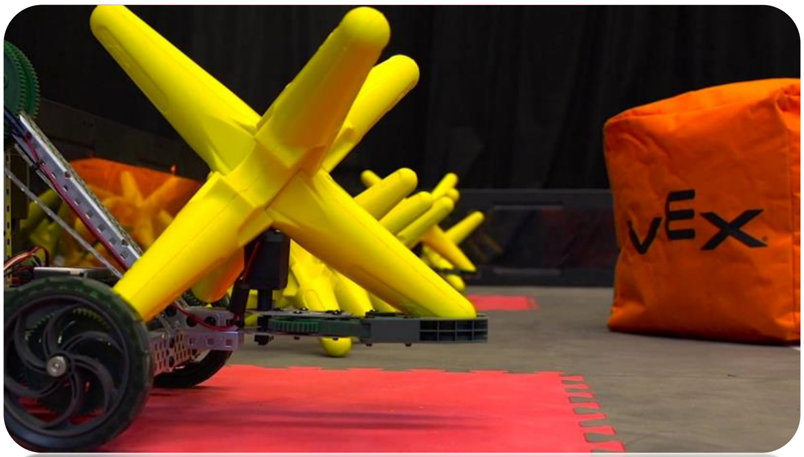

VEX COMPETITION ENGINEERING NOTEBOOK

STARSTRUCK

INTRODUCTION OF SPICE DESIGN PROCESS

ROBOT STRUCTURE AND MOTION

RESEARCH AND ROBOT DESIGN PROBLEMS

MATERIALS USED

STRATEGIES AND TEAM BACKGROUND

PREPARED BY:
1104G, DISCOBOTS CANADA

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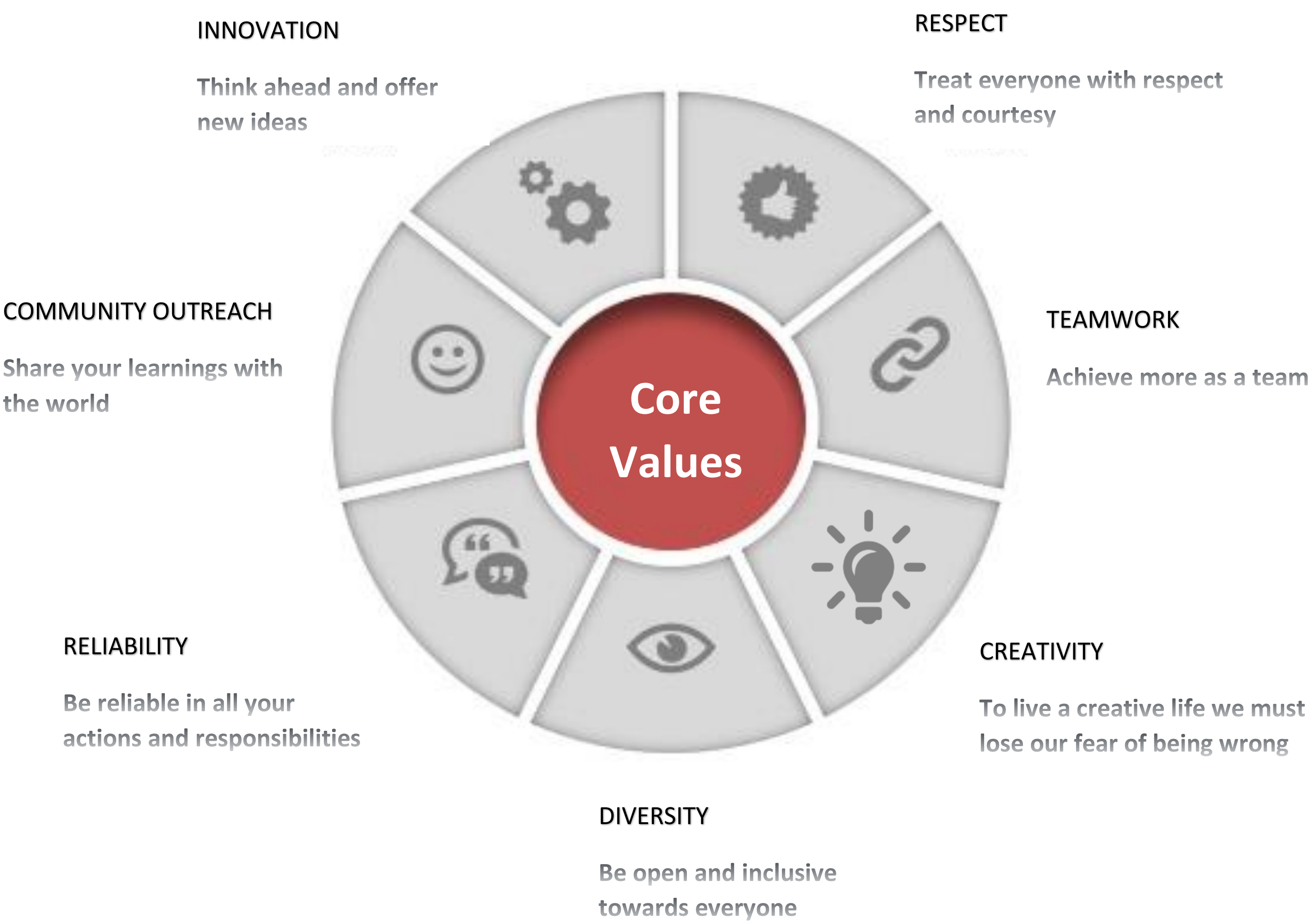
TEAM INFORMATION

Core Values



About Us

Brampton Robotics is a student run initiative to promote Science, Technology, Engineering, and Mathematics (STEM) education within the youth community. As a member of Brampton Robotics, students are provided with the opportunity to participate in STEM-based competitions and are provided resources they need to do so. The organization is structured to benefit new members to help educate them by providing a mentorship program. The current mentorship program consists of senior students, as well as professionals within various industries. Simultaneously, Brampton Robotics strives to mould members into future leaders by assimilating them into leadership scenarios.

The community lies at the heart of Brampton Robotics as we believe that by giving back to everyone now, we will be contributing to cultivating a better, more advanced future. We believe every student has their own respective strengths, and that all individuals are capable of achieving great lengths. Brampton Robotics helps to unlock their true potential by means of educating, nurturing, and guiding younger students along the right path to help them unlock their full potential. As students mature and enter new phases of their life, the experiences they have under their belt is what will help dictate the person they will become. The experience students will have as a member of Brampton Robotics is sure to be a memorable and incomparable addition.

All of our members have their own life goals that they pursue after leaving Brampton Robotics. Many have gone on to study in STEM-related fields such as pure science, architectural studies, engineering, mathematics, etc. Regardless of their post-secondary choices, all students gain an appreciation for the innovative world of science and technology and enhance their critical thinking, problem solving abilities. In the 21st century, the most valuable asset any company can have is its intellectual capital. That is the combined brain-power of each and every one of its employees. Having the proficiency to analyse a problem from multiple perspectives and solve it in various ways is a key employable and imperative ability. Not only are we providing students with a fun learning experience but we are preparing them to enter the future workforce through teaching them the correct skills, discipline, and rigour.

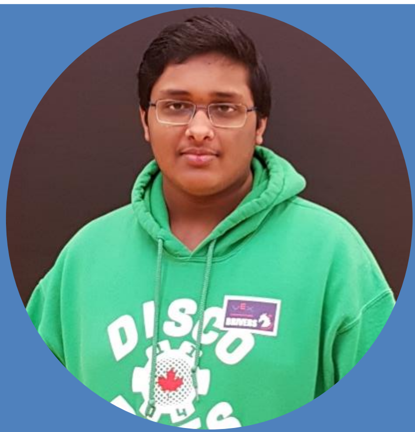
MEET THE TEAM

Prabhjot Lakhesar

Prabhjot is the team captain. His role is to coordinate all team efforts, design, build and program the robot. He is also the driver.

Thomas is a veteran member of the team. His job is focused around designing, building and programming the robot. Thomas is also a member of the drive team.

Thomas Wu



Taijus has been a team member for two years. He is in charge of scouting, troubleshooting, and the engineering notebook. He is also a member of the drive team.

Stardeep Sohi

Stardeep is a new addition to the team. His main focus is on team coordination and scouting.

Ashwin has been a member of the team for the past two years. His job is to coordinate scouting efforts and external affairs.

Ashwin Singh

Kaustav Sharma

Kaustav has recently joined the team. His role is to match scout, pit scout and organise the Engineering Notebook.

Angad

Angad is the newest addition to the team. He has a universal role as his interests lie in learning about all aspects of the team.

This is Ashvinder's first year of robotics. He is responsible for managing external affairs and match scouting.

Ashvinder Suri

GAME INFORMATION: VEX STARSTRUCK

How the game is played

The 2016-2017 VEX Robotics game is titled *Starstruck.* The game is played on a 12 foot by 12 foot field, divided in half by a fence stretching the width of the field, with each half further divided into halves by white indication tape (for simplicity purposes, these halves will be referred to as “zones”). The game features two alliances, each composed of two teams, fighting to clear their own side of the field to achieve a higher number of points.

The objective of the game is to toss the game elements form your own side of the field over (or under) the fence and onto the opponent’s side. The point system for *Starstruck* (refer to **POINT SYSTEM BREAKDOWN)** is setup to reward teams based on the final placement of the game elements at the end of the match. Each star in the near zone (area closest to the fence) on the opponent’s side of the field is worth 1 point. Stars on the far side of the field are worth 2 points each. With the cubes being a scarce game element, the cubes are worth double the points as stars. That is, 2 points for cubes in the near zone, and 4 points for cubes in far zone.

Each match begins with a 15-second autonomous control period. During this period, robots must perform solely on the sensory and pre-programmed inputs to score more points than the opposing alliance. At the end of the 15-second period, the team who has achieved the highest score is awarded 4 bonus points to be included in the final score at the end of the match.

Following the autonomous period, the match continues with 1 minute and 45 second driver control period. During this period the robot is controlled manually via a wireless connection between the Vex Nets connected to the cortex and the controller. As alliances fight to clear their respective sides of the playing field, one additional orange cube may be placed on the starting tile OR directly onto a robot in the starting tile during the last 30 seconds of the driver control period. This driver load is limited to one per alliance. In addition to this, a robot may also lift itself onto a vertical pole in the corner of the playing field during the last 30 seconds of the match. A robot lifted above the ground between 0-12 inches is deemed a low hanging robot, and is rewarded 4 points. A robot that has successfully lifted 12” above the ground is deemed a high lifting robot, and is awarded 12 points.

REGULATIONS GUIDELINE

The checklist below highlights the restrictions teams are confined to. Our team chose to use this checklist while developing and testing new ideas to ensure the validity and legality of the design as a whole.

Restriction	Checklist
Max size for drivetrain: 18” x 18” x 18”	
Robot must be placed in alliance starting tile at beginning of match such that it stays within area of tile and does not touch any game objects	
A maximum of one robot can be placed per alliance starting tile	
Each robot must use a preload of one star at start of every match*	
Driver control loads may only be placed with the confined area of a starting tile**	
Robots may not make contact with zones across fence separating both alliances	

*Star is legally placed if it touches robot, does not touch any grey field tiles, and remains within perimeter of alliance starting tile

**If illegally placed, opposing alliance is automatically awarded points equivalent to the scoring cube in far-zone

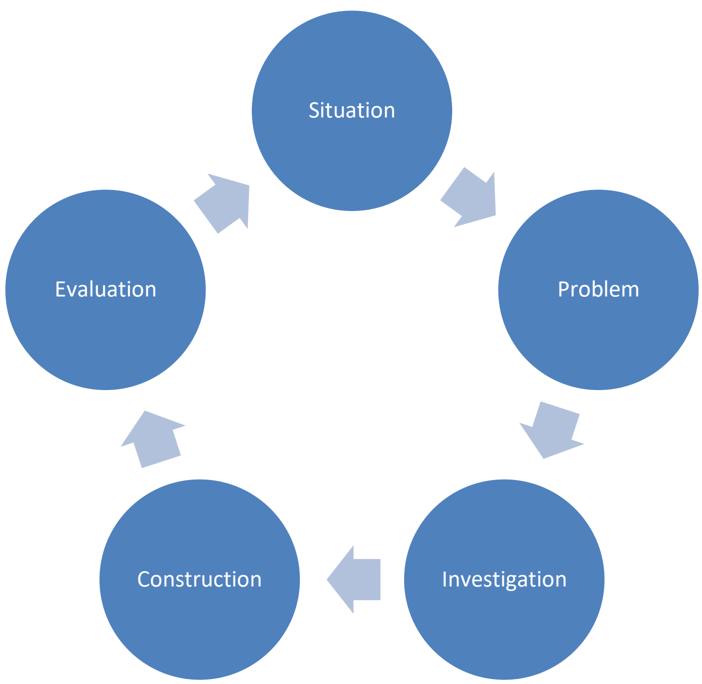
POINT SYSTEM BREAKDOWN

Scenario	Points Awarded
Star in near-zone	1
Star in far-zone	2
Cube in near-zone	2
Cube in far-zone	4
Low hang	4
High hang	12

THE DESIGN PROCESS

S.P.I.C.E. MODEL

S.P.I.C.E. is a design model used to approach and solve problems in a reiterative manner to simulate the engineering process. S.P.I.C.E. is a design process model that separates different stages of a project (usually involves with engineering design). It is used to bold each individual stage of the project to easily distinguish the problems and flaws and relationship between each stage. S.P.I.C.E. makes it so that we are able to go into each stage of the process with ease. In this section we will talking about this design process and how it has been incorporated to help build our entire robot and so on.



MODEL BREAKDOWN

S – Situation and Scenario	This is where the situation of the problem is stated. Most of the research is done about the situation and ideas are brainstormed.
P – Problem	This is where the problem is stated and the problem is discussed and ideas are beginning to be tested. The focus of the technological solution is also discussed.
I – Investigation	Brain storming and drafting usually begins this time. The performance specifications and constraints are determined.
C - Construction	Designing (CAD) and technical drawings are made. Sometimes a mock up is created, a prototype, and then the final product. In our case we created multiple designs before arriving at the final design we used.
E - Evaluation	This is where the other parts of SPICE are investigated and flaws are found. The product is to be improved to change any of these known flaws. It is a continuous process meaning it should be used in every stage of SPICE.

Overview of Situation

Our situation was to create a fully functional robot that was able to participate in the Vex game "*Starstruck*" This robot will be used to perform in various VEX Competitions and be able to work well in different situations that features different forms of alliances and opponents. The robot's performance must also be flexible in terms of strategic execution which will be discussed in the strategy section.

The robot must be light weight, stable, quick, and very precise since it needs consistently pick up and transport game objects. It has to be robust in order to last through multiple matches without requiring extensive repair. The robot also needs to be very quick in order to collect all the game objects at a fast pace and efficiently transport them to the opposing side. According to the game, the robot must be able to hang itself as well in order to score additional points. The robot must also be multifunctional and adaptable to any situation, giving it both defensive and offensive capabilities to overcome any obstacle standing in its way. Giving it such flexibility allows the driver to control the pace of the game, and react to both his/her ally's and opponent's moves to gain the edge in battle. Finally, the robot must follow the 18" x 18" x 18" size restriction when beginning the match. In addition to this all, the robot must have a good autonomous program so that it can dominate both the driver control and autonomous control period and perform successfully in every match.

We began to consider the types of robots other teams had created in past years so we could innovate and build/improve the design to suit the game. Being a rookie team, we strive for success and hope to obtain what we came for. We gained inspiration from each team's innovations and added our twist to the design to create an original and effective design for the robot.

Overview of Problem

The design must be adaptable so it can be paired alongside different alliance partners and execute a variety of strategies to combat the plethora of tactics it will be faced against. In addition to this the robot must be robust, precise, and agile in order to efficiently navigate the field.

It has to be built well in advanced of the competition date in order to account for driver and programmer practice time to perfect manual and autonomous robotic systems control.

Overview of Investigation

Online research was done on different types of designs suited to different situations. Past and current competitions were analyzed to determine the shape of the robotic subsystem used and the approach to how it was implemented during the game. This provided further insight into the flaws of each design. With cross examination between game rules and opponent ideas we could formulate an effective set of strategies and produce the right drivetrain to accomplish them.

TYPES OF METAL

Steel is a stronger, heavier metal than aluminum which means that it is harder to cut, bend and manipulate into different pieces. Since it can add quite a bit of weight to the robot's overall design, it can make it more difficult for the robot's attachments and drivetrain to work effectively. The arm for example relies on a single pair of motors to move it, therefore the greater the weight of the arm becomes, the more strain is put on the motors. The robot's center of gravity is consistently shifting throughout its motion due to the arm's vertical displacement, therefore it is important to take this into account and opt for a lighter alternative which allows the robot more freedom of movement. In addition to this if parts are to be manipulated then it becomes even more difficult with steel as mentioned previously, therefore the degree of customisability is limited which can be problematic when a specific design is required using VEX parts but it cannot be achieved due to the metal's properties.

In contrast aluminum is lighter and weaker than steel, which means it is easier to cut, bend and manipulate into different pieces. It makes the robot very lightweight and takes strain off of its motors greatly. Not only does this keep the motors safe and in optimal condition, but it allows the robot to move quickly throughout the fields and score as many game objects in the opposing zone as it can within the time limit.

Wheel Configuration

The robot consists of a drivetrain with four standard 3.25” Omni-Directional Wheels. These wheels allow for it to easily move across the field with a minimal force of friction acting upon the robot due to the plastic surface of these wheels. We decided to use these wheels since we found out that they provide the perfect amount of friction for the driver to control the robot correctly and still allow for it to move at a fast pace. Unlike the standard 3.25” wheels which would slow down the robot’s overall speed, these Omni-directional wheels do a good job of balancing driver handling with overall velocity.

Given the fact that the robot has a great mass this must be taken into consideration when looking at the stress analysis on the motors of its drivetrain. When it is turning the motors must act against the robot’s own weight and the force of friction which is resisting its change in motion. Therefore in order to reduce the force each motor must exert on the robot when it moves, Omni-directional wheels are used which once again reduce the force of friction acting upon it.

These wheels serve a key role in supporting and strengthening the robot’s overall design.

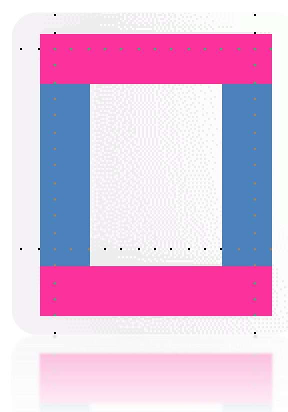
CHASSIS DESIGNS

The shape and structure of a drivetrain is influenced by several key factors, including but not limited to:

- The objective of the game
- Size constraints
- Shape of the field, in order to maneuver through it

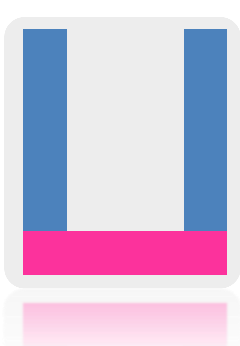
Therefore with careful consideration of the aforementioned factors, we were able to narrow down our choices for the chassis design.

RECTANGULAR BASE



This base is structurally sound, and can help the robot become agile if it is built to be small. It is the most balanced design that can have a load lift installed onto it at the front. This is helpful for collecting and moving multiple stars or a single cube onto the opposing alliance near or far-zones.

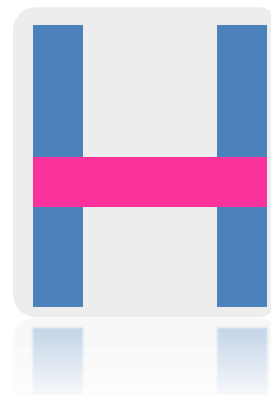
U-BASE



This base enables the robot to use a grabber, arm, or an intake system due to the wide space in the center of it. Distribution of the robot's weight must be carefully considered due to its vertically asymmetric design. However overall if built for the correct purpose then this base will be effective. Given the large space between the widths of its chassis, it can be used in conjunction with an arm or intake system. For the game *Starstruck*, the arm can be helpful for picking up stars and lifting the robot. However all cubes will be too large for it to handle and so it will be restricted in the range of game objects it can manipulate.

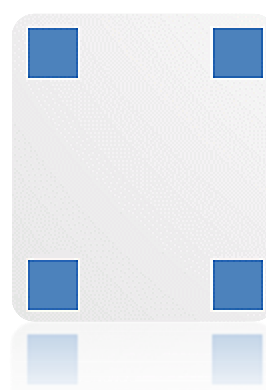
H-BASE

This base is structurally robust, offering a symmetrical design with space in the center for additional attachments such as an arm similar to the U-Base design. However due to its shape it once again cannot fit a lifting mechanism between the drivetrain as the width of the cube is so large that to fit it in, the drivetrain would surpass legal size limits. So it has similar restrictions as the U-Base does.

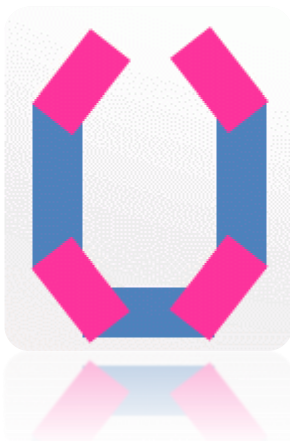


POINT BASE

This base consists of four pillars moving onto the ground, down from a tray. This design is not very useful at all since it is difficult to implement a stable lift mechanism on it. Due to its height off the ground in addition to that, lifting any heavy objects will create a major imbalance in its center of gravity, which can make it unstable. Overall this design is not suitable at all for *Starstruck*.



HOLONOMIC U-BASE



This is similar to the U-Base design except that now its wheels are tilted at 45-degree angles each. This allows for the robot to navigate along an x-y coordinate system. That allows for programmers to accurately control the robot autonomously since it is easier to work with precise coordinates than it is to work with a turning system. Yet this can be difficult for drivers to manually control and it faces the same problems as the U-Base did.

HOLONOMIC X-BASE

This is very similar to the H-Base and Holonomic U-Base design in the way its drivetrain is shaped and wheels are implanted. Therefore, it faces a combination of problems that both of those designs have with the same advantages. Due to the onset of issues it will face with lack of benefits, this design is simply unsuitable for the *Starstruck* game.

MODIFICATIONS OF BASE TYPE

All of the above are simply guidelines and starting points for designing the base of the robot. Any of these shapes can be combined, edited, and refined until the team is content with the design that they have. Each design is effective in its own way, and at the end of the day, it all comes down to the objective of the game which teams are competing in. There is no perfect design for any competition, and so finalising on a set design comes down to a mixture of extensive planning and experimenting.

DRIVE BASE CONCLUSION

Out of all of these designs on the drive base, we found the rectangular base to be most effective due to its potential to install a large lifting mechanism. Although it has a lack of an arm, other attachments can be installed onto the chassis to lift it. This design enables the robot to pick up as many stars as it can in the shortest amount of time, and in addition to that, pick up cubes. So it has the highest potential to score the most points out of every design mentioned due to its design capabilities.

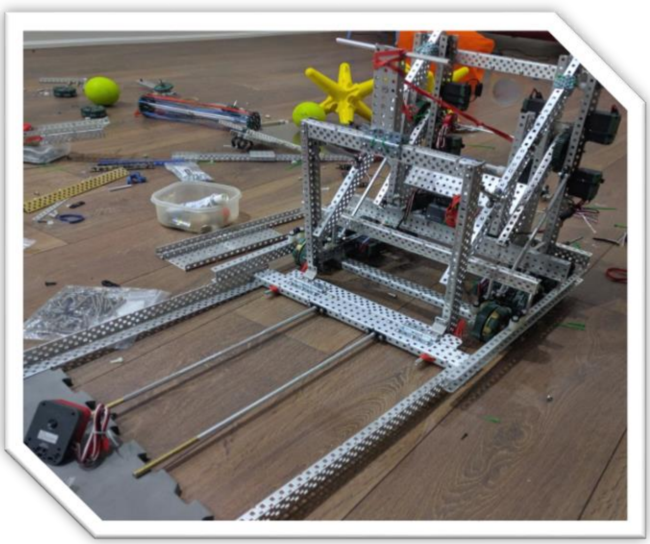
The robot's drive operates on four motors geared for turbo speed so that the robot can quickly navigate the field. It is not heavy enough to justify gearing the motors to torque since this setting is ideal for it.

Our robot in specific also features a pair of tracking wheels to allow for smoother autonomous programming. The tracking wheels are two internal wheels placed on a pivotal joint. These wheels are unpowered; they are not powered by any motor, but instead spin freely as the robot moves. The wheels are attached to encoders, which measure values based on how much each wheel spins. The tracking wheels allow the robot's movements to be taken into consideration even if it is pushed, or moves without the use of the drive as the tracking wheels always remain touching the ground regardless of whether the drive is slightly lifted in the air, or if it is in use on the ground.

GAME-INTERACTIVE ATTACHMENT DESIGN

PASSIVE INTAKE SYSTEM

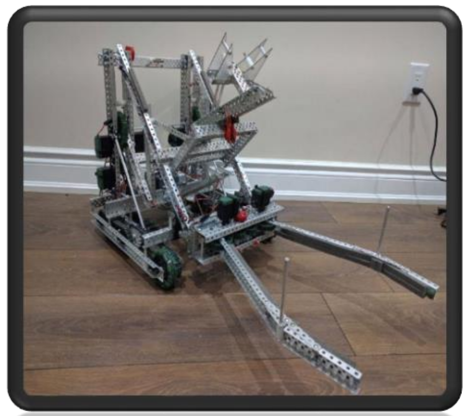
A passive intake system has the ability to pick up multiple game objects at once, albeit at a slower pace. This attachment requires a strong structural design to support it as it is very bulky. However due to its size, it is easier to control it manually and autonomously. This design would be equal to the width of the robot so the load put on it can be distributed over a greater area to reduce stress. The intake would also make use of rubber bands in order to help the lifting mechanism function and relieve stress on its joints. In order to make it function ideally, the linkage lifting mechanism must drop game objects at an angle to ensure they fall as quickly as possible. Time is of the essence in this game mode.



We attempted to use this design initially and figured out that it had worked effectively. However it ran into problems with objects getting stuck within the loading area or dropping out of it pre-emptively. The design also encountered issues as such picking up the game elements or require perfect angle and adjustments, thus reducing the cost and time it takes. This made the amount of points which we scored much lower than projected and so we had scrapped this design for the claw.

CLAW

Using a claw would mean that the robot is able to precisely and efficiently pick up singular game objects at a time. This in conjunction with an agile design could allow for a strong competition robot. If built correctly, the claw has the ability to efficiently and effectively pickup game objects of varying types, making it an ideal design.



The lift is built using a 1:5 gear ratio on a 6 motor torque system. The heavier emphasis is put on power over speed allows the lift to move a heavy mass in a stable manner, even if off-set from its pivotal point. The heavy robot is therefore able to be countered by a powerful enough lift system.

The claw also houses a 2 motor system geared for torque with a 1:5 gear ratio. This allows the claw to garnish enough power needed to pick up multiple stars and cubes simultaneously, thus allowing us to score fast while playing offensively. The additional power also allows us to pick up the cubes by means of tightly squeezing them. Squeezing the cubes serves as a method to grip them, allowing us to retain strong control of the larger and less elastic game elements.

The claw provided the robot with the ability to consistently pick up all game objects and efficiently place them into the far-zones of the opposing alliance area.

OVERVIEW OF CREATION

DESIGN SPECIFICATIONS

DRIVE TYPE: RECTANGULAR TANK DRIVE

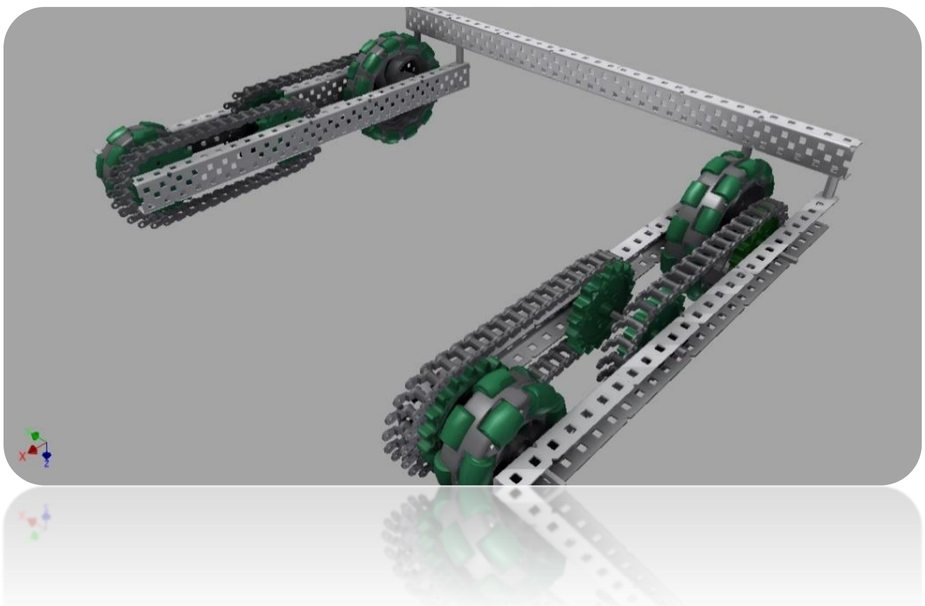
- Extremely lightweight
- Turbo gears installed for faster movement
- Consists of four motors connected to 3.25” Omni-wheels
- Offset four-bar linkage
    - Allows for ideal dump angle
- Uses rubber bands to make lift functional and relieve stress on it
- Claw added for precision

3D SIMULATIONS MODELLING

Computer-Aided Design (CAD) software is practically 2D and 3D modelling on the computer. It helps us create a design with having to waste any money or time reproducing it repeatedly. We could see a deeper understanding of how our robot works and what flaws that were happening in the robot. Using the method of constraining in Autodesk Inventor we could see how individual parts moved and we also could tell how they would react with their environments.

CAD helps improves the productivity of the creation of the project and help people visualize individual parts in their design. CAD also reduces time on math calculations. Most CAD programs allow the user to measure any objects they have created in almost any way they want. Autodesk also includes features such as stress testing which assesses the design and identifies the points with the greatest and least tension using a heatmap. In addition to this it can simulated testable features such as the robot's center of gravity in true scenarios. These are dynamic stress and frame analysises which allowed us to test each design's capabilities to determine the best one to meet our needs while wasting the least resources. This modelling software was an imperative tool.

We utilized CAD in our robot design by using the Assembly feature of Autodesk Inventor.

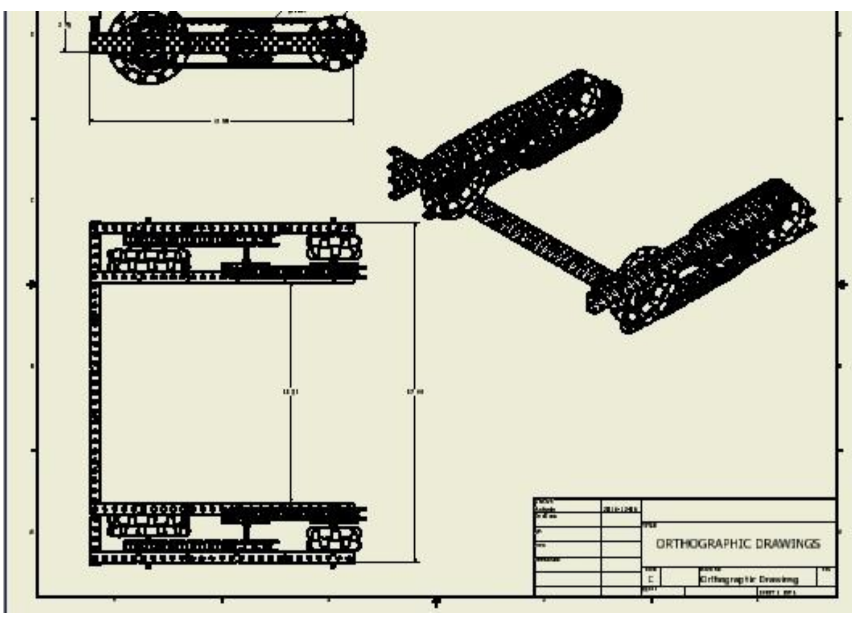


CAD had also helped communicate different ideas within our group. We were able to visually show different members of our group different parts of the robot in the CAD to allow them to fully understand before we can continue any further with robot. The CAD of the robot was done with extreme precision and because of this we were also able to extrapolate calculations from the CAD.

ISOMETRIC DRAWINGS

Autodesk Inventor has a drawing file function for looking at different views of a robot. The program professionally sets up different aspects of the robot onto the drawing sheet. The general views included Top, Side, Front, and Isometric Views. Isometric views are views that practically shows the robot drawn in 3D at an angle.

The drawing files also all us to put in a variety of annotations. These include text boxes and measurements. We could also add vital parts onto to robot design such as a center, hidden, and solid lines. Each of our subassemblies had a drawing that represented the parts and were all annotated to be used as reference when we were to make the robot.



Having an accurate visualization of each part made it easy to re-build the robot if it became damaged or determine which parts are exactly missing.

3D RENDERING

This part of Autodesk Inventor gives the CAD a more realistic look to it. The good thing about this we get to see an overall appearance of the robot. Once we see it we ask us the question: Does it look good? It does not just matter if the robot works well but it also must turn out to look good.

Autodesk provides different forms of rendering such as orthographic and perspective views. It also features different realism tools such as Ray Tracing. You can also add the reflections and see different shadows. Such as Ground, Object, and Ambient shadows.

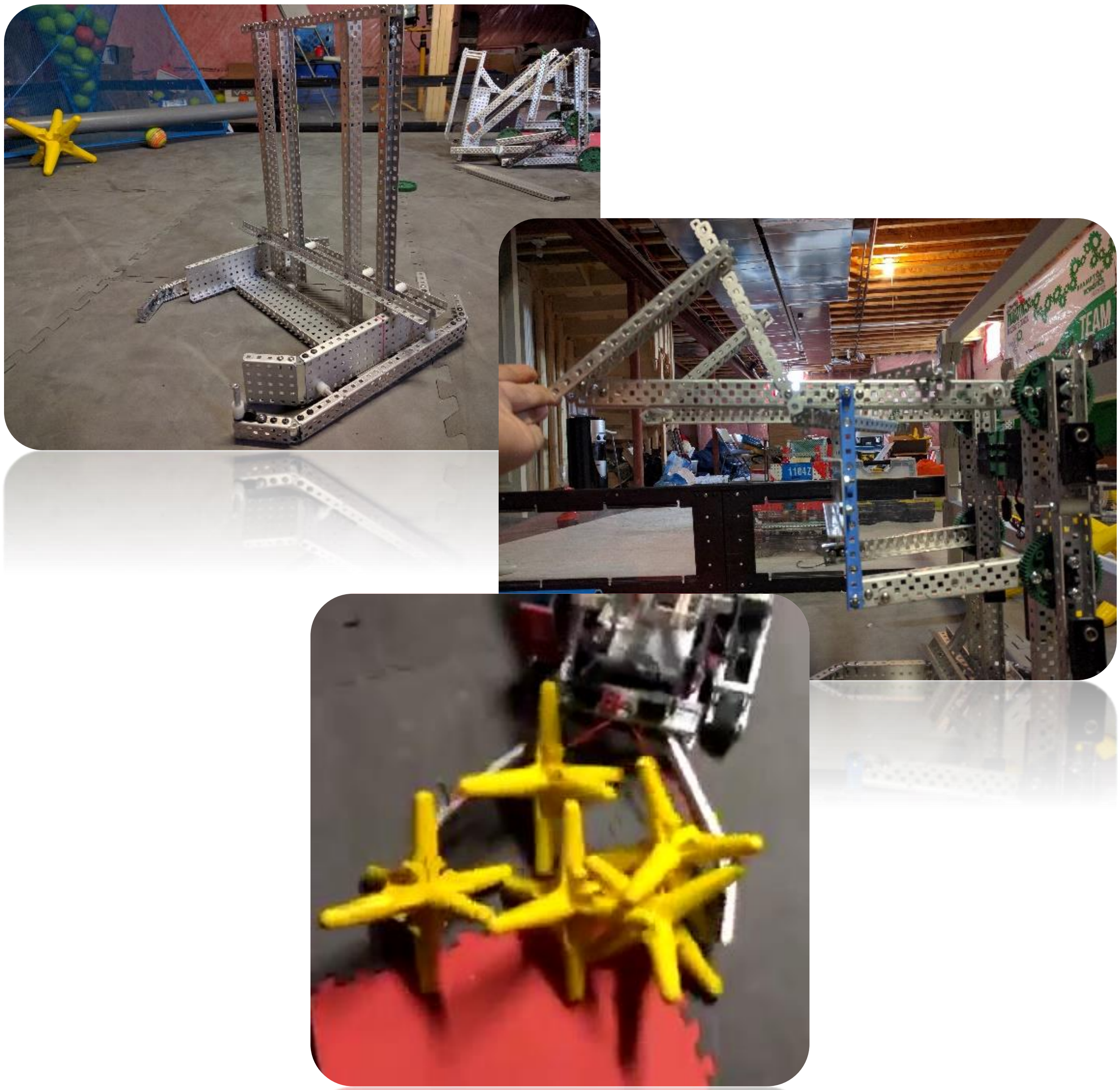
Each color and material in Autodesk Inventor contain a specific set of textures. This textures can be added and can be enhanced using Ray Tracing. You could also change the background to contrast with the CAD or you can change the background reflection.

But for our purposes, we used a program called “Keyshot” as it provides more realistic renders for inventor files, and lets you choose what resolution you want the picture at.

THE BUILDING PROCESS

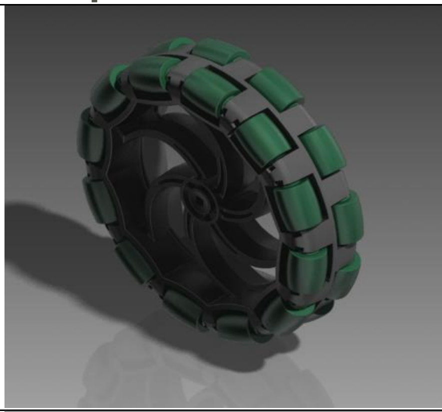
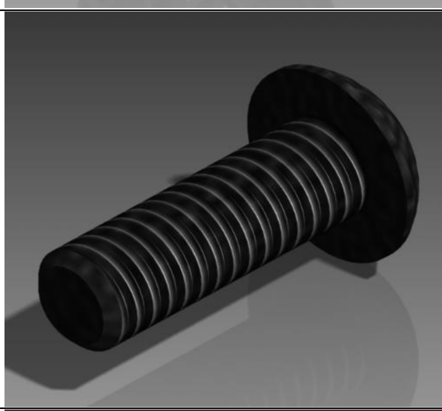
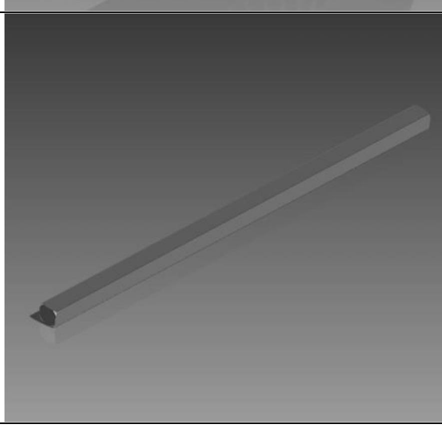
The building was very easy because we were able to reference back the drawings we had made on Autodesk and that we knew a lot about it thanks to CAD even if we had not built it right. We had begun with making the drive train. It was the first part because it was practically the base of we had to build off of. We had run into a few problems during building. The financial problem of getting the money to buy the parts were one of the biggest problems.

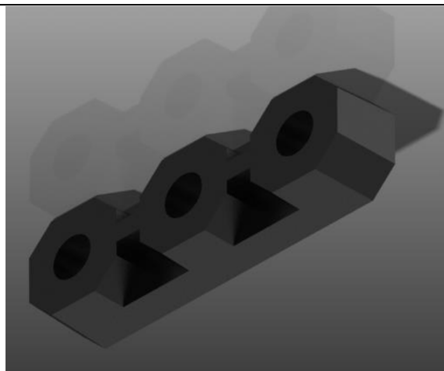
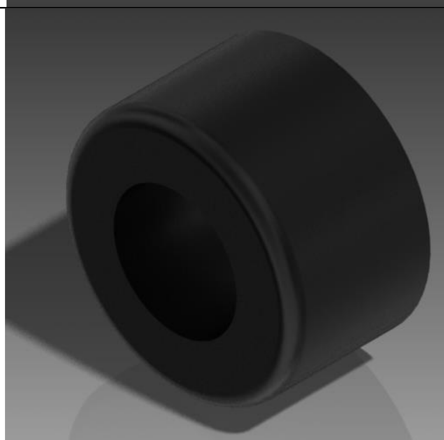
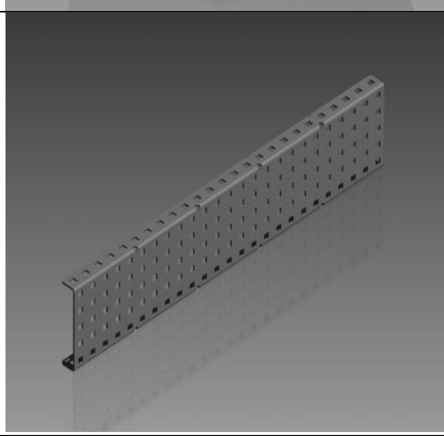
Over the summer, we began construction on our robot. We began by building a passive intake design with a rectangular base drive. This gave us the movement we desired while being able to pick up multiple stars simultaneously. By doing this, we were able to clear the field relatively quickly with minimal risk of failure. However, we realized this design contains a few flaws, including the inability to pick up cubes without having to run across the field and use the perimeter barrier to push the cube onto the lift. It also required precise positioning in order to pick up multiple stars without running the risk of it failing to pick up and/or getting stuck inside the intake. For these reasons, we decided to attempt a redesign, this time focusing on gripping each individual element to eliminate all risks associated with the prior robot. By making a large claw, we are able to grasp multiple stars and cubes regardless of where they are on the field. Our team aimed to have finished a tangible version by the end of summer vacation. This provided us ample time to test, practice and adjust the robot however we saw fit.

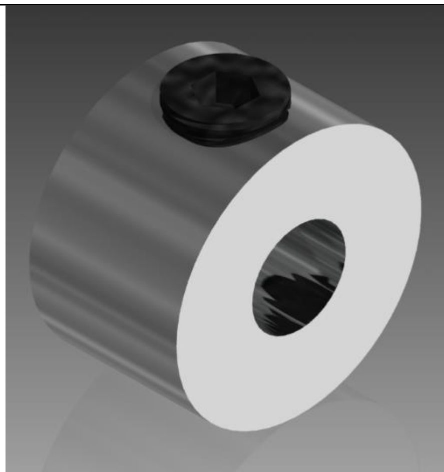
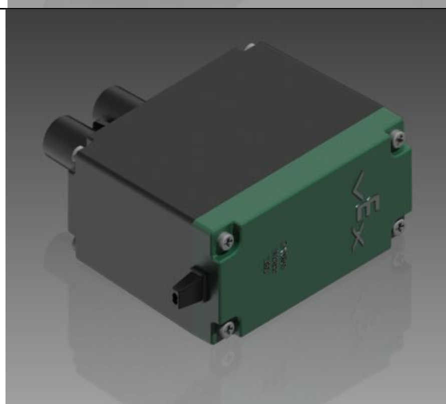
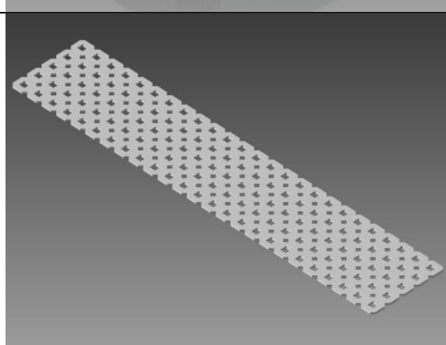
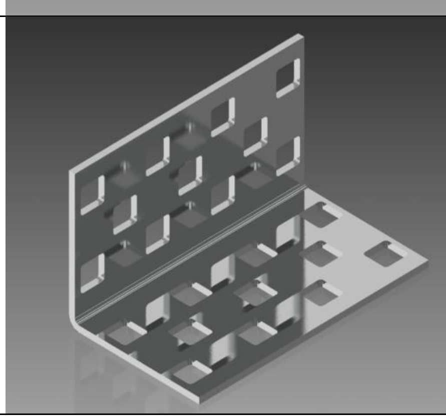


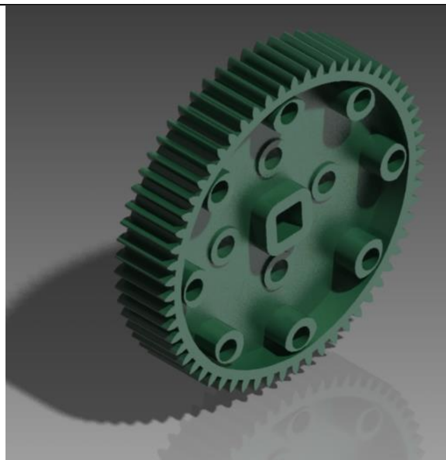
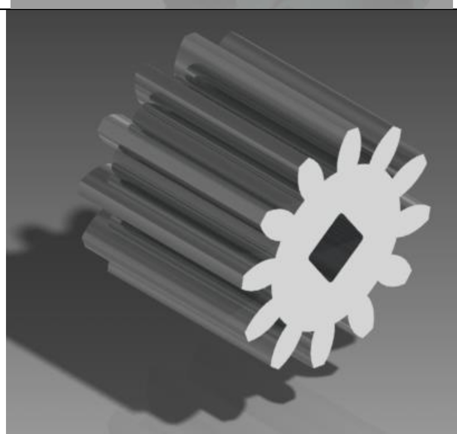
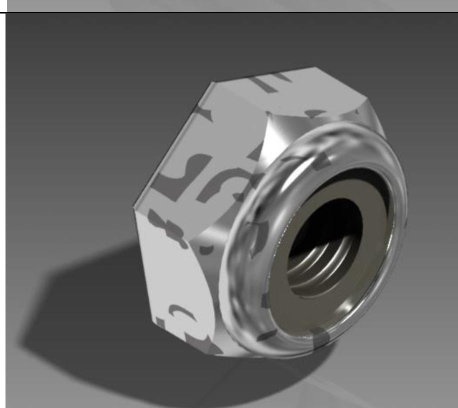
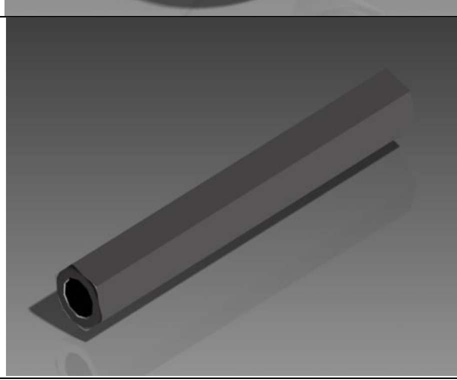
MATERIALS

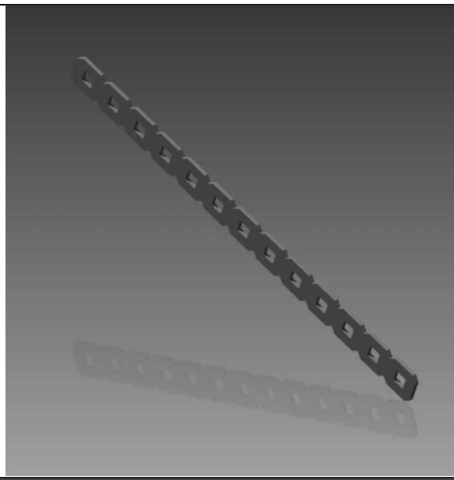
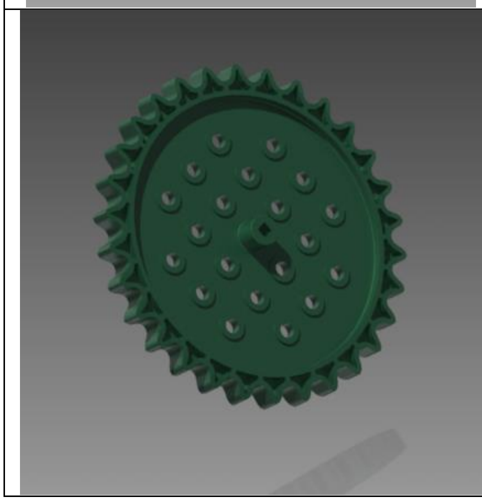
PART BREAKDOWN

Component	Description
	**THE OMNI WHEEL** The Omni wheel was used in the drivetrain of our robot. If mechanized it allows the robot to move sideways. It also provides good traction for the robot almost better than other wheels. It helps move around the field because it get slide sideways. They consist of a wheel frame and separately made Omni wheel rollers
	**8-32 THREAD/ 6-32 THREAD SCREWS** These screws are used to attach individual pieces together and are fastened by Vex standard nylocks, keps nuts, or regular nuts. They come in a variety of sizes ranging from .5 inches to 1 inches and above. The 6-32 Thread screws are thinner and are used to screw in motors.
	**SHAFTS** Shafts are used as pivot points for different parts of our robot especially on the drivetrain. It helps spin many parts of the robot. They are spun by Motors. Shafts range from .5 inches to 10 inches and above. Shafts can be cut using metal cutters to fit the size of a particular application

	**BEARING FLATS** These are used to guide and fasten different parts of the robot. For the drivetrain the bearings allows the shafts to turn smoothly and properly.
	**SPACERS (THICK AND THIN)** These were used to create space on different parts the robot. This was done to probably adapt to other parts that required to be placed in a certain position without moving the process. Depending on the amount of space needed spaces come in both thick and thin sizes.
	**C-CHANNEL** C-Channel is used for the main structure frame of the robot. It comes in many different and adaptable sizes such 151-25 (A seen on left) or 121-25. The 1 of 121 is the number of holes in the top extrude while the other 1 is for the bottom extrude. The middle number 2 represents what is the width of the amount of holes on the front surface on the C-Channel. The final number 25 tells what the length in number of holes is.
	**KEPS NUTS** This is one of the VEX fasteners we had used. It gets a good grip on the structure because of the grips on the circumference of it. This is good for fastening metal together. It uses an 8-32 Thread. These however begin to loosen after a while meaning they are not resistant to vibrations.

	**SHAFT COLLARS** These Vex fasteners are used to fasten shafts to the structure and all them to pivot easily. They contain a setscrew in a hole on the side that is used to hold it in place one the setscrew is tightened
	**VEX 393 MOTOR** The motors are responsible for most of the motion the robot creates. It moves the shafts that is connected too. The motors were used are set at High Torque Settings. This means the motor rotates at 100rpm. The motors can be configured to meet different rotational speeds by replacing the gears within the motor.
	**VEX METAL PLATES** These are another structural component on our robot. Most popular ones are 5x25 holes. Some are made in other different sizes. They can however be cut and modified to fit the robots needs.
	**ANGLE PLATES** These structural components come in longer sizes. The one shown on the side was modified to attach both the tower and the drive train together. This mean they can be modified to fit the needs of the robot like the other structural components.

	**HIGH STRENGTH 60 TOOTH GEARS** These were used in the tower. The larger extrude allows it to be able to pull a larger amount weight. There are 2 different types of Inserts that are put into the gears. These allow them to work differently. One of the inserts we used was called a rubber shaft insert.
	**HIGH STRENGTH 12 TEETH GEARS** These were the pinion gears for the tower. They were added to add more torque to the rotation of the larger 60 teeth high strength gear. This had not required an insert because they were made to fit the shaft.
	**NYLOCK FASTNERS** These are the other types of fasteners we used. They work just like a Keps nut but they contain a nylon lining in the inside of it. This makes it vibration resistant and makes it ideal for any lift or part that seems to move a lot.
	**STEEL BEAMS (STAND OFFS)** These are different form of spacers but they also act like a supportive binding for different parts of the structure. They come in different sizes like 3 inches and can be cut and modified to fit the right space. Beam couplers can also be used to connect 2 different beams.

	**METAL BARS** These are straight bars of metal. They are always 1 hole in width. We used these for added support on the robot, primarily our Lexan hood.
	**SPROCKETS** Sprockets come in different sizes ranges from different teeth counts. They are usually moved together using a chain. They are helpful for making intakes because they are compatible with the tank treads which intake flaps can be inserted into.

FINANCIAL BREAKDOWN

In addition to the parts used in previous years and as listed in "**PARTS BREAKDOWN**", the team recognized certain necessities in order to construct our robot to the best of our ability. Below is a breakdown of the additional parts purchased and used in the construction of the robot.

Item	Stock Keeping Unit	Quantity	Cost (CDN $)
Bearing Attachment Rivet (50-pack)	276-2215	1	10.99
Nylon Spacer Variety Pack	275-1066	1	6.99
Washer, Teflon (25-pack)	275-1025	1	6.99
Power Expander	276-2271	1	64.99
Aluminum C-Channel 1x2x1x35 (6-pack)	276-2289	1	45.99
Aluminum C-Channel 1x3x1x35 (6-pack)	276-4359	1	49.99
Screw 6-32 x 0.500" Locking (100-pack)	276-1958	1	12.99
Nut 8-32 Keps (100-pack)	275-1026	1	3.99
Standoff Pack	276-2013	1	20.99
2-Wire Motor 393	276-2177	5	99.95
Drive Shaft 2" & 3" Pack	276-2011	1	7.99
Screw 8-32 x 0.250" (100-pack)	275-1002	1	9.99
Screw 8-32 x 1.000" (100-pack)	275-1008	1	12.99
		Subtotal	354.83
		Shipping & Handling	11.65
		Tax	47.66
		Grand Total	414.14

In addition to part expenses, the team recognized team registration and competition fees were a substantial cost, and so the organization implemented a $150 registration fee + $18/competition. The total fee per person upon registration worked out to:

$$Registration\ fee + \frac{Parts\ Cost}{Total\ Members}$$

$$= \$150 + \frac{\$414.14}{5}$$

$$= \$150 + \$83$$

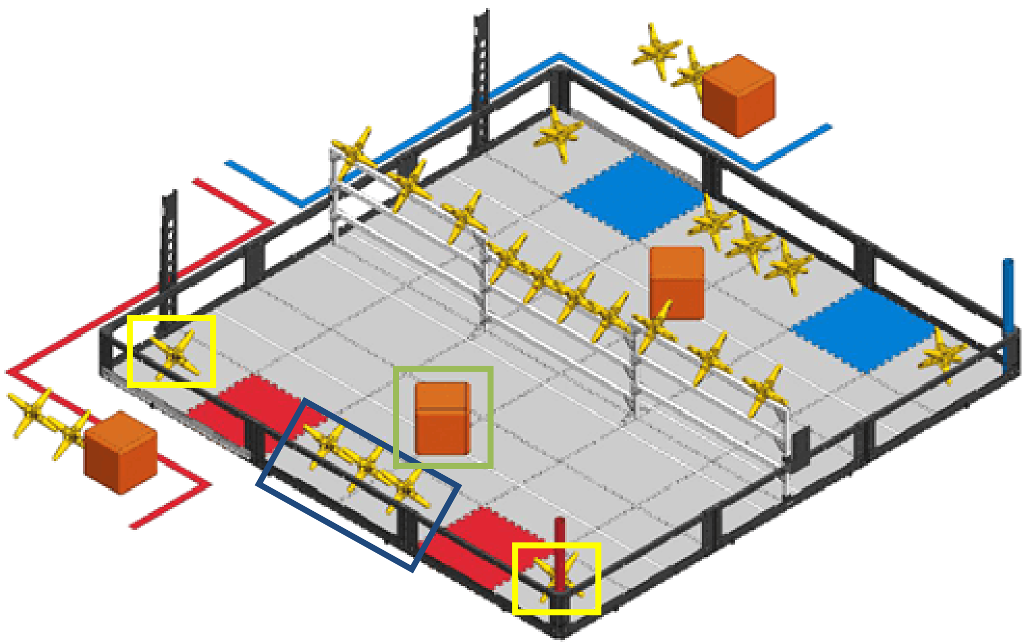
$$= \$233$$

Total Members was relative to the number of members on the team at the beginning of the season. Each member must also pay an additional $18 per competition as the team attends various events.

STRATEGIES AND TACTICS

GAME TACTICS

DEFEND AND CONTROL

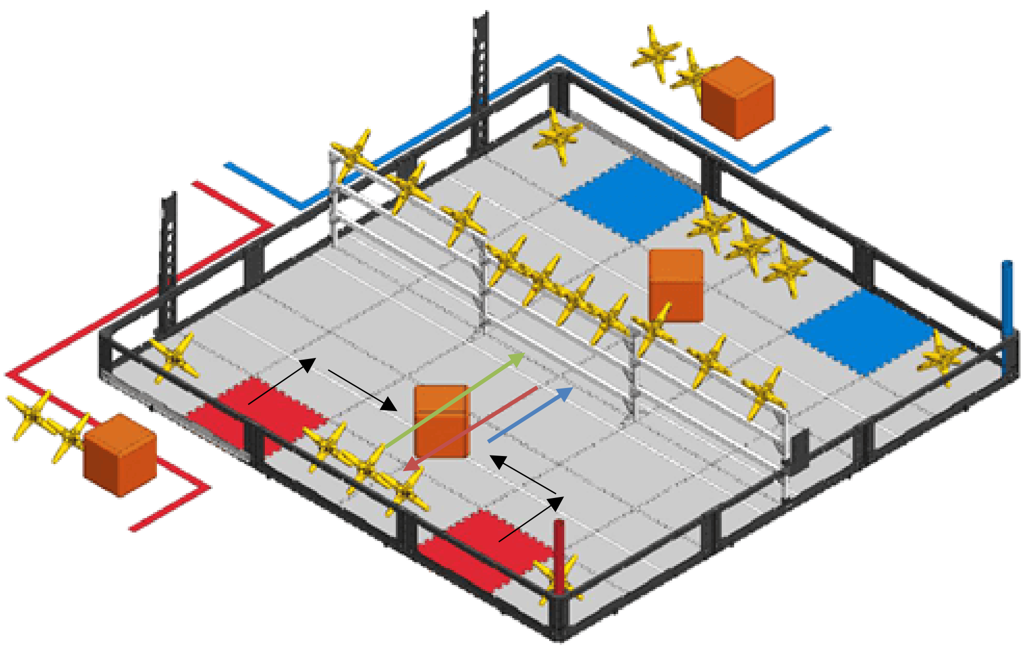


The key to this strategy is collecting the three stars in the center (highlighted in blue) and dumping them into the opposing team's far-zone. Then the robot is in ideal position to collect the cube and move it as well (highlighted in green). Then it becomes a priority to get the remaining stars (highlighted in yellow) to the far-zone as well. This will be part of the autonomous program to maximise points scored and clear the field. This is so the stars placed across the separating racks can be displaced in order to force the opposing to play defensively.

Then, as the opposing alliance scores game objects into friendly zone immediate action will be taken to return them to the opposing far-zone. This will be kept up until the last thirty seconds in which the driver control load can be dumped and the friendly field is to be cleared.

This strategy is used in conjunction with a robot that can high hang to maximise points.

AREA DOMINANCE



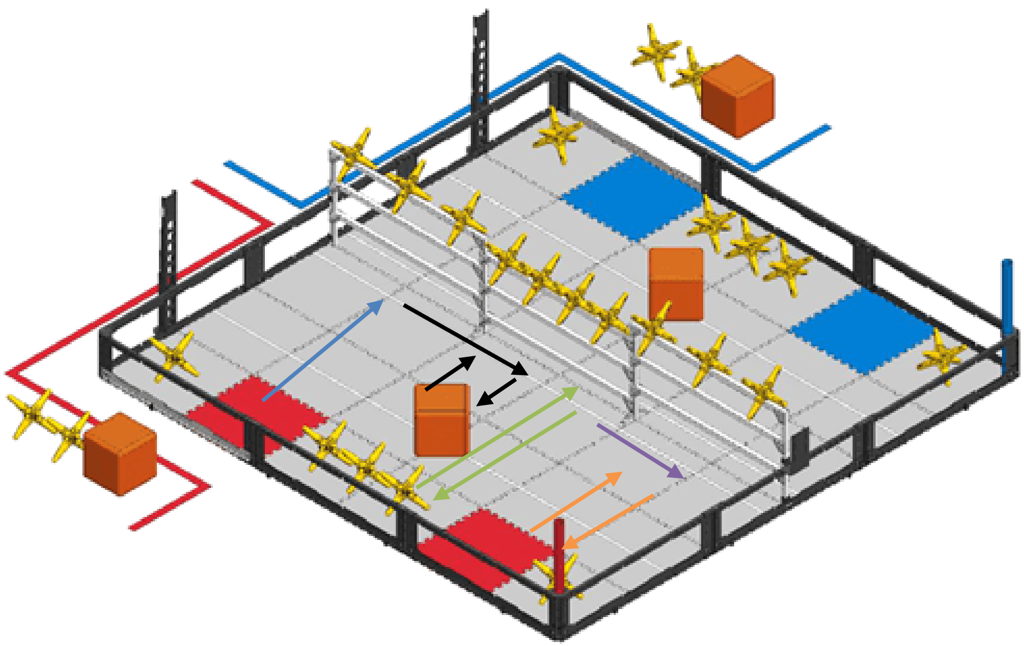
During the autonomous period of this tactic the robot will grab the game cube in the center (as indicated by black arrows which reference the alliance tile it begins on). It will move backwards and dump the game object (as indicated by blue arrow). Then it will move forwards and pick up the three stars (indicated by red arrow), move backwards again and dump the game objects (indicated by green arrow). Once it has done so, the robot will hold its position.

As soon as manual driver control begins, the robot will collect the stars on the separating rack in the middle of the field and dump them in the far-zone. It will continue to retaliate the opposing alliance if any stars are placed in its zone.

It will be up to the alliance robot to dump the driver control load in the last thirty seconds of the match in the far-zone. Our robot in this time period will prepare and execute a high hang.

This strategy is to be used with a strong alliance robot which can function self-sufficiently.

ROBOT SKILLS CHALLENGE



The skills strategy for this year is to head to one of the far sides of the field (indicated by blue arrow). Then collect and dump the stars on the rack nearby. Then the robot will move towards the middle, collect and dump the stars on the rack there. This is indicated by the black arrows of the diagram. It will proceed to move forward and move the cube to the far-zone, and the stars that are in the middle, close to the alliance starting tiles. This action is indicated by the green arrows of the diagram. The robot will then move to the far-side again, collect and knock the fence-stars into the opposing territory. That is indicated by the purple arrow. Finally during the last thirty seconds of the run, the robot will return to its nearest starting tile and attempt to transport all driver loads (two cubes and four stars) which is indicated by the orange arrows.

If practice enough and done efficiently, it is possible to clear the field almost entirely with this strategy and maximise points scored. If executed perfectly, this strategy will put us within the leaderboards of global rankings for the Robot Skills Challenge.

SCOUTING STRATEGY

Scouting is one of the most important elements to the success of our team in terms of build, and competition. Our scouting strategies mainly involve using

information from alliance teams and sourcing information ourselves through our scouters. Scouters are advised not to wear a team hoodie or anything that has our team name on it for the sake of not disclosing our identities to other teams, which may result in a changed attitude towards giving us information. We promote confidence and persuasive body language with our scouters as this would make the process of getting information from other teams quick and unquestionable.

Questions that are commonly asked by our pit scouters include; asking about drive-train and gear rations, autonomous performance capabilities, time taken to successfully hang (if they can hang at all), and most importantly, driving skills. Alongside the questions that we ask, another scouter takes detailed photographs of the robot making sure to include the drive train, hanging mechanism, dumping mechanism(s), and the team number plate. This information is all organized into our scouting log sheet with is shared with every member of the team instantaneously through Google Docs (partially shown on right). All of this information is used after the qualification round, where we select the teams that best suite our needs to be able to win the tournament. The build information and pictures that are compiled can later be used after the competition, where they can be used as inspiration and ideas for building mechanisms and write more efficient code for the next matches. All in all, our scouting practices require very bold, highly motivated and convincing individuals who use our framework to offer the team a plethora of information, which helps us in, and out of competitions.

	A	B	C
3		Match 1	
4	Team Number	DC Points (M1)	Autonomous Points (M1)
5	188A	12	0
6	188B	18	10
7	188C	38	12
8	188D	24	8
9	200A	14	11
10	200B	22	14
11	200C	30	6
12	211S	4	4
13	211W	29	0
14	211Z	42	0
15	356A	11	0

Sheet1

BUILDING TACTICS

This year, in order to keep our structures completely rigid, tight, and easily fixable, we as a club came up with a few strategies in building.

IMPLEMENTING LOCTITE

Over the past 2 years of our team doing vex, we found problems with standoffs and motors easily unscrewing themselves after vibrations, so we came up with a simple solution: Loctite

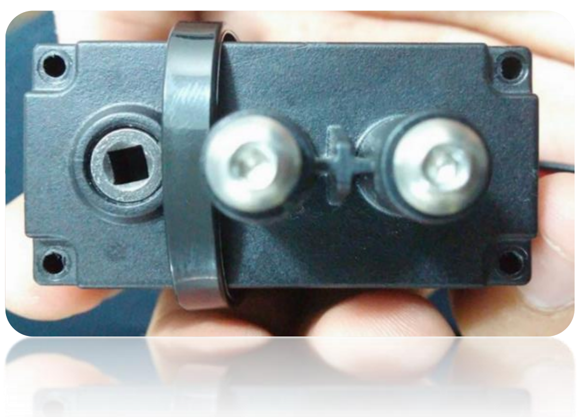
Loctite is a blue thread locker (non-permanent) which has a blue goo that you put onto the screw before putting into a motor or standoff. Loctite dries in the absence of oxygen, and expands the threading of the screw, which means that we cannot use it on things such as nuts. Here is a picture of a Loctite bottle:

These are the Loctite bottles.

INSTALLING MOTOR ZIP-TIES

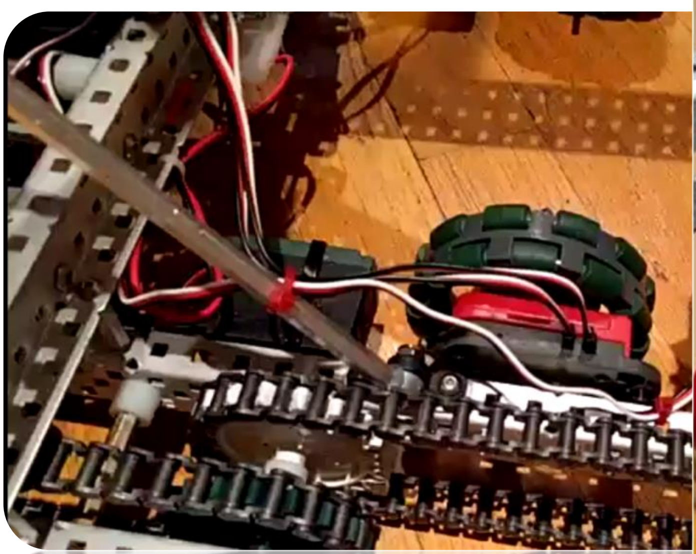
In our previous VEX experiences, we noticed motors would either consistently break, or required different internal ratios to power a mechanism effectively. To counter this, we replaced all of the motor screws with 1 large zip tie. This way, if we ever needed to change ratio or had a dead motor, we would not need to take it all apart, we can just cut off the zip tie and complete what is needed.

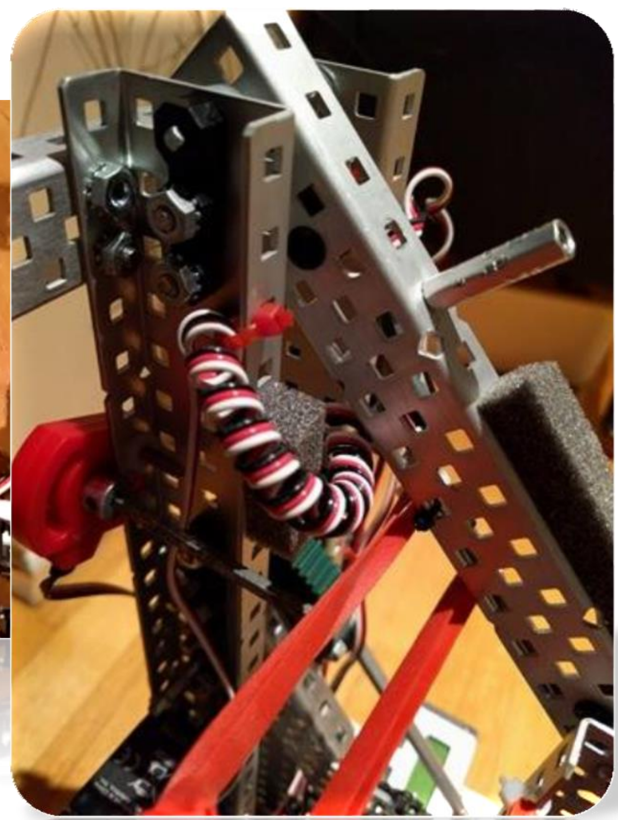
This proved to be very useful as the drive train and lift require multiple running motors for the full match. This lead to many dead motors which we could replace in less than 10 minutes, whereas without this, it would be closer to 1 hour.



WIRING

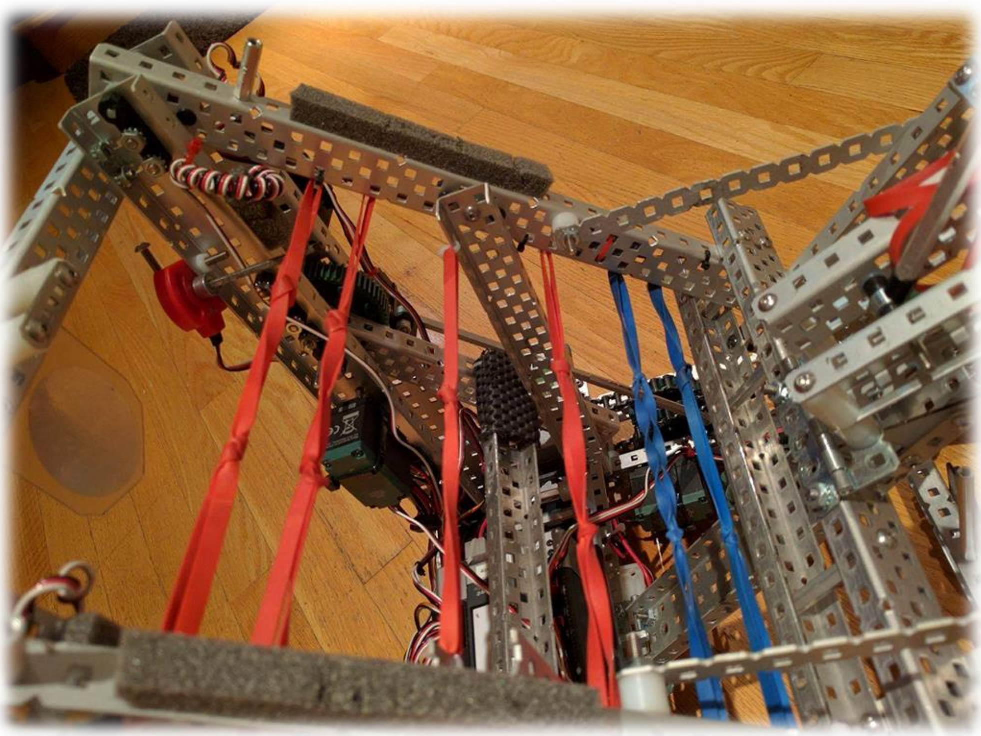
We have previously determined the wiring and cable management of the robot to be an important area where we have lacked in the past. As a result, the wiring on our robots would occasionally get damaged or destroyed, and simply even tangle to the point where modifying the robot would result in us having to waste time re wiring everything in attempts to follow the wires and where they lead. To save time and energy this year, our team has decided to coil all relative wires together and wrap them neatly together in a manner such that they would not get in the way with the robots functionality during the competition.





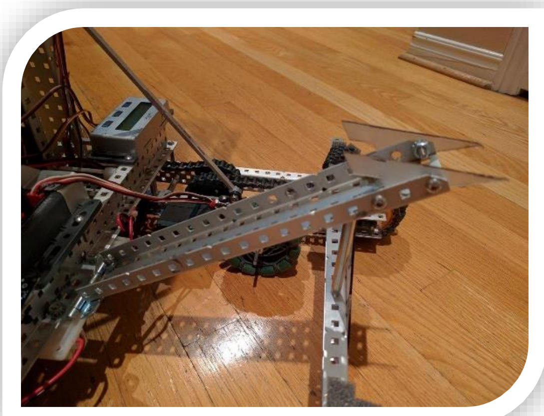
ELASTIC NET

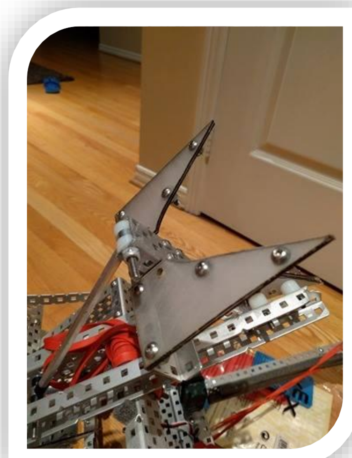
Originally, our robot would perform rapid actions and as a result, the occasional star would get stuck behind our lift mechanism. This would hinder the functionality of the robot, reduce the maximum number of points we could score, and prevent our robot from hanging in the final seconds of a match. The current design houses multiple rubber bands to create a net-like area underneath our lifting mechanism. This prevents any stars from getting stuck in this area, while allowing the lift to operate with full functionality.



HANG-LOCK

The robot features a locking mechanism to be used when hanging itself at the end of the match. As the robot latches onto the pole, it pulls itself up using the cross bar lift, all while using the whale tail to align itself correctly on the pole. After the robot has lifted itself, it locks itself in place using the built in locking mechanism to prevent any field disruptions (and gravitational forces) from causing the robot to fall back down. The robot also houses a limit switch to ensure the robot is at its correct height and has been placed all the way down to ensure stability for the design.





PROPORTIONAL INTEGRAL DERIVATIVE

Our robot attachments are programmed with a unique coding style referred to as Proportional integral derivative, or PID for short. PID is used by initiating a base value the encoders on the robot constantly evaluate their current states against. While attempting to approach the predetermined value, the program will analyze whether the values has been overshot/undershot (motors run too long/motors do not run long enough respectively). If one of these cases has been met, the program will automatically attempt to correct the values by increasing or decreasing the motor power/speeds to an appropriate amount so that the base value is reached. PID allows our robot to automatically perform actions such as opening and closing the claw hands when the lift reaches specific heights. This reduces the need for the driver to manually input several commands on the controller at once, and instead is only required to lift the attachment. The claw will automatically open to drop the game elements over the fence once the lift reaches a certain height, effectively reducing the time taken to perform the action as a whole while also reducing the risk of human error such as accidentally releasing the claw's grip too early. Our current presets for the claw attachment using PID loops include the following:

Preset Function	Purpose
Open Claw	The claw is fully open while the lift is not raised. This allows the robot to collect more stars simultaneously as it drives around the field.
Dump	This function is used to open the claw a suitable amount to drop the game elements over the fence when the lift has extended over the fence.
Closed Claw	This function is used to collect the game elements and continuously squeeze them together to allow for the maximum grip. This eliminate the need for the driver to hold the down the claw button while maneuvering across the field. This also reduces the risk of the game elements being dropped by the claw prior to the lift reaching its full stretch.

WEEKLY LOGS

WEEK 1

In this week the team came together for a short debrief session in which a variety of designs were brainstormed with everyone's inputs. A small document was started with a short description of each design and a rough sketch of it. The designs discussed were edited and tweaked to meet the game requirements better. Each one was carefully analyzed for its pros and cons and a list was generated to determine the best theoretical design based off of initial game knowledge. We arrived to the conclusion that a dumper robot would be ideal for its ability to grab a large quantity of game objects of varying sizes and efficiently move them into the opposing zone. We thought that if it is built to move quickly throughout the field and created with the correct design elements in mind, then it would have the ability to move game objects at a fast pace as well. In addition to this, being able to dominate the field makes the robot more suitable to excel in the skills challenge where a hang is not required. Its inability to hang was this design's only drawback in our minds and we considered getting a sister team or forming an alliance with another robot which can hang in order to maximize the amount of points that we score.

WEEK 2

During this week the plans that we created were taken to action and the so the building process began. Every year we constantly build the robot over and over again since each design has its own flaws which are not apparent until it is ready to be tested. Through an intensive quality control process we are able to determine the flaws of each design and build on them to produce a refined one. This repetitive process continues from the beginning of the season until the end of it once the robot has reached near-perfection. We take every practice session very seriously and attempt to emulate a true competitive environment by working under pressure and as quickly as possible.

We began creating this design and were able to complete the base drive for the robot relatively quickly. The next part came adding the dumping attachment to it. We played around with this part of the robotic design quite a bit since we needed to find the perfect balance between making a well-sized loading area and maximizing the attachment’s speed as it moved from its rest-position upwards. This required us to change the motor settings, gear ratios, support structure, and other components until the design worked better. Then testing for the design began and it appeared to be quite lackluster despite its effectiveness in theory. So we decided to scrap the idea and go back to the drawing board.

WEEK 3

In this week we decided to focus more on what other teams were doing and learn from them. We believe that people learn best through each other and so we built off the strengths of other team's designs. We looked at a variety of teams across America, China, and some other countries to look for design trends that powerful teams were incorporating into the game. More importantly however we looked at how they approached the game. It's important to have a strong design with the potential to dominate, but priority must be given to the game strategy which will determine the overall winner at the end. For now we focused on how the driver control period of the match was being played, and decided to begin the autonomous programming once a design was finalized for the first tournament. That's when we noticed how important having a robot that was able to hang was since it often became the tie-breaker for many close games between high-level teams. In addition to this we noticed that many robots were making use of a cross-bar linkage in conjunction with an intake system in order to collect game objects and effectively move them into the far-zone of the field. That's when we decided to apply those design elements into the next design.

So the planning process for this robotic design began. We thought of using many different drivetrains when this robot was created. At first we thought of creating an x-drive to easily program the robot for autonomous control period however realized that it made it too difficult for the driver to control with this type of base shape due to the joystick controls. So in order to support the robot's large intake system and cross-bar linkage design components we decided to create a rectangular tank drive which provides it with stability and easier control for the driver of the robot. Having good robotic handling is pertinent since the majority of points are scored in the driver control period, not the autonomous period, hence priority was given in this situation to the rectangular drive.

The initial sketch of the design was created and we planned to begin building the following week.

WEEK 4

In this week we began building the next design with the intake system and the cross-bar linkage. This design was much more complex than the last one since it required us to engineer a lot more moving parts into the same size limit used previously. In this week all that we managed to do was create a functioning passive intake for the robot to pick up game objects. We tested it out and it worked very effectively as it was able to pick up both types of game objects however the cross-bar linkage was difficult to perfect. We continued working on it the following week.

WEEK 5

In this week we continued tweaking the design and added the cross-bar linkage. The cross-bar linkage was difficult to build since it required a lot of work to be exerted onto it by the motors. They simply could not provide such a great amount through simple mechanical means, so we had to resort to using rubber bands to help support the weight of the cross-bar linkage and make it easier for it to expand

and collapse. Once this was done the cross-bar worked effectively and game objects were able to be picked up by the intake and moved over into the far-zone of the field with the help of the cross bar linkage. In the following week, the robot's hook was created to help it hang.

WEEK 6

Once this design was tested it was proven to be effective and so we decided to stick with it. A hook was planned to be attached to the back of the robot so that it could be aligned with the hanging bar to hang the robot. We thought of using an arm to move the hook with and this took a lot of redesigning to master. The main problem we ran into was creating the hook in such a way that it was able to consistently grab onto the hanging bar with a certain degree of error in mind. During competitive settings, it's impossible for the driver to be perfectly precise and so it is important to take this into account when designing the robot. We decided to slightly curve the hook however by using Lexan and VEX pieces together and this made it much easier for the driver to latch onto the hanging bar and allow the robot to hang.

WEEK 7

Once the robot was completely built the testing phase began. This entire week was spent upon getting familiar with driving it throughout the field and working under timed practice sessions to score as many points as possible. In addition to this we began practicing for the skills challenge with the entire drive team. The design worked very effectively and we were satisfied however as we watched other teams perform we noticed that we were performing well, but we were nowhere close to dominating them in terms of points scored. So we considered our design and tried to improve it. We figured out ways to move the robot in a faster, controlled way in order to help it navigate the field efficiently. This was good but it still was not enough so we began planning other types of designs.

WEEK 8

In this week we began creating sketches of new designs for a robot and decided that creating an entirely different drivetrain was foolish. The drivetrain was not the problem in this design, but in fact it was the precision of the intakes and how they functioned. Sometimes game objects got stuck between the intake system and other times they would fall out of it before being moved over to the other side effectively. This made the attachment imprecise and inconsistent in its performance despite working quickly. We realized that this was holding our design back from performing to its fullest potential so we decided to redesign the intake system.

We added metallic parts above the intake system in order to help guide the game objects along it and hold them securely in place so that they could be moved. We thought this would fix the initial problem, but it caused even more interference. We attempted to redesign the intake system's supports multiple times again until it worked better but we were never able to reach an effective end-result. That's when we threw in the towel and decided to create a different attachment design altogether.

WEEK 9

During this week we planned another design attachment and decided to go through with an arm. The robotic arm was initially thought to be useless due to theoretically small size and therefore inability to pick up larger game objects. However we reconsidered the design this time and engineered it to be adaptable to picking up game objects of varying size. We did this by creating an arm with a wide open-mouth claw. Again we built this attachment and tested it many times over during the course of this week until we were able to nearly perfect it. We ran into many problems along the way with objects falling out of its grasp as it picked them up, however we pushed through this problem by creating to be wide enough to surround the largest game object entirely. This provided it with an optimal hold onto everything and made the attachment work very effectively. Another issue with the design that we did run into was installing the motors correctly. It was tricky to figure out how to place the motors since they were very large parts that needed to be fitted into a tight spot which moved around, so we had to ensure that the motors were not in contact with other parts of the robot. This would have caused interference with them which could lead to complications such as the claw working ineffectively, or the motors break entirely due to external stress. This was a problem we had to carefully consider when designing the robot as it could have become the robot's greatest flaw. We finally did figure out the perfect placement for the claw's motors however and we tested the attachment finally. It worked better than every design we used in the past and we were very happy with our progress thus far.

WEEK 10

Similarly to week 8 we tested the design intensively to see how many points we could score in the game and skills. The robot performed at its maximum potential at this point and worked very effectively with the claw attachment. It took the driver quite a bit of time to get used to operating the robot now since previous designs made use of a very large loading area which was easier to control, however the claw required a high degree of precision. This took practice to get used to however it was manageable.

WEEK 11

During this week the robot was compared to international competition and it appeared to work much better than its foreign opponents. So we decided to finally work out some strategies for the driver control and autonomous periods. The autonomous program had a single version which we continued testing until we found a path that put our robot in the ideal position and scored as many points as possible. We thought of having multiple autonomous programs to throw opposing teams off and in case our alliance may have an autonomous program that makes it so their robot collides with ours. This is a bad situation to be in and so having multiple alternative programs provided us with a good safety net to rely. This week was spent on creating those programs and perfecting them all until we were satisfied with our results. We used RobotC to do all of our programming and it was a timely task to complete it but an important one to do.

WEEK 12

During this week we decided to continue practicing our driver skills to improve and practice sessions were dedicated to this week entirely.

WEEK 13 – 16

During these weeks we decided to meet with our sister teams and hold mock tournaments at our meeting place to emulate a real tournament environment. This allowed us to gain feedback from our teammates on our strategies and gave us helpful insight into how to react during different scenarios during the game. We were also able to practice working together with sister teams so that we could become a strong alliance during competitions.

WEEK 17

The first tournament came close to approach during this time so we decided to put a focus on our scouting plans now in order to gain a competitive advantage over other teams. We created an extensive master tracking sheet for in-game statistics gained from match scouting. This would have been when team members were sent to analyze matches played by opposing teams. Another master tracking sheet was created for pit scouting which focused specifically on the qualitative design elements of each team's robot. We planned on collecting information through observation, conversation, and analysis. We carefully thought of cross-referencing each team's claims to their robotic design to their true performance to find effective alliance partners who we could trust. Finally a scouting plan was created which went over roles for pit scouts and match scouts.

We wanted pit scouts to focus on going to every team's pit and interview them on their robot's design and take relevant observational data.

We wanted match scouts to focus on the numerical data of the game which was a much larger job that included a variety of key metrics such as the average number of game objects scored by a team over all of their matches. These jobs required a fast and consistently updated stream of information so we thought of creating Google Sheets for each scout to fill out simultaneously. This made it easy for all scouts and captains to access to information. In addition to this each important teams were color-coded to see if they would be good alliance partners or not. This electronic information relay plan was thought to be the most efficient and effective.

The team utilized a google drive for all competitor teams attending the tournament. The drive was divided into folders for each team, consisting of pictures and videos of the team's robot for later reference should we need it.

We take our competition very seriously and believe that understanding each opponent is key to determining their weaknesses and performing well at the competitions. That is why scouting plays such an integral role in our success as a team and why we dedicate such careful planning into it.

WEEK 18

This was the final week of the tournament and in this week we did some more practice sessions, finalized plans for the upcoming tournament and finished organizing toolkits for the tournament.

COMMUNITY OUTREACH

In order to continue funding the team's efforts we have organised community events in the past and reached out to companies to request a sponsorship.

One example of a fundraising event we did was the Walk for Westpark Healthcare Center in which half of all proceeds were donated to our local medical clinic.

We wouldn't be where we are today if it were not for our sponsors listed below.

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