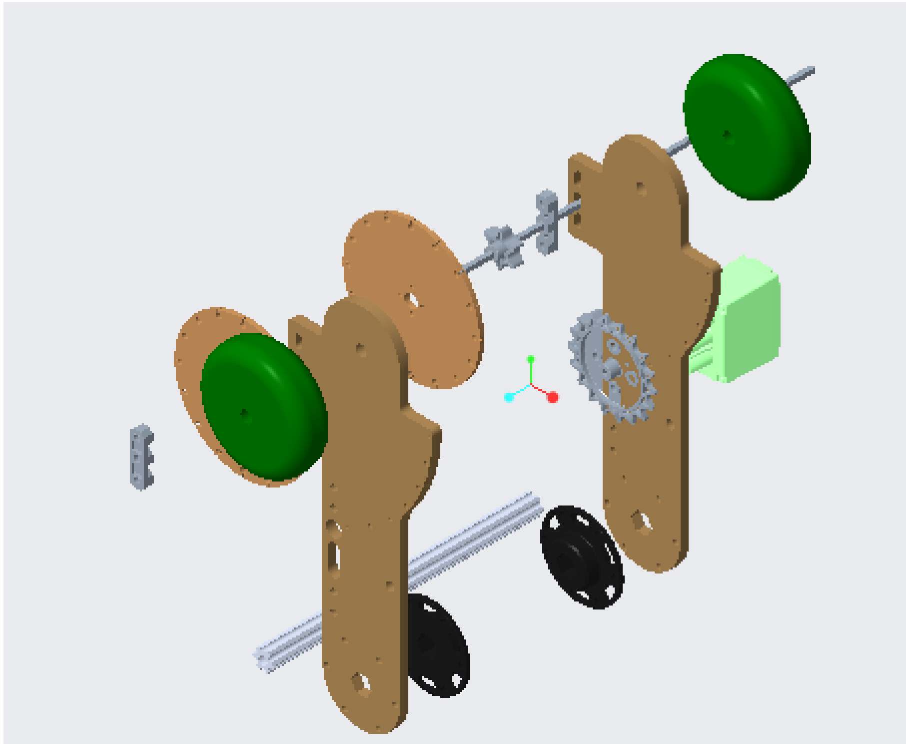


Figure 1.9: Exploded View of the Intake Mechanism

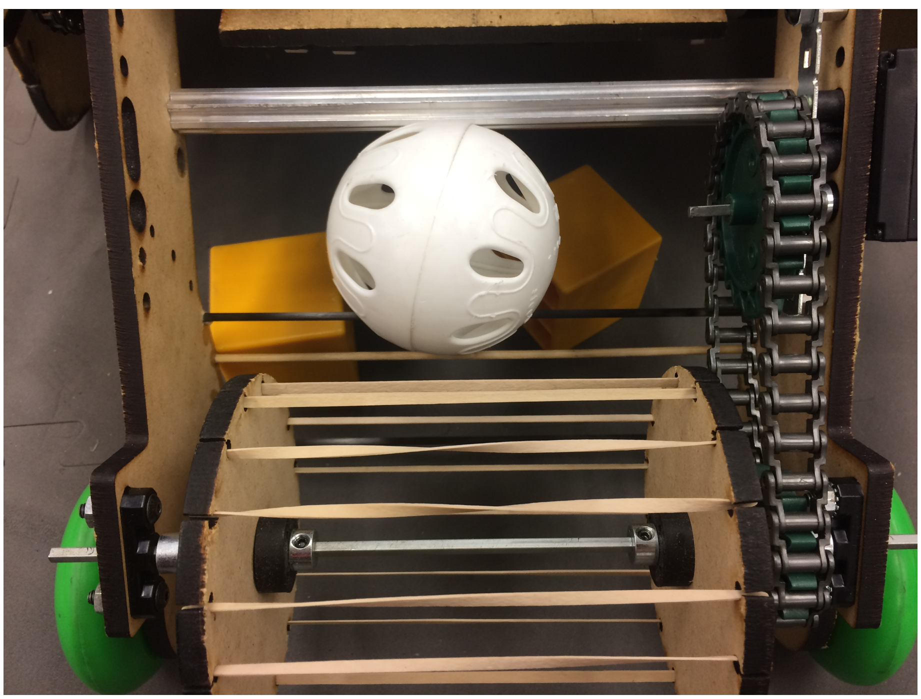


Figure 1.10: Passive Sorting

Modelling & Simulation

Much like all of our other mechanisms, we designed and simulated the intake using body and motion skeletons in PTC Creo. The most challenging issue with designing the intake was determining how far forward the rubberband wheels would be, as well as the size of the wheel itself. To make this easier on ourselves, we created sketches of the silver and gold minerals in the body skeleton and referenced it to design a smooth curve upwards that would maintain contact with the intake wheel. Our use of skeletons makes part implementation simple and fast, and facilitated continuous design iteration. See below in Figures **??** and **??** to see how we implemented skeletons into our design.

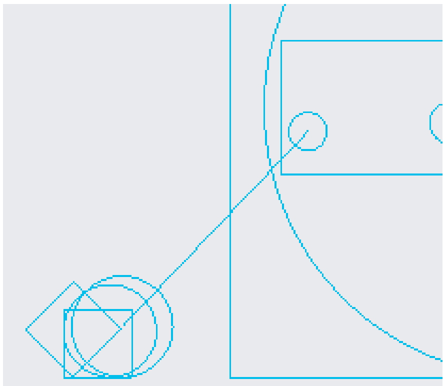


Figure 1.11: The Intake Arm and Minerals in the Body Skeleton

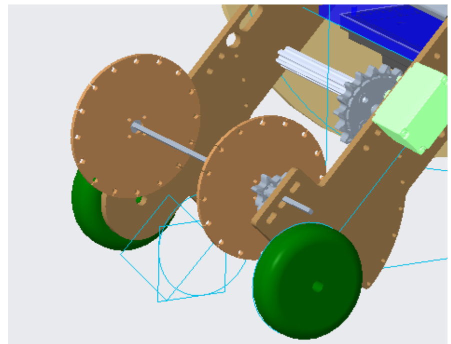


Figure 1.12: The Skeleton in Use with Intake

The Phillip Mech

At the back of the intake, we have a mechanism to transfer the silver into the shooter (something our team refers to as Phillip). This consits of a REV servo that flips up. The arm is made of laser cut mdf made to have specially bent piano wire that works by having the intake bend the piano wire slightly out to get the silver in and then bends back to normal when the silver gets all the way in. The reason we use piano wire is that it holds its shape really well which means that it is hard to bend permanently but is easy to flex outward to allow for the silver to fall into the tray that goes up to the shooter.

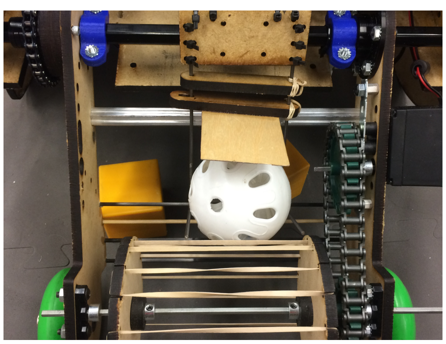


Figure 1.13: Loading The Transfer Mechanism

Figure 1.14: Transfer Mechanism Deposit to the Shooter

Iterations

The placement and size of the rubber band wheels took several iterations to complete. We struggled with figuring out where we'd need to place it in order to pull in minerals smoothly, and used the robot's body skeleton as well as several stages of prototyping to figure it out. In addition, we changed our geared intake to one with a chain and sprocket in order to move it further back up onto the arm. After our first prototype, we also replaced an intake plate with strategically placed dowels for sorting.

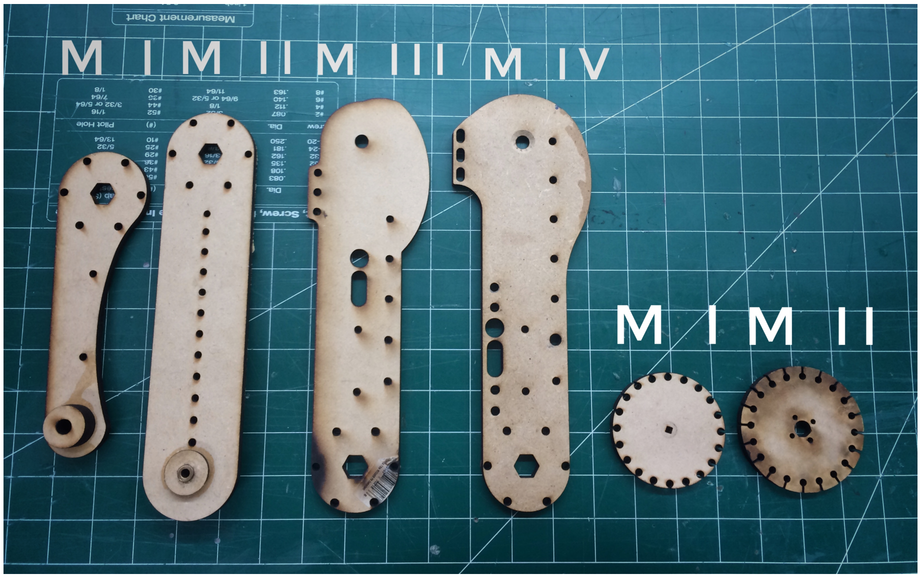


Figure 1.15: Design Iteration of the Intake, Mark I to IV

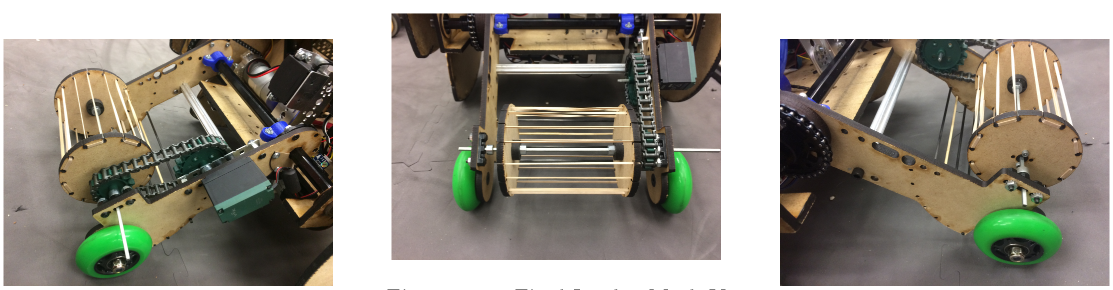
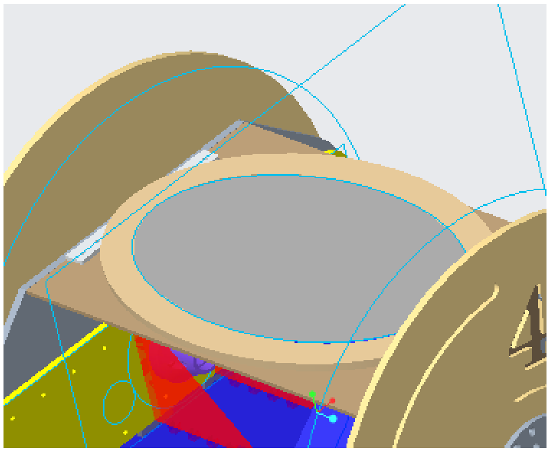
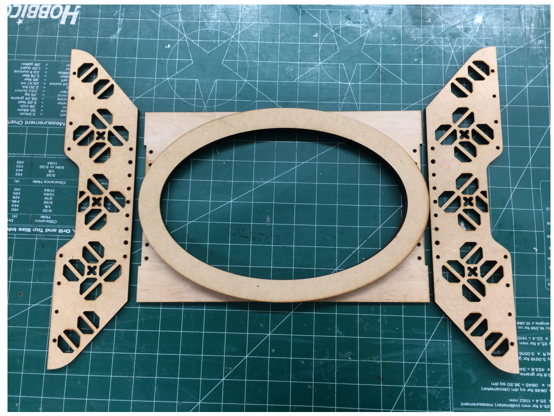


Figure 1.16: Final Intake, Mark V

The Black Hole Shooter

Goal: **Shoot quickly and efficiently into the lander**





Core Materials

Elastic Sheet (25% Spandex and 75% Nylon), quarter inch MDF, lexan, one way bearing, steel ball, aluminum

Manufacturing Processes

Laser Cutting, 3D Printing, CNC Routing

How it Works

A ring is cut from MDF in an oval shape with a closely fitting larger ring. The larger ring is not continuous and aluminum material is screwed onto it to allow tightening. The elastic sheet is placed, taut, over the inner ring and under the larger ring. The larger ring is then tightened to secure the sheet. The steel ball is then placed in the center of the sheet and tied into the sheet on the underside. On the shaft of a REV core hex motor is a lever cut from lexan with a one way bearing secured within it. The lexan lever is then tied to the steel ball on the underside. The REV core hex motor rotates a 1.5 inch lexan lever down. When the lever rotates past 180 degrees, the one way bearing is allowed to freely move back to the original position. The lexan lever is tied to the elastic sheet and is pulled down up to 3 inches when it is rotated.

Modelling & Simulation

Iteration

The lever was initially made of quarter inch MDF which snapped due to the vertical force on the lever. The lever was also extended longer than it needed to be initially. The ring initially did not have a tightening ring around it, instead the sheet was tied to the ring.

Figure 1.17: Design Iteration of the Shooter, Mark I and Mark II

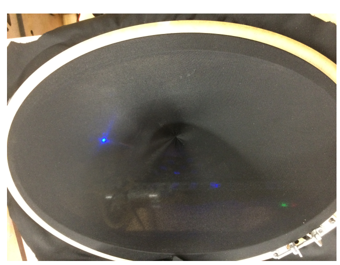


Figure 1.18: Final Stabilization Arms, Mark III

Sensors and Control

An equation was made by the physics team to describe the peak vertical force on the system. Another equation was made to calculate the torque as the lever goes around. This is to ensure that the material and structure of the lever made will be able to support the tension from the sheet. Refer to the engineering section to find the formulas we calculated and used.

List of Figures