FRC TEAM 5962
Documentation
Binder 2017

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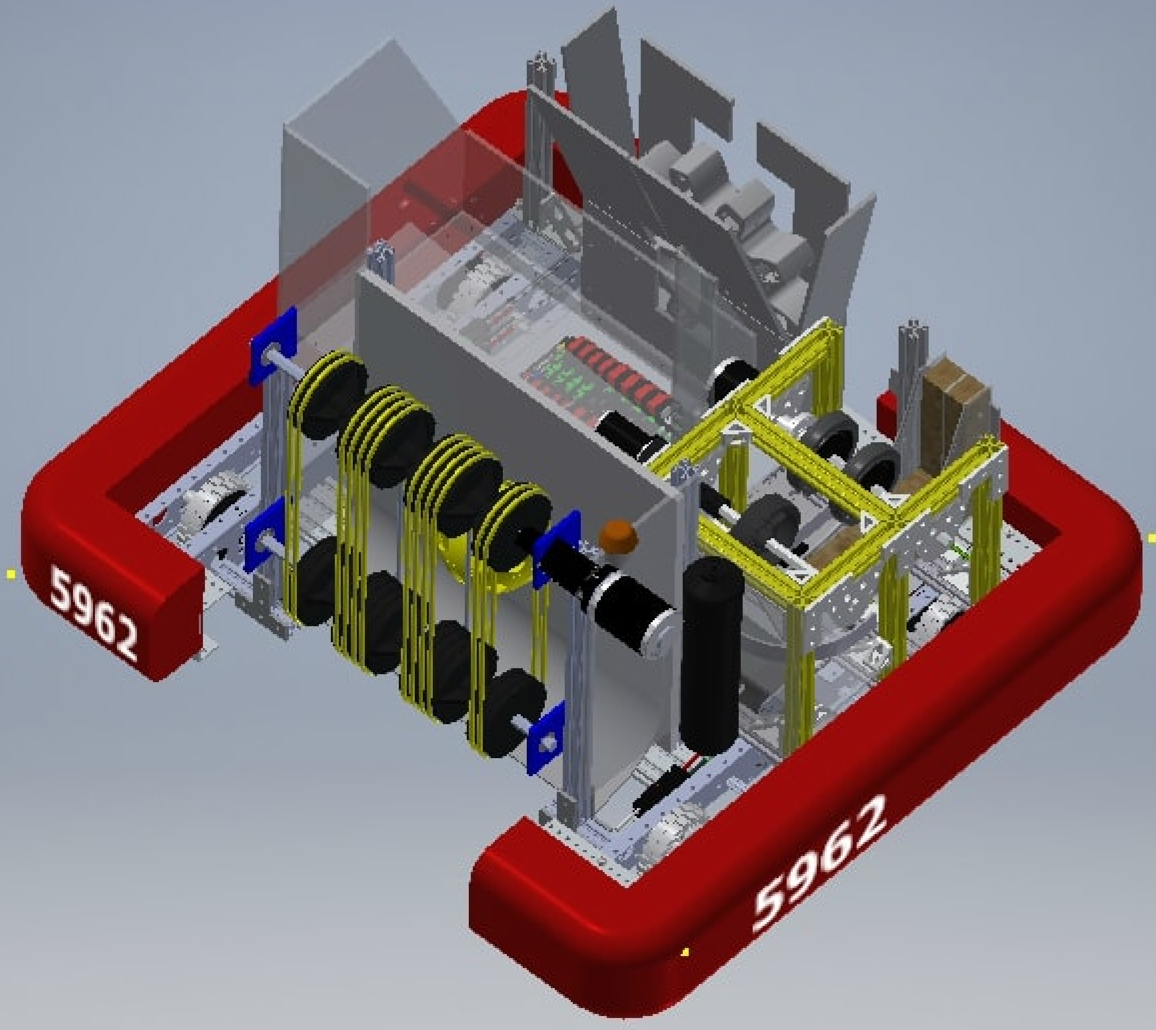
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- Follow safe work practices, including safe use of all tools and personal protective equipment (safety glasses, shoes, gloves, hearing protection, etc.). Maintain a healthy attitude regarding safety.
- Always walk and work in a controlled and thoughtful manner. Keep full control of robot at all times
- Disconnect the electric power source
- Best Practice: Always de-energize the robot before working on it by opening the main circuit breaker (“re-set” lever is released) and unplugging batteries
- Always vent any compressed air to the atmosphere (this applies to all parts of the pneumatic system)
- Open the main vent valve and verify that all pressure gauges on the robot indicate zero pressure
- Store sharp-edged or pointed tools in a safe place. When carrying tools, cover the point or any sharp edges with shields. NEVER carry unshielded tools in your pocket. Don’t leave tools on overhead work surfaces. They may fall and strike someone below. Store equipment in a location where it will not create a safety hazard or get damaged.
- Avoid the following electrical power supply setups to prevent overloading: • Extension cord plugged into another extension cord. • Extension cord plugged into a power strip. • Multi-device receptacle plugged into a power strip or extension cord.
- Set aside a damaged battery and handle accordingly:
    - Immediately flush any contacted skin with a large quantity of water.
    - Seek medical treatment.
    - Periodically inspect your batteries for any signs of damage or leaking electrolyte.
    - Remember that a dropped battery may be cracked, but the crack may not be visible and might eventually leak electrolyte.
    - Treat it as a hazardous material and process it in accordance with the battery's SDS.
    - Don’t take a chance- don’t use it!
- 3.5.3 Procedure for Handling a Leaking Battery When an electrolyte leak occurs: Neutralize it by pouring the sodium bicarbonate on all wetted surfaces.
    - The bicarbonate of soda itself is not dangerous, and will react with the acid in the electrolyte leaving a safe residue that can be disposed of in a conventional manner such as rinsing with water.
    - Follow emergency handling instructions of the SDS and notify Mentor. Put on gloves before handling the battery.
    - Place the battery in a leak-proof container for removal.
    - Be sure to neutralize any acid on the gloves before removing and storing them.
    - Seek medical attention if skin came into contact with any chemicals.
    - Properly dispose of the battery, which is now a hazardous material

- Keep the battery-charging area clean and orderly.
- Periodically inspect your battery for any evidence of damage, such as a cracked case or leaking electrolyte.
- No torches or open flames of any kind are allowed in event venues, except by authorized personnel in specified areas (such as the event Machine Shop).
- Wear eye protection in the following situations:
    - When performing any work on the robot including grinding, drilling, soldering, cutting, welding, etc.
- When engaged in FIRST activities, FIRST Robotics Competition participants must wear shoes that completely cover the entire foot.
- Make sure the robot is safe to move:
    - o Are all parts of the robot secured?
    - o Is the robot powered off?
    - o Is anyone still working on the robot?
    - o Are there enough people to perform the lift safely? Two to four people are preferred.
- o Lift with your legs, keeping your back straight.
- Use patience and control when moving the robot, especially in crowded areas (do not run).
- Climbing over the railing is prohibited.
- Relieve all stored energy and open the main circuit breaker on the robot.
- Ensure that the robot is made safe prior to lifting it off the playing field, no dangling parts, etc.
- Remove debris from the playing field.
- Use the above "Pre-lift" and "During the lift" procedures. Use the gate opening to exit the playing field.
- Climbing over the railing is prohibited.
- Refrain from wearing dangling jewelry or loose, baggy clothing near the robots; Tie back long hair so that it will not get caught in the robot or other machinery; and
- Wear gloves to protect hands and fingers when handling the robot or the robot crate; finger injuries are one of the most common injuries at events.
- Bring and use work gloves for uncrating and re-crating, if a crate is in use
- o Clean floor in and around your Pit Station
- o Proper tool storage
- o Proper care of batteries and battery chargers
- o Tidy storage of personal belongings and equipment

January 8, 2017 *Rules*

<u>Rules Presentations Q&A</u>

Robot Rules:

- Are hazardous materials defined?
    - Anything that blocks the view of drivers, flammable gasses, mercury, lasers, etc. (R07)
- Can items purchased in bulk exceed $400?
    - Yes. KOP items and items purchased in bulk may exceed $400.
- Can the team create its own pneumatics system?
    - No. Pneumatics systems must be approved.
- Why are there two options for robot sizes?
    - It allows for two classes of robot sizes. We will have to choose A or B frame and inform inspectors at competition. You cannot vary between those two.

The most pertinent aspect in regard to strategy/design is robot size.

Match Rules:

- Is there a rule designating which robot climbs which rope?
    - No. Teams may bring their own compliant ropes, but it is up to alliances to coordinate which ropes they climb.
- Is there anything in the rules about burlap/nylon?
    - No. Teams may not use ropes with any metals, however.
- Are rubbery materials banned?
    - No.
- What are we allowed to possess at the beginning of the match?
    - 10 fuel and 1 gear per robot.
- How do the goal limits work?
    - Only 5 fuel balls may be scored in each goal per second.
- What is a technical foul?
    - Technical fouls are fouls which cause damage or pin for too long. For example, pinning for too long or intentionally flipping robots are technical fouls.

Point values and rope rules will be important aspects in regard to strategy/design.

Arena:

- How are balls brought to the hoppers?
    - Human players are responsible for refilling the hoppers. Robots then push into a plastic piece to release fuel balls.
- How do keys work?
    - Robots cannot be within their opponents' keys for more than 5 seconds.
- What is a touchpad?
    - It is what scores the rope endgame.
    - The touchpad must be activated for a minimum duration of 1 second. It will be scored as long as the game ends within some part of this duration.
- What is the purpose of the lifts?
    - Lifts are used by the pilots to safely collect gears from the field.

The way pilots interact with the gears and rotors will be important aspects in regard to strategy/design.

8 ROBOT Rules

8.1 Overview

A commercial-off-the-shell must be commonly available from venders, not costom ordered

- Must have a Federal Tax Identification number.
- The business and activities of the team and venders must be completely separable
- Teams may be asked to provide documentation proving legality of non-2017 KOP items during Inspection where a Rule specifies limits for a legal part (e.g. pneumatic items, current limits, COTS electronics, etc.).

8.2 General ROBOT Design

- The ROBOT (excluding BUMPERS) must have a FRAME PERIMETER, contained within the BUMPER ZONE, that is comprised of fixed, non-articulated structural elements of the ROBOT. Minor protrusions no greater than ¼ in. (~63 mm) such as bolt heads, fastener ends, weld beads, and rivets are not considered part of the FRAME PERIMETER.
- Maximum ROBOT size, including BUMPERS and all extensions, must be constrained to one of two volumes:

A. 36 in. by 40 in. by 24 in. tall (~91 cm by 101 cm by 60 cm tall).

B. 30 in. by 32 in. by 36 in. tall (~76 cm by 81 cm by 91 cm tall).

- The ROBOT must remain constrained to the maximum inspected volume at all times during the MATCH (i.e. A ROBOT may not switch between volume A and volume B without being reinspected).
- The ROBOT weight must not exceed 120 lbs

Excluded : A. ROBOT BUMPERS.

B. ROBOT battery

8.3 ROBOT Safety & Damage Prevention

- Traction devices must not have surface features such as metal, sandpaper, hard plastic studs, cleats, hook-loop fasteners or similar attachments that could damage the ARENA. Traction devices include all parts of the ROBOT that are designed to transmit any propulsive and/or braking forces between the ROBOT and FIELD carpet
- Protrusions from the ROBOT and exposed surfaces on the ROBOT shall not pose hazards to the ARENA elements (including the GAME PIECES) or people.
- ROBOT parts shall not be made from hazardous materials, be unsafe, cause an unsafe condition, or interfere with the operation of other ROBOTS.

- ROBOTS must allow removal of GAME PIECES from the ROBOT and the ROBOT from FIELD elements while DISABLED and powered off.
- Lubricants may be used only to reduce friction within the ROBOT. Lubricants must not contaminate the ARENA or other ROBOTS.

8.4 Budget Constraints & Fabrication Schedule

- The total cost of all items on the ROBOT shall not exceed $4000 USD. All costs are to be determined as explained in Section 8.4 Budget Constraints & Fabrication Schedule. Exceptions are as follows:

  A. individual COTS items that are less than $5 USD each

  B. KOP items

- No individual, non-KOP item shall have a value that exceeds $400 USD. The total cost of COMPONENTS purchased in bulk may exceed $400 USD as long as the cost of an individual COMPONENT does not exceed $400 USD.

- The CAW cost of each non-KOP item must be calculated based on the unit fair market value for the material and/or labor, except for labor provided by Team members
- Physical ROBOT elements created before Kickoff are not permitted. Exceptions are:

A. OPERATOR CONSOLE,

B. BUMPERS

C. battery assemblies per R04-B,

D. FABRICATED ITEMS consisting of one COTS electrical device (e.g. a motor or motor controller), connectors, and any materials used to secure and insulate those connectors

- Software and mechanical/electrical designs created before Kickoff are only permitted if the source files are available publicly prior to Kickoff.
- All ROBOT elements with the exception of the WITHHOLDING ALLOWANCE per R21, BUMPERS, and COTS items, must be bagged and sealed, by 04:59 UTC on Stop Build Day, Wednesday, February 22, 2017.
- ROBOT May use two (2) bags to “Bag and Tag” the pieces. However, no more than two (2) bags may be used and each bag must have its own numbered tag and entry on the ROBOT Lock-up Form.
- Team must reseal your bagged robot before leaving an event.
- Teams must stay “hands-off” their bagged ROBOT elements during the following time periods:

A. between Stop Build Day and their first event,

B. during the period(s) between their events,

C. outside of Pit hours while attending events

- Team may only unlock their ROBOT for a total of six (6) hours during the 7-day period preceding any 2-day event in which their Team will be competing with their ROBOT.
- The six hours may be broken up in any way the team wishes, with the exception that no single access period may be shorter than two (2) hours
- In the event, the unbagging must be noted on the ROBOT Lockup form and the ROBOT must be rebagged. The ROBOT must remain in the bag until:

A. Your ROBOT Lock-up Form has been checked and approved by an Inspector

B. The pits have officially been opened for ROBOT work.

8.5 BUMPER Rules

- ROBOTS are required to use BUMPERS to protect all outside corners of the FRAME PERIMETER. For adequate protection, at least 6 in. (~16 cm) of BUMPER must be placed on each side of each outside corner (see Figure 8-1). If a FRAME PERIMETER side is shorter than 6 in. (~16 cm), that entire side must be protected by BUMPER (see Figure 8-2). A round or circular FRAME PERIMETER, or segment of the FRAME PERIMETER, is considered to have an infinite number of corners, therefore the entire frame or frame segment must be completely protected by BUMPER(S).
-

- BUMPERS must be located entirely within the BUMPER ZONE, which is the volume contained between the floor and a virtual horizontal plane 7 in. (~17 cm) above the floor in reference to the ROBOT standing normally on a flat floor. BUMPERS do not have to be parallel to the floor.
- BUMPERS (the entire BUMPER, not just the cover) must be designed for quick and easy installation and removal to facilitate inspection and weighing.
- Each ROBOT must be able to display Red or Blue BUMPERS to MATCH their ALLIANCE color, as assigned in the MATCH schedule distributed at the event

8.6 Motors & Actuators

- See table on R32 for permitted motors and actuators.
- The integral mechanical or electrical system of any motor must not be modified.
- With exceptions, each actuator must be controlled by a power regulating device.
- Servos to be only connected to PWM ports on roboRio and WCP sensor board, and Rev servo power module.

8.7 Power Distribution

- Battery must be a non-spillable sealed lead acid batter, with a nomical voltage of 12V, capacity 20-hour discharge, Shape rectangular, dimensions: 7.1 in x 3 in x 6.6 in, weight 11 lbs to 14.5 lbs, Nut and bolt style.
- Anay cicuits must be sourced by a single source.
- All electrical devices and wiring shall be isolated from the robot frame.
- The roboRio power input must be connected to the dedicated supply terminals on the PDP.
- Only one wire shall be connected to each WAGO connector on the PDP.
- Fuses must only be replaced with fuses with identical functions.
- Custom circuits shall not directly alter the power pathways between the Robot Battery, PDP , etc.
- A resistor may be used as a shunt load for the PWM control signal feeding a servo

8.8 Control, Command & Signals System

- Robots must be controlled by one RoboRio.
- One OpenMesh Wireless Bridge that has been configure with the appropriate encryption key for your team number at each event.
- The RobotRio ethernet port must be connected to the wireless bridge.
- Ethernet connected COTS devices or CUSTOM CIRCUITS may connect to any remaining eithernet port on the wireless bridge but not transmit or receive UDP packets.
- Bandwidth no more than 7 Mbits/second.
- All signals must originate from the operator console.
- Diagnostics light must be easily visible. No more than two allowed.
- Everything must be connected to its respective correct port on the rio.
- Everything must be controlled with signal inputs sourced from the roborio.
- No devices that block communication with the RoboRio are permitted.

8.9 Pneumatic System

- Must use an approved pneumatics system.
- All pneumatics must be a COTS item.
- Pneumatics must be in unaltered condition except for tubing, wiring for control system, and labeling applied to indicate device purpose, connectivity and function performance.
- If pneumatics components are used the following items are required: Compressor, Pressure relief valve, Nason pressure switch, at least one pressure vent plug, “stored” pressure gauge, “working” pressure gauge, “Working” pressure regulator.
- Air must be provided by only one compressor and must be controlled by the Robot’s power. Stored air pressure must be no greater than 120 psi. Working air pressure must be no greater than 60 psi.

Pneumatics continued

- Pressure gauges must be placed in easily visible locations.
- The relief valve must be attached directly to the compressor o rattached by legal hard fittings connected to the compressor output port.
- Pressure switch requirements: must be Nason P/N SM-2B-115R/443, It must be connected to the high-pressure side of the pneumatic circuit, The two wires from the pressure switch must be connected directly to the pressyre switch input of the PCM controlling the compressor. If connected to the Roborio, the program must detect state of the switch.

8.10 OPERATOR CONSOLE

- The Drive Station software provided on the National Instruments website is the only application permitted to specify and communicate the operating mode and operating state to the Robot.
- Must have a graphic display to present the Driver Station diagnostic information.
- Devices hosting the driver station software must only interface with the field management system.
- The operator console must not be longer than 60 in, deeper than 14 in, extend more than 6 ft 6 in above the floor, attach to the field.
- May only be wirelessly connected to the arena.

Game Rules

Section 7 of the game manual

Section 7.1

Each robot must be in compliance with all rules
The robot must be the only item left on the field by the drive team
The robot must be confined to its starting configuration and set on the carpet.
The robot must be in contact with the diamond wall
The robot cannot possess more than 10 fuel and 1 gear at the start of the match
Violation protocol: If the fix is quick, the match will be delayed until the issue is remedied. If it is not a quick fix or the issue is repeated, the robot may be disabled and re-inspected.
Drive teams **MUST** be positioned as follows:
Drivers/coaches must be in their alliance station and behind the starting line.
At least one pilot **MUST** be in the airship
Human players (That are NOT pilots) must be behind the starting line and in their respective alliance station or loading lane

Section 7.2

The robot cannot exceed the volume for which it passed inspection during the match (I.e. Extending parts/mechanisms) Violation: Foul or Red Card (If strategic)
Bumpers must be kept together-must be in compliance with bumper rules throughout the match. Violation: Foul-disabled if the bumper becomes completely detached or the team number/alliance colour becomes indeterminate.
Robots **MUST** be removed from the field by hand
Robots cannot be re-enabled after the match ends.
Teams also may not tether the robot unless approved by an FTA or referee-penalty is a yellow card.

Section 7.3

Leave opponent robot alone when it's on it's rope

No attacking opponent robots (only pinning)

No contact opponent when it's on or inside vertical extension of its frame perimeter

No blocking off major facet of match play with allies

Pinning: 5 seconds max; 15 seconds = Red Card; must leave pinned robot for 3 secs and 6 ft away; doesn't require contract always

Leave downed opponent robot alone

Avoid retrieval zone of opponent

No climbing on any robot

Section 7.4

Be careful what you grab.
Drive Teams, Robots, and Operator Consoles are prohibited from the following actions:
A: Grabbing Items
B: Grasping
C: Attaching to
D: Grappling
E: Hanging
F: Deforming
G: Becoming Entangled
H: Damaging
Items A and B exclude DRIVE TEAM interaction with FIELD elements in their areas. Item C excludes use of the PLAYER STATION hook-and-loop tape, plugging into the provided power outlet, and plugging the provided Ethernet cable into the OPERATOR CONSOLE. Items A-E exclude GAME PIECES. Items A-G exclude ROPES installed on an ALLIANCE'S AIRSHIP.

Section 7.4 cont’d

Robots may not intentionally detach parts or leave parts on the field (Red Card)
Robots may not park in the opponent’s key. Breaching the line is considered as being in the opponent’s key. This will result in a foul, and another foul for every 5 seconds spent in the opponent’s key afterwards.
There may only be one robot on each rope (Red Card)
The robot may only climb on a fully deployed rope (Red Card)
Robots may not contact an opposing alliance’s rope during the last 30 seconds of a match (foul)

Section 7.5

Follow what is directed

Can't make Game Piece easier or more challenging

Game Pieces are inside

Shoot Fuel from only your launchpad

Dont throw GEAR

Airship run on steam, not fuel

Delivering Gears use LIFT (one at a time)

Don't use air to direct/redirect fuel

Section 7.6 Auto Period Rules

- ROBOT may not go the the enemy launchpad during AUTO period. What about Teleop?
- Pilots may not remove the reserved GEAR from the slot in which it begins in the match

Section 7.7 Human Action rules

- Drive Team: same as last year (stay within your station, do not touch anything you are not supposed to, common sense rules, etc)
- Pilot: Do not touch the GEARS once the ROTOR has started. How many gears do you need to get the motor started?
- Pilot: If FUEL (aka the green boulders) get inside the AIRSHIP, PILOTS may only remove them through the PORT. Where is the PORT?
- Pilot: Pilots may only start ROTORS 2, 3, and 4 by turning the CRANK installed on the first GEAR in the set. Is this Gear the same as the one mentioned in 7.6? Where does it come from?

Match Rules

Key Points

- Up to 4 teams per Alliance (3 real ones and a backup)
- Objectives are to add wiffle balls to “Boilers”, add gears to the tower, and hang from a rope coming off the towers

Periods

- Auto Period:
  - 15 seconds
  - Robots run strictly on pre-programmed instructions
  - Some points are increased
  - Robots attempt to deliver preloaded game pieces, retrieve additional game pieces, and cross their baseline before the start of the next period.
- Teleop Period:
  - 2:15 minutes - last 30 seconds allowed to climb
  - Pilots can control robots
  - Objectives: retrieve and deliver game pieces, defend against their opponents, and climb their ropes to prepare for the impending departure of their airship after the match.

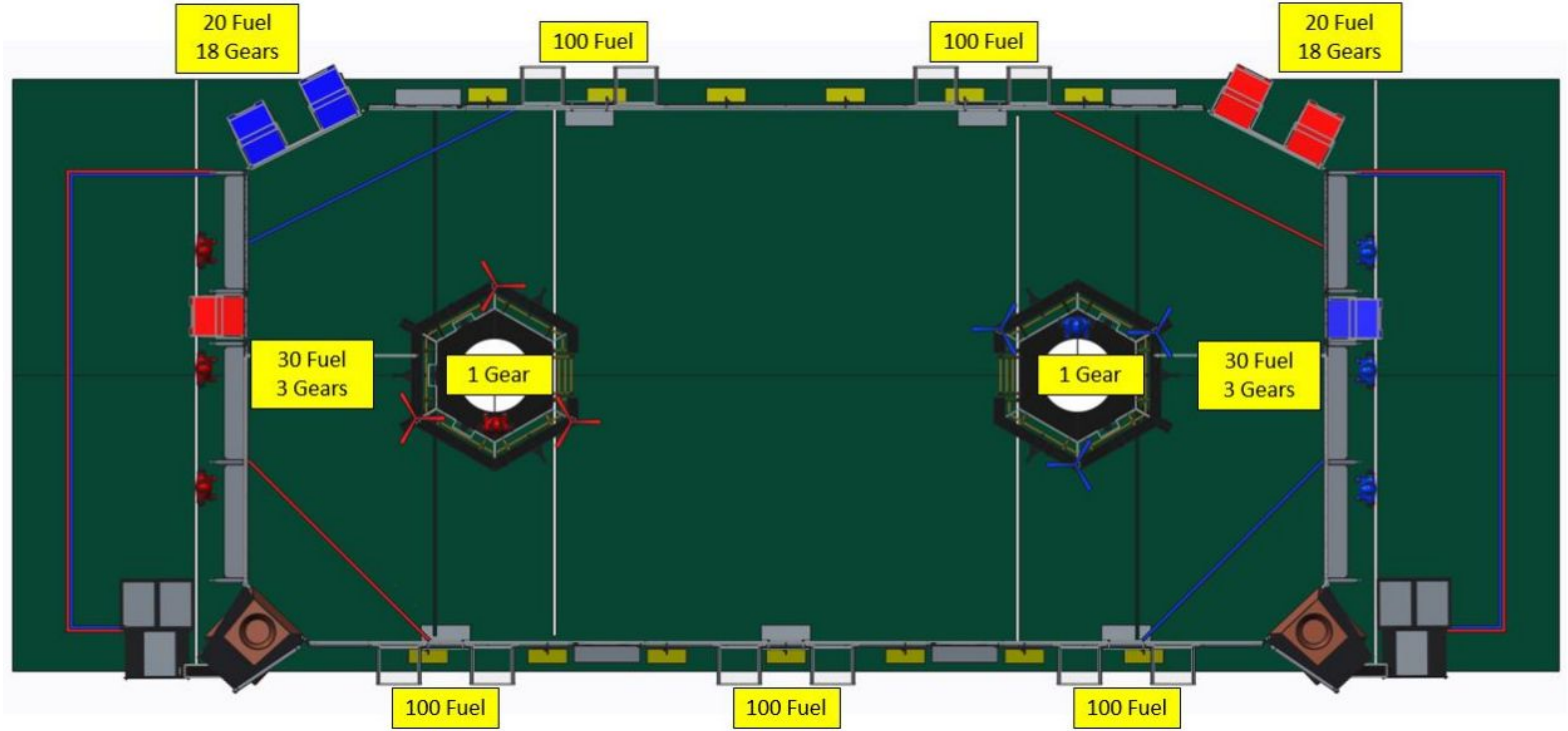
Match Setup

- Staging details of the game pieces:
  - Fuel: 10 for each team to preload, 20 in each loading land, 100 in each hopper.
  - Gears: 1 to each team to preload, 18 in each loading lane, 1 in each airship.
- When a drive team loads their robot onto the field for a match they may:
  - Pre-load one gear in or on their robot such that is fully and only supported by the robot. **AND**
  - Pre-load up to ten fuel in or on their robot such that they are fully and only supported by the robot.
    - Any fuel or gears not preloaded in a robot are transferred to a return bin in their loading lane.

Match Setup (Cont.)

- Team may switch one of the ropes on their airship for their own rope
  - Max width of 1 in., length of at least 5 ft. 3 in. but to not exceed a length of 8 ft..
  - Entirely flexible, non-metallic fibers twisted, tied, woven, or braided together except for the last 4 in. of each end which may be dipped in a coating material to prevent fraying
  - Has a serialized inspection tag.
- If order placement of robots or ropes matters to either or both alliances, the alliance must notify head referee during setup for that match. Upon notification, the head referee will require alliances alternate placement of all robots and then all ropes, starting with the red alliance and in order of player station assigned.

Match Setup



20 Fuel
18 Gears
100 Fuel
100 Fuel
20 Fuel
18 Gears
30 Fuel
3 Gears
1 Gear
1 Gear
30 Fuel
3 Gears
100 Fuel
100 Fuel
100 Fuel

SCORING

Action	Criteria	MATCH Points AUTO	MATCH Points TELEOP	Ranking Points
AUTO mobility	For each ROBOT that breaks the BASE LINE vertical plane with their BUMPER by T=0	5	-	-
Pressure accumulation	For every three (3) FUEL counted in the Low Efficiency GOAL by T=0	1 + 1 kPa		
	For every one (1) FUEL counted in the High Efficiency GOAL by T=0			
	For every nine (9) FUEL counted in the Low Efficiency GOAL by T=0	-	1 + 1 kPa	
	For every three (3) FUEL counted in the High Efficiency GOAL by T=0			
	If ALLIANCE exceeds a threshold pressure of 40 kPa		20 (Playoffs only)	1 (Quals only)
ROTOR engagement	For each ROTOR turning by period's T=0	60	40	-
	If all four (4) ROTORS turning by T=0		100 (Playoffs only)	1 (Quals only)
Ready for Takeoff	For each TOUCHPAD triggered by a ROBOT at T=0		50	-
Win	ALLIANCE's final score exceeds their opponents'		-	2 (Quals only)
Tie	ALLIANCE's final score equals their opponents'			1 (Quals only)

- Rewards are granted either via MATCH points or Ranking Points
- Points will be accumulated regardless of the match, but will be rounded to the lower number at the end of match
    - Ex: 3 and ⅔'s will be rounded down to 3.
- Steam Tank have an upper limit to the amount of pressure they can display, but there is no limit on the pressure an alliance can accumulate.
- Fuel contributes to an alliance's pressure and match score only once it is counted
    - Boiler's rate: 5 fuel per second per goal,
        - Actual rate is dependent on the amount and packing of fuel in the goals
        - Boiler counters shut off at end of teleop and any uncounted fuel does not contribute to scores.

Rule Violations

- Foul
  - 5 Points Added to the opposing team
- Technical Foul (Tech Foul)
  - 25 points added to the opposing team
- Yellow Card
  - A warning. Another one in the same match becomes a red card
- Red Card
  - Disqualifies the team
- Disabled
  - A robot is stopped. No input or output goes to the robot
- Disqualified
  - The team will receive 0 Qualifying Points in the Qualifying Rounds
  - The entire Alliance will get 0 Match Points in Playoffs
- Referees can give red/yellow cards as they see fit

Drive Team

- Set of 5 people Max
- Any combination of the positions below

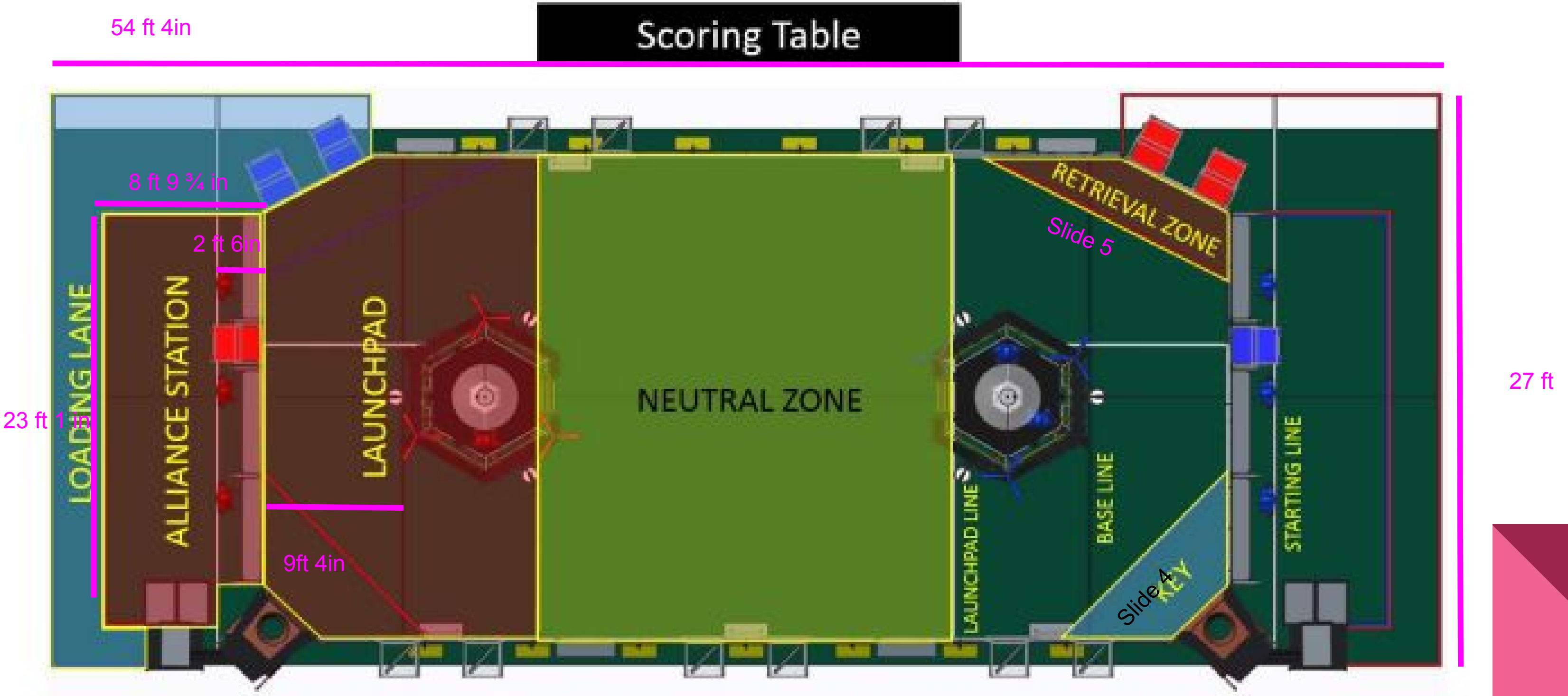
Role	Description	Max./ DRIVE TEAM	Criteria
COACH	responsible for acting as a guide or advisor	1	• Pre-college student or adult mentor • Must wear "Coach" button
DRIVER	responsible for operating and controlling the ROBOT	4	• Pre-college student • Must wear one (1) of the four (4) "Drive Team" buttons
HUMAN PLAYER	responsible for managing GAME PIECES	4	• Pre-college student • Must wear one (1) of the four (4) "Drive Team" buttons
PILOT	responsible for installing GEARS, starting ROTORS, and deploying ROPES	1	• Pre-college student • Must wear one (1) of the four (4) "Drive Team" buttons

Logistics

- Game Pieces that leave the field will not be returned to the field
  - Any game pieces that somehow bounce back will be fair game
- Game Pieces that move from a loading lane to an Alliance Station now belong to the Alliance
- There won’t be an arena fault (restart) for matches with the following
  - Incorrect number of game pieces
  - Damaged game pieces
  - Rope Failure

Arena

Zones and Markings

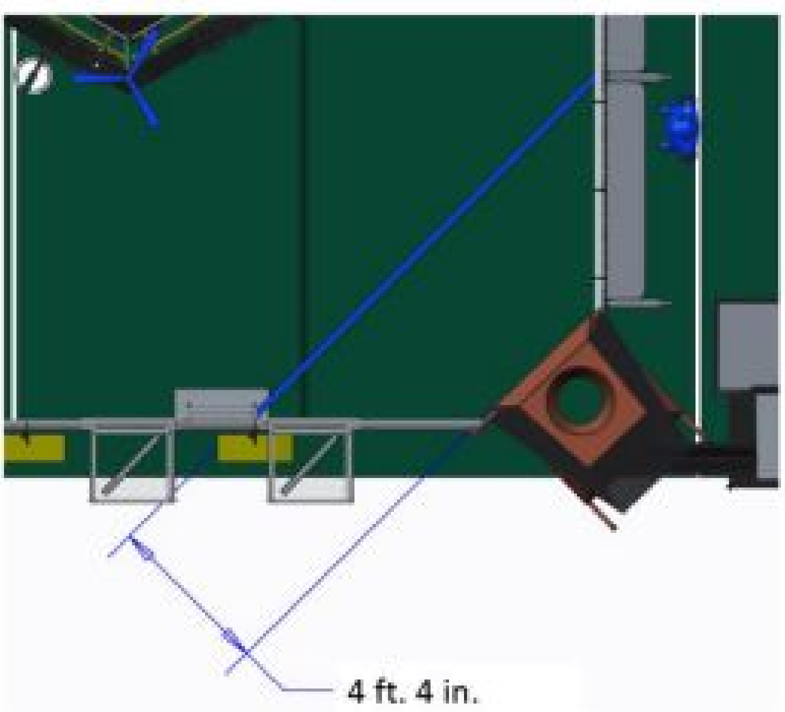


Zone & Markings

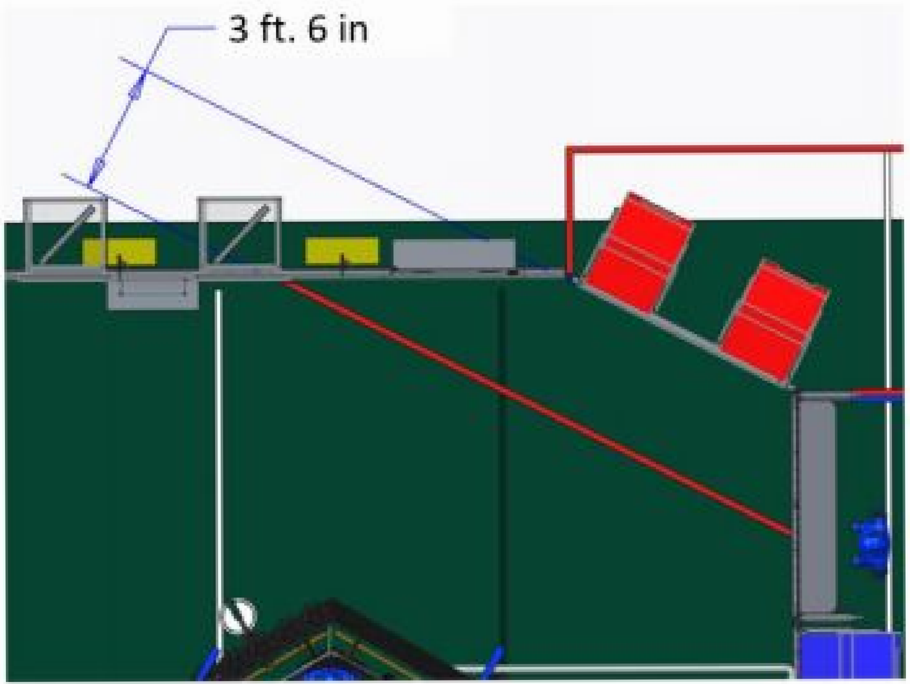
- LAUNCHPAD: Area where robots begin match. Incorporates everything before the neutral zone.
- LAUNCHPAD LINE: The line before the neutral zone and after the launchpad.
- LOADING LANE: an area where you grab balls and gears and is behind the alliance station.
- NEUTRAL ZONE: an area of the field which is neutral bounded by the guardrails and the launchpad lines.
- The RETRIEVAL ZONE :The area when you load the balls & gears. The far edge of the tape is parallel to and 3 ft. 6 in. (~107 cm) from the front face of Loading station.
- STARTING LINE: The area where the robots starts the match.

Key

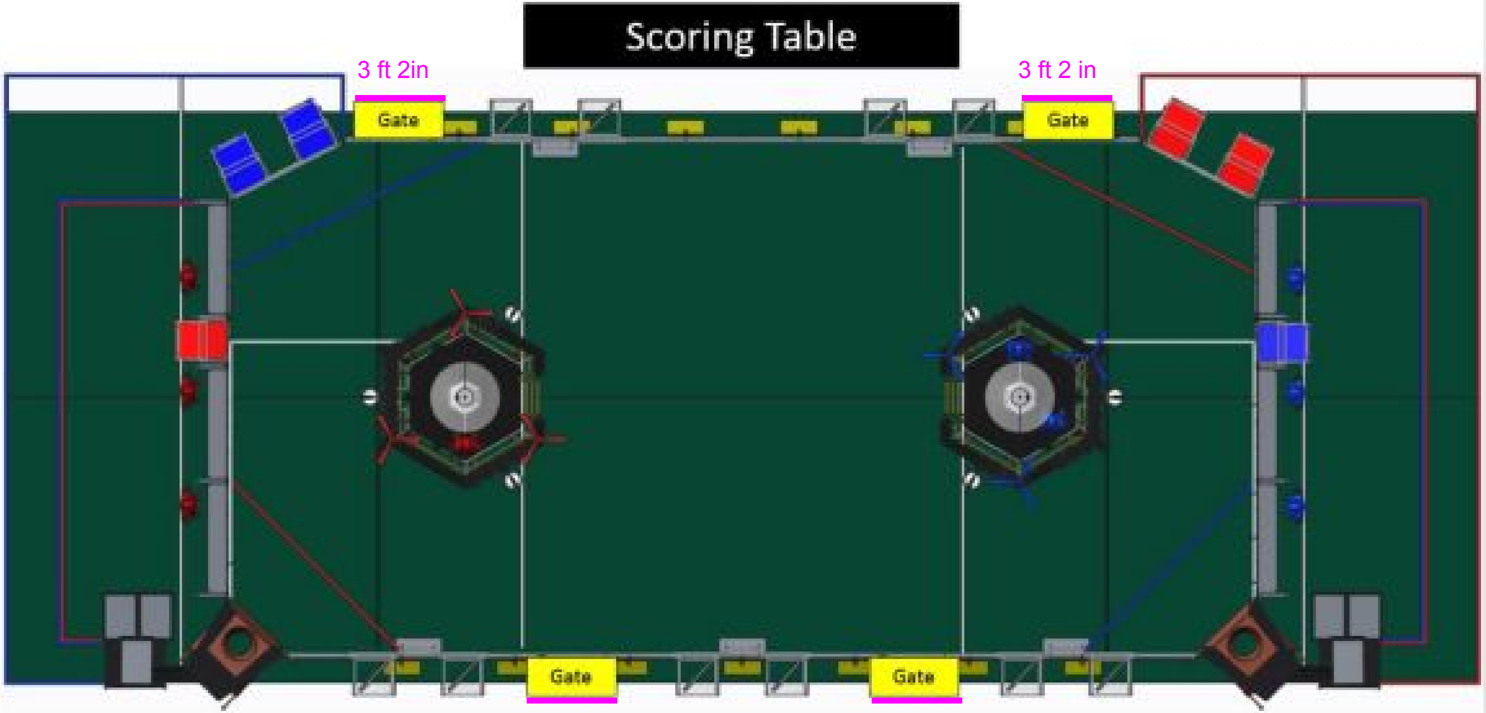
Figure 3-3: KEY



Retrieval Zone

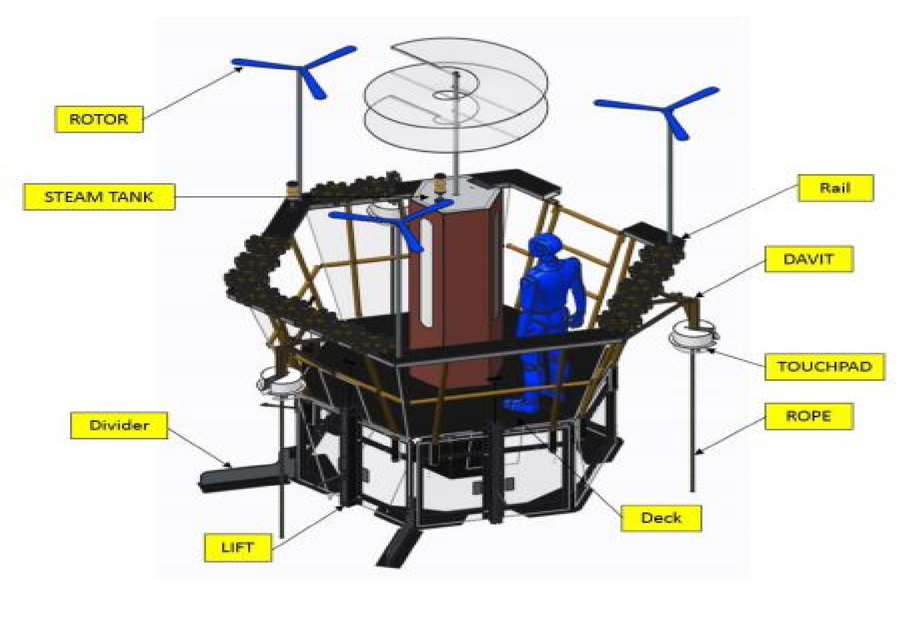


Gates



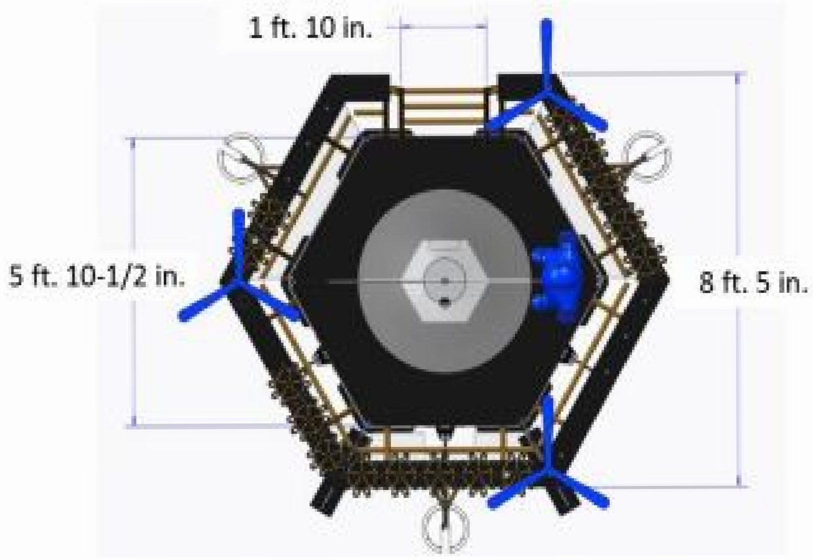
AirShip

- The central rotor is modeled after the Da Vinci Aerial screw.
- Rope is held by the touch pad



Hexagonal Deck

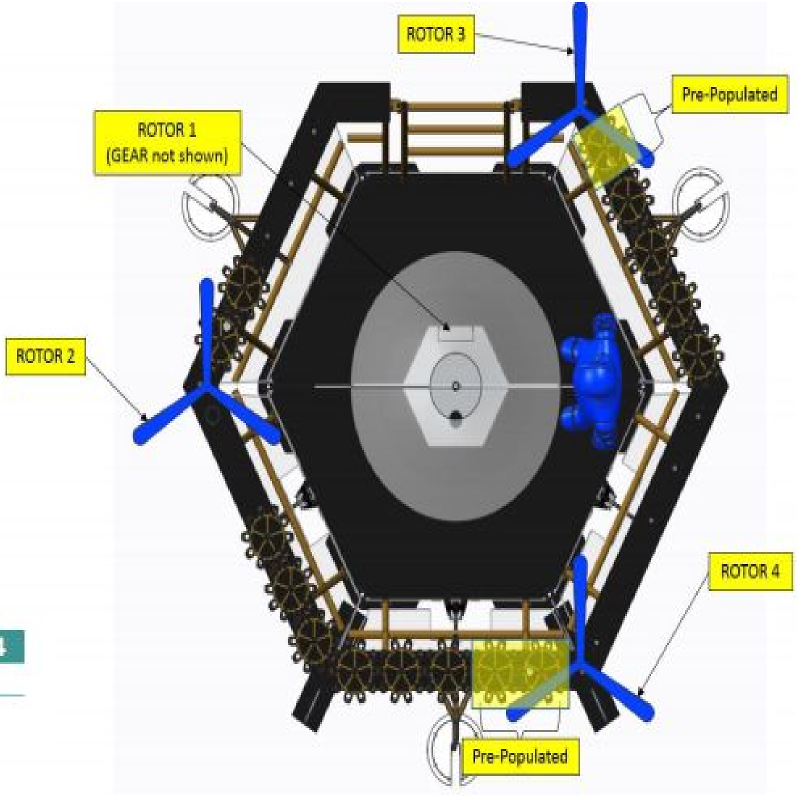
The step ladder is 1 ft. 10 in.

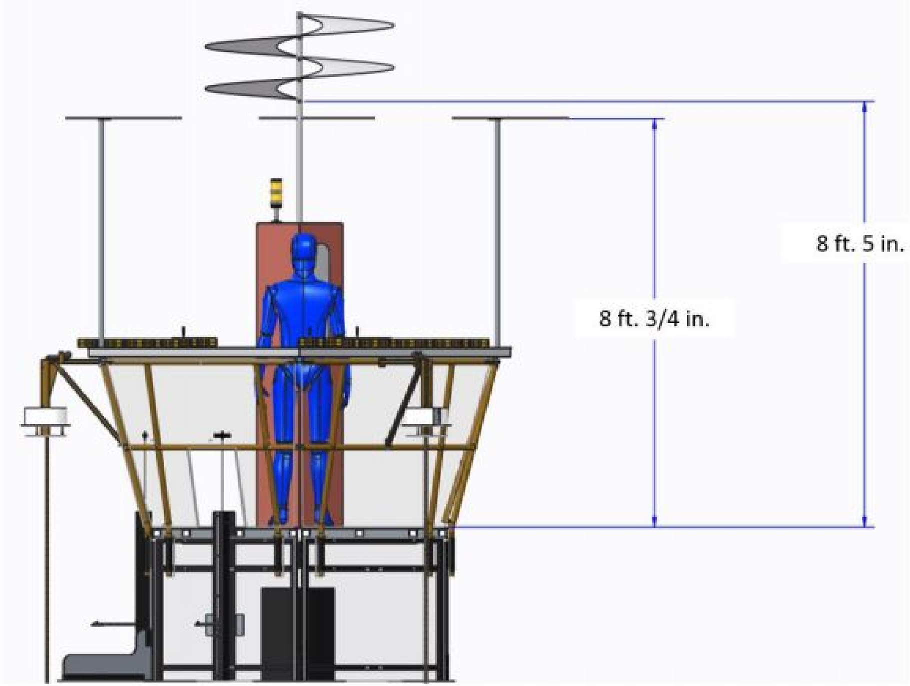


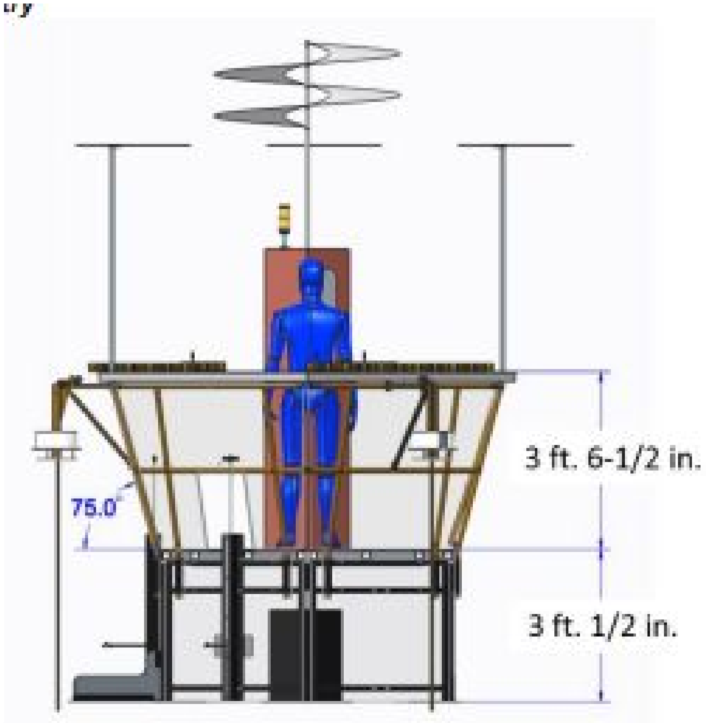
Gears and rotors

- A rotor is turned on for the rest of the game when the gears are installed in the order 1, 2, 3, 4
- The placement of gears are 5 per rotor.
- There is one reserved gear at the base of the steam deck.
- To turn on Rotor 1, the pilot places a gear in a gear slot opposite of the yellow stack light
- A crank is used to turn on Rotors 2, 3, 4
- A yellow light turns on if the rotor is turned on during auto

	ROTOR 1	ROTOR 2	ROTOR 3	ROTOR 4
Pre-populated GEARS	0	0	1	2
PILOT placed GEARS	1	2	4	6



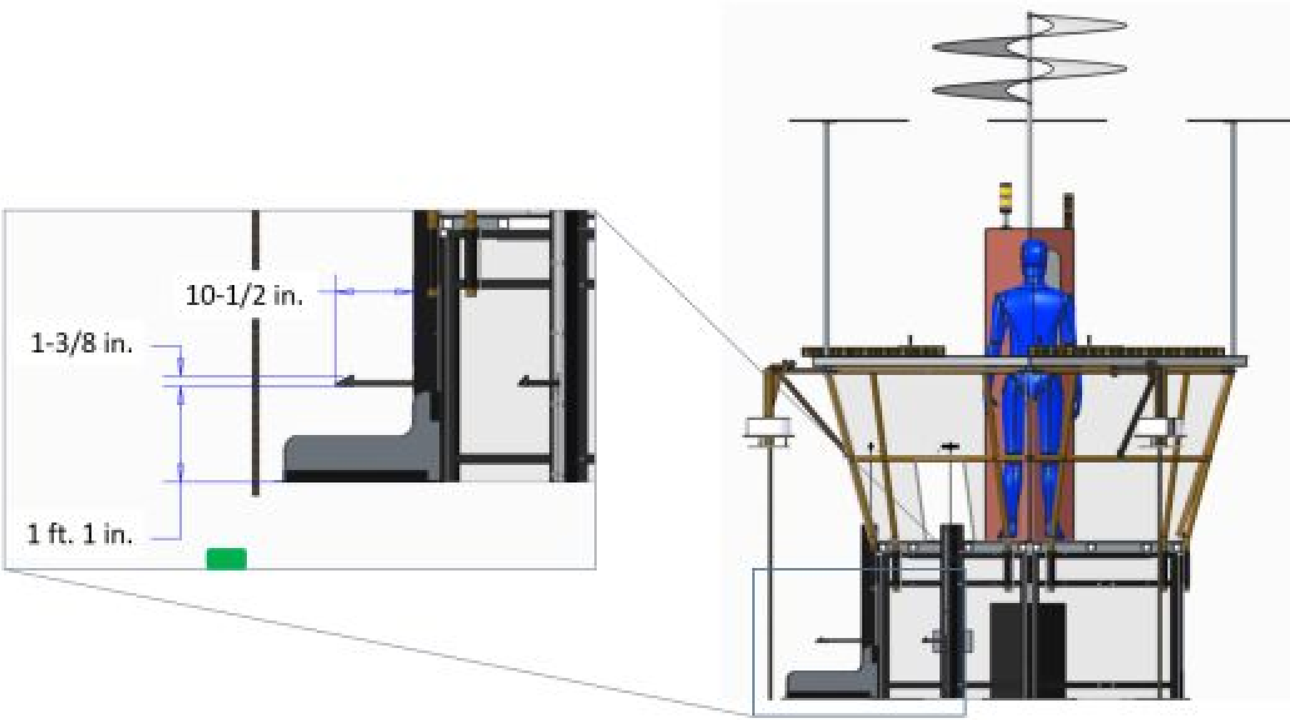

8 ft. 5 in.
8 ft. 3/4 in.


75.0
3 ft. 6-1/2 in.
3 ft. 1/2 in.

Lift

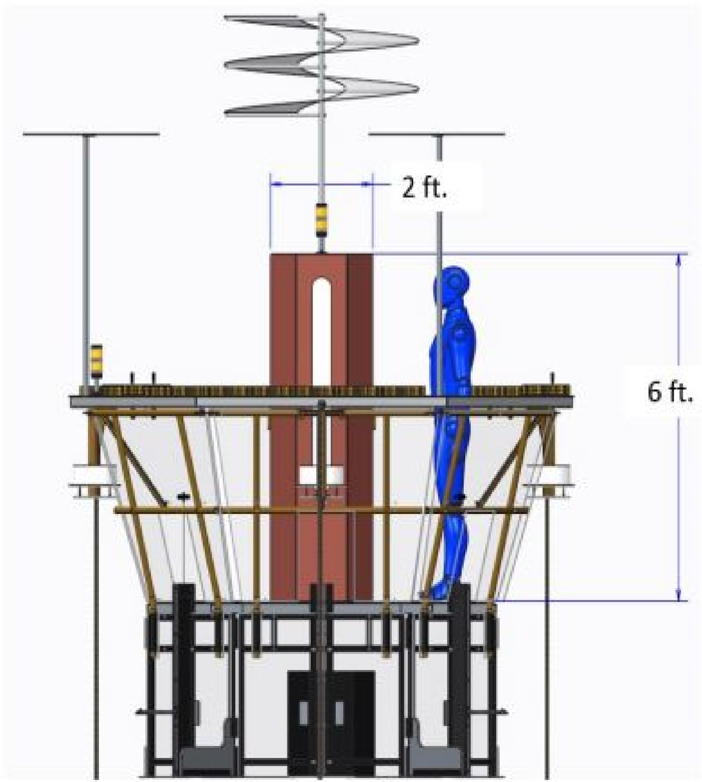
- Three lifts on the airship
- A cable is pulled by the pilot to bring the gear onto the airship

Figure 3-15: LIFT geometry



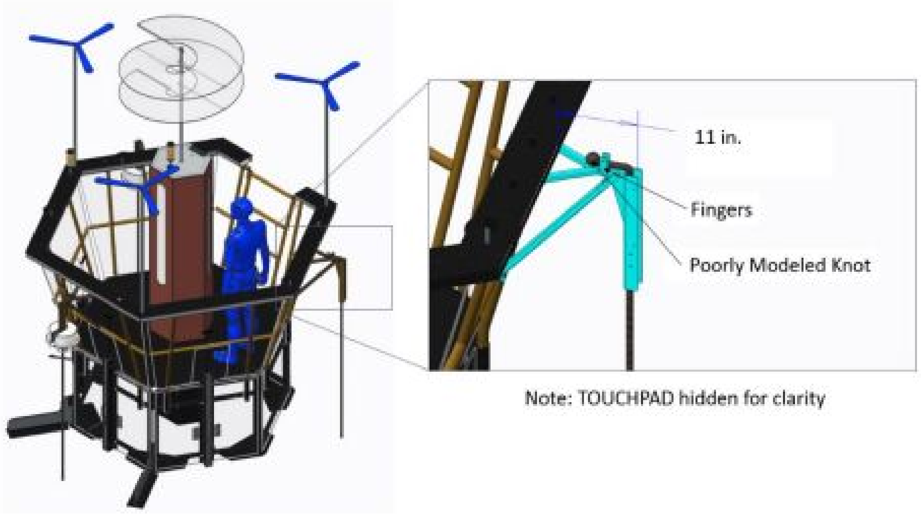
Central Tank

- The central tank contains LED’s to indicate the amount a pressure in the Boiler
- Two rows of LED’s turns from off to on in white, then turns to the alliance color for every 10kPA



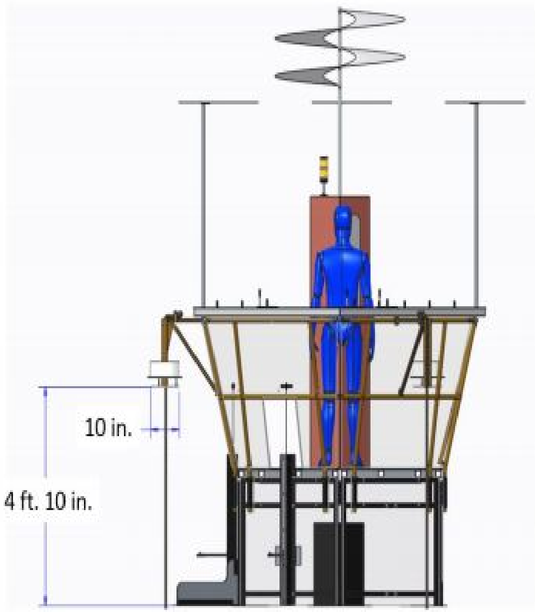
Divot and Rope

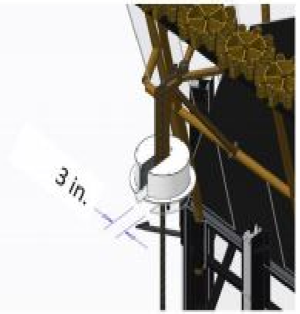
- The divot hangs from the airship carrying the rope.
- Rope hangs down from the divot and is 7 ft 2in
- Pilot removes the retention chat to let down the rope



Touchpad

- Displaced by ½ in
- Pressed for 1 sec
- Pressed when Teleop towards the end of the match





Hopper

- Store fuel at beginning of match
- 6 in total, 2 on scoring table, 2 opposite of the scoring table and the last 1 is centered on the guardrails.

Hopper Locations

Alliance Wall

- The alliance wall is a barrier that separates robots from the drive team excluding the pilot, and consists of a boiler, 3 player station, an overflow loading station and a return loading station.

Player Station

- Player station is one of three assigned positions in an alliance wall from where a drive team operates their robot
- Over each drive teams assigned position is the team’s banner

Overflow Loading Station

- An overflow loading station is located two player stations away from each boiler on each alliance side.
- Used to feed fuel from the overflow bin onto the field.

Return Loading Station

- Return loading station are located in each of the two corners of the field opposite the boilers.
- A return loading station is used to feed fuel and gears on to the field.

Strategy Breakout and Decisions

Group 1:

Strategy 1

- Focus on gears, and hang at the end
- Autonomous:
    - Cross the baseline (5pts)
    - Put one gear on the peg (60pts and ¼ to ranking point)
    - Head over to gear collection area (because it is closer to the next one)
- Teleop:
    - Go back and forth, get gears and put them on pegs (120 pts + 1 Ranking Point)
    - Keep going, and get all the rotors spinning
    - If time climb the rope
    - Perfect game : 235pts
- Pros
    - High score
    - 1 Ranking Point
- Cons
    - Difficult for drive team
    - Robot needs to be really fast
- Comments
    - What if you are on an alliance with no shooters?

Strategy 2:

- Shooting bot, high and low, hangs at the end
- Autonomous
    - Start from point and go to boiler, shoot high (10 kPa, 10pts)
- Teleop:
    - Collect balls and shoot high (40 kPa, 40 pts, 1 RP)
    -
    - Keep shooting, until last 30 seconds
    - Hang (50pts)
- Pros
    - High Score
    - 1 Ranking point
- Cons
    - Needs Speed
    - Accuracy with drive teamStrategy 3:
- Low shooting and Hang
- Autonomous
    - Go across baseline (5pts)

  - Score 10 balls into low goal (3pts, 3kPa)
- Teleop
  - Keep shooting until done with 40kPa
  - Hang at the end
- Pros
  - Easier for drive team
  - Simpler task for shooting
- Cons
  - Low point value

Strategy 4:

- Shoot in the low goal and gears
- Autonomous
  - Score a gear and cross line (65 pts)
- Teleop
  - Get all the rotors (120pts, 1 RP)
  - Low goal scoring
- Pros
  - A lot of points
- Cons
  - Time sensitive to shoot and get the rotors

Optimal strategy: stratey 1

Group 2

Strategy 1

- Automous
  - Cross baseline
  - Place one gear
  - Move toward retrieval zone
- Teleop
  - Place gears
  - At end hang
- Comments: reach goal to shoot high

Strategy 2

- Autonomous
  - Shoot high,
  - Cross baseline
  - Move toward hopper
- Teleop

    - Shoot as many as possible, high and low
    - Go for rope at the end
- Pros
    - Qual for kPa and 20 extra point
- Cons
    - Low scoring

Strategy 3 x

- Bulldozer for the fuel, dump a lot into the low goal
- Autonomous
    - Unload balls into low goal
    - Move toward hopper
- Teleop
    - Keep all the balls corraled on our side
    - Dump balls into low goal
    - Hang at the end
- Pros
    - Low effort
- Cons:
    - Relies on the other team

Strategy 4

- Shoot high
- Autonomous
    - Shoot the balls high during auto, constantly flinging them up, and scooping the ones that miss
- Pros
    - Doesn't require accuracy
- Cons
    - Not accurate

Optimal Strategy: Strategy 1

Group 3

Autonomous Strategy 1

- Go over the line, put gear on life
- Pros
    - 65 points
    - 1 out of 4 rotors
- Cons
    - Requires some amount of sensing and accuracy for gears
    - Needs to be manuverable

Autonomous Strategy 2

- Go to top goal, shoot ten balls, cross line
- Pros
    - 10 kPa
    - 15 points
- Cons
    - Cross line and back track (not a direct route)
    - Requires sensing for accurate shot

Autonomous Strategy 3

- Do gear, then shoot high, cross the line
- Pros
    - 75 points
    - 10 kPa
    - 1 out of 4 rotors turning
- Cons
    - Time sensitive
    - Not easy route
    - Requires significant sensing/vision

Autonomous Strategy 4x

- Cross the line
- Pros
    - Easy
    - 5pts
- Cons
    - Lame

Teleop Strategy 1 x

- Defense
- Pros
    - Easy
    - Prevent other scoring
- Cons
    - Easy to get penalized
    - No actual points

Teleop Strategy 2

- Fast high shooter, high capacity of balls
- Pros
    - More kPa than low goal

    - 1 RP
    - Only need to do ~100 balls (if shot in autonomous)
- Cons
    - Accuracy may be hard
    - Time sensitive
    - Capacity may be limited by given volume

Teleop Strategy 3 x

- Dump truck low shooter
- Pros
    - Easy
    - Can get 40kPa (1 RP)
- Cons
    - Speed, time sensitive
    - Need to do 360 balls

Teleop Strategy 4

- Do rotors quickly & accurately
- Pros
    - 40 points/rotor (max of 160 points)
    - 1 RP
- Cons
    - Time sensitive, has to travel large distance
    - Can only hold one at a time
    - Hard to pick up and align

Ideal autonomous: Either Strategy 1 or 2, depending on alliance capabilities
Ideal Teleop: Both 2 and 4, do some rotors and shoot high as much as possible

- Comments: rope is a reach, not necessary

****NOTE: Strategies marked in red were voted against specifically by the team****

Final Strategy Decision:

No go: (decided right off the bat because of low scoring capability)

- Defensive
- Low shooter, bulldozer

Top Options:

- Group 1: Gear + hang
- Group 2: Gear + hang
- Group 3: Gear + high shooter

<u>Hang vs. High Shooter</u>
Hang:
Pros:

- Fewer people can do it, gives pizzazz

- 50 pts

Cons:

- Robot can fall and break
- Only have one shot
- It’s hard to design

High Shooter:

Pros:

- Flexibility during teleop and autonomous
- More ranking points
- Holding balls so other team can’t have them
- Fill more roles, higher versatility

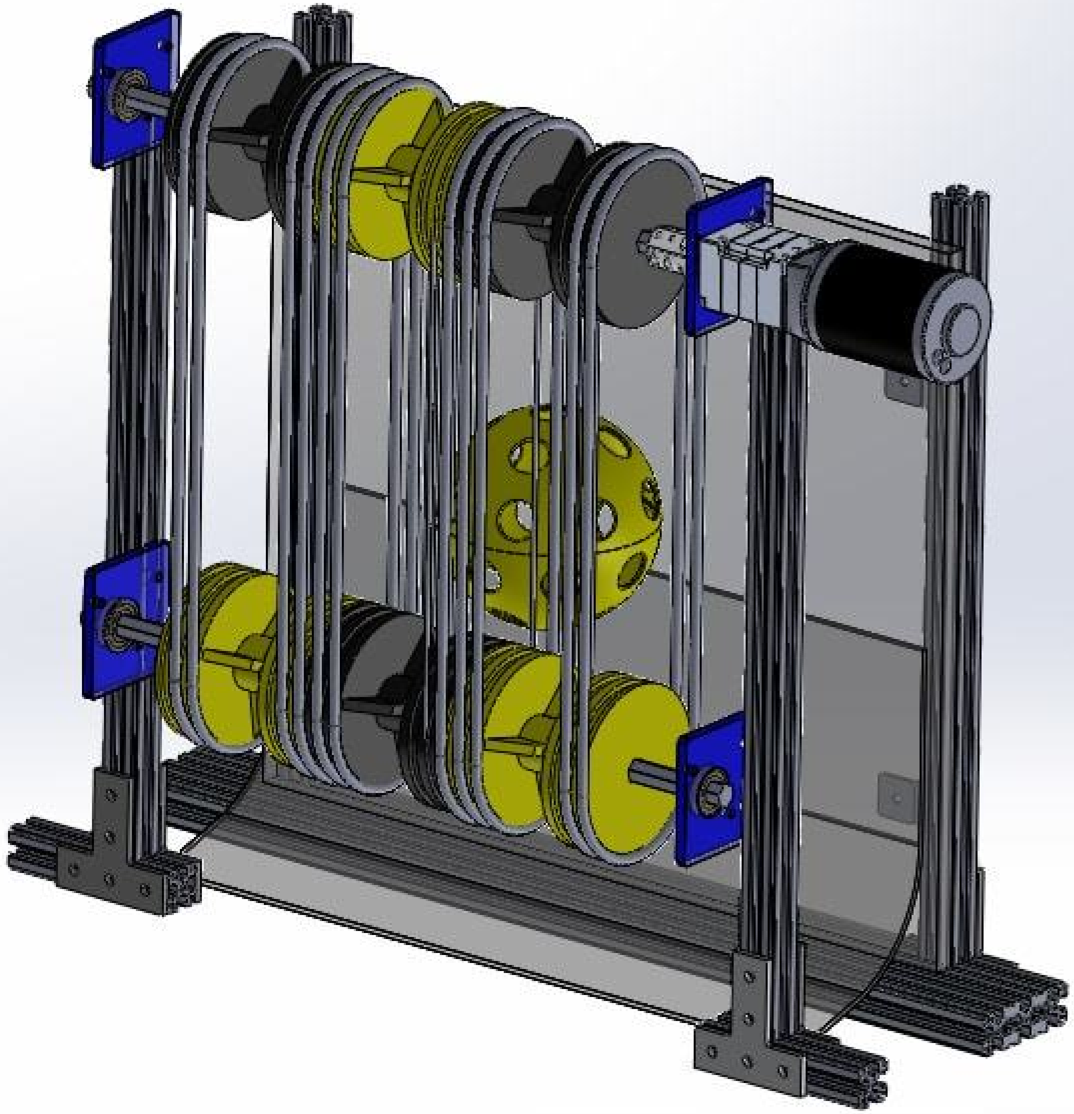
Cons:

- Difficult to do both in a match

Based on Unanimous vote: high shooter is a priority

Final strategy:

Go for high shooting and the gears, if there is time try to incorporate a hanger, but that's a reach.



Rope Climbing Prototyping and Design

January 15, 2017

Motor Option 1:

Linear Motion Gearing Design Calculations

Motor Specs

Spec Voltage (V)	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
12	5700	0.494	44	1.4

Mechanism Gearing:

Driving Gear	Driven Gear	Reduction
1	81	0.012
1	1	1.000
1	1	1.000
1	1	1.000

Overall Gear Reduction	
0.0123	**81.0 : 1**

Mechanism Physical Chacteristics:

Applied Motor Voltage (V)	Load Torque Lever Arm (in) [Pulley Radius]	Gearbox Efficiency	Travel Distance (in)
12	2	90%	58

Mechanism Outputs Under Loading:

Applied Load (lb)	Max Loaded Current Draw (amp)	Time to move Travel Distance when under load (sec)	Loaded Linear Speed (in/sec)	Loaded Linear Speed (ft/sec)
120	30.27	15.94	3.64	0.30

Mechanism Unloaded Performance Outputs:

Stall Load (lb)	Time to move Travel Distance when unloaded (sec)	Linear Free Speed (in/sec)	Linear Free Speed (ft/sec)
159.36	3.94	14.74	1.23

Uses 2 RS-775 motors with a Vex Versaplanetary gearbox, with dual inputs and geared at 81:1. The motors and gear box were chosen using calculations for time and current that each combination would take. It is important to make sure the max draw current never exceeds 40 amps. Also take note of the stall load, to be safe, it is important to make sure you can do over the max robot weight for safety.

Motor Option 2: 775Pro:

Linear Motion Gearing Design Calculations

Motor Specs

Spec Voltage (V)	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
12	18730	0.7	134	0.7

Mechanism Gearing:

Driving Gear	Driven Gear	Reduction
1	100	0.010
1	1	1.000
1	1	1.000
1	1	1.000

Overall Gear Reduction	
0.0100	**100.0 : 1**

Mechanism Physical Chacteristics:

Applied Motor Voltage (V)	Load Torque Lever Arm (in) [Pulley Radius]	Gearbox Efficiency	Travel Distance (in)
12	1.75	90%	40

Mechanism Outputs Under Loading:

Applied Load (lb)	Max Loaded Current Draw (amp)	Time to move Travel Distance when under load (sec)	Loaded Linear Speed (in/sec)	Loaded Linear Speed (ft/sec)
120	45.88	1.87	21.39	1.78

Mechanism Unloaded Performance Outputs:

Stall Load (lb)	Time to move Travel Distance when unloaded (sec)	Linear Free Speed (in/sec)	Linear Free Speed (ft/sec)
318.61	1.17	34.32	2.86

Uses 1 775 Pro, deemed impossible because of current restrictions and gear limitations with VersaPlanetary Gearbox. Gearing can be done up to 100:1, but it is not feasible for our purposes.

Motor Option 3: MiniCIM

Linear Motion Gearing Design Calculations

Motor Specs

Spec Voltage (V)	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
12	5840	1.41	89	3
	5840	1.41	89	3

Mechanism Gearing:

Driving Gear	Driven Gear	Reduction
1	50	0.020
1	1	1.000
1	1	1.000
1	1	1.000

Overall Gear Reduction	
0.0200	**50.0 : 1**

Mechanism Physical Chacteristics:

Applied Motor Voltage (V)	Load Torque Lever Arm (in) [Pulley Radius]	Gearbox Efficiency	Travel Distance (in)
12	1.75	80%	58

Mechanism Outputs Under Loading:

Applied Load (lb)	Max Loaded Current Draw (amp)		Time to move Travel Distance when under load (sec)	Loaded Linear Speed (in/sec)	Loaded Linear Speed (ft/sec)
154	40.15		5.89	9.84	0.82

Mechanism Unloaded Performance Outputs:

Stall Load (lb)		Time to move Travel Distance when unloaded (sec)	Linear Free Speed (in/sec)	Linear Free Speed (ft/sec)
285.23		2.71	21.40	1.78

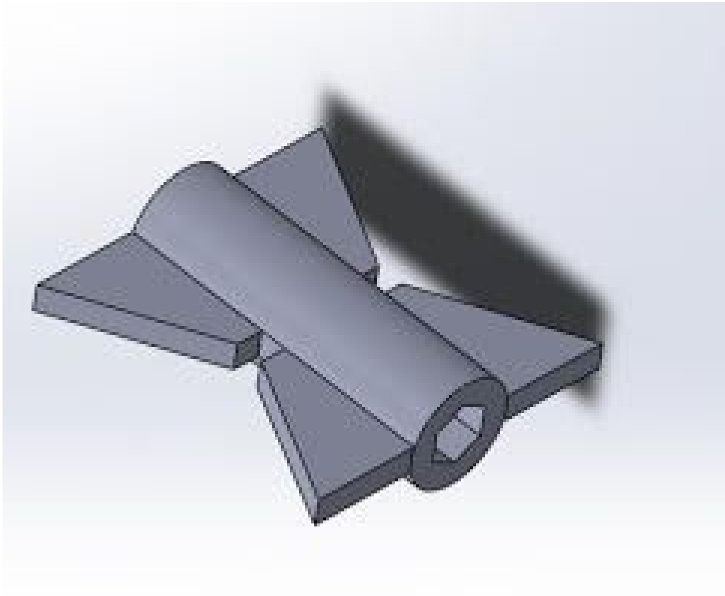
Uses MiniCIM geared at 50:1, just over 40 amps of current at max possible weight, which is unlikely. (takes into account 120lb robot + 14 lb battery + 20 lb bumpers) If we reach 154 pounds, we would instead gear it at 63:1. Which is just a tenth of a second slower than 50:1. It also puts us in range of current, at 32.48 amps. Gearing was done keeping in mind that with ½” hex shaft, gearing is not recommended for over 63:1 on a miniCIM.

Rope Collectors:

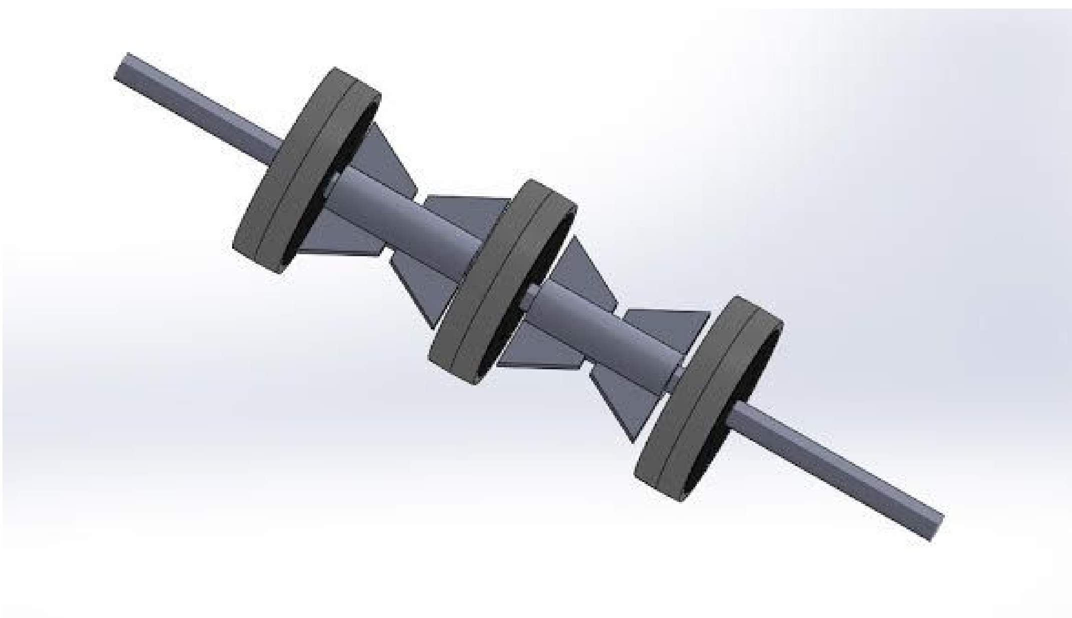
Version 1: 2 y-shaped slots on a single piece of lexan, for prototyping it was zip tied onto ½” lexan

Version 2: Multiple iterations of y-shaped cuts in wood, zip-tied onto ½” hex shaft. With ¼” paracord as rope.

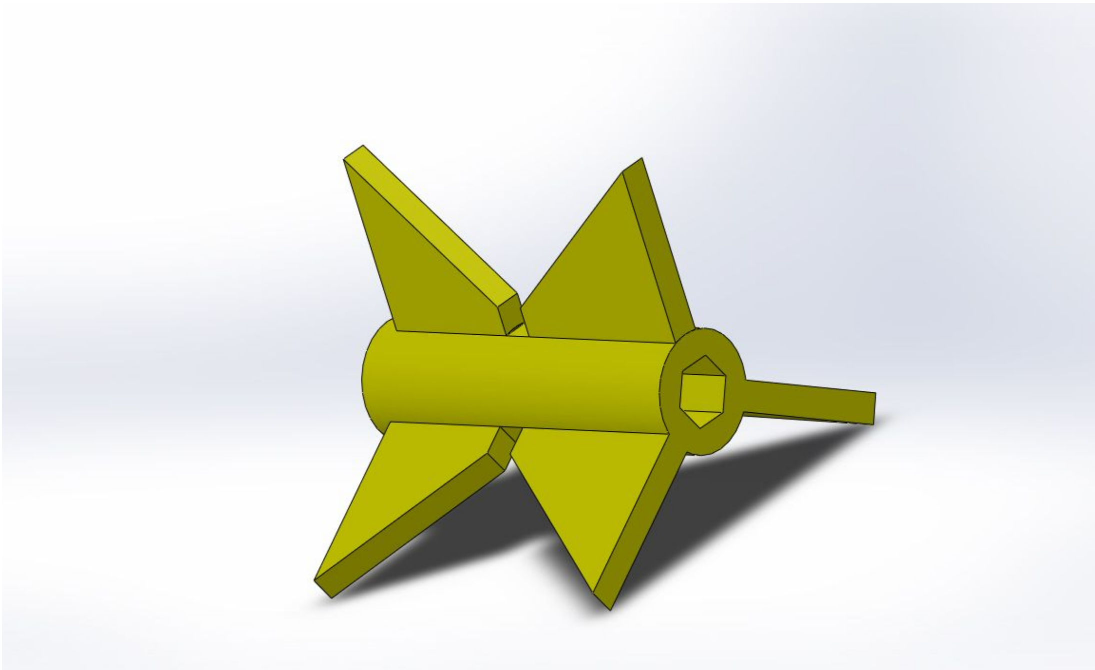
Version 3: 3D printed hex adapter with y-shaped wings, each a separate piece with wheels in between to make sure the touchpad is always in contact with the device. Two sets of wings on each side.

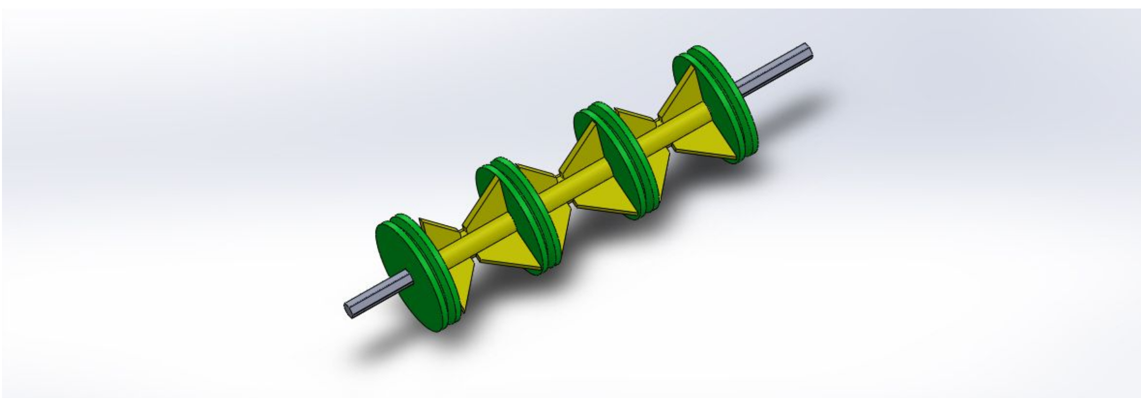


Part modeled in SolidWorks.
Assembly modeled in SolidWorks with two iterations.



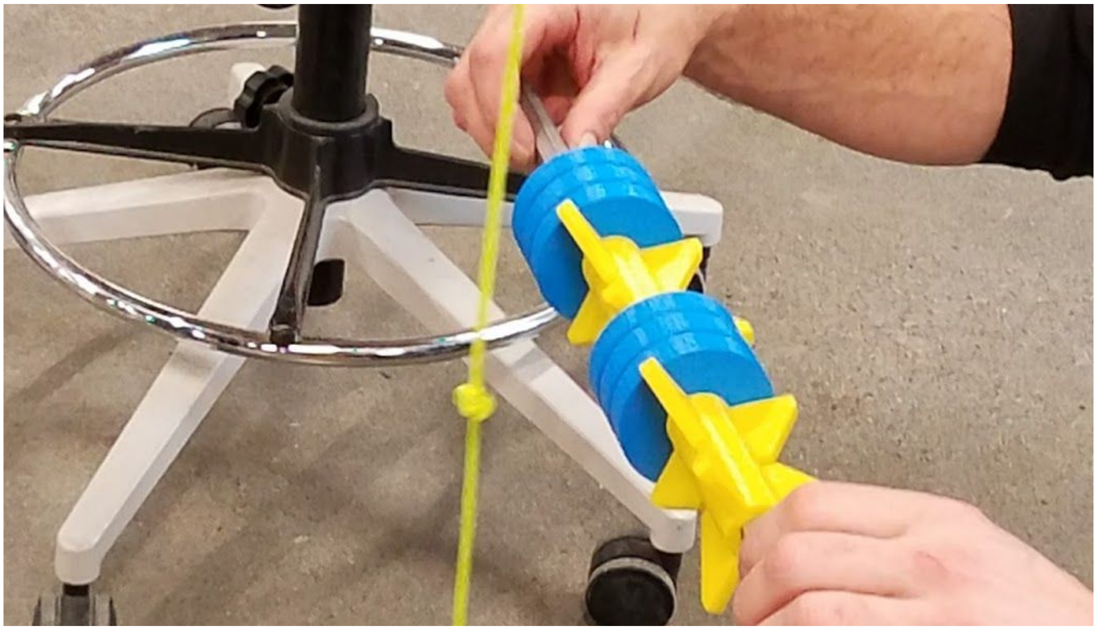
Part with three iterations:
We put together a piece with three iterations of the wings so it would be better able to grab the rope.





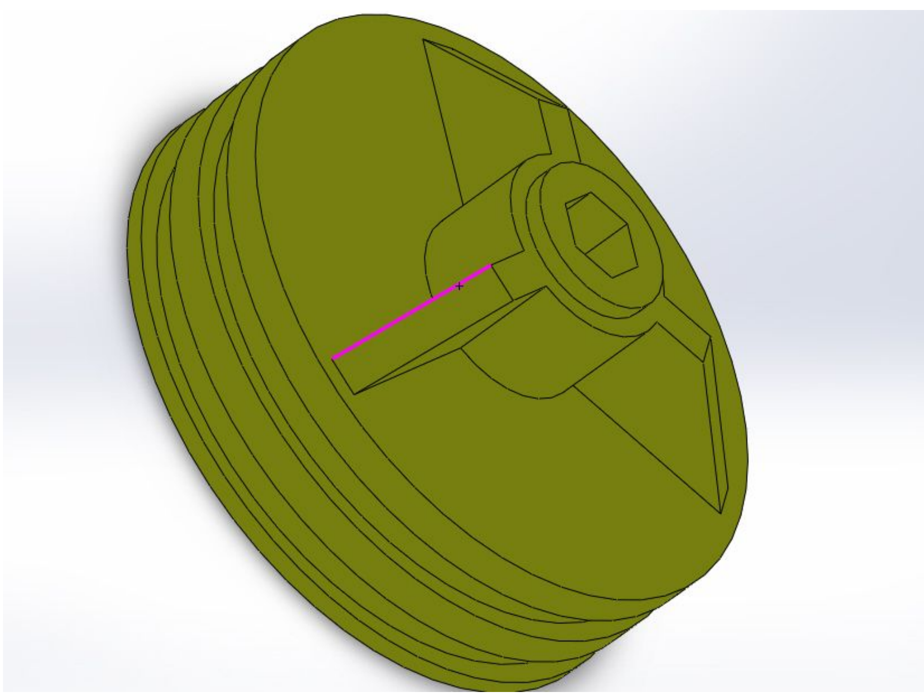
As we began integration between systems we decided it might be a good idea to combine the motor for the intake and the motor for the rope climber. Because of the large gear ratio, we needed to compensate for the speed by making the pulleys holding the polycord larger in diameter. We designed pulleys with grooves for the polycord to go in between our rope grabbers. These would be four inches in diameter. Because they don't interfere with the rope, the issue of spool diameter and current draw isn't an issue. Also, because they are circular it solves the problem of losing touch of the touchpad.

Testing the rope grabbing pieces:

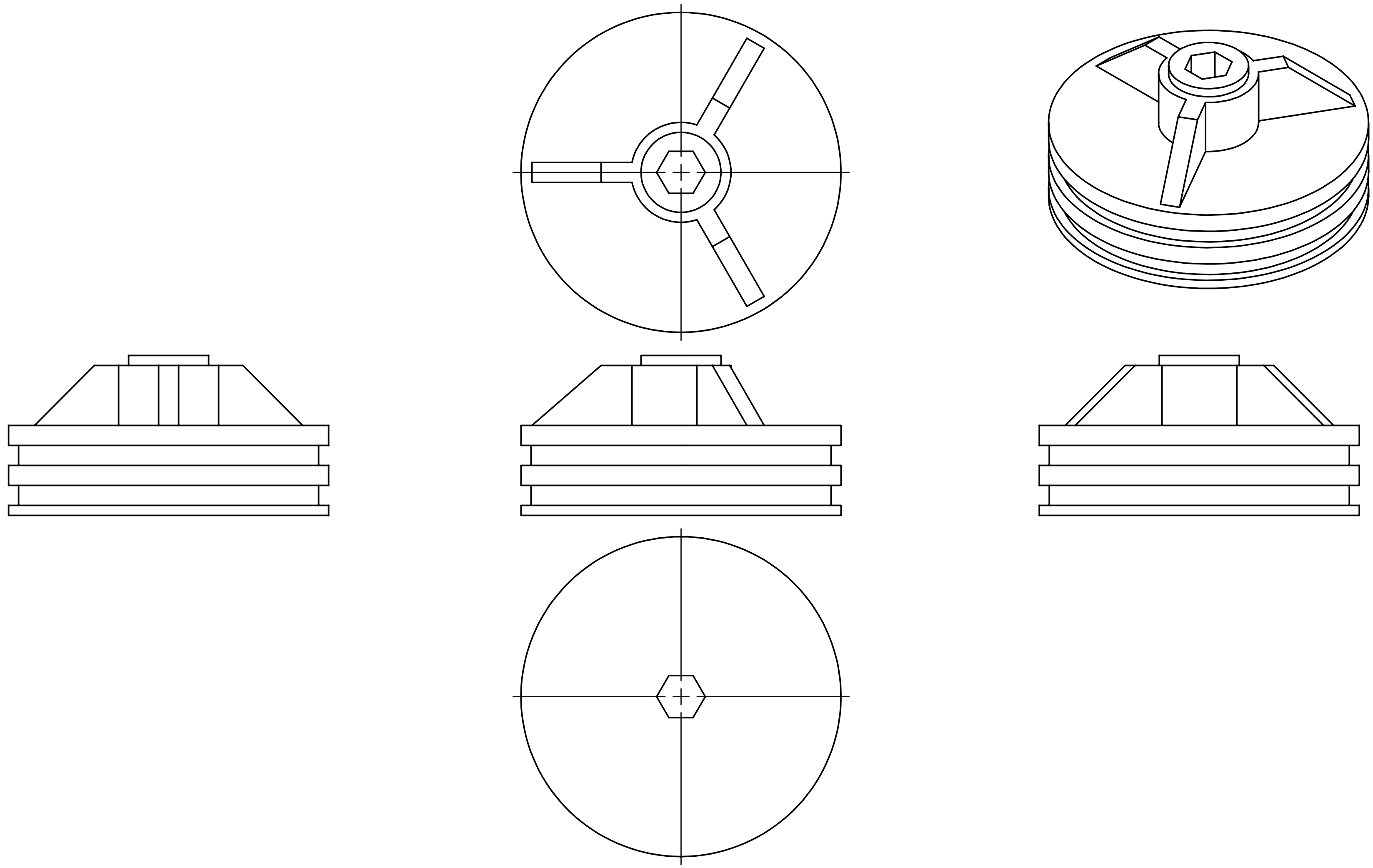


As we began to integrate the climber and intake, we made adjustments to the wheels to optimize the intake. We made the pulleys for the polycord and the rope climber pieces one solid part and we 3D printed them.
We soon realized that this was not going to be sturdy enough as someone dropped and our twenty hour print was broken into two. We decided to make it into two modular pieces to make them sturdier.

Final Rope Manipulator Pieces:(2/10/17)



We printed 12 of these wheels so we had three pairs on the top and on the bottom. Each wheel took about 10 hours to print, and due to some warping on the build plate, some did not work. To compensate we tried to file them down, but reprints were necessary in the end.



SOLIDWORKS Educational Product. For Instructional Use Only

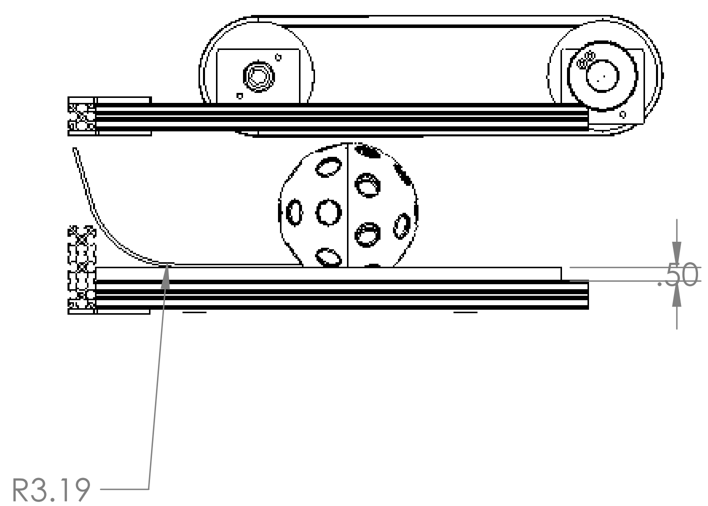
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	2/10/17
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL PLA	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

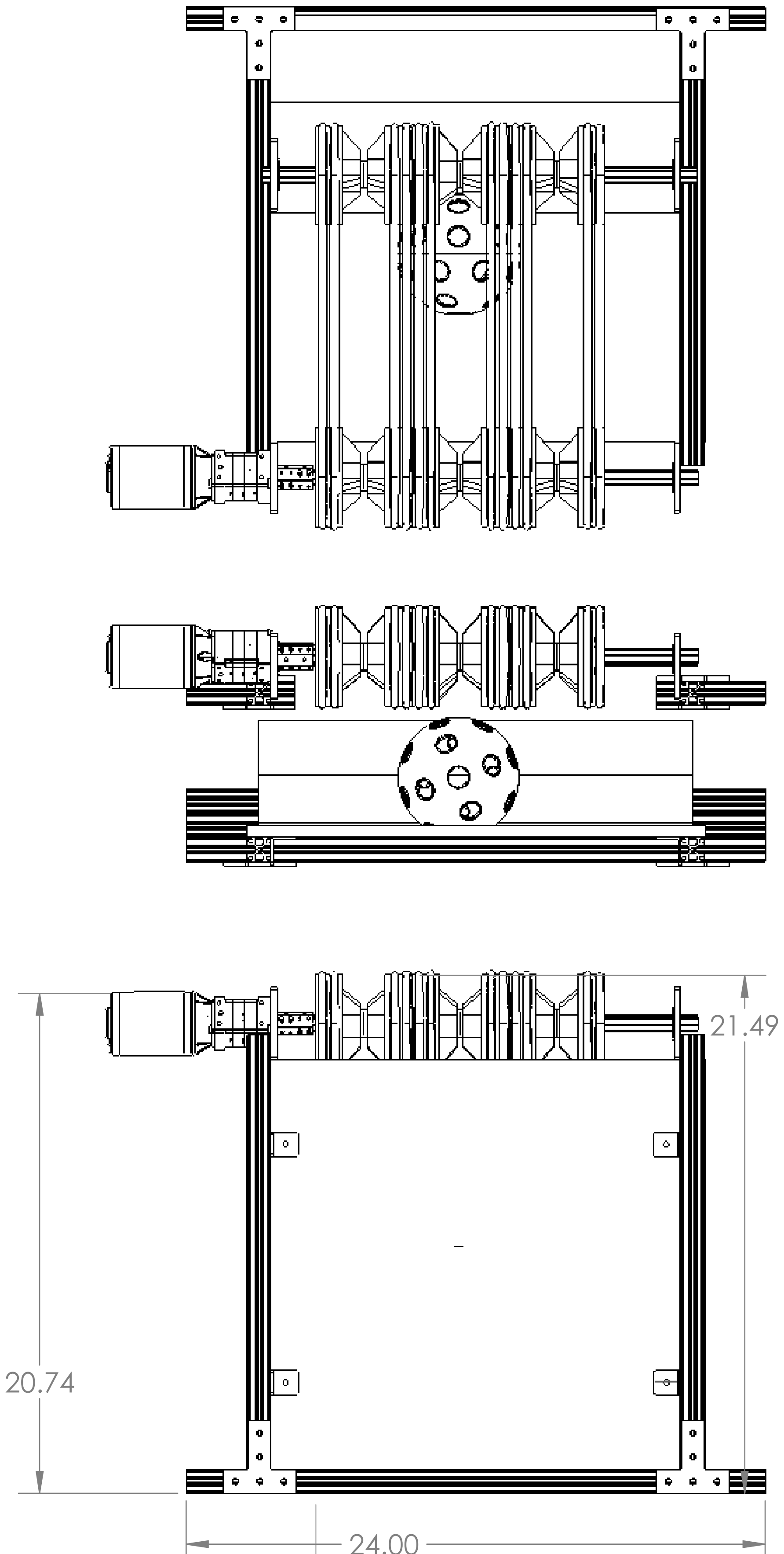
TITLE:

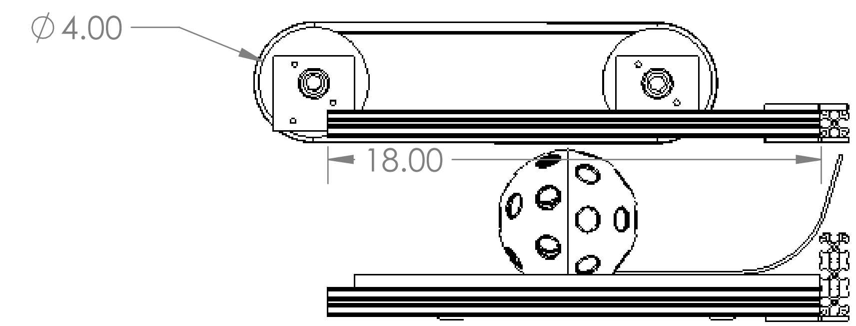
Rope Climber Modular Part

SIZE	DWG. NO.	REV
A	1.0	3

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1







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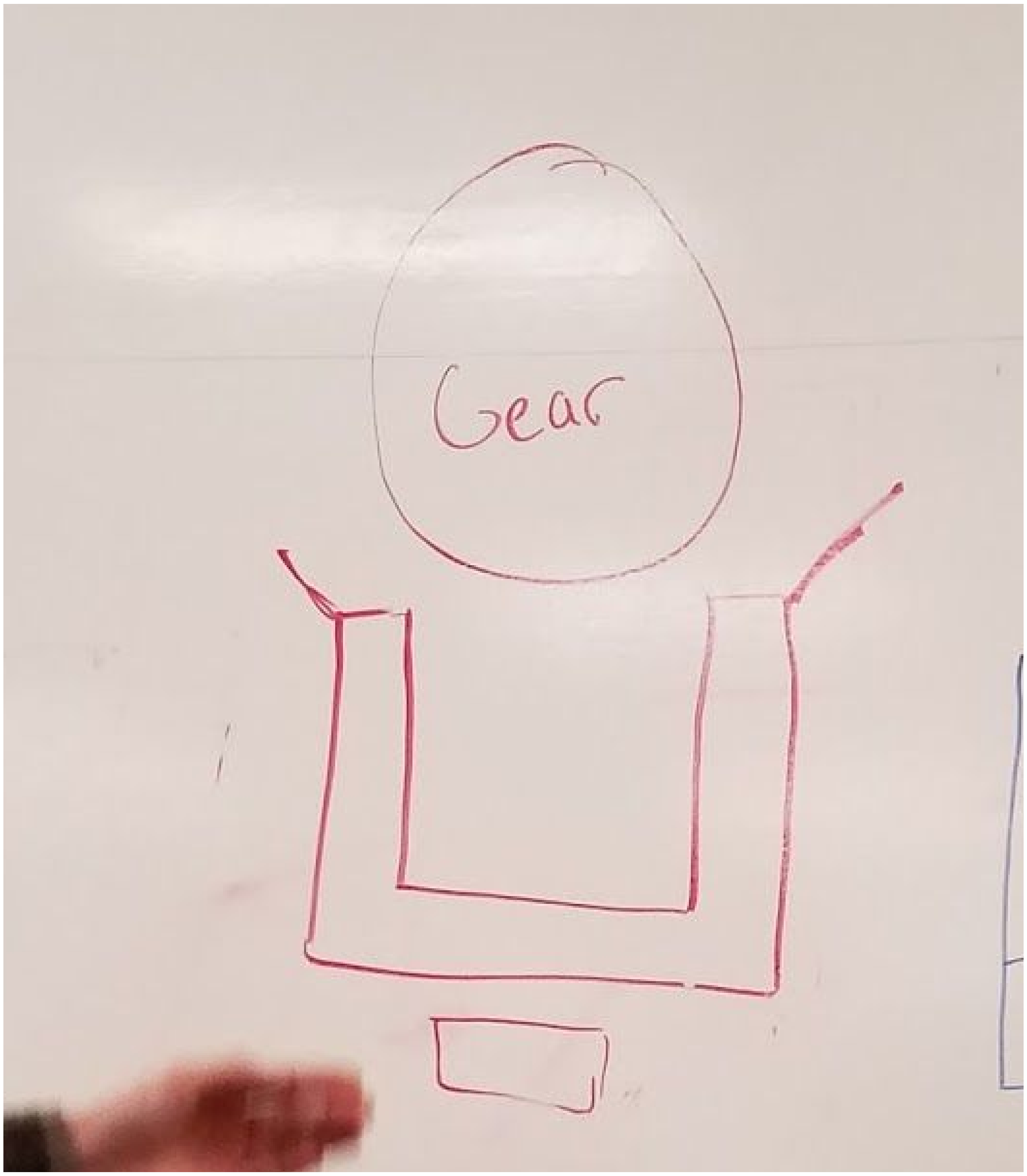
UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	2/18/17	
	CHECKED			TITLE:
	ENG APPR.			Intake
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL	COMMENTS:			SIZE B · DWG. NO. · REV 2
FINISH	Partially dimensioned			
DO NOT SCALE DRAWING				SCALE: 1:7 · WEIGHT: · SHEET 1 OF 1

APPLICATION

Group 1:

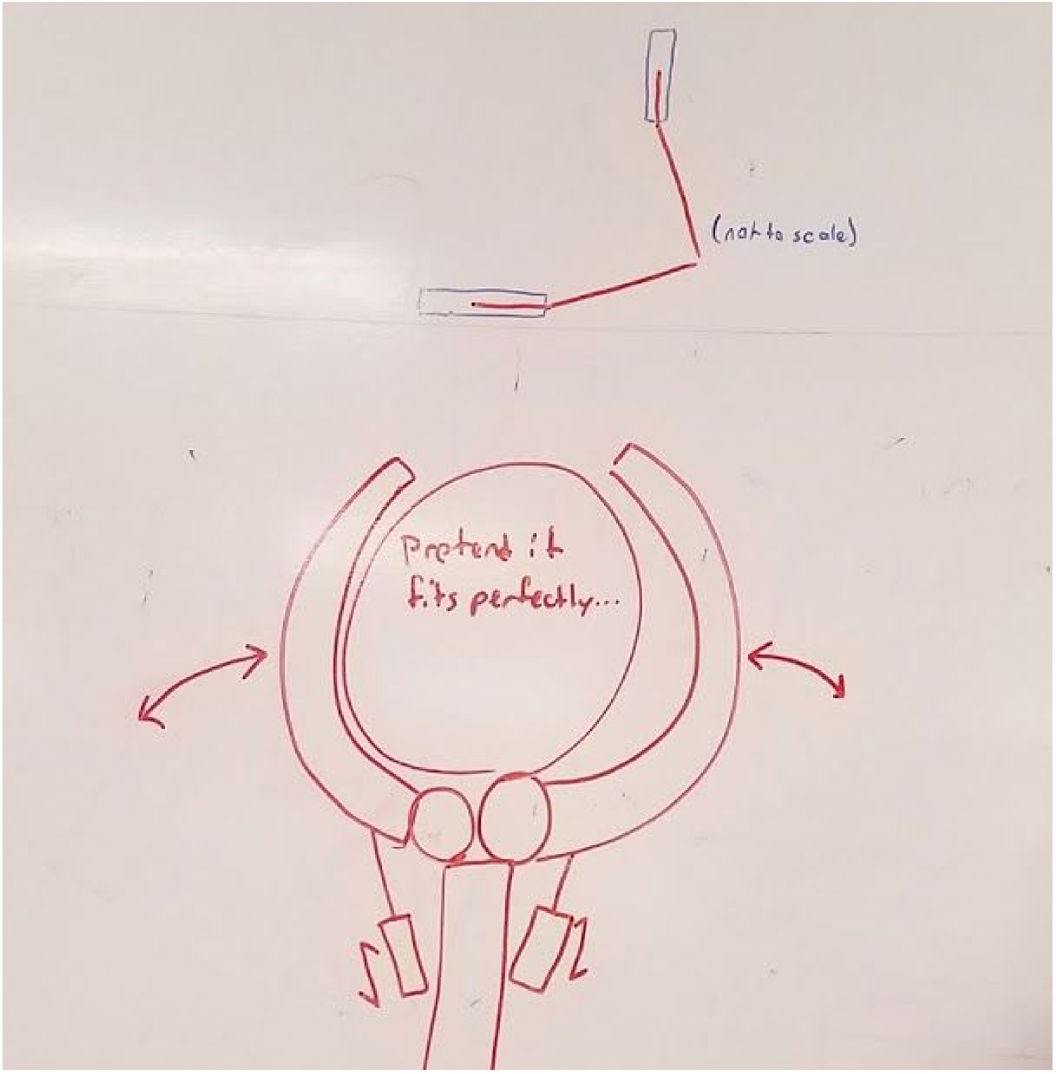
Design 1:



Explanation: completely passive, picks up gear from hopper, can't pick up gear off the ground alone. Possible claw to pick gears off ground (if time). The peg will lift it right out.
Comments: human player would need to pull the gear away right away, so the robot can do other things.

Possible prototype materials: wood or lexan

Design 2:

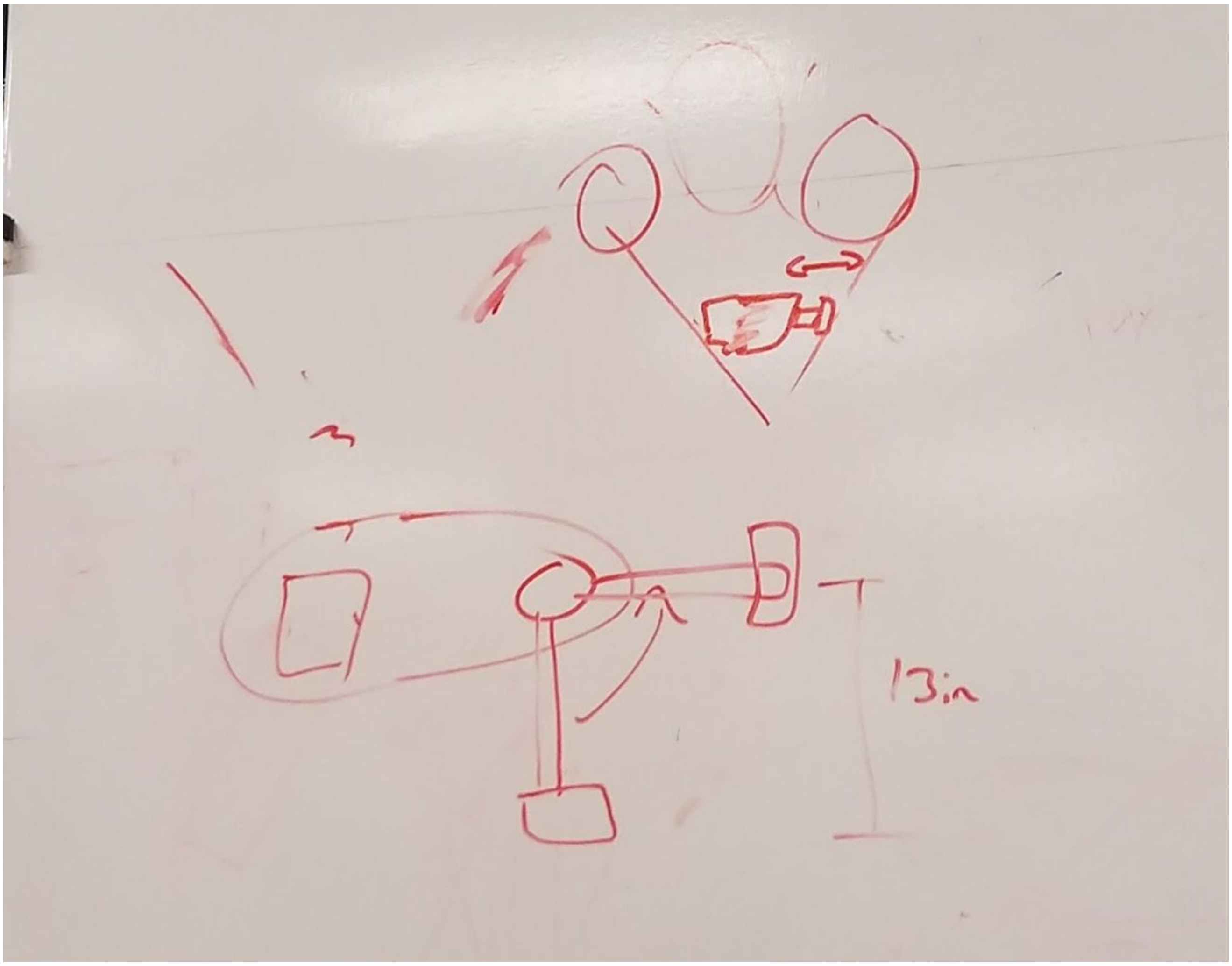


Explanation: A claw that actively grabs and places the gear on the hook. Adjusts orientation with a motor. Opens the gripper pneumatically. Would need at about 18 inches.

Possible prototype materials: rubber bands (to simulate pneumatics), wood, lexan

Group 2:

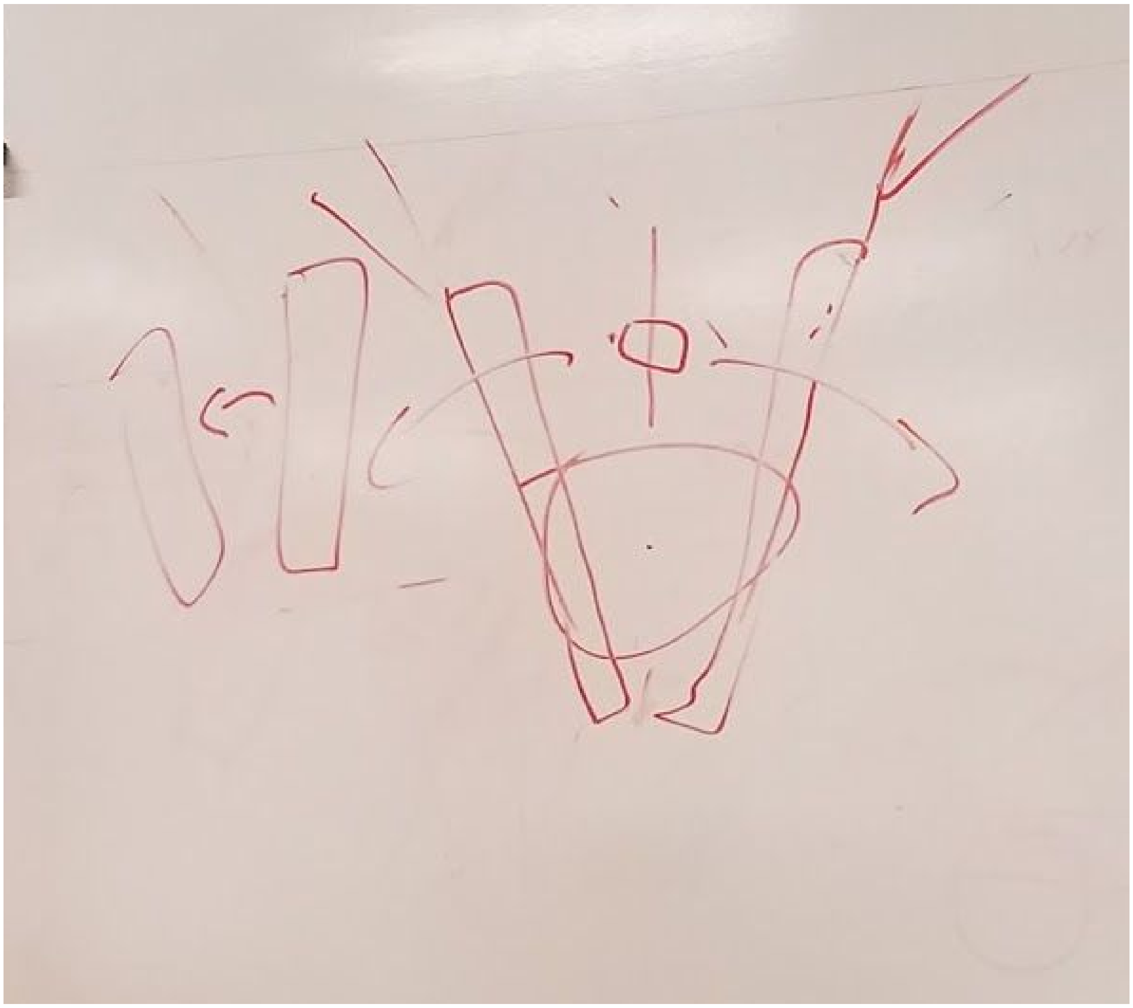
Design 3:



Explanation: Rollers on each side of an arm that would suck up a gear inwards. Open and close the claw pneumatically. Hinge would would swing arm side to side. The piston would separate the arms so it would drop on the peg.

Prototype materials: wood, 8020, motors, elastic bands

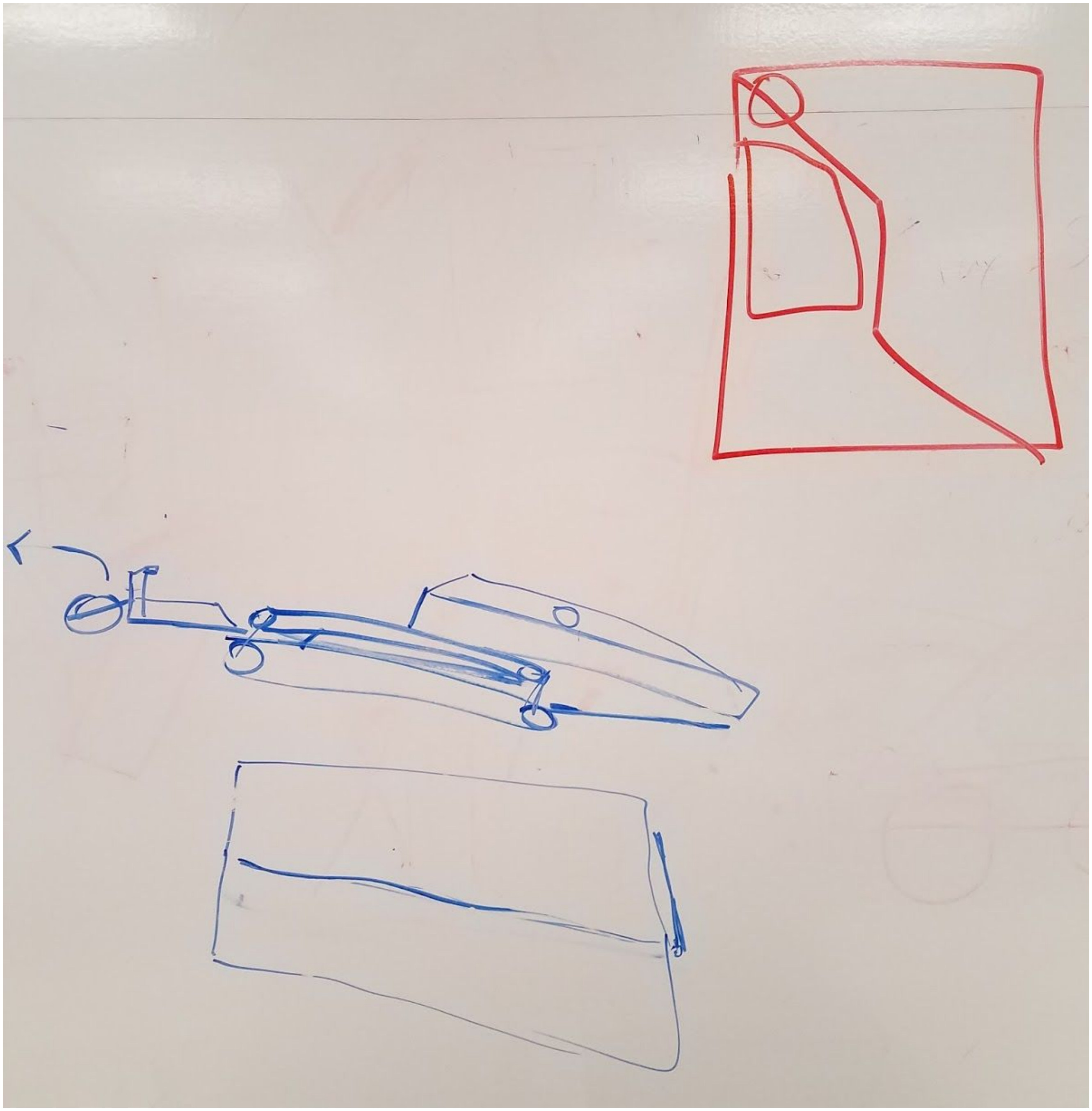
Design 4:



Explanation: Piston in the center to separate two brackets after it was retrieved from hopper. Some sort of hinge to make it rotate or adjust angle.
Prototype materials: 8020, or wood, rubber bands

Group 3

Design 5:



Explanation: The gear would always be on the ground. A conveyor belt would be in the robot, robot driving over gear. Gear would be caught in conveyor belts to claw. Claw flips gear to vertical with a motor, and places gear. Could also work for ball collection. Conveyor and claw are on opposite sides of the robot for each. One iteration is for gears, one for balls

Prototype materials: Elastic bands, surgical tubing, pvc, motor

Criteria for Evaluating Designs:

- Can it do ground pick up or hopper pick up? Or both? #4
- Reliable? #2
- Can it pick up and deposit a gear? (meets the requirements) #1
- Amount of material
- Ease of build #3
- Cost? #5
- Weight? (heavy, medium, light) #5
- Space (out of permitted volume/ out of dimensions) #3
- Resources (specific things) #3

Number refers to rank in importance*

Design vs. Criteria Comments

Criteria	Design 1	Design 2	Design 3	Design 4	Design 5
Hopper or ground	Hopper	Ground	Ground	Hopper	ground
Reliability	Human player needs to quickly retrieve gear quickly	Many motors, pneumatics, more precision needed for driver	High	Highest	Very High
Meet requirements	Human player needs to quickly retrieve gear	A little slower in comparison	Pretty fast	Very fast, can collect gear more reliably	Medium speed
Amount of material	low	low	medium	medium	high
Ease of Build	Easiest to build	hard	harder	medium	hard
Cost ($)	Very low	high	high	medium	medium
Weight	Medium	high	high	medium	heaviest
Relative Space	Low-Medium	high	high	medium	most
Resources	Low (0 motors, 0 pneumatics)	(2 pistons, 1+ motors)	High (3 motors, 1 piston)	Low-medium (1 pneumatics and 1 motor or 2 pneumatics)	Medium- high 2-3 motors

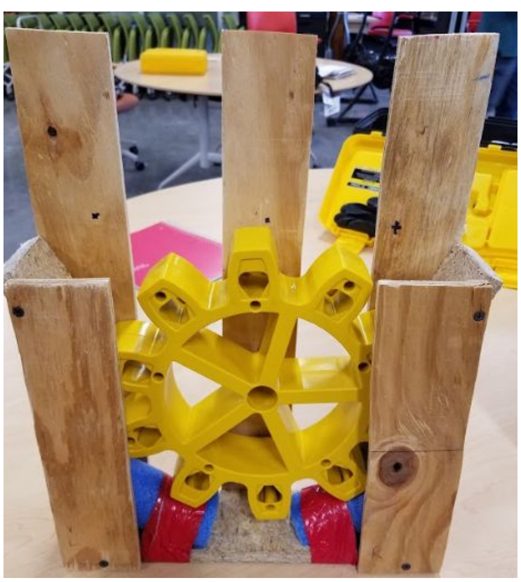
January 15, 2017

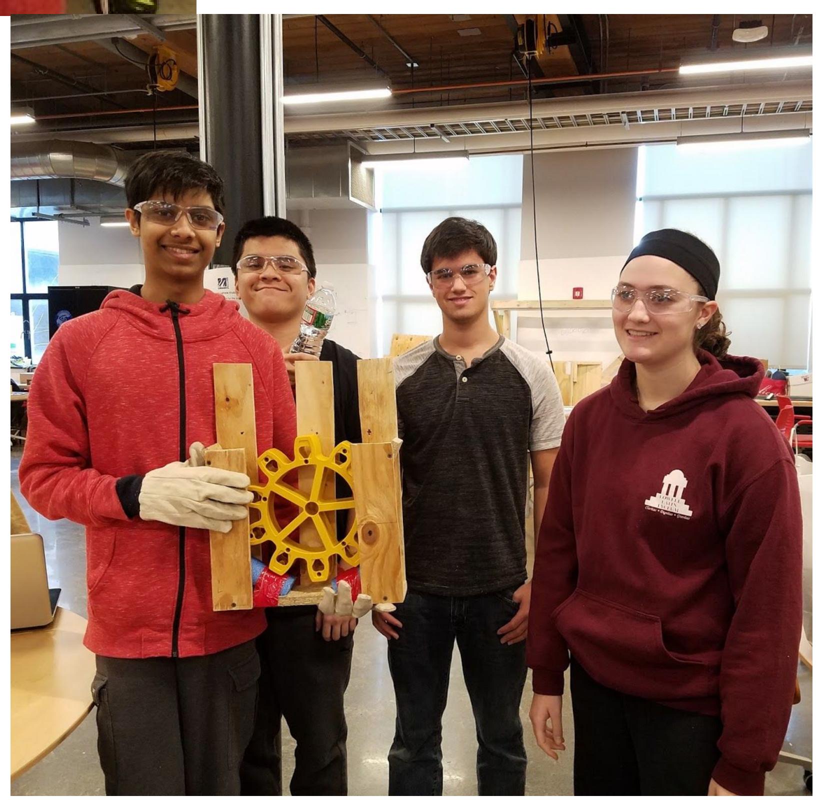
Members working:
Amanda Satterfield
Anh Bui
Nick Reinhold
Yash Patel

Mentor:
Jamie Nicolas

Prototype 1: (Box)

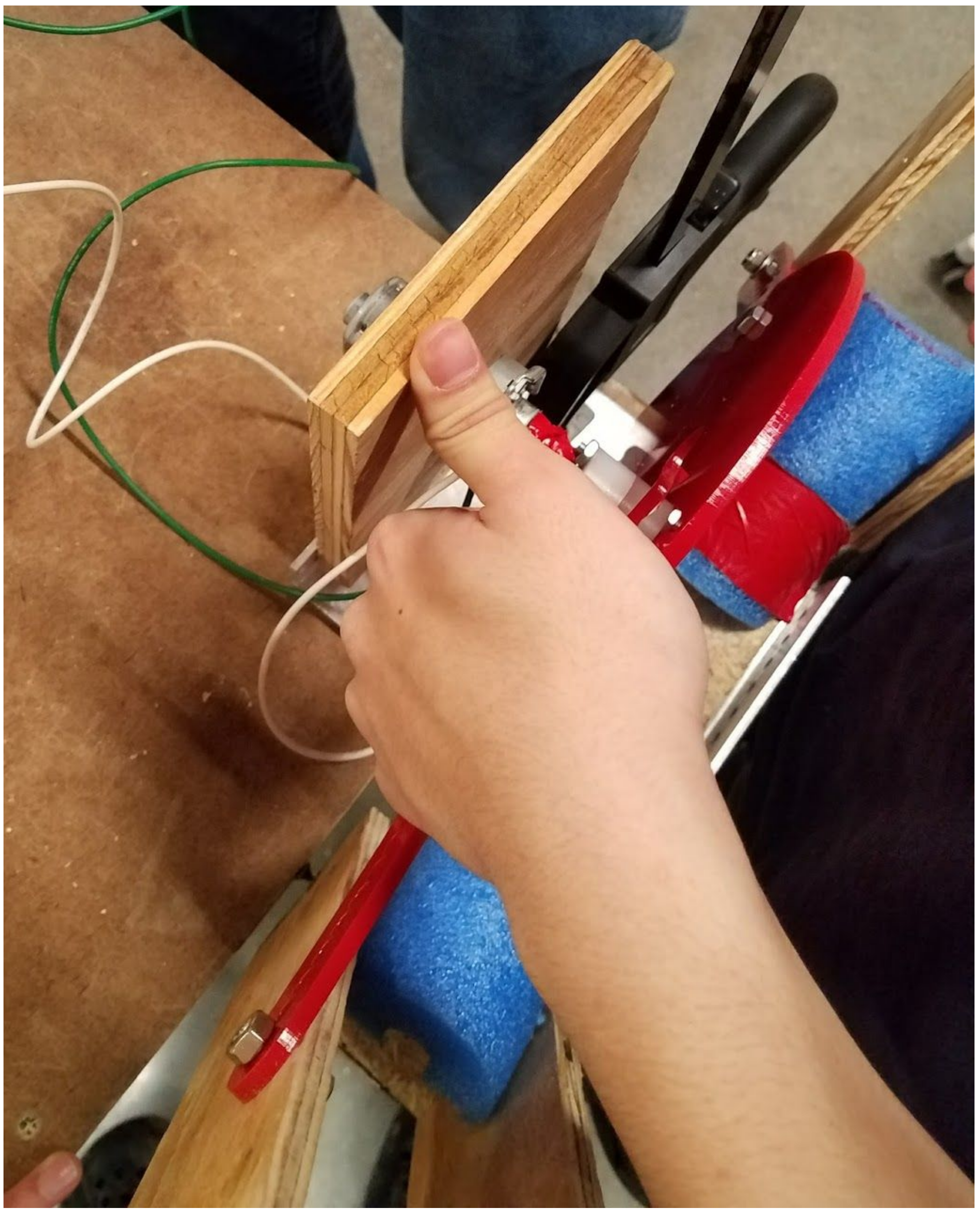
- The backdrop was made into three pillars so there is less material to use for making it
- The Brackets were added so the gear isn't moving around side to side too much
- The pool noodles were added on the brackets so the gear isn't crashing into the box and won't break.
- The supports keeping the front and back together were tilted to make sure the gear will fall into place and not out
    - Areas of Improvement:
    - Making a more funnel shape
    - Using Lexan for front parts and base
    - The supports that will extend into a funnel will be made out of lexan on an angled bracket
    - The back will be 80/20 so it stays sturdy and doesn't need more support



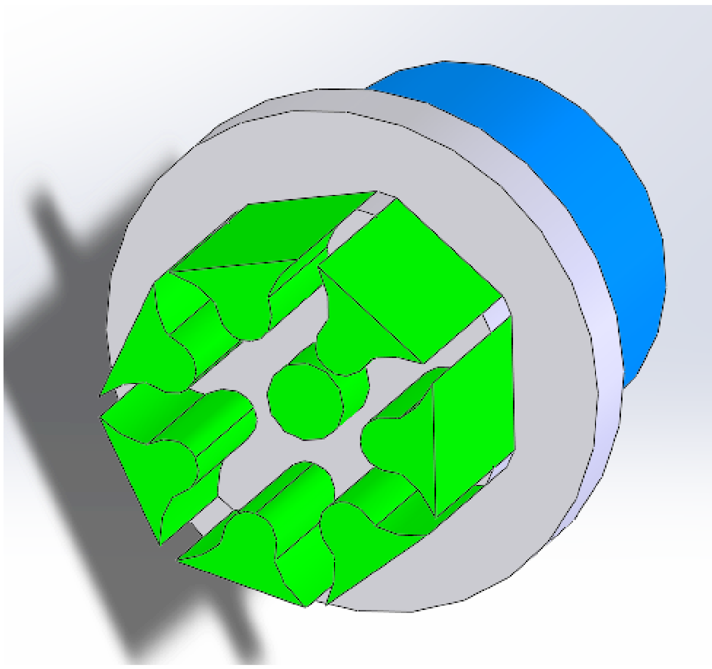


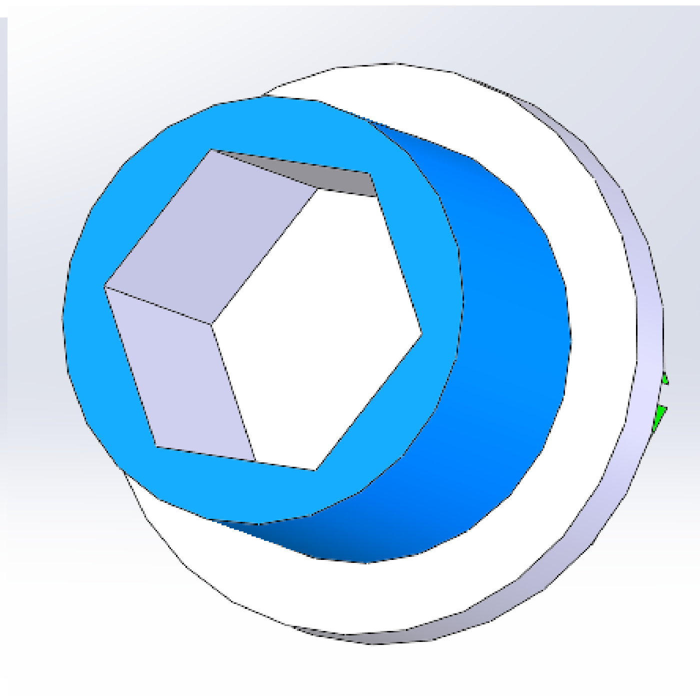
Design 2:

- Uses wheel with two arms that are collinear when the gear holder is open and when turned are pulled inwards to shut the gear holder. The first iteration used a pg71 motor for ease of build.
- Wheel can be turned into a straight bar. Instead of wood, the box can be built out of lexan.
- For ease of build and adjustability we prototyped the arms by drilling a line of holes down the “arms” and adjusting our bolt position.

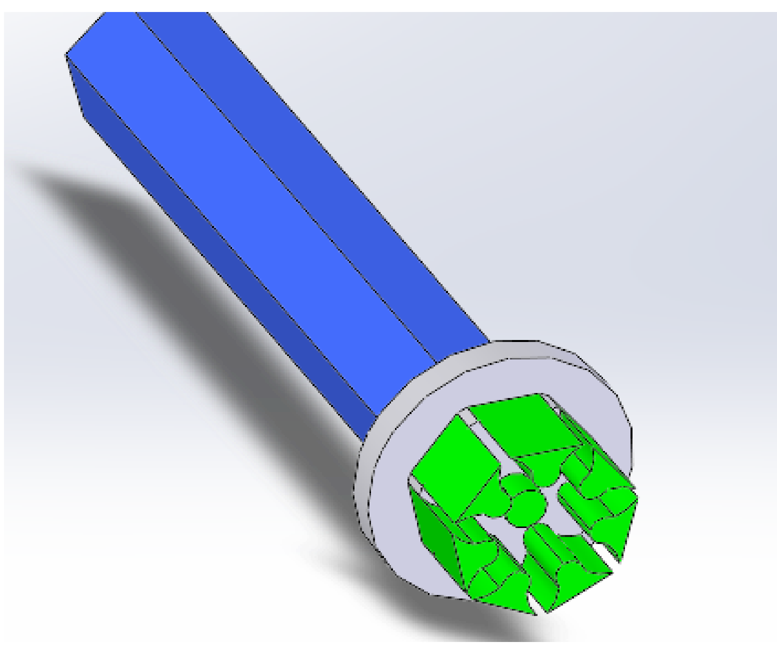


Motor Choice:
1/26/16 Denso Snow Blower Motor:
This motor is flatter, and has the rpm and torque necessary. The only problem was the seven point star gear shaft, which we have to convert to hex shaft to drive our wheel. To fix this challenge we designed several parts to be 3D printed and go over the motor. The first being a hex converter, the second being a hex shaft attached to the converter. It was difficult to get the tolerancing right to fit the gear exactly.





Hex inverter: (1/26/17)
Hex Shaft Attachment: (1/26/17)



Prototype with motor fully assembled and open. Uses PG71 motor and linkage to open and close the box. Limit switches will be added to control openness. (1/27/17)

More adaptations for the snowblower motor
Without a proper CAD file of the motor, it was incredibly difficult to get the adapter to fit by directly building it off a to-scale model of the gear itself. After several failed attempts at scaling it to fit, the model was restarted and built from a circle with several rectangles built off. After several close fits and tolerancing, we build up to a heftier adapter. We also needed to make a custom plate to fit the motor. The prototype was designed in cad and laser cut in acrylic. The final version will be made out of a stronger material. It took several attempts to get the fit right on the motor, so for the sake of time the rough copy was filed down and used, and a new one was fixed in CAD for the future.
Final adapter for snow blower motor: (1/29/17)

After being printed and fitted onto the motor: (1/29/17)

Plate for Snow Blower Motor SolidWorks (post revisions) (1/29/17)

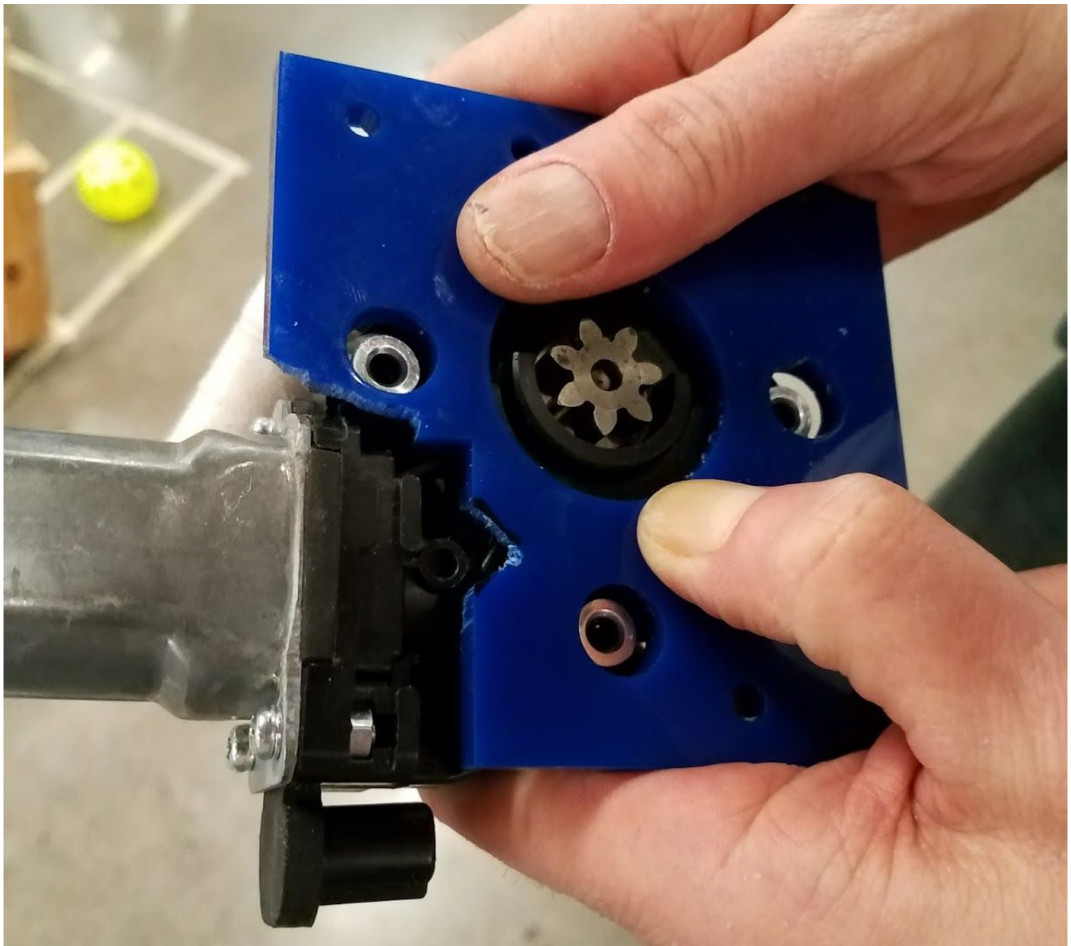
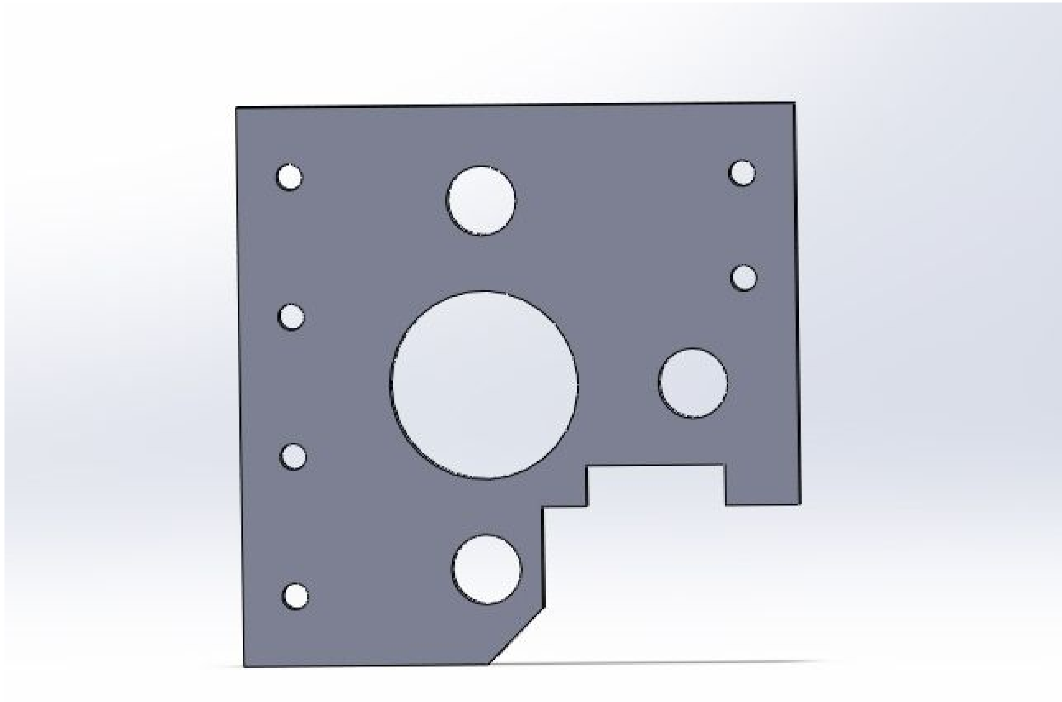


Plate in Acrylic (first draft) on the motor:

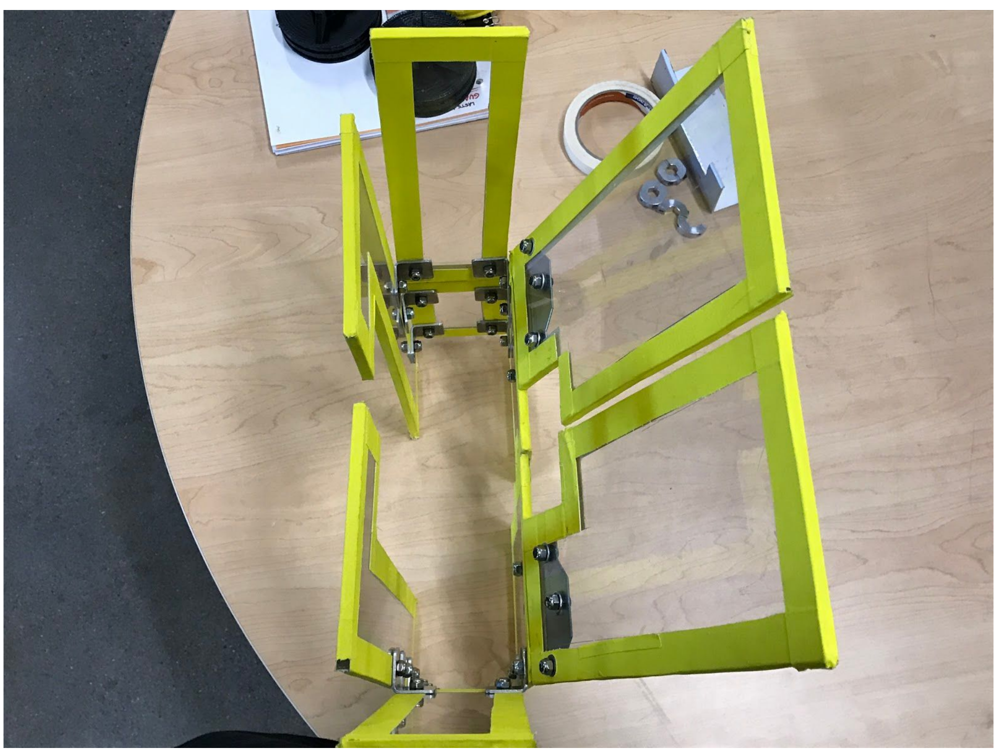


- Driver must not drive full speed when approaching peg
- Rotators must be lowered by 3 inches
- 3 inches from surface of robot to center of motor

Decision for pneumatics vs. motor gear manipulator

Functions	**Weight**	**Motor**	**Pneumatic**
Open and Close	10	8/10	10/10
Holds onto Gear (even during impact)	10	10/10	10/10
Able to catch gear	9	8/9	9/9
Doesn't interfere w/ other functions	8	6/8	6/8
Easy to assemble and disassemble	6	5/6	4/6
Build can be done in 10 minutes	7	6/7	6/7
number of parts	4	2/4	3/4
Weight of the system	5	4/5	3/5
	Totals:	**64.5/80**	**66.6/80**


TRASH
60
The Best Value in Fundraising

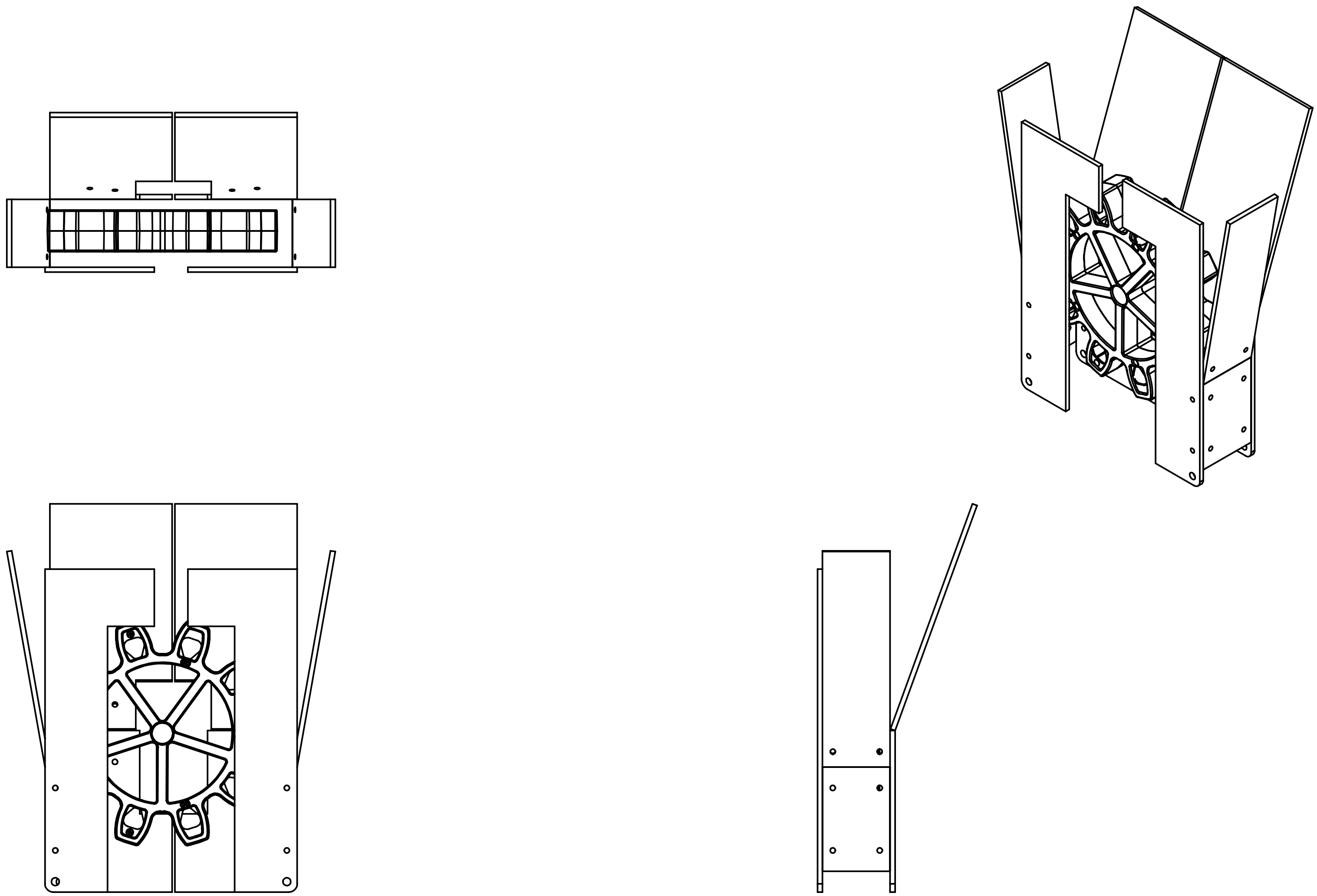


Gear Manipulator v2

Our first gear manipulator had issues collecting gears from the loading station. Gears would frequently bounce from the top portion of the gear manipulator onto the floor.

After extensive testing, it was concluded that a ramped top would effectively solve the issue.

A second gear manipulator was designed and built with a ramp of 70 degrees from the horizontal.



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	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

TITLE:

Gear Manipulator

SIZE	DWG. NO.	REV
A	1	

SCALE: 1:10 WEIGHT: SHEET 1 OF 1

Team decision (of people present)

- Standard (6 wheel drive)
- Wheel types (tbd)
    - Performa (colson wheels)
    - Plaction (tread wheels)

<table>
<tr>
<td>
Performa</td>
<td>Performa

Colson
Easy rolling and turning – for ergonomic advantage
Quiet rolling, impact resistant, and very floor protective
Absorbs shock to help protect equipment
Maximum weather-ability and resistance to chemicals, water and steam
USA-Made for fast lead times and the highest quality
Rejects floor debris, such as metal shavings, for long service life
</td>
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<tr>
<td>Plaction
</td>
<td>Plaction

Andy Mark
Blue Nitrite
$30.00/ wheel
Width: 1.00 inch
Width at Hub: 1.54 inches
Bore: 1.124 inch bore, 0.25 inches deep on either side
Bolt Pattern: 12 Holes around a 1.875" diameter circle, every other hole is sunken
Body Material: Black Polycarbonate
Load Capacity: 150 pounds (estimated)
Weight: 0.84 pounds
Tread Capture: 0.9 inch wide (clamps tread)
</td>
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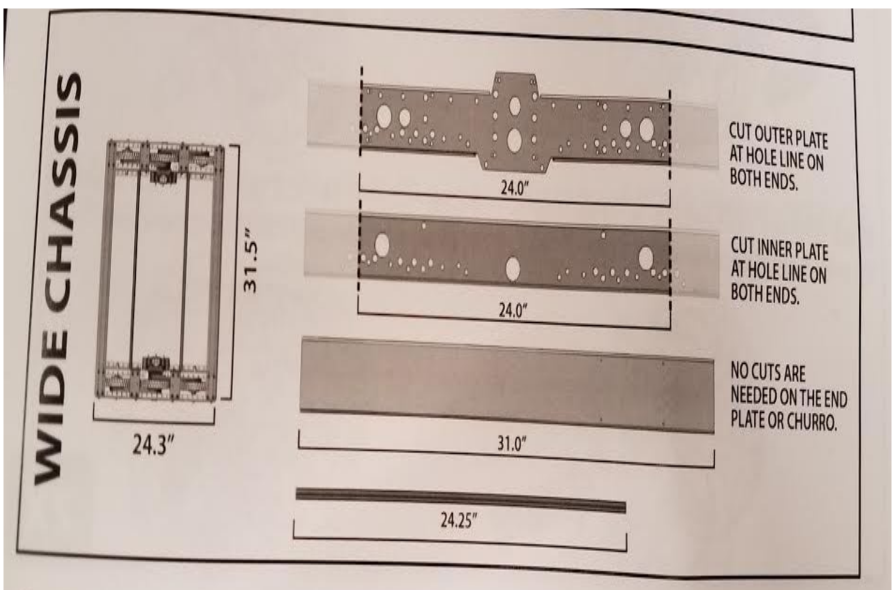
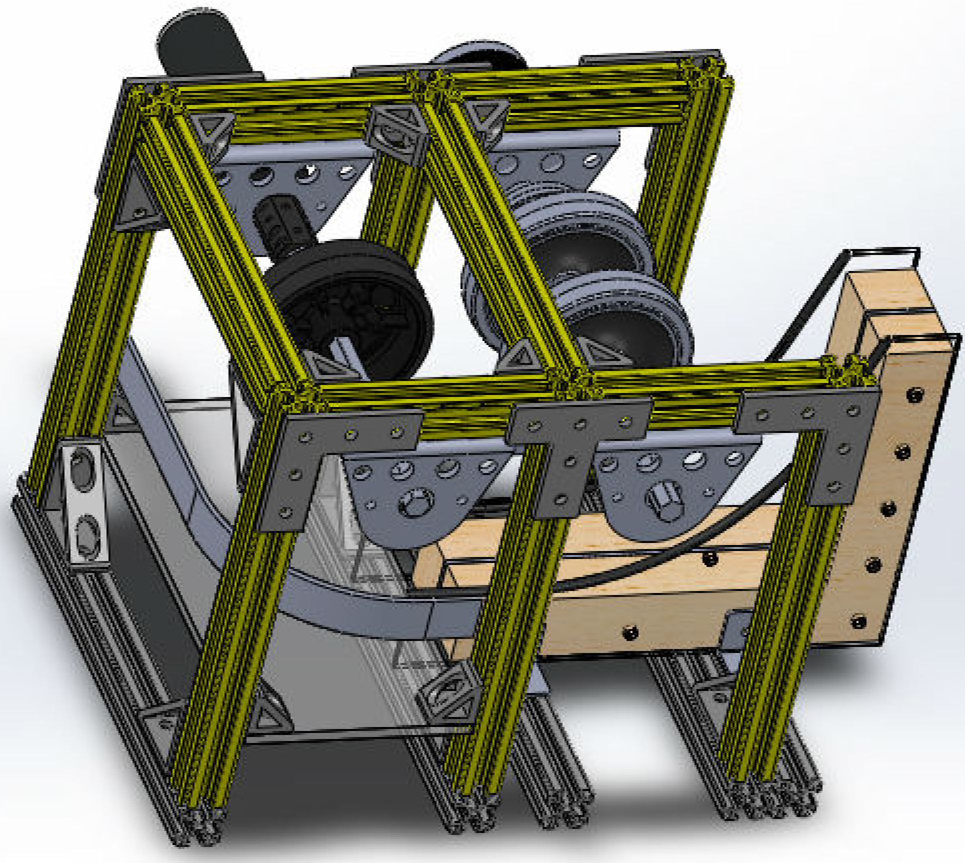
DuraOmni Wheel 	● Andy Mark ● 6” DuraOmni Wheel ● $35.00 ● Width Across Middle: 2.0" ● Bore: 1.125 inch diameter x 0.36" deep with a 0.96" diameter thru hole ● Bolt Pattern: 6 holes (0.197in) on a 1.875 inch bolt circle ● Body Material: Black polycarbonate ● Load Capacity: 120 pounds ● Weight: 0.99 Pounds ● Number of Rollers: 10 ● Allows lateral movement as well as back and forth
6” Standard Mecanum Wheel 	6” Standard Mecanum Wheel ● Andy Mark ● Diameter: 5.95 inch (151mm) ● Width Across Middle: 1.13 inch ● Width at rollers: 1.79 inch ● Bore: 1.125 inch (28.6mm) ● Bolt Pattern: 0.2 inch diameter holes (6) on 1.875 inch bolt circle ● Body Material: Steel, 0.05 inch thick ● Load Capacity: 80 pounds (36kg) ● Forward / Reverse Coefficient of Friction: 0.7 (on tight pile carpet) ● Sideways Coefficient of Friction: 0.6 (on tight pile carpet) ● Weight: 1.3 pounds per wheel (0.59 kg) ● Number of Rollers: 16

Pros and Cons of Performa	
Pros	Cons
● Incredibly grippy ● Cheap ● Simple build ● Very good reviews	● Max size of 4” on Vex Site ●

Pros and Cons of Plaction	
Pros	Cons
• Higher traction on low-pile carpet (coef. 1.19) • Reliable •	• Assembly required • Expensive in comparison to other wheels •

Pros and Cons of Omniwheel	
Pros	Cons
• Free movement laterally, driven forward and back	• Little traction, couldn't be used for defense •

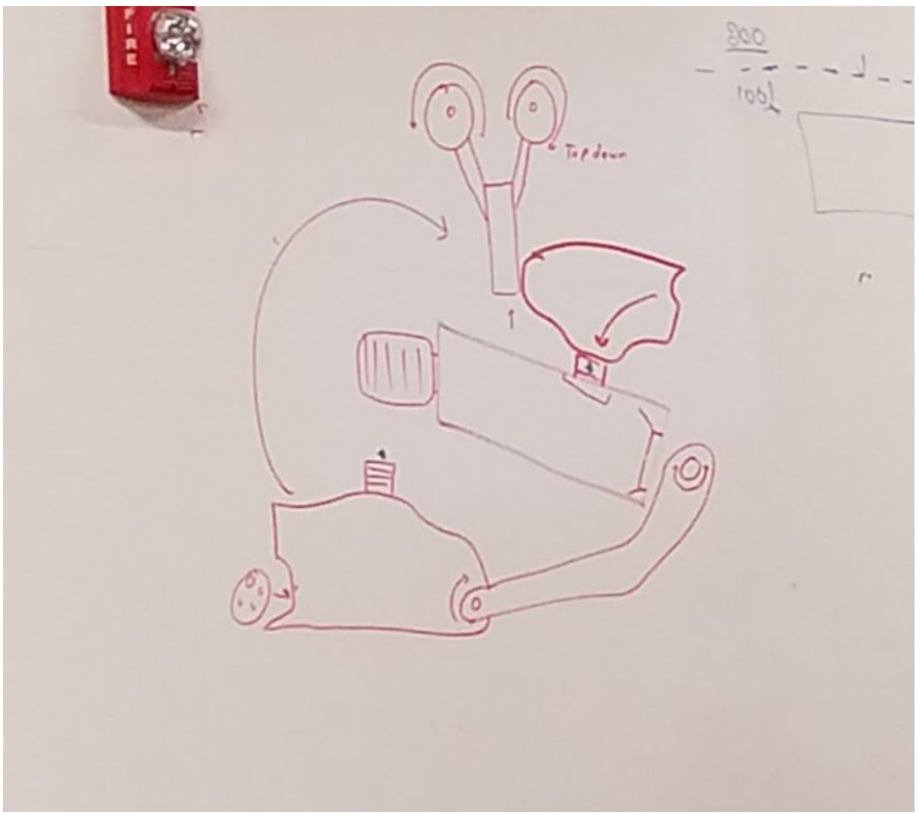
Wide Chassis

If we were to use the base kit, this would be the only orientation we could use it. (Volume A) Bumpers : 3.25 inch, 6.5 inch in each direction. Volume A : 36x40x24, Volume B : 30x32x36 Base Chassis : 30.8x38x24, must add the size of the bumpers to get full size. Custom Chassis : 23.5x25.5x36



Group 1

Shovel idea

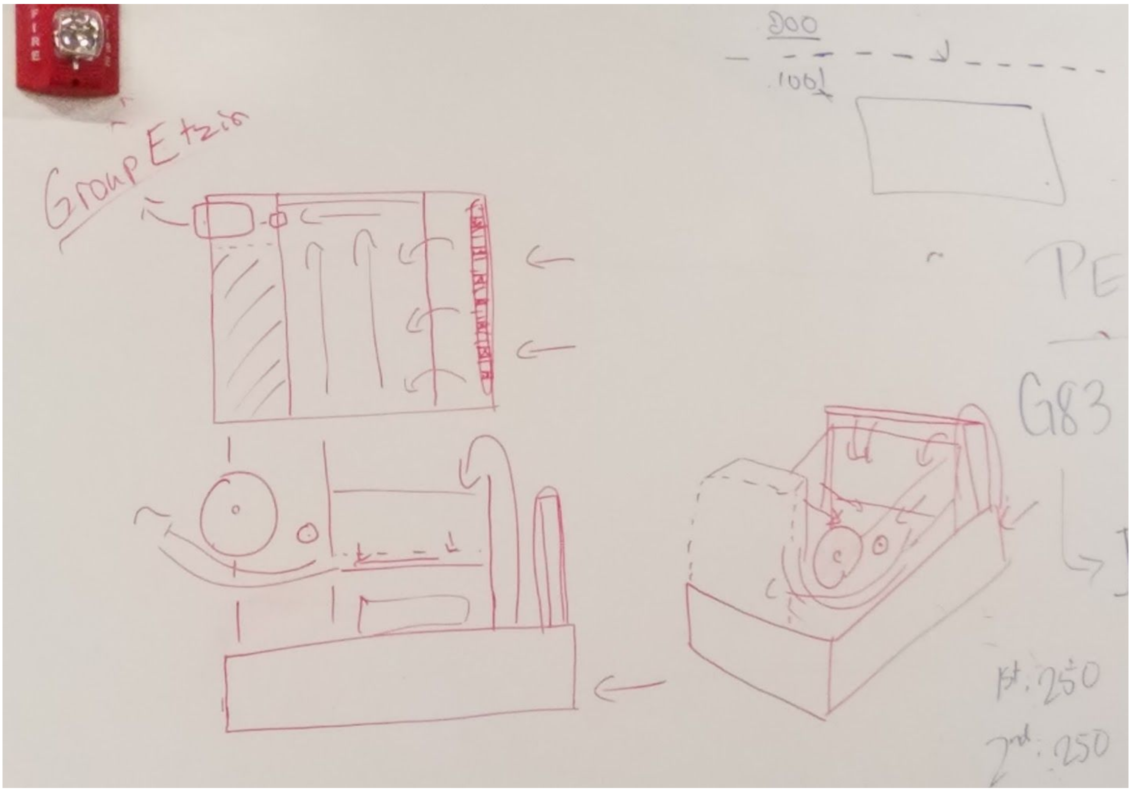
- Shovels balls into pneumatically triggered flywheel shooter
- Extends out of robot, bucket comes up and into robot
  - Directly into shooter
- One shot of pneumatic piston = one shot fired



Group 2

Simple hopper & shooter

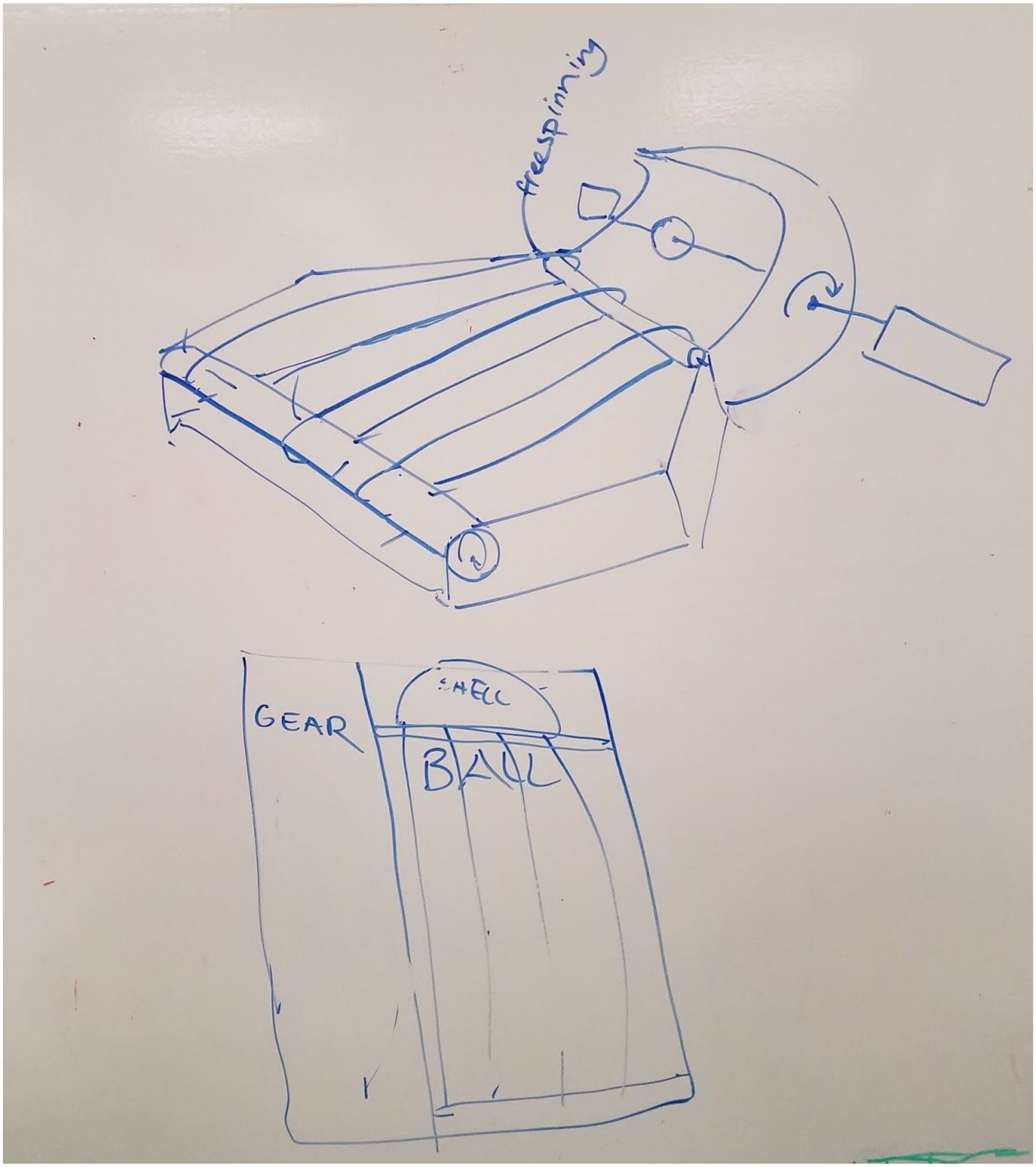
- Front intake and lifter
  - Lifts balls into container
  - Back end of the bot will shoot out.
    - One loader wheel, one flywheel to shoot
- Basically the idea of the Green Horns Ri3D robot



Group 3

Roller

- Roller in front with artifacts
    - Moves belts to back roller
    - Moves balls to a back shooter, with aimable shell
    - Fits as a tray in front, with shooter within frame perimeter?

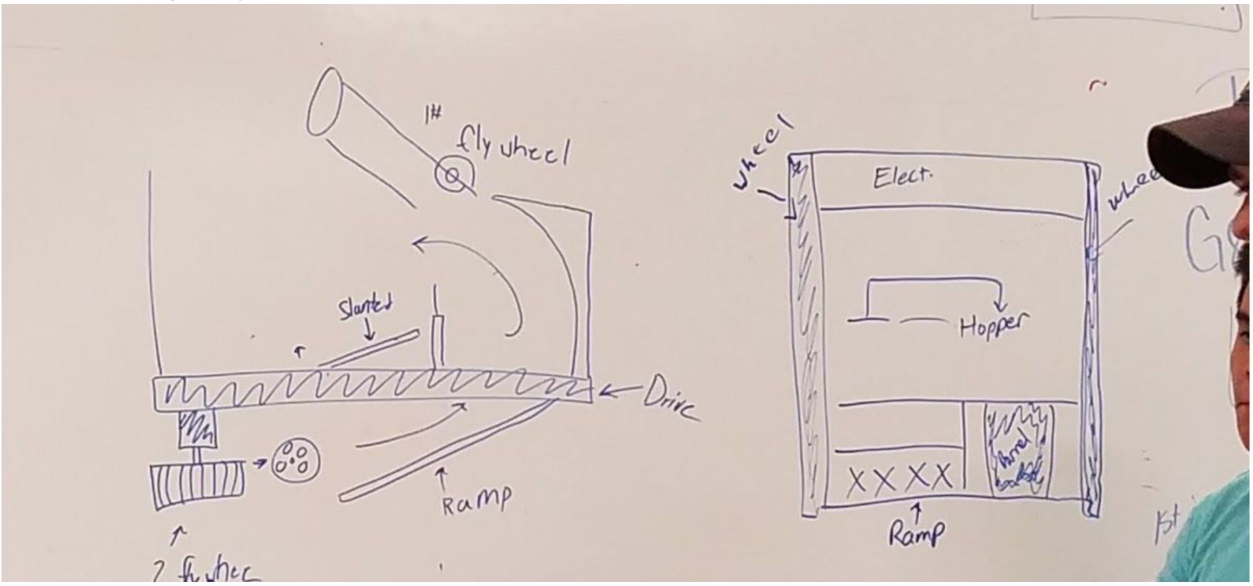


Group 4

Hopper and back shooter

- Ramp comes up from floor into hopper
  - Balls fed into it by two motors

- Balls gravity fed into the shooter mechanism

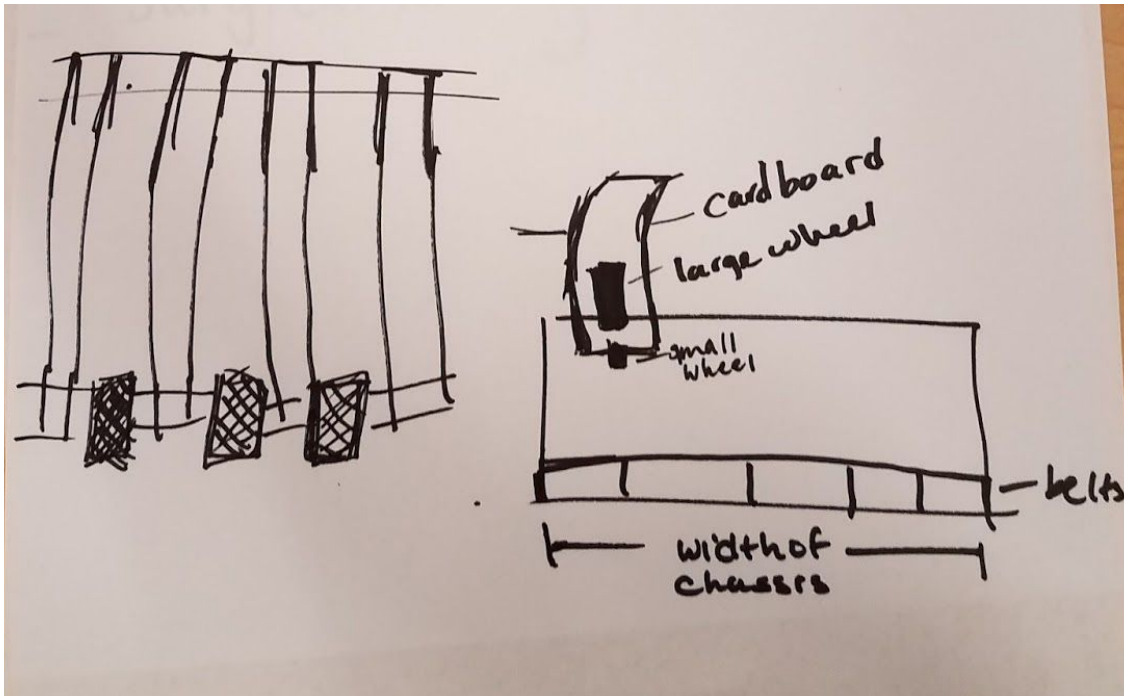


Group 5

- Balls wedged between two rollers and fed into angled bucket
- Bucket would lead to a funnel that would be grabbed by a belt toward a shooter
- Shooter would be adjustable and would shoot one ball at a time

Design vs. Criteria Comments					
Criteria	**Design 1**	**Design 2**	**Design 3**	**Design 4**	**Design 5**
Hopper or ground	ground	both	ground	ground	ground
Accuracy	Can aim (high)	Fixed aim (medium)	Can aim (high)	medium/high	medium/high
Speed	medium/low	high	medium/high	high	medium
Material/ Resources/ Cost	high	low/medium	medium	medium	hgih
Ease of Build/Time	difficult	easy/medium	easy	easy	difficult
Weight	heavy	heavy	medium	medium	medium
Space	Extends out one side of robot	Full robot, front and partial back	medium	medium	Takes up entire bottom; very little height
Capacity (# of balls)	10-15	Depends on space	Depends on space (medium)	Depends on space	Depends on space
Prototype materials	PVC, roller wheels, wood, Lexan	Wood, some motors, belts, PVC (argh)	PVC, surgical tubing, cardboard, wheel	Plywood, some motors	belt, wood, cardboard some motors, polycord or some sort of cord

January 15, 2017

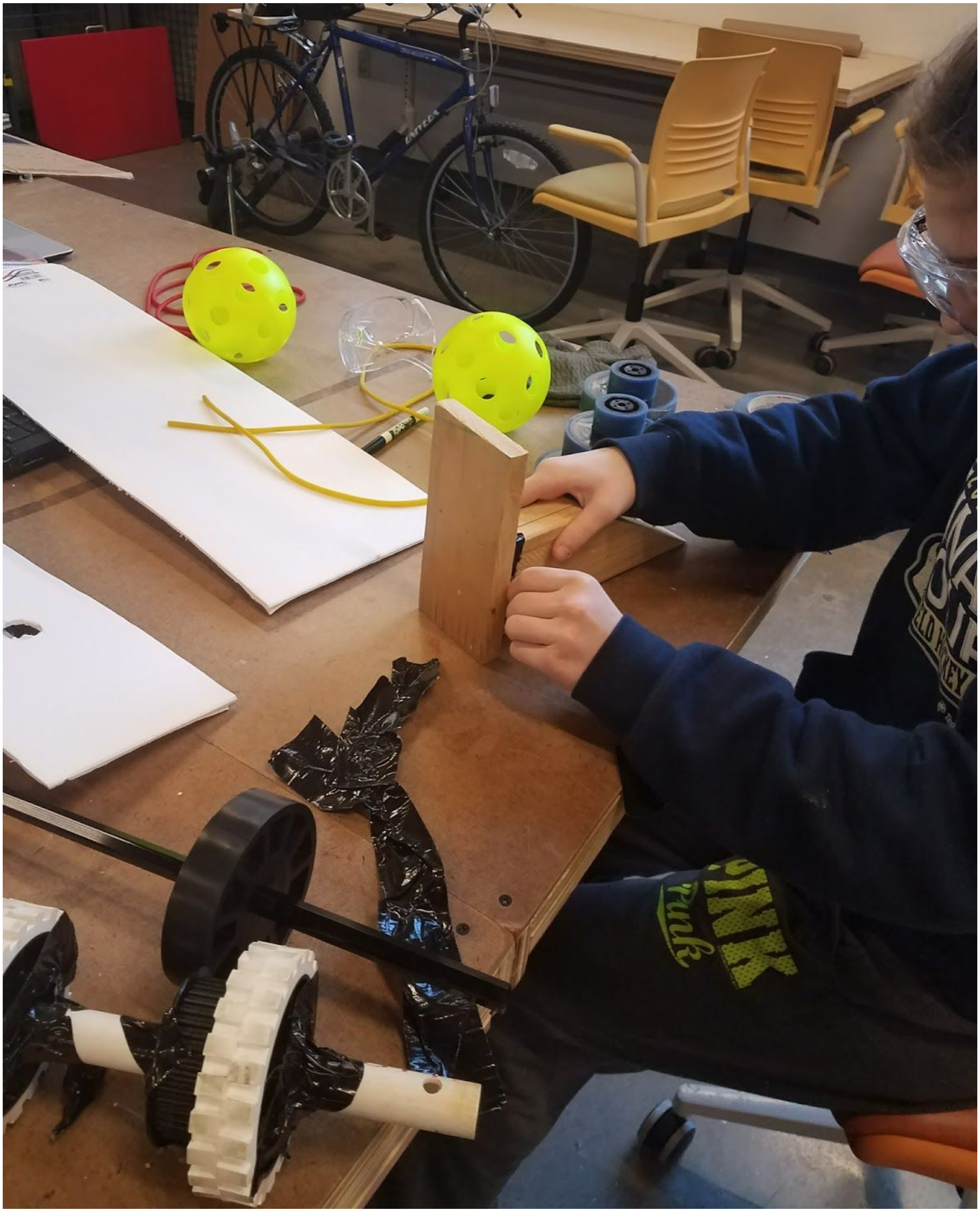


Design 1:
Materials
- Wheel (1)
- Small wheel (1)
- Cardboard
- Surgical tubing
- PVC pipe
- Bearing
- Shaft
- Motor

Design 2:
Materials
- Bearings (2)
- Motor (2)
- PVC pipe
- Zip ties
- Cardboard
- Mini wheel
- Surgical tubing

Prototype 1
- Prototyping to intake two balls at a time maximum
- Wheel spaced just inside diameter of ball (4” apart)
- Bottom intake does intake balls in the intended fashion
- Both directions tested, both work
- Distance between rollers inversely proportional to required height
- Distance between all rollers must be uniform
- Height of shaft = 6 inches above ground
- One foot distance from bottom shaft to top shaft
- Ball relies on impetus force, provided by movement over balls
- Design doesn’t work well without metal
- Surgical tubing does not adequately move balls upward
- Ramp needed to direct balls upward
- Switch to all metal design with pulley belt system

- New wheel radius but height unchanged and still effective.
- Likely due to smaller distance in between wheels (2.875”)
- Back wall/ ramp made of corrugated plastic
- Support brace on front to keep frame square
- Measured give of pulleys in order to determine distance wall should be from pulley



Work on ball intake (1/ 14/17)

Speed of Motor Necessary to Score a Ball from a Given Distance and Angle (without air resistance)

X

Units	Angle Against Horizontal	Distance from Boiler (m)	Height of Shooter off the ground (m)	Height of Boiler (m)	Change in Height (m)	Diameter of Wheel (cm)	Weight of Ball (grams)
Metric	70	1.32	0.432	2.46	2.028	10	

Initial Velocity of Ball (m/s)	Speed of Motor (rpm)	Time Rise	max height (m)
6.756796633	1290.4531	0.6478889731	2.488824595

Speed of Motor Necessary for Given Distance and Angle

Angle (Degrees)	Distance from boiler (m): 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
45	#NUM!	#NUM!	#NUM!	2176	1819	1725	1703	1711	1734
50	#NUM!	#NUM!	2206	1686	1586	1572	1590	1621	1659
55	#NUM!	3271	1620	1484	1472	1497	1536	1581	1630
60	#NUM!	1680	1411	1393	1425	1473	1528	1585	1642
65	2931	1376	1331	1370	1430	1496	1563	1631	1696
70	1457	1282	1328	1405	1488	1571	1652	1730	1806
75	1251	1297	1401	1511	1618	1721	1819	1913	2003
80	1276	1435	1595	1746	1887	2018	2143	2260	2372
85	1582	1871	2126	2354	2562	2755	2935	3105	3267

Trajectory Measurements & Motor Decisions

We developed a spreadsheet to calculate the velocity and motor speed necessary to get the ball in the high goal of the boiler when given an angle, distance from the boiler and distance our shooter is from the ground. Once we found the necessary velocity, we converted that to motor speed with the math shown below. These calculations do not take into account air resistance, so motor speeds would have to be adjusted accordingly, but it helps us get an idea of an ideal fixed angle and which motors to use. With this method, we can control how it shoots with just changes in the speed of the motor, which could be measured using an encoder or another method. We chose a 3:1 gear ratio for a miniCIM motor so we could stay within the rpm necessary to shoot the ball at 70 degrees from a range of 1 to 4.5 meters away and give us the torque necessary to actually move our flywheel. The chart at the bottom of the sheet is a reference for the number of rpm needed at each distance.

$\Delta x =$ *distance from the boiler* $\quad \Delta y =$ *difference in heights of boiler and shooter*
$\theta =$ *angle against horizontal of shooter* $\quad t =$ *time* $\quad v =$ *initial velocity of ball*

Projectile motion (x) $\Delta x = v_x \bullet t$ *and* $v_x = \cos\theta \bullet v \Rightarrow \Delta x = v \bullet \cos\theta \bullet t \Rightarrow t = \frac{\Delta x}{v \bullet \cos\theta}$

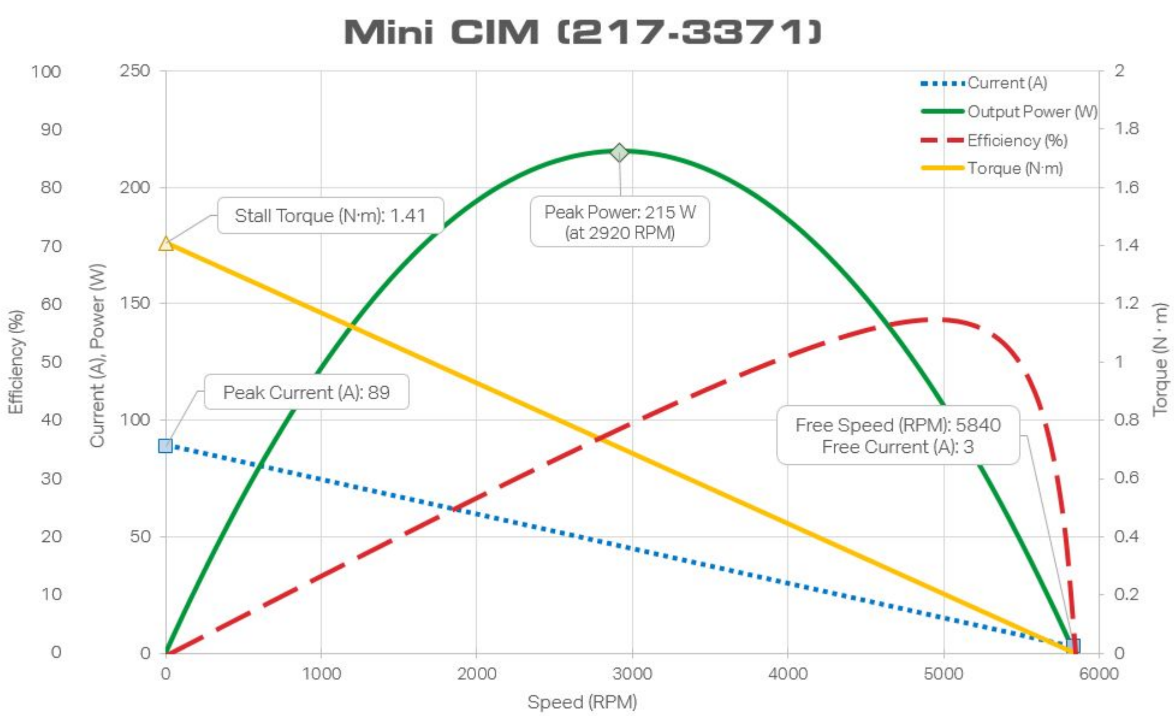
Projectile motion (y) $\Delta y = v_y \bullet t + \frac{1}{2}t^2 \bullet g$ *and* $v_y = \sin\theta \bullet v \Rightarrow \Delta y = v \bullet \sin\theta \bullet t + \frac{1}{2}t^2 \bullet g$

$\Delta y = v \bullet \sin\theta \bullet \frac{\Delta x}{v \bullet \cos\theta} + \frac{1}{2}\left(\frac{\Delta x}{v \bullet \cos\theta}\right)^2 \bullet g \Rightarrow \Delta y = \tan\theta \bullet \Delta x + \frac{1}{2}\left(\frac{\Delta x}{v \bullet \cos\theta}\right)^2 \Rightarrow 2(\Delta y - \tan\theta \bullet \Delta x) = ($

$\Rightarrow \sqrt{\frac{2(\Delta y - \tan\theta \bullet \Delta x)}{g}} = \frac{\Delta x}{v \bullet \cos\theta} \Rightarrow v = \frac{\Delta x}{\sqrt{\frac{2(\Delta y - \tan\theta \bullet \Delta x)}{g}} \bullet \cos\theta}$ (m/s)

To calculate rpm:

$v = f \bullet pi \bullet d \Rightarrow f = \frac{v}{pi \bullet d}$ $(rev/s) \Rightarrow 60 \bullet \frac{v}{pi \bullet d}$ *rev/minute*



Motor Curve of MiniCIM
We used this for understanding our peak speeds and capabilities of our motor.

Criteria For Shooter:

- .8 balls per second or 1.25 second per ball to get to 40 kPa (worst case scenario)

- Ball efficiency shot = 90%
- Be able to shoot from different distances (30 inches - 180 in (launch pad line))
- 1 ball at a time
- Adjustable speed of motor in software
- Fixed angle 70°

Criteria for Intake:

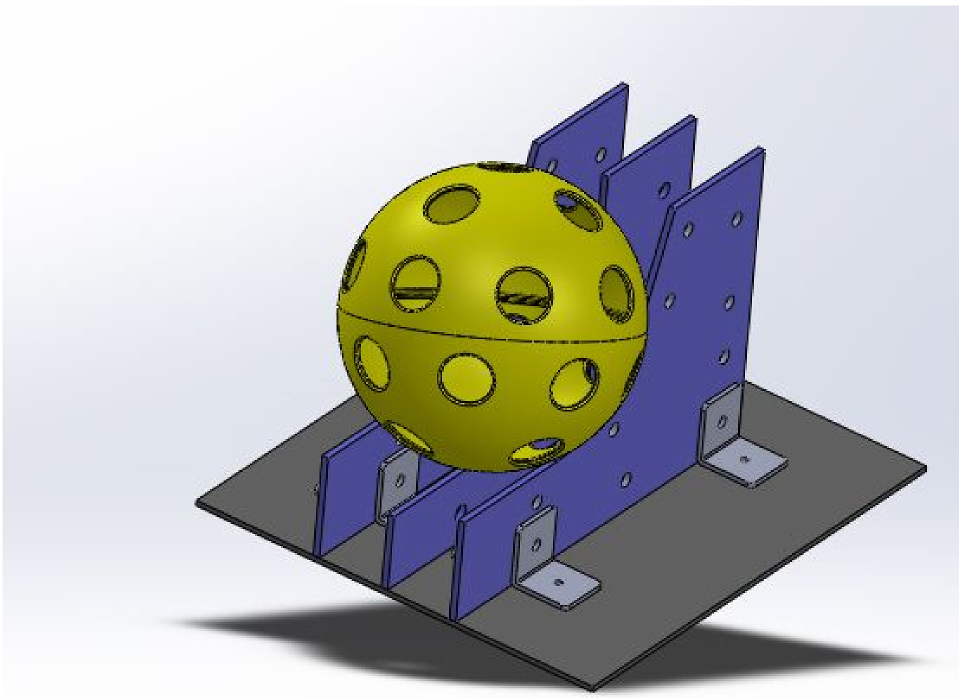
- Needs to be able to pick of at least 5 at once
- Maximum of 30 balls in the hopper (Estimate from robot room)
- 5 balls in per second
- Needs to lift the ball into hopper
- Can be integrated with rope climber

Criteria for Rope Climber:

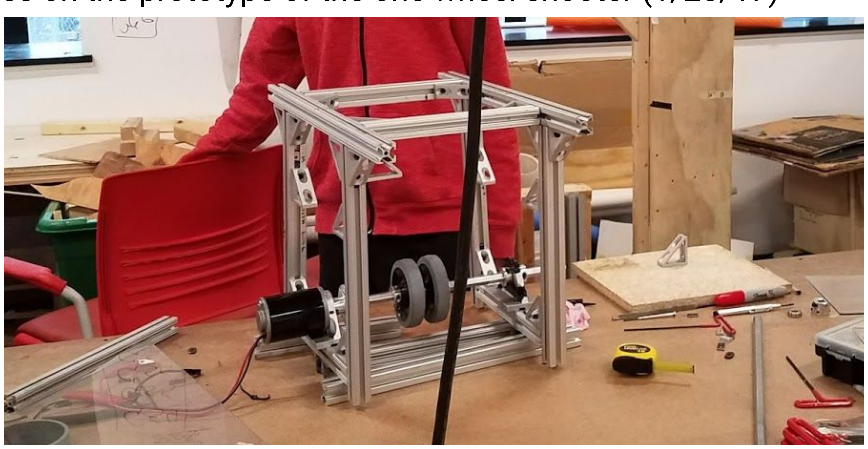
- Must support robot's weight
- Can't get tangled
- Can't fall down
- Can't stop touching touchpad
- Needs to grip rope
- Needs to climb rope in under 30 seconds (max) (ideal under 10sec)
- Needs to grip paracord

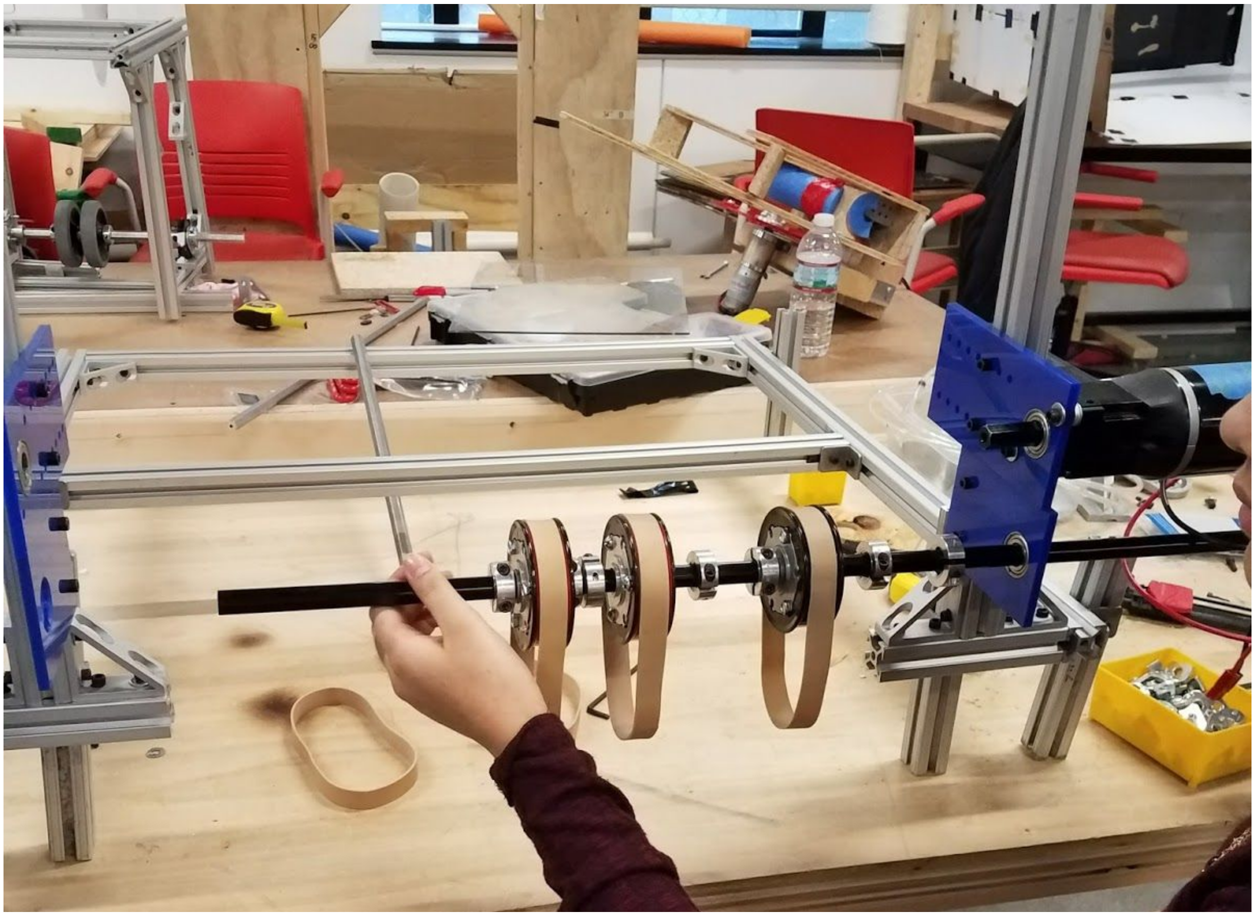
Single Wheel Shooter:
CAD model of ramp, which were laser cut out of acrylic pieces to get a perfect 70 degree angle. They were adjusted to cradle the ball and touch it from 1.25” from the center on each side. The acrylic pieces are ⅛” thick. They are held down with 1 inch l-brackets and wooden spacers between them.Originally, we planned on using three plates to cradle the ball, with two on each side and one in the center that would touch the ball. We changed this idea because it would dent the ball too much when pressure is applied. In the final draft, there is an L bracket between them that serves as a spacer.

Assembly of the shooting ramp



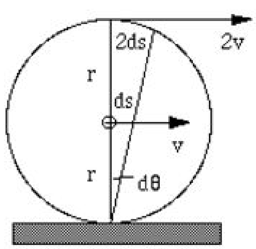
Progress on the prototype of the one wheel shooter (1/28/17)





Progress on the intake (to be integrated with the rope climber) (1/28/17)

Reason prototyping two wheel shooter as well. At a 3:1 gear ratio, it impossible for the minicim to do double the speed necessary to get the ball in the boiler at our range of shooting.

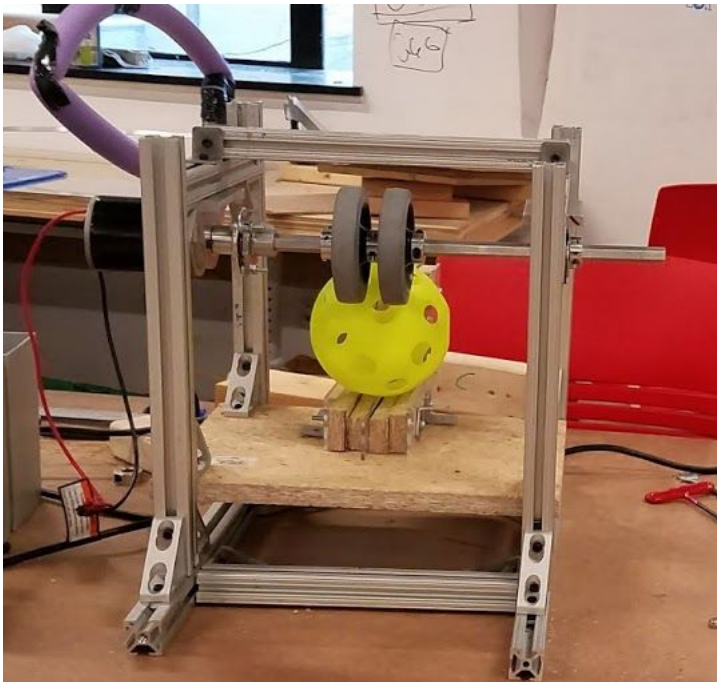


Consider a bicycle wheel, where the bicycle is traveling with the speed V.

The bottom point of the wheel touches the ground and therefore has zero velocity. If you try to figure out what would be the speed of the top point of the wheel you will see that it has to be 2*V.

With launcher we have the same situation. One side of the ball touches the static ramp and is stationary. In order to speed up the ball to V you will need to make the other side of the ball to have velocity 2*V.

However the bigger problem with single flywheel is rolling resistance . You will end up loosing some energy to deform the ball and momentum transfer will be less efficient.



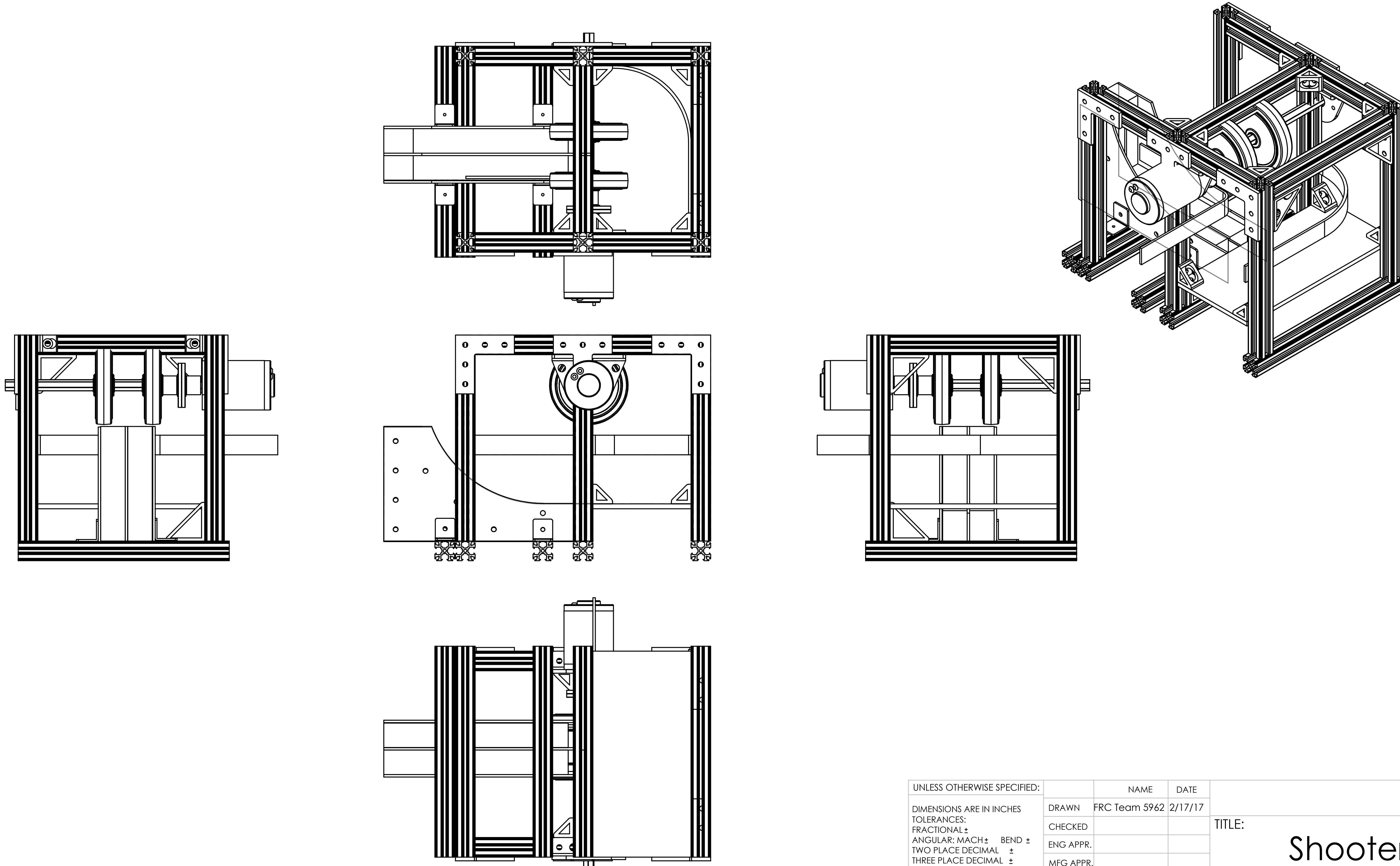
Single wheel shooter with ball on ramp (1/29/17)

Work on assembling acrylic ramps that were designed in CAD for prototyping (1/29/17)

Work on the intake mechanism with polycord(1/29/17)

Test 1	Percent of Motor	Height	Distance away from boiler	Number of balls in
No extra padding				
One layer of tape	67	8 ft.	6 ft.	4/10

Trial two: One layer of tape	70	8 ft.	6 ft.	6/15
Trail three: One layer of tape	68			First ball goes in, second comes up short



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	CHECKED			Shooter
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL N/a	COMMENTS:			SIZE B · DWG. NO. 1 · REV 4
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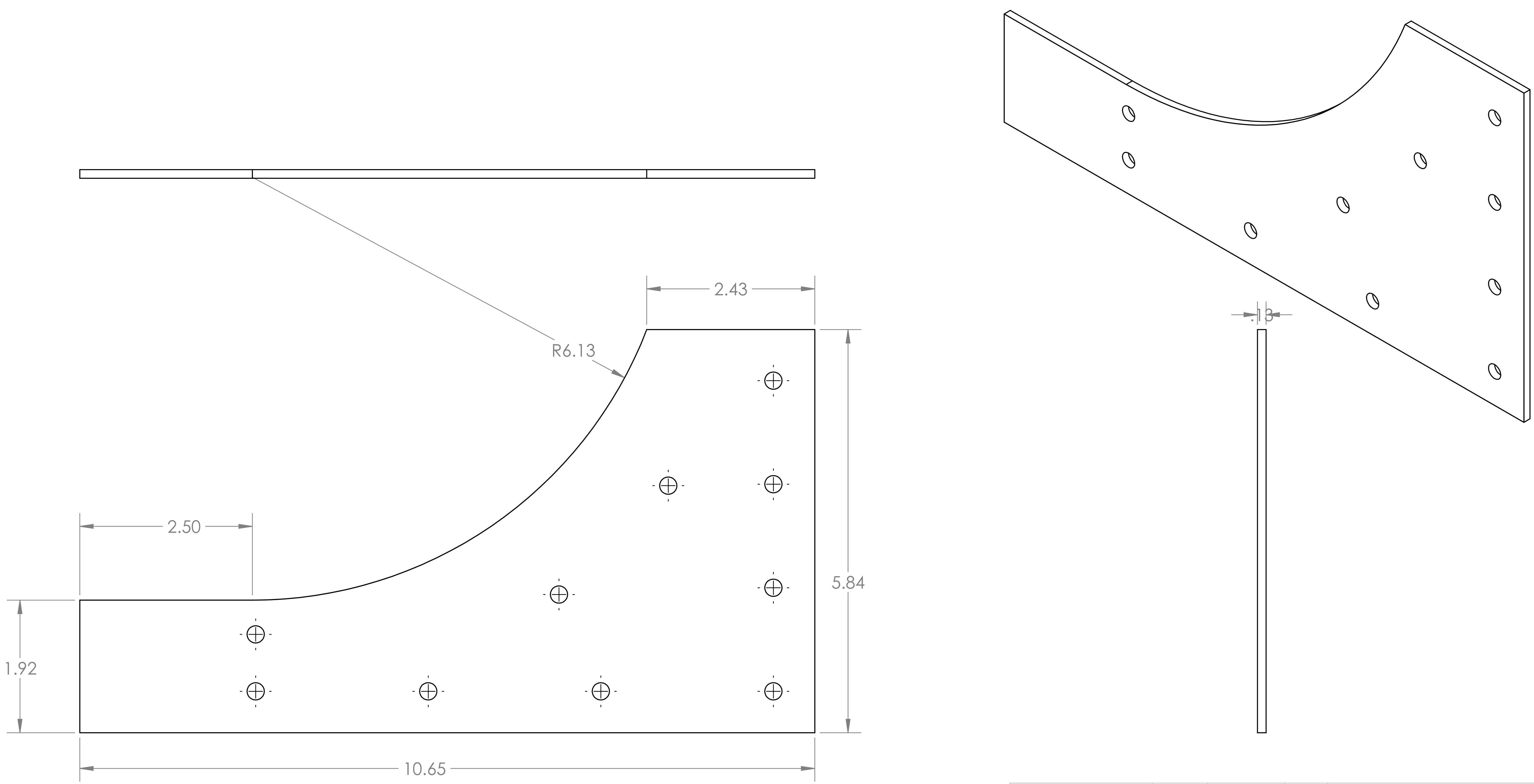

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	CHECKED			Shooter Ramp bracket
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL Acrylic	COMMENTS:			SIZE B · DWG. NO. · REV 3
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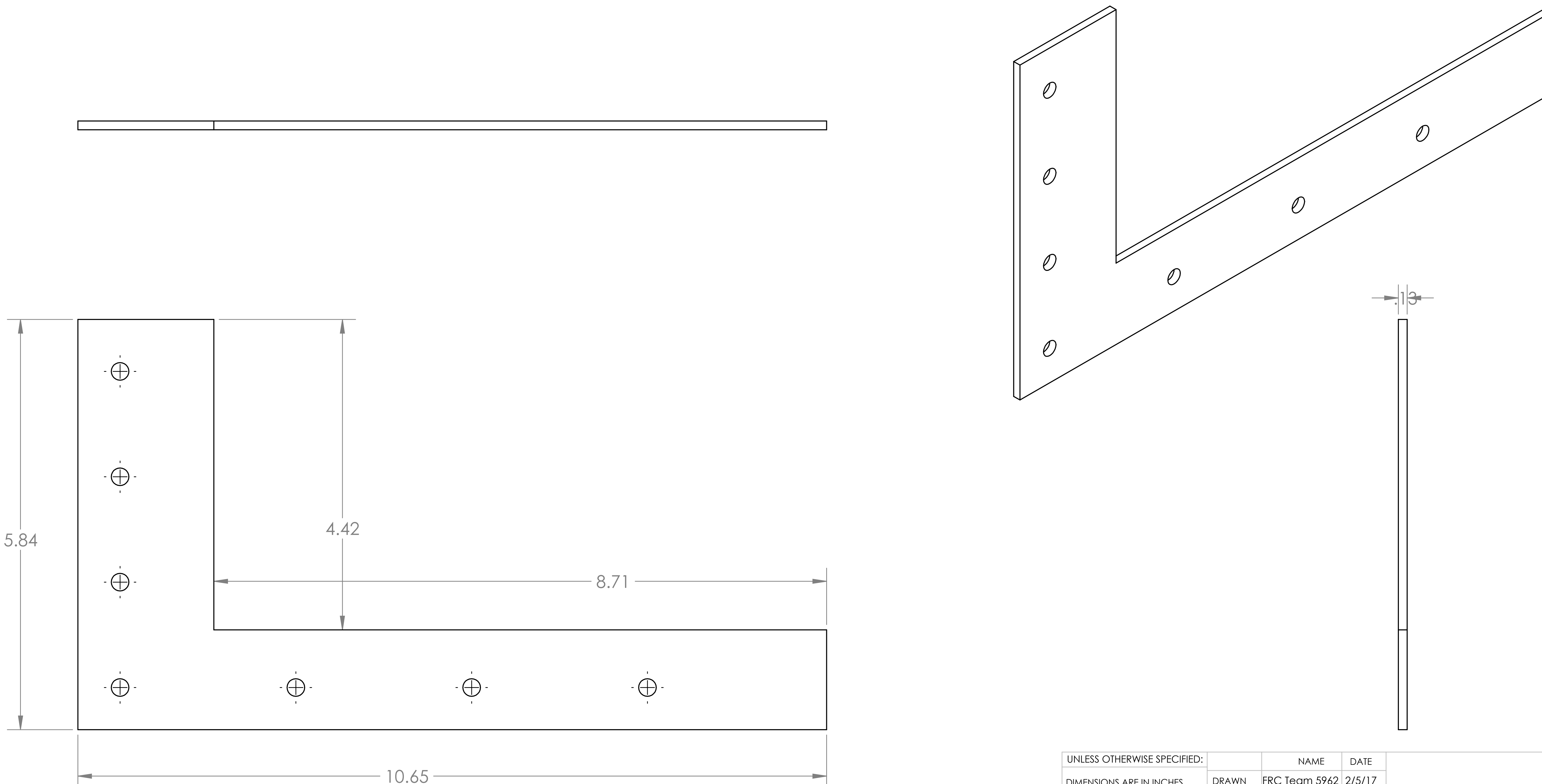

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UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	2/5/17
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

TITLE:

Shooter Ramp L-Bracket

SIZE	DWG. NO.	REV
B		3

SCALE: 1:5 WEIGHT: SHEET 1 OF 1

Idea 1- Wooden Circular Agitator

Description:

A wooden circle with wooden blocks zip tied on it in a four way form. It spins using a windmill from the bottom of it.

Result:

It did not work because it crushed the balls against one of the walls instead of moving them.

Idea 2- Wooden Circular Agitator w/ Pool Noodle

Description:

There will be a pool noodle that will spin in a circle using the wood circle before and let the balls come out. The pool noodles were used to allow more give for the balls.

Result:

The pool noodle lost its original shape so it isn’t a permanent part.

Idea 3- Horizontal Agitator with Slight Ramp

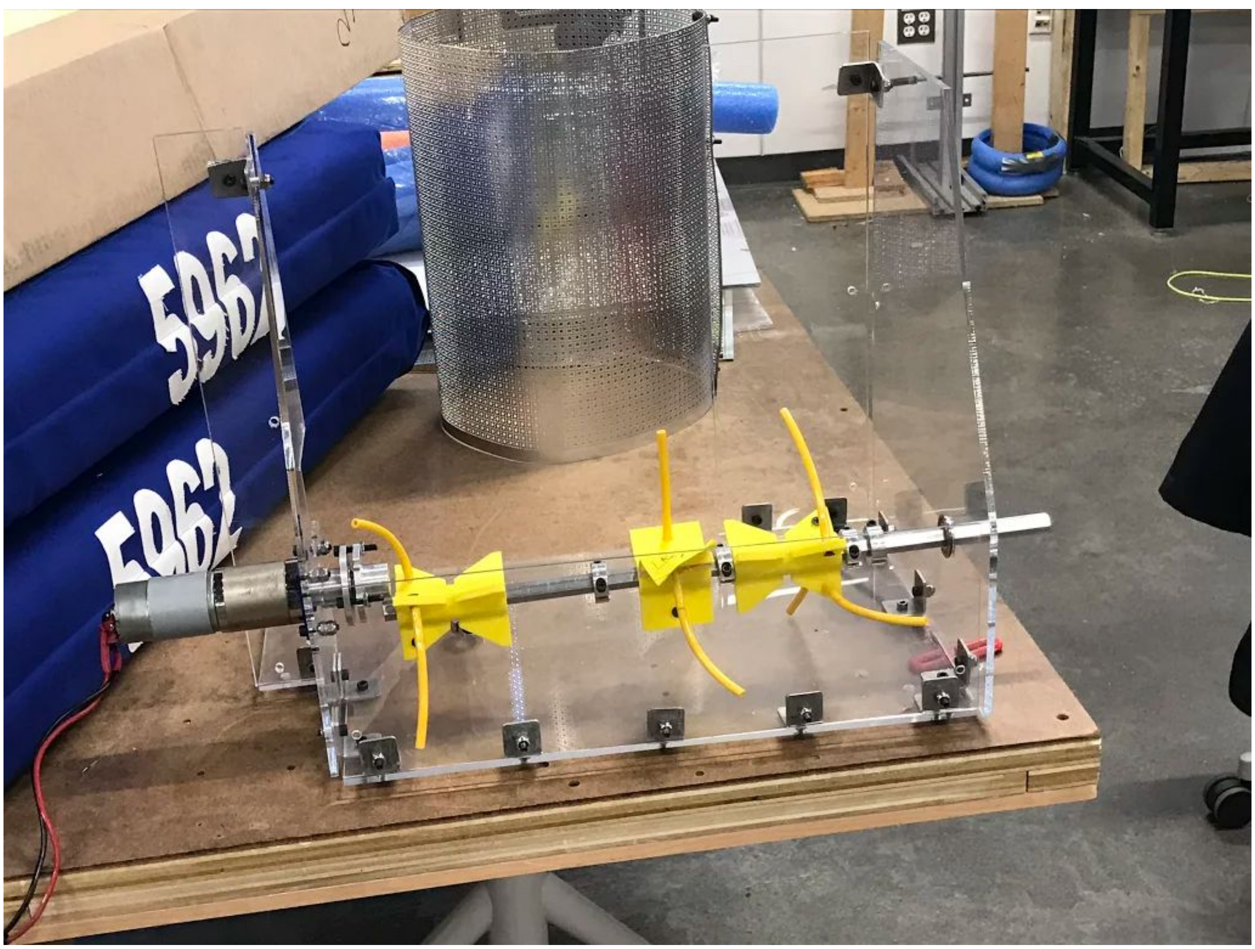
Description:

An Andy Mark motor attached to a shaft by a hub. Attached to the shaft are 3-D printed parts that will spin the ball to a ramp. The ramp will let the ball go into the shooter.

Result:

The shaft if moved in a certain way it will crush the balls. It would work a bit of the time however the balls can get stuck without some movement.

Idea 4- Shaft with Polychord Extensions with Ramp

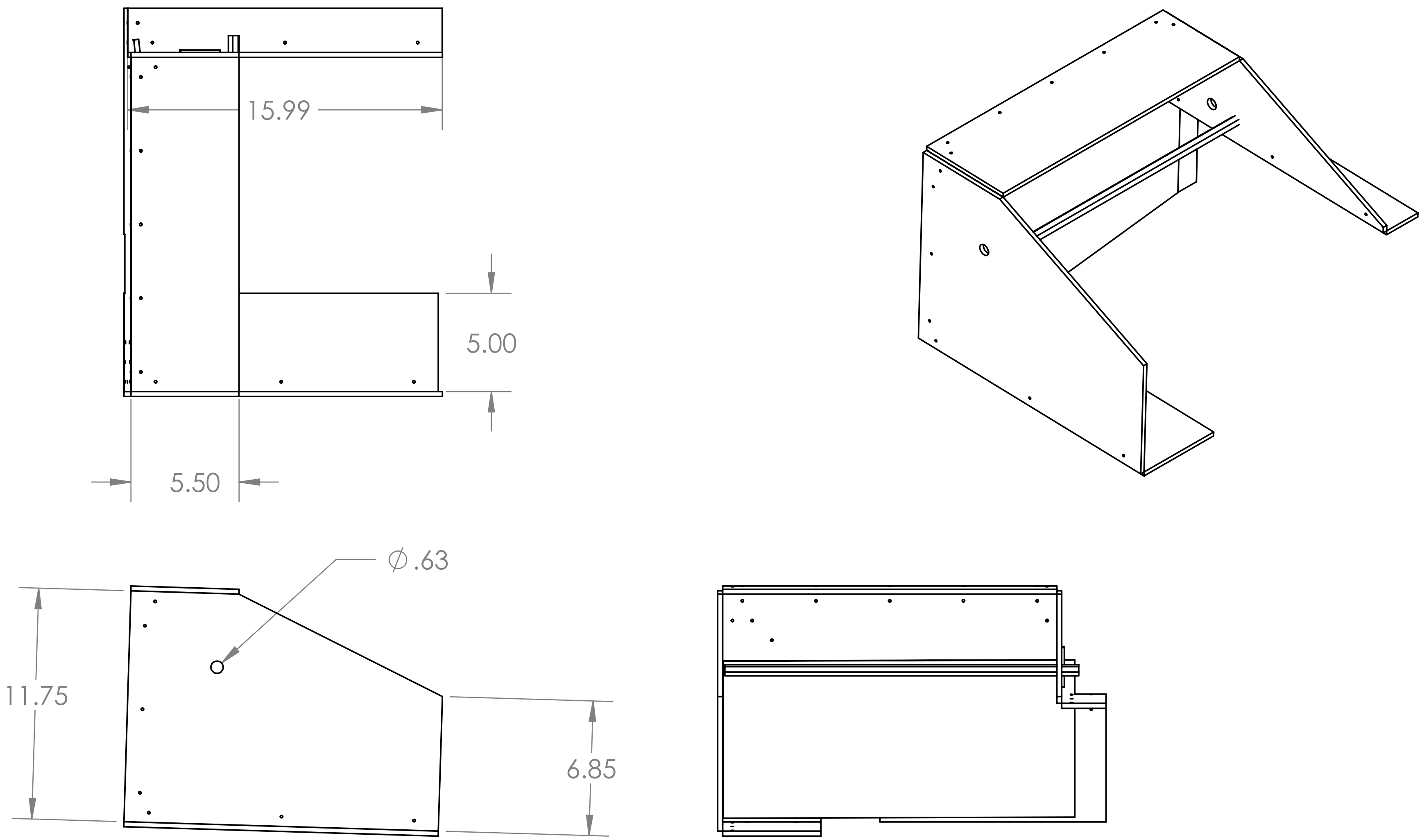


Description:

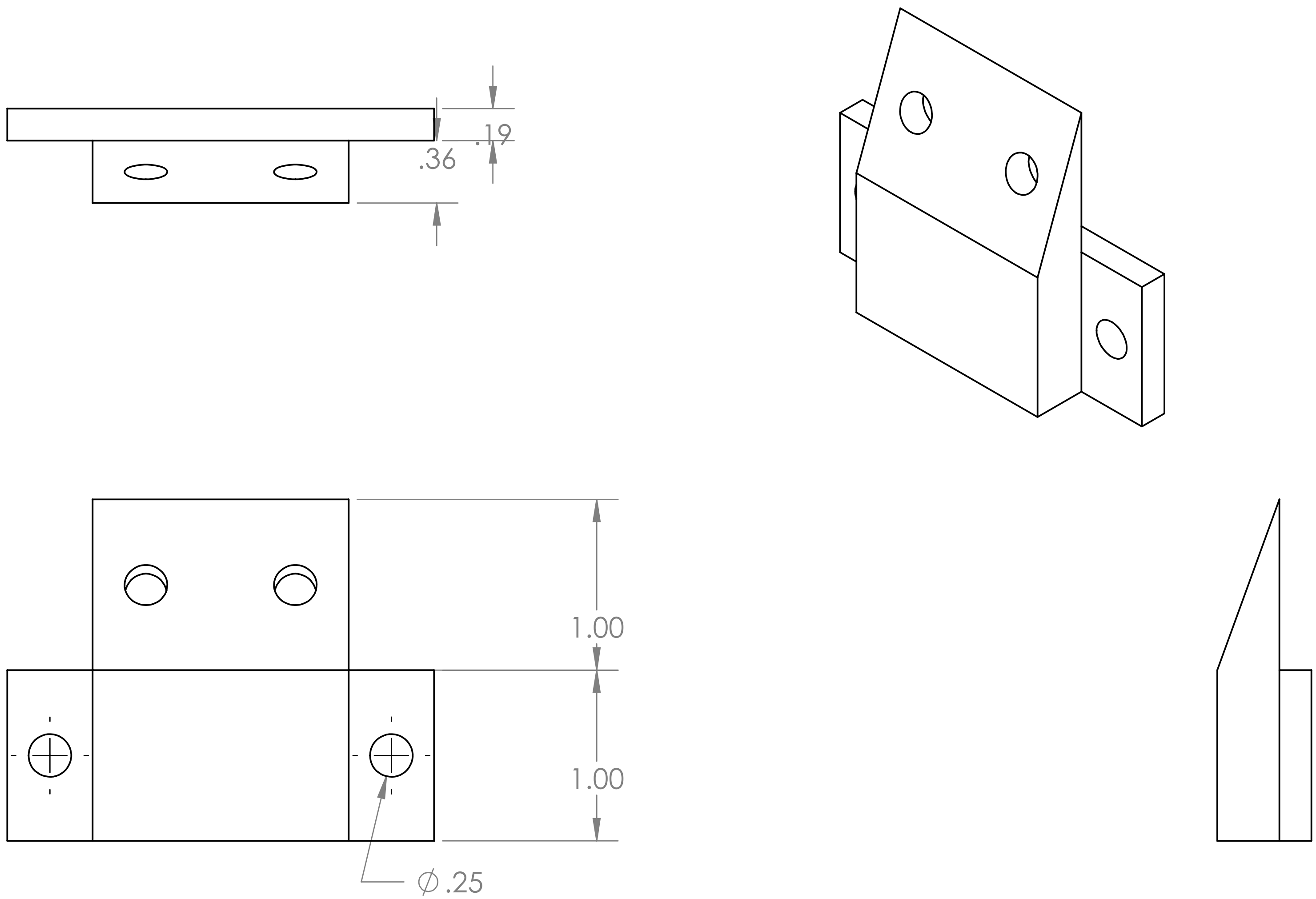
A PG71 motor is used on a shaft with 3D printed windmills to move the ball onto a ramp. Polychord extensions are used to push the balls forward. The box design was cut in order to optimize the use of the gear manipulator. The Gear manipulator had priority over the hopper design so the volume was reduced.

Result:

Still Pending



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	3/9/17	
	CHECKED			TITLE:
	ENG APPR.			Hopper
	MFG APPR.			
	Q.A.			
INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:			
MATERIAL				SIZE A · DWG. NO. 1 · REV
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:8 · WEIGHT: · SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL: PLA

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	FRC Team 5962	3/11/17
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

Slanted Hopper Bracket

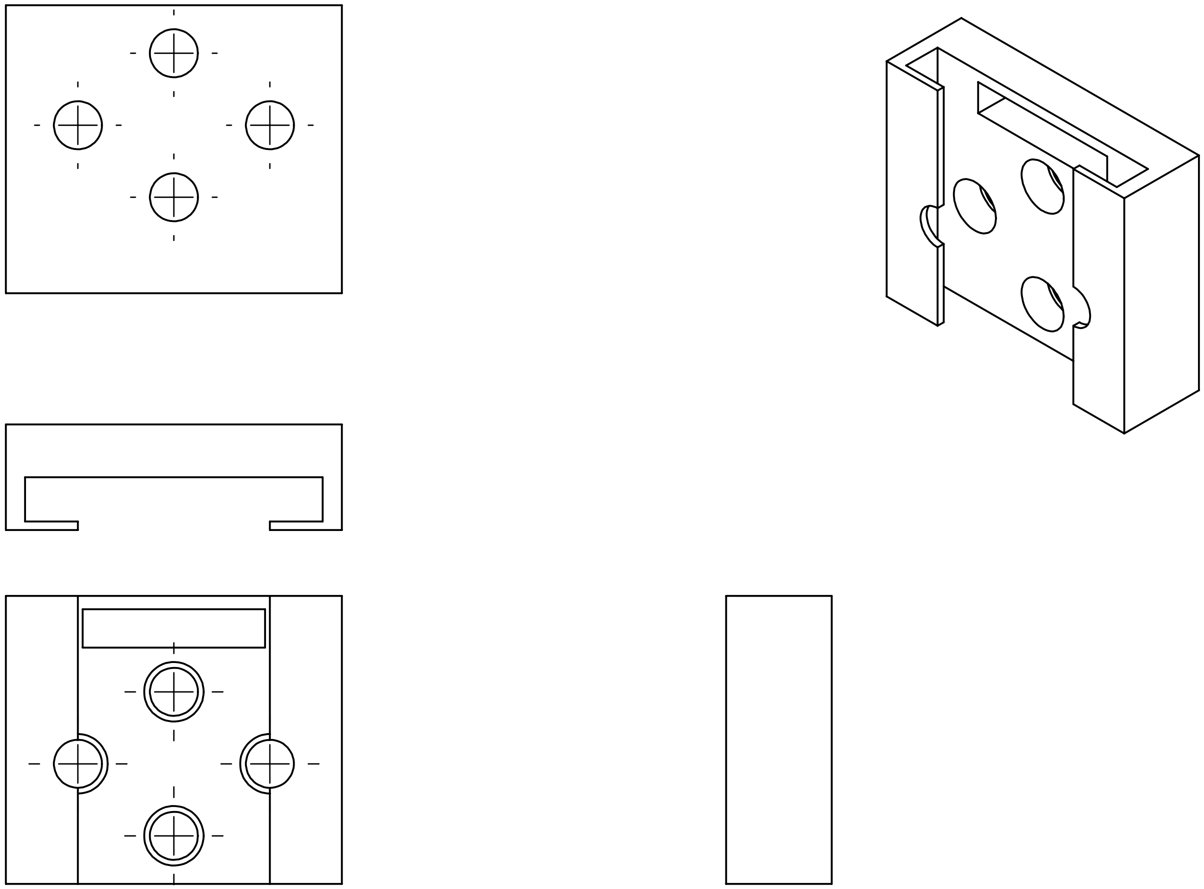
SIZE	DWG. NO.	REV
A	1	1

SCALE: 1:1 WEIGHT: SHEET 1 OF 1

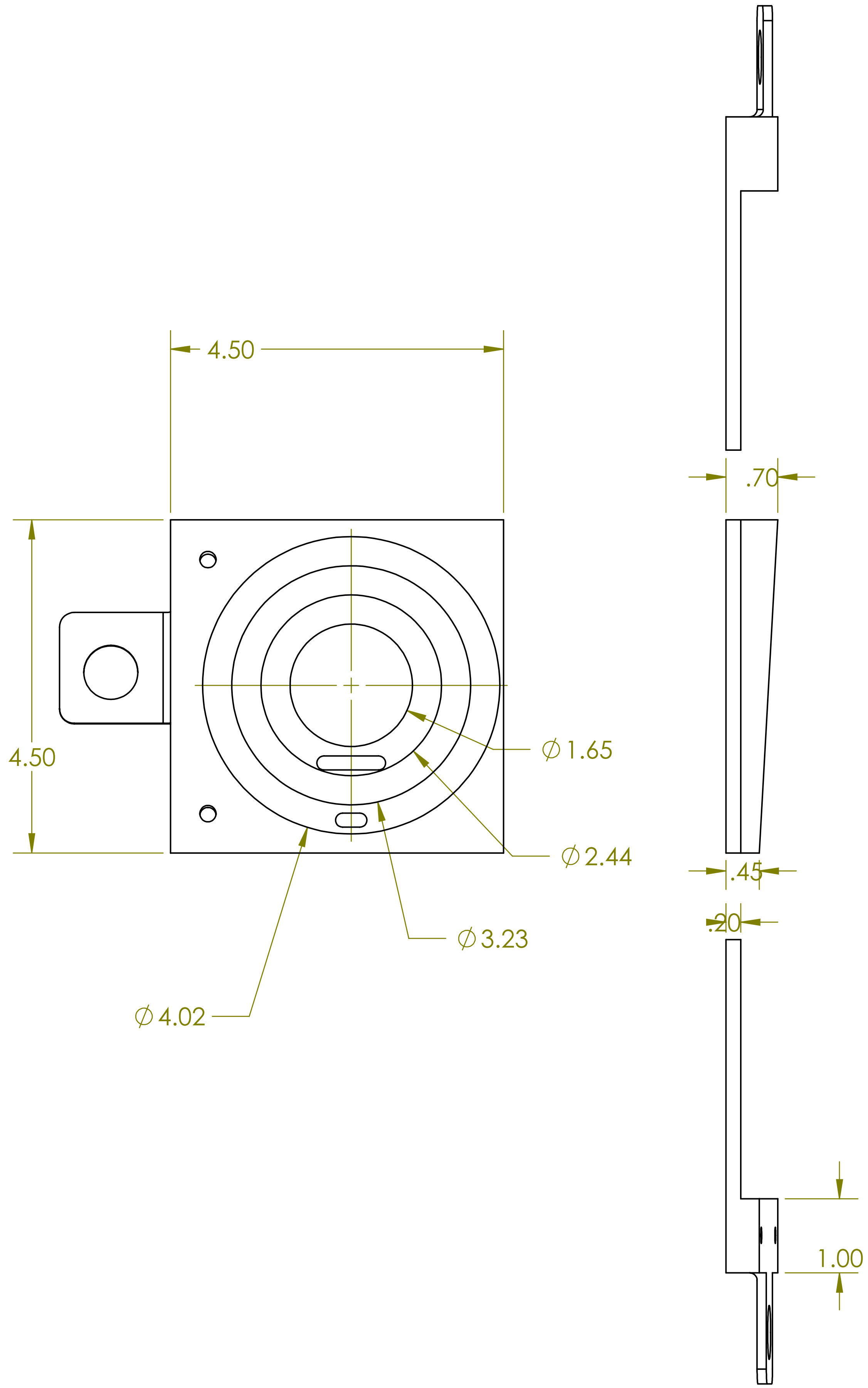
Electrical Board Team 5962

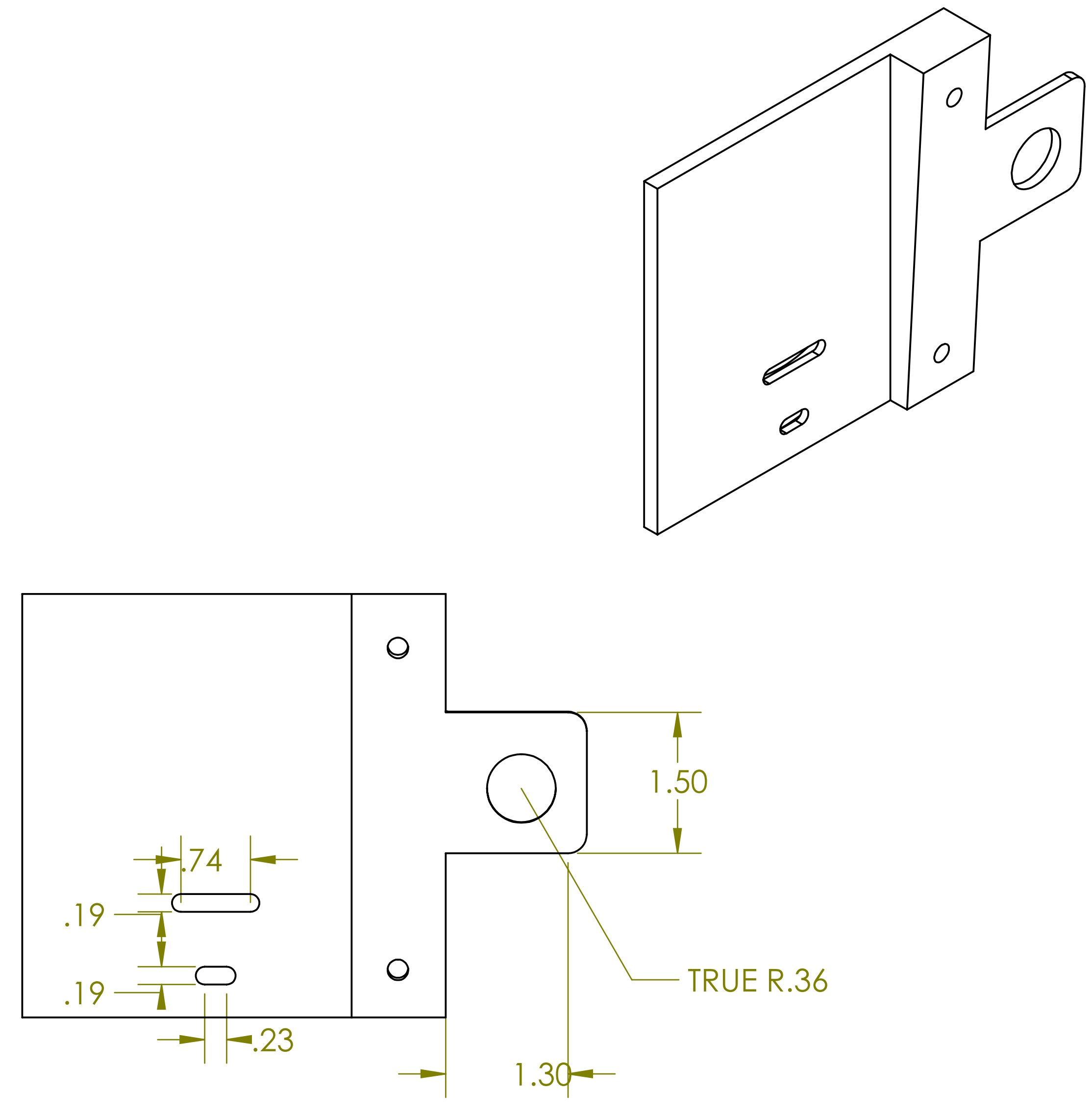
Electrical Bill of Materials

Subsystem 5:							
Electrical & Software	Power Distribution Panel		andymark	1	piece	$200.00	$200.00
	Pneumatics Control Module		vexpro	1	piece	$88.99	$88.99
	Voltage Regulator Module		vexpro	1	piece	$44.99	$44.99
	Victor SP Motor Controller		vexpro	4	piece	$59.99	$239.96
	Talon SRX encoder breakout board		andymark	2	piece	$10.00	$20.00
	Talon SRX Motor Controller		vexpro	3	piece	$89.99	$269.97
	NI roboRIO		andymark	1	piece	$435.00	$435.00
	Microsoft Lifecam HD-3000 Camera		andymark	3	piece	$32.00	$96.00
	E4T Optical Encoder		andymark	2	piece	$42.00	$84.00
	Green Light Ring (small)	fc17-129	superbrightled	1	piece	$4.95	$4.95
	Green Light Ring (large)	fc17-129	superbrightled	1	piece	$9.95	$9.95
	AmazonBasics 4 port USB hub	fc17-129	amazon	1	piece	$17.00	$17.00
	SanDisk 120 GB SSD drive		ebay	1	piece	$40.00	$40.00
	Ultrosonics with cord	fc17-129	andymark first choice	2	piece		$0.00
	Gyro/Accelerometer	fc17-129	andymark	1	piece	$35.00	$35.00
	Acer Aspire E11 (ES1-111M-P2YU)		walmart	1	piece	$280.00	$280.00
	CIMcoder		andymark	2	piece	$42.00	$84.00
						Subtotals:	$1,949.81



UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	2/20/17	TITLE: Camera to 8020 Mount
	CHECKED			
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL PLA	COMMENTS:			SIZE A · DWG. NO. 1 · REV 1
FINISH DO NOT SCALE DRAWING				SCALE 1:1 · WEIGHT: · SHEET 1 OF 1





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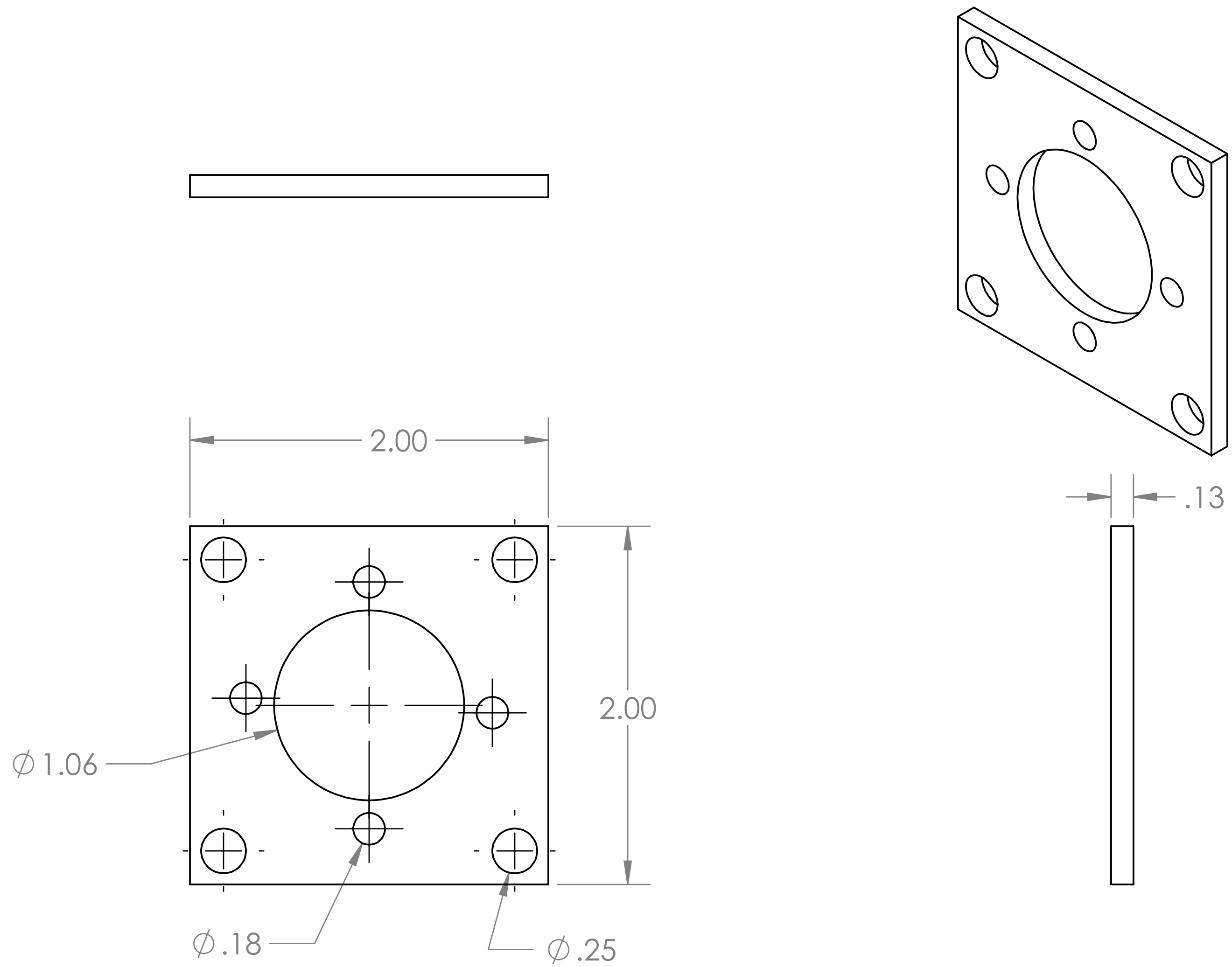
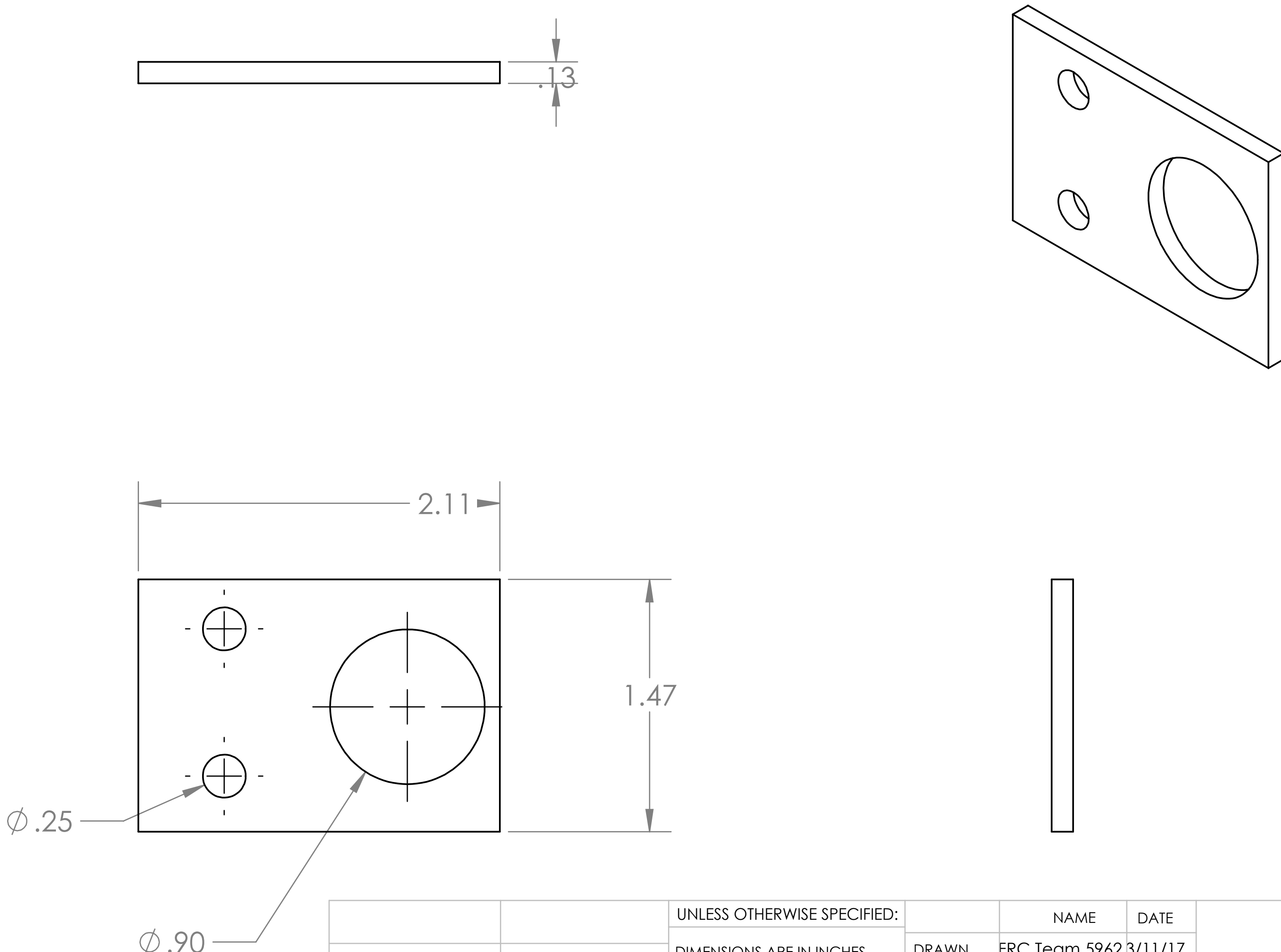
UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	2/20/17	TITLE: LED-Ultrasonic Bracket
	CHECKED			
	ENG APPR.			
	MFG APPR.			
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
MATERIAL PLA	COMMENTS:			SIZE B · DWG. NO. 1 · REV 2
FINISH				
DO NOT SCALE DRAWING				SCALE: 1:2 · WEIGHT: · SHEET 1 OF 1



SOLIDWORKS Educational Product. For Instructional Use Only

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	3/1/17	
	CHECKED			TITLE: PG71 Motor Bracket
	ENG APPR.			
	MFG APPR.			
	Q.A.			
INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:			
MATERIAL PLA				SIZE A — DWG. NO. 1 — REV 2
DO NOT SCALE DRAWING				SCALE: 1:1 — WEIGHT: — SHEET 1 OF 1



		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN	FRC Team 5962	3/11/17
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL PLA	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

Gear Signal Light Bracket

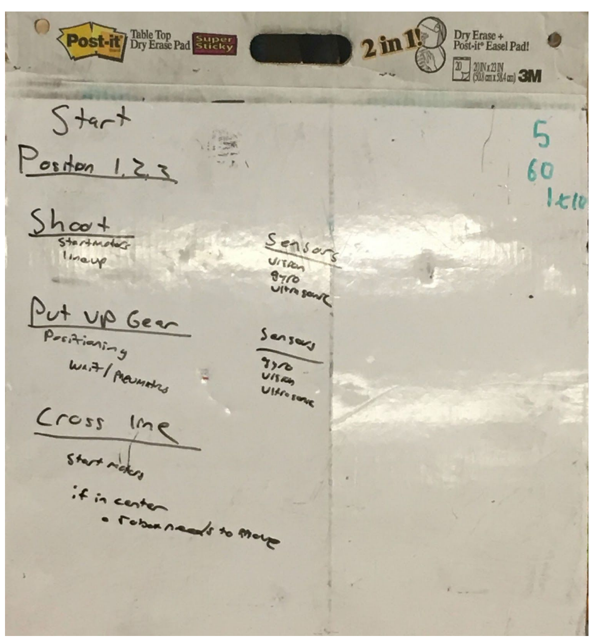
SIZE	DWG. NO.	REV
A	1	

SCALE: 1:1	WEIGHT:	SHEET 1 OF 1

Continuing the agile practices that the team adopted last season the Software Team followed the engineering planning methodology known as Scrum. The process is a loose interpretation of Scrum done with the purpose of exposing the students to the process at the same time giving them a tool to properly plan the work to be done.

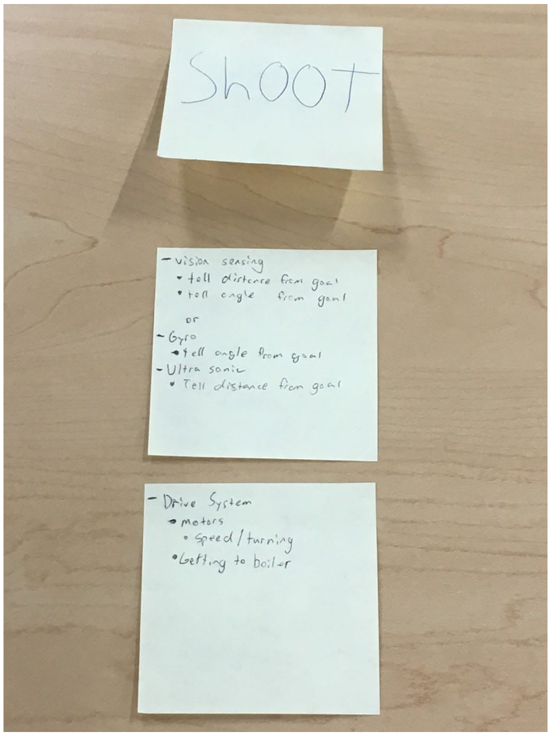
The initial planning meeting was conducted on Sunday, January 24th. The team, lead by Junior Mentor Greg and Student Software Lead John, first defined the high-level software components.

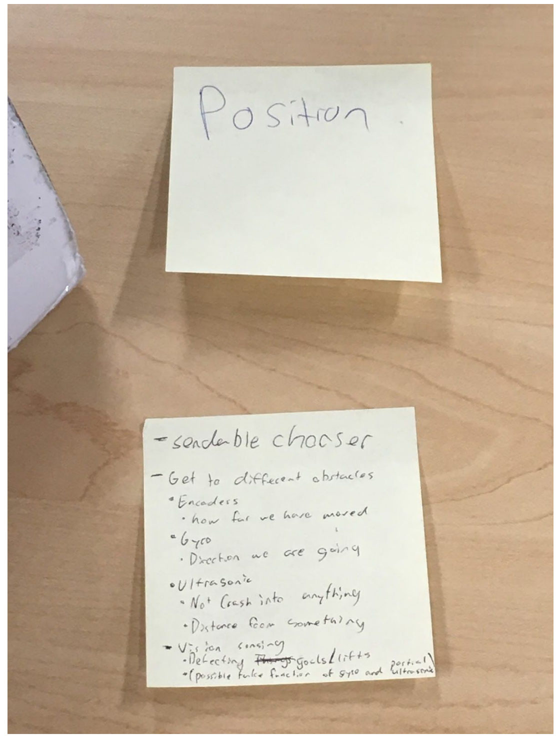
Team Planning: defining the high-level components

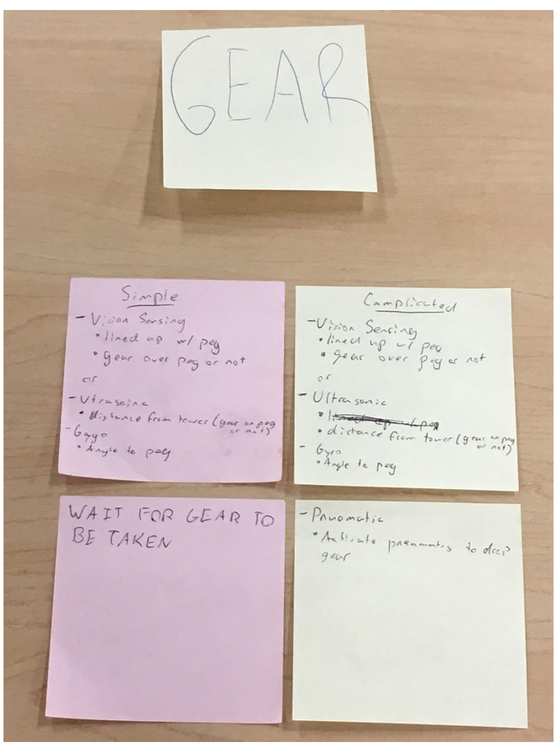


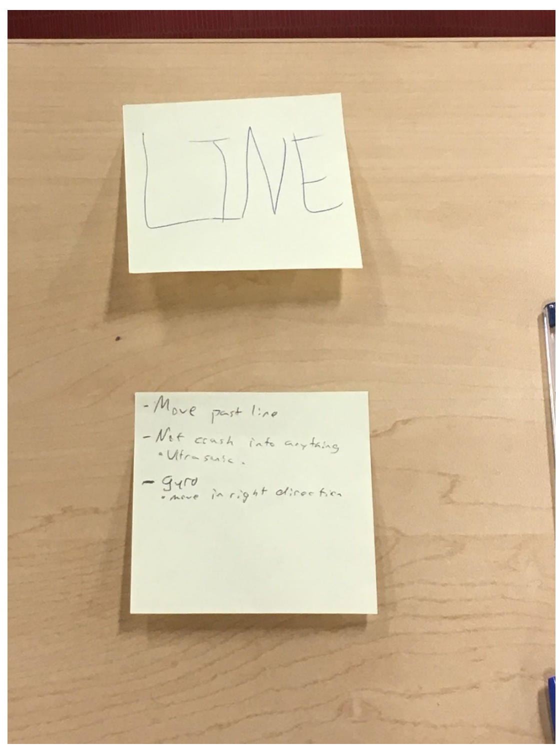
High-Level Components

The next step was to list out everything that they could think of that would need to be done/considered for each component. The did this using sticky notes and each student contributed their ideas. All ideas were included, nothing was excluded.

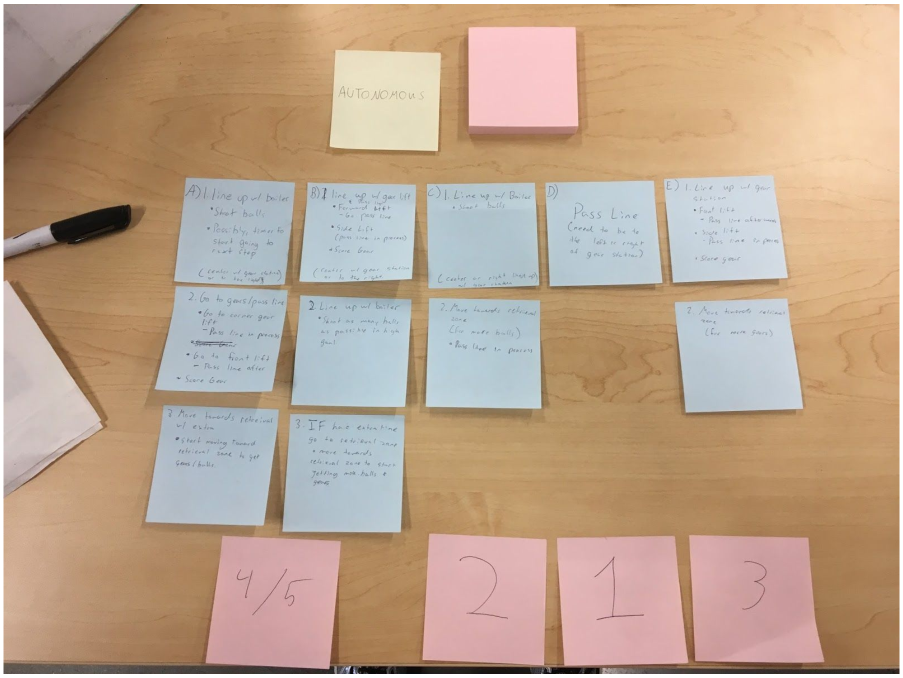






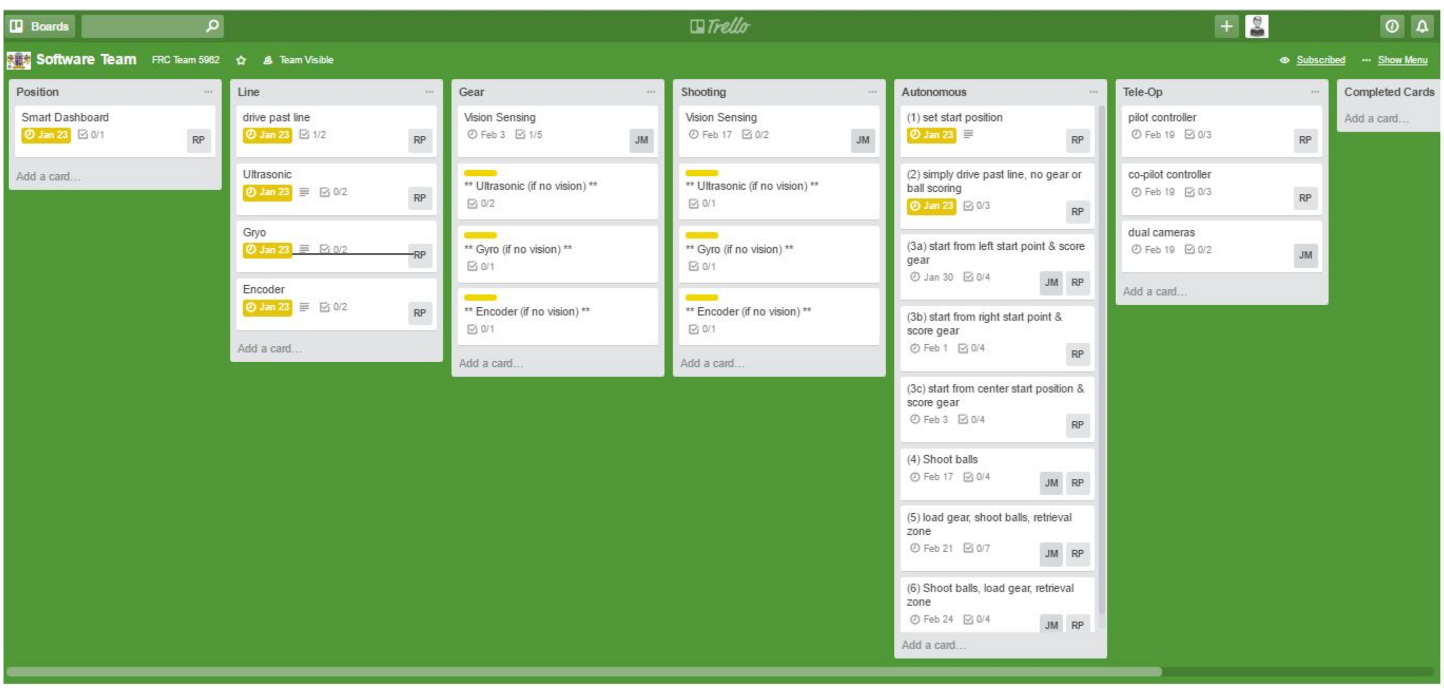


Once the team felt they had identified everything they moved on to planning how the autonomous would work with these components. Again they used sticky notes to identify the work. When they were done they prioritized the work.



Autonomous Work: Identified and Prioritized!

Once the planning was completed we added everything into Trello, the on-line Scrum planning tool that the Software Team is using.



https://trello.com/b/3qHCBCc5/software-team

January 23, 2017

Finished updating the smart dashboard to have all the sensor outputs needed.

--

Created the base autonomous code to drive past the baseline, and implemented sensors to help accomplish this (encoders.)

--

Created and implemented the ultrasonic sensor class.

--

Created and implemented the encoder sensor class.

--

Created and implemented the gyro sensor class.

January 25, 2017

Finished setting up vision processing on the secondary laptop.

February 5, 2017

Created the base framework code for vision processing.

--

Determined the source for the LED ring.

--

Tested Lining up w/ peg with the vision.

--

Released the gear with pneumatics

February 10, 2017

Finished implementing autonomous code for ultrasonics, encoders, and gyros for when we don't have vision.

--

Implemented framework for different autonomous mode for which position we start in and various different options for autonomous.

February 17, 2017

Implemented the talon encoder for the shooter.

February 18, 2017

Created a new GRIP framework for using two cameras for vision processing.

--

Finished framework for using vision to line up with boiler.

--

Finished code for POV camera to make it pan and tilt.

February 19, 2017

Finished creating and implementing framework for having cameras for both the drivers and for the vision.

February 25, 2017

Finished improving vision process for both gear and boiler.

--

Looked into implementing RGB filter for vision processing.

March 2, 2017

Implemented tank drive mode for drivers, and replaced arcade mode as the default control configuration.

March 4, 2017

Implemented a second ultrasonic, for lining up with the gear collector.

--

Improved the gyro and encoder autonomous code.

--

Finished coding and testing the pilot, co-pilot controllers.

--

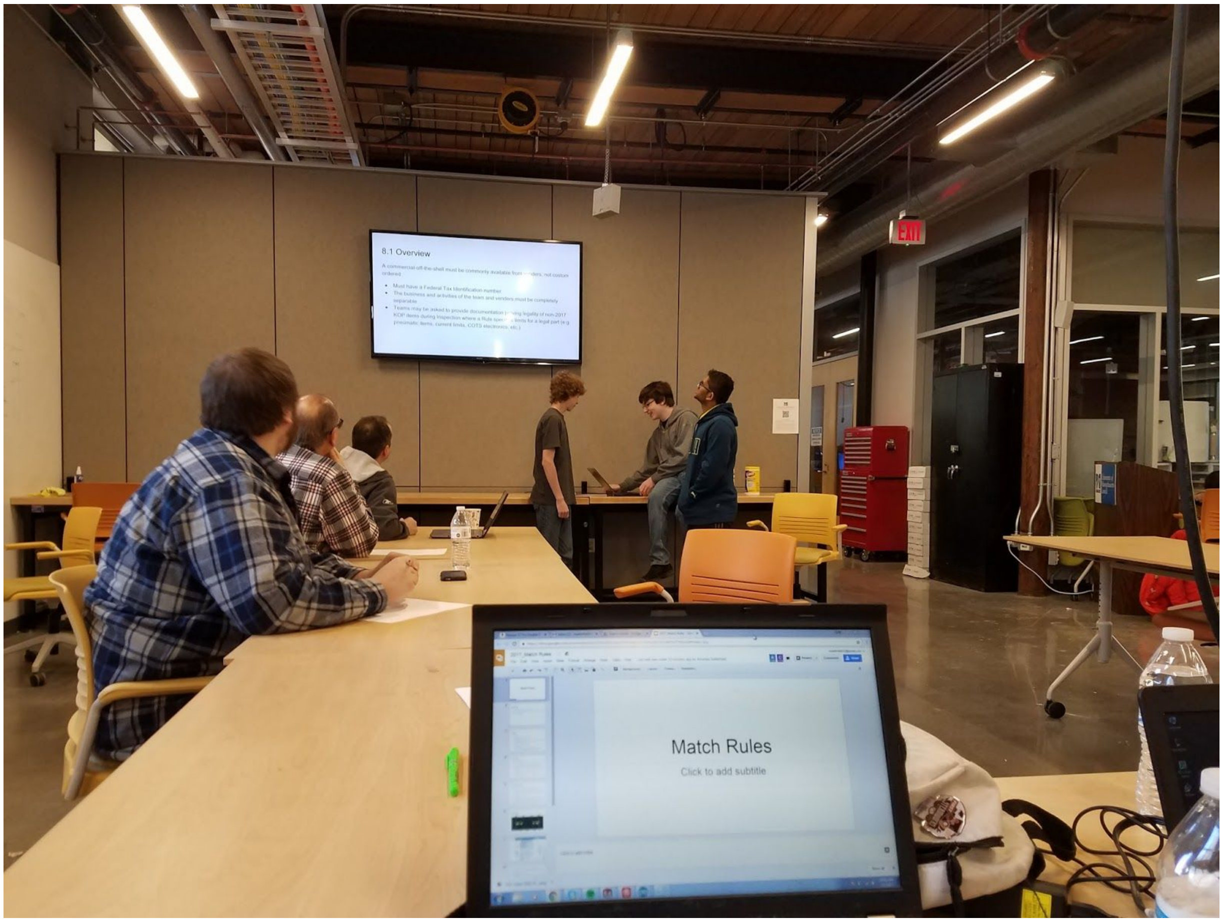
Updated the smart dashboard for driver use.

March 5, 2017

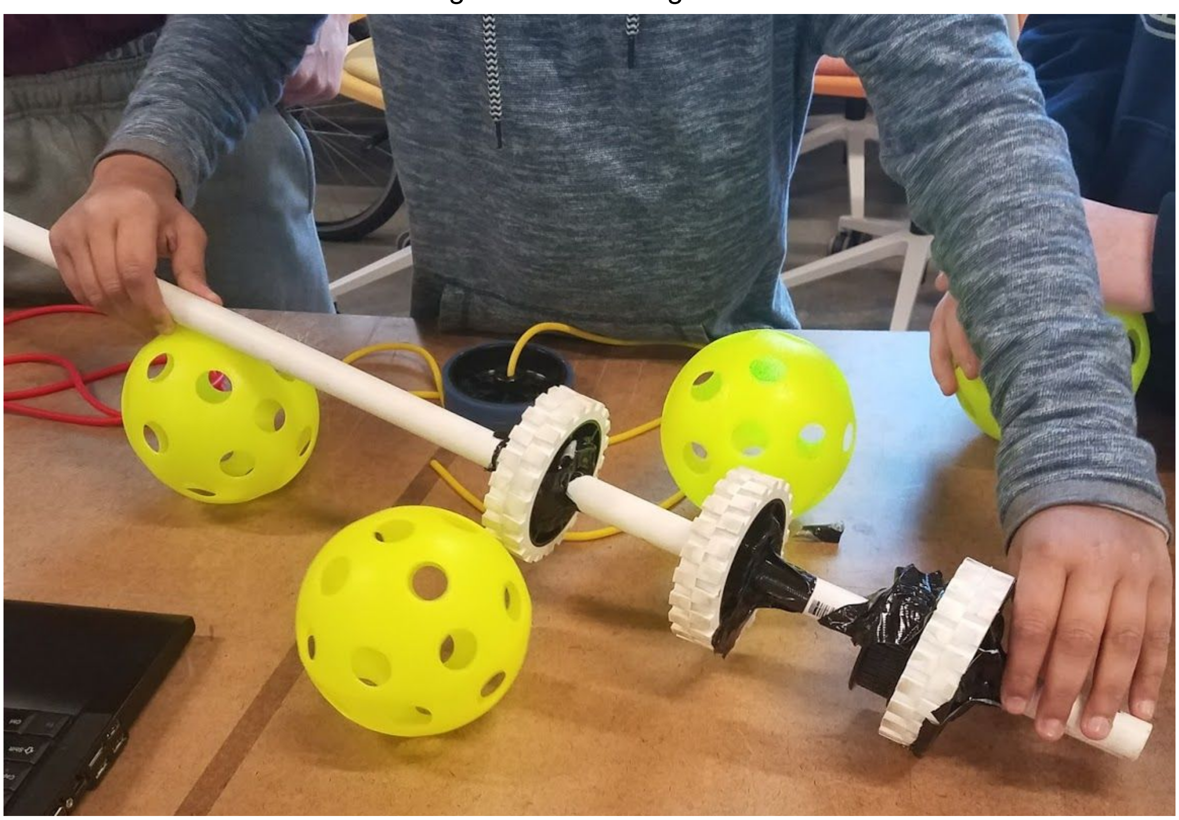
Tested the various different versions of autonomous.

--

Tested and improved driver controls.

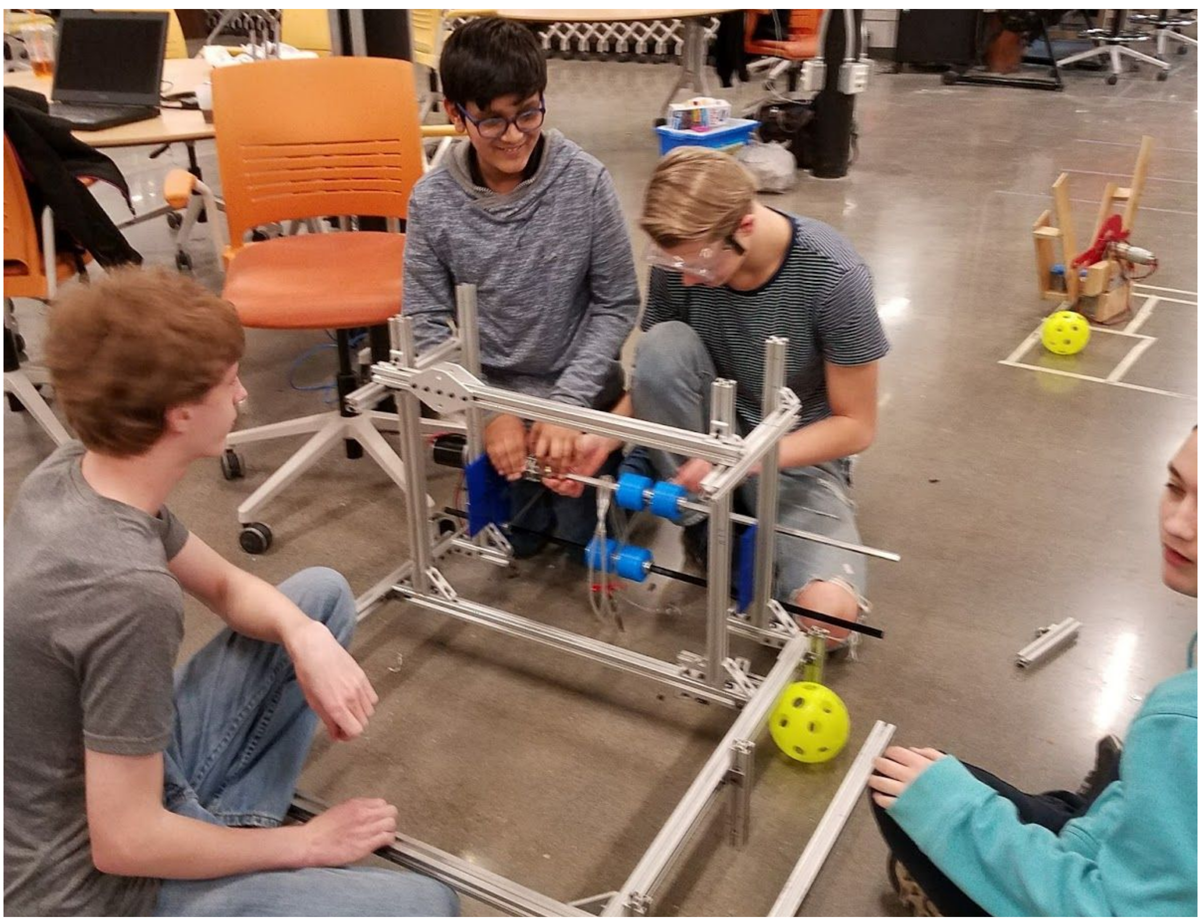


Presenting the match and game rules 1/9/17

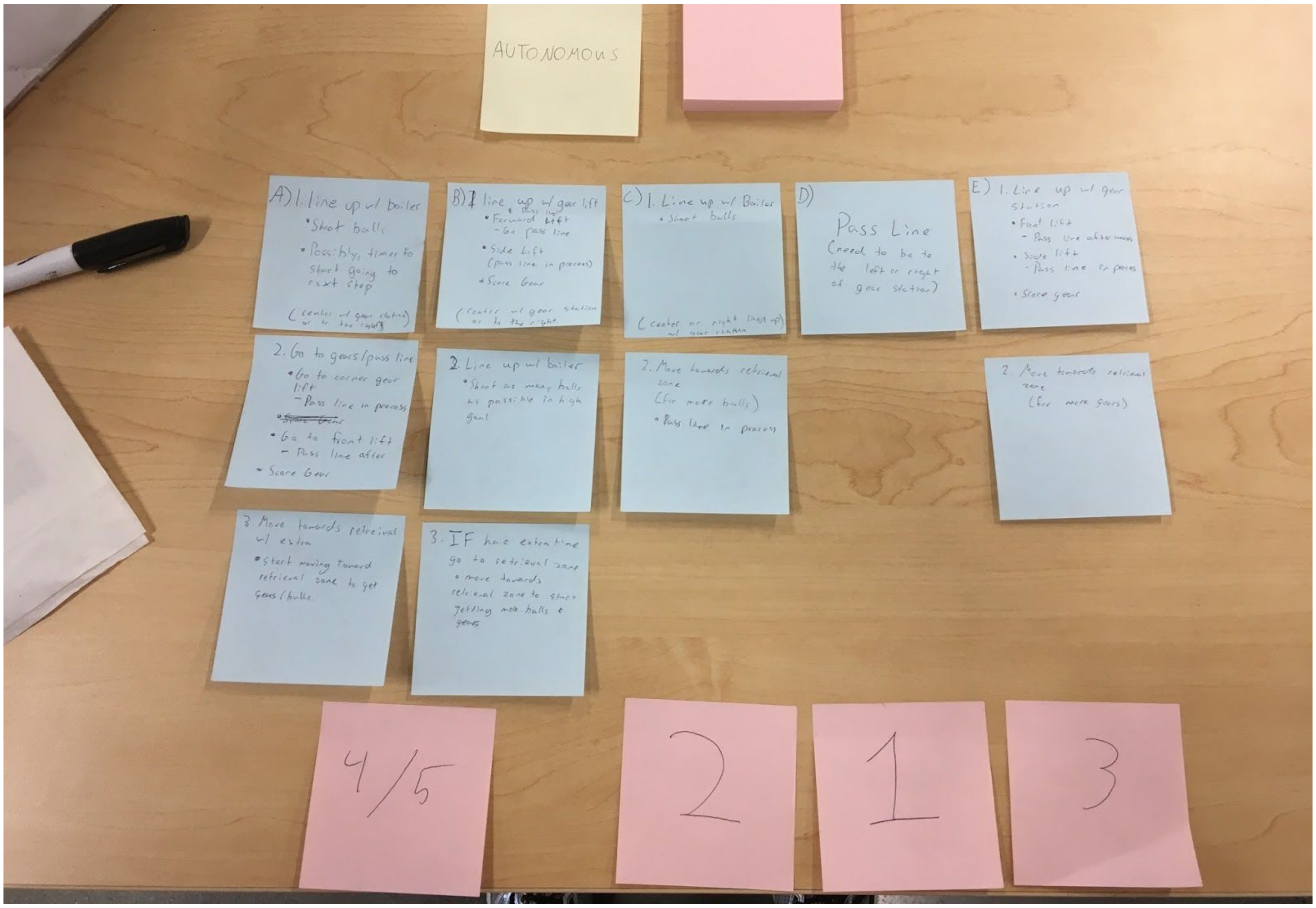


Prototyping ball manipulators for the intake (1/15/17)

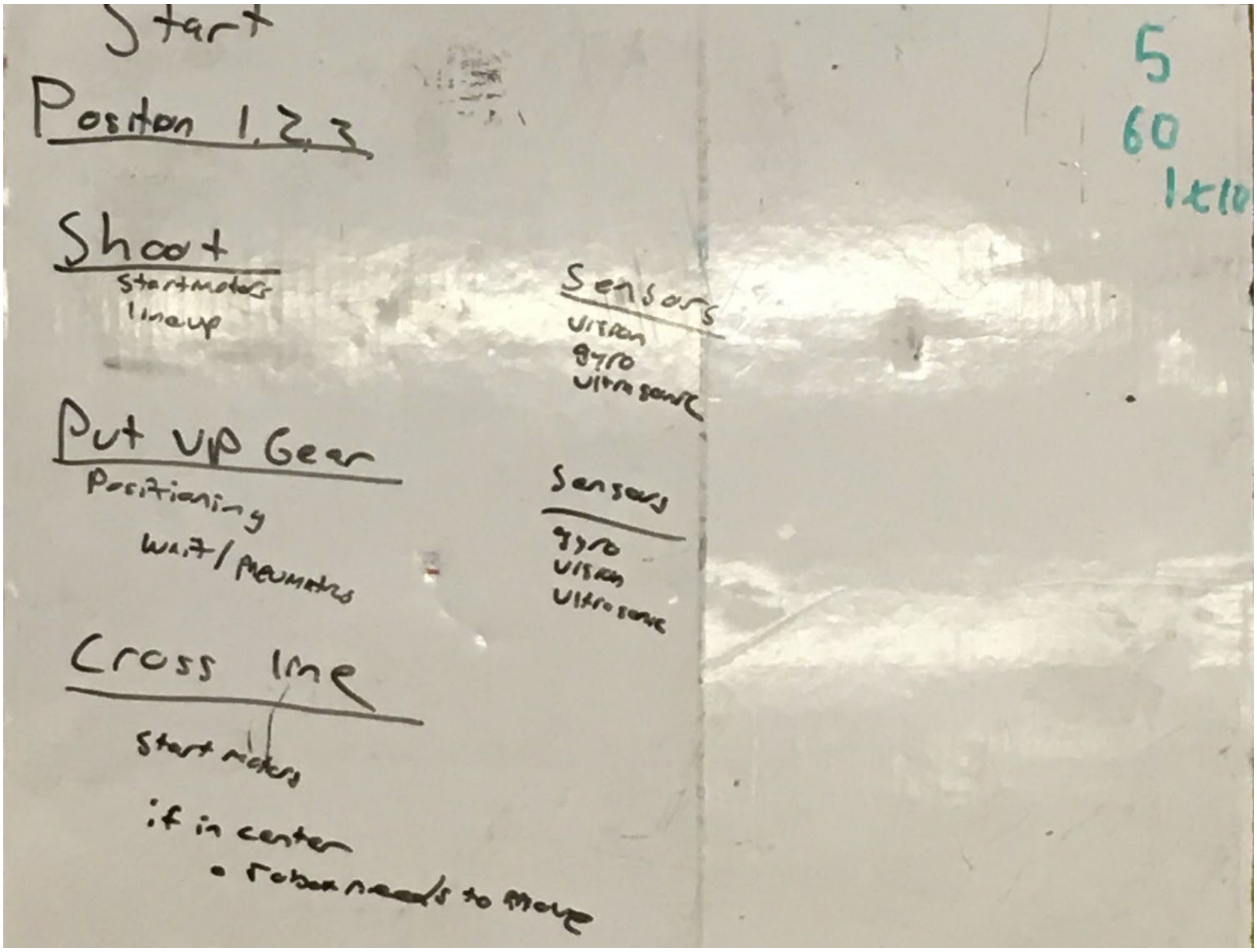
Opening the Kit of Parts (1/7/17)



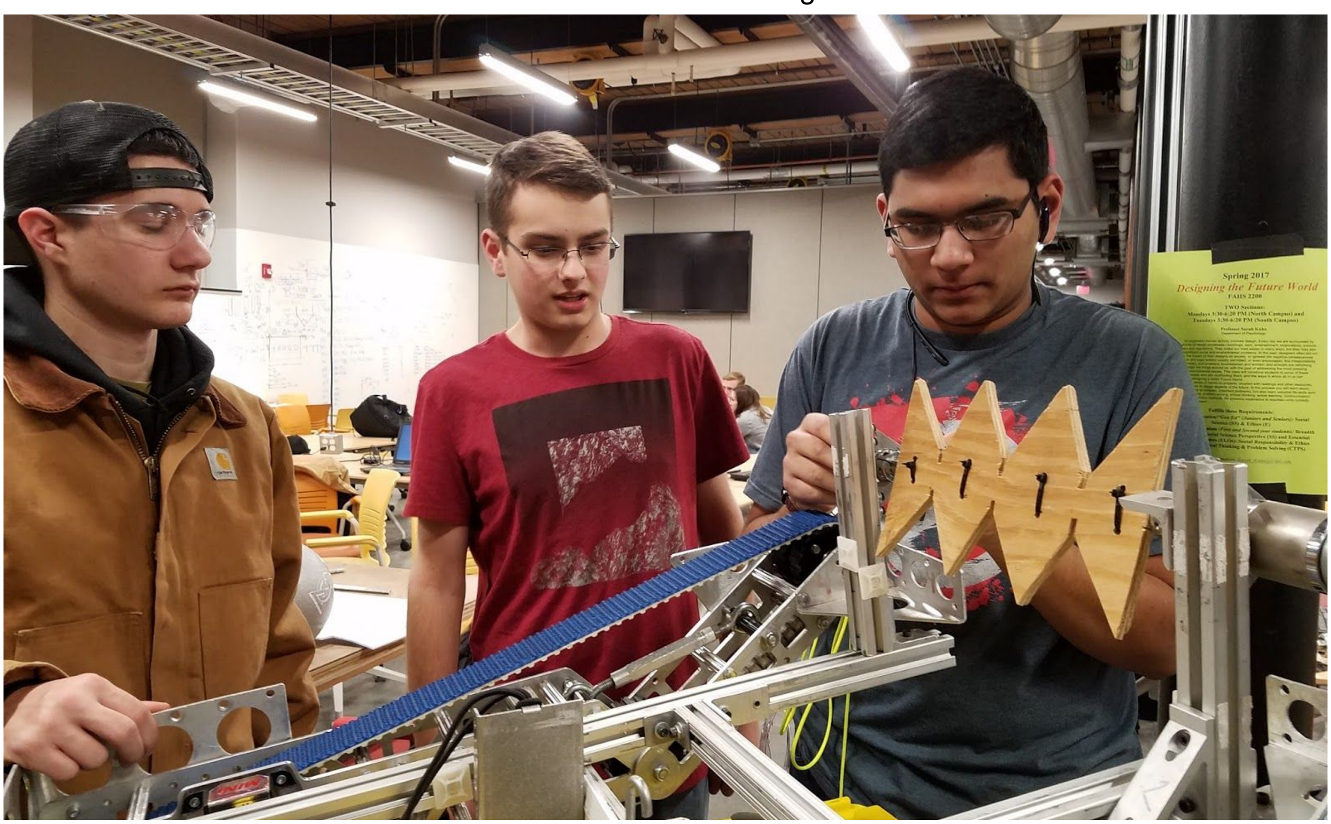
Prototyping the intake (1/29/17)



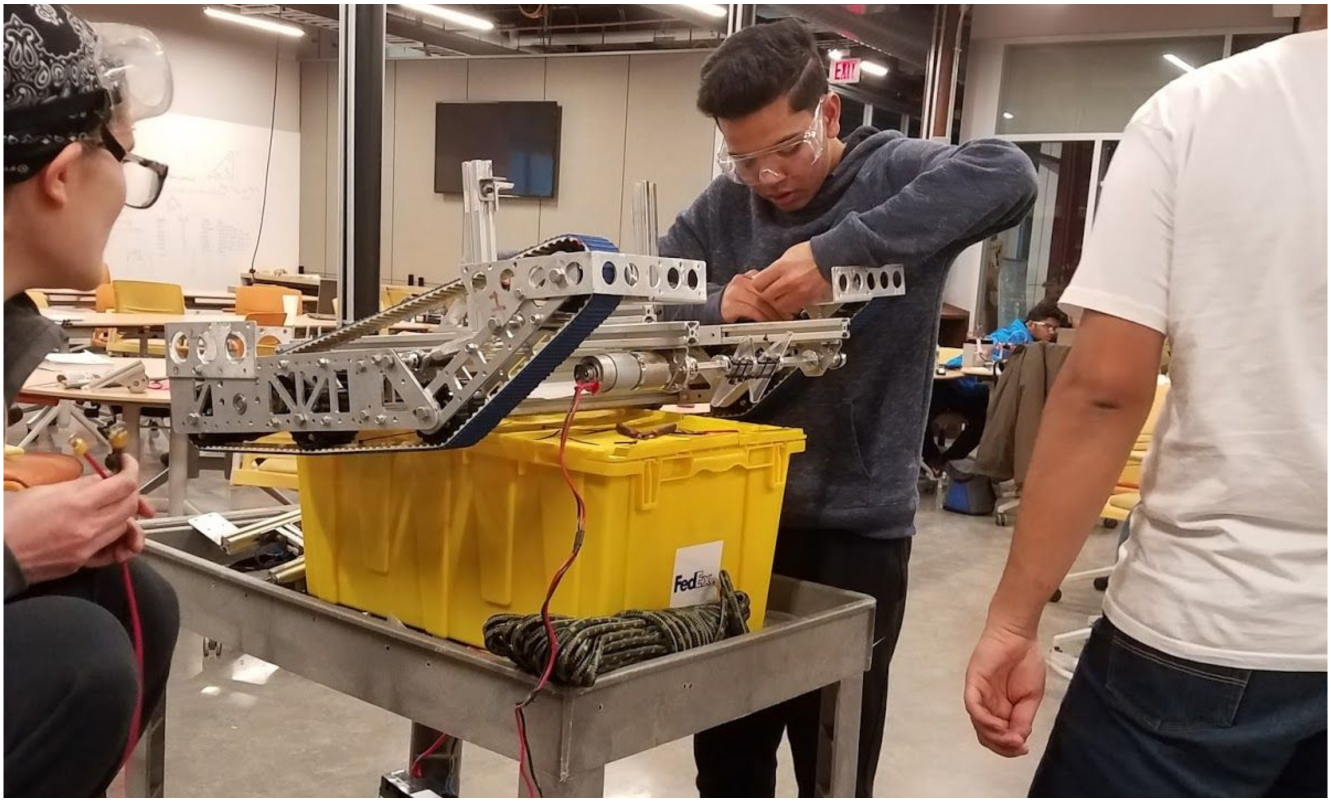
Software planning 1/24/17



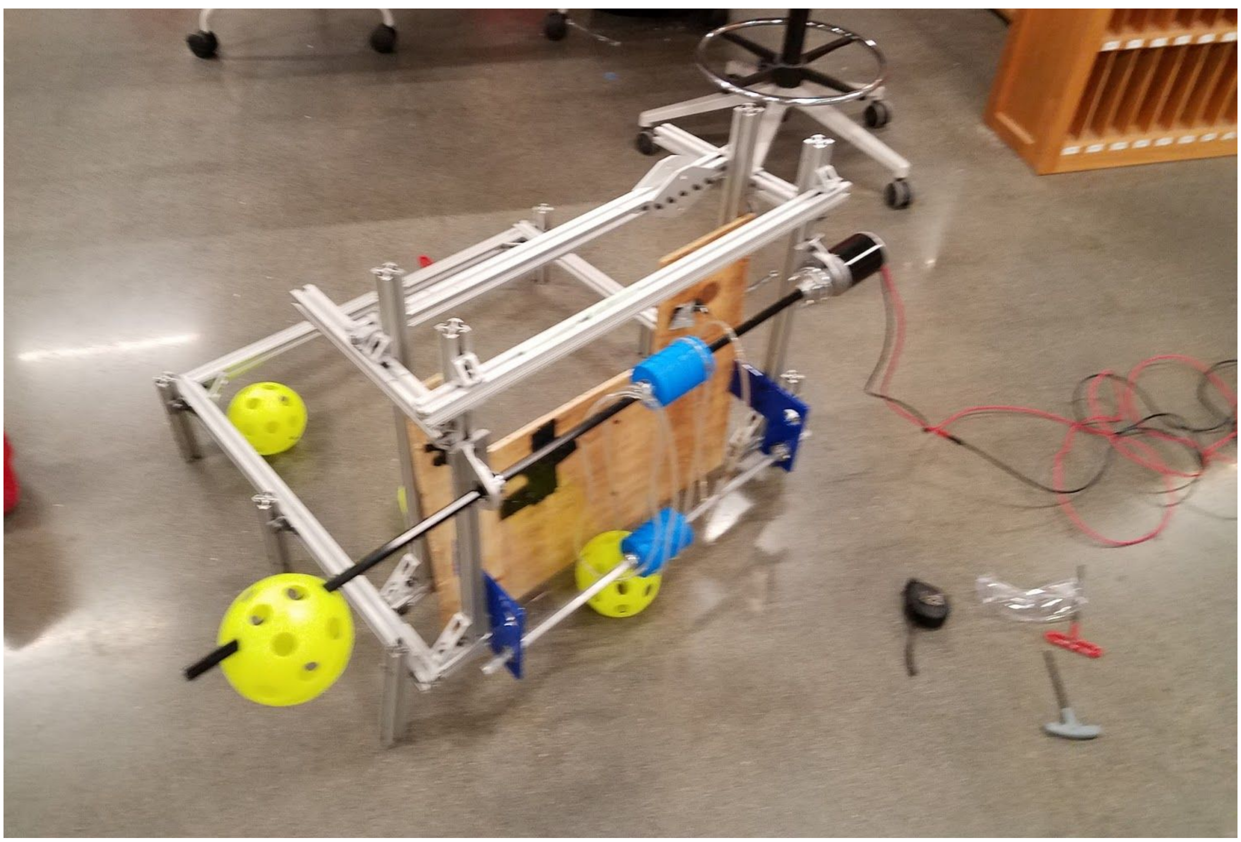
More Software Planning



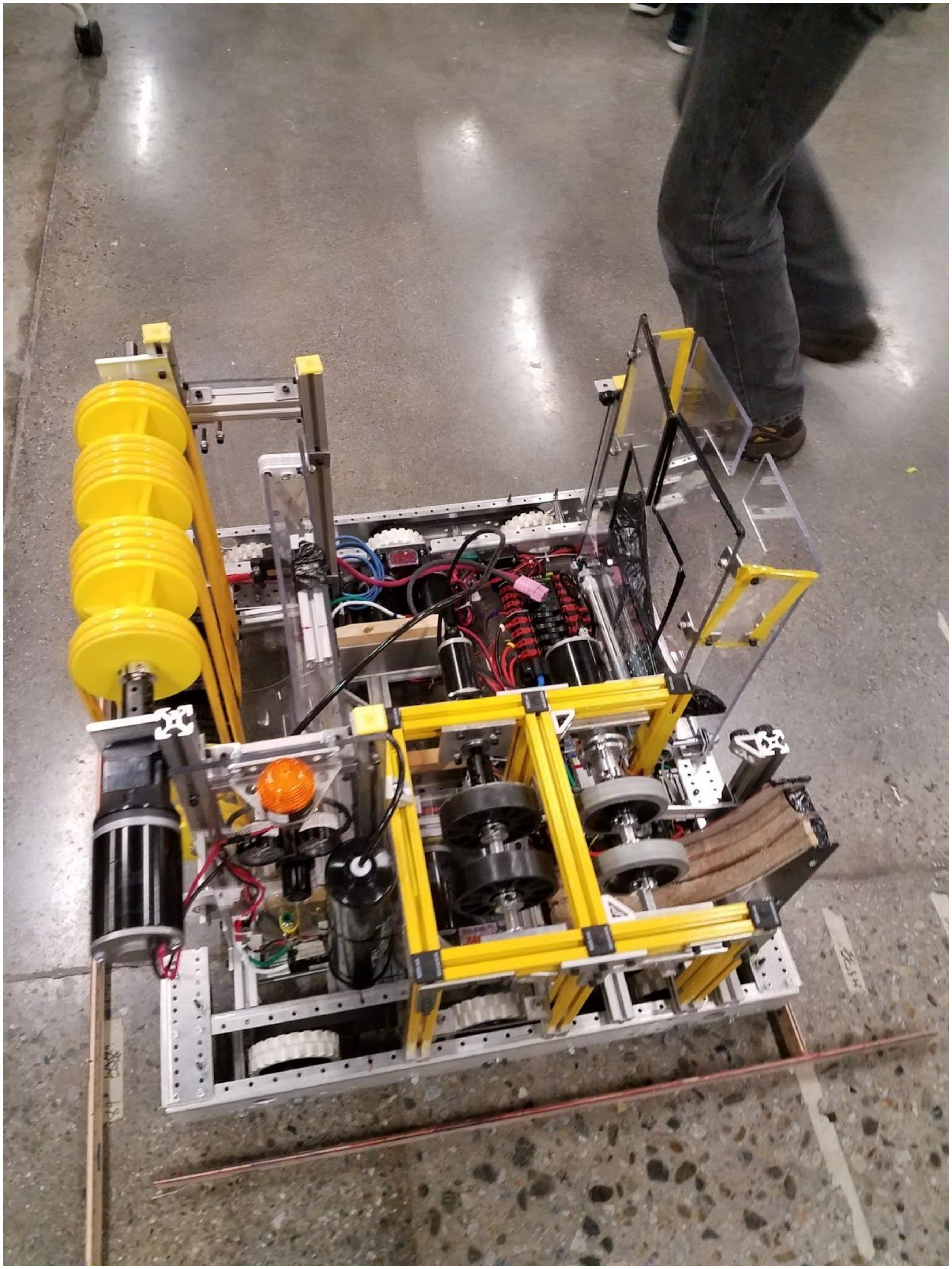
Early prototype of climber



Working on a mounting system for the climber



Early prototyping of ball intake



Picture of the bot right before bag time

Kick off 2017

General Materials
Safety Goggles
Screwdrivers
Alan Wrenches
Screws
Nuts
Bolts
Chisel
Ratchet
Battery
Somewhat of an electrical board

Design 4 (Gear)
- Wood
- Piston
- Motor

Design 1 (Gear)
- Wood

Design 2 (ball)
- Wood
- 3 motors

Design 3 (ball)
- Pvc
- Surgical tubing
- Cardboard
- Wheel

Design 2&3 (rope)
- Gearbox
- CIM motor
- Ratchet
- Metal

COOL CLIMBERS Mike J	BALLERS Mr. Iarrapino	GREAT GEARS Mike R Jamie	INTEGREATION/ Just being awesome Alex
Cole	Piper	Yash Patel	Emily
Angenie	Emily (Lil' Cash Register)	Amanda	Jeff
Khushil	Shivam	Nick	Jeremy
	John	Evan	Connor
Yushai	Igor	Anh	

2017 *FIRST* Robotics Competition
Bill of Materials

Team Name:	perSEVERE	Team #:	5962	Date:	3/5/2017
Event:	NE District - North Shore Event	City:	Lowell	State:	MA

Item	Description		Source	Quantity	Measurement	Unit Price	Total Price
Major System Names Here	*Describe the Part (Axle, Bearing, Lifter, Solenoid)*		*Where did you buy it (Home Depot, AndyMark, Supply House, Etc.)*	*How Many*	*Piece, Inch, Etc.*	*Cost Per Unit ($)*	
Subsystem 1:							
Drive Base	AndyMark Drive Base		Kit Of Parts	1	Kit	$599.00	$0.00
	CIM Motor		Kit Of Parts	4	Piece	$28.00	$0.00
	1030 extruded aluminum(all)		80/20	25	inch	$0.55	$13.75
	10-32 scews (all)		hawkmold.com	200	Piece	$0.10	$20.00
	T-nuts (all)		80/20	200	Piece	$0.16	$32.00
	1010 extruded aluminium(all)		80/20	212	inch	$0.23	$48.76
	1010 extruded aluminium(all)	yellow	80/20	101	inch	$0.41	$41.41
	Polycarbonate Sheets in Clear 1/4" X 48" X 96" Clear Polycarbonate Sheet		eplastics.com	1	piece	**$205.31**	$205.31
						Subtotals:	$361.23
Subsystem 2:							
Ball Inake/Climber	mini-CIM Motor		Kit Of Parts	1	Piece	$24.99	$0.00
	Vex versaplanetary gearbox (50:1; CIM to 1/2" hex)	50:1	Vexpro	1	Piece	$94.94	$94.94
	3D printed rollers		Home-Made	12	Kilogram	$14.99	$179.88
	Hex collar shafts	1/2"	andymark	7	Piece	$4.00	$28.00
	Steel hex shaft	1/2"	McMaster-Carr	40	inch	$0.23	$9.20
	polycord		McMaster-Carr	41.25	feet	$1.53	$63.11
	polycord pins		McMaster-Carr	12	piece	$0.44	$5.28
	Coupler		vexpro	1	piece	$19.99	$19.99
							$0.00
						Subtotals:	$400.40
Subsystem 3:							
Ball Management/Shooter							
	Steel hex shaft	1/2"	McMaster-Carr	28	inch	$0.23	$6.44
	Gearbox(all)		vexpro	2	piece	$69.67	$139.34
	Shooter intake wheels		vexpro	1	piece	$5.00	$5.00
	Shooter wheels		vexpro	2	piece	$10.00	$20.00
	Bag Motor		vexpro	1	piece	$24.99	$24.99
	Hex Hub		Kit Of Parts	4	piece	$9.50	$0.00
	Ball Guides		McMaster-Carr	1	piece	$11.42	$11.42
	pg71 Gearmotor		Andymark	1	piece	$89.00	$89.00
	90 degree rivet bracket		Andymark	25	piece	$0.40	$10.00
	3-D Printed Agitators		Home-Made	3	kilogram	$14.99	$44.97

	Impact Resistant Acrylic (48" x 96" x 1/8")		Home Depot	1	piece	$119.09	$119.09
						Subtotals:	$470.25
Subsystem 4:							
Gear Manipulator	3/4" bore pneumatic cylinder	NCDMB075-0500C	SMC Pneumatics	1	piece	$29.60	$29.60
	125 psi Pressure Relief Valve		McMaster-Carr	1	piece	$5.26	$5.26
	Pressure Gauge		IMI Precision	2	piece	$16.77	$33.54
	Pressure Regulator		IMI Precision	1	piece	$23.74	$23.74
	Angled Brackets		Home Depot	2	piece	$1.86	$3.72
	soleniods		andymark	1	piece	$52.00	$52.00
	PG71		andymark	1	piece	$89.00	$89.00
	8/32 Hardware (bag of 8)		Home Depot	1	piece	$4.83	$4.83
						Subtotals:	$241.69
Subsystem 5:							
Electrical & Software	Power Distribution Panel		andymark	1	piece	$200.00	$200.00
	Pneumatics Control Module		vexpro	1	piece	$88.99	$88.99
	Voltage Regulator Module		vexpro	1	piece	$44.99	$44.99
	Victor SP Motor Controller		vexpro	4	piece	$59.99	$239.96
	Talon SRX encoder breackout board		andymark	2	piece	$10.00	$20.00
	Talon SRX Motor Controller		vexpro	3	piece	$89.99	$269.97
	NI roboRIO		andymark	1	piece	$435.00	$435.00
	Microsoft Lifecam HD-3000 Camera		andymark	3	piece	$32.00	$96.00
	E4T Optical Encoder		andymark	2	piece	$42.00	$84.00
	Green Light Ring (small)		superbrightled	1	piece	$4.95	$4.95
	Green Light Ring (large)		superbrightled	1	piece	$9.95	$9.95
	AmazonBasics 4 port USB hub		amazon	1	piece	$17.00	$17.00
	SanDisk 120 GB SSD drive		ebay	1	piece	$40.00	$40.00
	Ultrosonics with cord		andymark first choice	2	piece		$0.00
	Gyro/Accelerometer		andymark	1	piece	$35.00	$35.00
	Baomain LED indicator Pilot Light		amazon	1	piece	$6.72	$6.72
	Acer Aspire E11 (ES1-111M-P2YU)		walmart	1	piece	$280.00	$280.00
	Hitec Hs-322hd Servo		ebay	1	piece	$10.00	$10.00
	MG996R Servo		Amazon	1	piece	$10.00	$10.00
	CIMcoder		andymark	2	piece	$42.00	$84.00
						Subtotals:	$1,976.53
NOTE: The Fair Market Value provided by *FIRST*® of the Kit Of Parts items are subject to change on an annual basis.							
NOTE: Enter only the Totals Amount on the Export Invoice for Robot value. Be prepared to provide this worksheet upon request.						**Subtotals:**	
NOTE: It the responsibility of each team to complete each section above to get an accurate value for their robot.							
NOTE: Once all items are listed above, insert the subtotals and total in the appropriate boxes.						**Totals:**	**$3,450.10**

2017 *FIRST* Robotics Competition
Bill of Materials

Team Name:	perSEVERE	Team #:	5962	Date:	3/23/2017
Event:	NE District - Southern New Hampshire	City:	Lowell	State:	MA

Item	Description		Source	Quantity	Measurement	Unit Price	Total Price
Major System Names Here	*Describe the Part (Axle, Bearing, Lifter, Solenoid)*		*Where did you buy it (Home Depot, AndyMark, Supply House, Etc.)*	*How Many*	*Piece, Inch, Etc.*	*Cost Per Unit ($)*	
Subsystem 1:							
Drive Base	AndyMark Drive Base		Kit Of Parts	1	Kit	$599.00	$0.00
	CIM Motor		Kit Of Parts	4	Piece	$28.00	$0.00
	1030 extruded aluminum(all)		80/20	25	inch	$0.55	$13.75
	10-32 scews (all)		hawkmold.com	200	Piece	$0.10	$20.00
	T-nuts (all)		80/20	200	Piece	$0.16	$32.00
	1010 extruded aluminium(all)		80/20	212	inch	$0.23	$48.76
	1010 extruded aluminium(all)	yellow	80/20	101	inch	$0.41	$41.41
	Polycarbonate Sheets in Clear 1/4" X 48" X 96" Clear Polycarbonate Sheet		eplastics.com	1	piece	**$205.31**	$205.31
						Subtotals:	$361.23
Subsystem 2:							
Ball Intake/Climber	mini-CIM Motor		Kit Of Parts	1	Piece	$24.99	$0.00
	Vex versaplanetary gearbox (50:1; CIM to 1/2" hex)	50:1	Vexpro	1	Piece	$94.94	$94.94
	3D printed rollers		Home-Made	12	Kilogram	$14.99	$179.88
	Hex collar shafts	1/2"	andymark	7	Piece	$4.00	$28.00
	Steel hex shaft	1/2"	McMaster-Carr	40	inch	$0.23	$9.20
	polycord		McMaster-Carr	41.25	feet	$1.53	$63.11
	polycord pins		McMaster-Carr	12	piece	$0.44	$5.28
	Coupler		vexpro	1	piece	$19.99	$19.99
	1/2"Adjustable Ratchet		Sears	1	piece	$71.96	$71.96
	15 Series & Ready Tube 2 Hole Gusseted inside Corner Bracket		8020	4	piece	$4.30	$17.20
						Subtotals:	$489.56
Subsystem 3:							
Ball Management/Shooter							
	Steel hex shaft	1/2"	McMaster-Carr	28	inch	$0.23	$6.44
	Gearbox(all)		vexpro	2	piece	$69.67	$139.34
	Shooter intake wheels		vexpro	1	piece	$5.00	$5.00
	Shooter wheels		vexpro	2	piece	$10.00	$20.00
	Bag Motor		vexpro	1	piece	$24.99	$24.99
	Hex Hub		Kit Of Parts	4	piece	$9.50	$0.00
	Acrylic Sheet		McMaster-Carr	1	piece	$11.42	$11.42
	pg71 Gearmotor		Andymark	1	piece	$89.00	$89.00

	90 degree rivet bracket		Andymark	25	piece	$0.40	$10.00
	2 7/8" x .4" banebot t40 Wheels		Banebots	8	piece	$2.70	$21.60
	1/4" Brushed Aluminum Machined Bracket (24" x 24" sheet)		McMaster-Carr/ homemade	1	piece	$193.20	$193.20
						Subtotals:	$520.99
Subsystem 4:							
Gear Manipulator	3/4" bore pneumatic cylinder	NCDMB075-0500C	SMC Pneumatics	1	piece	$29.60	$29.60
	125 psi Pressure Relief Valve		McMaster-Carr	1	piece	$5.26	$5.26
	Pressure Gauge		IMI Precision	2	piece	$16.77	$33.54
	Clippard Air Tank 574mL		Andymark	1	piece	$14.00	$14.00
	Pressure Regulator		IMI Precision	1	piece	$23.74	$23.74
	Angled Brackets		Home Depot	2	piece	$1.86	$3.72
	soleniods		andymark	1	piece	$52.00	$52.00
	PG71		andymark	1	piece	$89.00	$89.00
	8/32 Hardware (bag of 8)		Home Depot	1	piece	$4.83	$4.83
						Subtotals:	$255.69
Subsystem 5:							
Electrical & Software	Power Distribution Panel		andymark	1	piece	$200.00	$200.00
	Pneumatics Control Module		vexpro	1	piece	$88.99	$88.99
	Voltage Regulator Module		vexpro	1	piece	$44.99	$44.99
	Victor SP Motor Controller		vexpro	5	piece	$59.99	$299.95
	Talon SRX Motor Controller		vexpro	2	piece	$89.99	$179.98
	NI roboRIO		andymark	1	piece	$435.00	$435.00
	Microsoft Lifecam HD-3000 Camera		andymark	3	piece	$32.00	$96.00
	E4T Optical Encoder		andymark	2	piece	$42.00	$84.00
	Green Light Ring (small)		superbrightled	1	piece	$4.95	$4.95
	Green Light Ring (large)		superbrightled	1	piece	$9.95	$9.95
	AmazonBasics 4 port USB hub		amazon	1	piece	$17.00	$17.00
	SanDisk 120 GB SSD drive		ebay	1	piece	$40.00	$40.00
	Ultrosonics with cord		andymark first choice	2	piece	$0.00	$0.00
	Gyro/Accelerometer		andymark	1	piece	$35.00	$35.00
	Baomain LED indicator Pilot Light		amazon	1	piece	$6.72	$6.72
	Acer Aspire E11 (ES1-111M-P2YU)		walmart	1	piece	$280.00	$280.00
	Hitec Hs-322hd Servo		ebay	1	piece	$10.00	$10.00
	MG996R Servo		Amazon	1	piece	$10.00	$10.00
	CIMcoder		andymark	2	piece	$42.00	$84.00
						Subtotals:	$1,926.53
NOTE: The Fair Market Value provided by *FIRST*® of the Kit Of Parts items are subject to change on an annual basis.							
NOTE: Enter only the Totals Amount on the Export Invoice for Robot value. Be prepared to provide this worksheet upon request.						**Subtotals:**	
NOTE: It the responsibility of each team to complete each section above to get an accurate value for their robot.							
NOTE: Once all items are listed above, insert the subtotals and total in the appropriate boxes.						**Totals:**	**$3,554.00**