ANIMATRONICS ROBOTICS

Team #14300

Dougherty Valley High School, San Ramon, CA

HIGHLIGHTS OF 2019-2020 SEASON

ENGINEERING SUMMARY

ROBOT PART	HIGHLIGHTS	Page No
Final Robot Design	What the robot we are taking to regionals looks like	
Chassis	The structure for the base of the robot	
Drawer Slide Lift	A mechanism that extends vertically to stack blocks	
Block Intake	A suction mechanism to draw-in blocks	
Claw	Can hold blocks to stack	
Drawer Lift Extender	Provides flexibility to stack blocks easily	

MOTIVATE OUTREACH SUMMARY

Timeline	EVENT	Page No
May 2019	Education Day at Giants Baseball game: 1000+ students from 25+ schools	
June 2019	Robotic day at Alameda County Fair: 800+ students from 39+ schools	
July 2019	Hosted Robotics Info session @ Quail Run Elementary School	
Aug 2019	Community Clean-up: Team cleaned the outside of 2 schools in the community to inspire other kids	
Sep 2019	Mentored FLL team: Team Robo-Rockstars: design and presentation	
Nov 2019	Robotics Info session- Bella Vista Elementary School	
Dec 2019	First Robotics Booth at a local Indian community festival. Over 300 kids from 12+ schools stopped by to learn and play	

CONNECT OUTREACH SUMMARY

Timeline	EVENT	Page No
May 2019	Learning from experienced FTC team ACME (#8367)	
June 2019	Synechron (Services organization): Successful sponsor pitch	
June 2019	Learn/exchange ideas with experienced FTC team Bio-Bots (#14318)	
July 2019	Fluid Touch (Educational Apps company): Successful sponsor pitch	

Aug 2019	Consulted and received assistance with Graphic design and team logo from Expert at Arista Networks (Networking organization)	
Sep 2019	Learned all about CAD software from an industry expert at Qualcomm	
Nov 2019	Fisec Global (Consulting services org): Successful sponsor pitch	
Dec 2019	Exchanged ideas with experienced FTC team Iron Reign (#6832)	

BUSINESS AND MARKETING

TOPIC	HIGHLIGHTS	PAGE NO
Successful Sponsors and attempts	We display our attempts at receiving much-needed sponsorships, failures and success.	
Team Logo	Our thought process for creating a team logo, including help from outside mentors	
Creating Tri-Valley Robotics	Created Non-Profit organization: Tri-Valley Robotics	

SOFTWARE

TOPIC	HIGHLIGHTS	PAGE NO
CAD DESIGNS	How CAD helped us design our robot	
AUTONOMOUS	How we programmed for autonomous period	
SENSORS	Which sensors we used and why	

1. The Team

Team Animatronics is comprised of a group of high schoolers interested in robotics who live in San Ramon, CA. The team members are ninth graders that attend Dougherty Valley High School. The team was founded in 2016. They started with First Lego League and one of the major achievements was getting a first prize in the “Most Innovative Idea” category for their “Flapper Stopper” product which saves hundreds of gallons of water in each household by optimizing the amount of water used in a toilet flush. The team then moved on to First Tech Challenge and 2018-2019 was Rookie year for the team. The team participated in 3 qualifiers in the 2018-2019 season and overcame several challenges and successfully won the “Finals” in the FTC Qualifiers held at Walnut Creek, CA. Team Animatronics has been actively involved in educating the local community to get more kids interested in Robotics and First challenges. They participated in San Jose Education Day and Alameda county fair during the off-season to reach out to a large number of students to motivate them in STEM. Team Animatronics is mentored by a few industry experts in various fields and some dedicated parents who motivate and guide the team.

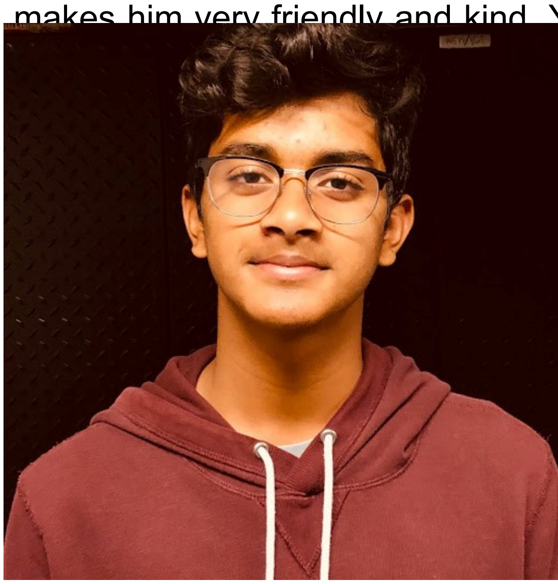
First Prize: Walnut Creek Qualifier, Jan 2019

Innovation award: FLL 2017

1.1 Team members

<u>**Sai Chebrolu** - Hardware Lead, Captain, Driver-1</u>

Sai has been with Team Animatronics since 2016. Sai has a strong passion for playing soccer. Sai goes to the park whenever he's free to play soccer with his friends and get better. He is the driver of the drive station and lift mechanism of the robot and the hardware lead. Sai chose this lead as the team felt he wouldn’t break under pressure during competition. He has an enjoyable personality which makes him very friendly and kind. You can always catch Sai smiling and making



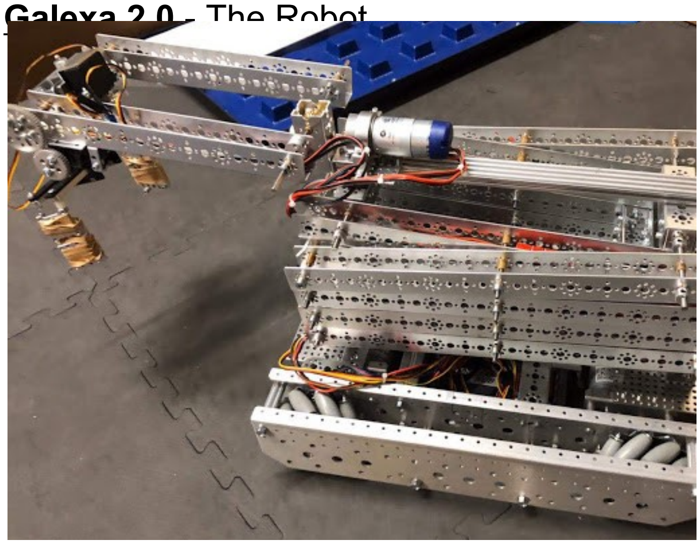
Why did you join the team?

I joined robotics because I want to help improve the future of engineering. I enjoy working with technology and seeing what I build come to life and become animated. As well as working on hardware, I take pleasure in writing software and program.

Where do you envision robotics most used in the future?

I feel robotics will be a major influence in the fields of military and medicine. I want to be a Hardware Design Engineer as my career goal.

Galexa 2.0 - The Robot



This is Galexa 2.0, Robot for team Animatronics. Galexa 2.0 is 3 months old and is home schooled. Galexa thinks Robots are never EVER going to take over the world *wink* *wink*. Her future goal is to help us win the Inspire award and the Winning Alliance Captain Award.

1.2 Mentors

Rambabu Chebrolu - Mentor & Engineering advisor: Mr. Rambabu is a Software Architect with experience in designing and developing software solutions for Cloud Video platform, a digital Set-Top-Box, Cable and Satellite Video broadcasting and the IT industry. He has worked for some large tech firms like Cisco and Comcast. His love for technology, robots and anything mechanical makes him the perfect mentor to motivate and help the team.

1.3 Team plan and strategy

The success of a team depends on how well they plan ahead and strategize the game plan. The first thing we did when we met as a team in the summer was to come up with an overall strategy for the season. We all agreed to the team principles that we will adhere by and assigned roles to everyone. Below are the details of our team principles, roles and our schedule planner for the season.

1.3.1 2019-20 Season planning and strategy

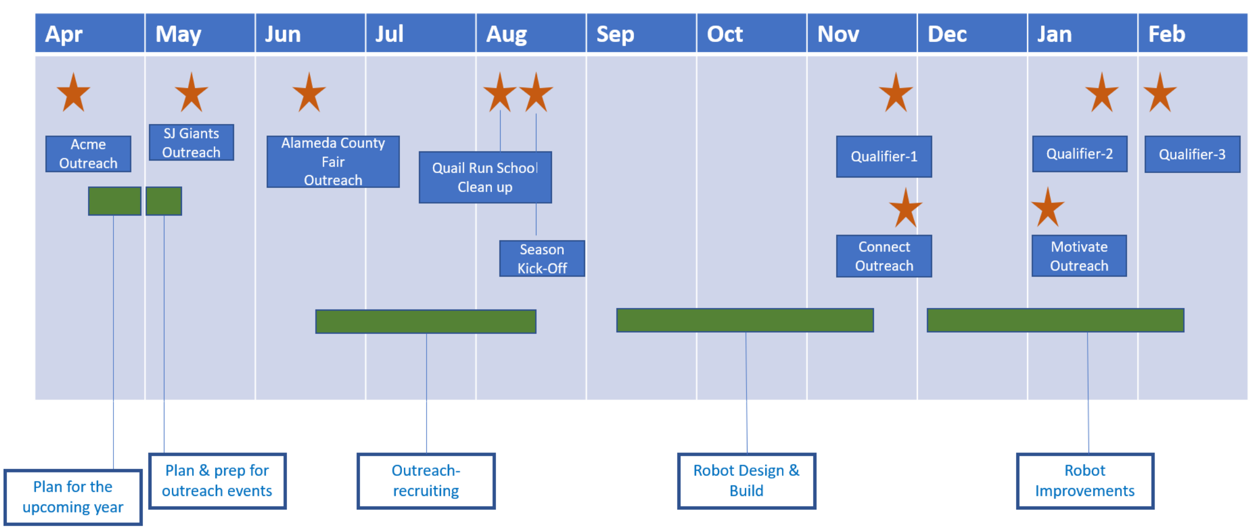
Key team Principles	- Taking responsibility and being Accountable - Goal setting and deadlines - Adhering to deadlines - Communications - Helping each other
Documentation	- Engineering Notebook - Hardware - Engineering Notebook - Software - Outreach Notebook - Reaching out to custom parts manufacturers
Team Roles	- Notebook lead - Hardware design lead - Software lead - Drivers - Captain - Scheduler/planner
Learning	- Autocad - Java/Android Studio - Design sessions - Github - Learning from others

1.3.2 2019-20 Team roles and definitions

Role	Responsibility
Software lead	Lead software strategy for the team. Brainstorm ideas with team members. Seek guidance from mentor(s). Online research. Accountable for completing the software portion of the robot. Work with H/W team to ensure the software goes along with the H/W design.
Hardware lead	Lead hardware design and build for the team. Brainstorm ideas with team members. Seek guidance from mentor(s). Online research. Identify appropriate suppliers for the parts needed. Work with the treasurer to order parts. Overall responsibility for completing the hardware portion of the robot. Work with S/W team to ensure the software goes along with the H/W design.

Drive Coach	Works with the drivers during competitions. Devices the game plan for each competition.
Planning lead	Responsible for the overall plan for the season. Comes up with the initial plan by working with team members and Mentors. Responsible for the upkeep of the plan throughout the season. Works with communication lead on communications
Notebook lead	Leads notebook related activities. Works with other team members to keep the Engineering notebook up to date. Works with notebook helpers to complete the outreach notebook on a periodic basis.
Communications Lead	Responsible for the communications internally. Keeps everyone on the same page with regards to latest status.
Outreach Lead	Responsible for planning and organizing outreach activities, including communications. Works with Planning lead and the team to ensure the team is ready for outreach events and activities.
Scouting lead	Comes up with the framework for scouting.Works with other team members to organize scouting

1.3.3 Season Schedule:



1.3.4 Weekly plan for 2019-20 season

Pre-season	• Sponsor letter and video • Synechron

	● Fisec global ● Fluid touch
Week 1	● Daly city kickoff ● Coming up with basic design
Week 2	● Original claw ● Original lift ● Cad designs ● Deciding drive train
Week 3	● Motors ● Constructing drivetrain and chassis ● Using encoders
Week 4	● Constructing claw and lift ● Deciding on string
Week 5	● Thinking about logos ● Contacting William Bailey ● Asking Anirudh Bhat for CAD help
Week 6	● Thought process of new kit ● Lift fail ● Claw oversized (failed)
Week 7	● Back to the drawing board ● Craw and lift new ideas ● Making poster board
Week 8	● Building claw ● Building lift ● Deciding motors ● Developing a Lap Stone
Week 9	● Lift extender design process ● Expansion hub breaking ● Going to David Chen
Week 10	● Color sensor testing ● Distance sensor testing ● Vuforia testing ● Driving practice

Week 11	● Driving practice ● Autonomous ● Competition Presentation

2. Business Plan and Marketing

Our team made significant efforts this season to have a solid business plan to support our financial and marketing needs. We successfully got 3 sponsors which helped us tremendously with our budget. We have streamlined our marketing and promotional material and can now reach out to organization and potential sponsors with a short notice.

2.1 Financial Statement

Item	Cost	Category	Explanation
Expenses			
Registration	$275	Registration	Registration Fees from FIRST and FIRST WA
Field	$0		Re-used Field from previous year
Qualifiers Registration	$500	NorCal FTC	Registration for qualifier rounds
Parts & Supplies	$4000	Robot	Annual parts and new technology

		Supplies	
Miscellaneous	$500	Others	Hoodies and other miscellaneous items
Creating Non-Profit Org	$800	Others	Fees to create a non-profit organization
Sub-total	**$6075**		Projected total expenses for the 2018-19 season.
Income			
Parent Donations	$2000	Income	Donations from parents
Sponsors	$3500	Income	Grants/sponsorship from organizations
Robotics Workshop	$1638	Income	Money raised from Robotics workshop donations
Sub-total	**$7638**		Projected amount of money coming in during the 2018-19 season.

2.2 Marketing activity

Having a sponsor would be very beneficial for our team by helping in numerous ways. A team sponsor helping to fund our team would lessen the heavy expenses caused by building a robot. Having a sponsor means we don't have to worry about spending too much on the robot, and instead we could devote more time into actually building and testing out our robot and making it the best possible.

This large effort put forth by our team this year to get a sponsor worked. Our efforts not only got us one sponsor, but three sponsors that could all help lower the team expenses.

Our team trying to receive sponsorships not only benefited our team, it also benefited robotics as a whole. We introduced these sponsors to the world of FIRST and robotics. We sparked interest in the minds of the sponsors which could help get them further involved in robotics.

The following is the letter sent to our potential sponsors:

Dear Potential Sponsor,
Hello, we are Team Animatronics. Team Animatronics is a group of nine 9th graders who attend Dougherty Valley High School. Team Animatronics participates in a robotics event called FTC. FTC is short for First Tech Challenge. The First Tech Challenge is designed for students from grades 7–12 to compete head to head, by designing, building, and programming a robot to complete tasks in order to score points. The robot kit is programmed using Java, the MIT App Inventor, or other Android programming systems. Teams compete in this competition with an alliance format. For example, in the previous season, the game was called Rover Ruckus.

We have written this letter to your company to request for your support. We need the sponsorship funds to offset the cost of building parts or all of our team's necessary expenditures, and any donation amount would aid our team greatly. The parts we use for our robot are very costly and we use many of them. It would be our pleasure to give your company recognition by adding your team logo to team clothes, posters, etc. All of these examples are shown to a wide array of people. Sponsors will also help us win awards. We would like to offer three different levels of sponsorship, Silver, Gold, and Platinum. Silver sponsors donate 500 dollars. Gold Sponsors donate around 1,500 dollars. Finally, Platinum Sponsors Donate around 3,000 dollars. Silver Sponsor's logos will not be guaranteed to be placed on our team clothes unless we get another sponsor, but all sponsor logos will be posted on our team poster. It would mean a great deal to all of our team members if you decide to sponsor our team. Thank you for giving Team Animatronics a chance. We all greatly appreciate it.

Based on the amount of money you give us, we can then use that money in different ways to increase our, and your benefit. The more money we have, the more we can do for you. Here is an approximation of what we can do based on the donations we receive from you:

Silver= Poster, (shirts if another sponsor provides sufficient money, logo size-)

Gold = Poster, Shirts, Hoodies(logo size-)

Platinum = Poster, Shirts, hoodies, and advertisement (logo size-)

These are some of the projects that we need to offset the cost of:

Parts for the robot; $3,432.09

Team Registration; $550 per person

Team Clothes; 850-and more depending on the sponsor plan

Sincerely,

Team Animatronics

2.3 Our sponsors

- **<u>Synechron</u>**

  Synechron Inc. is a New York-based information technology and consulting company focused on the financial services industry including capital markets, insurance, banking and digital.

- **<u>Fluid Touch</u>**

  Fluid Touch is dedicated to creating note taking and diary apps for the iPhone and iPad. Officially founded in 2009, they are a team of developers, designers and marketers that have built two critically acclaimed apps — Noteshelf and Daily Notes. Both the apps have a loyal fan base across the world and continue to enjoy success on the App Store.

- **FiSec Global, Inc**
  They are a US based company, headquartered in California, SFO. They provide a comprehensive range of software and technology solutions to the business world. The technology and marketing alliances with reputed companies across the world enable them in providing seamless support and services to customers.

Promoting Sponsors: To further support our sponsors, we decided to wear FiSec branded lanyards.

FiSec, has been kind enough to provide us with FiSec lanyards. This way, everyone at the competition will be able to see that FiSec sponsored our team.

We are very thankful for all the sponsors have done for us. They have devoted their time, energy, and funds in order for our team to *thrive*. As a result, we want to give back to the sponsors in any way we can.

Sponsor Lanyard

Attached to the lanyards will be a list of or sponsors. Team Animatronics is doing this to show we are a strong team funded by numerous sponsors.

In a final attempt to give thanks to our three sponsors, we are designating a spot for their logo on our Team posters as an extra step to show who we are funded by.

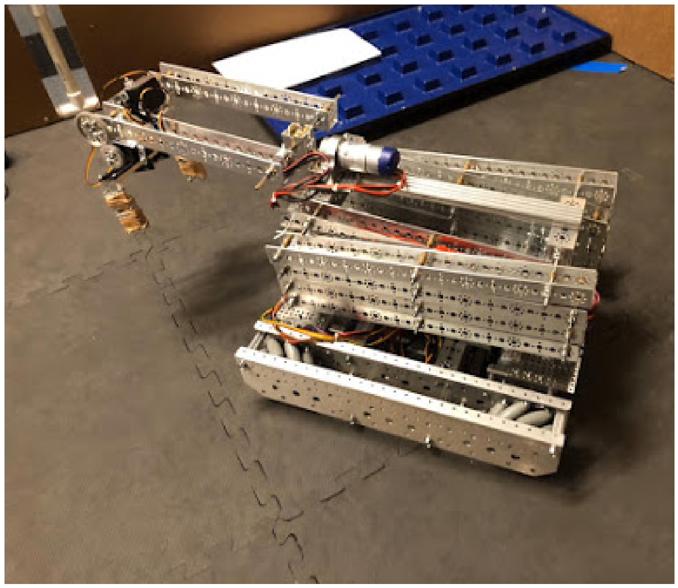
2.4 Other sponsorship efforts

Team animatronics has been continuously trying to reach out to other organizations to connect with them and convert them to a potential sponsor. Below are a few organizations where we have made significant progress and we are few steps away from getting sponsored by them.

VMWare
Home Depot

3. Engineering design: Hardware

3.1 Robot Design overview



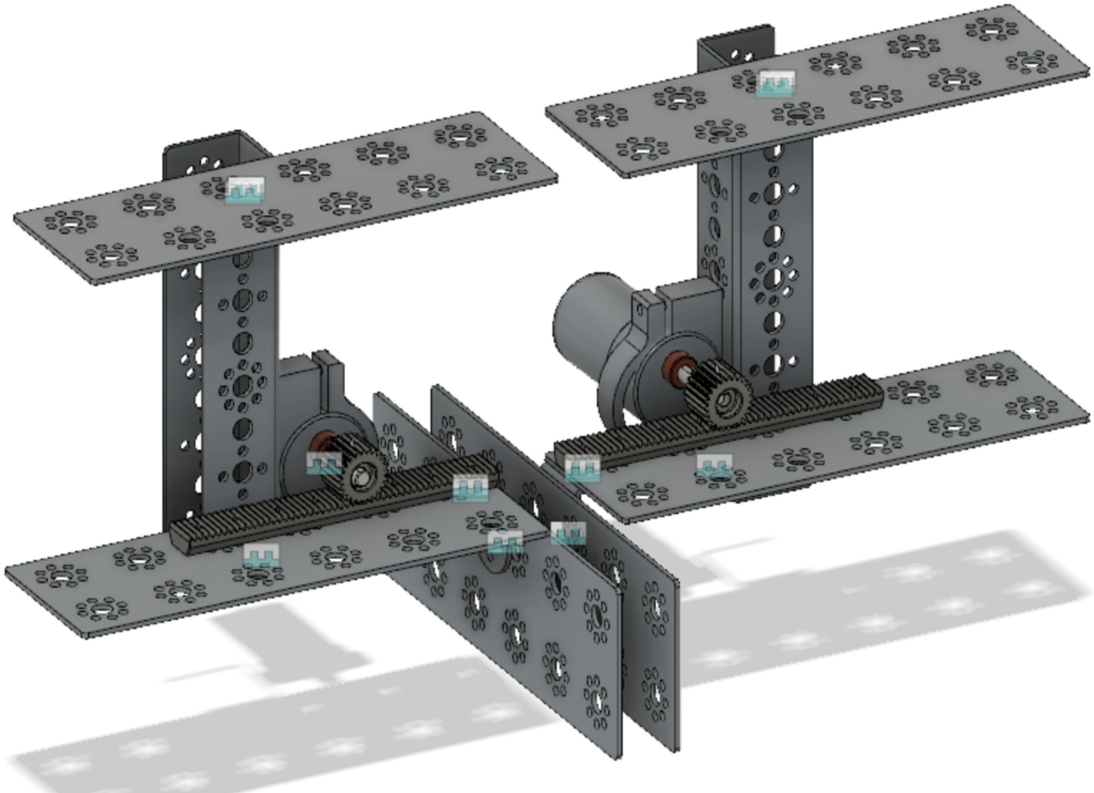
The robot's power lies in the claw. A product of countless iterations, the claw has an impressive 270-degree spherical rotation. This results in the claw being able to grab blocks in areas where most other contraptions fail. Originally, the claw was designed in CAD. CAD allowed us to make multiple prototypes of the claw without physically constructing them. This helped us save both materials and time.

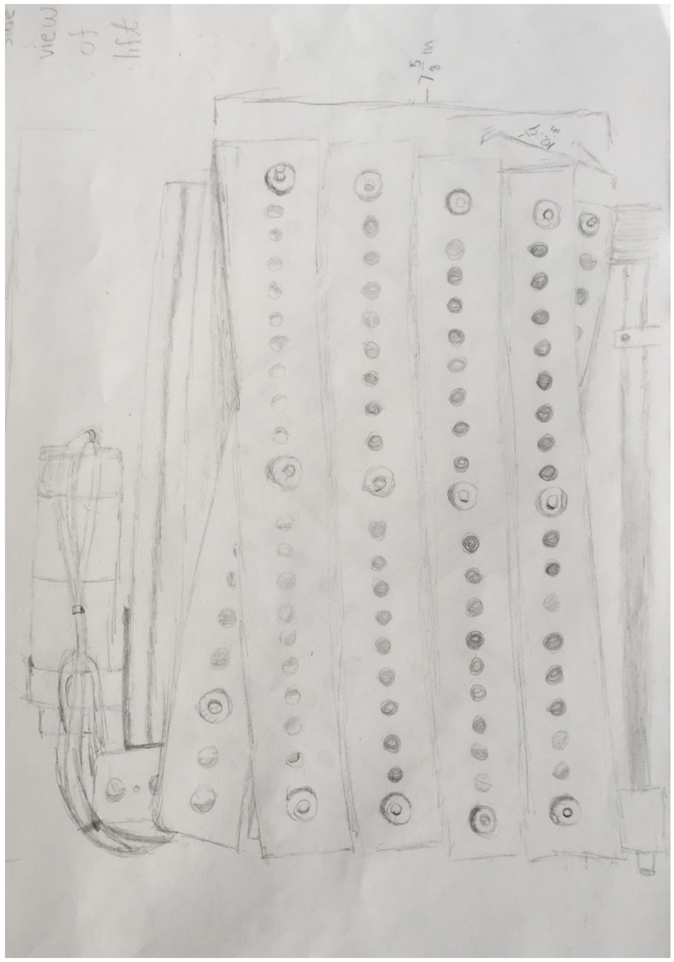
Furthermore, the robot features a scissor lift design. We chose the scissor lift over the other lift designs because of the speed that it possesses when it comes to retraction and extension. The scissor lift is also more durable than our first iteration of the lift, the linear slides. Linear slides sounded good in theory, but truly they didn't perform well. They were wobbly, took too long to extend and contract, and couldn't extend that far out. They were also too fragile to withstand the rough and tough of the competition. We then had to come up with a new lift design.

We inbuilt 3 sensors into the robot: A touch sensor, a distance sensor, and a color sensor. These three sensors are crucial for the robot to run. The robot utilizes the touch sensor to make sure that it doesn't bump into obstacles. That ensures that the robot doesn't get damaged by running too hard into a wall during autonomous. The distance sensor ensures that the robot doesn't hit obstacles. It also tells the robot how close it is to an object, which is useful for picking up stones in autonomous. The color sensor tells the robot which way it is facing by detecting the pictures on each wall. This is utilized by the autonomous, where the specific route the robot has to take can incorporate the pictures to know when to turn. With sensors, our robot is both durable and smart.

3.2 AUTOCAD designing

We brainstormed ideas for a claw and created their CAD designs with the mechanism to close the claw and open. We chose one of the three ideas and decided to improve upon the design.



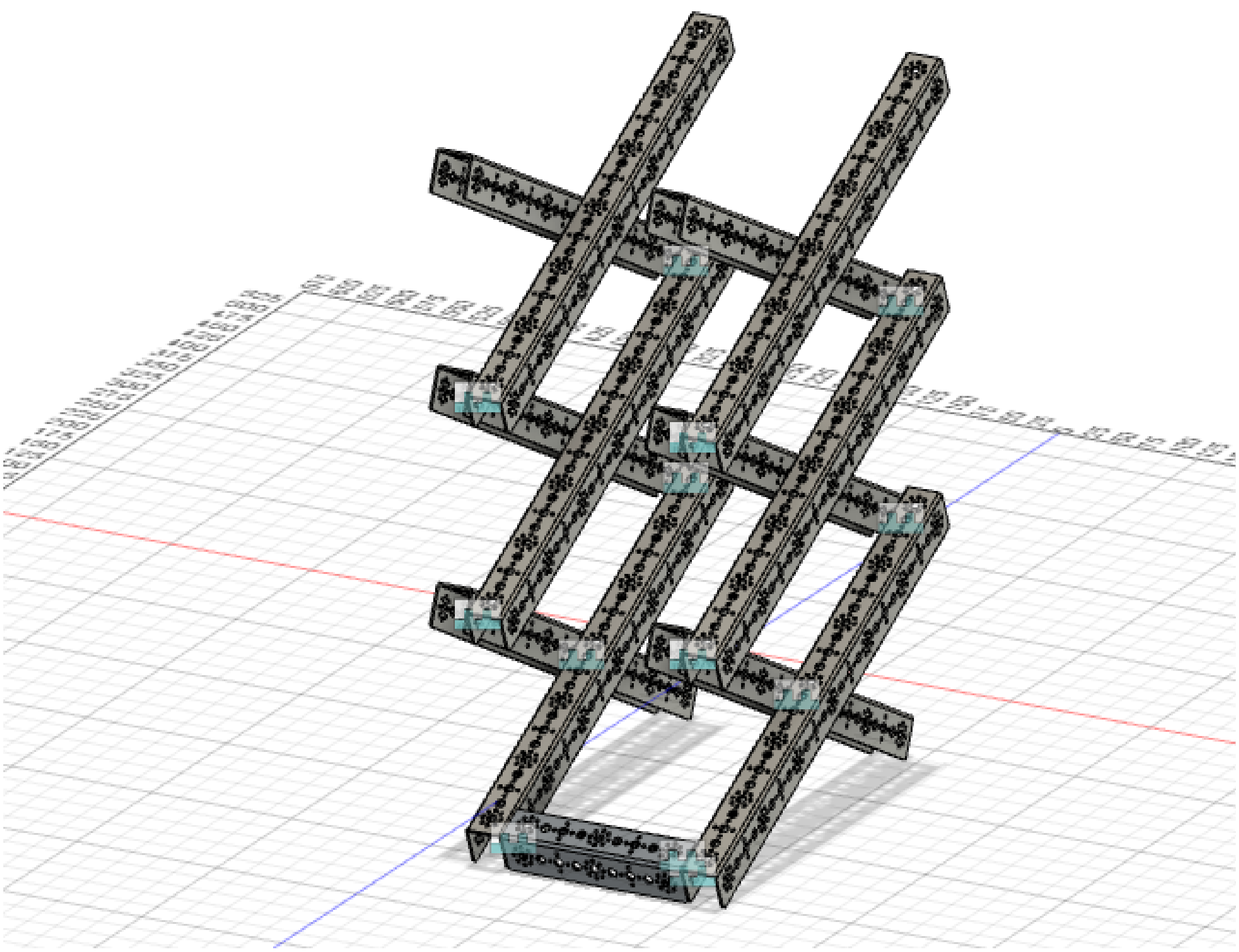


This design had used a pulley system. We added exponential growth to the power of an object that applies at the beginning. This basic principle is what we used last year as well to extend a heavy arm. The idea was agreed upon and we began constructing the arm and claw.

Our team used a strong thread to loop through our pulley system. When we had attached the lift it’s initial performance was outstanding. It was smooth, fast and agile but when we began to attach the claw the flaws became more and more apparent. The claw was too heavy for the linear slides to hold and continuously be stable. On top of this, the linear slide was also too tall to fit under the 14 ft bars. This required our team to do some serious redesigning.

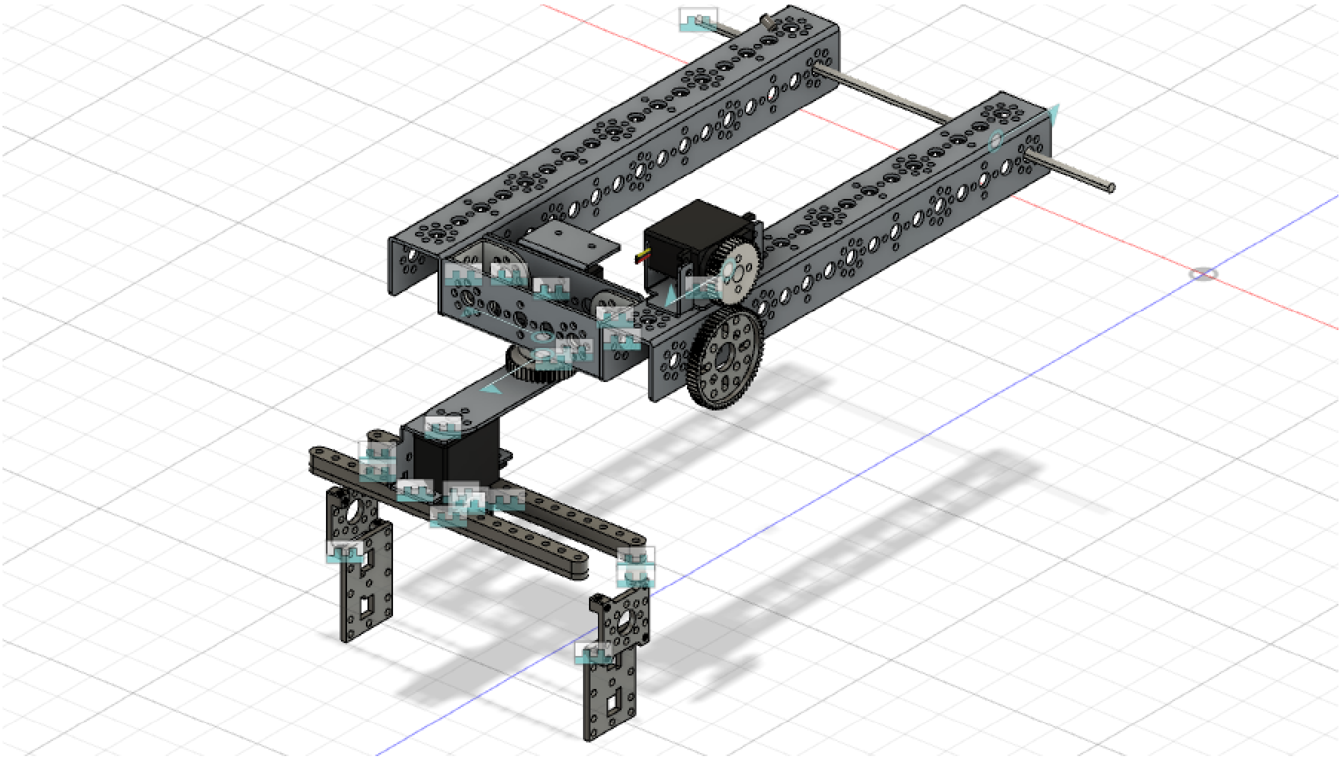
The team then got together to brainstorm ideas to fix the lift to be stronger under 14ft and durable. We came up with 6 ideas and discussed the pros and cons of each design. Lifts with heavy cons outweighing the pros we immediately dropped as we wanted more pros.

We then narrowed our options down to the scissor lift. Its real-life application had already made it a strong candidate as it had given us a lot of data on what its pros and cons are. Our team then split into two teams. One was to figure out ideas on how to attach a claw to the scissor lift and tell the other team, who is designing the Scissor lift on cad, how they will attach it. When we finished our CAD design we had a plan in mind on how to attach the mechanism learning from our failures of the linear slides.

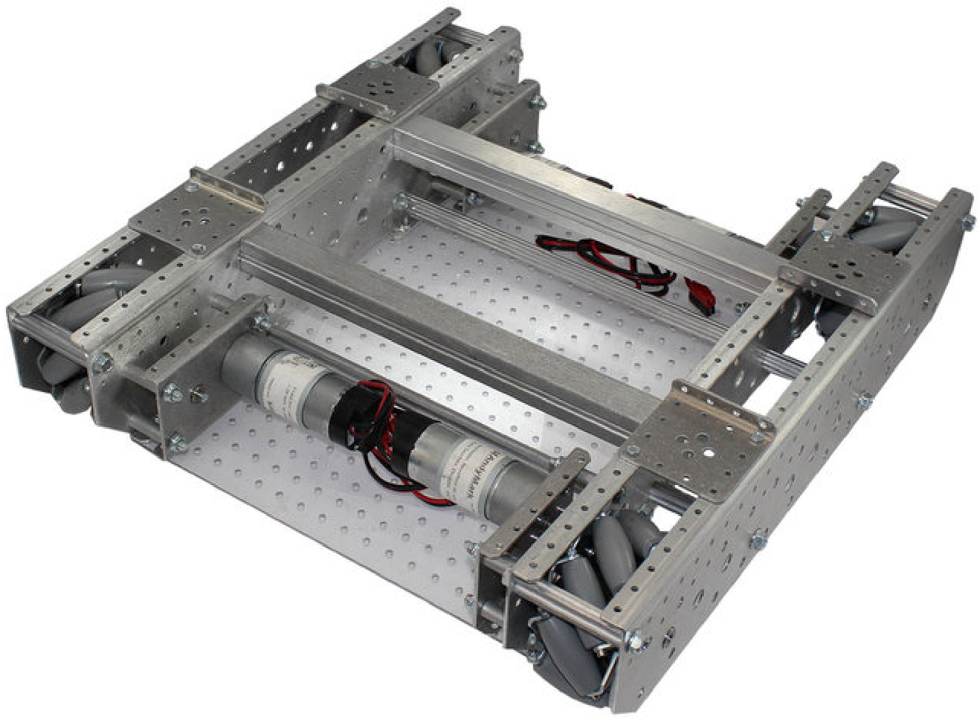


This design pros heavily outweigh the cons our team thought of, the cons were simply being difficult to attach to the robot.

After our team's drivers tested the robot on our field they experienced a difficulty we had all noticed while watching. To pick up the block the driver controlling the drive train had to position himself either parallel or perpendicular to the brick so the second driver can pick up the brick. Our team arrived at the conclusion of redesigning our claws features. We then noticed other flaws with this design as it is extremely heavy it requires a strong motor to lift it. This led us to create a lighter design with a plastic and metal beam for stability and to make it light. We also switched the DC motor to a servo motor to make it even lighter. Finally, we added 2 servos sacrificing some of the weight we took off. The outcome was one of the best features of our robot. We ran a simulation in CAD to test it and it can turn from side to side and up and down. This could help our drivers collect bricks from all positions. Now CAD is of course very robotic making it seem to move perfectly in a 180-degree circular motion. When our drivers tested it out on the field the result allowed it to move in a 270-degree spherical motion.



3.3 Base Chassis design



Driver Base

For this season we decided to use the Rev TileRunner. This chassis model comes in several versions. The TileRunner has a well made and supported base made of 0.09-inch thick aluminum components that provide a sturdy structure to build on. This is very important in this year's challenge where the robot is surely going to collide with other robots and structural integrity is very important so our robot doesn’t malfunction or disconnect in the middle of the round. We decided to get the mecanum version because we decided that a mecanum drive train would be the best drivetrain for this year’s challenge. The chassis is made of 4 mecanum wheels, 4 Neverest Classic 40 Gearmotor, 2 TileRunner Outside Plate and a Perforated Polycarbonate sheet.

Drivetrain Choice

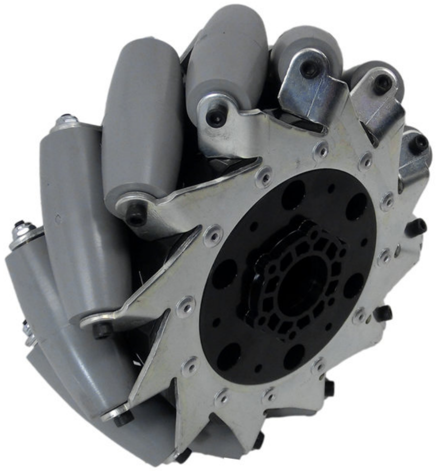
Before we decided what type of drivetrain to use we came up with important traits our robot should have. We decided that the most beneficial traits to have this year are:

- Having quickness
- Being able to maneuver
- Being able to withstand collisions

For the important trait of being quick, it is important to know that motors are what is in control of power and speed. The wheels are just complementary to the motors to maximize the power and speed.

The second point is to be able to maneuver on the playfield. A key aspect of maneuvering side to side using lateral movement. The two types of wheels we can use for this are Omni wheels and mecanum wheels.

Wheel Choice

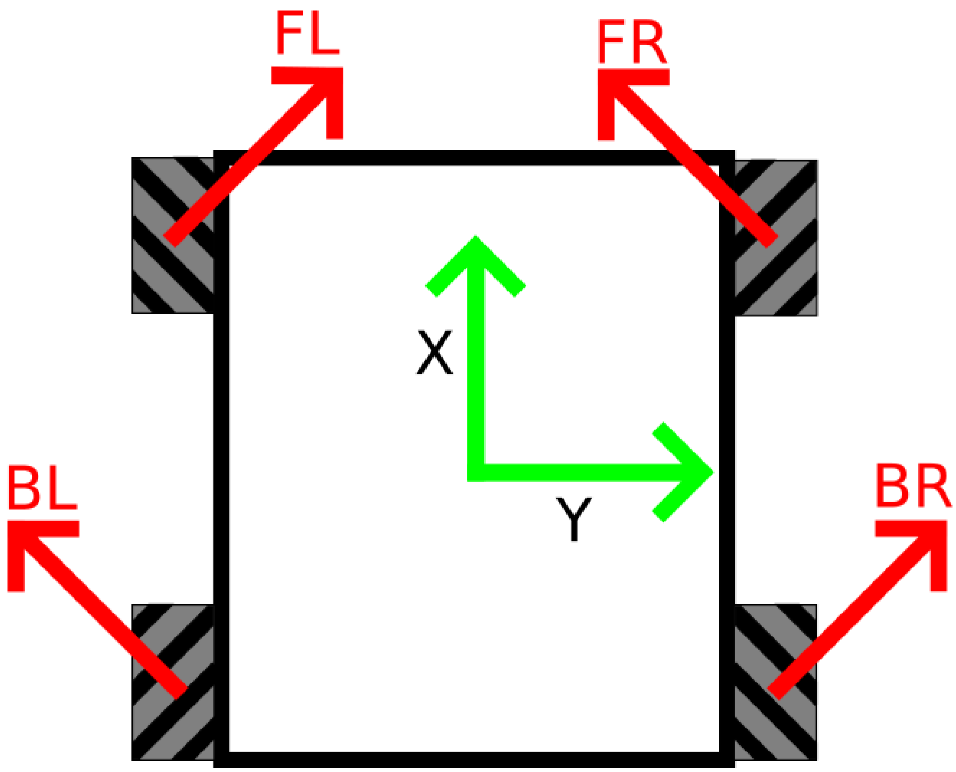


For the third point of being able to withstand collision, we need a whole robot that is sturdy, including to a base, which is why we decided to get a chassis that has sturdy wheel protectors.

Since the choice comes down to Omni or mecanum wheels; mecanum wheels are the way to go because they are built with metal exterior and rubber rotators while Omni wheels have an all-plastic build which is very weak. These wheels can handle a 200-pound load per wheel for a total 800-pound load when used as drive wheels. The interior body of this wheel is made of molded black polycarbonate, while the perimeter side plate is made of 1/8 inch thick steel, zinc plated. The perimeter plate is attached to the interior body, and each perimeter bent tab rests on the interior body rim. This support allows the wheel to handle more load.

Through intense research, we saw that Omni wheels had a bad record of being unsustainable and not being fully efficient. We realized Omni wheels couldn’t be relied upon as they, over time, would start to slowly be down and start to become less efficient.

The wheels are able to move in a lateral motion due to their diagonal rollers on the wheels. As seen in the image below, these rollers push the robot in the direction perpendicular to them. This way if the FL and FR wheels both move forward, the robot itself can move forward because the two directions cancel out and it moves in the center. To move sideways, the two wheels that are on the side the robot wants to move inwards while the other two move outwards.



After thinking about these factors it was very obvious as to what type of drivetrain to choose, so the final decision was to use a mecanum wheel/ chassis. The mecanum wheel was proven to be the right choice.

Benefits

- Has metal exterior

- Ability to go sideways
- Stability

The mecanum wheels having a metal exterior meant they were very strong and durable. The Omni wheels had rubber wheel exteriors meaning they couldn't be as durable as the mecanum wheels. The mecanum wheels could be proven to last much longer and be more sustainable.

The ability to go sideways may seem like a minor benefit, but it is very beneficial in competition. The wheels are much easier to control and we don’t need to get out of a tight space.

The mecanum wheels have more surface area than Omni wheels meaning it can be more stable than the Omni wheels. Omni wheels don’t have that much surface area, and holding up the heavy robot we have would pose a difficult challenge.

Motor choice

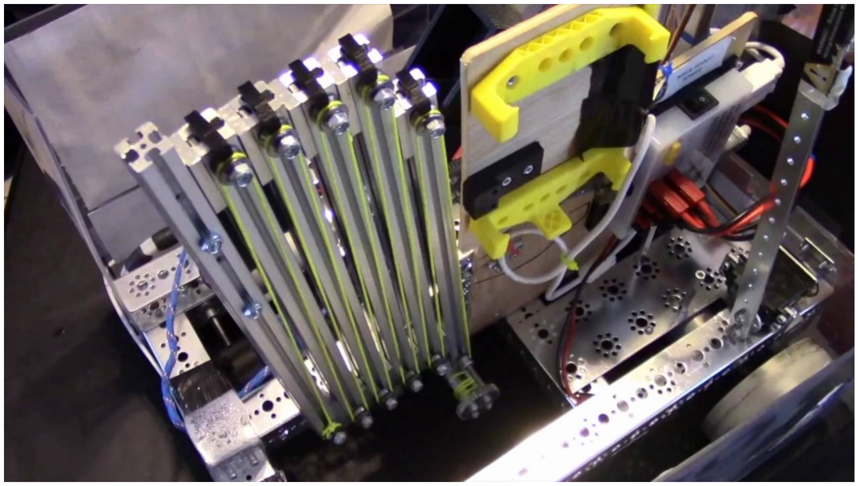
Every motor we used this year has an encoder wire attached to the motor so it is easy for the whole team to program if we can always know the motor’s degree it is easier to program for autonomous mode where every little turn can have a major effect of the robot and if or if not the robot can successfully do the tasks of autonomous.

When programming the lift, it is helpful to have encoders to put code blocks so that when we are programming the motors it is impossible to burn the motors by overpulling the lift even though it can't move. For this year's competition, we have used a total of 11 motors. We used 3 continuous servos, 5 NeveRest Classic 40 Gearmotor, 2 core hex motors, and 1 Torquenado. We used all 3 continuous servos for the claw mechanism, one allowed the mechanism to rotate left and right, another allowed it to go up and down, and the last one allowed the linear racks to expand. Out of the five Gearmotors we used four for the wheels since the motor is very powerful and will help the robot move around the field quickly as mentioned before. The fifth Gear Motor is used for the lift because it has lots of power and can handle the weight of the lift mechanism. The torquenado's job is to lift the claw mechanism. In order to pull the foundation into the building site. we added 2 hooks that are moved by the 2 core hex motors.

Continuous Servo NeveRest Gear Motor

All the motors that were incorporated into the robot were motors that we thought helped us accomplish the tasks most efficiently.

3.4: Linear Slide design for the lift mechanism



We decided to use the Linear Slide since it was the most efficient part we could use for the robot. It had all the important traits we felt necessary for the robot to be most productive.
The linear slides at first proved they could be effective, but then we soon realized we had to find a better alternative for numerous reasons.

Beneficial Traits

- Ability to go up and down
- Collapses onto itself
- Durable

The Lift's ability to collapse onto itself is a large asset since the robot can become compact when trying to go under the bridge and then can extend to pick up blocks when necessary.

Early Steps

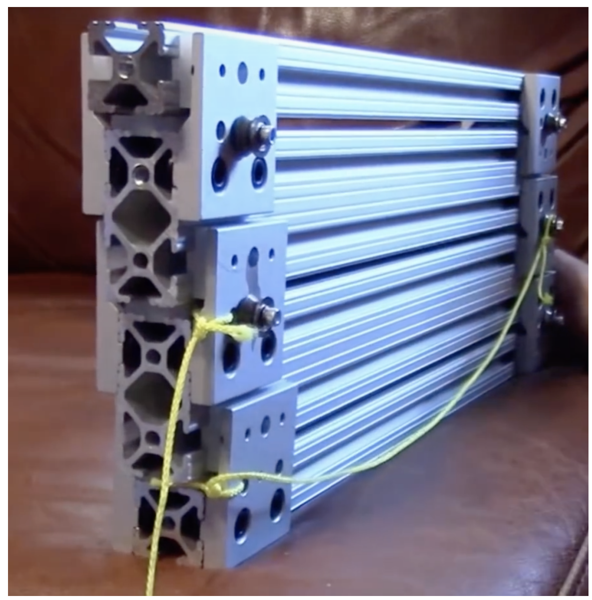
We went through a similar developmental phase last season and hence chose the linear slides. We tested out a lot of lift designs last year and all proved to be deficient. This led us to use linear slides as we believed this was the only lift design that could work properly.

In an attempt to be time-efficient, we skipped the development phase we went through last year and instead just decided to use the Linear Slides without putting in much effort to design a better lift. This was a bad idea on our part as we didn't truly understand the downfalls of the Linear Slides, which got worse every time we tested the robot.

We didn’t test out any lifts prior to the Linear Slides because our initial test showed that the Linear Slides could prove to work perfectly. It was a much better alternative to the lift we used last year.

Extender

The extender is attached to the Lift and also is made up of linear slides. The extender’s function is to adjust how far out the claw could go out to collect and drop bricks. Without having an extender also a part of the lift and claw, it would be harder to precisely grab a block, however with it, getting a block would be much easier.



Functions:

- Ability to go in and out
- Collapses onto itself

Benefits:

- The length it can extend
- Durable
- Smooth function

The reason we decided to use Linear slides is that last season, we experienced trial and error, and realized what is best for us. We didn't have an extender last season which made things more difficult for us, especially when we had to put minerals on the other side of the lander. Since we have to stack a tower and precisely place a brick, rather than dumping it into something, we need an extender.

Flaws

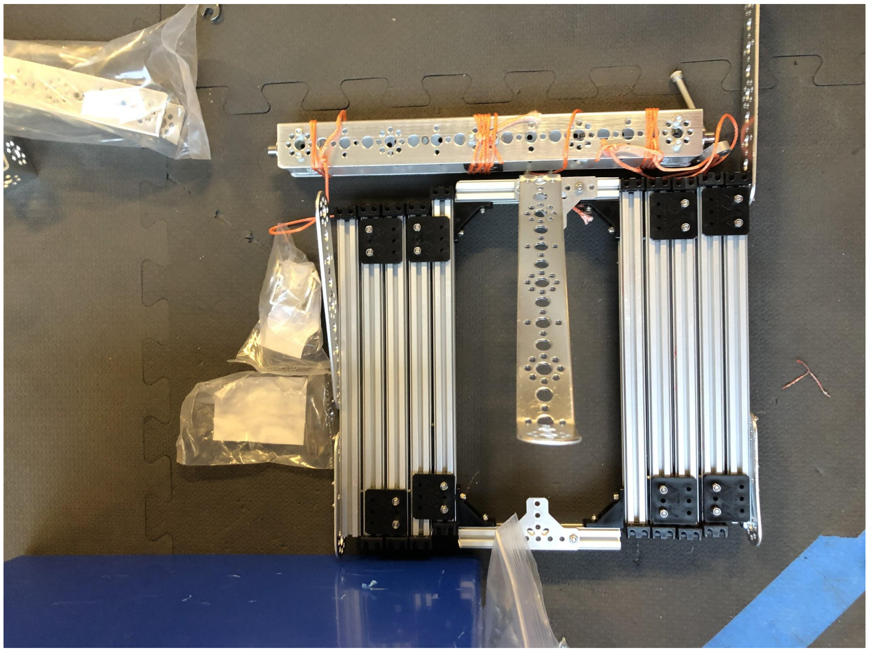
Testing our design we came to a conclusion the linear slides carried too many design flaws for us to continue forward; some flaws are:

- Unsustainable when overused at max reach
- The danger of knocking the tower over past 3 blocks
- Has a max height of 5 blocks
- Pulley System breaks down often

The robot being unsustainable meant we couldn't take our robot to competition and not have the constant fear of the robot suddenly breaking down. It's unsustainability caused us to not fully trust the robot that it wouldn't break down while we were testing it, therefore the Linear Slides were too unreliable for us to use.

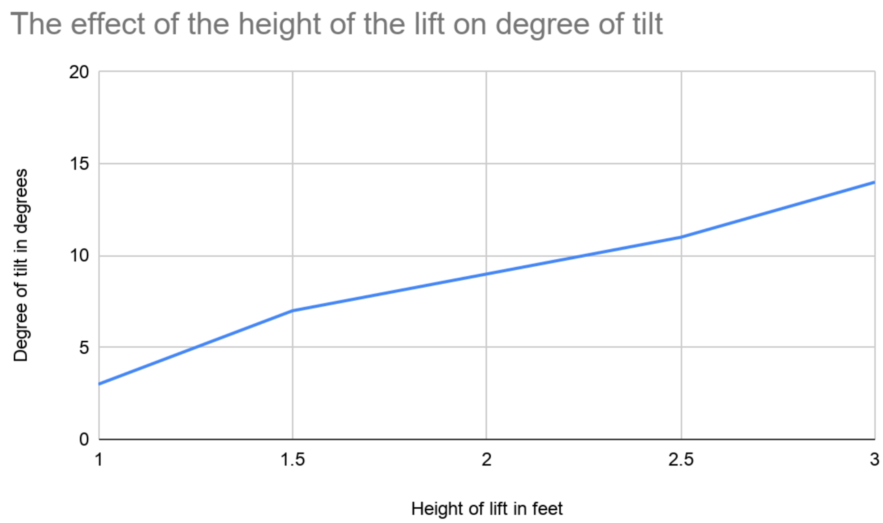
The robot linear slides having a max height of 5 blocks we couldn't rely on the robot to build a high tower. This was a very bad disadvantage as we couldn't get that many points as the height our robot could go wasn't very high. If we used any other lift, we could build a tower higher than 5 blocks and get more points.

Since the pulley system kept on breaking down, if we took it to the competition it could break down out of nowhere. We couldn't keep on fixing the pulley system every time it broke down, therefore we needed to find a better alternative.



Brainstormed Lift Designs

- Vertical drawer slides
- A linear slide powered by a linear actuator
- Scissor lift
- Add a lift at the base of the chassis to lift the robot itself
- A suitcase handle design



Two design factors that determine linear slide performance characteristics are track geometry and raceway arrangement. Track geometry has a significant influence on the bearing's friction and load capacity, while raceway arrangement determines the internal stresses on the rail and block and the amount of torsional moment loading the bearing can withstand.

The decision on the lift mechanism

In the end, we decided to have the most functionally and sustainable lift, we needed a scissor lift. Linear slides didn't work properly and had too many disadvantages leading us to find a better alternative

We looked at numerous designs and found one that could be fully functional. We tested out all the designs, thoroughly viewed all the benefits and disadvantages. It was clear to us which lift we needed to use.

The Linear Slides, as well as all the other brainstormed ideas, seemed well on paper, but for us to use on our robot wouldn't be the best decision.

The Linear Slides had advantages but even more disadvantages. Therefore the linear slides aren't reliable for our drivers to use in competitions.

3.5: Scissors Lift design for the lift mechanism

When we saw that the Linear Slides wouldn't work productively, we had to quickly find a better alternative. After realizing that the Linear Slides weren’t the most efficient, we decided to use the Scissors Lift.

Early Challenges

The only problem with the Scissors Lift was the challenge to build it. Once we overcame this obstacle, we found that the lift had no problems. It worked near perfect for what we wanted.

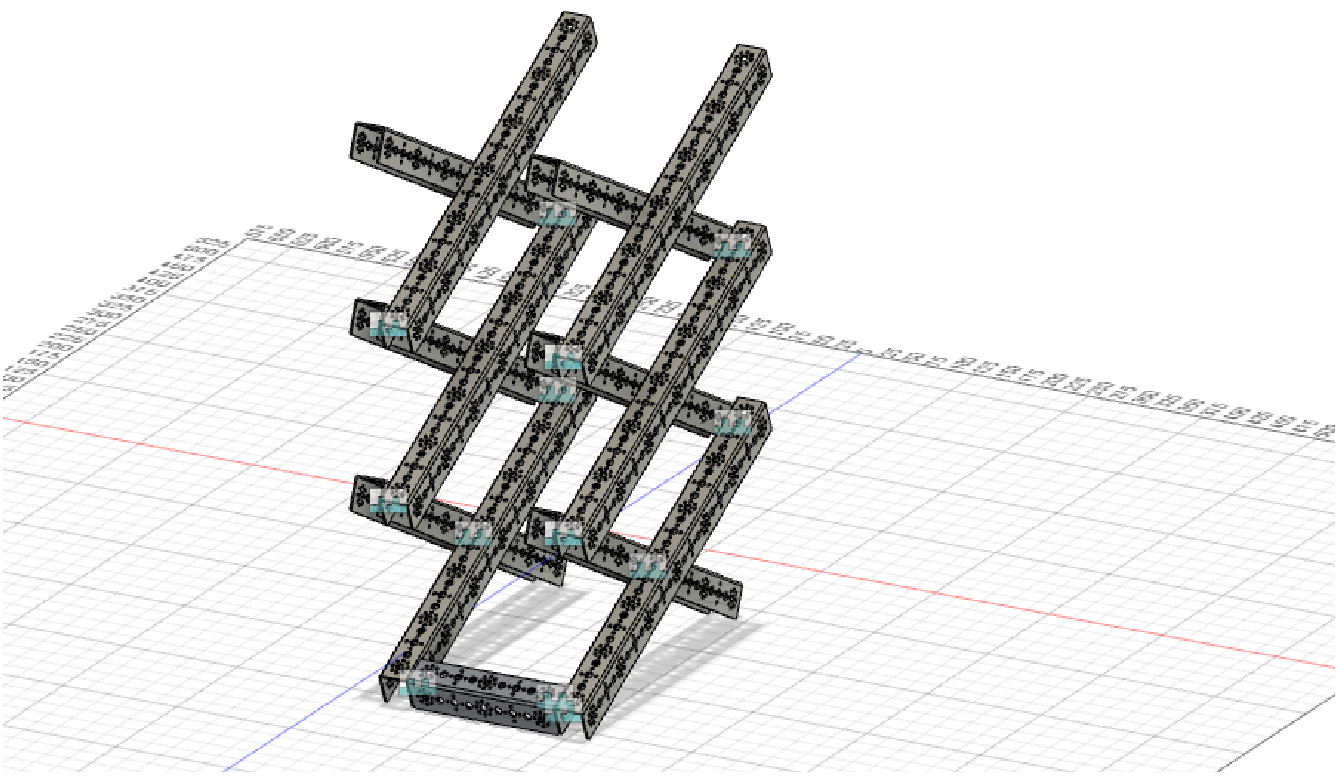
Through research, we saw that many found that scissor lifts are a pain, but if you build/design them correctly, they can be a fantastic mechanism. Single-stage lifters are especially useful for all sorts of applications, and if you operate them near the center of the device, you can gain quite a bit of lift. With our design, we didn't find the Scissors Lift to be a pain but instead very useful.

How It Works

The Scissors Lift consists of multiple beams crossing each other in an X pattern. The Scissors Lift also came with more benefits and proved to be more sustainable than the previous Linear Slides. Hence the name, it works like a scissor that gains height by the beams slicing in the bottom and goes down sliding down much like a scissor. They are mainly used for trying to reach something high and being stable while doing it. This fit the exact criteria for what we needed.

The scissor lift uses the linear extender to extend up and down. The top of the linear extender is attached to the top layer of the scissor lift. Since the joints of the scissor lift are loose they can move easier. So as the linear extender extends, the joints of the lift compress causing the lift to move up.

A **scissor lift** is essentially a mobile platform that can raise you to a certain height vertically, using hydraulic mechanisms, to complete a particular job. Various scissor lifts use different types of power in order to function. Some rely on mechanical power. Others use ultra-smooth hydraulics or pneumatic power instead. Scissor lifts also come in a variety of different sizes and types, making them a great fit for a wide range of different settings.



The Scissors Lift has the ability to do all the Linear Slides can do it more efficiently.

The Linear Slides had the ability to:

- Go up and Down
- Collapse onto itself

The Scissors Lift had the benefits of being:

- Very Stable
- Collapse onto itself without wearing out strings

- Very Durable without Breaking down
- Simplicity of Operation
- Compact Storage

Although the Linear Slides were stable at first, they started to quickly become unstable. The Scissors Lift was continuously stable without any sign of it wearing down and becoming unstable.

We believed the Linear Slides would be durable and would pose no problems. Through testing the Linear Slides we saw we needed a more effective lift.

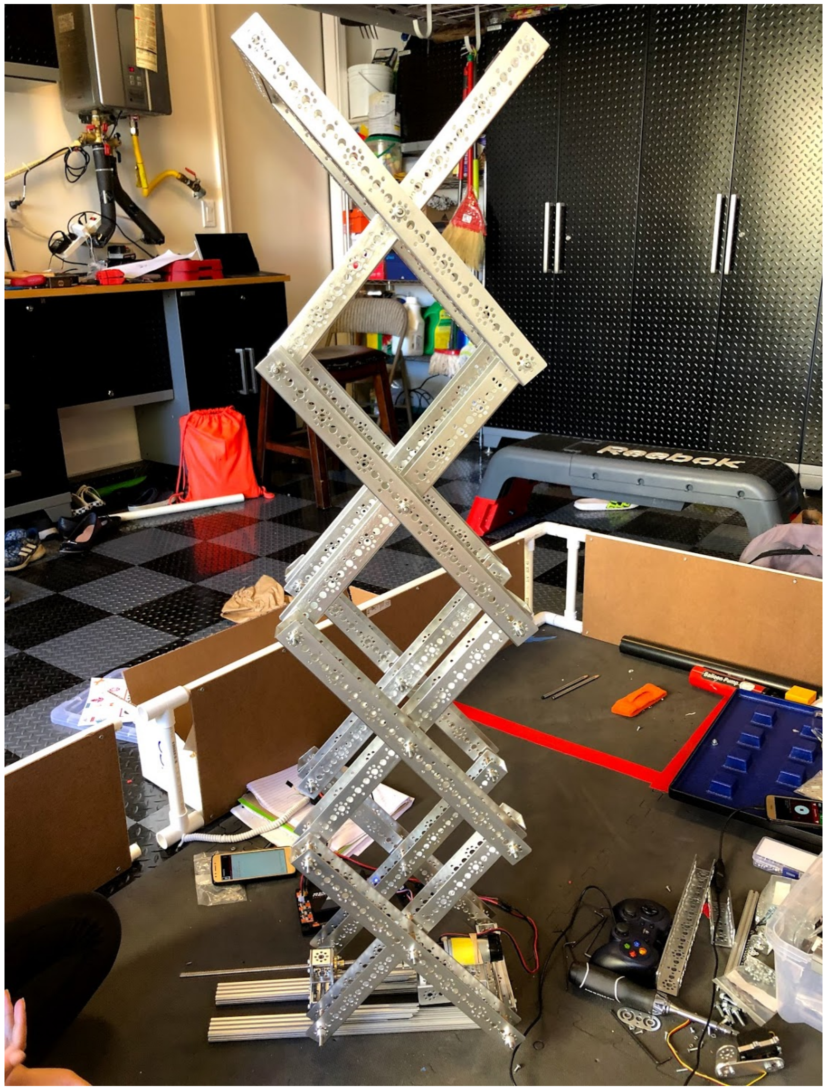
Scissors Lift Advantages

The Scissors Lift has the ability to collapse onto itself just like the Linear Slides but quicker and more effectively. The Scissors Lift took half the time the Linear Slides took to go up and then back down. The Linear Slides had strings that would come undone as we used the Linear Slides. We would not have to face this problem with Scissor Lifts.

As we continued to pick up the blocks with the Linear Slides, with constant use it started to break down and not pick up blocks as effectively as it did at first. The scissor lift could repeatedly pick up blocks without it being less effective.

The Scissors Lift is also very easy to use and operate. When trying to operate the Linear Slides, we ran into a bunch of problems. When operating the Scissor Lift, it ran very smoothly and effortlessly.

The Scissors Lift has the ability to go ***13*** blocks high which gives us an advantage. With the Linear Slides, we would only be able to build a tower 6 blocks high. When we used the Linear Slides, its ability to only go 6 blocks high was a major limitation. It prevented us from building a tower any higher than 6 blocks high. We wouldn't have this limitation with the Scissors Lift.

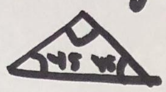


Truss theorem:

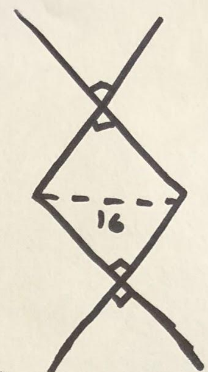
The team used the Truss theorem to find the optimum length of the beam to make the strongest and stable list mechanism.

Truss Theorem:

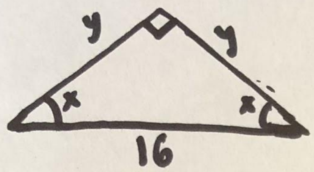
Strongest Trusses are 45°, 45°, 90° triangles



example lift:



Example Truss:



Knowing that x had to be 45° to form a strong truss we used it to find the optimum length of y.

$\cos x = \frac{1}{1} = 1$ because we know $\frac{y}{y}$ will equal 1.

$\operatorname{Arc}\cos \frac{y}{16} = 45$

$\operatorname{Arc}\cos y = 45(16)$

$y = 16\cos(45)$

$y = 11.31$ inches

$\operatorname{Arc}\sin\left(\frac{y}{16}\right) = 45$

$\operatorname{Arc}\sin y = 45(16)$

$y = 16\sin(45)$

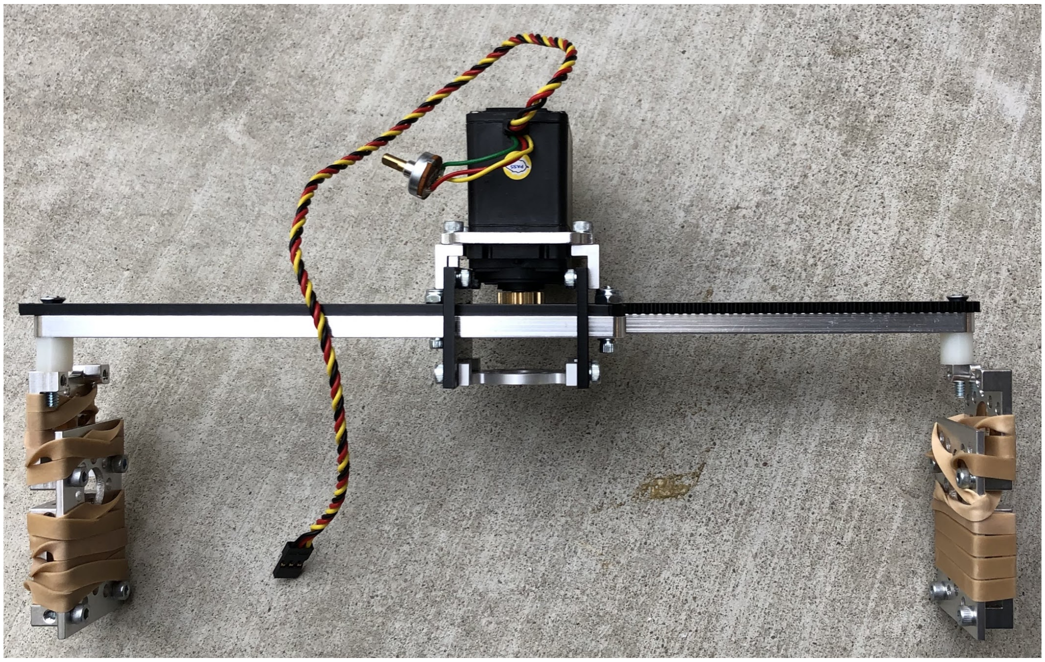
$y = 11.31$ inches

Just to cross check our work we solved in one more way

Major Advantage

In this graph, we can truly see why we chose to use the Scissors Lift over the Linear Slides. For the Linear Slides when the height of the lift was at a height of 3 feet the lift was tilted 14 degrees, making it very wobbly. For the Scissors Lift when the height of the left was 6 feet height the degree of tilt was 14 degrees. This shows the Scissors Lift wasn't nearly as wobbly as the Linear Slides, and proved to be more efficient.

3.6: Claw design



Function:

The main function of the claws is used to grip bricks, lift them, and release. The claw can open and close horizontally to fit the measurement of the brick, pick it up and place it down by opening up. The claw has an impressive 270-degree spherical rotation and is very practical.

Features:

The most unique part of the claw is that it can extend. This feature is very significant as the process to pick up a brick becomes more efficient. Without this feature, we would have to directly align the robot to the brick every time and then pick it up. This process consumes a large sum of time and that is detrimental to improving our chances of winning.

This inspired us to think of an attachment for the claw that can also allow it to turn in a spherical motion of about 270 degrees. With this control, we can get even the most difficult positions of blocks without having to maneuver the robot too much. This attachment can also help us place blocks on our tower from different sides of the build plate. This unique design had a drawback: it didn't utilize 2 servos, limiting its spherical rotation. We soon fixed that, making the claw a lot more efficient at grasping blocks in unfavorable locations. For the rotation of the claw, we had to optimize two continuous servos to achieve while simultaneously decreasing unneeded weight to our robot to increase efficiency.

Since the bricks are large in size being 4x5x8in and need to be placed precisely, we needed to come up with a different design for the claw than we used last season.

Extender:

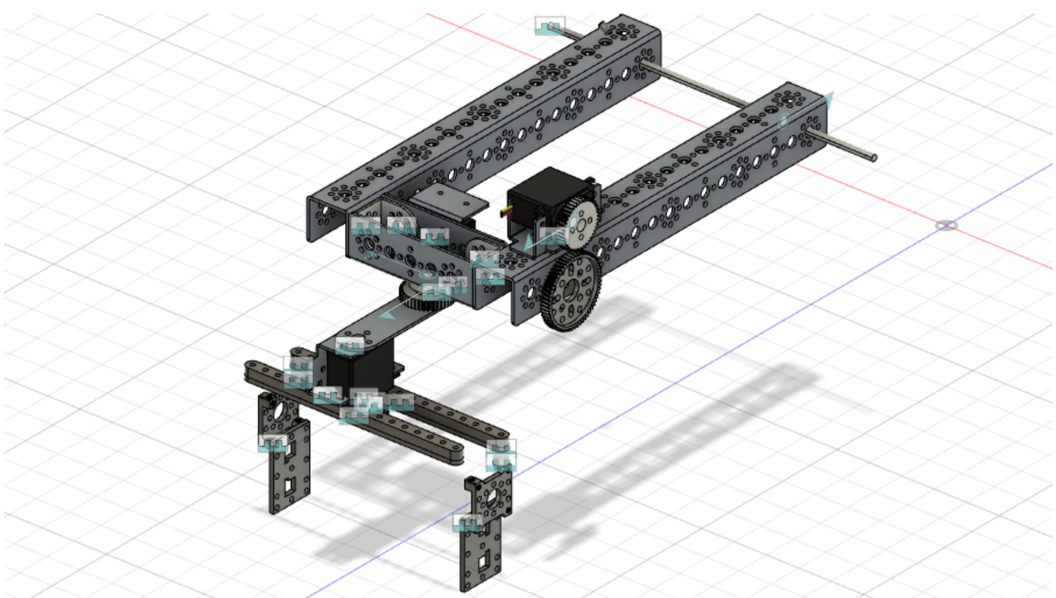
Using an extender is critical for fine maneuvers. The movements have to be incredibly precise yet the robot has to be easy to control for it to be successful in the game.

Extenders also allow us to grab stones that are far away without moving the main body of the robot. This conserves battery and is quicker and more efficient. Also, extenders are a necessity for making high towers out of the stones.

We decided to use linear slides for the extenders due to the fast retraction and protrusion times. This means that the robot can grab blocks far away incredibly quickly, thus saving time and battery power at the same time. We believed that this would be a huge advantage in a game against teams that have to move their whole robot and travel to stone to grab it, and then travel back and place it. Due to our main driving motors being really powerful and responsive, driving the robot precisely to get to a block is way harder and time consuming than remaining stationary and letting the extenders do the job for it.

In the end, extenders improved the efficiency of our robot without compromising much. The increased range and speed helps in grabbing more blocks and placing them within the time limit. Due to the added extenders, the robot became better overall.

Improvised Claw:



In this claw design, we added a lot of changes to improve the previous claw design. We soon realized the problems with the previous design, and therefore put effort into creating a new and improved claw design that would prove useful.

The new claw design had the ability to spherically rotate 270 degrees. This advantage is very beneficial as it gives more functionality to the claw. It makes the claw easier to use. If this feature wasn’t included in the claw design, it wouldn’t be properly functional. It would be very difficult to grab stones placed in unfavorable locations.

This design saves time and works very effectively. The claw doesn't have any disadvantages, making it even more amazing. The claw truly showed its usefulness through these benefits:

- Efficient
- 270-degree rotation
- Quick grab/release
- Very Sturdy

The claw was for the most part perfect. The only downside was the time it took to actually construct the claw. This was a minor obstacle that we eventually overcame. Once we built the claw, it ran smoothly without any problems.

3.7: Sensors

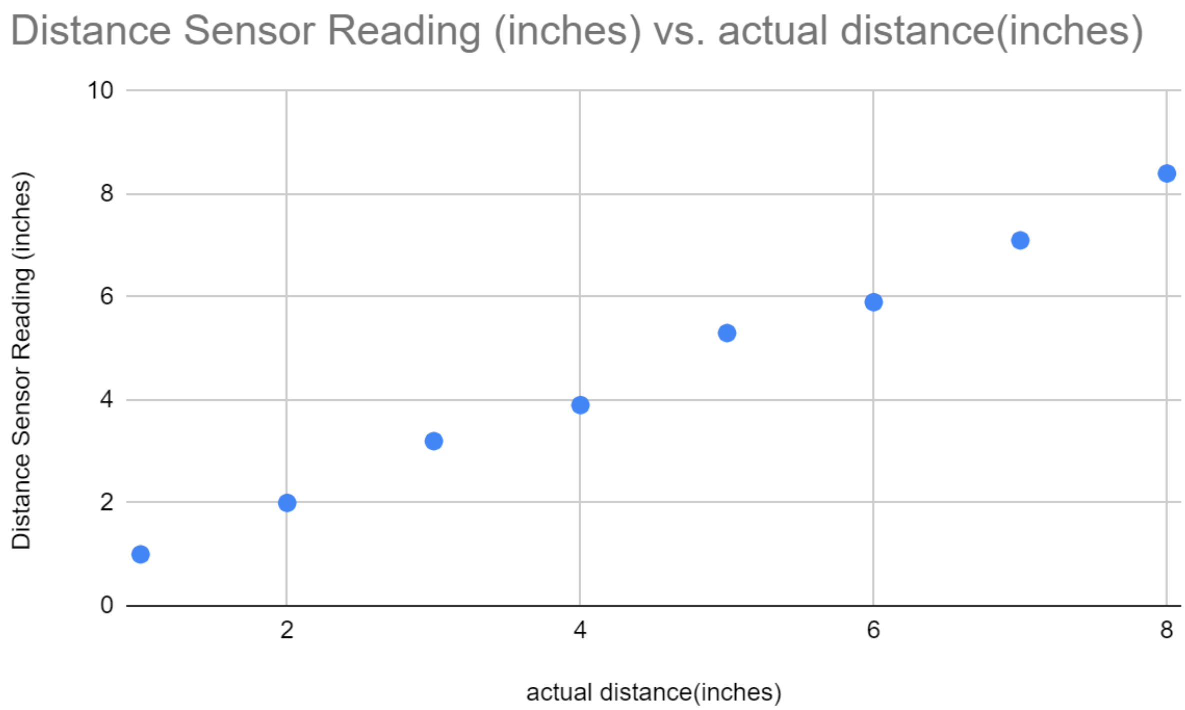
The sensors we decided to use for this year were

- Touch
- Color
- Distance

We used these 3 sensors because in this year's game there is always a threat of being hit by other robots due to the field having routes that would be really busy, causing the routes to be crowded.

This obstacle could cause our robot to crash into other robots. When our robot collided with another robot last season, it completely wrecked our robot.

Our distance sensors help us maneuver around the map and we can avoid a collision that might cause a robot to break or malfunction in the round.



Here we can see that the distance sensor is almost always accurate within 4 inches and starts to become more in-consistent at 8-inches. This is why the distance sensors can help us dodge collisions and protect the robot.

We used the touch sensor to help our robot not burn through the motors. We realized that our lift mechanism had a chance of burning through the motor because if we over pushed the motor in the driver-controlled period the lift would have to be fixed and a motor would have to be replaced causing us to waste time. This is why we added a touch sensor to sense when the lift was completely turned down and put a lock on the motor that will keep the robot from breaking. The touch sensor also responds faster than putting an encoder block which is why we finally decided to put the touch sensor.

We started to use the color sensor to detect the pictures around the playfield but they were significantly slower than Vuforia which is software that we decided to use. Vuforia allows us to use the FTC pictures library given by FTC to see where we are on the field. Since this is a software we have to use the camera of the phone, we had already put the phone in a place where the camera could see so it worked out perfectly and it made no sense to use the color sensor.

4. Engineering design: Software

Now heading into the Software side of our team. During the autonomous section of the robot game, we use many different tools to make sure we have an edge and the robot is accurate. If we start on the side of the field that has the foundations, we can pull the foundation into the building site and park under the bridge. If we start on the side of the field that has the depots, we can scan for a skystone and pull it through under the bridge.

Those are the goals of our autonomous and now to how we get that done. To find out which side of the field the robot is on, we use a software called Vuforia. Vuforia is a software that can hold 3D objects or images and uses machine learning to find them in certain settings. Vuforia already had files of the Perimeter Targets, Skystones and other objects used in this year's game. FTC had libraries of these files that we borrowed from. When we start the autonomous, the first thing we do is scan for the perimeter targets.

……

…….

```
            // Move forward 2 feet
            robot.encoderInchesDrive(this, 0.5f, 22, 22, 5);
            // Turn Left camera towards wall
            robot.encoderInchesDrive(this, 0.5f, -24, 24, 5);
            robot.idleFor(this, 0.25f); // Give some time for vuforia to find
target
            // Find where is the Robot
            Navigation.Position pos = navigation.getRobotPosition(this);
            System.out.println("*************** main: Position: "+ pos);
            if(pos != null) {
                System.out.println("*************** main: Position Name: "+
pos.name);
                startedPosition = pos;
                // Found Perimeter wall target
                if(pos.name.equals(Navigation.Target.BLUE_PERIMETER_1)) {
                    searchBlueSkystome();
                } else if(pos.name.equals(Navigation.Target.BLUE_PERIMETER_2)
|| (pos.name.equals(Navigation.Target.REAR_PERIMETER_1))) {
                    moveBlueFoundation();
                } else if(pos.name.equals(Navigation.Target.RED_PERIMETER_1)
|| (pos.name.equals(Navigation.Target.FRON_PERIMETER_2))) {
                    searchRedSkystome();
                } else if(pos.name.equals(Navigation.Target.RED_PERIMETER_2))
{
                    moveRedFoundation();
                }
```

In the autonomous, so move the robot around we have encoder wires on each of the robots motors. These encoder wires give the program information on the position of the robots motors. So if we tell the encoder to move the robot 24 forward, and set the variable to inches, then the robot will move that certain motor 24 inches forward. It can do this because we predefined the circumference of the wheels to the program so the circumference is the wheels diameter times pi.

5.0 Outreach activities

<u>Outreach Objective</u>: To motivate young kids to participate in Science, Technology, Engineering, and Math (STEM) and to connect with industry experts and community to promote First.org

<u>Outreach Achievements</u>:
Motivate Outreach: Reached out to over 500 elementary and middle school kids to promote robotics, first and STEM

<u>Connect Outreach</u>: Connected with over 10 businesses, 7 industry experts and 5 First teams

All of our outreach events have benefited our team, and the community. From spreading First to improving our team's efficiency, to building character, they have all had a positive impact on us.

Our main goal without Motivate Outreach was to reach out to other kids who aren't familiar with STEM and provide opportunities for them to become more involved with technology that will shape the future generation. In our San Jose and Quail Run outreaches, we reached out to younger kids to get them excited about robotics and FLL and offer to help them start a new team.

In our two sponsorship outreaches (Synechron and Fluid touch) and the meeting with team Acme, we demonstrated Connect outreach and got help for our team to make it better for the next season.

There are so many different ways that our outreaches have demonstrated that we have made this community a better place.

<u>The Quail Run Motivate Outreach</u> was targeted to spread STEM and help start new FLL teams for young kids. We did a presentation, a demonstration and a question and answer section. Overall there were many kids that were impressed by the program from our EV3 and wanted to join a team.

<u>The Alameda County Fair</u> outreach also was helpful to many kids who are interested in getting involved with STEM. The Alameda fair is a popular place visited over the summer by all age groups, this way we were able to demonstrate FTC and FLL.

When team Acme met up with us, it helped up immensely. Although we do have the robot part down we didn't have the other portion which would help us win awards. Then helped us with time management and notebook organization, and it was an outreach event for them as well.

The Quail Run cleanup was a team-building exercise. It helped up with working together and helping our community a cleaner place. Additionally, we got to reach out to the kids and parents at the school and talk a little bit about who we are and what we do.

5.1 Motivate Outreach

a team, we decided that our Motivate goal
hat we wanted to spread the word about
otics and the growing need it will have in
future. When automation grows it is
portant to have the skills necessary to get a
cure job because repetitive jobs will be
laced and it will be important to have skills
rounding robotics. Our goals as a team
re based on a 3 step cycle. This cycle is
led the MOTIVATION CYCLE.

STEP 1. Spread the word about Robotics
We did this by doing many community events to spread the word about robotics. We went to events and fairs where we can spread the word to the most number of people.
STEP 2. Get the attention of the youth
We did this by showing off are robot and flash programs that show off what is possible with robotics. When the youth see this they get interested and want to start a robotics
STEP 3. Start FIRST teams
As a team, we worked on starting teams by holding a seminar at our local elementary school to tell parents and the students how to make teams and gave them detailed instructions on how to make first teams.

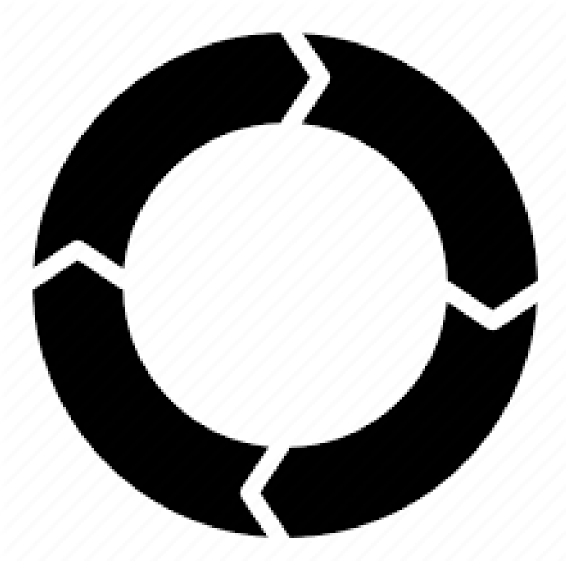
5.1.1 Education day at San Jose Giants

Animatronics Robotics Booth at San Jose Giants game

Who: We introduced 220+ kids to First and explained what benefits come with joining First.
Where: San Jose Giants Stadium. Education Day, STEAM Convention.
What: We first presented our FLL demo robot to the kids as legos seemed to interest and hook in the kids more. While explaining we gave them a flyer explaining how they can register. Our demo elucidated the UltraSonic sensor and the Color sensor. We then showed that if they continued with first they will do FTC and gave them a brief overview of that.
How: Many kids came over and asked how they could start a team and were very interested in how the sensors worked. We also seemed to get the parents interested and many kids wanted to know more about sensors and programming. We explained how the FLL block program can help kids understand the logic and create growth mindsets by creating what they want with programming and legos.

5.2 Connect Outreach

As a team we decided that we want to teach and share other FTC teams,



nd experts about first and Robotics in
et feedback about what other teams are
t robotics and how the up and coming
participate in robotics. We are willing to
TC teams that we might end up going
a two way street and we also end up
ch give us an opportunity to rethink our
er game plans that might be better. We
e with their experience they can help us
Most of the people we talk to have
their ball park to think about new and
innovative ideas.

5.2.1 Learning from FTC team "ACME"

Team Acme giving us tips for the next season

- On their way to regionals, team Acme kindly agreed to help us out and give us a couple tips for the next season. Team #8367 Acme have won the inspire award at the first qualifier due to their amazing notebook, something that we were lacking in that season. We met them through our third qualifier where they were our alliance team for the semifinals.
- They started off by talking about how they have made their way along so far, how they got sponsorships, what outreach events they have done etc. Two of their teammates and two coaches came. We told them what our problem was; we had the robot part down but not the other events such as winning awards.

7.0 Robot Redesign post Qualifier #1

After our first qualifier we realized that our robot required many revisions. There were many factors of our robot that made us come to a conclusion of changing the entire robot. Our robot was severely lacking in being quick, sturdy, and consistent. Our robot might have been considered efficient when we practiced, but compared to other robots at competition our robot was much slower than other robots. Our robot had weak autonomous compared to most robots, and was very inconsistent. While other robots performed the same for most rounds, our robot wasn't consistent, and performed differently every round. We needed major change to improve our robot.

<u>7.2 Root cause analysis:</u>

One reason why the robot weighed so much was because of the scissors lift. Our lift was very heavy and contained many layers of heavy beams and a hefty linear actuator. At first we thought about reducing the layers of the scissors lift to reduce weight. Nevertheless we realized that would severely decrease the functionality of the scissors lift. The better alternative we could do was to replace the entire lift with a lighter lift.

We came to this conclusion because the lift wobbled when we moved while it was extended, and the lift's soaring height was never used to its full extent. Furthermore, we planned on adding an intake, and for the intake linear slides would be much more efficient. We wanted a narrow, light lift instead of the previous bulky scissors lift. This would be achieved by replacing the entire lift.

The scissors lift made it very difficult to precisely place the blocks on the platform or on top of each other as a direct result of the severe wobble. The wobble also caused the arm to knock the whole tower over many times. For example, our robot could be stacking a fourth block on the tower, but a sudden wobble from the lift being extended could accidentally topple over the entire tower, which happened during competition.

The scissors lift had simply become a burden to the robot. It was very unnecessary, and needed to be replaced very soon with a much better alternative.

We wanted to make sure this would never happen again, but the only way to successfully do that was by replacing our lift. Therefore, we decided to reuse our first design that is sturdy and light so the robot can move freely. The scissor lift was 30 pounds, with our overall robot being 39 lbs. This clearly demonstrates how by replacing the wobbly, inconsistent lift, we would make our robot weigh much less. Another lift could for example weigh 10 pounds, and therefore we could eliminate 20 pounds off the robot.

The lift added so much unnecessary weight, especially since we didn't use the entire height. This meant we had many beams on the robot that would never be used to extend. During the competition, we usually stack about 3-5 blocks which is about 12-20 inches high. The scissor lift could extend 13 blocks or 52 inches high. More than half of the scissor lift served useless, so we considered shortening the scissor lift. This wouldn't work, as then the robot would still weigh a lot.

7.4: New Lift Mechanism

For the new lift we needed everything that our previous lift failed to meet. A lift that could be agile and quick. A lift that could pair well with our new intake mechanism. A lift that would be very efficient and not a bulky lift.

Here are the key features:

- Light
- Extends quick
- Sturdy when extended and not extended
- Efficient

The highlight of the scissor lift was that it was durable and that it could extend far. After we built it, it didn’t break down once because it had a fail safe mechanism. This was one of the main reasons we decided on using the scissor lift in contrast to the linear slides. The fail safe mechanism was that even if the motor was held down after it was fully retracted, it still wouldn’t break.

Furthermore, we needed a lift that would pair well with our new robot and intake mechanism. A lift that wouldn’t be effective with our old robot could be effective with our new robot. Therefore, we needed to look over all the options for a lift.

Linear Drawer slides:

- Not smooth (can get stuck)
- Fast
- No motor so cannot extend up
- Light
- Inconsistent

- Fragile

  Previous experience from last season drove us away from using the Linear Drawer Slides. Additionally they cannot work with the current design of our robot.

The fail safe mechanism was something that we lacked last season with the Linear Drawer slides design we made. The drawer slides in all honesty were very inefficient, and we needed a much more powerful lift that wasn't nearly as fragile as the linear drawer slides. The scissor lift might have been more efficient than the linear drawer slides, but would not be still the best option for our robot's lift.

Linear Actuator:

- Fast
- Requires a very strong motor
- Extremely Delicate
- Heavy

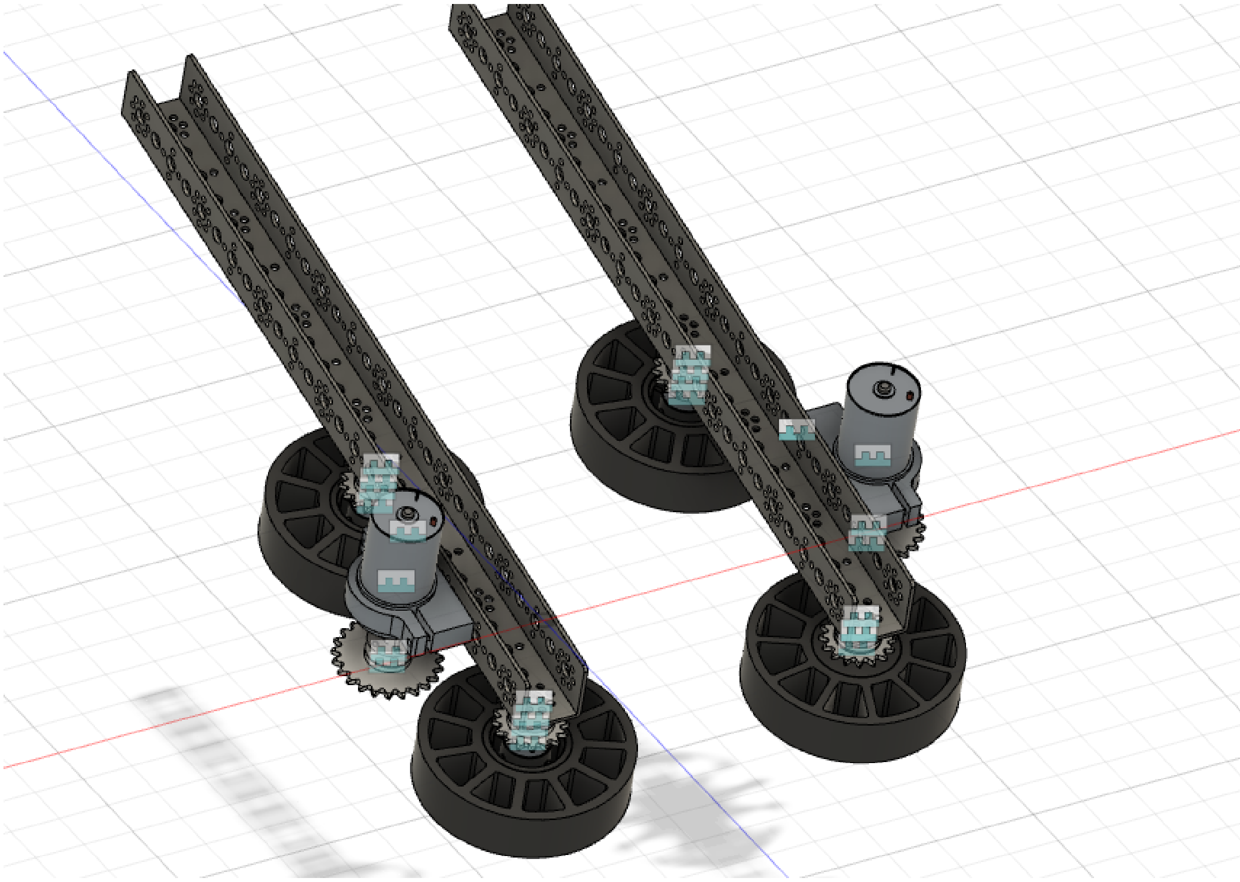
Last season, the linear actuator broke during the competition and was difficult to fix because we lost a certain piece that was small but vital. Moreover, we needed it to be as light as possible. The linear Actuator is already heavy, but to power it, it requires a hefty motor. This showed that the linear actuator wouldn't serve as the best option. The linear actuator may have been more effective than the drawer slides, but still couldn't compare to the scissor lift. We needed to find a lift that would be quick and at the same time be light and consistent.

7.5: Block Intake Mechanism

One of the main reasons why the robot weighed so much was because of our scissors lift. Our lift is very heavy and contains many layers of heavy beams and a heavy linear actuator. Our robot being heavy also resulted in our robot being very slow which resulted in less skystones being transported.

Through extensive brainstorming, we decided to build our robot from the ground up. Painstakingly, we took apart our whole robot. We decided to build our own chassis this time to eliminate weight. Finally, we were going to have a fast robot.

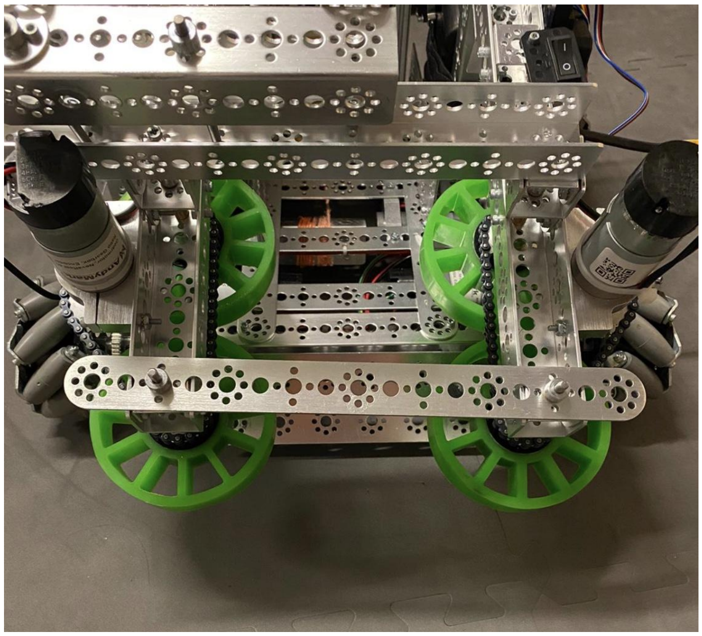
Rebuilding the chassis turned out to be a good idea because it eliminated a lot of unnecessary weight. Through many revisions and ample CAD designs, we finally made an effective design for our intake. The CAD design is shown below:



This dual motor-complaint wheel hybrid design was perfect for sucking in bricks quickly and easily. It also added barely any weight to our robot, which was perfect for us. We now had to find a way to attach our intake mechanism to our robot. We settled on using a bent L-shaped connector bolted to a beam to hold the intake mechanism at an angle to help with the intake process. Now all we had to do was to come up with a lift mechanism.

We originally thought about using our scissor lift mechanism, but we didn't want the extra weight. As mentioned before, the scissor lift was too heavy to be practical. We had to go back to the drawing board to come up with a new lift mechanism.

After much thought, we decided to use linear slides as our lift mechanism. Linear slides were compact, stable, quick to extend and retract, and added barely any weight to our robot compared to the scissor lift. They also served as a wall to stop the stones from flying out. With this many pros and barely any cons, the linear slides were perfect for our robot. Finally, our robot was complete.



7.7 Revisions to Autonomous:

At the competition, one of the first things we noticed were the mats. This small observation might have seemed irrelevant at the time, but nevertheless would play a significant role on our autonomous. The mats at competition were distinctly different from ours.

The mats we tested our robot on had a very rugged, rough texture. On the other hand, mats in the pit of competition were conversely very smooth. We didn't realize how major of an impact the mats' texture played on our autonomous until we tested our program.

In the practice pit, our autonomous was completely off. We were not prepared for this unexpected obstacle. We had designed our autonomous program in such a way where it wasn't easy to change. This led us to performing poorly during the autonomous section in rounds.

This unexpected obstacle helped us realize we would have to create a different autonomous that we could change depending on the texture on the mat.

The wheels would travel farther in one rotation on a smooth mat in contrast to a rugged mat. Meaning we would have to be prepared to tweak our autonomous at competition.

7.8: Summary of Redesigned Robot

We had spent a lot of time revising our previous robot until we believed it was perfect. Evidently, our robot still had room to improve. We had to persevere, and that meant if we put more energy into completely changing our robot in means to improve it, we would perform better at competition.

Our robot had completely changed. Before, our robot was bulky, slow, and inefficient. This made us realize it was time for some major changes. This led us to a new and improved robot. The new robot was everything the old robot wasn't. It was very consistent, swift, and light. Our whole game plan had changed for the better. We adapted and improved on our weaknesses as a result of wanting to do even better.