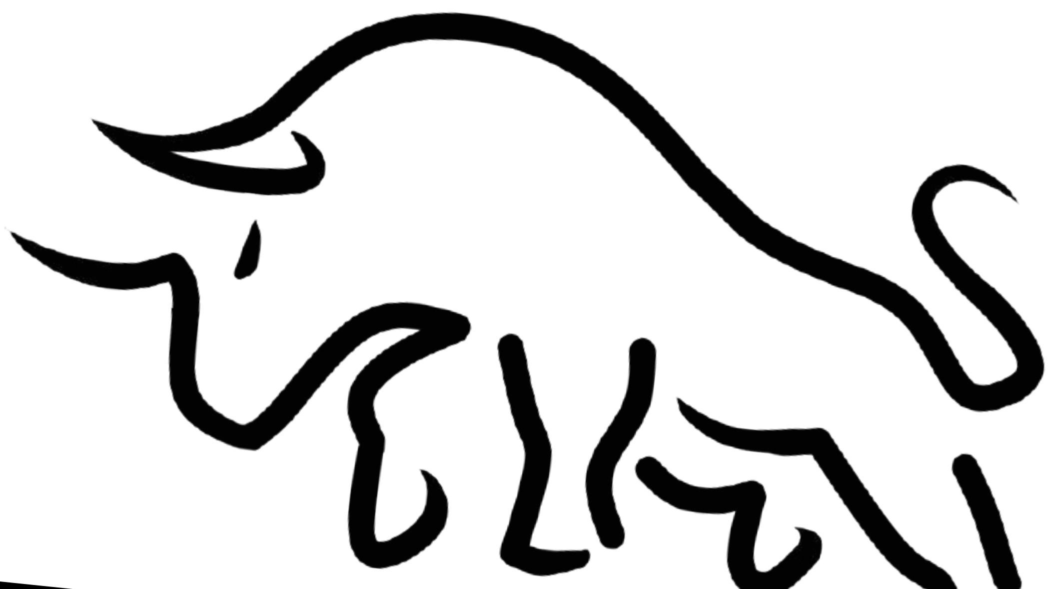
Hurricane
3388H
2023-2024 Engineering Notebook
VEX Over Under



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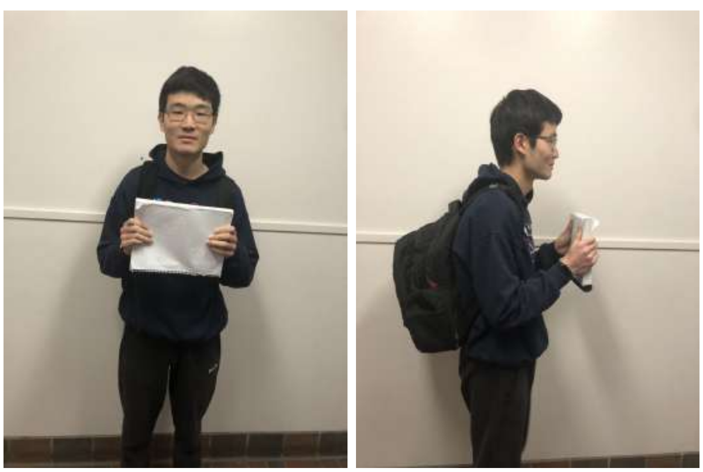
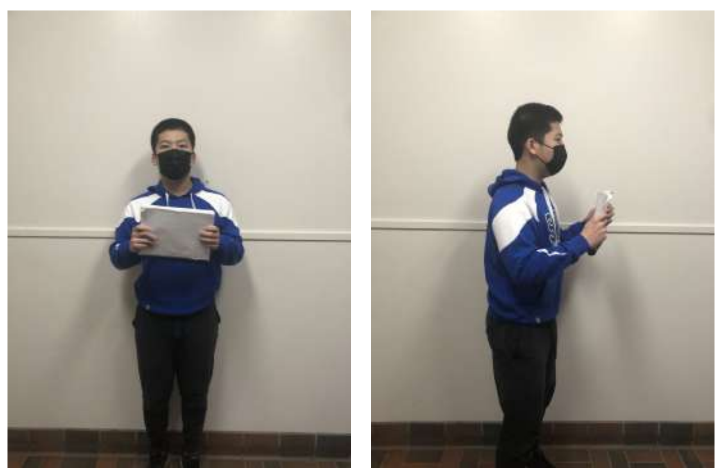
The Team



Matthew Zhang

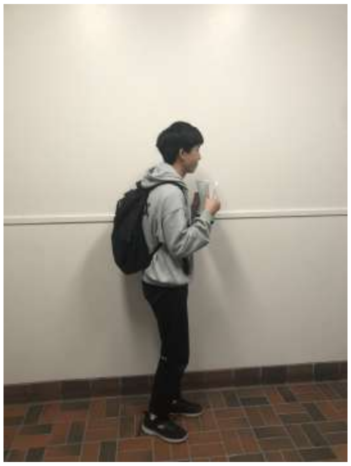
Matthew is one of the primary builder and the primary designer of the team. He also helps with coding and driving the robot.



Austin Ma

Austin the primary programer of the team. He also helps out with building the robot and writing entries in the Engineering Notebook.

The Team

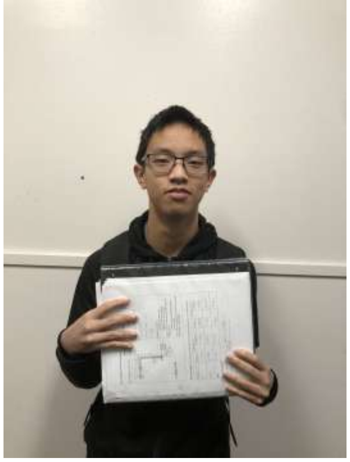



Oliver Liu

Oliver is one of the primary builders of the team. He also helps with writing entries in the Engineering Notebook.


Bolo Wang

Bolo is one of the builders on the team. He also helps by assisting others and keeping the workplace neat and tidy.




Darien Ng

Darien is the primary Notebooker of the team. He is in charge of writing entries in the Engineering Notebook and also helps with building the robot.

Members who left:
Julia Miao - Helped with building and notebooking.
Joined June 13, 2023
Left October 21, 2023

Ronald Li - Helped with building and coding.
Joined November 2, 2023
Left November 21, 2023

Jeffrey Wang - helped with building and notebook.
Joined October 20, 2023
Left December 1, 2023

How to Read this Notebook

Title	This font will be used for page titles.
Dates	This font will be used for the dates on which the page was made.
Text	This font will be used for regular text in this notebook.
Text	This font will be used for descriptions of images or figures.

Color Coding: Each page will have a color code corresponding to the step in the design process.

- Identify Problem Tab
- Brainstorm Solutions Tab
- Select and Plan Tab
- Prototype/Build Solution Tab
- Test Solution Tab
- Miscellaneous Tab

For diagrams, different colours of arrows may be used while labelling. These colours are just to provide contrast with the image and have no other meaning unless specified otherwise.

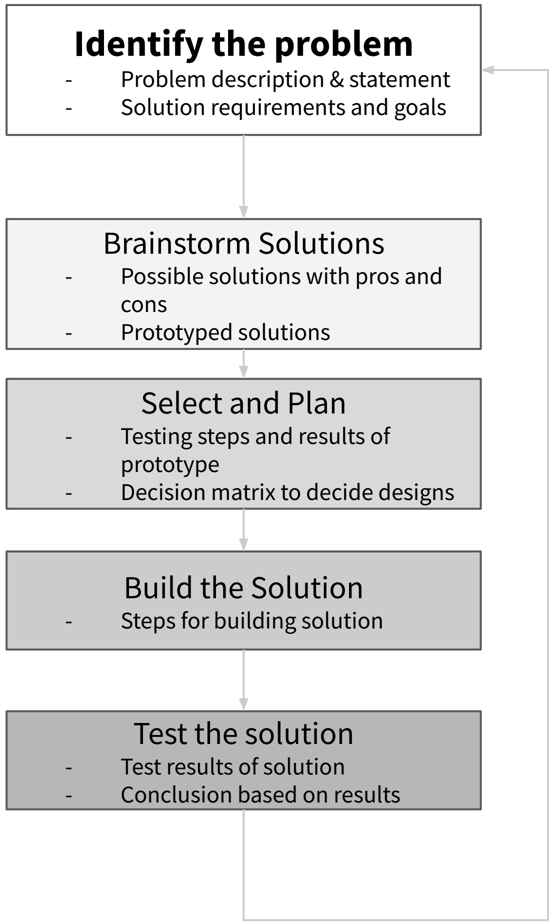
Early Design Process

2023-06-10

In our Over Under season, we will be using the standard design process. The major reason for using this is because:

When designing subsystems, we often realize that we would not always understand how or why a specific mechanism would work in an actual environment. By using this design method, we quickly cycle through designs and discover issues and faults with them through prototyping and testing. These mistakes help us develop more skills and knowledge as to why some designs work while others fail, allowing us to ensure all of our designs are consistent and optimal for us.

The design process forces us to prove that whatever we have on our robot is the best choice possible, instead of randomly picking something and hoping for the best. This way, we can optimize the performance of our robot.



Designed by:

Matthew Zhang

Witnessed by:

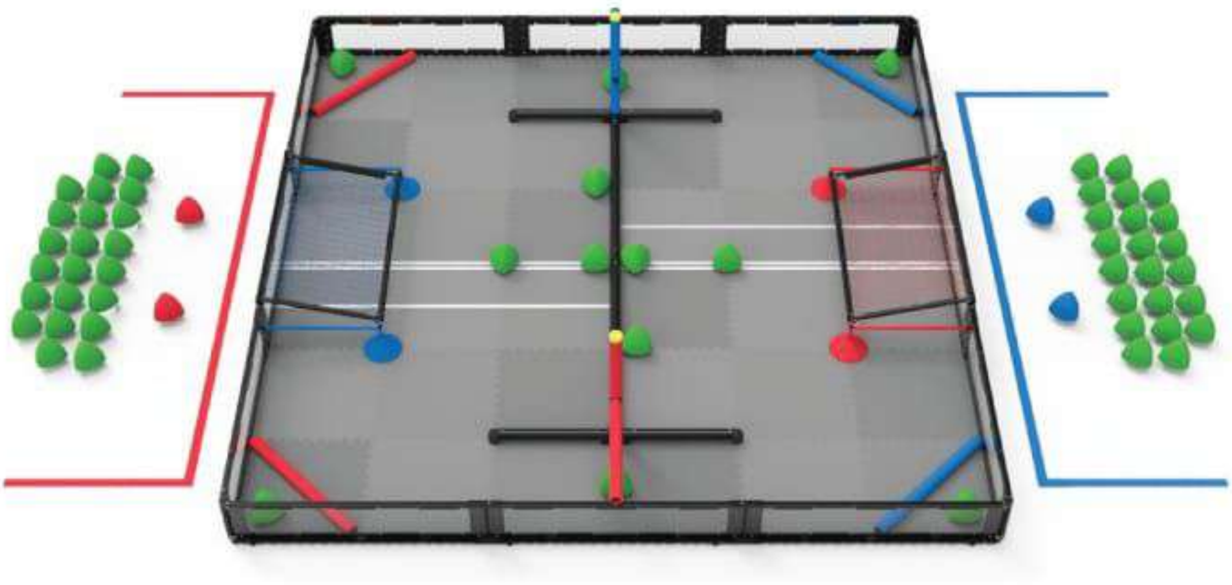
Oliver Liu

Game Overview

2023-06-10

The Field

In VEX Over Under, the goal of the game is to score more points than the opposing alliance by scoring triballs into low goals and the offensive zone, and climbing the elevation bars to elevate the robot at the end of the game. The field is 12 feet by 12 feet in size with two low goals and a barrier in the middle. There are also match load zones on each corner where teams can load triballs onto their robots.



The field for VEX Over Under.

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Matthew Zhang

Game Overview

2023/06/10

Triballs

The primary game element for VEX Over Under is the triball. The triball takes the shape of a Reuleaux tetrahedron. This shape has a relatively constant width while having an asymmetrical, curved shape. This shape causes the triball to move in a chaotic manner.

A triball.

Scoring

In VEX Over Under, different things are worth different amounts of points. The scores given for each action are listed below.

Action	**Score**
Triball score in the low net	5 pts
Triball in opponent offensive zone	2pts
Elevation (depending on tier)	5-20 pts
Autonomous bonus	8 pts

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Matthew Zhang

Game Overview Continued

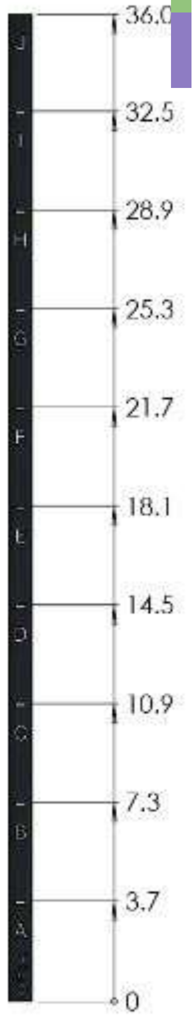
2023/06/10

Elevation

Elevation points in VEX Over Under are slightly more complex than other actions such as scoring triballs in low goals, which are fairly self-explanatory. Elevation points are not the case, and they are dependent on the elevation of our robot on the elevation bars relative to other teams. Elevation in VEX Over Under is measured with an elevation measurement stick, which has ticks at various heights, each corresponding to a separate elevation tier.

The scoring works by having the team with the highest elevation tier receiving 20 points, second receiving 15, third receiving 10, and fourth receiving 5 points. Teams on the ground do not receive any elevation points. Any tied teams will both receive the higher ranking.

The specifications for the elevation measuring stick can be seen to the right. All numerical values for the measuring stick are in inches. The lowest elevation tier is A which starts just off the ground and the highest is J at 36 inches or more off of the ground.



Designed by:

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Matthew Zhang

Game Analysis

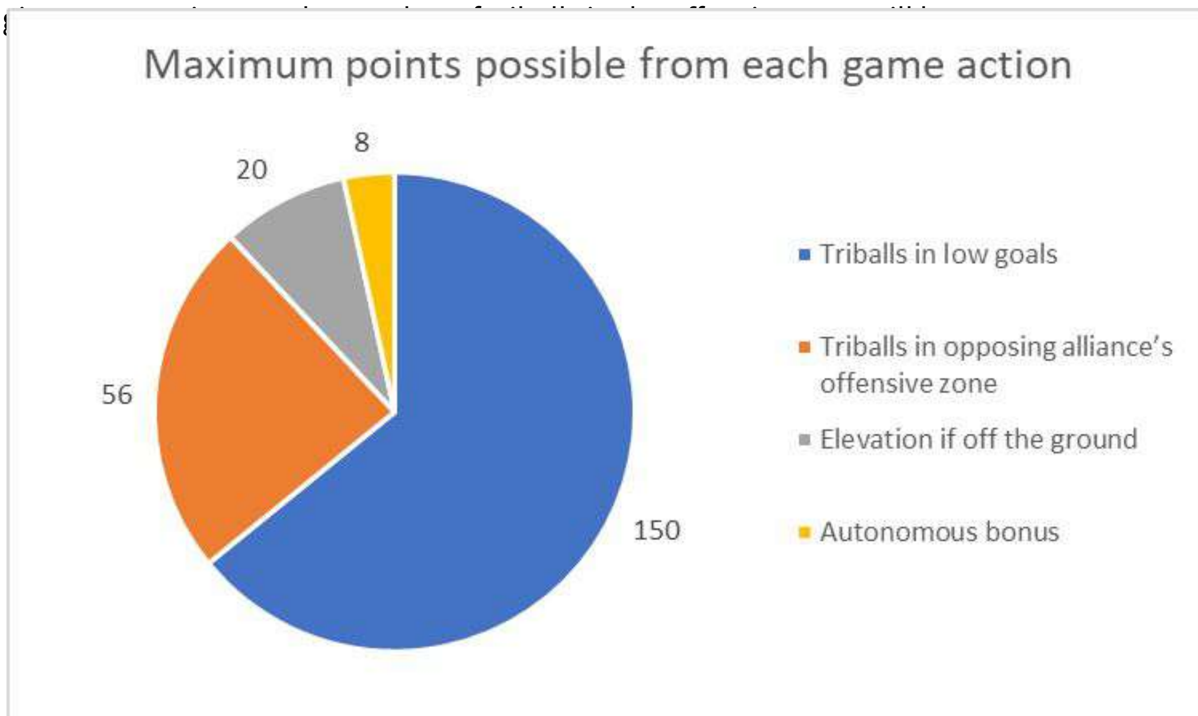
2023/06/10

Goal

In order to be successful in this game, we believe that it is necessary to gain a good understanding of the game and to set priorities on the different ways that we can gain points, so that we can design our robot to be as effective as possible during matches. This process will also help us establish some priorities for our robot.

Scoring Prioritization

Because each action is worth a different amount of points and there are differences in how many times each action can be done (there are 60 triballs while elevation points are only counted once at the end), we will be comparing the total amount of points reasonably possible from each action. For the table and graph below, it will be assumed that we can fit a maximum of 30 triballs in the goal, and that the remaining triballs will be in the offensive zone. Note that the two alliance triballs that belong to the opposing alliance will never g



From this pie chart, it is clear that triballs in the low goals should be a first priority as it makes up a large majority of the total points possible in the game. Next would be getting triballs in the offensive zone. Third is elevation and last is the autonomous bonus. However, it should be noted that all of these actions are still important, as every point that we get will increase our overall chances of winning.

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Game Analysis Continued

2023/06/10

Win Points

Win points are the first basis of ranking teams, and are extremely important if we want to be able to advance through the tournaments. Win points are gained through winning or tying a game, and through the autonomous win point for completing the three tasks required during the autonomous period. Win percentage is also important but that increases as our win points do, so we don't need to worry about that too much.

The autonomous win point is a good way to gain win points while being quite easy to get. It is important to note that an autonomous win point is a win point and is separate from regular points gained through the autonomous bonus. An advantage of the autonomous win point is that we can also get them quite consistently while it is practically impossible for us to win every game that we play. There are 3 tasks that we have to complete during the autonomous period without breaking any rule to gain the autonomous win point which are listed below.

1. Removing the triball from the match load zone on our side of the field that matches with our starting tiles
2. Scoring an alliance triball in our own goal
3. End the autonomous period while touching our own elevation bar

Designed by: Darien Ng

Witnessed by: Matthew Zhang

Game Strategies

2023/06/10

Robot Requirements

In VEX Over Under, there are a few rules which must be followed in order for our robot to be legal to compete. The rules that are relevant to what is discussed in this section are as follows.

- The robot's starting size must not exceed 18"x18"x18"
- No horizontal dimension on the robot may exceed 36" at any point in the game
- The robot must be built using VEX legal parts
- The combined wattage of all motors on the robot must not exceed 88W
- The robot cannot have more than 2 pneumatic reservoirs

Offensive Strategies

From the ways in which points are scored and the prioritization discussed above, we believe that our robot should have these following offensive qualities, all of which will be further discussed below.

- Ability to score into the low goals quickly and consistently
- Ability to climb onto the elevation bars and stay at that height
- Ability to quickly and consistently move triballs into the offensive zone.
- Autonomous code that can fulfill all the requirements for an autonomous win point

Ability to score into the low goals quickly and consistently

There are many advantages to being able to score triballs into the low goal. Firstly, they are worth a lot of points as each triball scored in the goal nets 5 points. Combined with the 30 triballs that can reasonably fit into a single goal, goal scoring alone can bring us up to 150 points. Scoring triballs into the goal also brings the triball out of play, as they cannot be descored unless our alliance double-zones and has both robots on the same side of the field. By bringing triballs out of play through this method, we reduce the amount of triballs that our opponents have access to, so they have less scoring opportunities while we gain points. In addition, scoring can be done in quick succession with multiple means, which will be discussed later on.

Disadvantages to scoring triballs in the low goal mainly come from difficulties presented by how the goal is 0.4" (1cm) shorter than the triball's width. Because the goal opening is smaller than the triball, there needs to be substantial force or momentum on the triball to force it into the goal, and any scoring systems have to be built accordingly. This also presents problems when there are already triballs in the goal, as more energy will be needed to move the triballs inside the goal to make room for new triballs while scoring. The scoring process can also be time consuming and we would need to be careful of double zoning.

Designed by: Darien Ng

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Game Strategies Continued

2023/06/10

Offensive Strategies Continued

Ability to climb onto the elevation bars and stay at that height

Climbing onto the elevation bars at the end of the game can help us gain an edge over our opponent because of how the elevation point system works. Since points given through elevation are based on a robot's elevation tier relative to all other elevated robots, by elevating higher than opposing robots, we are able to gain a decent amount of elevation points while our opponents will be gaining less through their elevation. This makes the modest amount of points given through elevation more than it appears to be.

One of the major disadvantages of focusing on elevation is that we are unable to focus on other parts of the game such as scoring triballs while elevating or elevated. This can lead to our opponents being able to move triballs at ease around the field since we would have no capability to defend any offense from our opponents.

Ability to quickly and consistently move triballs into the offensive zone

By moving large amounts of triballs into the offensive zone, we are able to quickly rack up points. Each triball is worth 2 points, and with mechanisms such as a pusher, we are able to move huge amounts of triballs at a time. Like elevation and low goal scoring, moving triballs to the offensive zone means that the opponent loses points while we gain them, making this method quite effective.

The most major disadvantage of this offensive strategy is that the opponents can move the triballs back into their offensive zone just as easily as we are moving it to ours. Because triballs are also individually worth quite little, we need a mechanism to move mass amounts of triballs in order for this strategy to be viable.

Autonomous code that can fulfill all the requirements for an autonomous win point

The primary advantage of fulfilling the requirements for an autonomous win point is that we gain a win point, which helps us advance through the tournament. The disadvantage is that we may be focusing on the autonomous win point while our opponents may just be trying to rack up points, so they likely have a higher chance of winning the autonomous bonus, giving them an advantage in the overall game.

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Game Strategies Continued

2023/06/10

Defensive Strategies

The strategies discussed below are strategies that combat offensive strategies. The most effective offensive strategies are the ones that we have listed above, so many of these strategies will combat those. By listing and evaluating these strategies, we hope to be able to find a balance between offense and defense that will best suit the playing style of our team. These defensive strategies will be discussed in the same way as the offensive strategies and are as follows.

- Pushing opponents
- Blocking triballs getting pushed across the barrier
- Blocking opponent match load shots
- Blocking triballs from getting shot into the goal

Pushing opponents

By pushing opponents, we can stop them from being able to complete actions that gain them points, mainly shooting match loads and scoring triballs into the goal. This helps us keep more triballs in the field which we can use to score on the opposing team. Pushing opponents also restricts their movement, which allows our alliance to move more freely across the field and score points.

The main disadvantage to pushing opponents is that we are unable to do other actions while pushing our opponent, so we are unable to do point-scoring actions while blocking our opponents from scoring. We may also find complications with the five second rule where we are not allowed to restrict opponents to a one tile space for more than five seconds. Pushing also fails whenever the opponents have a stronger drivetrain than us or if they have mechanisms to escape these situations.

Blocking triballs getting pushed across the barrier

Blocking triballs getting pushed over the barrier into our offensive zone prevents our opponents from scoring high amounts of points from getting the triballs into our offensive zone. By blocking these triballs, we additionally keep the triballs in their offensive zone, which scores points for us. This is also fairly easy to implement, only needing the bot to serve as a physical blocker to block the triballs.

One of the disadvantages of this strategy is that due to the bouncy and chaotic nature of triball movement, it is hard to block all the triballs from going over the barrier. Additionally, we are also unable to complete other tasks while blocking the opponent from moving triballs across, especially if they are persistent in trying to get their triballs across. We also have to be able to react quickly to the opponent's actions when using this strategy.

Designed by: Darien Ng

Witnessed by: Matthew Zhang

Game Strategies Continued

2023/06/10

Defensive Strategies Continued

Blocking opponent match load shots

By blocking the opponent's matchload shots, we are able to prevent them from getting triballs into our offensive zone, which keeps our opponents from gaining points this way. It can also create risks for our opponents if they keep trying to shoot since triballs can bounce back on their robot, causing overposession problems for them.

Like the other defensive strategies already mentioned, blocking matchload shots prevents our robot from completing point-scoring actions while blocking. This strategy also requires us to have a blocker mechanism to block these shots. This mechanism may have to be mounted quite high depending on how high our opponent's shooter is mounted. We also have to be careful about overposession in case the triball bounces back onto our robot.

Blocking triballs from getting shot into the goal

By blocking triballs from being shot into the goal, we are able to keep most of the triballs in play, meaning that we are able to use them for scoring for our alliance. It also stops our opponents from gaining 5 points per triball that they are able to get into the goal.

Disadvantages are the same as the other defensive strategies where while we are blocking our opponent, we are unable to use a robot for point-scoring tasks. It can also be hard to stop all the triballs since our remote cannot expand to more than 36" in any horizontal dimension, meaning that we are unable to block the entire goal. Pushers robots are also able to get mass amounts of triballs into the goal, which combined with the chaotic nature of triball movement, we may struggle to block all the triballs from going into the goal.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Brainstorming Solutions: Drivetrain

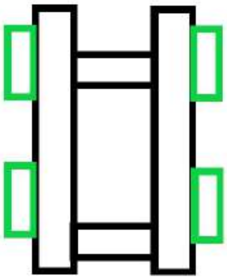
2023/10/01

Goal: Brainstorm possible solutions for drivetrain so that we can choose the best for our design.

Possible Solutions: Drivetrain Type

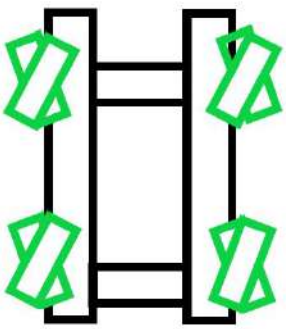
Green is wheels

Black is body of robot



Omnidirectional wheels tank drive:

Positives	Negatives
- Has many options for gearing/speed of the robot. - Simple - Compact - Multiple Size Options(2.75, 3.25, 4 inch)	- Low sideways traction - Moves in only 2 directions



Positives	Negatives
- Capable of Strafing(moving side-to-side) - Simple - Allows for more agility on the field for interaction elements and other robots.	- High Friction due to Rollers of Mecanum Wheels - Only one wheel size - Wheels are extremely wide

Designed by:

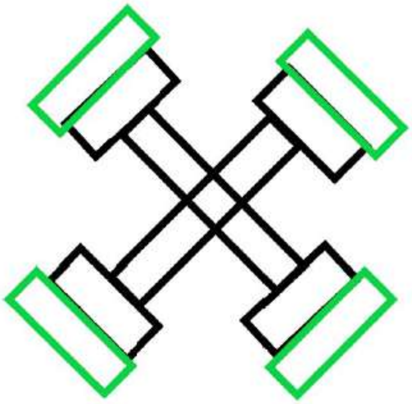
Darien Ng

Witnessed by:

Oliver Liu

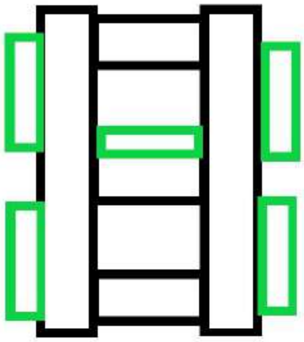
Brainstorming Solutions Cont.

2023/10/01



Omnidirectional wheels X-Drive:

Positives	Negatives
- Moves in all directions - Fast turning - Allows for strafing/better maneuverability	- Complex programing - Large, uses up a lot of space for other subsystems. - Slow speed



Omnidirectional wheels H-Drive:

Positives	Negatives
- Moves in all directions - Simple to build - Allows for high amounts of forward speed/torque	- Limited power and speed when strafing - Takes up space in robot chassis - Uses up an extra motor

Designed by:

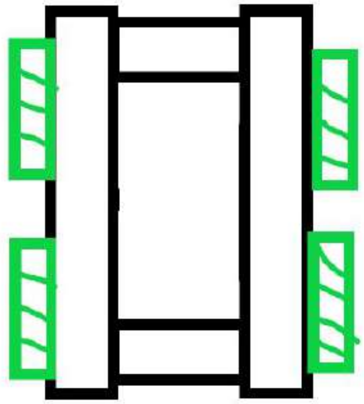
Darien Ng

Witnessed by:

Oliver Liu

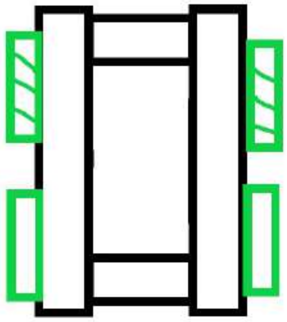
Brainstorming Solutions Cont.

2023/10/01



Traction Wheels tank drive:

Positives	Negatives
- Good traction - Simple - Compact	- Extremely high friction when turning due to skidding - Greatly reduced turning speed - High wear on motors



Omnidirectional and traction wheels mix tank drive (1 omnidirectional, wheel 1 traction wheel each side):

Positives	Negatives
- Good traction - Simple - Compact	- Semi-high friction when turning due to moderate skidding between the two middle wheels

Designed by:

Darien Ng

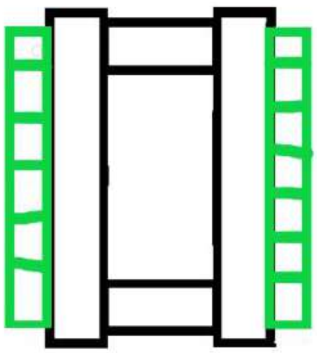
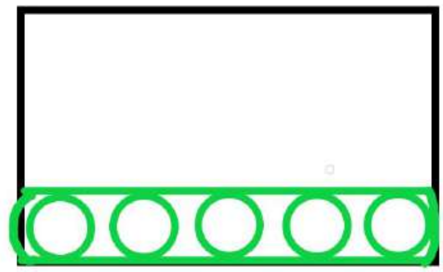
Witnessed by:

Austin Ma

Brainstorming Solutions Cont.

2023/10/01

Tank Tread

Positives	Negatives
- Great traction - Strong - Great at climbing objects	- Very slow - Takes up a lot of space - Not great for turning

Designed by:

Darien Ng

Witnessed by:

Austin Ma

Brainstorming Solutions Cont.

2023/10/01

Possible Solutions: Wheel size

4 inch wheels (omnidirectional and traction wheel):

Positives	Negatives
- Common wheel size, easy to obtain - Large radius allows for easier ability to go over middle barrier.	- Possibility of getting stuck on game objects - Poor centre of gravity - Large size may affect space for other components.

3.25 inch omnidirectional wheels:

Positives	Negatives
- Smaller size allows for more space for other subsystems. - Smaller size makes it possible to run four wheels per side instead of 3 or 2, allowing for more points of traction/easier to go over barrier.	- Smaller wheels may mean the robot may more easily get stuck on the middle barrier.

2.75 inch omnidirectional wheel:

Positives	Negatives
- Great centre of gravity - Compact size allows for running 4 wheels per size, giving more traction.	- Often out of stock in most places - Small wheels may have trouble riding up onto the middle barrier/crossing it.

Designed by:

Darien Ng

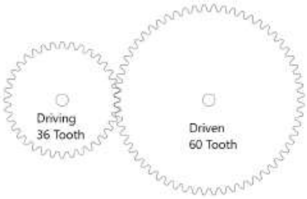
Witnessed by:

Oliver Liu

Brainstorming Solutions (Continued...)

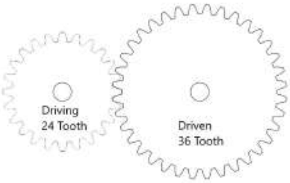
2023/10/01

Possible solutions: Gearing



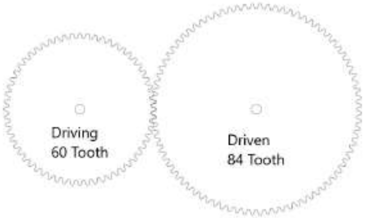
3:5 (360 rpm, blue)

Positives	Negatives
- Fast - Possibility to perform evasive maneuvers	- Weak - Possibility to be pushed by other bots



2:3 (400 rpm, blues)

Positives	Negatives
- Faster - Higher chance of performing successful evasive maneuvers	- Weak - Can be pushed by other bots



5:7 (428 rpm, blues)

Positives	Negatives
- Fastest - Possibly able to outrun other bots	- Very weak - Easily pushed by other bots

Designed by:

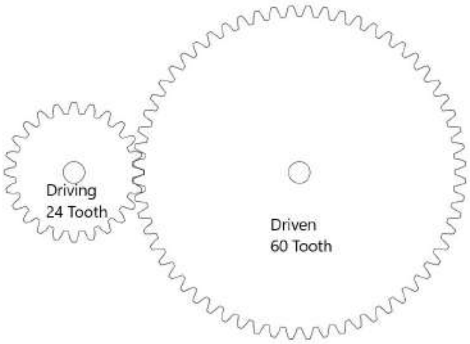
Oliver Liu

Witnessed by:

Matthew Zhang

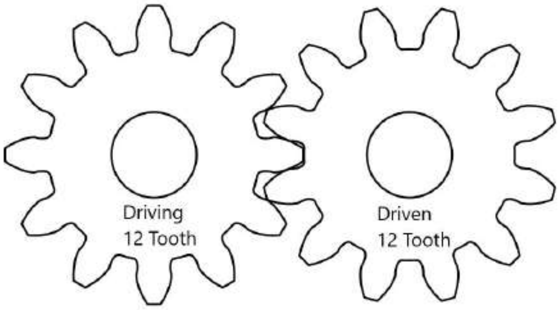
Brainstorming Solutions (Continued...)

2023/10/01



3:7 (257 rpm, blues)

Positives	Negatives
- High Amounts of torque, enabling better defence -	- Slow - Likely to be outrun by other bots



5:5 (200 rpm, direct greens)

Positives	Negatives
- Stronger - Simple - Most likely able to push other bots	- Slower - Very likely to get outrun by other bots

Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Intake Brainstorming

2023-10/03

Goal: Brainstorm possible solutions to create a simple yet fast, light, and efficient intake.

Possible Solutions: Intake Type

Rubber Band Intake

Positives	Negatives
- Leaves no gaps in the intake - Simple to build - Easy to modify and replace - Light - More compliant, making it possibly easier to grip triballs	- Rubber bands could experience wear and tear - Could potentially tangle when colliding with other bots - Takes up more space, as requires large sprockets to do so.

Flex Wheels

Positives	Negatives
- Sturdy - Reliable - Does not need replacement or maintenance - Is near impossible to get entangled.	- Leaves gaps in between each wheel - Less surface area to build - Heavy - Takes up more space, for 3-4 inch flex wheels - Harder to build and implement

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

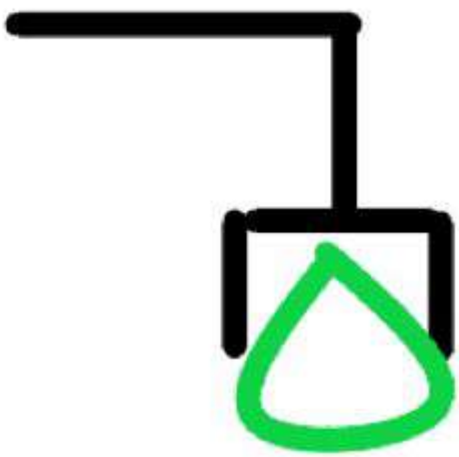
Intake Brainstorming Cont.

2023-10/03

Possible Solutions: Intake Type

Flip-out

Positives	Negatives
- Use of a motor is not required - Simple	- Heavy - Not practical during matches - Difficult to manage - Takes a large amount of space - Slow



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Intake Brainstorming Cont.

2023-10/03

Given that a majority of teams are running flex wheel based intakes, we wanted to have considerations to the different choices we have, to fully determine the most optimal flex wheel intake compared to other designs.

Possible Solutions: Flex Wheel Sizes

1 ⅝” Flex Wheel

Positives	Negatives
- Takes up minimal space - Extremely light	- Likely to have issues with reliably picking up Triballs - Least surface area for grip

2” Flex Wheel

Positives	Negatives
- Takes up small amounts of space - Light	- Potential issues with reliably picking up Triballs - Low surface area for grip

3” Flex Wheel

Positives	Negatives
- Reliable for picking up Triballs - High surface area for grip	- Takes up large amounts of space - Heavy

4” Flex Wheel

Positives	Negatives
- Most reliable for picking up Triballs - Highest surface area for grip	- Takes up extensive space - Extremely heavy

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

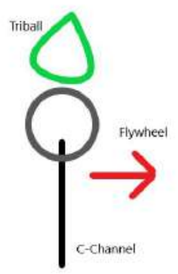
Delivery Mechanism Brainstorming

2023-10/03

Goal: we are going to create a mechanism that will successfully deliver the triballs to the other side of the field to allow the other robot to effectively push them into the net.

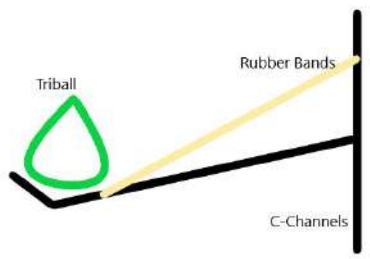
Possible Solutions: Delivery Types

Flywheel



Positives	Negatives
- Can launch triballs at a rapid pace - No need to load triballs one by one - Adjustable velocity allows for different arcs	- Also must build a lift to allow the triball to shoot further when it is loaded - The launcher can be inconsistent at times

Catapult



Positives	Negatives
- The shot will be more accurate than the flywheel - The triball can be launched further than the flywheel	- Can only launch one triball at a time - We must constantly replace the rubber bands

Designed by:

Oliver Liu

Witnessed by:

Darien Ng

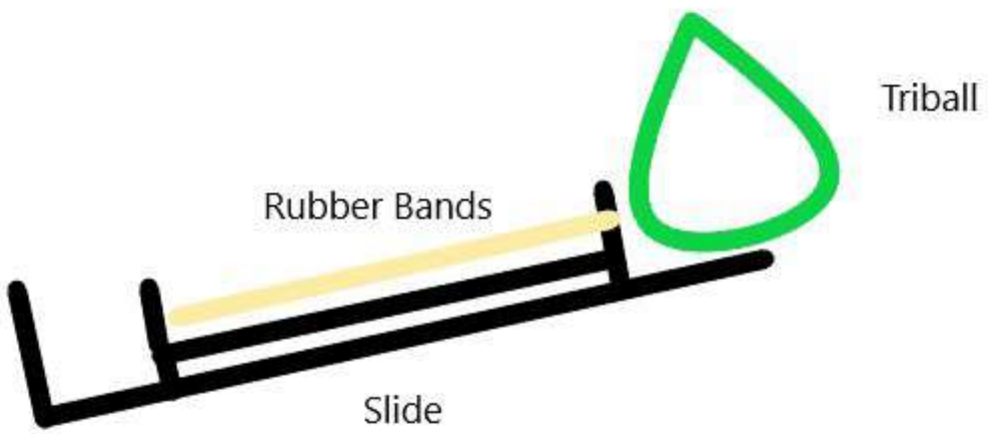
Delivery Mechanism Brainstorming cont.

2023-10/03

Possible solutions: Delivery types

Puncher

Positive	Negatives
- Launches the tribal quickly - Takes up little space on the bot - Shoots at a decent rate	- Can only load one triball at a time - Must constantly replace the rubber bands due to the amount of tension placed on them



Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Delivery Mechanism Brainstorming cont.

2023-10/03

Possible solutions: Flywheel types

Single Compression flywheel

Positives	Negatives
- Easy to build - Can have adjustable launch angles - More portable, can be easily mounted anywhere	- Less consistent compression - Lower accuracy, more easy to miss.

Double compression flywheel

Positives	Negatives
- Does not put a spin on the triball, allowing it to accurately land - More consistent shooting	- Takes more time to build - Unadjustable launch angles, can be blocked easily - Takes up much more space

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Delivery Mechanism Brainstorming cont.

2023-10/03

Possible solutions: Flywheel Wheel Size

3 inch flex wheels

Positives	Negatives
- Weighs very light - Spins faster, which will allow us to shoot triballs quicker	- Covers a small diameter - Group must be more careful when dropping the flywheels

4 inch flex wheels

Positives	Negatives
- Covers more area on the bot - Will shoot the tribals further from the amount of strength it possesses	- Will add more weight onto the robot - Requires more energy to spin fast

Designed by:

Darien Ng

Witnessed by:

Austin Ma

Delivery Mechanism Brainstorming cont.

2023-10/03

Possible solutions: Flywheel Wheel Softness

The 30A light grey colour wheels are the **softest** type of flex wheel available to us. It is **extremely compressible** and grips onto the tribals firmly. However, due to this type of flex wheel's softness, it will compress greatly without much force . Nevertheless, this type of flex wheel is best suited for a lower speed flywheel or for stronger power.

The 45A grey coloured flex wheel is a **moderately compressive** and moderately hard flex wheel. This wheel can be used as a flywheel for the delivering technique or a wheel used on the drivetrain. However, this flex wheel can only perform its duties we assign to an extent because of the inability to achieve any of the two tasks to a great extent. However, our group choses to use this type of flex wheel because of the amount of resistance it can bear from when a loader drops a tribal onto the flex wheel and how it will still be able to launch the flywheel farther than the 60A's from the grip it still possesses.

The 60A black flex wheels are the most hardest flex wheels available to us. It has the lowest retention out of the three and is also the most heaviest. This type of wheel **barely compresses** and retains the lowest grip out of the three. Nevertheless, these flex wheels are best suited to be the for shorter rpms and higher launch ranges.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Current Strategies

2023/10/05

Before we began to build our bot, it is crucial for us to brainstorm and plan out ideas for the bot beforehand to keep everything more organized and clear. After some brainstorming, we decided we wanted the following features on our robot:

- **Drivetrain**
    - When analyzing this game, we knew that speed and maneuverability would play a large part in determining a bot's success. This is further amplified by the limited space on the field taken up by the goals and barriers.

- **Intake**
    - We believed that having an intake to be able to manipulate game objects would prove to be extremely useful. From analyzing other games and some testing of our own, we found that Triballs against walls are nearly impossible to grab and score without some form of an intake. Having a way to retrieve these Triballs, we thought, would drastically help us in both skills and matches.

- **Shooter (Flywheel)**
    - Having a shooter, our team decided, was likely the single most important mechanism for us to have on our bot. By having a shooter, we would be able to send all of our match loads in bot skills and matches to the other side, where they can easily be pushed in afterwards to score them. We eventually decided on building a flywheel due to its simplicity, speed, and potential for tight grouping with the backspin it provides. We also considered having a way to elevate the flywheel to be able to shoot above opposing bots.

- **Blocker**
    - Early on, after seeing the dominance that a shooter can have, we had ideas of creating a blocker to prevent these shots from going to our side. Having a blocker would ensure that the opposing team wouldn't get too many match loads on our half, and therefore would limit them in their scoring capabilities.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Current Strategies cont.

2023/10/05

- **Lift**
  - A lift would have multiple usages when paired with the other mechanisms. Firstly, it would solve our issue of elevating the shooter, as the flywheel would be able to be mounted on the top of our lift. It would also support the blocker, acting as a sort of extension of it. This would increase the height of the blocker, making it near impossible to shoot past. Additionally, the lift could also be used for a low hang on the horizontal pole at the end of the game.

- **Wedges**
  - Having wedges on our bot would help increase the pushing power of our bot by lifting other bot's wheels off the ground, reducing their traction. We thought wedges would be quite helpful with our bot as we wanted it to remain fast, and therefore the wedges would be able to help offset some of the torque lost by a faster bot.

- **Wings**
  - Having a form of locking wings would be extremely vital in a game like this in our brainstorming. The most efficient way to score, from our analysis, was to shoot match loads and then push them all in. Wings would help with the second part of that, acting as an extension of our robot to allow it to push more Triballs in.

- **Odom Wheel**
  - When we began thinking of ideas for autonomous, we knew that the sheer number of Triballs launched on the other side would throw off our bot from knowing where it was on the field. To help with this, we thought of using odometry to help the bot know its location and how much it has been displaced by in order to help with autonomous.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Identify Objective - Drivetrain

2023/10/05

Goal: Identify an objective for our robot so that we can build an effective drivetrain.

Problem Statement:

- Build a mechanism to move around the so that the bot can interact with game objects.

Solution Requirements:

- Must be constructed completely out of VEX Robotics Competition parts
- Must fit within 18” x 18” x 18” cube
- Must work using at most 6 motors. We require at least two motors for other functions, such as scoring, intaking, shooting or other possible mechanisms.

Solution Goals:

- Traverse the length of the field in a fairly short amount of time.
- Be fairly lightweight
- Be able to fit under the horizontal bar and the goal.
- Have a small profile to easily maneuver accounting for the limited space on the field

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V1 - Drivetrain

2023/10/05

Focus: Build a clean, sturdy drivetrain that will allow us to effectively interact with game objects and support subsystems on our bot

One of the biggest priorities we had when brainstorming and designing a drivetrain was for it to have a small profile. This would enable us to go underneath the barrier and remain light and quick, as we felt that this would be extremely beneficial for this game. One of the first issues we ran into was deciding on which type of drivetrain to use that would allow us to accomplish this goal. Based on previous discussions, we came to 4 different bases that we could use. The following drivetrains would be graded based on the following criteria:

- **Simplicity**
  - How simple is this drivetrain to build?
- **Speed/Maneuverability**
  - How fast can the Robot move?
- **Torque**
  - How capable will the robot be in pushing objects or other robots.
- **Size**
  - How large/heavy is the Drive Train?

	Simplicity	**Speed/Maneuver-ability**	**Torque**	**Size**	**Total:**
Tank Drive	5	4	4	4	17
X-Drive	3	5	3	3	14
H-Drive	3	5	4	3	15
Mecanum Drive	4	2	2	3	11

Final decision matrix comparing all 4 possible drivetrain types. ***Higher scores means better design.***

Based on the decision matrix mentioned above, we decided that a tank drive would best fit our priorities for our drivetrain type. This is because we believed it had a strong balance of everything, whereas many other drives had one notable flaw in their design. Additionally, this type of drive has been repeatedly proven to be effective, resulting in us using a tank drive for our bot.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V1 - DriveTrain

2023/10/05

With the type of drivetrain decided, the next issue we faced was the type of wheels we needed to use. Referencing back to our priorities, we brainstormed 4 different types of wheels we could use to fulfill these requirements, which will be graded on the following standard:

- **Compactness**
  - How compact is this wheel?
- **Speed**
  - How fast can the robot move with these wheels?
- **Center of Gravity**
  - How will the size and weight of the wheel affect our center of gravity?
- **Pushing Power/Resistance**
  - How powerful or resistant are these wheels regarding pushing

	Compactness	**Speed**	**Center of Gravity**	**Pushing Power/Resistance**	**Total:**
3” Flex Wheels	5	1	4	4	14
3.25” Omniwheels	4	4	4	3	15
2.75” Traction Wheels	4	2	4	4	14
4” Omniwheels	3	5	3	3	14

Final decision matrix comparing all 4 possible wheels.

In the end, we ended up deciding on using 3.25” omniwheels. Although it did beat out the other options by a slight amount, one of the driving factors that led to us making this decision was its all around balanced nature. When compared to wheels such as flex wheels and traction wheels, omniwheels provide more speed, which was one of our priorities in designing a drivetrain. We decided against using 4” omniwheels as we felt that the extra speed it offered was limited by its bulkiness and the amount of space it took, leading us to settle on 3.25” omniwheels.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Select and Plan - Drivetrain

2023/10/05

Goal: Analyze the best combinations of gearing, wheels, and type of drivetrain to create a solution that best fits the needs of our team

With our combination of gears, wheels, and drivetrain type, we felt that this combination of a tank drive, 3.25” omni wheels, and a 4:6 gear ratio on 400 RPM would effectively allow us to complete our primary objectives in creating a drivetrain for our bot. There were multiple strategies and aspects we had to consider while designing this, which are the following:

- **Ability to push robots:** Having enough torque to withstand the force or sometimes out-push other bots was an important element to consider if we wanted our drivetrain to effectively interact with game objects and score properly

- **Speed:** With our gearing and the size of our wheels, we felt that it would sufficiently cover the speed we needed to be fast but remain some level of torque.

- **Sizing:** We thought that the gear ratios, wheels, and type of drivetrain used would allow us to fulfill our requirement of having a small bot to allow us to maneuver through the limited space on the field.

- **Simplicity:** This combination allowed us to create a simple yet efficient drivetrain to support our bot.

- **Sturdiness:** We ensured that this configuration would not compromise the strength and sturdiness of our bot to allow it to support the remaining subsystems and resist ramming from other bots.

With our design in mind, we were able to start constructing our drivetrain base and prepared it for prototyping and testing.

Designed by:

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Witnessed by:

Matthew Zhang

Build and Testing - Drivetrain

2023/10/08

In addition to using online resources to aid us in our decision, we also experimented around with our own designs in order to ensure the information presented was accurate. By this point, we had already decided on using a 4 motor tank drive, and so we built a simple prototype in order to test the speed of our design.

The following chart represents each of our tests where the bot drove for 6 tiles or 12 feet. We measured the time and calculated the speed in feet/second.

	Time (seconds)	**Speed (feet/second)**
Test 1	2.45	4.9 ft/s
Test 2	2.33	5.15 ft/s
Test 3	2.61	4.6 ft/s
Test 4	2.54	4.72 ft/s
Test 5	2.37	5.06 ft/s
Average	2.46	4.87 ft/s

Test results from a 4 motor tank drive. The experiments were carried out over the distance of 6 field tiles (12 feet)

From these tests, we see that it takes an average of 2.46 seconds to travel 6 tiles, and the average speed was 4.87 feet/second. When calculating the ideal speed of a 400 RPM on 3.25” wheels drive, the speed comes out to be 5.67 feet/second. This discrepancy is likely caused due to multiple factors, such as friction, imperfections in timing, and issues with motors for example. Nonetheless, we were still fairly content with these results for our drivetrain.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Identify Objective - Intake

2023/10/08

Goal: Identify an effective solution to create an intake that best suits our bot

Problem Statement:

Create an intake that will allow us to interact with Triballs on the field

Solution Requirements:

- Must work using only 1 motor to allocate enough motors for other systems on the bot
- Must remain fairly light in order to reduce weight on the bot
- Must be constructed completely out of VEX Robotics Competition parts
- Must be able to easily and seamlessly pick up and place Triballs into the goal

Solution Goals:

- Using lighter materials and removing unnecessary components to optimize weight
- Allowing the intake to move up and down to easily pick up and place Triballs
- Have enough grip, speed, and torque to allow us to pick up Triballs while almost stationary
- Ensuring the intake is structurally sound to prevent damage from other bots

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V2 - Intake

2023/10/12

Focus: Build a smooth, fairly lightweight intake that will allow us to easily manipulate game objects.

We want an intake that was both quick and consistent. When brainstorming ideas, 3 major designs came to mind for our intakes, which we marked based on the following:

- **Smoothness/Speed:** Is the intake able to easily pick up and place Triballs without many stops or needing to slow down?
- **Consistency:** Is this design able to consistently pick up Triballs every single time?
- **Weight:** How does each design impact the overall weight of the intake and bot?
- **Strength:** Is the intake able to withstand the force of other bots without breaking?

	Smoothness/ Speed	Consistency	Weight	Strength	Total:
Rubber Bands	5	4	5	2	16
Flex Wheels	5	5	3	5	18
Flip-Outs	2	3	3	4	12

Final decision matrix comparing all 3 types of intakes.

After some consideration, we ended up deciding that flex wheels would be the best contender for our intake. As shown in the decision matrix above, flip-outs are far too slow and inconsistent for us to consider using on our intake, since a main priority for our intake is speed. When deciding between rubber bands and flex wheels, the main factor that ended up determining our design choice was the strength. Although flex wheels are considerably heavier and bulkier than rubber bands, brief tests showed that rubber bands were less consistent than flex wheels, and that the possibility of the rubber bands breaking during a match was a risk we didn't want to take. We found that flex wheels were the best option in terms of speed, consistency, and strength, and in the end, we will be using flex wheels for our design.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V2 - Intake

2023/10/12

After we decided on the design of our intake, the next step for us was to consider the different sizes of flex wheels we could use. Once again, each different options will be graded and selected from the following:

- **Grip:** Is the intake able to easily grip Triballs to smoothly intake them?
- **Consistency:** Is this design able to consistently pick up Triballs every single time?
- **Weight:** How does each design impact the overall weight of the intake and bot?
- **Compactness:** How do the different designs impact the space taken by the wheels?

	Grip	Consistency	Weight	Compactness	Total:
1 ⅝” Flex Wheels	1	2	5	5	13
2” Flex Wheels	2	2	4	4	12
3” Flex Wheels	4	5	3	3	15
4” Flex Wheels	5	5	2	2	14

Final decision matrix comparing all 4 types of flex wheels.

Initially, we thought that 1 ⅝” or 2” flex wheels would be the best choice, they are both light and compact, thus reducing the overall weight of our bot. However, in our testing, we noticed that these smaller wheels simply did not have enough surface area to grip the Triballs consistently. We also found that 4” flex wheels are far too bulky and heavy for this design, despite its high grip and consistency. The 3” flex wheels were able to consistently grip Triballs without sacrificing too much weight, which is why we decided to choose that one.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V2 - Intake

2023/10/12

Our final step in designing our intake was deciding on an RPM amount. We wanted to use no more than 1 motor to ensure that the other 7 could be used in other systems. Each RPM amount as well as their gear ratios and cartridges.

- **Grip/Torque:** Is the intake able to easily grip and intake Triballs?
- **Consistency:** Is this design able to consistently pick up Triballs every single time?
- **Speed:** How fast can this RPM amount intake Triballs?
- **Compactness:** How do the different gear ratios impact the size of the gearing?

	Grip/Torque	Consistency	Speed	Compactness	Total:
400 RPM (2:1, Green)	3	4	4	5	16
600 RPM (3:1, Green)	2	3	5	4	14
300 RPM (3:1, Red)	4	4	3	4	15
266 RPM (4:3, Green)	5	4	2	2	13

Final decision matrix comparing all 3 types of intakes.

We found that 400 RPM on a 2:1 gear ratio with green cartridges was the perfect balance between speed and torque, allowing it to consistently intake Triballs at a reasonable speed. Another factor that drove us to using this RPM amount was its compactness, as achieving a 2:1 ratio is easier compared to the other options on this table. Upon testing this with 3” flex wheels, we found it to be quite consistent in terms of grip and speed while not being too heavy, which we found to be ideal for our bot. This resulted in us deciding on a flex wheel intake using 3” flex wheels on 400 RPM with a 2:1 gear ratio as our design.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

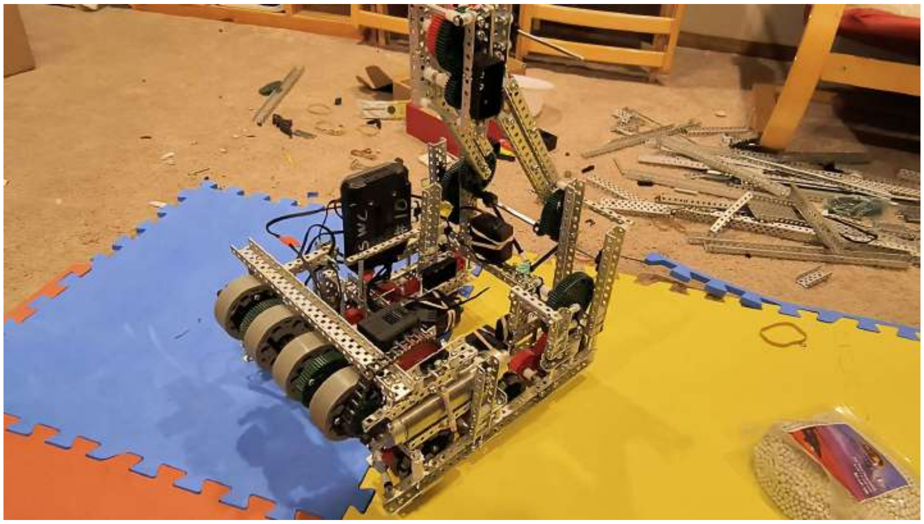
Select & Build - Intake

2023/10/14

Goal: Build a smooth, fairly lightweight intake that will allow us to easily manipulate game objects

From some testing, our team discovered that it was extremely difficult for Triballs lodged in corners or against walls to get unstuck. Thus, we decided early on that we wanted an intake on our bot to help solve this issue, as we felt it would be especially useful during matches and minimize time wasted trying to grab triballs.

For our first iteration, we built a fairly simple intake utilizing four 3” flex wheels connected together by gears and standoffs mounted in a box-like pattern. We made sure to hinge the connection between the bot and the intake with screw joints to allow the intake to bob up and down. It used a 2:1 gear ratio on green cartridges, providing us with 400 RPM.



We decided on using flex wheels because we felt that it would be the most consistent and would be worth the extra weight they offer. These wheels were connected by gears and standoffs to prevent them from sliding around on the axle, as well as the fact we did not have enough high strength spacers to space them out properly. When creating gaps between the flex wheels, we made sure the wheels were able to cover the entire width of the intake to provide as much space as possible for them to grip and intake Triballs.

We believed that 400 RPM on our intake was sufficient in both speed and torque, allowing us to quickly intake Triballs with enough grip when paired with 3” flex wheels. Another benefit of this RPM amount was the fact that the gear ratio was incredibly easy to make with sprockets using a 12 tooth and 6 tooth sprocket. Different gear ratios would likely use larger teeth amount, and therefore would take up more space.

Designed by:

Matthew Zhang

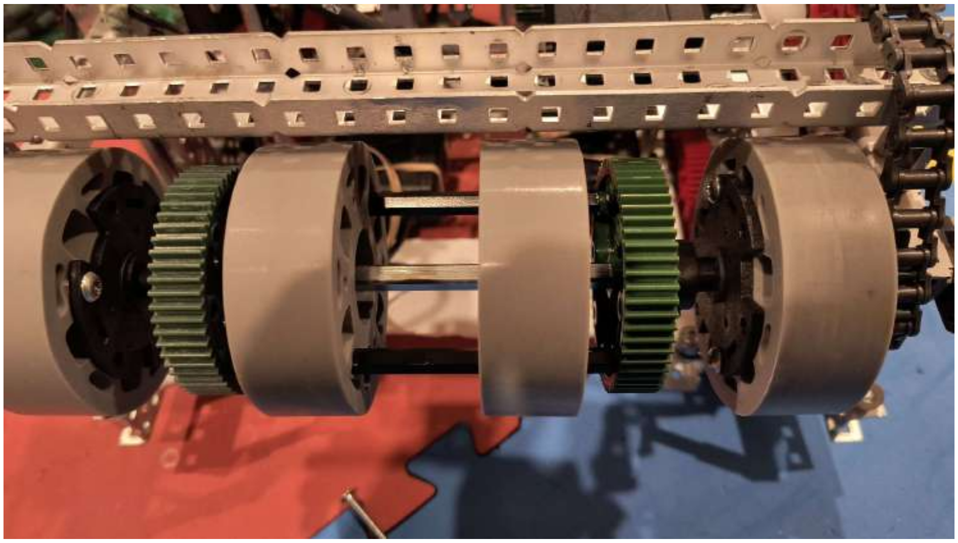
Witnessed by:

Oliver Liu

Testing - V1 Intake

2023/10/14

When we began testing our first intake, we quickly ran into some issues with it. The first problem we found was that due to a c-channel brace connecting both ends of the intake, it did not leave enough room for our sprockets and chains. As a result, the chain would constantly grind against the c-channel illustrated in the picture below, increasing friction and reducing the overall smoothness of this mechanism.



We also found that with the entire intake built, the weight was much heavier than expected. We plan on finding a way to cut unnecessary weight on the bot in order to remain light and nimble.

One of our major problems with the intake was that it was unable to cleanly score Triballs. With our intake, it required us to intake the Triball, shoot it out, and then push it into the goal. However, we ran into 2 issues with this. First was speed, as shooting the Triball out beforehand was much more inefficient when compared to other methods, and we knew this would not be viable in an actual match. The second issue was consistency. Due to the shape of the Triball, it is almost impossible to control or predict its path while it is rolling. Our testing reflected this, as the Triball would sometimes roll away when we shot it out.

In the future, we wanted an intake that could simply ram into the goal to score Triballs. From watching other teams, we knew that this was a much easier, quicker, and consistent method for scoring, and was something our team wanted to implement.

Designed by:

Matthew Zhang

Witnessed by:

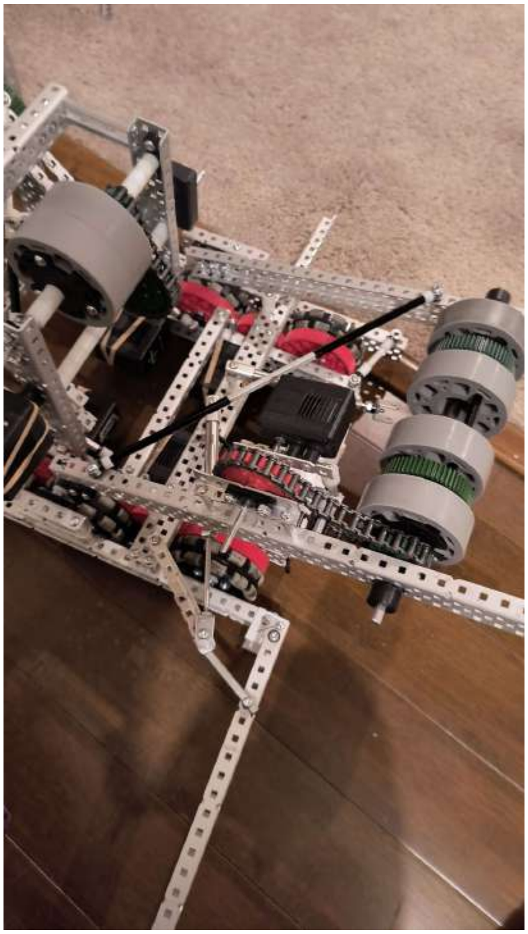
Oliver Liu

V3 - Intake

2023/10/14

For our third version of the intake, our primary goal was to revise the previous iteration to make it smoother. The main difference we made was having our intake hinge around a point closer to the back of our bot. From previous testing, we realized that the intake was connected at a point too far forward in the bot. Because of this, the intake was struggling to lift itself over the goal, and would therefore be unable to score Triballs. This revision allowed the intake to fully lift over the bar, and after some testing, we found it to be much more consistent than the previous 2 versions.

A longer beam reduces the amount of rotation for the intake, while maximising it's up and down movement, which was optimal for space saving. Also, a longer beam allows us to fit our wall pistons/mechanism underneath it easily. By mounting it on the out sides, we can have a wider intake, which increases tolerance.



Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

V4 - Intake

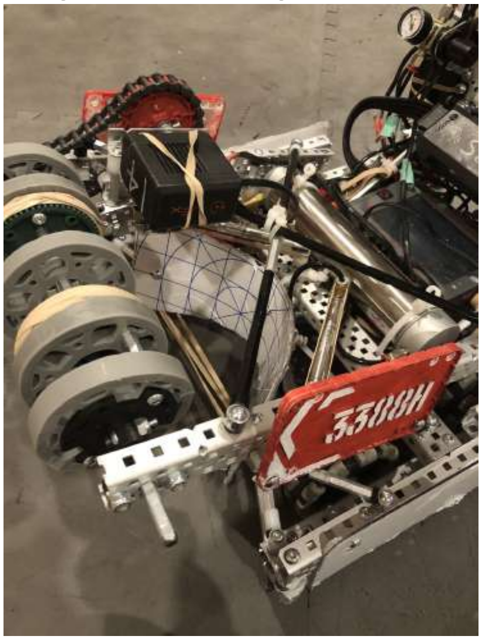
2023/10/14

With the fourth iteration of our intake, we were quite satisfied with how the third iteration functioned. As such, our focus for the next couple of iterations was improvements and optimizations to increase the efficiency and speed of our intake. On this fourth version, our main revision was cutting the 3” flex wheels in half to save weight. One thing we disliked about the previous design was the extra weight full flex wheels gave, as weight was a major issue for our bot. Since the majority of the weight came from the flex wheels, by cutting them in half, it nearly halved the weight of the intake.

A couple of issues arose when implementing this change, however. The most obvious one was that the half-cut flex wheels offered less surface area horizontally. However, this was a fairly simple change, as we added 5 wheels instead of the previous 4.

Another slight issue we had was connecting the flex wheels together. Since the wheels were thinner, it was unable to support versa hubs on both sides. To solve this issue, we simply connected all of the flex wheels and placed versahubs on either ends of the chain of flex wheels, and this solution seemed to work quite well.

The last major issue we ran into with this design was the Triball hitting the gears connecting the flex wheels together. Since the wheels are now thinner, they are more flexible, and when approached at the wrong angle, the Triball would bounce against the gear instead of the flex wheel. To fix this issue, we just wrapped rubber bands around the gears to provide more grip. Surprisingly, we found this solution to be fairly consistent, and rarely did the Triball get stuck on the gear.



Designed by: Oliver Liu

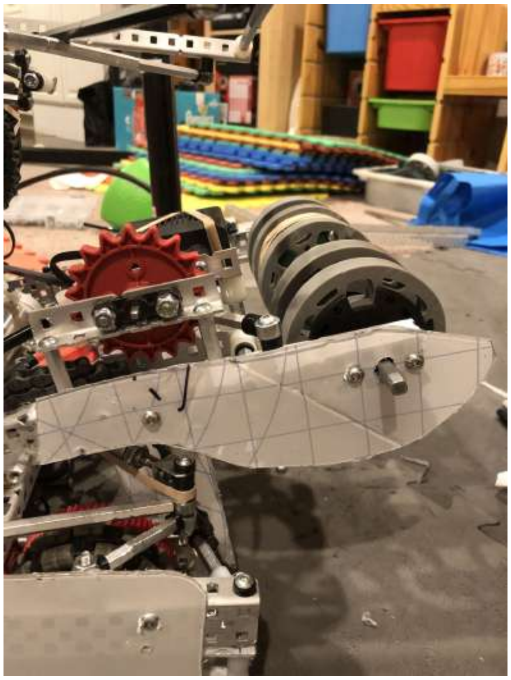
Witnessed by: Austin Ma

V5 - Intake

2023/10/14

For iteration 5 of our intake, we once again were making slight optimizations to our intake to prevent issues with it in the future. At this point, we had installed a blocker onto our bot. However, in order for us to go underneath the barrier, we needed to have both the lift and blocker fully collapsed. This resulted in an issue with the intake, as for it to function properly, it needed to be able to lift over the goal, which the lift and blocker prevented from doing so cleanly. We didn't want to just have the blocker extended while using the intake, as we felt that it would be too difficult to manage as well as using up too much air in our air tank. Also, due to the softness of the intake now, it would sometimes actually bend downwards and cause the intake to get stuck underneath the goal when we tested on a field. Therefore, we had the idea of creating lexan sleds on our intake to allow it to smoothly ride up the goal and ensure that it does so every time.

After some testing, we found these sleds to work fairly well. We rarely ever ran into issues with the intake getting caught on the goal, blocker, or lift, and was able to score much cleaner and smoother.



Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Building - Intake

2023/10/21

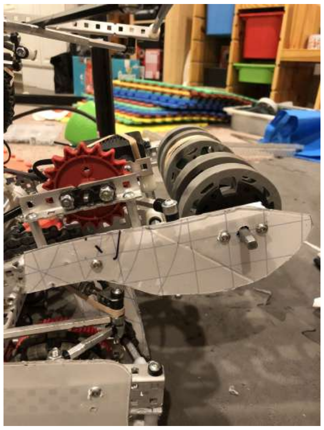
When we built the first iteration of the intake for our bot, it ran on 400 RPM on a 2:1 gear ratio using a 24 tooth and 12 tooth sprocket. The 4 flex wheels were connected together using gears and standoffs running through the flex wheels in order to connect them and prevent them from sliding around too much. Everything was connected by 2 c-channels mounted to the base of the bot using screw joints, which allowed it to bounce up and down. In addition, a c-channel brace was used to help strengthen the overall structure of the intake

For iteration 2 of the intake, we removed the boxy appearance of the previous intake, and instead had the c-channels connecting the base on a screw joint and the intake to hinge directly from the base rather than 2 c-channels creating a square. Also, hard stops were added to keep the intake from dipping below a certain level, allowing it to remain at a height we want it.

For the third version, the main difference was placing the point at which the intake rotated around to be further back in order for smoother scoring.

The fourth iteration introduced a couple of changes to the previous design. Firstly, we installed an X-brace on the intake. This change significantly increased the sturdiness of the intake and prevented it from wobbling around too much. In addition, the flex wheels were cut in half to reduce weight. Due to the reduction of surface area brought by this change, we needed to increase the amount of flex wheels used from 4 to 5 as well as wrapping the gears in rubber bands to help grip Triballs if they ever hit the gear, which became a problem due to the reduced width.

For the fifth version, the only difference was the introduction of lexan sleds to the intake to resolve an issue of the intake catching onto the lift, blocker, or goal. These sleds would allow the intake to ride up the goal much cleaner, allowing for more consistent scoring.



Designed by:

Oliver Liu

Witnessed by:

Bolo Wang

Identify Objective: Lift

2023/10/21

Goal: Create a lift mechanism to elevate and support other mechanisms

Problem Statement:

- Build a mechanism to elevate the delivery mechanism, be able to hold a blocking mechanism, and have the ability to elevate the robot.

Solution Requirements:

- Must fit within a 18x18x18 in cube
- Must be constructed out of legal VRC parts
- Must work using no more than 2 motors
- Must be sturdy enough to support multiple mechanisms on top of it

Solution Goals:

- Use a gear ratio that provides enough torque to elevate the bot
- Use bracing to help strengthen the structure of the lift
- Using a suitable type of lift that will allow us to gain lots of height while staying compact

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Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Identify Objective: lift

2023/10/21

We are also planning to add a lifted delivery mechanism on our robot. We will use this lifted shooter to allow the tribals to be shot out from a higher point, reducing the energy required on the motors to shoot normally, or if we are getting blocked by an opponent, we can use more power with a higher arc of shooting, and combined with the height offset, we should be able to shoot over most blockers. As seen in 9364c's game in Hub City Finals, their bot was able to bypass the defenses from their opponents. Our lifted shooter will work the same way by surpassing the barriers to the enemy and allowing our flywheel to deliver more tribals closer to the enemy's net.

An issue with the lifting mechanism would the change in center of gravity upon raising the lift, which would make us more tippable.

Furthermore, we think that by mounting a blocking mechanism onto the lift, we can increase our ability to block other opponent's shots. Allowing us to prevent opponents to rapidly put triballs into their offensive zone.

Additionally, we believe that by powering the lift with a motor, we have the added benefit of torque, allowing us to add a mechanism that allows us to lift the robot up by the horizontal elevation bar, which would give us more points if other teams were to simple elevate on the barrier, and giving us anywhere from 15-20 points possibly.

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Identify Objective: lift Cont.

2023/10/21

Goal: Identify objective for a lift that can hold our delivery mechanism.

Problem Statement:

- Build a mechanism to elevate the delivery mechanism, be able to hold a blocking mechanism, and have the ability to elevate the robot.

Solution Requirements:

- Must fit within a 18x18x18 in cube
- Must be constructed out of legal VRC parts
- Most work using no more than 2 motors

Solution Goals:

- Lift relatively quickly
- Hold a delivery mechanism and blocking mechanism.
- Have enough torque to elevate the robot on the horizontal elevation bar.
- Be able to provide enough height to shoot over any robots trying to block our shots

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Select & Plan - Lift

2023/10/21

Goal: Determining the type of lift mechanism that will allow us to most effectively do the required objectives.

The double reverse 4 bar is a four bar lift is a four lift bar powered by gears to expand its height. It comprises of two bar sets between the gears, which allows it to extend higher than most lifts . The bar is can extend to a very high altitude and can also lift objects that are heavy to that high altitude. However, the lift covers a giant portion of the robot, which will make this lift very inconvenient to use.

An example of a Double reverse 4 bar lift from Tower Takeover by VEX U team BLRS
(from): https://wiki.purduesigbots.com/hardware/lifts/dr4b

Designed by:

Matthew Zhang

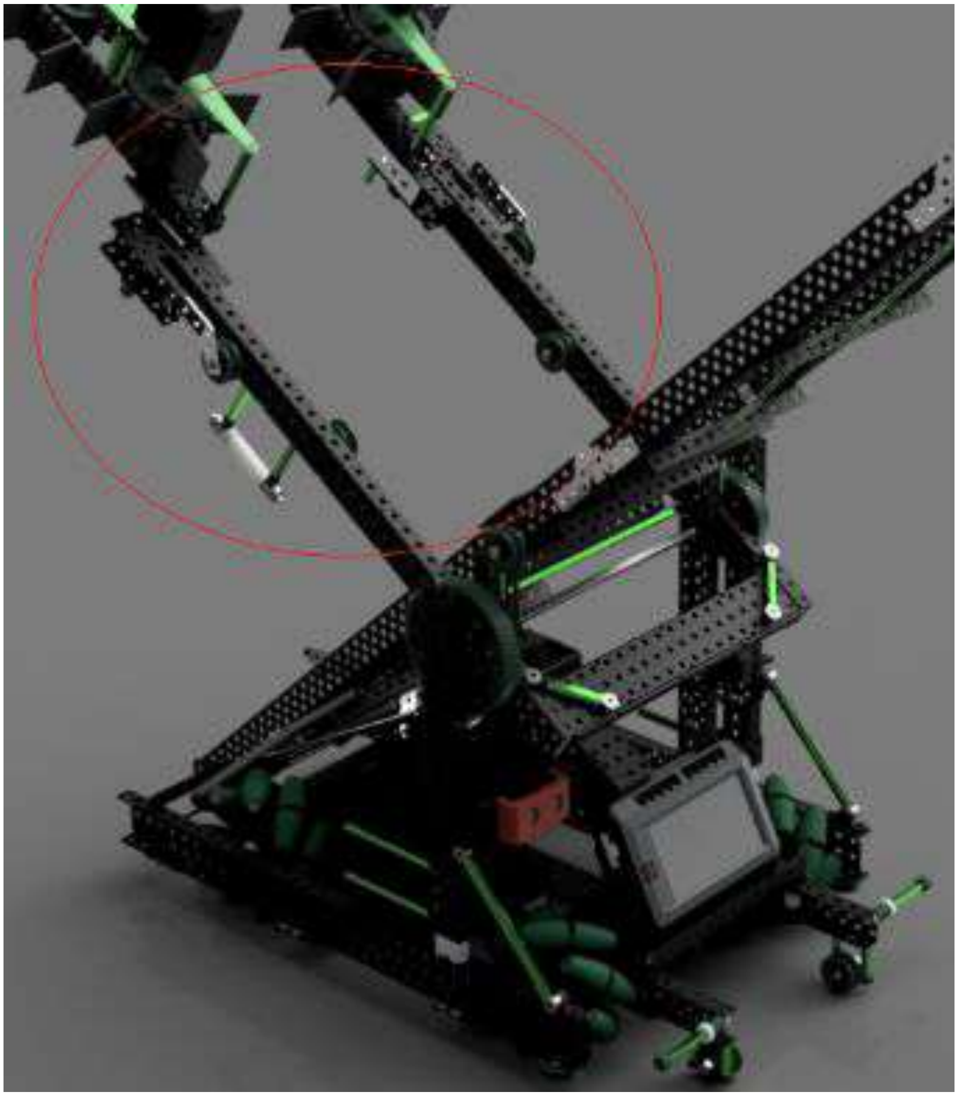
Witnessed by:

Oliver Liu

Select & Plan - lift cont.

2023/10/21

The two bar lift is a lift on a robot that comprises of mainly two bars on each side of the robot to lift our flywheel. This type of lift is very easy to build from its simplicity, very light from the lack of components required to build and it will not take up too much space on our robot. However, The 2 bar lift lacks strength to hold the entire weight of the robot for elevation. Additionally, anything mounted to the end of the lift will rotate, which will be an issue for our delivery mechanism orientation and blocking mechanism, since we still want to shoot/block people without lifting our lift for flexibility and efficiency in some cases.



An example of a two bar lift from Tower Takeover.
(from)
https://wiki.purduesigbots.com/hardware/lifts/other-lifts

Designed by:

Matthew Zhang

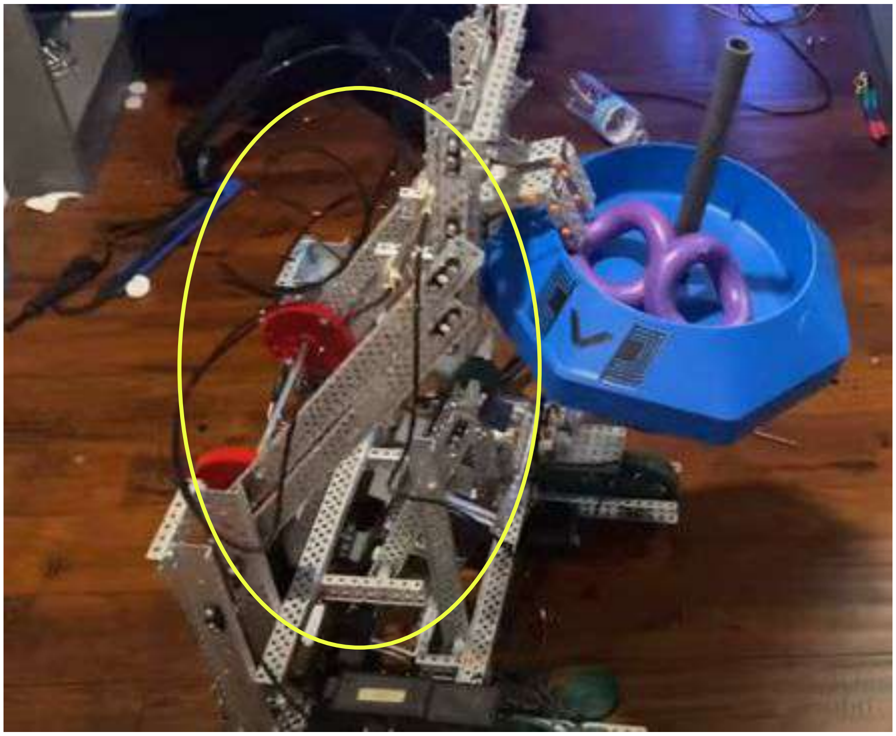
Witnessed by:

Oliver Liu

Select & Plan - lift cont.

2023/10/21

The four bar lift is a lift constructed from two sets of parallel bars that will move up in unison. One key strength about the four bar lift is that it can maintain orientation of the end of the lift, which is good for holding our delivery, blocking, and lifting mechanism. A four bar is still capable of lifting to a rather high height as seen in the image below. A 4 bar is strong enough to hold the weight of a robot, while being the most space efficient solution that can do so.



An example of a four bar lift from Tipping Point.
https://www.youtube.com/watch?app=desktop&v=_Qh4D33niwc

Designed by:

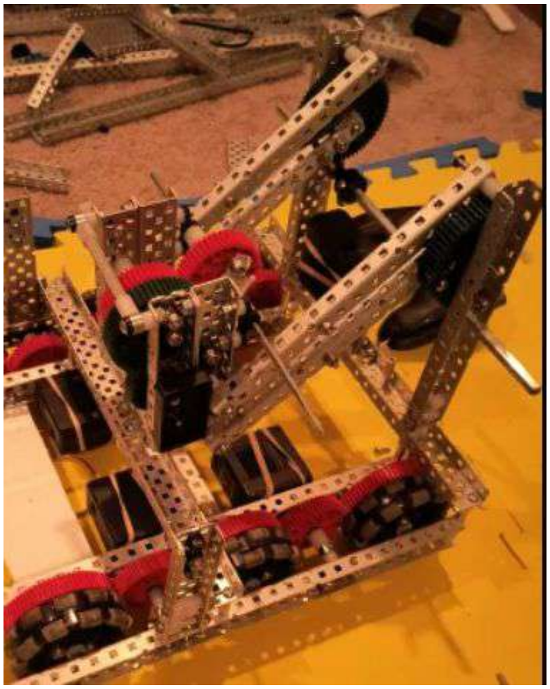
Matthew Zhang

Witnessed by:

Oliver Liu

Prototype and Build - Lift

2023/10/21



Goal: Build a 4 bar lift that will hold the delivery mechanism

We constructed the 4-bar lift using boxed half cuts. We chose this method since half cuts are lighter than proper 2 wide C-Channels, which helps with reducing weight. By boxing them, they are able to provide similar levels of strength, at nearly half the weight and size compared to normal c channels.

We used screw joints for mounting the lift bars due to their strong and compact nature, since axles require bearing flats, shaft collars, etc.

Currently the 4-bar is not braced and requires additional bracing later on, but we have found that currently, the lift is able to lift up and down with minimal friction.

Designed by:

Oliver Liu

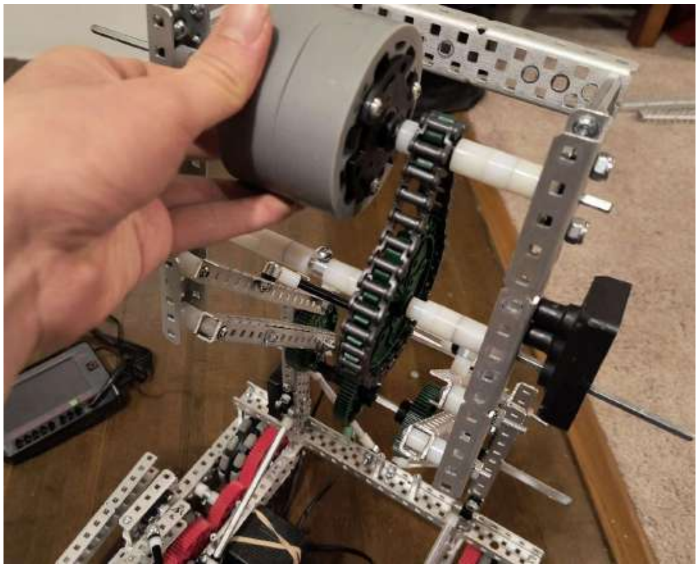
Witnessed by:

Matthew Zhang

Test & Redesign - Lift V2

2023/10/21

Goal: test the capabilities of the lift, and improve/redesign as needed.



After thorough testing of our lift, we found out that our lift was too tall and could not fit under the bar for elevation. Additionally, the lift tended to wobble around when moving or lifting.

So we shortened the lift mounting beams to allow the robot to drive under the bar used for elevation and we removed the boxing on top of the lift so the robot will not have as much bulkiness, and making it easier for us to mount things/braces onto it without having to deal with boxing the half cuts inside with spacers each time, which affects convenience. We also braced the robot with cross bracing to stabilize the the lift when it is expanding and retracting.

Designed by:

Jeffrey Wang

Witnessed by:

Oliver Liu

Identify Objective - Shooter

2023/10/27

Goal: Identify objective for triballs so that we can build an effective triball launching mechanism.

Problem Statement:

- Build a mechanism to interact with the triballs and score with them.

Solution Requirements:

- Must fit within a 18x18x18 in cube
- Must be constructed out of legal VRC parts
- Most work using no more than 2 motors
- Must work when mounted on our lift

Solution Goals:

- Launch triballs to the other side of the field quickly
- Be able to work with match loads well
- Be able to shoot over any robots trying to block the shots
- Must be able to consistently shoot Triballs in roughly the same area
- Must have minimal delay in between shots for rapid match loading

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

2023/10/17 Scrimmage

2023/10/17

Today, we played two matches against teams in our school. The performance of our robot in these two matches will be discussed, to help us improve our bot for future matches.

Round 1:

Our robot performed poorly in this round, and our intake was unable to allow the triball to go into the goal effectively if at all. The rollers went too high and were unable to grip the triballs enough to push them into the goal, but not high enough that the blocker at the back would be able to push the triball in. This will warrant modifications to our intake design. Additionally, we had some issues with the wiring on our robot, and the connection cut off after about 30 seconds. Additionally, the battery wire got caught between the gears in our drivetrain and got cut, so power was also lost. To fix this issue, we will need to be more organized in our wiring between the electrical components of our robot.

Round 2:

In this round, we performed a little better, and primarily focused on pushing the triballs into the goal as well as trying to use the intake once in a while. This strategy seemed to work better, and we got more triballs into the goal. We also noticed that our robot is able to recover from being flipped onto the intake, though the components were likely under a lot of stress from the weight of the robot. THis shows two main things: that our robot has a low enough center of gravity to recover from being flipped onto that side, and that further bracing of the intake is necessary to prevent any damage to the intake in the future. We also ran into wiring issues again, though this time one of the motor wires got caught in the gears and the radio also disconnected. Combined with the previous round, this issue shows us that we need to organize our wires better to prevent any disconnections, especially when we attend tournaments.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

V2 - Shooting

2023-11-06

For Shooting type

- **Speed or shooting**
  - How fast can it shoot
- **Size factor**
  - How much space will it take on the robot
- **Consistency/accuracy**
  - How can the robot shoot accurately and how well does it repeat this task
- **Angle of launch**
  - How defendable are the shots delivered by the robot

Ranked out of 5, higher is better quality

	Speed	Size Factor	Consistency/ Accuracy	Angle of Launch	Total:
Flywheel	5	3	2	5	15
Catapult	2	3	4	4	13
Kicker	2	2	4	3	11

Final decision matrix comparing all 3 shooting mechanisms

Based on our findings from the chart, we have concluded that the Flywheel is the most suitable delivering mechanism for our robot. This is because we believe that shooting a numerous amount of triballs towards the opponents side will overpower the opponent's defenses. The inconsistency that the flywheel has will play towards our advantage because by launching the tribals all over the place, the opponents will have a harder time trying to defend the tribals we are launching. Furthermore, we can adjust flywheel speed and how we place it onto the the flywheel, giving us a variety of angles.

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

V2 - Shooting

2023-11-06

FOR Flywheel wheel size:

- **Size**
  - How much space does the wheel take up
- **Weight**
  - How much do the wheels weigh
- **Power**
  - How far the Triball will go, based on how fast will the flywheel be rotating at when contacting the tribal.
- **Energy Retention**
  - How much energy is lost when a triball is shot.

Ranked out of 5, higher is better quality

	Size	Weight	Spin	Energy	Total:
3 inch	4	4	3	5	17
4 inch	3	2	5	3	12

Final decision matrix comparing both flex wheel options

Based from the data we gathered from the comparison table, we were able to conclude that the 3 inch wheels prove to be a better fit for our bot than the 4 inch wheels. This is because of the better fit and weight compared to its counterpart and it will also allow us to have a faster chain and gear ratio. It will also be good for our lift and it will also benefit our lift because of its light weight.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V2 - Shooting

2023-11-06

FOR Flywheel wheel TYPE

- **Size**
  - How much room does the wheel take up
- **Speed**
  - How fast does it shoot the tribals out
- **Consistency**
  - How consistent can it shoot the tribals
- **Adjustment**
  - How easy is it for us to adjust the shooter

Ranked out of 5, higher is better quality

	Size	Speed	Consistency	Adjustment	Total:
Single compression Flywheel	4	5	3	4	16
Double Compression Flywheel	2	4	4	1	12

Final decision matrix comparing both flywheel types

As seen from the information gathered above, Our group will be using the single compression flywheel as the delivery mechanism to launch out tribals to the other side of the arena. Although the flywheel suffers from a lack of consistency in launching the tribals, we believe that the speed at how fast the flywheel can launch the tribals and how easily the adjustments can be made when the robot is in play on the field.

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

Building - Flywheel

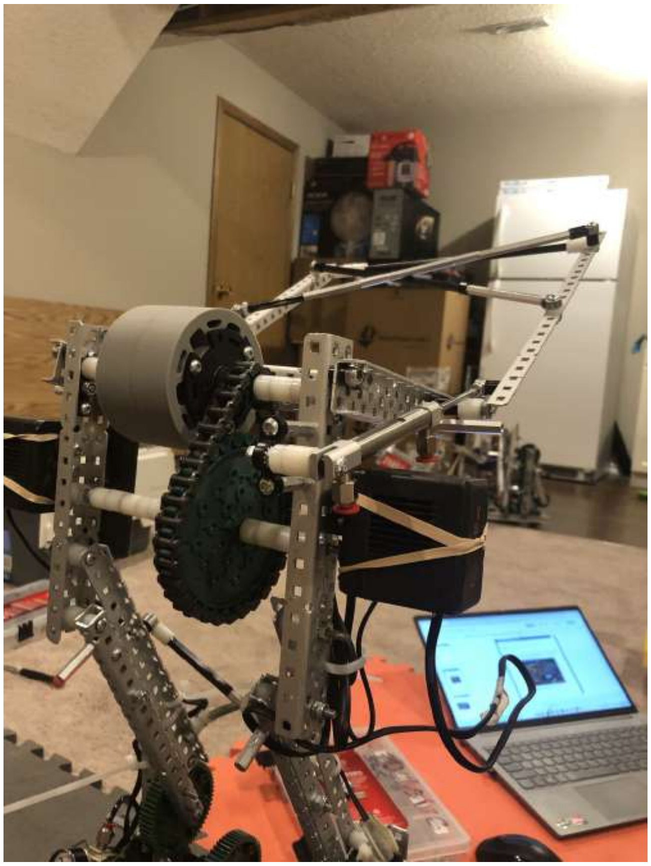
2023-11-14

The flywheel for the third version of our bot ran on 3600 RPM using two motors with blue cartridges. With this combination, it reduced the drop-off time from the flywheel slowing down after each shot, meaning we could place the Triballs on at a quick pace. The motors drove an axle connected to a 36 tooth sprocket, which was chained to a 6 tooth sprocket giving a gear ratio of 6:1.

The flywheel itself was created from two 3” flex wheels connected together with standoffs and screws with versahubs joining them with the axle.

In addition, to help aid with strength, a c-channel brace was constructed connecting the two pillars which the flywheel was supported on. This helped reduce the vibration of the flywheel and kept it more steady.

This flywheel was then placed on top of our lift. This offered multiple benefits, such as having access to a lower elevation for skills, and a higher elevation for matches to shoot over opposing bots and blockers.



Designed by:

Oliver Liu

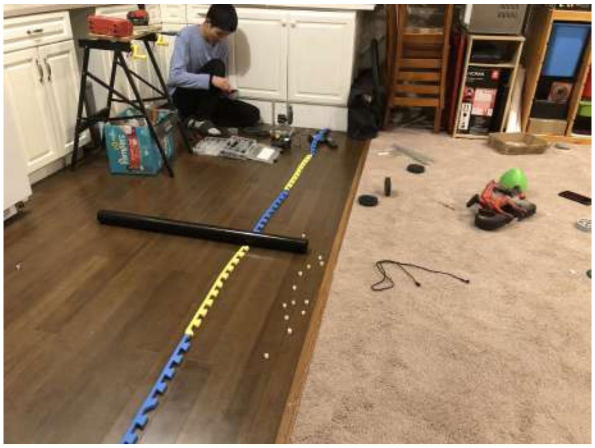
Witnessed by:

Matthew Zhang

V2 - Flywheel Testing

2023-11-14

In the early stages of testing, one of our first priorities was ensuring that the flywheel was able to consistently clear the barrier without issue. We tested a 1 motor, 2400 RPM on a 3” flex wheel to start with. After some practice, we found that the Triballs were going over the barrier fairly consistently. We also knew that if we ever faced issues with distance, that changing the gear ratios to increase speed would be fairly simple and effective.



Example of the distance of the Triballs launched. The PVC pipe represents the barrier, and the spacers represent the place where each Triball landed.

Our team spent the most time testing regarding the consistency of flywheels. One of our first priorities was for our drive team to practice match loading, as unlike kickers, punchers, or catapults, the placement of the Triball matters much more on a flywheel, as a small adjustment can create large differences in the trajectory and spin. For a low arch, we found that placing the Triball near the center of the flywheel and tilting it slightly forward allowed it to quickly and accurately land in front of the goal, which would be useful for skills matches. For real matches, we found that placing it near the back of the flywheel tilting slightly upwards gave it a much higher arch, giving the Triball a higher chance to fly over opposing bots or blockers.

When practicing match loading, we also wanted to make sure we could match load quickly. One of the advantages of a flywheel is that if you can minimize the drop-off rate from flywheels slowing down after shooting, its speed is incomparable to other options. Since we will have 2 people match loading, we found that calling out to stay of rhythm, using gloves to grip the Triballs, and repeated practice allowed us to match load more consistently and quickly.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V2 - Flywheel Testing

2023-11-14

One of our major focuses on our shooter was the grouping, as placing Triballs closer to the net made it much easier for us to push them in with wings or an intake during skills and matches. Due to the unpredictable nature of Triballs, it is very difficult to consistently land a Triball without it rolling. When we compared a flywheel to other shooter methods, we found that the backspin offered by flywheels could be used to partially negate the forward momentum of the Triball as it lands, which is exclusive to the flywheel. Regardless, it was still extremely difficult for us to shoot Triballs in front of the net, as the slightest adjustments in match loading will create vastly different trajectories and backspin, which is near impossible to perfect.

Example of the grouping of the Triballs launched. The PVC pipe represents the barrier, and the cardboard box represents the goal.

The above image's results were created under ideal conditions, such as the lift not being fully extended and a lower arch, meaning this result would likely be seen in a skills run. However, in an actual match, we would likely need a higher arch to clear opposing bots and blockers, which would reduce the consistency of the grouping as the Triball would have more energy and be more likely to roll or bounce around.

Designed by: Oliver Liu

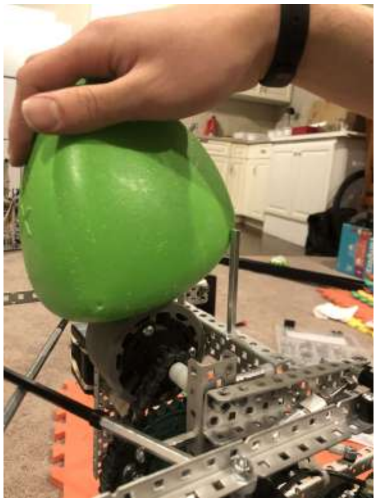
Witnessed by: Matthew Zhang

V2 - Flywheel Testing

2023-11-14

One issue we ran into with using a flywheel shooter was its consistency. We felt that during the pressure of an actual match, it was easy for us to mess up match loading due to its inconsistency. Because of this, we had the idea of creating guide rails that we could use to help align our shots

Our first idea for this was having 2 standoffs behind the flywheel so that we could jam one corner of the triball in between the standoffs, which would allow us to have a much more similar pattern in terms of placement.



However, a couple of problems arose with this strategy. The most glaring one was the fact that due to the increased height, our bot was no longer able to go underneath the barrier without the standoffs clipping it, as when our lift is fully retracted, the top of the flywheel brushes by the barrier.

Another issue was the fact that this setup did not help with the rotation of the Triball, which is arguably more important as it determines factors such as backspin, grip, and partially trajectory and distance.

Lastly, we found that with the standoffs implemented, match loading in general became a lot more sluggish. Previously, we were able to just place the Triball in roughly the right orientation and placement, but with the aligners, we needed to jam the Triball, find the right orientation, and place it without adding any additional spin.

In terms of consistency, we did notice a slight increase in the amount of Triballs successfully clearing the barrier after some practice. However, we began to wonder whether this improvement was worth the negatives that came with them.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

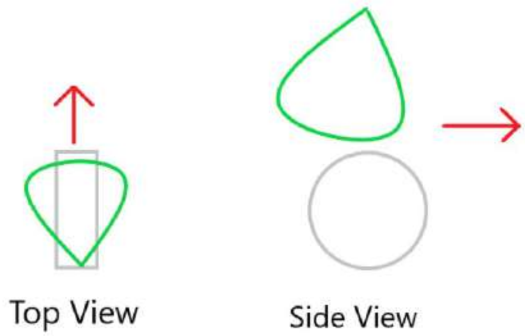
V2 - Flywheel Testing

2023-11-14

After learning from our previous standoff aligner design, we decided to change the material to using lexan. Immediately, we knew that this would fix the problem of the standoffs catching onto the barrier, as the flexible properties of the lexan allowed to to simply bend underneath the barrier.

We also believed that this could help fix our issues with rotation and speed. Rather than aligning the Triball against the standoffs, the lexan aligners could act as ramps, allowing us to place the Triball onto it to slide into the flywheel.

From our testing, we found that placing the Triballs in the orientation shown below provided a low arch and enough backspin to be able to help stop the Triball's forward momentum. When comparing the two images, we can see that the lexan helps orientate the Triball in the ideal position. Additionally, we believed speed would be improved, as we could just place the Triball onto the lexan rather than aligning it manually with the standoffs.



Designed by: Oliver Liu

Witnessed by: Matthew Zhang

V2 - Flywheel Testing

2023-11-14

As we began testing our lexan aligners, some issues began to show. The lexan ramps were not as sturdy as we had predicted, and so as we placed the Triballs onto the ramps, they sunk too far and would therefore have a bad orientation for the flywheel.

In addition, we were struggling to gain enough distance to go over the barrier. Our team believes that this may be caused because previously without aligners, we were able to drop the Triball extremely close and therefore have much more control. However, with the lexan ramps, we noticed that the Triball often slid and turned around as it glided down the ramp.

For our third iteration of our bot, we decided to not utilize the aligners as we felt they did not offer enough benefits compared to manually match loading them on.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Identify Objective - Wings

2023-12-01

Goal: Create a mechanism that will act as an extension of the robot to allow us to push in Triballs more effectively

Problem Statement:

- Build wings to attach on the side of our robot that can flip out to push Triballs in more quickly and effectively

Solution Requirements:

- Must remain in the horizontal expansion limit of 36”
- Must be completely powered by pneumatics
- Must be constructed out of legal VRC parts
- Must be rigid enough to withstand the force of Triballs and potentially other robots
- Must remain fairly light

Solution Goals:

- Create a locking mechanism to help withstand force
- Using lighter materials to help reduce weight
- Using pistons to swing out and retract wings

Designed by:

Oliver Liu

Witnessed by:

Bolo Wang

Select and Plan - Wings

2023/11/20

When selecting a design for our wings, one of our main priorities was to create a locking mechanism to aid the piston in keeping the wings in place. To accomplish this, we decided on using an over-center lock, which when fully extended, combines two joints into one, preventing the wings from collapsing easily.

The rest of the design is fairly simple, having two pistons, one on each side, pushing a c-channel connected to a piece of lexan. The piston and c-channel are mounted with screw joints, and an over-center lock is used to support the c-channel from behind. When building this design, we considered the following:

- **Strength:** Ensuring the wings are strong enough to push in multiple Triballs into the net at once.

- **Weight:** Making sure that the wings were not unnecessarily heavy to reduce weight.

- **Coverage:** Having the wings extend out just before the 36” horizontal expansion limit would allow us to cover the most area and therefore more efficiently push Triballs into the net.

- **Speed:** Having the wings able to extend and retract quickly would prove to be useful to optimize driver speed and skill for both skills and matches.

We believed our design met all of the aforementioned criteria. With the design selected, the next step for us was to begin building and prototyping with different designs.

Designed by:

Oliver Liu

Witnessed by:

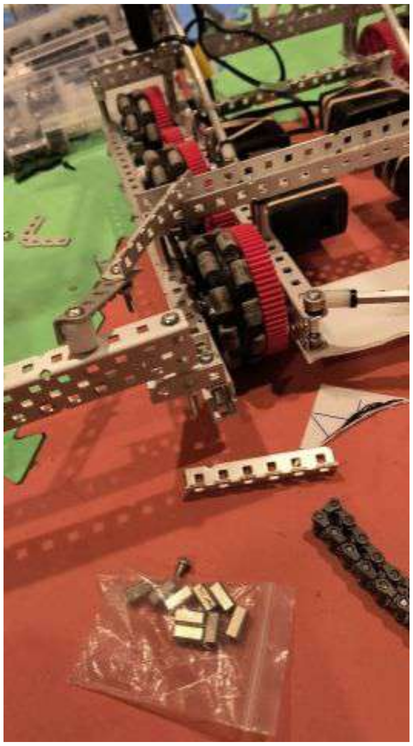
Bolo Wang

V1 - Wings

2023/11/20

Goal: Create a mechanism that will act as an extension of the robot to allow us to push in Triballs more effectively

For the first iteration of our wings, we tried using half-cuts powered by a piston connected together by screw joints to extend the wings. We made sure to place the piston, wings, and half-cuts in such a way that the two half-cuts would join together to create one joint when the wing was fully extended, as seen in the image below.



One of the largest issues with this design was the amount of friction generated. This was mostly caused due to the sheer amount of metal-to-metal contact in between joints, as seen above. When we powered it with a piston, although it was able to fully extend, we knew this was an issue that needed to be fixed immediately to ensure smoothness on our wings.

When we tested the locking capabilities of this design, it was able to help resist some force put onto the wings, allowing it to stay in place easier. However, the spacing for the lock was slightly off, and as such, the wings were folded outwards slightly, causing Triballs to roll off the wings. In addition, the lock was not very strong as the joints would barely reach over-center, and a slight nudge would cause the wings to collapse.

Designed by:

Oliver Liu

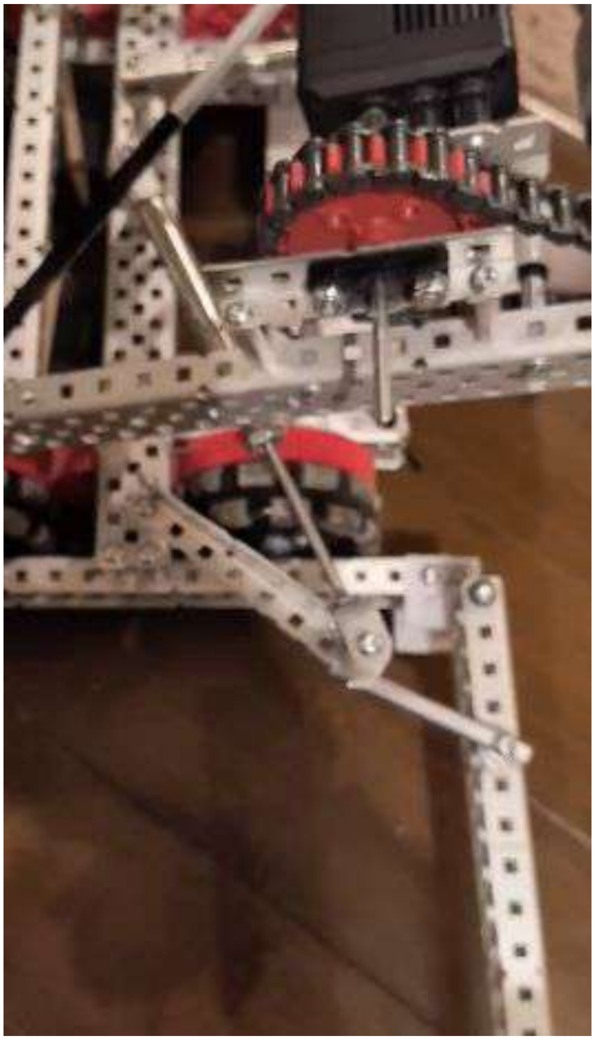
Witnessed by:

Bolo Wang

V2 - Wings

2023-12-01

For the second iteration of the wings, the most notable changes were replacing one of the half-cuts with a high-strength axle and adjusting the spacing the create a stronger over-center lock at 90 degrees. Using a high-strength axle allowed us to easily place a screw joint between the 2 joints, helping to reduce friction.



When testing this design, the first thing we noticed was that the locking mechanism was much stronger than last time, and was able to withstand a large amount of force. In addition, we were also much happier about the angle of the wings being much flatter, preventing Triballs from rolling off easily.

However, we were still not fully satisfied with the friction caused by the metal contacting each other, and we planned on fixing this on our next design.

Designed by:

Oliver Liu

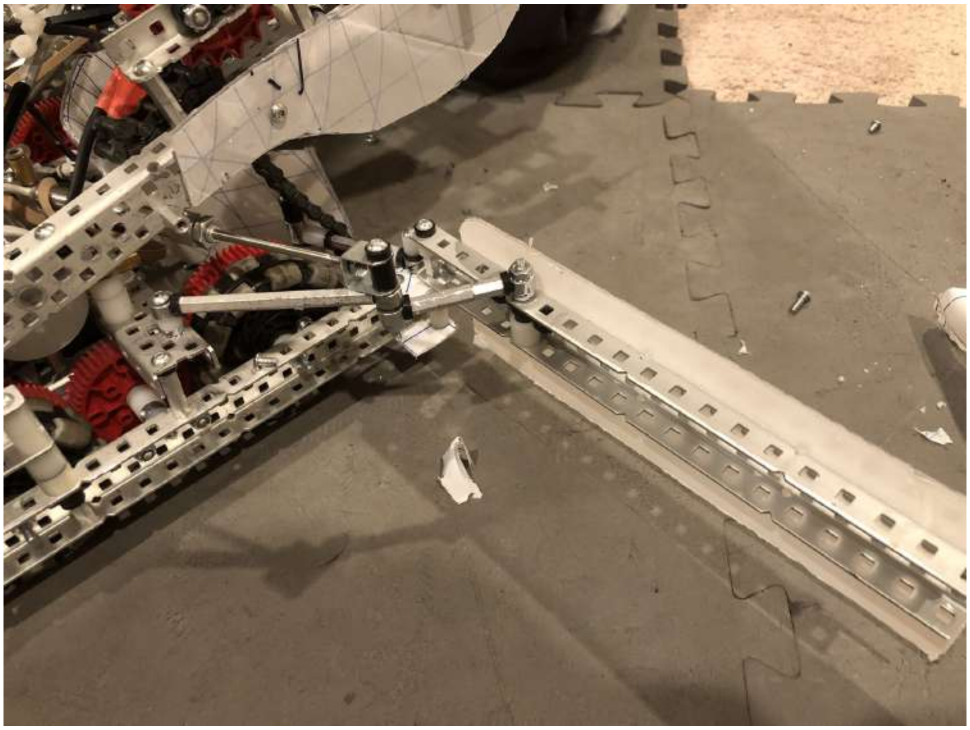
Witnessed by:

Matthew Zhang

V3 - Wings

2023-12-01

For our third iteration of the wings, we were mainly focused on improving friction to allow for a cleaner and faster extension and retraction of the wings. To fix this issue, rather than having half-cuts or high-strength axles as the joints for the over-center lock, we decided on using shaft collars rotating freely around a screw. This would help reduce the friction caused by half-cuts or axles scraping against each other as the wings extended and retracted.



One of the first things we noticed after we implemented this change was the fact that it was much easier to manually extend and retract the wings. Additionally, the sound of scraping metal was now gone.

When testing this design with pistons, we were quite satisfied with the speed it was going at. We believed this would be important in situations where the wings needed to be quickly used and then put away, as it would help reduce the time waiting for the wings to extend.

For the final change of this design, we placed a piece of lexan on both wings. This would help increase the amount of surface area vertically, preventing Triballs from slipping under or the c-channel from catching on top of Triballs. It also provided a flatter, smoother surface to push Triballs in.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Placements

2023/11/20

We mounted the brain directly under the 4 bar lift to balance the center of gravity closer to the ground. We also added the battery near the brain because it will be more accessible, in terms of connecting it to the brain and to also add more weight to that area of the bot to also balance the center of gravity towards the ground. We added the reservoir and the pistons closer to the front of the robot. This is because the pistons can connect closer to the wings at the front and the reservoir can connect with the pistons more easier. We also put a guard in front of the pistons and the reservoir to protect them from the impact that they might experience when we collect a triball.

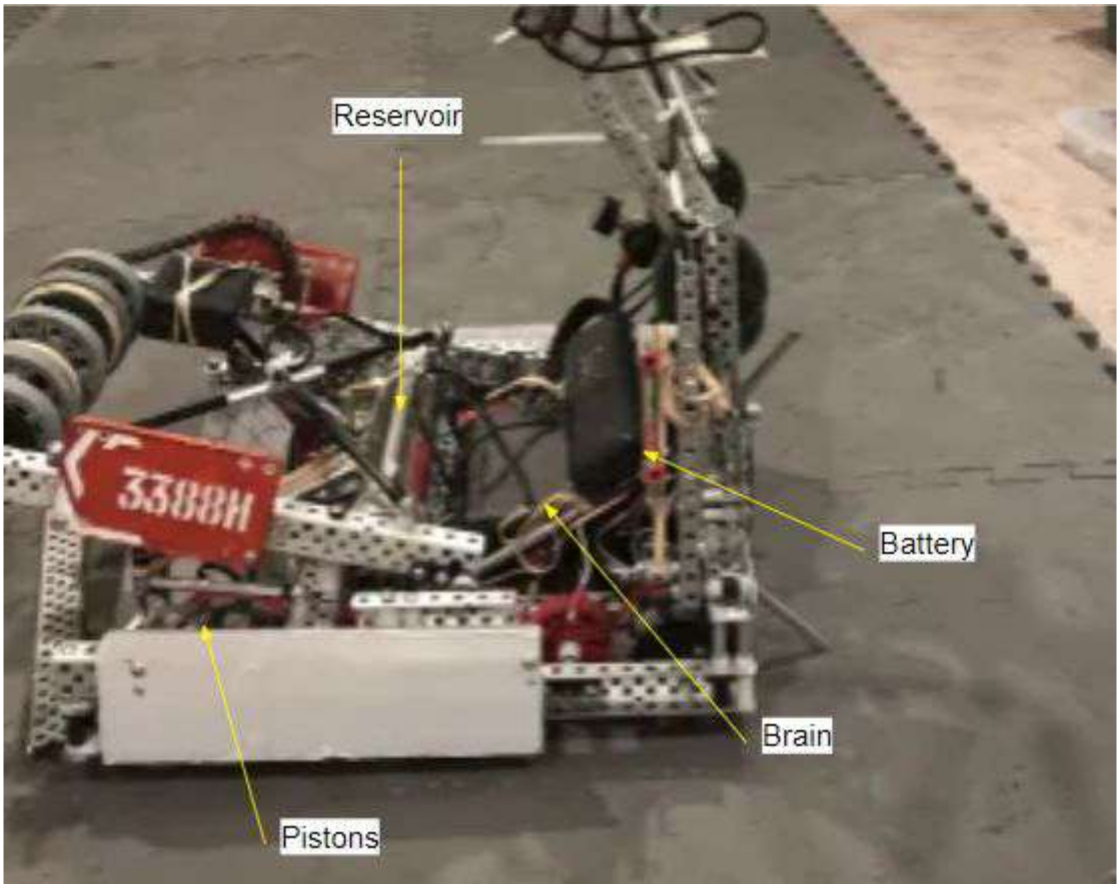


Diagram of the placements stated

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Identify Objective - Blocker

2023/11/20

Goal: Identify a strategy in order to defend from opposing match loads from shooters.

Problem Statement: Create a blocker mechanism that can effectively negate opposing alliance match loads from shooters.

Solution Requirements:

- Must be completely piston powered without the use of motors
- Must extend from the top of our lift
- Must create enough height to block opposing shooters even if the mechanism is elevated
- Must be able to lean over opposing bots to prevent shots from going overhead
- Must remain fairly light
- Must be sturdy enough to block opposing shots without much recoil

Solution Goals:

- Create a simple flip-out mechanism that can rest on top of our bot and extend via pistons
- Create braces and other ways to strengthen the blocker
- Use lighter materials such as half-cuts in order to reduce weight on the lift
- Create hard stops in different areas to control the angle of the blocker

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Select and Plan - Blocker

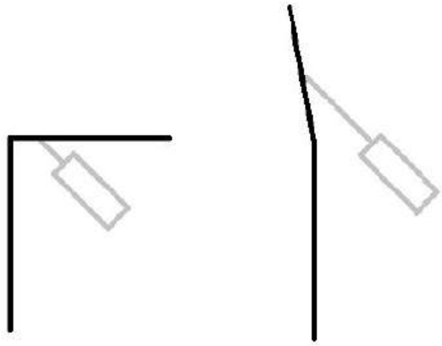
2023/11/20

Goal: Identify a strategy in order to defend from opposing match loads from shooters.

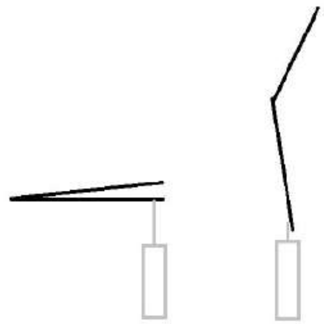
When we began creating the blocker, we had a couple of important decisions we needed to make, which were the location of the blocker and whether we were going to design a 2-stage blocker or a simple flip-out. We narrowed it down to 2 main options, which was a flip-out blocker on the top of our lift or a 2-stage blocker closer to the base of our bot. We believed that the other options were not practical, as they would offer excessive amounts of height and add unnecessary weight to our bot, or they wouldn't provide enough height to block most shooters.

Eventually, we ended up deciding on the flip-out on top of our lift. The primary reason for this was that our lift was currently only being used for our flywheel and elevation, and that adding a blocker on top of it would increase the value of our lift and would make the most sense, as building a 2-stage blocker seemed redundant with a lift.

The design of the blocker was fairly simple, 2 half-cuts attached to our lift via screw joints powered by a single piston. We also made sure to add hard stops to prevent the blocker from collapsing too far when retracted, and used bracing to connect the 2 half-cuts together while also creating a barrier in the gap between them.



Example of a flip-out blocker



Example of a 2-stage blocker

Designed by:

Oliver Liu

Witnessed by:

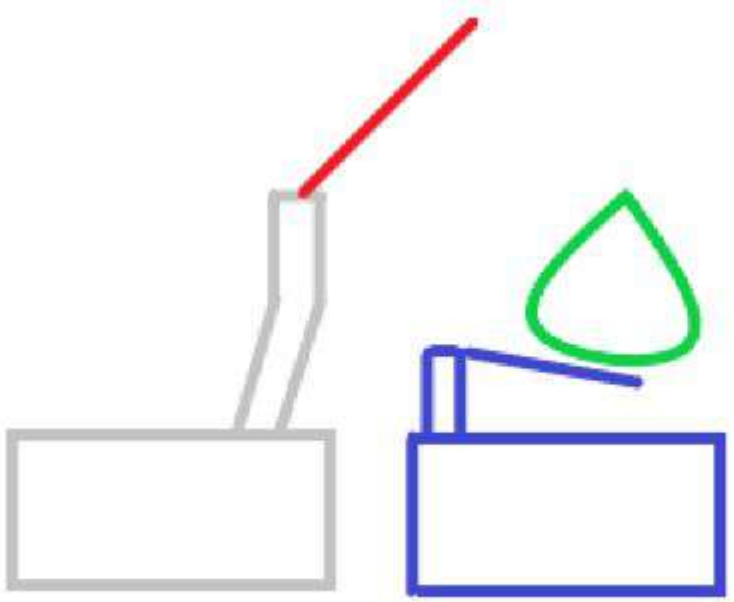
Matthew Zhang

V1 - Blocker

2023/11/22

For our first iteration of our blocker, our primary goal was just to test whether this concept was useful enough to implement on our bot. The design was fairly simple, a flip-out blocker consisting of a half-cut powered by a piston which was mounted on the top of our lift using screw joints.

With this simple design on our bot, we began to test to see if it was suitable for the needs of our bot. Right away, we did not find many issues with the blocker in terms of weight and space due to its simple design. However, its effectiveness was incredibly strong. Due to the placement of the pistons, the half-cut was capable of leaning over opposing bots, creating a sort of box around them. When testing this blocker with old shooter designs, it quickly became apparent that no shooter would be able to shoot over this blocker, even with lifts or high arches. However, since the design was quite skinny, shooting around the blocker was possible.



Example of our blocker. The red line represents the blocker and the blue robot represents an opposing robot.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V2 - Blocker

2023/11/22

Now that we understood the effectiveness of a blocker, we decided to revise the original design. Our main issue with the old blocker was that it did not cover enough area to block shots around it. To solve this issue, we added another half-cut to the other end of the lift, and connected the two using a large X-brace. Not only did this X-brace serve to strengthen the structure of the blocker, it also covered the wide area between each half-cut, creating almost a net between them.

With this blocker design, we ran into a couple of issues due to the increased size and weight. Firstly, when the lift and blocker are fully collapsed to go underneath the barrier, it would interfere with the intake, as it needs to be able to lift over the goal, which the blocker and lift prevents it from doing so.

We also found that the placement of the piston was not optimal. For the piston to smoothly extend the blocker, you would need it to be roughly perpendicular to the half-cut for the cleanest extension. However, the placement of our piston meant that when the blocker is retracted, the half-cut and piston are nearly parallel, making it so the blocker was unable to extend without help.

Designed by:

Oliver Liu

Witnessed by:

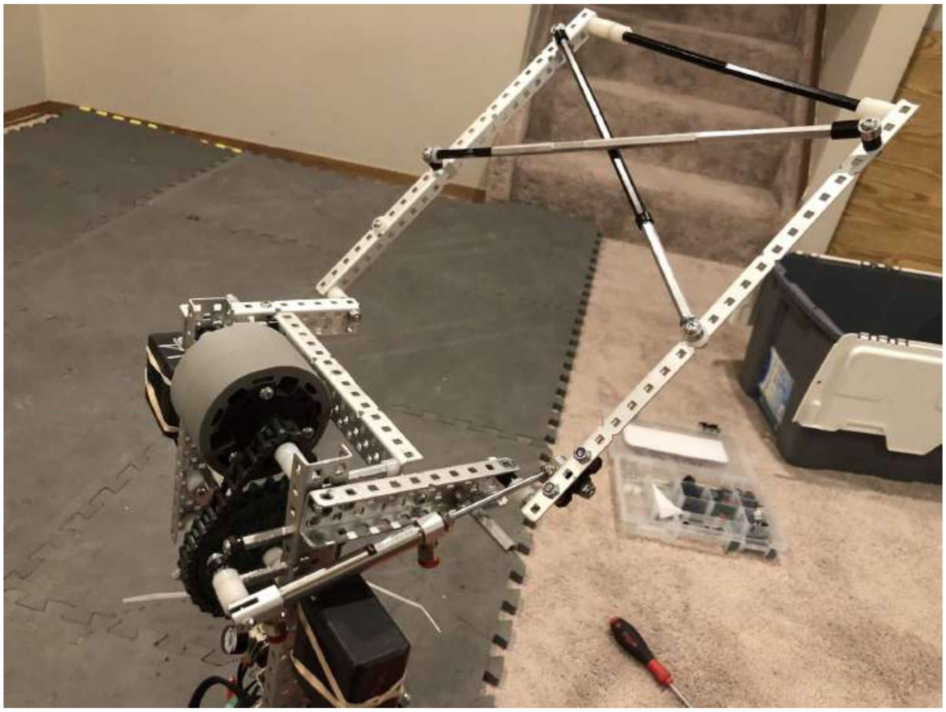
Matthew Zhang

V3 - Blocker

2023/11/22

The third version of our blocker continued to add onto the previous 2 versions. Firstly, to fix the issue of the blocker interfering with the the intake, hard stops were added to let the blocker lie down perpendicular to the ground rather than resting down on the intake. In addition, improvements to the intake were made to allow it to score more smoothly.

In addition, to fix the issue of the piston not being able to extend the blocker, adjustments were made in order that it may push the half-cuts at a more direct angle. This was accomplished by changing the points of contact with the half-cuts and lift, as well as extending the piston further backwards by using pillow bearings. This adjustment also helped straighten out the angle of our blocker to be more vertical, which we thought would be more useful when blocking shooters on lifts.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

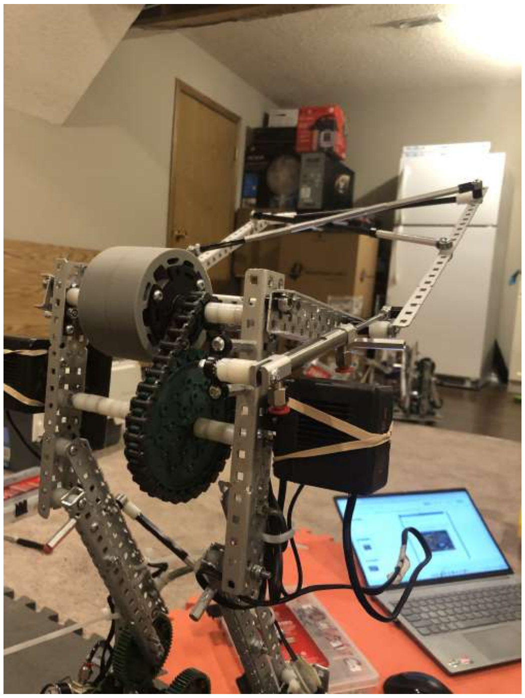
Building - Blocker

2023/11/22

When building the first iteration of our blocker, the building techniques used were fairly simple to understand. It consisted of a piston connected to the lift via screw joint, and the half-cut also connected using a screw joint, allowing for minimal friction as the piston and half-cut swings. Since the blocker was not experiencing much force and was unlikely to break, we did not feel the need to brace or box it heavily.

For the second iteration of our blocker, the main difference was a second half-cut on the other end of the lift on a screw joint, connected to the first using an X-brace as well as a straight brace running along the top. This change would allow for more area to be covered by the blocker, making it less likely for opposing shooters to bypass it.

The third iteration of the blocker involved placing the piston further back to allow the blocker to extend smoothly. This was accomplished using standoffs to space it out and the piston being connected on a pillow bearing on a screw joint. In addition, we also added a hard stop to prevent the blocker from interfering with other mechanisms when fully retracted. This was accomplished with standoffs sticking out, as well as using spacers and screw heads to space it out until we were satisfied with the spacing.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V1 - Odom Wheel/Gyro Mount

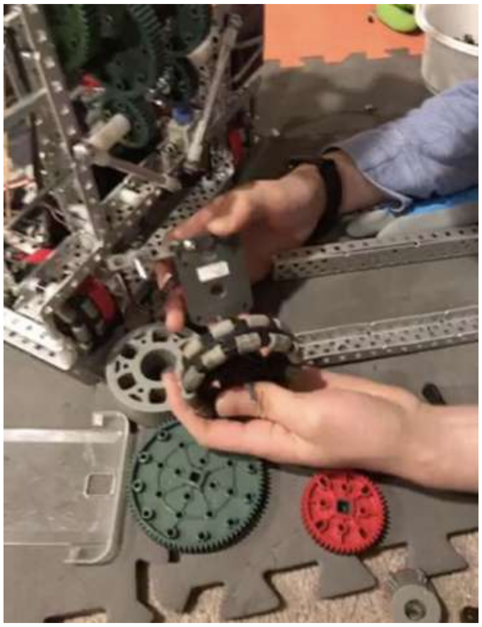
2023/11/22

Goal: Create a mechanism that will track the rotation and drift of the robot for autonomous

When brainstorming ideas for the autonomous portion of skills, we knew that if we coded a path without the use of any sensors, the sheer amount of Triballs on the field after match loading would completely throw off the robot in terms of rotation.

To solve this issue, we decided on building an odom wheel to track our rotation. By placing a wheel horizontally in our bot connected to sensors, it can calculate and track the amount the wheel rotates and how far it has moved sideways.

With this information, the bot is able to adapt to the inconsistency that comes when pushing large amounts of Triballs during skills autonomous runs.



However, we were struggling to get the code working after some testing. We found that the odom wheel wasn't able to detect its location properly, and as such, we decided to not use this feature for this iteration of our bot.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Robot Testing

2023/11/28

Today we tested all components of our robot in preparation of the event in Edmonton. Overall, all components of our robot are working to some extent, helping to set us up for success in Edmonton. The lift is not able to lift the robot, and our code is working well.

When testing the flywheel, we noticed that many of our triballs are overshooting and landing on top of the goal, which is not ideal. We realized that this problem could be fixed by placing the triball farther back on the flywheel when match loading, thus gaining more lift. This creates a higher arc for the triball, both helping us go over other team's blockers and also shooting the triball shorter, so that it would now land in front of the goal instead of on top. However, since we may not be able to matchload in this way consistently, especially under the pressure of the event, we have opted to instead reduce the speed of the flywheel.

Our walls are working well, and are able to push the triballs into the goal. Upon testing with some other teams, we have also concluded that our wedges are working well. This will prevent us from getting pushed into a wall and will prevent us from getting flipped over.

When testing the flip out meant for removing the triball from the match loading zone during the autonomous period, we did encounter some problems, and the flip out was unable to push the triball out of the zone. This is because the point at which the flip out contacts the triball causes the triball to actually be pushed down, which doesn't help it get over the bar, so this mechanism still needs some tinkering before the event.

FInally, we also realized that we are out of the 18" x 18" x 18" size limit at the start of the match, with no planned way to get back in regulation size. This is a problem, and we have considered using rubber bands to hold components in place at the start of the match, but with no legal way to allow these components to move after the round starts, we need to find another solution to this problem.

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Robot Testing

2023/11/23

Today we tested the intake and lift mechanisms of our robot. This is to make sure that everything is working and allows us to make sure that if any major redesigns are needed, that we can get those done before our first major event on December 2nd at Edmonton.

Our lift mechanism still does not work, this is because the motors and gearing we are using for the lift do not provide enough torque to lift the bot completely off the ground using the horizontal elevation bar. Our solution to this is to move some stoppers to allow the pivot point to be closer to the elevation bar. Although this reduces the total potential height we are able to obtain, we believe that this is the only option without a drastic redesign that would apply to a significant portion of our robot.

Our intake also performed poorly while testing today. This is because the flex wheels were unable to grip the triballs effectively. This results in the triballs simply bouncing off the intake rather than going into our robot. Our solution to this problem is to use softer flex wheels, which involves cutting our current flex wheels in half lengthwise, since softer ones are not available to us at this time and due to the nature of our team being a school team.

Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Robot Testing

2023/11/16

Today, we did a significant amount of testing with our flywheel design for getting match loads onto the other side of the field. This will help us improve our flywheel design and build quality. Below is an image of one of our results of where the triballs landed.

From these results, it is clear that our flywheel is shooting the triballs quite imprecisely. This signifies two main things. Firstly, the flywheel speed being inconsistent. This causes triballs to be launched differently each time. However, more importantly is the variation in the ways which we are placing the triballs onto the flywheel, which results in an even greater range of trajectories for the triball. A third problem that we have observed is that our axle is slightly bent, and this causes excessive friction and strain on the system. It is also a source of the mechanism slightly shaking, which also causes variations in the trajectory of the launched triball.

To fix some of these problems, we will be rebuilding the flywheel with the same design, but we will be putting much more care into making sure that the build quality is good and that tolerances are minimized to the best of our ability. We are also going to be attempting to straighten the axle the best we can to help with this problem. We are also going to be practicing match loading so that we are able to load the triballs into the flywheel in a fairly consistent manner and in quick succession. We are also going to be wearing garden gloves for increased grip and thus consistency when testing in the future, but extensive testing will have to be done with this as well as the increased friction from the garden gloves may cause new problems.

Some other problems that we have noticed are that each time a triball is launched, the flywheel loses momentum, making quick successive launches slightly inconsistent. Another thing that we noticed is that the triballs have a backspin to them, so we would have to aim for the far corner in other to make sure that the triballs don’t bounce and roll back onto our side of the field.

Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Program PID

2023/12/01

Goal: Program and tune PID so that we can have more accurate and precise autonomous programs.
General Overview:

- PID allows the bot to accelerate smoothly
- Sets the speed of the motors based on the displacement from the target

P - Proportion

- Proportion decreases the bots speed as it approaches the target
- By calculating the displacement from the target, we will multiply this by a constant factor so the closer the robot gets to the target, the slower it will move
- We will use this to slow the robot in drive commands

I - Integral

- Integral accelerates the drive when proportion undershoots the target
- Multiplies by a constant factor by the total accumulation of errors over time
- We will use this to accelerate the robot as it approaches the target to ensure that it reaches its destination.

D - Derivative

- Derivative restricts rapid changes in motion for acceleration
- Multiplies a constant factor by the change in distance from the target over the change of time
- We will use this in our autonomous programs to prevent the robot from making sloppy movements that cause drift from the intended route.

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

Program PID

2023/12/01

Code:

```
void drive_to_point(pdd targetCoord)
{
    // Vector stores the target points that we hope to hit in the path
    // All points are relative so 5, 5 would mean 5 units forwards 5 units to the right.
    // front of bot
    //  ^
    //  |  +
    //  |----->

    double current = 0;
    double integralActiveZone = 30;

    double kp = 0.15;                 1
    double ki = 0.05;
    double kd = 0.3;

    double displacementTotal;
    double lastDisplacement;
    double proportion;
    double integral;
    double derivative;

    double currentX = 0; // calculate from sensors
    double currentY = 0; // calculate from sensors
    driveLeftFront.tare_position();
    driveRightFront.tare_position();

    double targetX = currentX + meters_to_motor(targetCoord.first);
    double targetY = currentY + meters_to_motor(targetCoord.second);

    currentX = driveLeftFront.get_position();
    currentY = driveRightFront.get_position();

    double displacementX = targetX - currentX;
    double displacementY = targetY - currentY;
    double displacement = sqrt(displacementX*displacementX + displacementX*displacementY);
    double targetDisplacement = displacement;

    // calculate rotation change if any
    double theta = atan(displacementY / displacementX) * 180 / 3.14159265358979323846;
    double a = displacementX;
    double b = displacementY;

    if(a == 0 && b < 0){
        theta = -90.0;
    }
    else if(a == 0 && b > 0){
        theta = 90.0;
    }
    else if (a < 0) {
        theta += 180.0;
    }
    else if (a < 0 && b == 0) {
        theta = 180.0;
    }
    if(theta > 180) {
        theta = -360 + theta;
    }

    //copy pid and modify for rotation          2
    rotate_to_angle(theta);

    int timer = 0;
    int timeOut = 10;
                                                        3
    while(true){
        double currentPos = driveLeftFront.get_position();
        displacement = targetDisplacement - driveLeftFront.get_position();

        // Prevents integrals from adding on large amounts of numbers and causing the motors to spin too fast.
        if(displacement < integralActiveZone && displacement != 0) {
            displacementTotal += displacement;
        } else {
            displacementTotal = 0;
        }

```

1. Sets up variables and PID constants
2. Calculates an angle change and rotates the bot to the angle before driving towards the destination

   The rotate_to_angle(theta) function is another PID that has a similar structure to this one It is used for accurate rotations with an uncertainty of about 1 degree

3. While(true) infinite loop to cause the code to run until the break condition is met

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

Program PID

2023/12/01

```
        // Cap for integral
        if(displacementTotal > 50/ki){
            displacementTotal = 50/ki;
        }

        // Imediately sets deravitive to 0 instead of having it gradully return to 0.
        if(displacement == 0){
            derivative = 0;
        }

        proportion = displacement * kp;          4
        integral = displacementTotal * ki;
        derivative = (displacement - lastDisplacement) * kd;

        lastDisplacement = displacement;

        current = proportion + integral + derivative;

        drive_straight(current);     5

        if(displacement < 10 && displacement > -10) {
            timer++;
            if(timer >= timeOut){
                drive_straight(0);        6
                break;
            }
        } else  {
            timer = 0;
        }
    }
    pros::delay(20);
}
```

4. Calculates the three proportions from the sensors and the constants

5. Sets the drive

6. Break condition, will end the loop if the robot meets these conditions which means that the robot is at its destination.

Conclusion:

- Our PID requires tuning as it requires more accuracy
- The use of motor encoding may be hindering the accuracy of our PID
- Our tuning process is efficient and can be completed quickly
    1. Increase kp until the robot begins to oscillate
    2. Decrease kp to the last value before the oscillation
    3. Increase ki until the robot begins to oscillate
    4. Decrease ki to the last value before the oscillation
    5. Increase kd until the robot's motion becomes smooth

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

Tournament Analysis - Edmonton

2023-12-06

The following table from VEX Via shows our matches and results during our tournament at Edmonton on December 3, 2023.

Practice					
P 4	9:52 AM	210T 9409X	98	58	5760G 3388H
Qualification					
Q 3	10:21 AM	210Z 3300C	98	113	210T 3388H
Q 6	10:40 AM	5760H 9409X	97	118	9409Y 3388H
Q 12	11:19 AM	3388H 5760E	74	52	3300C 5760G
Q 15	11:36 AM	5760A 3388H	139	49	3388X 9409Y
Q 18	11:56 AM	2088K 3388H	81	121	210Z 4604S
Q 24	1:27 PM	5760H 9411C	144	46	2088K 3388H
Q 26	1:37 PM	9409X 9409Z	131	101	210F 3388H
Quarterfinals					
QF 2-1	2:31 PM	210Z 3388H	107	68	9409Z 9411C
Semifinals					
SF 1-1	2:48 PM	5760E 9409Y	64	84	210Z 3388H
Finals					
F 1	3:20 PM	210Z 3388H	87	100	210T 3388A

Overall, we think we did fairly well during this tournament. We made it to finals and also won the design award. In addition, we felt that, for the most part, our mechanisms were working as intended.

Designed by:

Oliver Liu

Witnessed by:

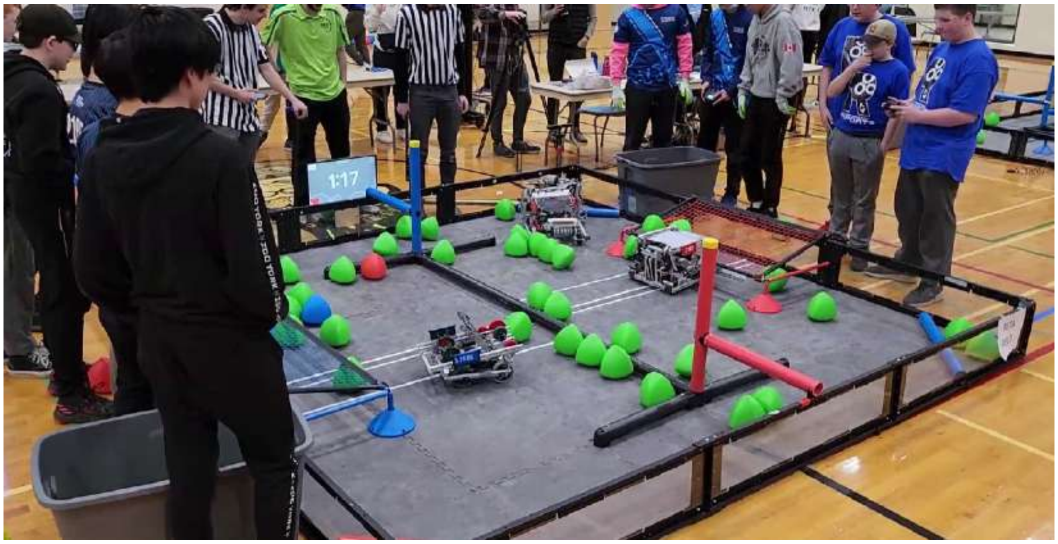
Darien Ng

Edmonton Tourney - Match Analysis

2023-12-06

Practice 4

- This match was one of our team's first time handling the bot in a real game scenario. During this match, we lost by a fairly large margin of 98 to 58. However, one thing to note was that due to a lack of time leading up to the tournament, our driver and match loaders had little to no practice with this bot. Regardless, we ran into two major issues during this match. Firstly, the match loaded Triballs were having issues fully clearing the barrier. Our Triballs were able to just barely go over, but due to opponents blocking them from crossing the halfway point as well as limited match loading practice, many of the Triballs ended up on our side, allowing the opponent to easily score them. Our second issue was our radio having connectivity issues as we drove to push Triballs in. This issue, we believed, was most likely caused by a faulty radio, and would continue to be a major problem for the duration of the tournament.
- From this match, we learned a few things. First was to consider re-mounting the radio in a higher, less obstructed area for the best connection. We also knew that our match loaders needed much more practice, and we also considered increasing the gear ratio and RPM of the flywheel to make shots more consistently. After the tournament, we also wanted to double check that everything was functioning properly, as checking the radio was not on our checklist.



Example of how many of our match loads (blue) landed on the opposing offensive area

Designed by: Oliver Liu

Witnessed by: Darien Ng

Edmonton Tourney - Match Analysis

2023-12-06

Qualification 3

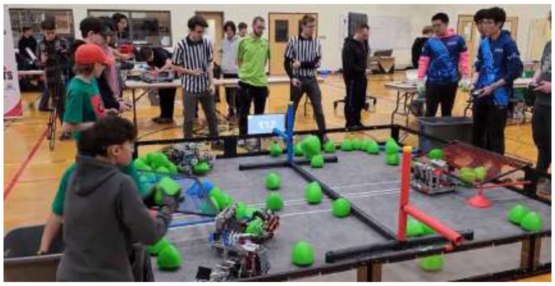
- After the first practice match as well as driving the bot around beforehand, we were beginning to get a feel for how our bot worked. Due to our design of a flywheel on a lift, very few teams at Edmonton were able to block us. As a result, our team was primarily responsible for match loading for the remainder of the tournament. During the match, we were able to get multiple match loads over and was able to push them in with our wings. However, this meant that no one on our alliance was blocking opposing match loads, allowing both sides to be completely filled with Triballs. In addition, we did experience a couple of radio issues, but they did not have a great impact on the game. We were able to win by a small margin of 113-98.

Qualification 6

- Similar to previous games, our team was in charge of match loading. However, unlike the last game, our alliance partner was successfully able to disrupt opposing match loads, preventing them from shooting too many Triballs over onto our side. Due to the sheer amount of Triballs we had paired with our wings, we were able to push many of them in. However, due to time constraints, we did not have our lift ready for elevation for a portion of the tournament. The opposing alliance was able to elevate themselves, adding 20 points. However, this still resulted in a narrow victory of 97-188.

Qualification 12

- During the tournament, we were able to code a simple autonomous that lifted our flywheel up, helping to save some time that could otherwise be spent pushing Triballs into the net. We ran into multiple issues during this match. Although match loading went fine, having the majority of the Triballs clearing the barrier, as we went to push the Triballs in, our radio kept disconnected, forcing our driver to reconnect every 2-3 seconds. Furthermore, our alliance partner was flipped over the barrier. Despite this, we still managed to win 74-52 due to our match loads overwhelming the opposing alliance.



Example of our match loads during Qualification 6

Designed by:

Oliver Liu

Witnessed by:

Darien Ng

Edmonton Tourney - Match Analysis

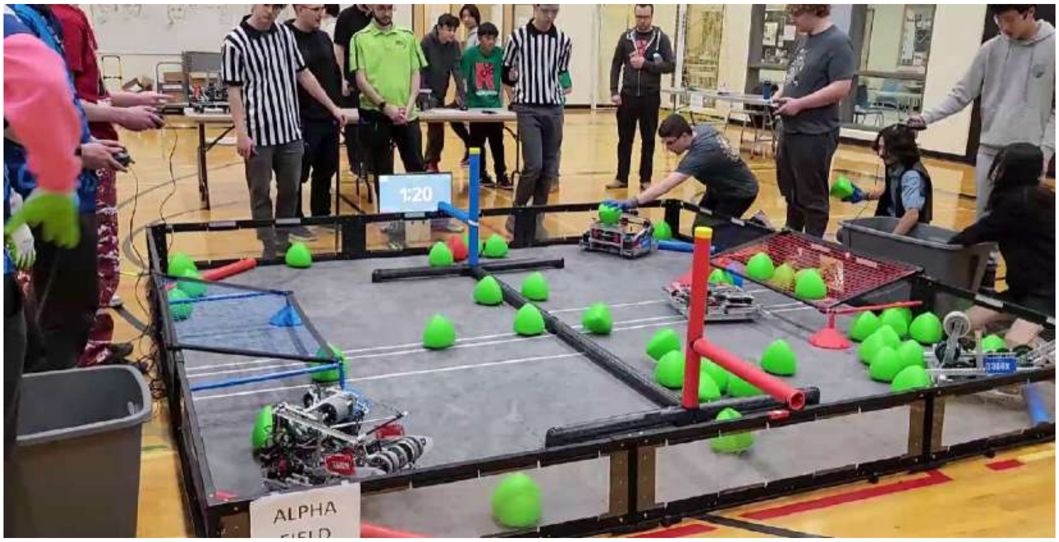
2023-12-06

Qualification 15

- This match was fairly straightforward; our bot was able to matchload quite consistently during this round, covering our offensive side with plenty of Triballs. All that was left for us to do was to push them in, which was done successfully. The only slight issue we had was our radio disconnecting in the last 15 seconds, however this had no major impact on the match.

Qualification 18

- This match was quite chaotic for both sides. To start, both alliances were successfully able to match load over the barrier, covering the field with Triballs. However, during match loading, 1 bot from either alliance got stuck, one on the barrier and one on the blue goal. With only one bot from either side still upright on both alliances, we began to push as many Triballs into our respective goals. However, when this happened, 2 issues occurred. Firstly, our chain powering our intake snapped, leaving us with no way to intake Triballs. Second, as we were approaching our net to score, many Triballs from our end were pushed over the barrier to the opposing alliance's offensive end due to the slope of our wings. Because of both of these problems, we lost 81-121.



Example of our match loads during Qualification 15

Designed by:

Oliver Liu

Witnessed by:

Darien Ng

Edmonton Tourney - Match Analysis

2023-12-06

Qualification 24

- This qualification match went quite poorly for us. To start, as we were match loading, many of our shots were blocked by an opposing bot, preventing us from shooting as well as landing some of our own match loads onto their side. The most pressing issue, however, was our radio completely disconnecting on us, disabling us from controlling our bot for the rest of the match. Paired with the opposing team's match loads, we lost by a significant 144-46.

Qualification 26

- This was our final qualification match before the alliance selection and elimination bracket. We believe this round went fairly well for both sides. For both alliances at the beginning of the round, one bot was in charge of match loading and the other attempted to block opposing shots. In both cases, however, the blockers were unable to defend from the match loads, causing both ends to be covered in match loads. However, due to the opponent's grouping being better than ours, they were easily able to push in all their Triballs and have enough time to defend us from doing the same. This resulted in a 122-102 loss for us, ending our qualification matches at rank 9 out of 17 with a 4-3 win loss ratio.

Example of our match loads compared to the opposing match loads in Qualification 26

Designed by: Oliver Liu

Witnessed by: Darien Ng

Edmonton Tourney - Match Analysis

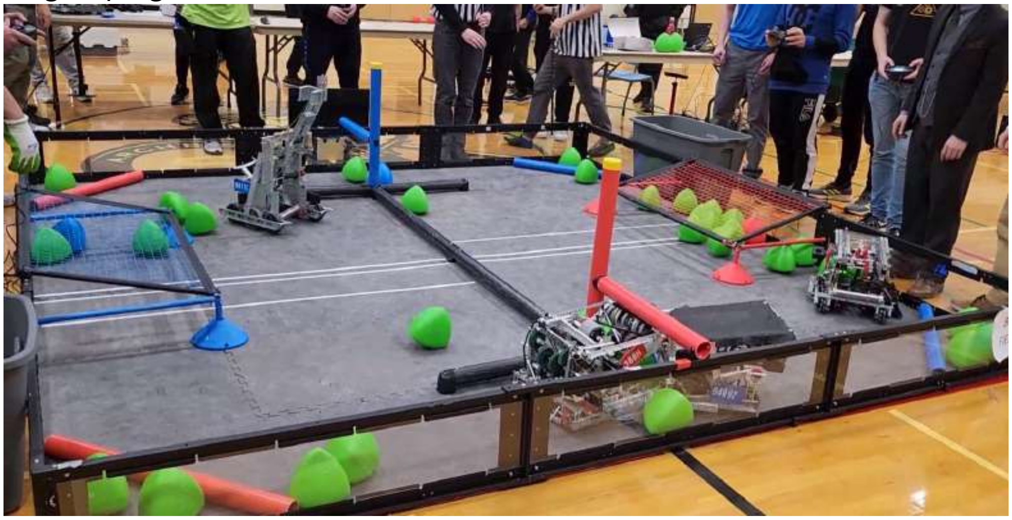
2023-12-06

Quarterfinals 2-1

- This was our first round in the elimination bracket, causing a lot more pressure on our drive team. Nonetheless, we were able to decisively win and control the match. Due to good match loading, our opponents were overwhelmed by the sheer number of Triballs on their half, allowing for a 107-68 win. Also, none of our mechanisms failed and we did not experience connectivity issues, which we hoped could last for the following rounds.

Semifinals 1-1

- The semifinal match was a roller coaster with ups and downs throughout the match. To start, our flywheel broke unexpectedly during match loading, forcing our alliance partner to take over as we took on the role of a blocker. Due to the height of the blocker, it made it near impossible for the opposing alliance to match load. However, due to the time lost with the flywheel breaking, multiple Triballs were scattered on our side of the field already. Our alliance teammate was able to successfully match load as well. At this point, the timer was running low, and we decided to try to elevate ourselves, as we had recently added lift bands to help keep our robot elevated after the power shut off. Unfortunately, we forgot to check if the lift bands were actually on beforehand, and as such, we could not elevate. We were able to narrowly win 84-64 despite the other alliance having better grouping than us.



Example of us having more Triballs on our offensive side in Quarterfinals 2-1

Designed by: Oliver Liu

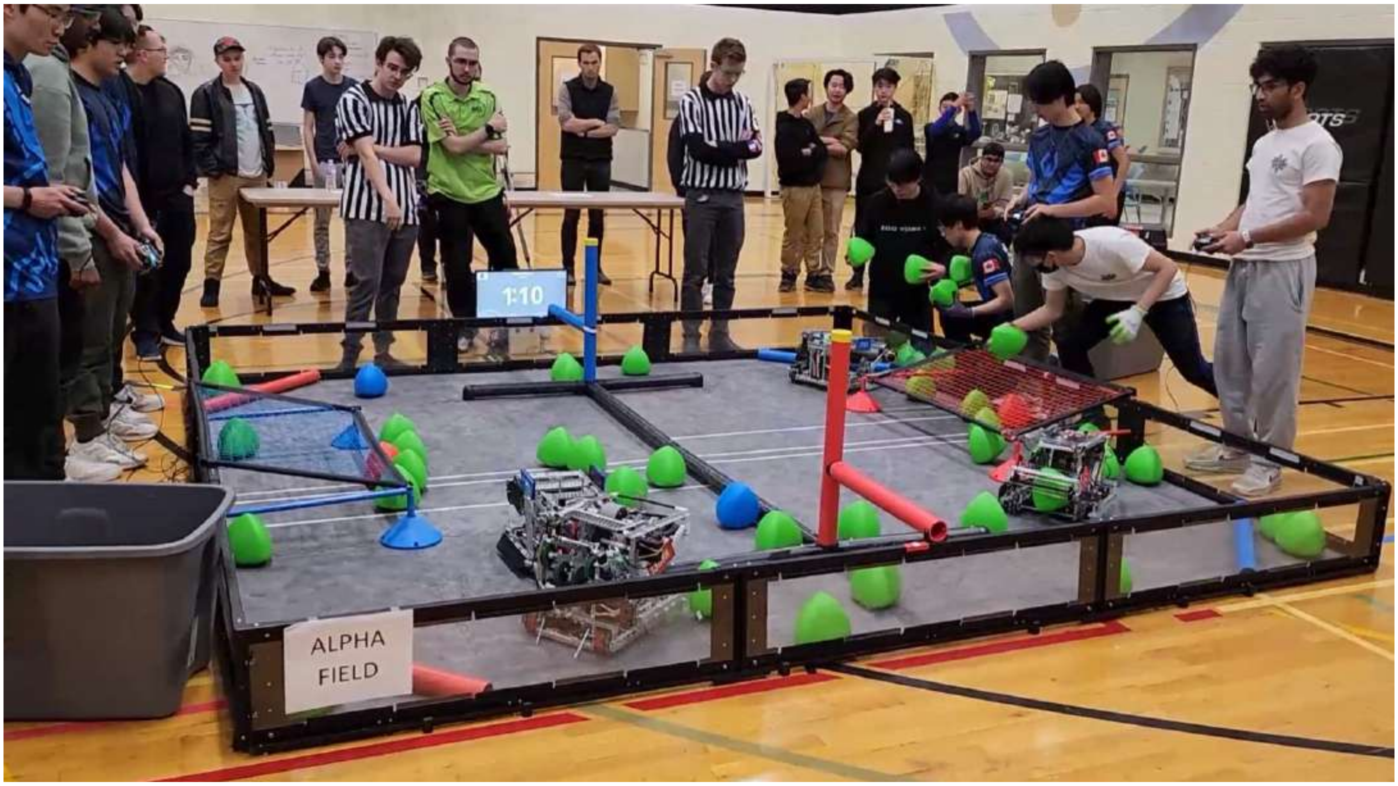
Witnessed by: Darien Ng

Edmonton Tourney - Match Analysis

2023-12-06

Finals 1

- After making it to finals, we could really feel the pressure on us, especially when considering the time crunch we had been on in the previous week. As for the game, it went fairly smooth for both alliances. We were both able to get roughly an equal amount of Triballs on either side. After pushing the Triballs in, we had a slight advantage with us having a couple more Triballs than the opposing alliance. However, disaster struck as our driver realized that our lift mechanism had broken, and that there was no longer a possibility of us elevating. This, as well as the fact that the opposing alliance was able to elevate and had won autonomous, caused us to lose by a small margin of 87-100, despite us having more Triballs scored.



Example of both alliances having roughly an equal amount of Triballs on either side

Designed by:

Oliver Liu

Witnessed by:

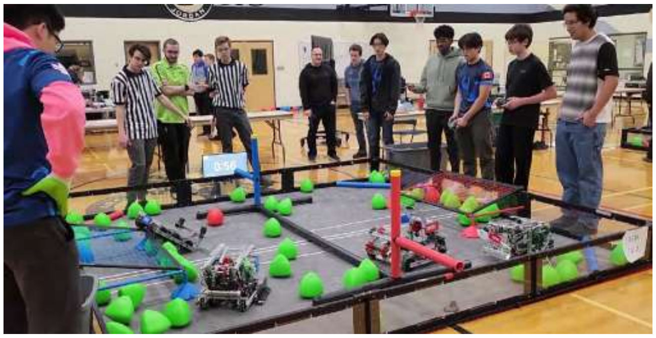
Darien Ng

Edmonton - What We Learned

2023-12-06

For our first tournament of the season, we learned multiple important things to consider for future tournaments.

1. **Double-checking everything is prepared**
   - Going into this tournament, we prepared a checklist to help us prepare before a match. This included things like pumping air, tightening screws, replacing rubber bands, etc. One thing we learned was to be more diligent and careful when going through this checklist. The biggest example of this was during our semifinals match, as we had forgotten to add our lift bands for our elevation, causing us to almost lose the match. If we had not forgotten and successfully elevated, we would have gained 20 points, creating a score of 104-64, a much more comfortable position to be in rather than 84-64.
2. **Ensure components are working properly**
   - This point was clearly demonstrated by our radio issues. During the tournament, over half of our matches had some issues with our radio, causing us to lose some because of it. Checking the radio before matches was not something we had considered, and if we had caught on sooner, we would be able to replace the radio immediately. However, other teams reported field issues concerning disconnects, but it appeared that most of our connectivity issues were with our faulty radio.
3. **Ensure mechanisms are unlikely to fail**
   - In Qualification 18, our chain for our intake snapped, and in finals, our lift was bent, preventing us from elevating. After the tournament, we believed the intake failed due to poor spacing allowing the sprockets to wiggle, causing the chain to shear off if the intake is hit. For the lift, we believed that it was not strengthened enough, and by adding a couple of braces, we would prevent this issue from happening. From this, we learned to ensure that our robot mechanisms were consistent and strong to help prevent a situation like this in the future.



Example of our intake chain falling off (bottom) during Qualification 18

Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Edmonton - Strategies

2023-12-06

During this tournament in Edmonton, another thing we wanted to look over was our strategy. Due to time, we were unable to effectively develop a strategy or get enough practice to execute these strategies. The following are some points we brainstormed that would improve our strategy:

- **Utilizing wings more often**
  - Wings are mainly used when a large cluster of Triballs are in front of the net, allowing our bot to cover more area and therefore push more Triballs in. However, after reviewing some footage, we felt that we weren't using our wings enough, especially since we always had plenty of air in our tanks after every match. Another point we considered was using our wings to push Triballs over the barrier. During some matches, we thought that we could push opposing match loads over the barrier to our offensive zone, which would both take away Triballs from the opponent while giving our alliance more Triballs to work with.

- **Using our blocker**
  - Since our flywheel on our lift was so dominant during this tournament, oftentimes we would find ourselves match loading while our opponent blocked, preventing us from fully utilizing our blocker. However, in some cases such as our flywheel breaking during semifinals, we realized the power that our blocker on a lift can provide, towering over the opposing bot, preventing them from matchloading.

- **Practicing**
  - Although this is a fairly straightforward and obvious tip, it has a large influence in determining the outcome of each match. For example, our drive team was fairly inexperienced with match loading due to time restraints, causing many match loads to fail crossing the barrier, allowing for the opposing alliance to score. Missing a single match load can cause up to a 10 point differential, 5 for the opponent scoring and 5 points lost due to our alliance being unable to score. If we were able to get some more practice in, we felt that many of the closer matches would have swung in our favor.

Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Edmonton - Strategies

2023-12-06

- **Adapting to opponent's play**
  - This tip was especially applicable in the case of our shooter. For example, adjusting the arch of our shots or the direction of our flywheel can allow us to shoot over blockers. Furthermore, if we see the opponent trying to block us on their half, we could try to put more power in our shots or delay our match loads for later. During Edmonton, our team felt that if we implemented this tip, it would give us a large advantage, even if it meant scoring a couple of extra Triballs that the opposing alliance would have otherwise scored.

- **Disrupting opponent's from scoring by playing defense**
  - During this tournament, a couple of matches were lost due to the opponent's stronger grouping of their match loads. We theorized that a combination of wings and wedges would be able to scatter opposing Triballs and potentially push them to our offensive side. In Edmonton, we rarely ever found ourself playing defense. We believed that if we were able to take opposing Triballs and score them, it would provide us with an easier time.

- **Using a hanging mechanism**
  - During Edmonton, we noticed that very few teams were capable of elevating during the end of the match. Since points scored from this is relative, teams with hanging mechanisms were able to add an additional 20 points within seconds. From this tournament, we saw the importance if hanging, and how it could swing a match in seconds. This was especially applicable during finals, as if we were able to hang, we would have won by a small margin.

The tips mentioned were the main takeaways we got from improving our strategy during this tournament. Looking back, our team felt that if we are able to successfully implement these strategies for future tournaments, it will drastically improve our team's competitiveness.

Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Edmonton - Strategies

2023-12-06

In addition to what we learned in terms of strategy, there were also multiple strategies that we thought we executed fairly well that helped increased our performance. Some strategies we liked during this tournament were:

- **Communicating with our alliance partner before matches**
    - Being able to easily communicate with our alliance partners before matches gave us a significant advantage before the match even started. We were able to pinpoint our strengths and weaknesses, and develop a strategy that allowed us to use both of our bots to its full potential. For example, one of our partners during qualifications told us that due to their bot's low height, it was able to wedge underneath opposing bots and push them. Therefore, we decided that it was best for them to play defense, while we played offense with our flywheel and wings.
    - Communication also helped us gain a stronger understanding on the other team's bots. This would prove to be extremely helpful in alliance selection and for developing a strategy to exploit the opponent's weaknesses.

- **Match loading**
    - Despite our team not having much experience with our flywheel, we found that this strategy was undoubtedly the most efficient way of scoring Triballs. During the tournament, we often found that teams with faster and more consistent shooting mechanisms performed much stronger than teams that did not. We thought that if we were able to practice more, our scoring potential would heavily increase.

- **Offense**
    - During the tournament, we rarely found any issues with our wings, wedges, and drivetrain. This combination allowed us to easily score multiple Triballs at once and help stop opposing defenders. During the end of a match, we usually found our half to be nearly empty of unscored Triballs, proving that these designs were effective in playing offense.

Designed by:

Oliver Liu

Witnessed by:

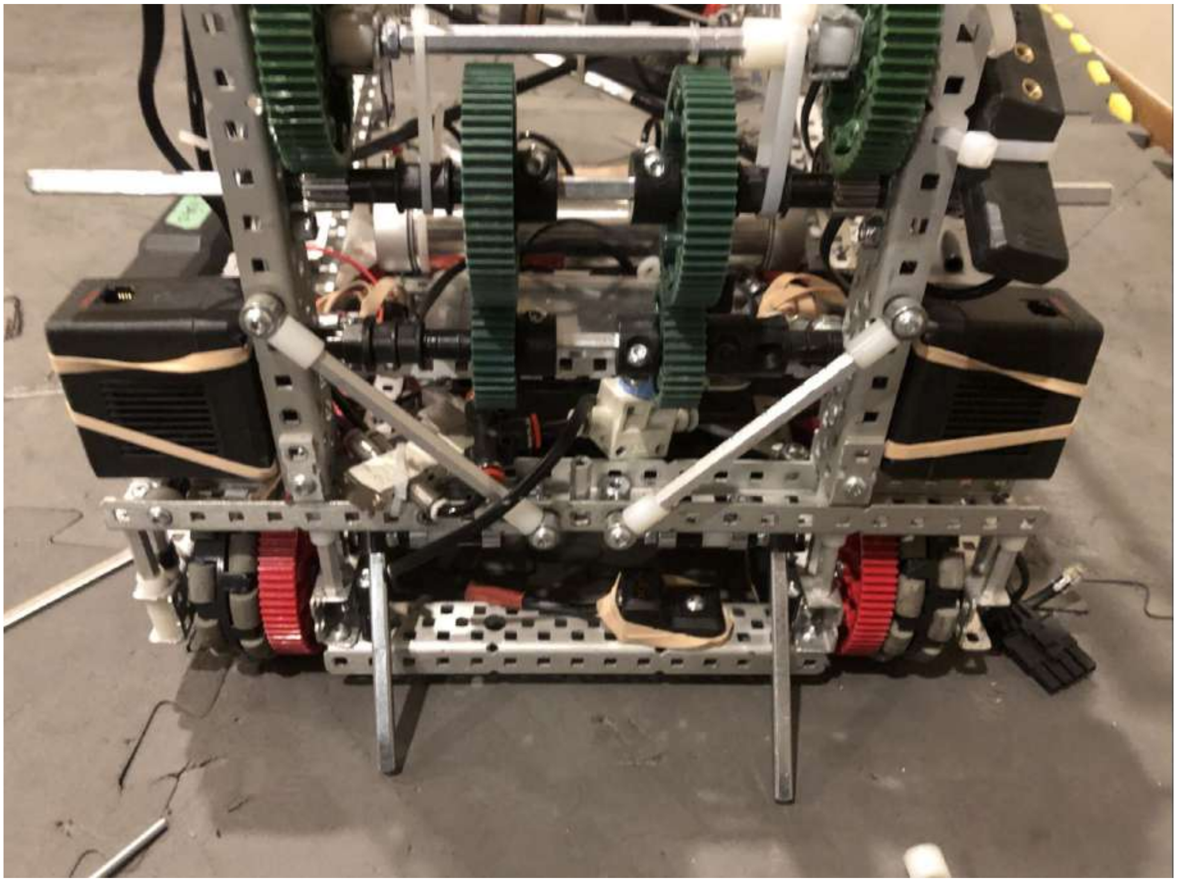
Austin Ma

Lift Redesign

2023/12/04

Because our lift had poor performance compared to other parts of our robot during the tournament in Edmonton, we are going to be making some redesigns to the lift.

One of the main problems that we have is that the power output of the lift is just a bit too small to reliable get the robot off the ground, especially after a full round of Over Under since the batteries will have less output at the end of the game than at the start, even when we are charging them between matches. Our solution to this is to move one of the flywheel motors to powering the lift. This will effectively double our lift power, allowing us to better lift the bot off the ground during elevation, while not sacrificing too much speed on the flywheel since the acceleration of that is quite fast anyway. We are also putting beating flats on the axles on the lift to reduce friction and increase the efficiency of our lift.



The two motors can be seen in the image above.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

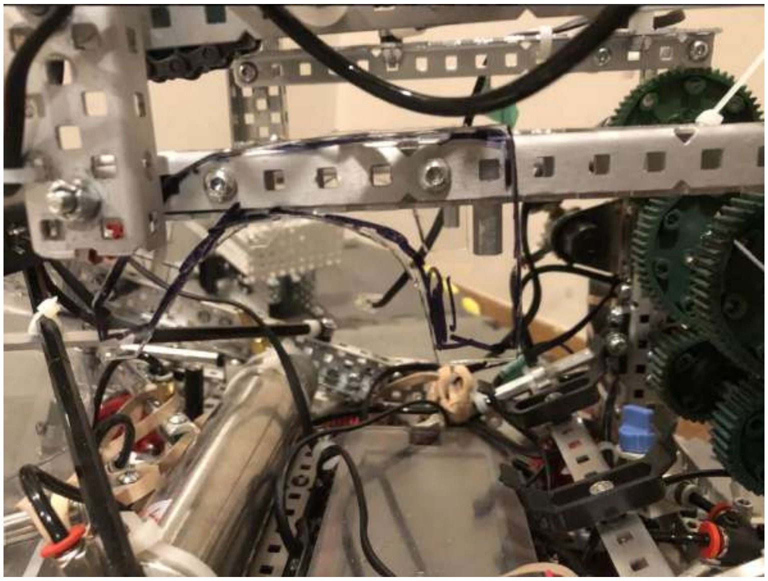
Lift Redesign Continued

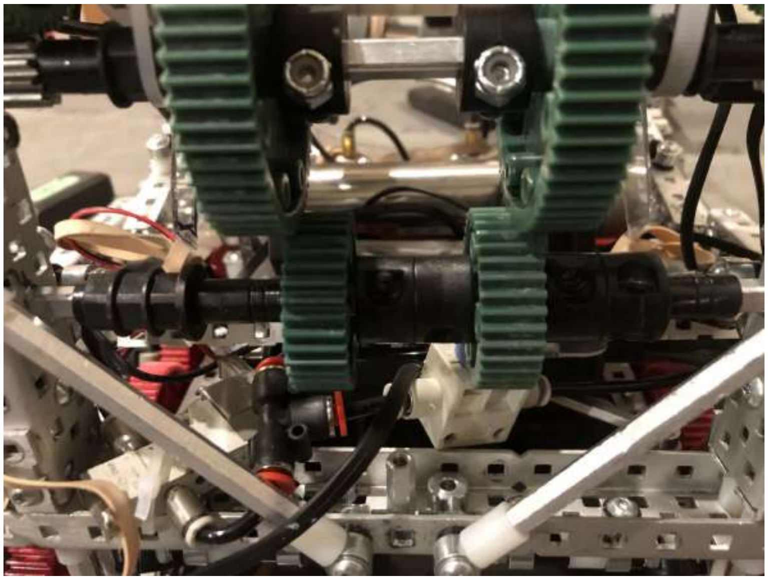
2023/12/04

We also need to ensure that the lift stays on the elevation bars securely even after the game ends and power is cut. Thus, we are using rubber bands as part of our lift. This will help ensure that the lift is securely grabbed onto the elevation bars, even after power is cut since the rubber bands provide a constant elastic restoring force to help pull the bot up towards the elevation bar.

Another problem is that the lift is poorly braced and many components are under a lot of stress. This resulted in some damage being done to the gears within the lift. There was also some skipping in the gears. Our solution to this is to increase the bracing between the two sides of the lift, preventing bending and and damage to the lift. We also noticed that our gears on the lift were not perfectly aligned, which is illustrated in the picture at the bottom right. This misalignment means that there was an unequal force acting on different parts of the gear, increasing stress. Because our gears also sustained damage, we have chosen to also replace the gears and align them better with spacers this time. We have also put a standoff across the top gears to prevent skipping and used high strength axles for the lower gears to reduce stress and possible bending of the axle.

The final thing for our lift is to place some lexan along the bar that contacts the elevation bar. This will help keep consistency in which part of the bot is contacting the elevation bar, and can also be modified for best performance of our lift. This can be seen in the image at the bottom left.





Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Flipout Claw

2023/12/06

Reflecting on our performance at Edmonton, we have noticed that getting pushed while shooting matchloads happens quite frequently. To combat this, we have built a flipout flaw to “hook” onto the matchload bar. This ensures that there is a part of our robot that is in the matchload zone at all times, allowing us to freely matchload without fear of accidentally violating any rules. This flipout claw will also function as a mechanism to get the triball out of the matchload zone during the autonomous period, pushing us towards an autonomous win point.

This mechanism will be built on the back right corner of our robot, and consists of a 15 long c-channel and a standoff. The standoff will be the main part contacting the triball and will help push it out of the matchloading zone during the autonomous period.

Designed by:

Darien Ng

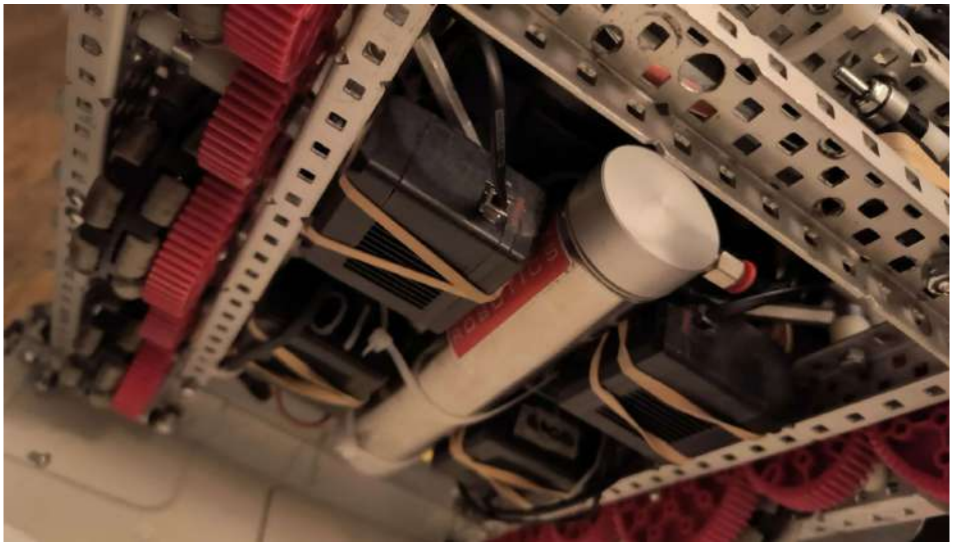
Witnessed by:

Matthew Zhang

Battery and Reservoir Placement

2023/12/07

We moved the battery and the air reservoir on our robot to lower the center of gravity so that it is closer to the ground. This helps increase our stability on the field, reduces the chance of rollovers, and also makes our hanging mechanism more stable as we will not tip over while hanging on the elevation bar, keeping us on the bar itself. We also noticed that the lower center of gravity and more stability helped us reach elevation tier B, while we were previously at elevation tier A. The new placements are shown in the images below.



The air reservoir is now at the bottom of our drivetrain just barely above the floor and the battery is now located right behind the brain. Since these are very heavy parts, having them at the base of our robot moves the center of gravity significantly towards the bottom of the robot.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Robot Testing

2023/12/07

Today we tested our robot on the field once again. Because of the upcoming tournament, we have tested all aspects of our robot. Some key points from our testing will be discussed below.

Firstly, we tested our flywheel with matchloads in a skills match scenario. We noticed that the flywheel was quite weak, and we were matchloading too quickly after changing the power to just one motor. Upon further inspection, we noticed that the axles holding our flywheel up were slightly bent, which caused excessive friction on the entire system, so we replaced the axle and it seemed to work better. We also opted to reduce our matchloading speed to ensure that the lost momentum of the flywheel can be recovered before loading the next triball into the system.

We also noticed that the distribution and spread of our matchloaded triballs is quite high, with around a third of them staying in our side of the field. This will prove disadvantageous and we have decided to use the walls to push the triballs onto our offensive zone after matchloading some of the triballs.

We also noticed that our walls can be used to help keep our robot touching the matchloading bar which allows us to matchload without fear of being pushed away. It also allows us to aim the flywheel at angles we previously weren't able to aim at, which is good.

Designed by:

Darien Ng

Witnessed by:

Austin Ma

Match Analysis - Bowness

2023/12/14

Qualifier #8

For this match, we lost track of time and were quite late and rushing to the match. This led to us being underprepared to compete, and our planning was lacking. This was reflected in our gameplay and we found ourselves getting stuck as our wedges got caught on the mats. Our opponents were also to descore our entire net while our alliance member was trying to get us moving again. We lost this match 84 to 105.

Qualifier #10

Again, with the short amount of time available, we weren’t able to do too much. However, we were able to get some things organized quickly such as discussing a strategy with our teammate, and being more perceptive of the field. We got a lot more triballs across and into the goals, leading to a win with a score of 118.

Qualifier #18

This was one of our best matches in the entire event and the highest scoring match of the event with a final score of 166. We were paired up with one of the best teams and we were able to matchload all of or triballs very quickly and efficiently, as we had a lot of time to plan ahead.

Qualifier #22

This match also went quite well for us, and all our mechanisms ran smoothly, leading to a win. Matchloading was slightly sloppy but we were able to recover quite well. We won with a score of 145 to 121.

Qualifier #25

In this match, we got stuck again and like before, our teammate came in to help us, but we double zoned in the process. Thus, our opponents were able to descore massive amounts of triballs from our goal, leading to an overall loss even with our elevation. The final score was 101 to 110

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Match Analysis - Bowness

2023/12/15

Quarter Finals

For the elimination portion of this event, we were paired up with the team 210F. For the quarter finals, we did quite well and got a plan established for all our other matches. We did a good job matchloading and we got all the triballs across quickly.

Semi Finals

This match was an intense one, and the final result was much closer than before, as we were put up against better teams. We still did a good job matchloading and our alliance member did a great job pushing the triballs into the goal. We were also able to elevate quickly and won.

Finals

This was our most intense match as we were up against the strongest teams in the event. We were able to win autonomous by a small margin, we got the triballs across the field quickly, and our driving was very good in terms of blocking. In the end, we won from the elevation points with a final score of 143 to 130

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Bowness - Strategies/What we Learned

2023/12/15

Because many of the strategies used by teams remained the same, refer to the information on the Edmonton tourney on pages 94 to 97 for information on what we learned and the strategies that we have to adapt better to. We did notice that we had significantly better defensive play, as we were able to stop many of our opponents from scoring massive amounts of triballs into the goal. This was done both by ramming our opponents and quickly pushing any triballs back into our offensive zone.

Quick thinking

Something new that we have to continue working on is making sure that we are able to think quickly and on the fly, as we had to make some very quick repairs or runs to get new parts at times. However, we believe that this will improve as we continue going to further events as there will definitely be more unexpected things that come up in the future where we have to fix quickly.

Double Zoning

Another thing that we also have to address is double zoning and our wedges, as it led to 2 losses at Bowness. During both matches, the wedges got caught on the floor, our opponent came to help, and we got massively descored from the other team. The primary solution for this is to fix our wedges and make sure that they don't go so low as to hit the floor. Another way to solve this issue for any other instances of double zoning is to scout out our opposing teams to make sure they cant fit into the goal and if they can, to make sure we communicate with our alliance partner to prevent any moments of double zoning.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Tournament Analysis - STEM

2023-12-20

The following table from Vex VIA shows our matches and results throughout the tournament on December 16, 2023.

Match	Red Alliance	Red Score	Blue Score	Blue Alliance
Qualification				
Q 5 10:47 AM	3300G 5760A	25	163	3388H 3388C
Q 14 11:42 AM	6659B 3300F	50	108	5760G 3388H
Q 20 12:15 PM	6659E 3388H	99	104	6659A 210F
Q 24 1:19 PM	2088C 3388H	117	90	210T 3388Z
Q 32 2:06 PM	2088K 2088S	84	105	3388H 5760H
Q 39 2:45 PM	3388H 3388A	165	50	45519B 45519C
Quarterfinals				
QF 1-1 5:30 PM	3388A 3388H	174	22	5760E 45519B
Semifinals				
SF 1-1 6:03 PM	3388A 3388H	158	59	3388B 210F
Finals				
F 1 6:24 PM	3388A 3388H	0	110	210T 210Z

We felt that we did fairly well during this tournament. Many of our subsystems worked as intended without issues, match loading and driving was quite smooth, and our time management was much better compared to our previous two tournaments. In addition to this, we were able to make it to finals and win the design award.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

STEM Tourney - Match Analysis

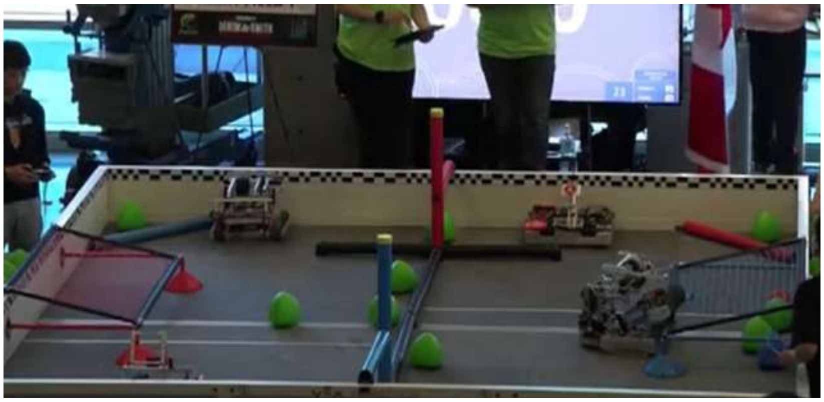
2023-12-20

Qualification 5

- This qualification match was our first match in the tournament, as they did not provide us with practice matches. However, since we had been tweaking and refining our bot over the past few weeks, we felt pretty comfortable with our bot. This match went extremely well for us. To start, our autonomous worked just as intended, scoring 3 Triballs. During the match, we were able to successfully match load without facing much resistance, and as a bonus, our grouping was fairly consistent. Although our teammate and one of the other opposing bots were stuck, we were able to use our wings to score every Triball was the last opposing bot attempted to defend us. Our scoring paired with our hang mechanism allowed us to win 25-163. At the end of them match, however, our bot slipped after the game due to a lack of rubber bands, causing us to fall from B tier to A tier. Although this did not affect the score of the match, it was something to consider when going into future games.

Qualification 14

- Although this match did not go as smoothly as the previous one, we were still able to decisively win. Our auton was only able to score the alliance Triball and failed to score the 2 extra Triballs. This issue would persist for the rest of the tournament, as every auton after this failed to work as intended. Regardless, we were able to match lad all 22 Triballs with most of them landing on our offensive end. However, due to the opponent attempting to block them on the other end, our grouping was much worse than before. Due to the amount of Triballs match loaded, we went on the offensive, scoring each Triball one by one. In the end game, we were able to successfully hang, ending the game in a 50-108 win.



Example of our autonomous scoring 1 alliance Triball and 2 Triballs in our net in Qualification 5

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

STEM Tourney - Match Analysis

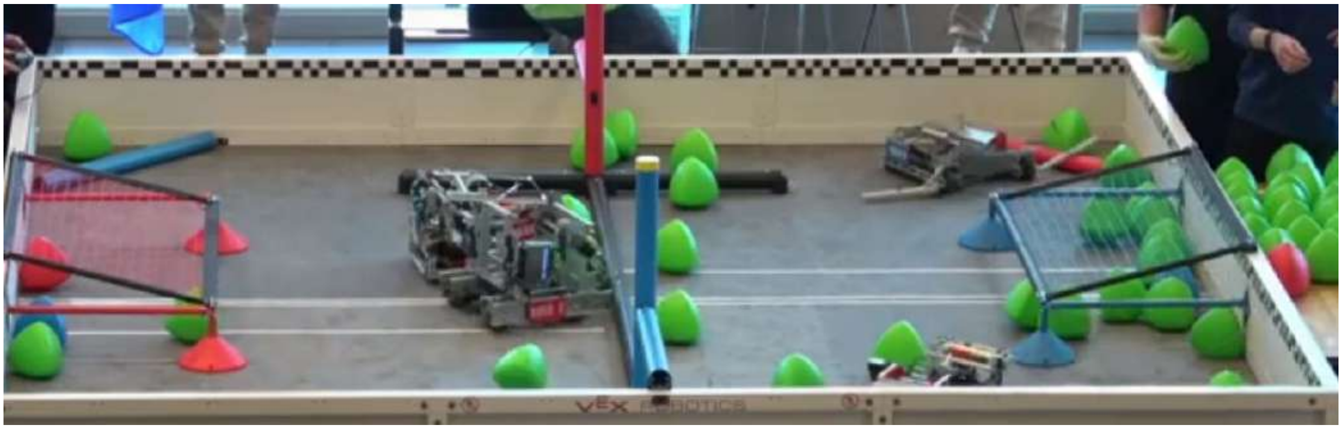
2023-12-20

Qualification 20

- When we started the match, our auton was able to run. However, when driver control began, we found that our radio disconnected on us. We began frantically restarting the programs and controller, and was able to regain control with 1 minute remaining. With a limited amount of time left, we began quickly match loading and scoring every Triball we could to make up the difference in an attempt to come back. With the opponent already finished match loading and beginning to score the match loaded Triballs, our chances of winning seemed bleak. Despite our efforts, we lost 99-104 even after considering our elevation points during the end game.

Qualification 24

- After the autonomous period, we decided to continue match loading, as this strategy was worked extremely well in the previous games and tournaments. However, one of the opposing bots had a tall blocker that was able to deny our shots despite our lifted shooter. Therefore, we decided on scoring the Triballs on the field rather than match loading, as the blocked shots would benefit the opposing team. Toward the end of the match, one bot from both alliances attempted to hang. Although our hang was able to elevate successfully, a hanging zip tie on the opposing bot touched the ground, causing them to fail elevation. Because of this, even though it was a close game, we were able to win by 27 points in a 117-90 win.



Difference of Triballs scored after 1 minute in Qualification 20. Due to radio issues, we started the game far behind.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

STEM Tourney - Match Analysis

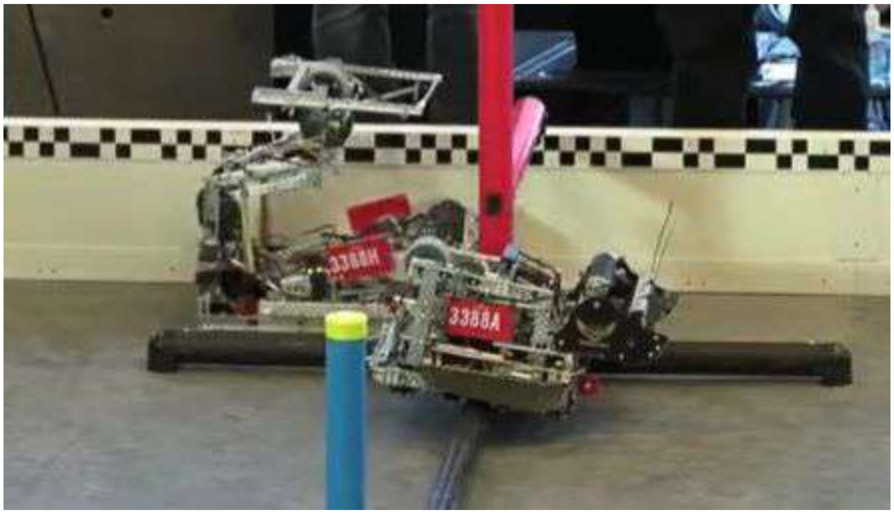
2023-12-20

Qualification 32

- Prior to this match, we tried fixing the autonomous code while waiting for our next qualification. However, we believe there was an issue while uploading the code, mixing up our defensive and offensive auton codes. Because of this, we ran the wrong code on the wrong side, causing our auton to fail. After auton, we were still able to match load and score effectively with our flywheel, wings, and intake, completely filling our net with Triballs. During the end game with around 20 seconds left, we began to drive to our elevation bar. But, due to the opponent stopping us from reaching the bar, we had to drive around the field to come from the other side. Regardless, due to a limited amount of time and multiple bots blocking our path, we ran out of time before we could elevate. Due to our match loading and scoring, we still won 84-105.

Qualification 39

- Unlike all of our previous matches, our alliance partner was in charge of match loading while we scored these match loads. Thanks to strong grouping and quick match loading from our teammates paired with our intake and wings, we were able to score very effectively. During the end game however, although our alliance partner was able to elevate by balancing on the barrier while touching the vertical pole, we found that our lift refused to elevate high enough for us to hang on the horizontal bar. Later, we discovered that this issue was likely caused by a wire jamming the gears connected to our lift, preventing it from fully lifting. Regardless, we still won at a comfortable score of 165-50.



Example of our lift failing to elevate due to a jammed wire.

Designed by: Oliver Liu

Witnessed by: Matthew Zhang

STEM Tourney - Match Analysis

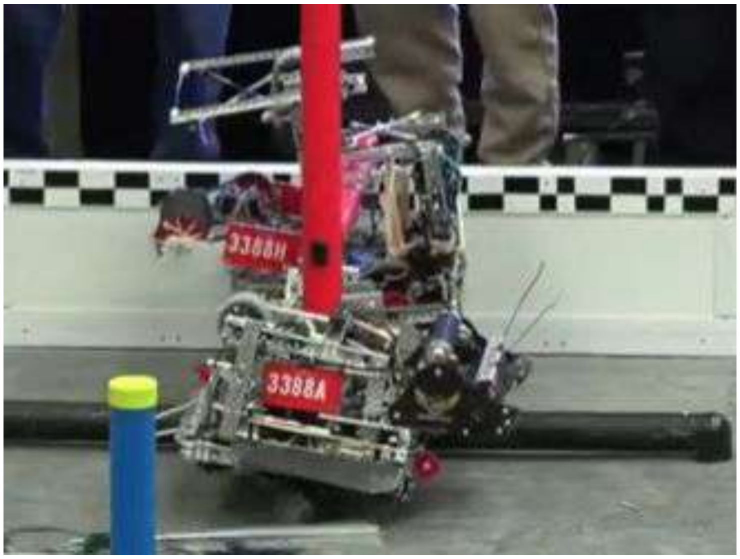
2023-12-20

Quarterfinals 1-1

- During the elimination segment of the tournament, we began discussing strategies with our alliance partner. One idea they came up with was a strategy called “tunnelling”. Tunnelling consists of match loading underneath the nearest elevation bar rather than shooting the Triballs over the barrier. When a group of Triballs has formed, the match loading bot will go underneath the barrier, pushing the Triballs along with it. For our first elimination match, we decided to test this strategy out. We found this strategy to be quite effective, as we didn’t need to worry about grouping and speed was increased. As our teammate match loaded, we were in charge of playing defense by blocking opposing match loads. During this time, both of our bots were able to flip the opposing two bots. This, along with our double hang, allowed us to win with a score of 174-22.

Semifinals 1-1

- When driver control began, we found that, like in Qualification 20, our radio disconnected. As we began trying to restart the controller, our teammate continued to tunnel and score for our alliance, while the opposing alliance began to match load and score as well. After around a minute, we were able to regain control of our bot, and attempted to disrupt opposing bots and score a few. At the end, we were also narrowly able to double hang, scoring an extra 40 points for our team, letting us win 158-59.



Example of both alliance bots elevating in Quarterfinal 1-1

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

STEM Tourney - Match Analysis

2023-12-20

Finals 1

- Our finals match was, understandably, the most carefully planned out match we had this tournament. To start, we analyzed the two opposing bots we would go up against in order to find weaknesses we could exploit. We found that only one bot was capable of consistently hanging, both opposing bots had blockers, and only one could consistently match load. We knew that the opponents would use their blockers to deny our shots and so we decided that our alliance partner would tunnel once again, as the Triballs only need to land underneath the elevation bar for the strategy to work. During this time, we would use our blocker to stop opposing match loads and score pushed Triballs. Near the end of the match, we would double hang to be able to score an extra 40 points. When driver control began, we were surprised that both opposing bots were attempting to block our teammate from tunnelling. With limited Triballs on the field, we found ourselves struggling to effectively and quickly score. However, during the match loading period for our teammates, they continued to match load even when the bot was not touching the match load bar. Although our tunnel was semi-successful and we were able to double hang, we were disqualified, as the score of 120-110 was not large enough of a gap for the illegal match loads to be justified.

Example of both opposing bots preventing our alliance partner from match loading

STEM Tourney - What we Learned

2023-12-20

Although we felt that we did fairly well in this tournament in terms of functionality, we still learned multiple lessons from this tournament.

1. **Tuning systems in advance before a competition**
    - An example of this point is our elevation mechanism. Before the tournament, we wanted to climb to at least B tier with our hang. Due to our center of gravity, however, our bot kept tipping forward before it could climb high enough, causing it to fall down. To fix this, we began lightening the front of our bot, such as replacing our flex wheel intake with rubber bands, as well as moving parts closer towards the back, such as our pneumatic tank. Even with these improvements, our bot was barely able to climb to B tier when positioned properly, and still carried the risk of tipping over if the lift extended too far. We felt that if we had been able to tune our elevation, it would perform a lot better due to its consistency.
2. **Improving our autonomous**
    - During this tournament, our autonomous only ever worked as intended once. Most of the time, it was only ever able to get 1 Triball in rather than 3 for our offensive side, and our defensive auton never touched the bar like it was supposed to. In addition, there were multiple times where we crossed the autonomous line since it wasn't tuned properly. We also believed that our routes for both sides were not optimized. For our defensive side auton, our bot ended by touching the elevation bar, which we didn't find useful currently because we did not have a way to descore the Triball from the match load area, and so we couldn't win the autonomous win point. For our offensive side, it is coded to push in the pre-loaded alliance Triball and then go for the two Triballs in the middle. However, we often found that when the bot would turn, it would knock the Triballs out of place, preventing our bot from scoring them. If we had been able to code a better route and tune it properly, we felt that this would allow us to win some of the games we lost in this tournament.
3. **Improving match loading**
    - Although we had much more match loading practice than the previous two tournaments, factors such as changing our driver and having a limited number of people attending the tournament made our match loading inconsistent. Additionally, we began reconsidering the idea of a match loader. This fact was made clear in our finals match, when the opposing alliance rarely match loaded but instead blocked our Triballs to use against us. Since blockers are becoming fairly common, we wondered if we should even use our match loads or if we should change our design to counter this.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

STEM Tourney - Strategies

2023-12-20

As well as improvements in our strategy for this tournament, we also felt that we had developed some strong ideas that increased our performance, which includes:

- **Having a double hang**
  - During the elimination round, our alliance was capable of having a double hang, with one teammate hanging on the horizontal bar and the other balancing on the barrier while touching the vertical pole. We were able to successfully execute this strategy for each of our elimination matches, scoring us an additional 35-40 points. These points could completely swing the match, especially when considering that in later matches, both alliances refrained from match loading, decreasing the total number of points that can be scored.
- **Match loader grouping**
  - During some of the qualification matches, our grouping was extremely consistent, with a group of Triballs forming in front of the net. This not only makes it easier for us to score them, but it also makes it harder for opponents to disturb them without pushing a majority of them into the net. Grouping is also especially useful during skills runs as it increases the efficiency of each time we push the Triballs into the net, therefore increasing our total score.
- **Tunnelling**
  - Although this strategy can be volatile at times, we felt that, during our eliminations round, it benefitted us for the most part. One of the main reasons for tunnelling is its speed, since instead of needing to align the shot properly, we can just essentially drop the match loads onto the bot. In addition, by positioning ourselves closer to the nearest elevation bar, it makes it difficult for opposing bots to block shots, effectively ignoring their blocker.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

BotV2 Lightning

Bot V3 - Strategies

2023/12/24

After the STEM tourney and by watching some VEX signature events, most notably Sugar Rush, we have noticed a significant shift in the strategies of some teams.

Instead of getting all the triballs in play, many now opt to not matchload unless necessary. This starves the opponent from triballs, meaning that their opponent is unable to score well without introducing their own triballs. However, by not matchloading, an alliance can have their robots do other tasks, such as blocking. This effectively stops the opponents from matchloading and scoring points that way. Overall, its a low-scoring game where the goal is to make sure your opponents are unable to get the opportunity to score.

To follow this strategy, a fast-moving robot with good driver control is very much required, as it ensures that we are able to get to the triballs before our opponents can. With the low scoring potential of these types of games, elevation becomes very important, and getting a high lift is necessary; getting high centered on the barrier just won't do if we want to follow this strategy.

Surprisingly, this strategy counters itself, as good driving and a fast drivetrain is necessary in order to beat the other team to the triballs. There were some instances where we saw the opponents try to counter by matchloading quickly, but a lot of these triballs simply got pushed back across the barrier and straight into the goal as the opponents have a good chance of getting to the triballs faster in a 2v1 scenario.. This also happened to some extent during the final match of our STEM tournament, leading to a significant amount of points lost.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Bot V3 - Strategies

2023/12/24

After the STEM tourney, we believe that it is best for us to do a complete rebuild of our robot, as we have encountered some issues with our current one in terms of build quality and to adjust to new strategies such as tunneling. Before we start building our new robot, we have brainstormed some strategies and qualities that our robot should have that we should keep in mind when building.

- **Drivetrain**
    - Although our bot was fairly maneuverable during the STEM event, we have seen the importance of having a good drivetrain that has good agility. This allows us to better move around the obstacles in the field, such as the barriers and goals so that we can play more effectively in both offense and defence. However, we must not sacrifice our ability to push others and maintain a strong drivetrain. We have also seen that it is a huge advantage to be able to drive over the center barrier, and will design our drivetrain accordingly.
- **Climb**
    - At STEM, we have seen more teams be able to get off the ground at the end of the game. This makes it imperative for us to increase our elevation to the best of our ability in order to keep that edge over our opponents in the future. Since many teams are simply getting high centered on the central barrier, we should try to get a B tier climb or higher in order to stay ahead of them in future events. Low-scoring games also emphasize the need for a high climb at the end of the game.
- **Goal Scoring Methods**
    - We have noticed that our intake worked quite well during the STEM tournament. However, there is always room to improve, and to do this, we will be trying to improve the build quality while reducing weight of the intake system. We will also be testing some more designs to see which one works the best for our robot. These improvements will make our intake even more effective. Our walls also worked quite well during STEM, and the locking mechanism proved to be very effective in pushing large amounts of triballs across the field and into the goal. Similar to the intake, we will be working to improve the build quality of this system. In addition, we may also look at designs that have the walls flipping out from a vertical position, which will keep them more rigid.
- **Matchloading**
    - Throughout the events that we have participated in with this robot, we have noticed that the flywheel design worked quite well in getting triballs into our offensive zone and combined with the different points of the flywheel that we can matchload onto, provided a good amount of flexibility when it comes to overcoming opponent blockers.. Thus, we will most likely be sticking to this design for our next robot. A major thing for us to improve upon is the build quality, as we noticed that our flywheel lost a lot of speed after successive shots as the friction was quite high.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Drivetrain - Select and Plan

2023/12/24

Here, our goal is to look at the strategies and qualities that our robot's drivetrain should have and choose the design that works best for us.

With the strategies listed on the previous page, we have made a list of qualities that our drivetrain should have in order for us to implement our strategies effectively. These qualities are listed below.

- **Agility**
    - As mentioned in the previous page, having an agile robot is very important for us to be able to traverse the field effectively. In this sense, having an agile robot means being able to turn, accelerate, and move quickly. This allows us to move around the field's obstacles and move quickly towards anywhere that we need to go on the field.
- **Strength**
    - Throughout our past event, we have noticed that being able to push and play defence in this way is extremely important to a team's success in VEX Over Under. For us to be able to push other robots, there are two key qualities that our bot needs to have: high torque, and good traction. High torque is needed in order for our bot to be able to exert enough additional force to push other robots, and good traction is needed as well to prevent slippage of the wheels against the foam tiles.
- **Ability to move over the barrier**
    - This ties into agility, as it allows us to move across the field with ease. In this case, it allows us to move between the two sides of the field without having to go all the way around and under the elevation bars, where we could be blocked by opposing robots. We have noticed that good speed with a mechanism for the first wheel to overcome the barrier is the best way to achieve this, and we will be building accordingly.
- **Stability**
    - Pretty self explanatory, a stable drivetrain sets the basis for a good robot as it is essential in moving the robot around the field. Some key features needed are low center of gravity, bracing, and rigidity.

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Drivetrain - Select and Plan

2023/12/24

To help us decide between our different options, we will be using a matrix to list out the different qualities of different drivetrain designs. The numbers rank the options where the highest number is the best and the lowest number is the worst. These qualities are all included and describe in the previous page. It is important to note that as a school team, we are unable to have every part available to us in abundant quantities, and some options such as 2.75" wheels are not available to us.

Drivetrain designs:

	Agility	Strength	Moving over the Barrier	Stability
X drive	3	1	1	1
Tank drive	1	3	3	2
H drive	2	2	2	3

For the design, we have chosen the tank drive, as it has all the qualities that we need out of the drivetrain. The X drive really falls in moving over the barrier and stability, as it can be quite difficult to brace and the large gaps between the wheels make it easy to get high centered. The H drive is also a solid contender, but there can be times where the wheel in the middle can cause more harm than good. For example, it can make going over the barrier more risky. Although the tank drive placed last in agility, it is not far behind the others, and its simplicity is also a huge advantage. The tank drive has good strength as we are able to gain good traction, and its bracing can be made just as good as the H drive if a horizontal beam is added in the middle in addition to those that would normally be on the sides already.

Designed by:

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Witnessed by:

Oliver Liu

Drivetrain - Select and Plan

2023/12/24

Now that we have chosen a rough design, we will be choosing between the different wheel types and sizes. These will be assessed on speed, traction, moving over the barrier, and stability. ‘Stability’ in this sense relates to how easily it is pushed away by opposing robots. ‘Speed’ relates to linear speed but turning is also considered.

Wheel Types/Sizes

	Speed	Traction	Going over the barrier	Stability
3.25” omni wheels	3	1	4	3
4” omni wheels	4	2	3	2
4” traction wheels	2	3	2	1
3” flex wheels	1	4	1	4

In the end, we have chosen to go with the 3.25” omni wheels, even though the 4” omni wheels tied them in this table. There are a couple reasons why we chose this. Firstly, the center of mass is quite a bit lower on the 3.25 omni wheels, making it much more stable than the 4” wheels. In fact, there were instances where people with 4” wheels tipped over during the STEM event. The 3.25” wheels are also much better at going over the barrier, which the table and ranking system struggle to show. Although the 4” wheels beat them in terms of speed, the gearing can simply be changed to fix this issue, albeit with a bit of additional friction. As for traction, the 3.25” wheels have just a little less surface area touching the floor at a given time, but this isn’t significant and we have found the 3.25” wheels work well for us in all our past events.

Designed by:

Darien Ng

Witnessed by:

Austin Ma

Drivetrain - Select and Plan

2023/12/24

Gearing and RPM

During the STEM event, we found our robot's drivetrain to be slightly lacking in terms of power, so we have opted to use a 6 motor drivetrain for this robot. This allows us to get more power out of our drivetrain.

As for the gearing that we want to use and the RPM we will be running at, the relationship is fairly simple. The higher the RPM, the higher the speed. However, acceleration and torque are sacrificed for the additional speed. Because we noticed that our robot was moving a bit too slow for our liking during the past few events, we have opted for a 480 RPM drivetrain geared down from 600 RPM with a 4:5 gear ratio. This gives us a very fast speed of 6.81ft/s and with the 6 motors, we believe it will give us a good amount of power and acceleration as well. However, we will be continuing to test this to see if it may be too fast, as many other teams with 3.25" wheels are running at 400 RPM or lower.

Designed by:

Darien Ng

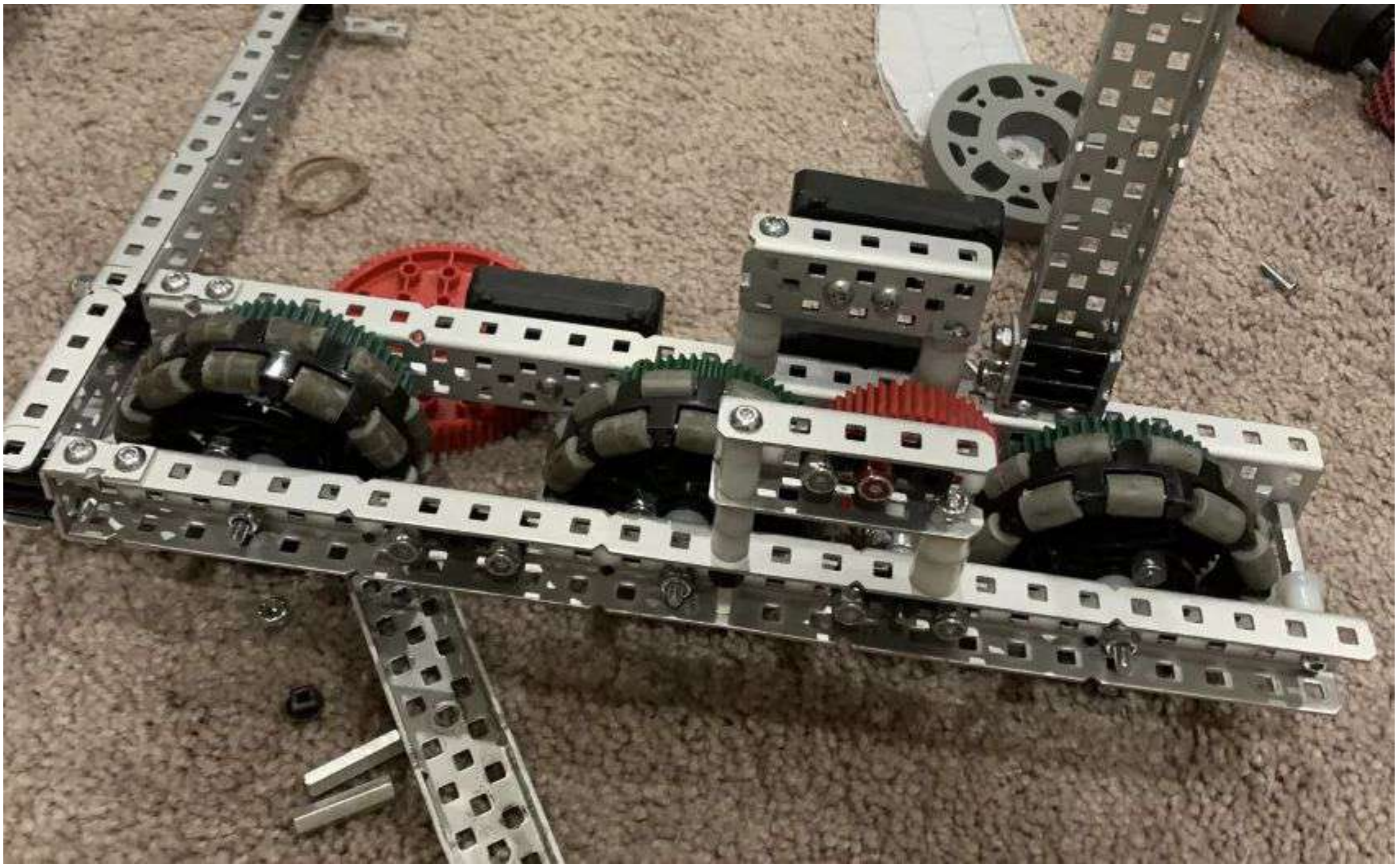
Witnessed by:

Austin Ma

Drivetrain - Building

2023/12/24

We built the drivetrain on a 26 long by 25 wide base made out of C channel. This drivetrain uses 6 3.25” omni wheels, as chosen in the previous few pages, and is a tank drive. We are currently running with blue cartridges and we are using a gear ratio of 4:5 to bring the RPM down to 480. Below is a picture of our drivetrain during construction.



The 3 motor caps can be seen in this image, and the top motor will simply be connected to the one right below it with a 48 tooth gear.

Designed by:

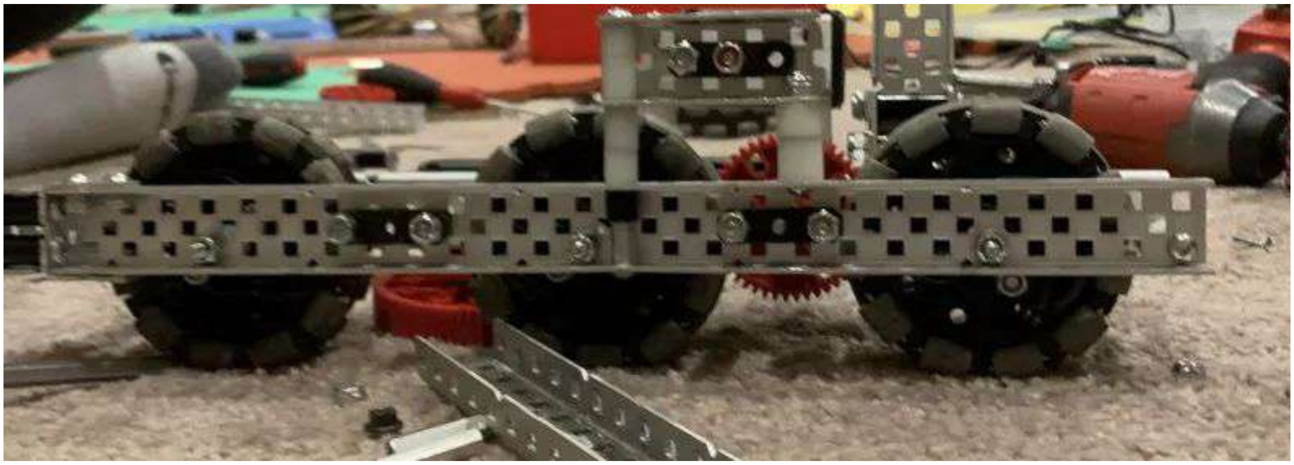
Darien Ng

Witnessed by:

Oliver Liu

Drivetrain - Building

2023/12/24



Above is a side picture of the drivetrain, showing where each wheel/axle is located. Instead of being on the center row of holes of the C channel, we have opted to put the wheels on the bottom. This allows the gearing to fit as well as giving us a little bit of extra room under the chassis to make it easier to drive over the central barrier in the field. We have also used screw joints instead of the regular axles for the wheels. This is because there is less wiggle room with screw joints than axles, allowing for a more effective drivetrain overall.

Designed by:

Darien Ng

Witnessed by:

Bolo Wang

Triball Delivery - Select and Plan

2023/12/28

Here, our goal is to brainstorm, select, and plan a mechanism to get matchloaded triballs into our offensive zone. Although the META is shifting to having less matchloads on the field and starving our opponents from points, opportunities to matchload and score large amounts of points through matchloading still come up, and it's important for us to be able to use these opportunities. For this reason, we will be implementing a mechanism that will allow for matchloading effectively onto our robot. There are a few qualities that such a system should have which we will keep in mind when planning and building. These qualities will be discussed below.

- **Weight / Size**
    - This is fairly self-explanatory. The weight of a system must be considered before we build it on the robot. This is especially important since we are also aiming to increase our agility around the field. Weight also affects how our lift can be designed, and the heavier the weight of our overall robot, the harder it gets to build an effective lift. Size applies in much the same way as weight.
- **Accuracy**
    - Accuracy is also vital in an effective triball delivery system as it allows for us to be able to reliably get the triballs into our offensive zone rather than score points for the opponent by having them land in our offensive zone. Good accuracy also results in a tight cluster of shots, which is good since we are able to push them into the goal all at once instead of one by one.
- **Power**
    - Power is very important in triball delivery mechanisms as enough energy has to be transferred to the triball in order for it to be able to make it to our offensive zone instead of falling short and landing in the opponents'.
- **Flexibility**
    - In this case, flexibility relates to the different ways in which we can matchload to result in the triball taking different trajectories. Flexibility is very important in such a system as we may not always get into an ideal position when matchloading, either from the opponent or from the obstacles present outside the field such as tables. (There was a table holding the matchloads and the entire field was elevated during the STEM event.) Flexibility allows us to give ourselves some wiggle room for these problems and makes sure that we can still matchload decently well.
- **Speed**
    - Having high speed is preferable to having a low speed, as we are able to get more triballs across in the same amount of time. This nets us more points in the time the opponent has to react to our plays.

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Triball Delivery - Select and Plan

2023/12/28

Similar to the drivetrain, we will be using a table to compare the different triball delivery mechanisms that we can implement on our robot. Again, they will be ranked relative to each other where 1 is the worst and 3 is the best. The basis of which they will be compared are all included in the previous page.

Different Triball Delivery Mechanisms

Mechanism	Weight / Size	Accuracy	Power	Flexibility	Speed
Flywheel	3	1	2	3	3
Kicker/ Puncher	2	3	1	2	2
Catapult	1	2	3	1	1

Between the three mechanisms, we are going to be choosing the flywheel. Although its weight is about the same as the others, its size is tiny. Its accuracy is not ideal, as it varies by how we put the matchloads onto it, but can be fixed with a good amount of practice. It also far surpasses the kicker and catapult in terms of flexibility and speed, as the flywheel is not limited by the time it takes to pull a large part back and the way in which we put matchloads on the flywheel can affect its trajectory. In addition to the reasons above, we also have good experience building flywheels, and as a result, we would be able to get a better build quality with flywheels than the other two options.

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Oliver Liu

Triball Delivery - Select and Plan

2023/12/28

Now that we have chosen to use the flywheel, there are a couple more details about the flywheel itself that we have to look at before building. This page aims to compare our different options, allowing us to choose the best one for our robot.

Size of the flex wheel

Firstly, we will be deciding on the size of the flex wheel that we want to use. With the parts available to us, we have two options: 3” or 4” flex wheels. Here, the larger the wheel, the more mass it has, which means it will have more momentum and will lose less momentum from shooting triballs but will take a longer time to accelerate. However, the increased momentum of the wheel is not too important, as even though it will lose less speed, a smaller wheel can be accelerated back to its maximum speed in the time it takes for us to grab triballs and load them. The larger flex wheels also take more time to accelerate and are heavier, so we will be using the 3” flex wheels for our mechanism.

Hardness of the flex wheel

The hardness of the flex wheel is also quite important, as it affects how well the triball is gripped by the flywheel. Softer flex wheels will have better grip, and harder ones will have less grip. More grip means more power, at the expense of the flywheel losing more momentum. Again, we are not too concerned with losing momentum since the motor can quickly accelerate it back up to its maximum speed, so we will be using the softest flex wheels to get more power out of our flywheel, as it allows us to get the triballs farther into our offensive zone, reducing the chance of it getting immediately pushed back.

Speed of the flywheel

The last major thing that we have to decide upon is the speed of the flywheel. Like all the other options discussed, there is a tradeoff to having a faster flywheel. Here, higher speeds will result in less torque. Less torque means slower acceleration, but we cannot sacrifice speed to the point where our matchloads can’t make it to our offensive zone. Out of the vast number of options available through different gear ratios, we have chosen to use a 600 RPM blue cartridge attached to a 5:1 gear ratio to run our flywheel at 3000 RPM. We believe that this speed gives us a good balance between power and acceleration on the flywheel, allowing us to matchload at quick speed while having the triballs make it to our offensive zone. This speed has also worked well for us for past events, so we are also more inclined to use it again, though we will be careful with testing to make sure it still works well.

Designed by:

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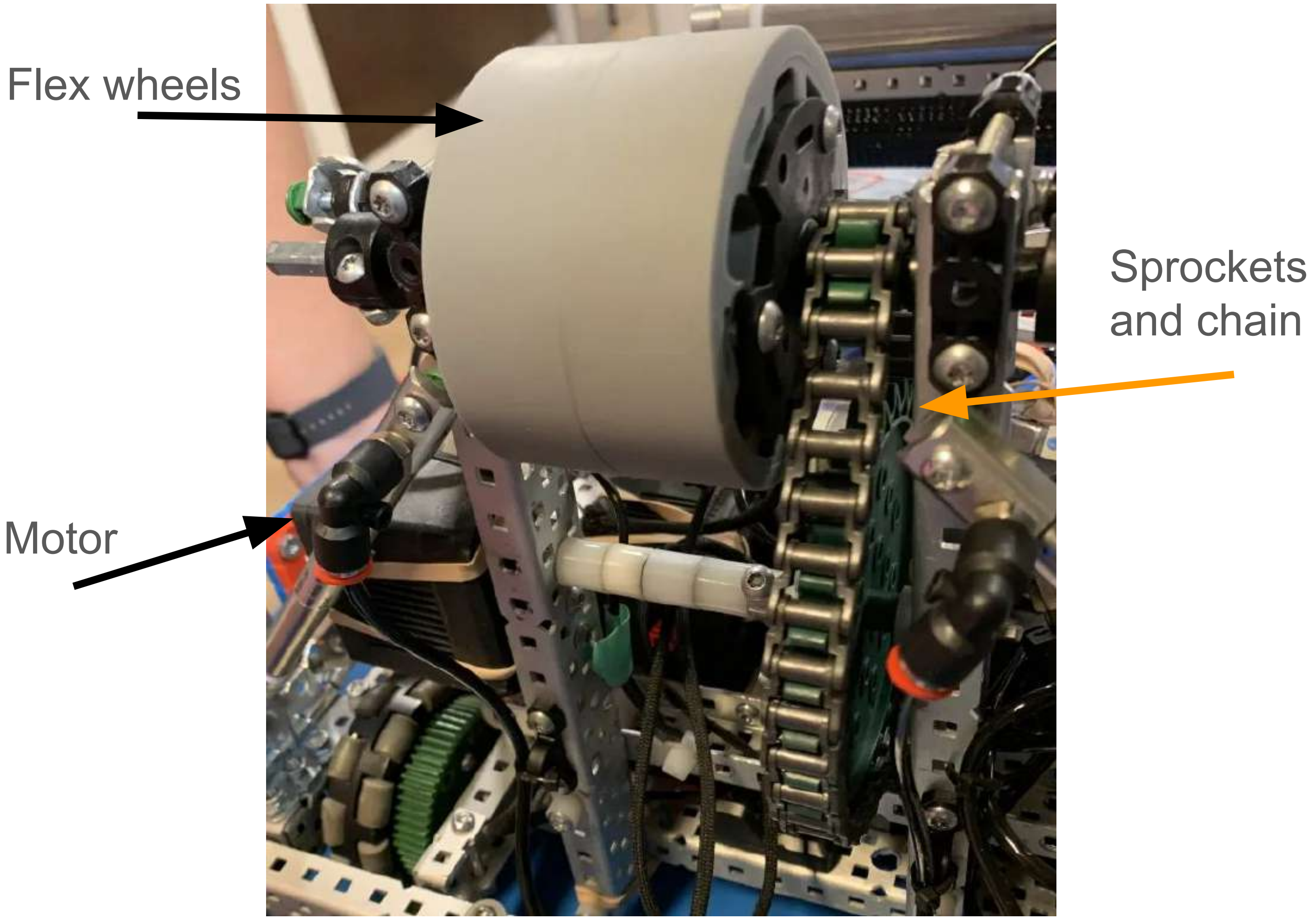
Witnessed by:

Matthew Zhang

Flywheel V1 - Building

2023/12/29

We are mounting our flywheel on a stationary C channel. Although other teams have high blockers, we believe that it is not worth it for us to build the flywheel on a lift, as it would add too much additional weight for the benefit that it gives us. As aforementioned in the plan, we are running the flywheel at 3000 RPM on a blue 600 RPM cartridge with a 5:1 gear ratio. We are also using the softest 3” flex wheels for the flywheel. A diagram of our flywheel can be seen below.



Note that chain is used instead of gears for our flywheel. This is because with our previous robot, and flywheels, we have noticed that gears have a lot of increased friction, wear, and will occasionally slip at these high speeds causing large RPM drops and making the flywheel take longer to accelerate, which loses valuable time in a match. Unlike gears, chains do not slip when there is sufficient tension between the sprockets, keeping our RPM more consistent and improving the flywheel’s efficiency.

Designed by:

Darien Ng

Witnessed by:

Bolo Wang

Wings - Select and Plan

2023/12/29

Our goal for this page is to decide between different designs for wings and to plan how we build the wings on our robot.

Wings are flipouts that act as walls when extended, allowing us to push large amounts of triballs into our offensive zone or goal at once, increasing our score.

Design

There are two possible designs that we can opt to use for our robot: vertical wings, and horizontal wings. The functionality for both are similar, but unlike the horizontal wings, the vertical wings do not need a locking mechanism. The vertical wings also have the added benefit of working as a descorer to get triballs out of the matchloading zones. This is helpful for getting the autonomous win point and helps us get more points by utilizing the triballs stuck in the matchload zone.

One thing we have to be careful about with the vertical wing design is making sure that we are still able to fit under the elevation bars in the barrier with the wings retracted. To ensure this, we will simply measure and cut the wings shorter as needed while still making them as long as possible for maximum efficiency when using them.

Since we are already utilizing all the motors we are allowed (6 on drivetrain, one on both the flywheel and the intake), we will be using pistons to power our wings. Pistons are also significantly better than motors for wings, since they provide a high amount of force in a quick amount of time, allowing us to open and close the wings quickly and effectively. Pistons also provide a simpler design, as it can be directly connected to the wings, whereas motors would require a system of gears and also a hardstop to make sure the wings don't overextend.

Designed by:

Darien Ng

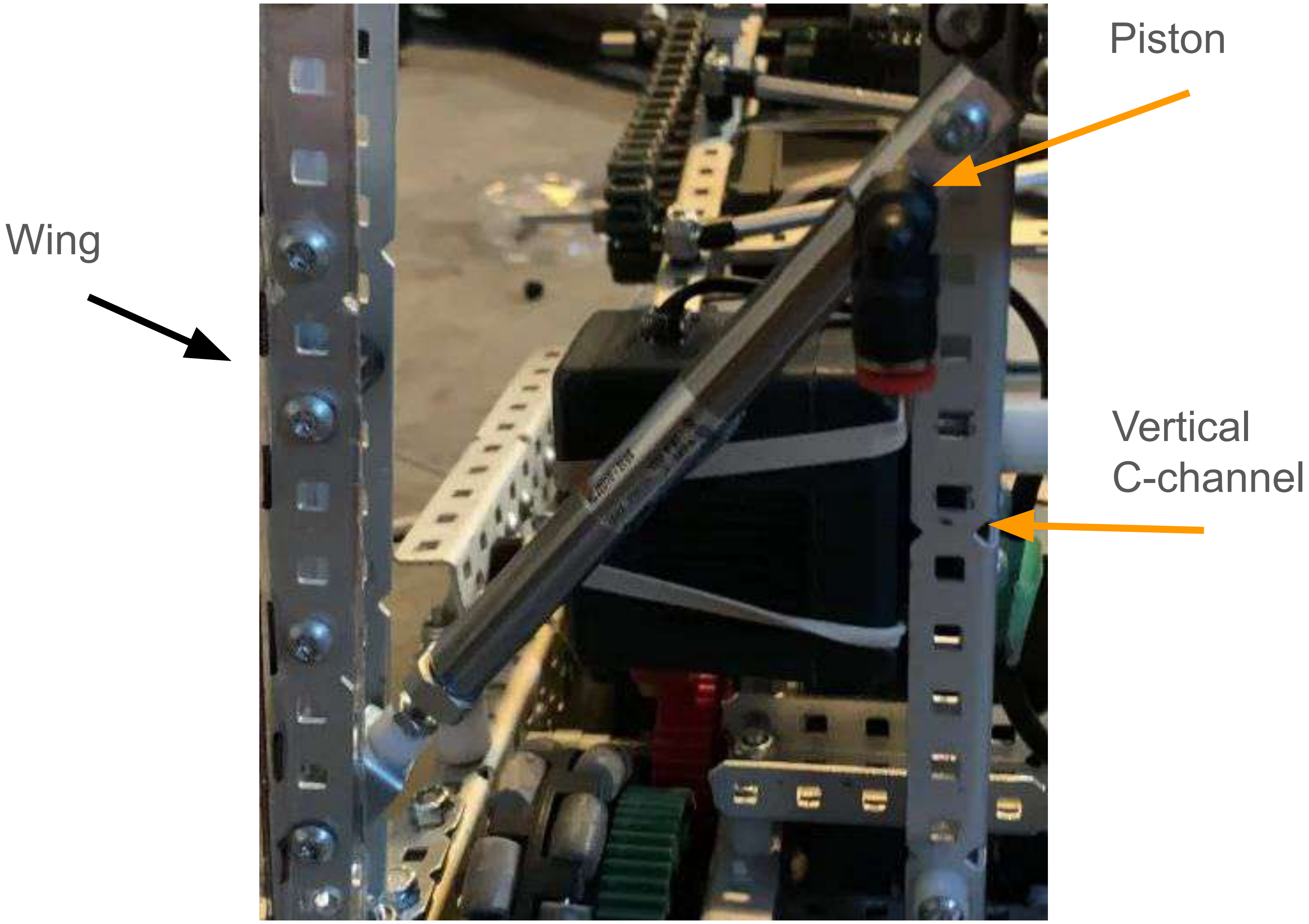
Witnessed by:

Oliver Liu

Vertical Wings - Building

2024/01/02

For our wings, we are building them with a hinge attached to the outer bar of our drivetrain. Our vertical wings consist of a 17 long c-channel mounted on the hinge. The c-channel is boxed periodically to ensure it does not bend during our matches. Since we are adopting a vertical wing design for the wings, our piston needs to be mounted vertically so that they can move the wings. For this reason, we are mounting the wings towards the back of our robot as the vertical c-channel holding the flywheel up allows for us to easily mount the pistons to power our wings. A diagram of the piston mechanism is shown below.



Designed by:

Darien Ng

Witnessed by:

Oliver Liu

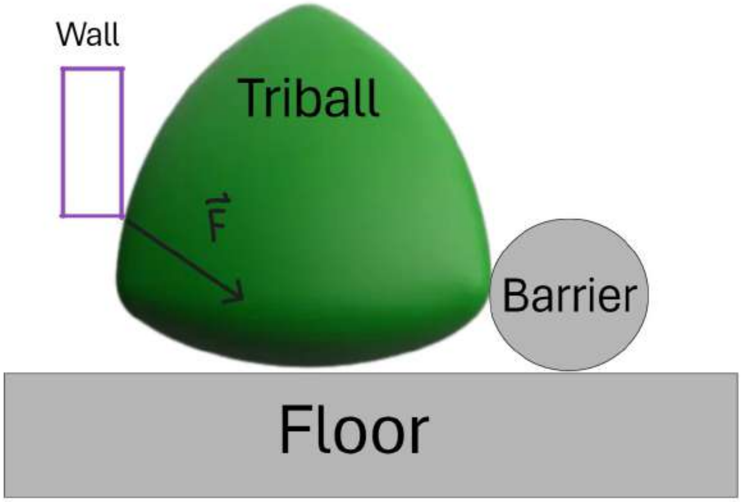
Vertical Wings - Building

2024/01/02

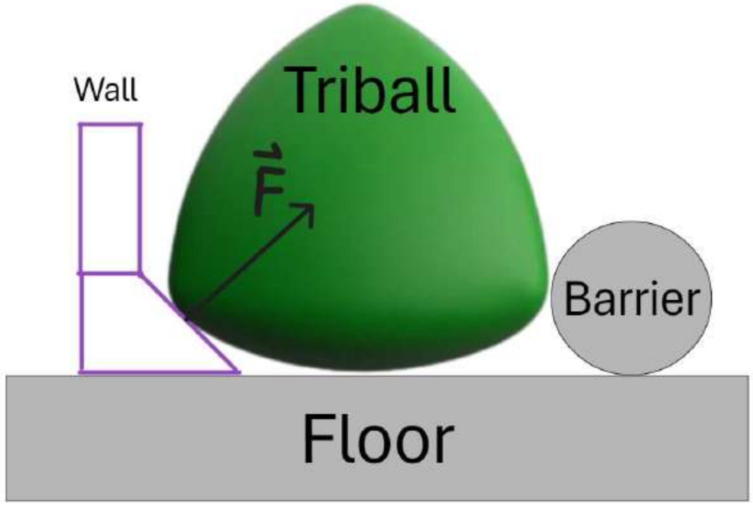
While doing some quick testing with the wings, we noticed that it struggled to push the triballs over the barrier. This is because the point where the wings contact the triball is quite high, causing a lot of force to be directed down due to the round shape of the triball. For this reason, we are also mounting bent pieces of lexan on the wings. These pieces of lexan are bent into a wedge shape. This not only allows the wings to contact a much lower part of the triball, but also helps push it up and over the barrier by directing force up.

Free body diagrams showing the difference between designs with and without wedges is shown below. The left diagram shows the direction of force without the lexan wedges while the right diagram shows the forces when the lexan wedges are added.

Without lexan wedges



With lexan wedges



Without the wedges, the force generated on the triball is shown in the diagram in the left. Here, the triball is simply getting pushed into the floor, so it won't be able to get over the barrier. With the wedges, the force generated is in the diagram to the right, and now the force is pointing upwards, allowing the triball to go over the barrier instead of into the floor. A diagram of the lexan wedges on our robot is shown on the next page.

Designed by:

Darien Ng

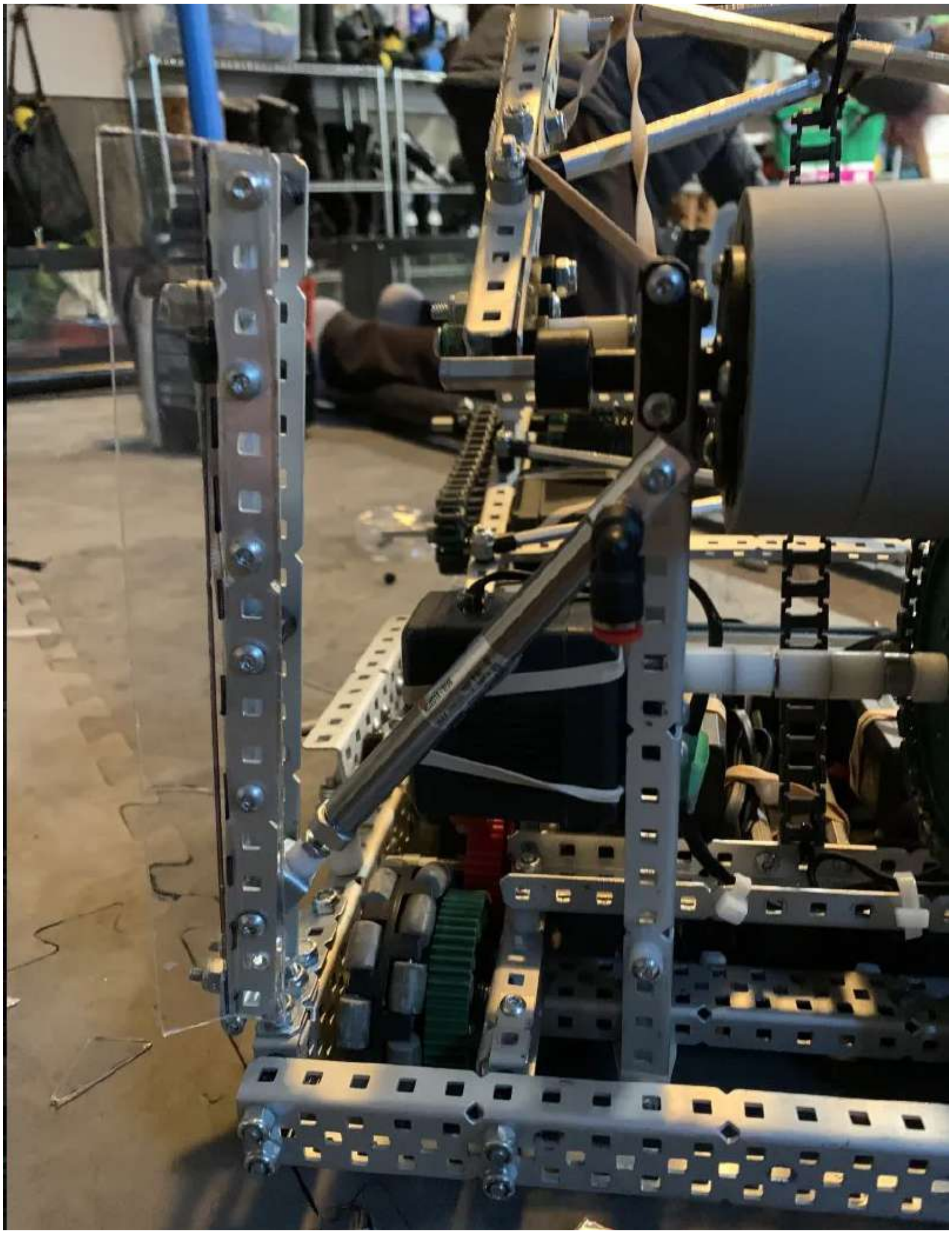
Witnessed by:

Matthew Zhang

Vertical Wings - Building

2024/01/02

Below is a picture of the completed vertical wing system on our robot. Information and the build process of this system are shown in the previous 3 pages.



Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Horizontal Wings - Planning

2023/01/03

While building our vertical wings, we recognized that there is a problem with the vertical wings that we are unable to fix. Since the vertical wings are mounted on the back of our robot, that means we are unable to efficiently use the vertical wings and our intake at the same time since they are on opposite sides of the robot. However, with the vertical wings being able to get the triball out of the matchload zone during the autonomous period, we cannot simply remove the vertical wings as the autonomous win point will be essential for the upcoming Mecha Mayhem signature event, which we are going to. Additionally, we also have no spots to mount the vertical wings on the front of our robot as we have the intake taking up space. For these reasons, we have decided to construct a second set of wings on our robot. These wings will be mounted horizontally and will be built on the front of our robot, allowing us to effectively utilize both our wings and our intake at the same time, like we have in previous events.

This set of wings will follow a very similar design to the vertical wings, just mounted horizontally this time instead of vertically. Like the vertical wings, we will be using pistons to move them. More information on why we are using pistons to power the wings is on page 127.

Designed by:

Darien Ng

Witnessed by:

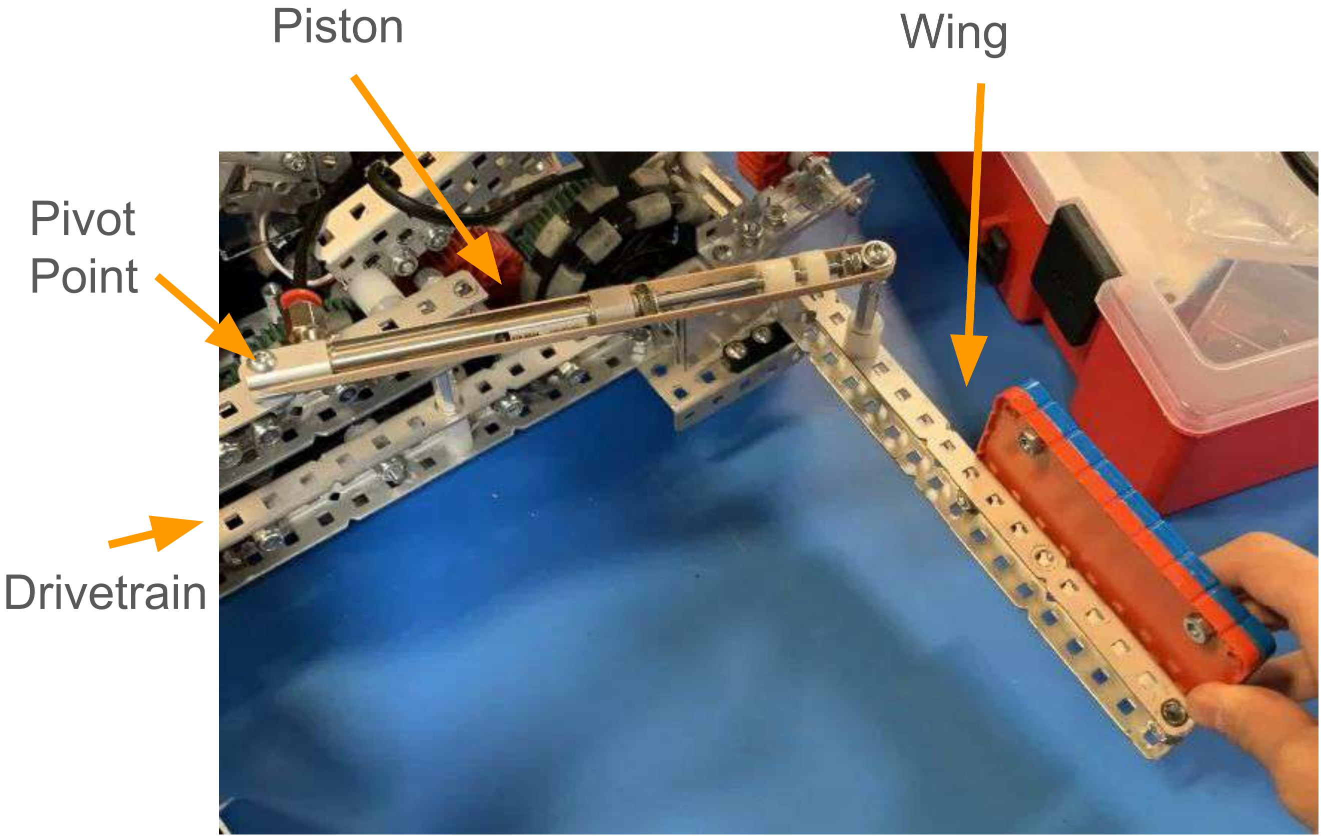
Matthew Zhang

Horizontal Wings - Building

2023/01/03

For our horizontal wings mounted on the front of our robot, we are using a 19 long c-channel with the pivot point at the front corners of our robot. Like most of the other pivots on our robot, we are using a screw joint to act as the pivot point for our horizontal wings. This is because they have less wiggle room than an axle does. Unlike the vertical wings, we are not using hinges since we do not have the necessary space to fit a hinge as we also have pieces of lexan mounted on these corners of our drivetrain to help us move over the central barrier.

Note that our horizontal wings on this robot are not locking wings. This means that they don't lock in place once they are extended. This makes it susceptible to getting pushed and closing from collisions with other robots. We have taken note of this as a potential problem. Another concern is that the strength of the piston may not be enough to keep the wings extended while pushing triballs into the goal. We will be monitoring how successful our wings are in doing this and we will make adjustments if necessary. A diagram of our horizontal wings is shown below.



Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Intake - Planning

2024/01/02

Throughout the past few events, we have found that having an intake on our robot is absolutely essential to having a well-performing robot. This is because an intake allows us to grab singular triballs scattered around th field and put them into the goal, which earns us a lot of points over the course of a match.

Since our intake worked very well on our last robot, we will be making a very similar design for this robot. Similar to our last robot, we will be using rubber bands as the part that grips the triball. This is because they have good grip, and are much more bendable than flex wheels, making them conform to the triball better. They are also much lighter than flex wheels, which helps keep weight down on our robot so that we are able to move quicker around the field.

Like the flywheel, we will be using chain to connect the motor to the intake. This is because we are unable to secure gears very snugly from both sides without adding a lot of additional weight or having it cantilevered. This would cause the gears to skip, producing excessive wear and tear as well as making the flywheel work less reliably.

For the intake, we will also be using a high strength axle to hold the parts touching the triball. This is because with low strength axles, we noticed that it would bend after significant force was put on it, like in a crash. High strength axles are much more durable, which keeps them straight throughout our events.

Designed by:

Darien Ng

Witnessed by:

Austin Ma

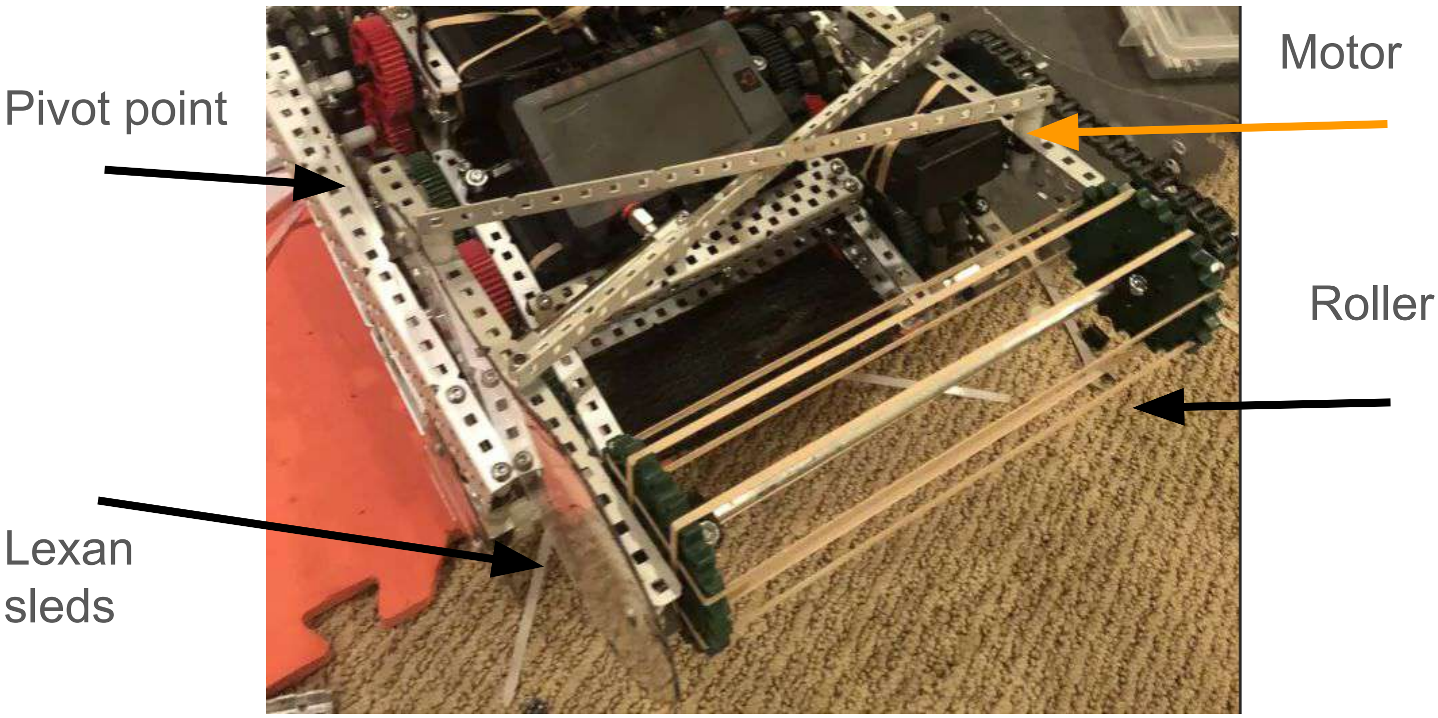
Intake - Building

2024/01/03

For the intake, we are mounting it on the front of our robot with the pivot point about halfway back on our robot. For the pivot, we are once again using screw joints, as they are more reliable and have less wiggle room than axles do. Our flywheel consists of a rubber mesh wrapped around 4 rubber bands strung between 2 30-tooth sprockets mounted on a high strength axle. Like our last intake, we are using a 3:2 gear ratio connected with chain. We are also using a green 200 RPM cartridge on our motor, resulting in an overall RPM of 300 for the intake.

One of the challenges we encountered was with drilling the holes into the c channel so that the high strength axle would fit through it. At first, there was a lot of friction since the holes were not aligned. To solve this, we widened the holes slightly on the c-channels, and the friction decreased significantly.

We have also made sure to brace the intake well, to make sure it does not bend during a match. For this reason, we have put an x-brace across the two main c-channels holding the intake together. We have also mounted pieces of lexan on either side of the intake. These ‘sleds’ made of lexan ensure that the intake is able to move up when we push triballs into the goal, as well as protecting the chain and intake from collisions with other robots.



Designed by: Darien Ng

Witnessed by: Oliver Liu

Placements

2024/01/03

The placements of our brain, battery, air reservoir, and other heavy components are very important in the functionality of our robot. This is because these objects most greatly affect our center of gravity, which if placed poorly, can make it easier for us to tip back and flip, lose our ability to climb, and lose our ability to make it over the barrier. It is also preferable to keep the center of gravity near the center of our robot for the same reasons. Having the center of gravity at the center of our robot also makes it much easier to go over the barrier.

For our robot, there are 3 main heavy objects that we have to consider: the brain, the battery, and the air reservoir. All of these components are placed at the bottom of our robot, near the drivetrain. This helps to lower the center of gravity, meaning that our robot is able to tip more before it ultimately flips over onto its side.

Firstly, our brain is mounted right behind the backboard of the intake. This provides a centralized, protected spot for the brain while also helping to keep the center of gravity low as the brain is very close to the motors on our drivetrain. Next, our battery has been placed between the lower 4 motors on our drivetrain. This is a very low spot, helping to keep the center of gravity down near the bottom on our robot. Finally, our air reservoir is mounted at the back near our flywheel right above our drivetrain. This keeps the center of gravity down, but also moves it back significantly, which may hinder our ability to go over the barrier as well as making us easier to flip over. We will be testing how our bot functions with these placements and we will move things around if necessary. Pictures showing where these items are located on our robot are shown on the next page.

Designed by:

Darien Ng

Witnessed by:

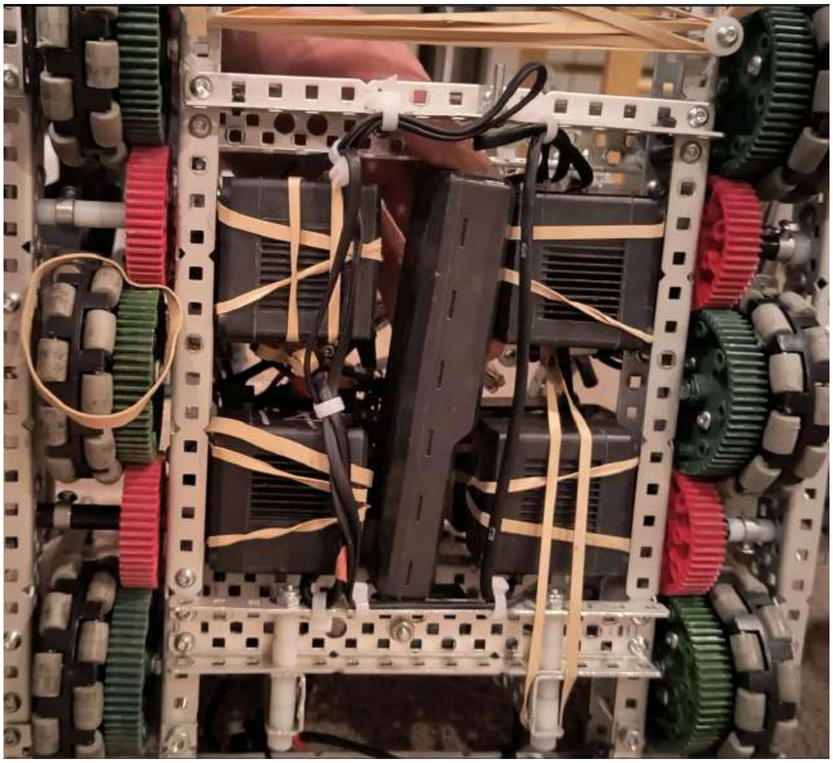
Matthew Zhang

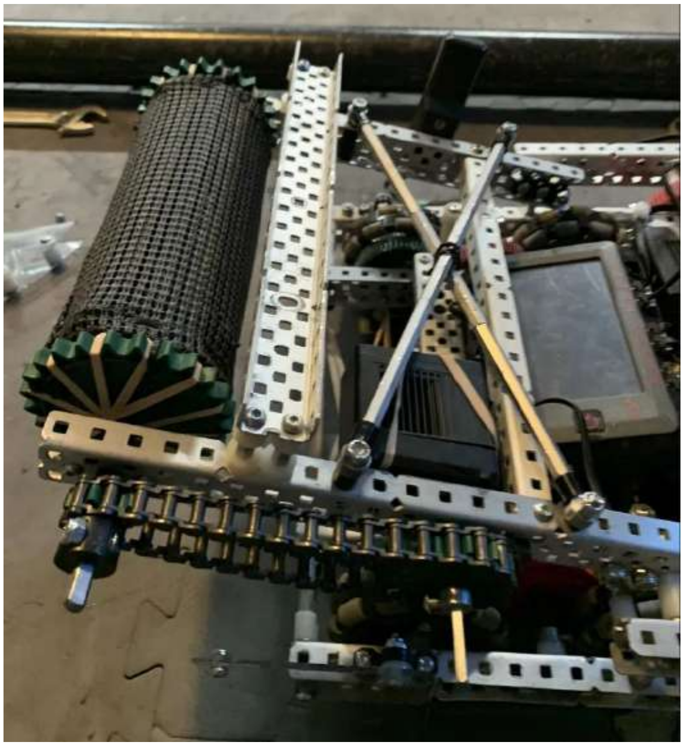
Placements

2024/01/03

Below are pictures showing where we are placing some of the heavier items of our robot. Rationale on why we chose these locations are given in the previous page.

The picture on the left shows the bottom of our robot and the location of our battery between the motors of our drivetrain. In this image, the front of our robot is at the top. At the bottom of the image, empty space at the back of our robot between various other parts can be seen. We have opted to put our air reservoir there to fill that space.





The picture on the right shows our intake as well as the location of our brain in a centralized location on our robot. Due to space limitations and also by how we don’t want the brain to be contacted by triballs in our intake, we had to mount the brain at a slight angle, which is not ideal. We will be monitoring these placements and will fix them if necessary to ensure our success.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Robot Testing

2024/01/03

Today, we tested our robot while practicing our skills for driving. Below are some of the things that we noticed with our robot.

Firstly, our flywheel works quite well, and it seemed more consistent than when we were at previous events such as STEM where we saw random drops in the flywheel speed. These drops seemed to disappear today which is good. We did notice that it was a little fast for our liking today, but we will continue monitoring and practicing with this flywheel in preparation for a league event on Saturday, January 6.

One problem we noticed was with our center of gravity of our robot. This caused our robot to flip as the climbing mechanism, the flywheel, air reservoir, are all at the back, with the brain, battery, and motors also towards the rear. This made us flip backwards whenever we went over the barrier or hit some defensive wedges on other robots. To fix this, we are trying a variety of adjustments to the placements of heavy components of our robot, such as moving the air reservoir to the front of the robot instead of the back.

Information on the results of testing on our intake is shown on the next page.

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Robot Testing

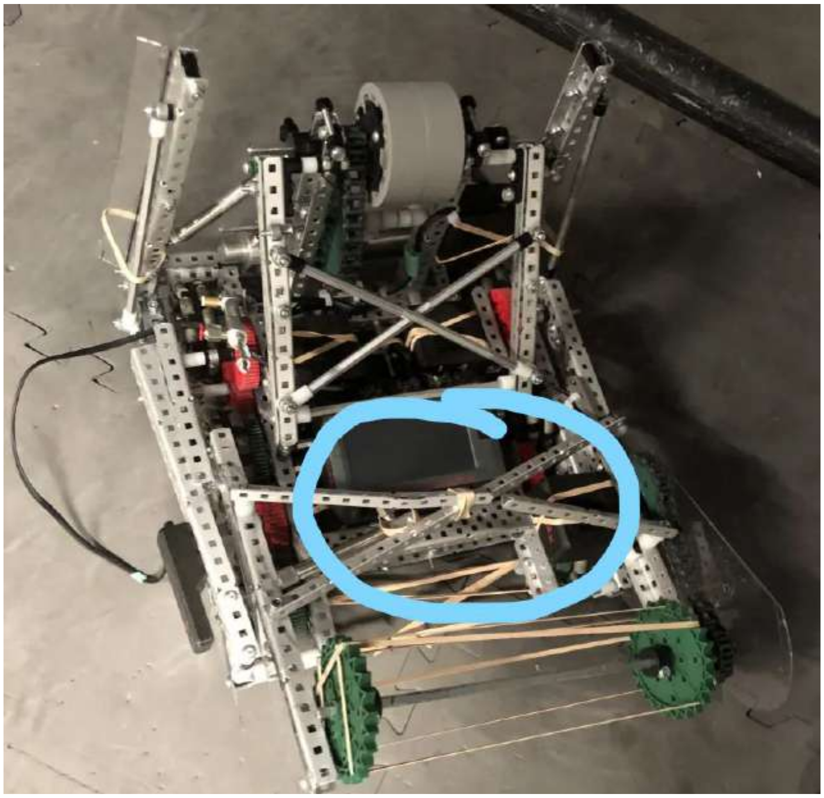
2024/01/03

While driving, we also found two large problems with the intake.

Firstly, the half cuts that we used for making an x-brace on the intake got very bent, and one of them even broke completely. This is a problem as without the bracing, our intake would get damaged in matches with other robots. We will need to either replace these half cuts used for bracing or find new ways to brace our intake.

Secondly, we found that the high strength axle that we used for the intake is not long enough, which resulted in the entire axle along with the roller falling out of the intake while we were driving. In a match, this would render our intake useless, resulting in a significant disadvantage against our opponents. We will need to either adjust our intake or preferably find a longer axle in order to fix this problem. Unfortunately, we do not have any longer axles right now, meaning that we will likely need to adjust our intake in order to fix this problem.

Below is a picture of our damaged robot. The axle used for the intake has been put on for the time being. The broken bracing on the intake has been circled in blue. We are currently using rubber bands to hold it together until we can find and implement a longer-term solution.



Designed by:

Darien Ng

Witnessed by:

Austin Ma

Intake - V2

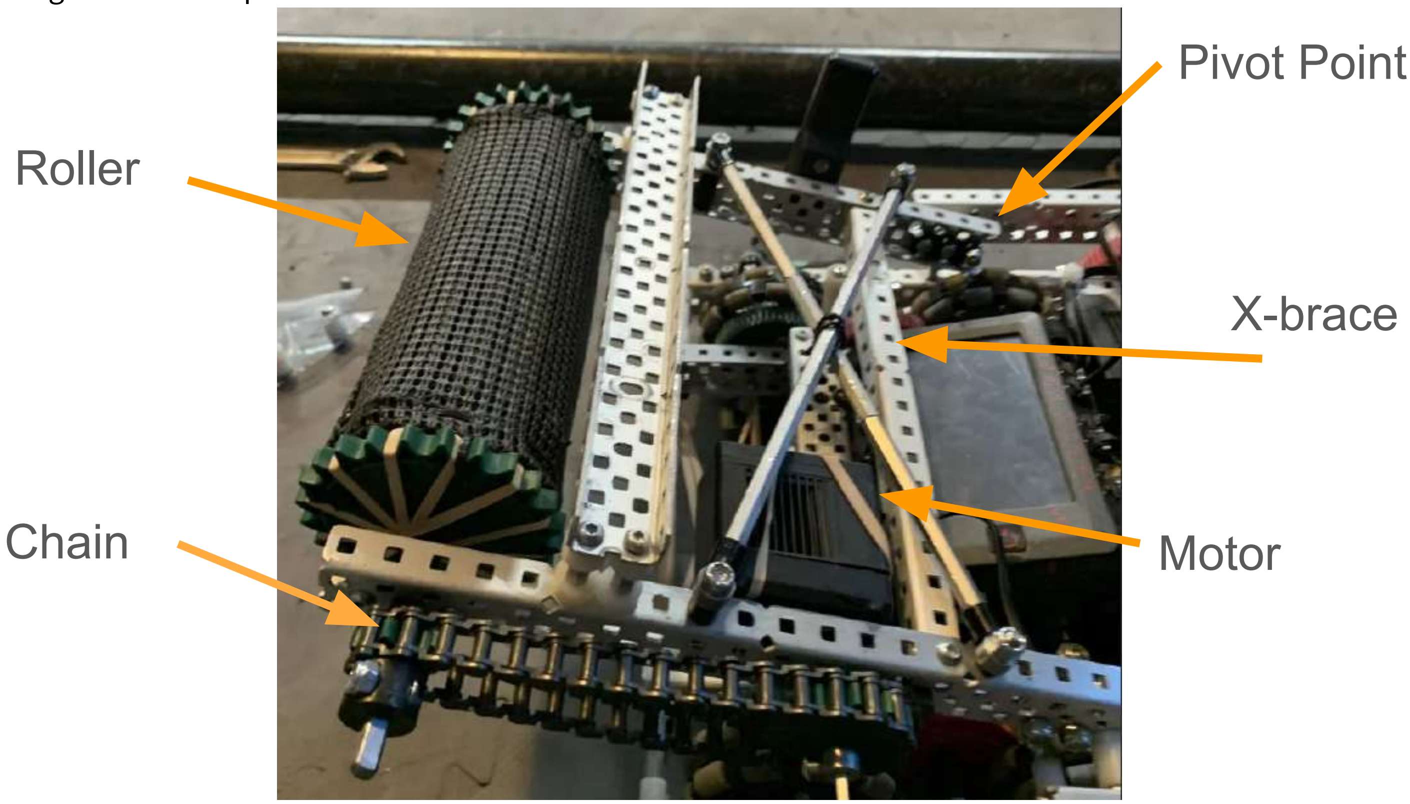
2024/01/04

To fix the intake, we have made some slight changes to the overall design

Firstly, we have added spacers on the hinge points of our intake to make the overall structure slightly narrower. This allows our new high strength axle to be long enough to span the width of our intake without slipping out. This allows us to ensure that our intake is consistently working throughout a match. A possible concern with using spacers to make the intake shorter without changing the connection points to the rest of our robot is that the intake may be structurally weaker at ihe connection point where the pivot is. We will make sure to continue monitoring this in case any problems come up.

To fix the bracing, we have replaced the half cuts with standoffs, which are much stronger with their increased width and shape compared to the half cuts. The new x-brace with standoffs seemed to work a lot better, which also helps to keep our intake in one piece during matches.

A diagram of our improved intake is shown below.



Overall, we are quite happy that our intake is now working well. We will most likely be staying with this intake for the league event on January 6th. After the event, we will be making some minor adjustments to the intake as we see fit.

Designed by:

Darien Ng

Witnessed by:

Austin Ma

Robot Testing

2024/01/04

Once again, we have tested all the components of our robot to make sure that they are working. Unfortunately, we still found a few very significant problems with our robot.

Firstly, we noticed that we were unable to make it over the barrier. There are two main parts to this problem. To start, our center of gravity was way too far back, making us unable to tip our robot over the barrier even though most of the drivetrain was already over the barrier. Secondly, after the second wheel was over the barrier, our robot was tipped backwards way too much, which also moves the center of gravity back on our robot, making the center of gravity problem even worse. The main reason why the robot was tipped back very far was because of how we put our wheels on the bottom row of holes on the c-channel instead of the middle row of holes. This made our crossbar quite high on this robot compared to our previous robots. Since at that point of crossing the barrier, the points of contact are the center wheels and the crossbar, the high crossbar made it so that our robot tipped very far back. With no easy way to fix this problem, we will have to brainstorm and keep thinking of possible ways that we can quickly fix this problem for our event on January 6th while we try to find a more permanent solution.

Another major issue we found was with our horizontal wings. With the way we mounted them, the piston would get bent as soon as any amount of pressure was put onto them. This is bad, especially if we were to hit another robot during a match. To fix this, we will be adjusting the placement of our pistons for the horizontal wings slightly and place them in a way where it will not bend the pistons again.

The hinge on our vertical wings also bent upon colliding with another robot while testing. If this bending were to happen in a match, it would compromise the effectiveness of our vertical wings, leading to major point losses or even a loss in some scenarios. The bending shows that the hinge is not reinforced well enough and we will be adding some additional bracing to it to stop it from bending in the future.

Lastly, we still need to fix the center of gravity problems from our last testing session; however, this ties into making sure that we can get over the barrier, so it is not too big of a concern for now.

Designed by: Darien Ng

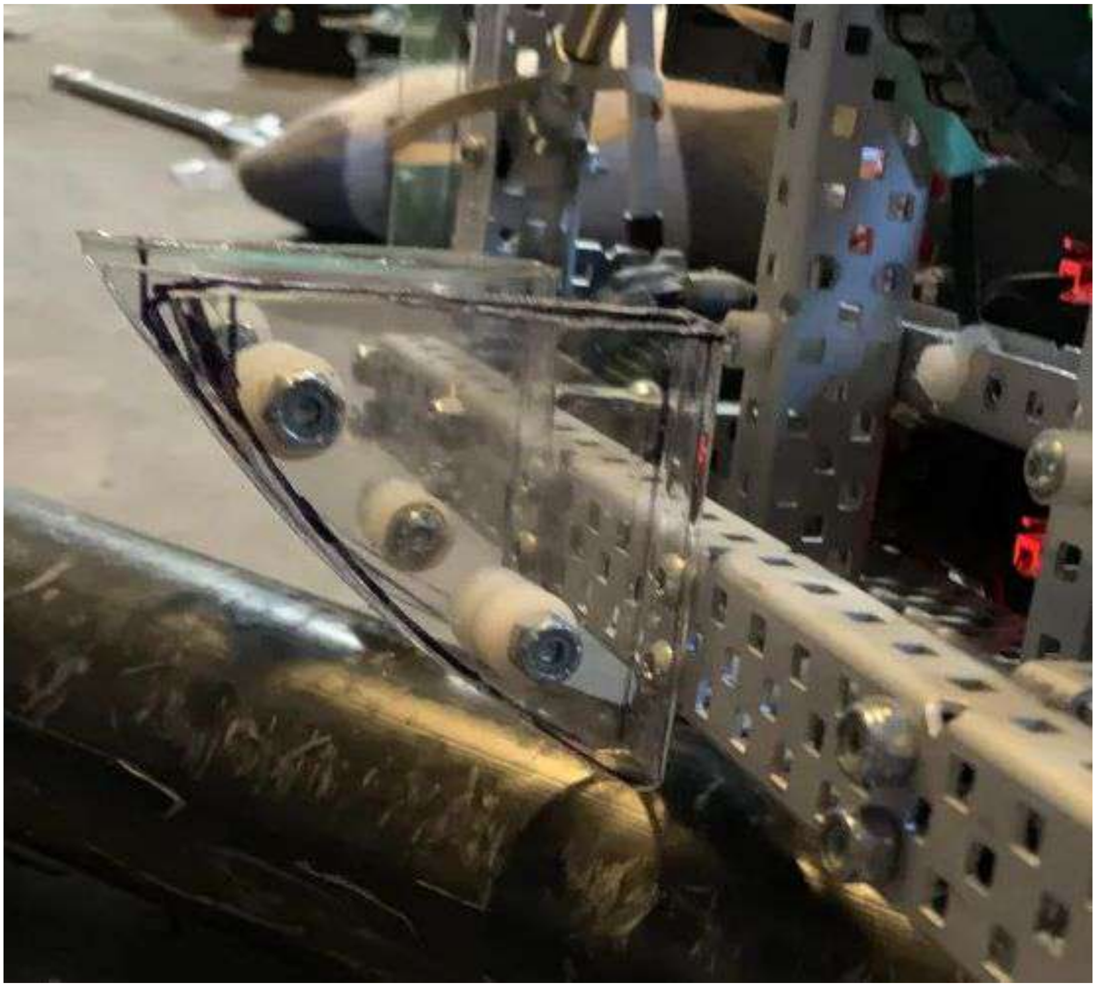
Witnessed by: Matthew Zhang

Getting Over the Barrier - V1

2023/01/04

One of the solutions that we have come up with to get over the barrier is to go over it backwards, and to put some lexan ‘sleds’ to help us get the first wheels onto the barrier.

To test this idea, we have made some lexan sleds and put them onto the rear crossbar of our drivetrain to try to get over the barrier. An image of these sleds is shown below.



While testing this solution, we found that the lexan sleds did get us over the barrier, but it was very inconsistent, as we were still tipping a significant amount while crossing the barrier, just that we are tipping on our front now. This makes it basically no better than before, so we are scrapping this idea and thinking of another way to temporarily fix this problem before we make significant efforts to make a more permanent solution after our league event on January 6th.

Designed by:

Darien Ng

Witnessed by:

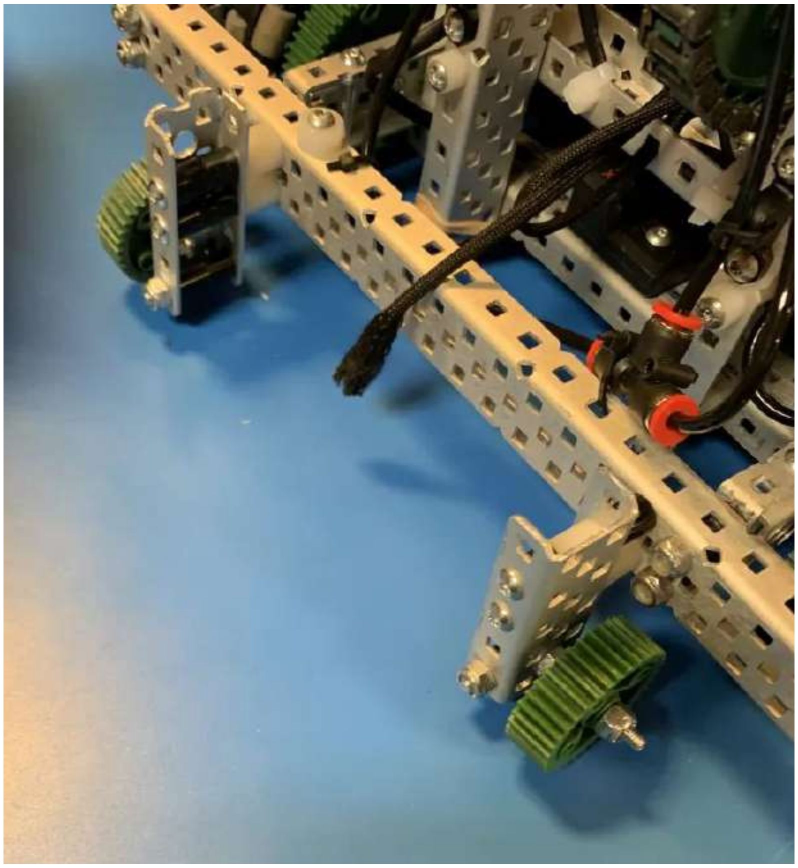
Oliver Liu

Getting Over the Barrier - V2

2024/01/05

With our first idea failing to get us over the barrier, we have come up with another possible solution. Here, we would still drive forwards normally over the barrier, but we would mount an additional set of wheels made out of free-spinning gears at the back of our robot to help us over the barrier. This set of gears is the point of contact with the floor instead of the horizontal bar at the back of our drivetrain, which is much higher than it. Overall, this mechanism would reduce our upwards angle while crossing the barrier, helping to keep our center of gravity forwards to hopefully tip our robot over the barrier.

A picture of the mechanism we built is shown below. The large horizontal bar spanning the image is the horizontal bar at the back of our drivetrain and the set of gears is attached to it.



Upon testing this mechanism, we found that it did get us over the barrier a couple times, but it was still very inconsistent, like the lexan sleds that we previously tried. We have tried adjusting the mechanism and the tension, but it did not improve the results much. Although we would like to completely solve this problem before the league event, we just don’t have the time to do that, so we will have to stick with this mechanism and fix it later down the road.

Designed by:

Darien Ng

Witnessed by:

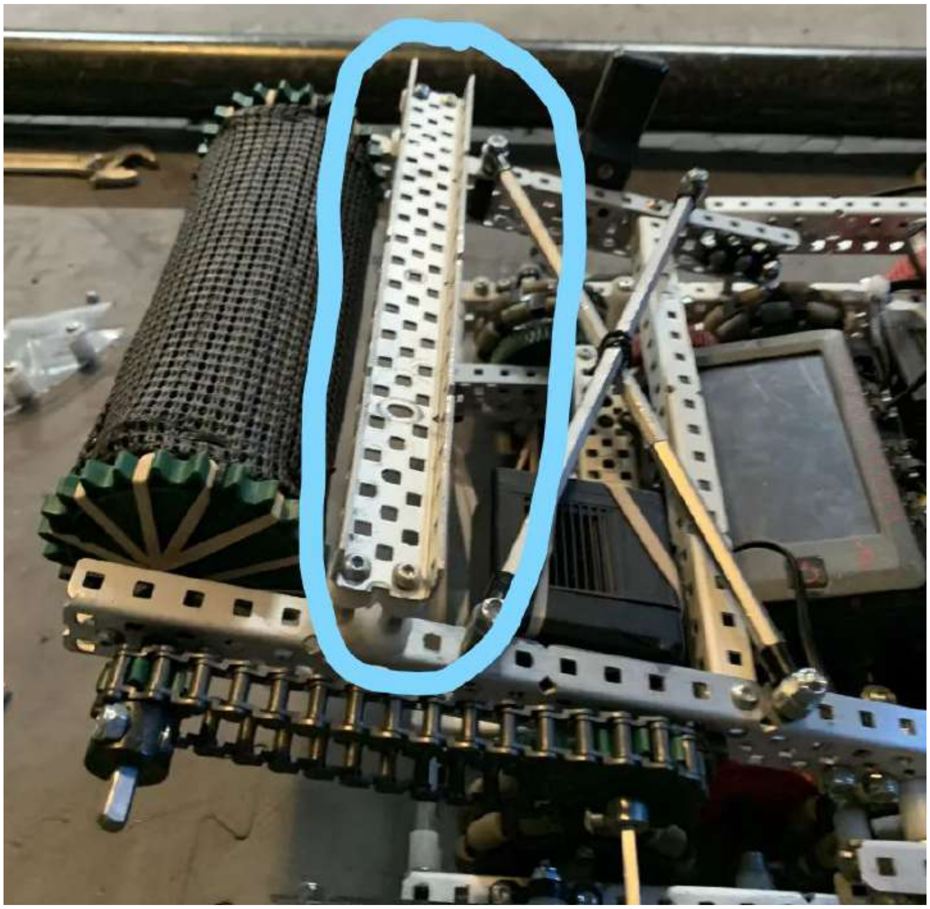
Oliver Liu

Placements - Redesign

2024/01/05

In an attempt to fix the center of gravity, we are moving the air reservoir to a spot at the front of the robot on the cross brace of the intake. This makes the heavy air reservoir move the center of gravity forwards on the robot, rather than backwards. This is an improvement from before, as our robot has been very back-heavy in both of our testing sessions. By moving the center of gravity forwards on the robot, we are less vulnerable to getting flipped over when we hit other robots' wedges or crash.

Our intake is shown in the image below. The large horizontal c-channel marked in blue is where we are mounting the air reservoir.



Upon testing with the new placement of our air reservoir, we found that we were much less prone to getting flipped over. Unfortunately, we are still unable to make it over the barrier, and we still do get flipped sometimes; however, this is a major improvement from before and we will be sticking with it for the league event.

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Program PID

2024/01/15

Goal: Program and tune PID so that we can have more accurate and precise autonomous programs.
General Overview:

- PID allows the bot to accelerate smoothly
- Sets the speed of the motors based on the displacement from the target

After many hours of coding and testing PID, we discovered that it was the easiest to use an online template as the basis of our PID. Thus, we began using EZ-Template as our base for our PID during our auton. The general idea of the PID remained the same as we still used it for the same function.

To reiterate:

P - Proportion

- Proportion decreases the bots speed as it approaches the target
- By calculating the displacement from the target, we will multiply this by a constant factor so the closer the robot gets to the target, the slower it will move
- We will use this to slow the robot in drive commands

I - Integral

- Integral accelerates the drive when proportion undershoots the target
- Multiplies by a constant factor by the total accumulation of errors over time
- We will use this to accelerate the robot as it approaches the target to ensure that it reaches its destination.

D - Derivative

- Derivative restricts rapid changes in motion for acceleration
- Multiplies a constant factor by the change in distance from the target over the change of time
- We will use this in our autonomous programs to prevent the robot from making sloppy movements that cause drift from the intended route.

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

Program PID

2024/01/15

Code:

```cpp
// Set drive PID
void Drive::set_drive_pid(double target, int speed, bool slew_on, bool toggle_heading) {
  TICK_PER_INCH = get_tick_per_inch();

  // Print targets
  if (print_toggle) printf("Drive Started... Target Value: %f (%f ticks)", target, target * TICK_PER_INCH);
  if (slew_on && print_toggle) printf(" with slew");
  if (print_toggle) printf("\n");

  // Global setup
  set_max_speed(speed);
  heading_on = toggle_heading;
  bool is_backwards = false;
  l_start = left_sensor();
  r_start = right_sensor();

  double l_target_encoder, r_target_encoder;

  // Figure actual target value
  l_target_encoder = l_start + (target * TICK_PER_INCH);
  r_target_encoder = r_start + (target * TICK_PER_INCH);

  // Figure out if going forward or backward
  if (l_target_encoder < l_start && r_target_encoder < r_start) {
    auto consts = backward_drivePID.get_constants();
    leftPID.set_constants(consts.kp, consts.ki, consts.kd, consts.start_i);
    rightPID.set_constants(consts.kp, consts.ki, consts.kd, consts.start_i);
    is_backwards = true;
  } else {
    auto consts = forward_drivePID.get_constants();
    leftPID.set_constants(consts.kp, consts.ki, consts.kd, consts.start_i);
    rightPID.set_constants(consts.kp, consts.ki, consts.kd, consts.start_i);
    is_backwards = false;
  }

  // Set PID targets
  leftPID.set_target(l_target_encoder);
  rightPID.set_target(r_target_encoder);

  // Initialize slew
  slew_initialize(left_slew, slew_on, max_speed, l_target_encoder, left_sensor(), l_start, is_backwards);
  slew_initialize(right_slew, slew_on, max_speed, r_target_encoder, right_sensor(), r_start, is_backwards);

  // Run task
  set_mode(DRIVE);
}
```

1. Takes in parameters of the PID including the target location and speed
2. Initializes encoders and calculates the value that needs to be sent to the encoders
3. Sets the constants which are tuned slightly differently for every bot in order to ensure a smooth PID
4. Starts a task that will continue to run the PID until the exit conditions are met

Conclusion:

- Our PID is tuned fairly accurately to yet can still be improved
- The PID is not entirely consistent, which may be an issue with the tuning or the exit conditions
- Our tuning process is efficient and can be completed quickly
    1. Increase kp until the robot begins to oscillate
    2. Increase kd until the robot stops oscillating
    3. Repeat steps 1 and 2 until increasing kd does not stop the robot from oscillating
    4. Decrease kp to the last value before the oscillation
    5. Decrease kd to the last value before the oscillation
    6. Increase ki until the robot begins to oscillate
    7. Decrease ki to the last value before the oscillation

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

Program Drive Functions

2024/01/15

Definition:

OP — Driver/Driver Control.

Goal: Program and tune the drive functions so that we can have simple and intuitive OP control.

General Overview:

- The longest part of a VEX game will be OP control.
- Most of the points in a game will be scored during the OP control period.
- It is very important to have good OP control code as the driver will have to be able to quickly and efficiently drive the bot around the field to complete the objectives.
- For our current version of the bot, there are a few key functions that it needs to fulfil
    - Fast, good drive
    - Intake and outtake triball
    - Flywheel and reversing the flywheel
    - Walls for pushing and vertical walls for removing the triball from the match load zone during autonomous
    - Piston climb mechanism

```
// Fly wheel
if (controller.get_digital(pros::E_CONTROLLER_DIGITAL_Y) && shoottoggle == false && fly <= timer) {
    Fly = flyReverse ? -power : power;

    shoottoggle = true;
    fly = timer + 50;
} else if (controller.get_digital(pros::E_CONTROLLER_DIGITAL_Y) && shoottoggle == true && fly <= timer) {
    Fly = 0;

    shoottoggle = false;
    fly = timer + 50;
}

// Reverse flywheel
if (controller.get_digital(pros::E_CONTROLLER_DIGITAL_X) && flyR <= timer) {
    flyReverse = !flyReverse;
    flyR = timer + 50;
}
```

Example: Flywheel Controls

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

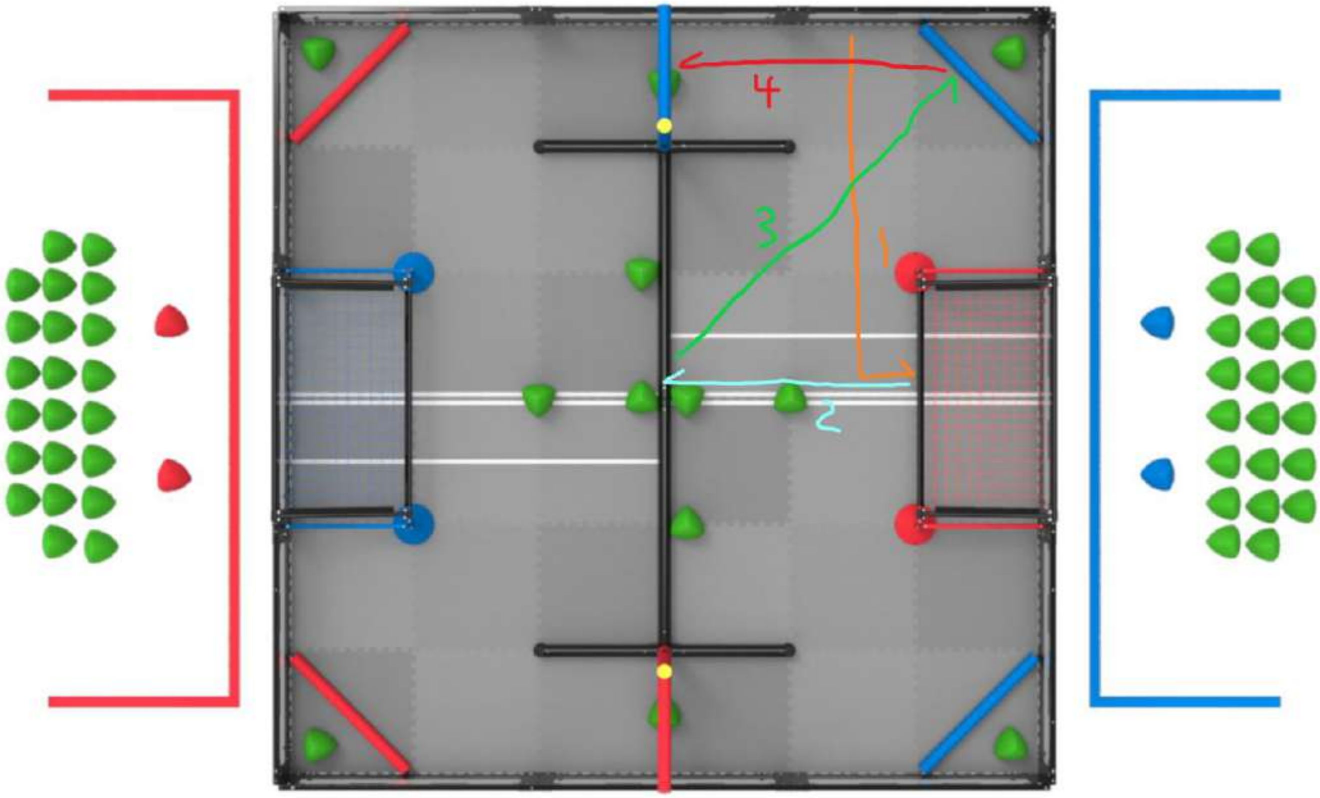
Program Autonomous

2024/01/16

Goal: Program and tune the autonomous paths so that we can consistently win autonomous and get the autonomous win point

General Overview: Autonomous is an important part to a VEX game. There are many important objectives that can be completed during autonomous such as scoring triballs, pushing triballs into your offensive zone, removing the triball from the match load zone and touching the elevation bar. In order to get the autonomous win point in VEX Over Under, an alliance must remove the triball from the match load zone, score a team coloured pre-load into the net and touch the elevation bar.

Defensive side: Autonomous Win Point (13 points, AWP)



1. Orange path, push pre-loaded triball into the net
2. Blue path, open walls to push the two triballs on the autonomous line over the barrier for 4 points
3. Retract walls and follow path to match load zone
4. Open walls to remove the triball from the match load zone and follow the red path to push the triball into the offensive zone, push the triball under the elevation bar to the offensive zone at the same time and touch the elevation bar

Designed by:

Austin Ma

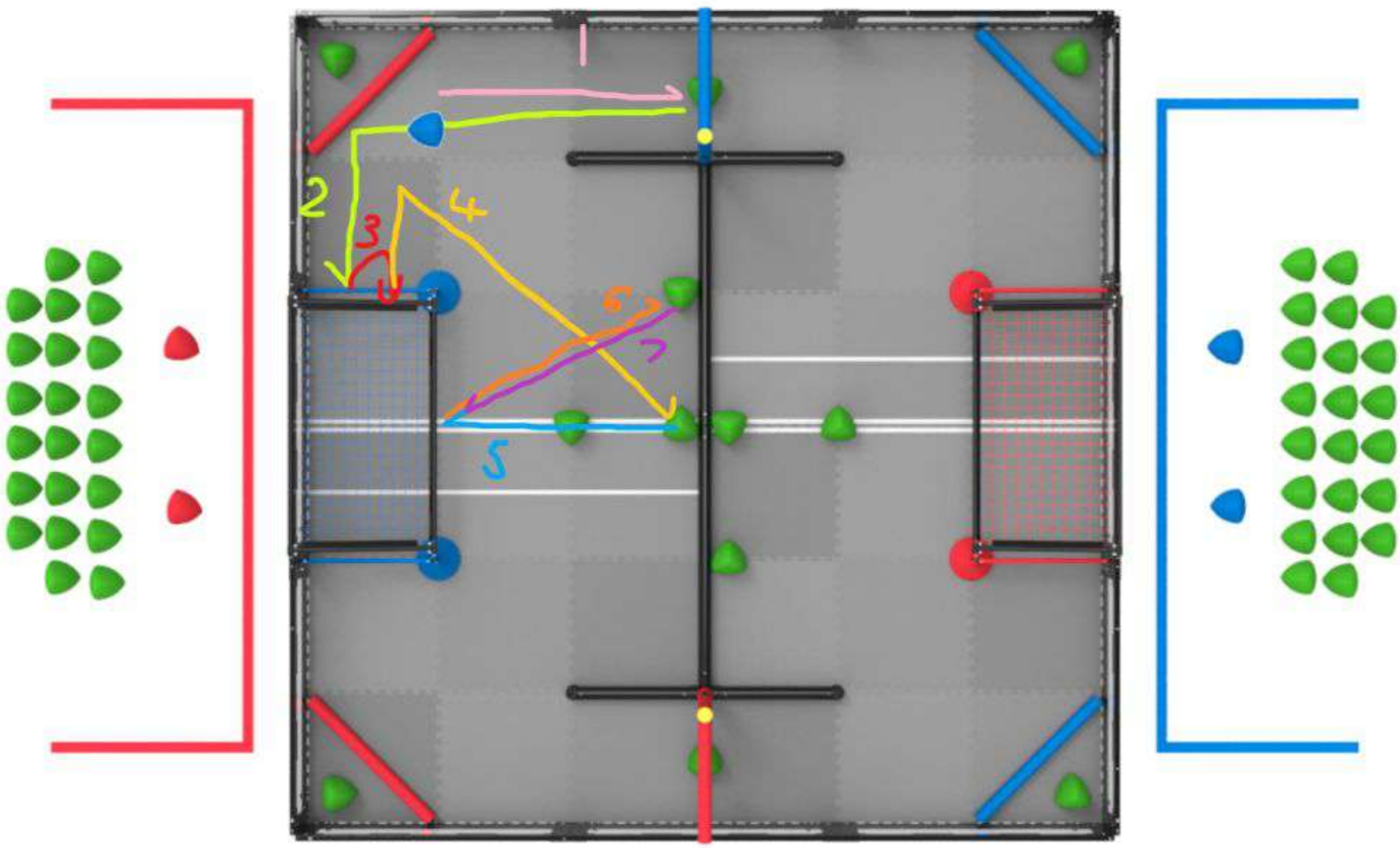
Witnessed by:

Darien Ng

Program Autonomous

2024/01/19

Offensive Side: 6 Balls Auton (30 points)



1. Turn on intake, follow the pink path
2. Reverse following the lime path, open descore mechanism at the turn, push preload and matchload into the net
3. Red, back up and rotate 360 degrees, then push in intaked triball into net
4. Reverse, then turn following the gold path, turn on intake and pick up the triball
5. Follow blue path, open walls and push other triball in along with the intaked one
6. Reverse, then turn, follow orange path, turn intake on, pick up triball
7. Turn 360 degrees and follow purple path, push final triball into the net

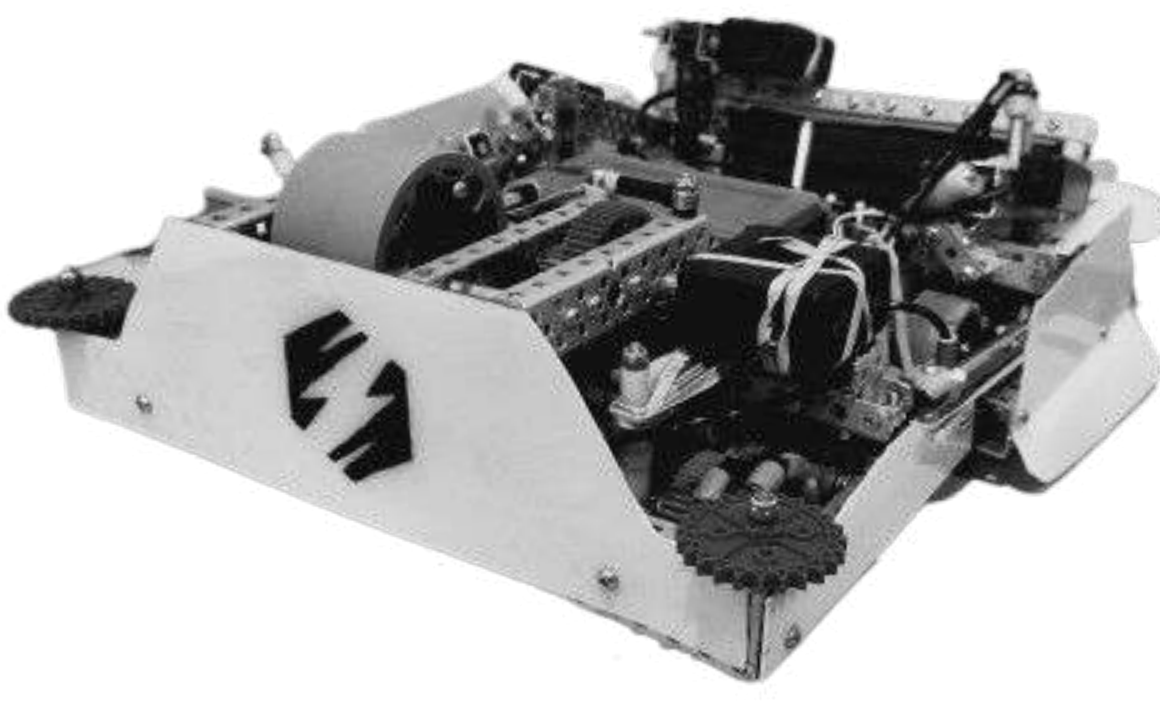
Designed by:

Austin Ma

Witnessed by:

Darien Ng

BotV3



Robot Image from March 1st

Why are we Rebuilding?

2024/01/5

After looking at our performance during the past month with our previous robot, we have decided to completely build a new robot from scratch. There are two main driving factors that led us to this decision as to how we spend the coming weeks leading up to the Mecha Mayhem signature event. These reasons will be listed and elaborated on below.

Things just weren't working.

Through the week leading up to the league event, we have ran into major issues with many different parts of our robot. An example of this is the broken bracing and the high strength axle being too short to span the width of our intake. Another is the drivetrain not being able to consistently make it over the barrier, which is very important if we are trying to follow our strategy of being faster than our opponents at getting to the triballs. During the league event, our autonomous code was also not working and our climb proved to be dysfunctional. Even now, many of these issues are still not fixed, as every time we fixed something, another component would break. With the time that it would take for us to fix all of these problems, we would be able to completely build a new robot from scratch, so that is what we are opting to do.

There is a limit to what we can achieve with our previous robot.

Although we have designed our previous robot to have a high level of potential by designing with high maneuverability in mind. Although we have made this robot, the limit for potential is not as high as we would like it to be, as the robot had some constraints with space and where we could fit various components, leading to unideal placements, causing problems that we found during our testing sessions. More information on these problems and our attempts to fix them are included on pages 137 to 143. Despite all the work done, we were still unable to fully resolve these problems, lowering the potential to what we can achieve with our previous robot. With this new robot that we are planning to build, we are also trying to increase the potential for a very good performance for Mecha Mayhem.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Schedule

2024/01/5

For time management, we are going to use a calendar to determine our workload. Having built similar systems in the past, we now know approximately how long each will take us. Furthermore, we added pockets of extra time/slack to allow for any delays in our construction of our robot.

JANUARY 2024

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5 Wheel Ordered	6 Take Apart current robot
7 Build Drivetrain structure	8 Mount Brain/battery	9	10 Wheels Expected Arrival	11 Mount motors, gear drivetrain and add wheels	12 Build Intake Test Drivetrain	13
14 Build Flywheel	15 Build & Test Flywheel	16 Extra Time	17 Build & Test Wings Build & Test Climb	18 Mount Pneumatics Wire Robot	19 Tune & program Robot and PID	20 Full robot test
21 Program Autonmous	22	23 Driver Practice	24	25	26	27
28 Slack Time Potential Scrimmage	29	30	31	Driver Practice Matchloading Practice	MECHA MAYHEM	

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

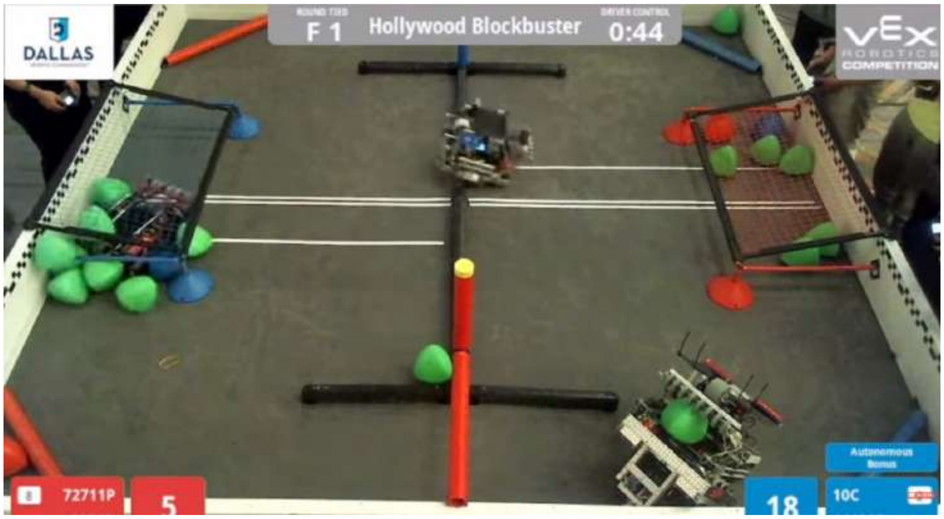
Current Strategies

2024/01/5

Descoring:

In recent matches, most notably at the Hollywood Signature event and Ignite, we've noticed the capabilities of descoring capable robots(under 6 inches). Descore can easily change the tide of the game, as currently teams rarely matchload, and slowly put triballs in by either tunneling or using their intakes, causing each team to only have 5-10 triballs in their goal per match usually. By removing even a few, and plowing them to the other side can mean whether we win or lose.

Another benefit of being able to descore is being able to force a playstyle that the opposing alliance is not familiar with. Even just the threat of descoring alone forces the opposing alliance to play much more cautiously by avoiding having two bots on the same side. Since descoring bots are not commonly seen currently, it is likely that the opponent has not prepared for this situation, causing them to change their strategies, which could offer us a significant advantage for future games.



Example of a descore bot, 72711P, being able to swing a match due to its descoring capabilities

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Current Strategies

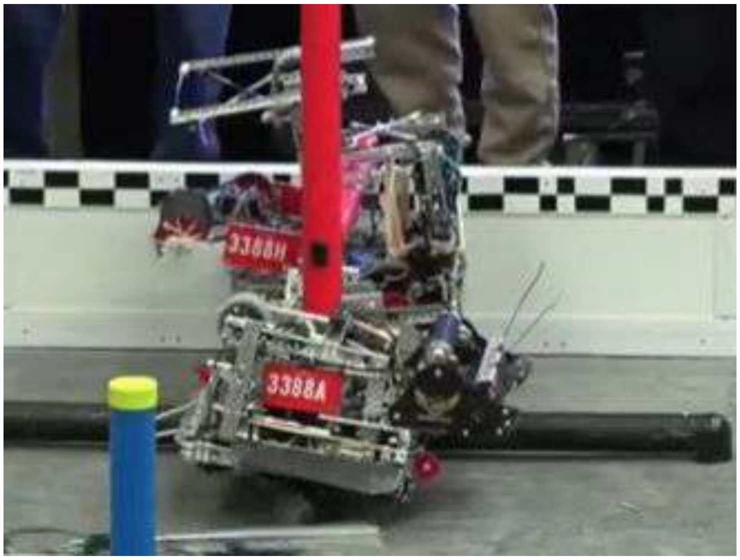
2024/01/5

Tunnelling:

Recently, the strategy of tunnelling Triballs underneath the elevation bars has become increasingly popular compared to traditional match loading. The issue with traditional match loading is that it is extremely easy for the opposing alliance to push all of the match loaded Triballs back onto their offensive zone to score rather than being able to score your match loads. By tunnelling 3-4 Triballs at a time, it makes it much more difficult for opposing alliances to stop these match loads, allowing you to slowly but consistently fill your net with Triballs.

Double Hang:

Due to a decrease in match loading recently, this causes the total number of Triballs scored to be significantly lower. As a result, points scored from elevation are becoming more valuable. Having both teammates hang at a high tier has the potential to swing matches. In order to be able to elevate both bots, one bot needs to climb on the horizontal pole and the other can climb by balancing itself on the barrier while touching the vertical pole. By having a method of climb for both situations, it allows us to compliment other teams' bot, allowing us to perform a double hang.



Example of a Double Hang by ourselves and 3388A, providing us with 35 points that match from just hanging.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Current Strategies Cont.

2024/01/5

Before we began to build our bot, it is crucial for us to brainstorm and plan out ideas for the bot beforehand to keep everything more organized and clear. After some brainstorming, we decided we wanted the following features on our robot:

- **Drivetrain**
    - Speed and maneuverability is crucial to success, being able to quickly push or grab triballs allows us to get more points into the goal. A faster drivetrain also allows for a easier time to get around all the obstacles. That being said, strong side traction(potentially traction wheels) would be also preferred, allowing for sharper turns in the tight field.
- **Intake**
    - Intakes are necessary to grab tribals, especially around corners and allows us to grab and quickly place them into the goal. Intakes are also good for efficiently and reliably carrying a triball from our matchload to the goal, across the field, which may occur given that match loading is not a safe option.
- **Shooter (Flywheel)**
    - Having a shooter allows us to quickly send matchloads to our offensive goal, allowing for easy scoring into the goal. However, because of the current strategies seen worldwide, these matchloads are easily able to be pushed back and into our opponents goal. Nonetheless, having this ability to quickly score, especially against weaker opponents gives us a major advantage. Also, shooting is necessary for consistent and high scoring skills runs.
- **Wings**
    - Wings play 2 crucial roles on our bot, it allows us to score more Triballs into the net at once as well as allowing us to push multiple Triballs over the barrier. Being able to score more Triballs at once will increase our total score by being more efficient with our scoring, and being able to push Triballs over the barrier allows us to take away Triballs from the opposing alliance for us to score.
- **Climbing Mechanism**
    - Having a climbing mechanism has proven to be extremely powerful in our past iterations, as it allows you to score up to an additional 20 points within a matter of seconds. These points are especially useful as traditional match loading has started becoming obsolete, thereby increasing the value of these extra points.

Designed by:

Oliver Liu

Witnessed by:

Darien Ng

Identify Objective - Drivetrain

2024/01/6

Goal: Identify an objective for our robot so that we can build an effective drivetrain.

Problem Statement:

- Build a drivetrain to move around the field so that the bot can interact with game objects.

Solution Requirements:

- Must be constructed completely out of VEX Robotics Competition parts
- Must fit within an 18” x 18” x 18” cube
- Must work using at most 6 motors. We require at least two motors for other functions, such as scoring, intaking, shooting or other possible mechanisms.

Solution Goals:

- Traverse the length of the field in a fairly short amount of time.
- Be fairly lightweight
- Be able to fit under the horizontal bar and the goal.
- Have a small profile to easily maneuver accounting for the limited space on the field

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V3 - Drivetrain Select and Plan

2024/01/6

Focus: Build a clean, sturdy drivetrain that will allow us to effectively interact with game objects and support subsystems on our bot

One of the biggest priorities we had when brainstorming and designing a drivetrain was for it to be able to go over the middle barrier, and be fast enough to keep pace with opponents. One of the first issues we ran into was deciding on which type of drivetrain to use that would allow us to accomplish this goal. Based on previous discussions, we came to 4 different designs that we could use. The following drivetrains would be graded based on the following criteria:

- **Simplicity**
  - How simple is this drivetrain to build?
- **Speed/Maneuverability**
  - How fast can the Robot move and/or how well does it move side to side(strafe)
- **Torque**
  - How capable will the robot be in pushing objects or other robots.
- **Size**
  - How large/heavy is the Drive Train?

-	Simplicity	Speed/Maneuver-ability	Torque	Size	Total:
Tank Drive	5	4	4	4	17
X-Drive	3	5	3	3	14
H-Drive	3	5	4	3	15
Mecanum Drive	4	2	2	3	11

Final decision matrix comparing all 4 possible drivetrain types. ***Higher scores means better design.***

Based on the decision matrix mentioned above, we decided that a tank drive would best fit our priorities for our drivetrain type. This is because we believed it had a strong balance of everything, whereas many other drives had one notable flaw in their design. Additionally, this type of drive has been repeatedly proven to be effective, resulting in us using a tank drive for our bot.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V3 - Drivetrain Select and Plan

2024/01/6

With the type of drivetrain decided, the next issue we faced was the type of wheels we needed to use. Referencing back to our brainstorming at the start of the season, we mainly considered 4 different types of wheels we could use to fulfill these requirements, which will be graded on the following criteria:

- **Compactness**
  - How compact is this wheel?
- **Speed**
  - How fast can the robot move with these wheels?
- **Center of Gravity**
  - How will the size and weight of the wheel affect our center of gravity?
- **Pushing Power/Resistance**
  - How powerful or resistant are these wheels regarding pushing

	Compactness	Speed	Center of Gravity	Pushing Power/Resistance	Total:
3” Flex Wheels	4	1	3	4	12
3.25” Omni Wheels	4	3	4	3	14
2.75” Omni Wheels Wheels	5	2	5	3	15
4” Omni Wheels	3	4	2	3	12

Final decision matrix comparing all 4 possible wheels.

In the end, we ended up deciding on using 2.75” omni wheels. As they are much smaller, and allows us to run 4 wheels per side of the drivetrain as opposed to 3. As a result, it will much more evenly distribute the robot as it goes over the barrier, allowing it do so easily. They are also more compact, and the ability to have 4 wheels per side versus 3 allows us to avoid stacking our motors in order to drive all the gears between the wheels. Such considerations were a priority as we noticed the major drawbacks from our V2 robot.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Select and Plan - Drivetrain

2024/01/6

Gearing:

Given that speed is a priority in this game as it helps with being able to rapidly score/defend opponents, and has been a commonplace strategy amongst most teams, we need to be able to move quite hastily around the field. In our perspective, we found our drivetrain on our first robot to be around the right speed, where it was fast enough, but not too fast. However, since we are using smaller wheels, our RPM actually needs to be a bit higher.

For 3.25” omni wheels @ 5.67 ft/s via 400 rpm gearing, we’d want a similar ground speed of +- 15% or so.

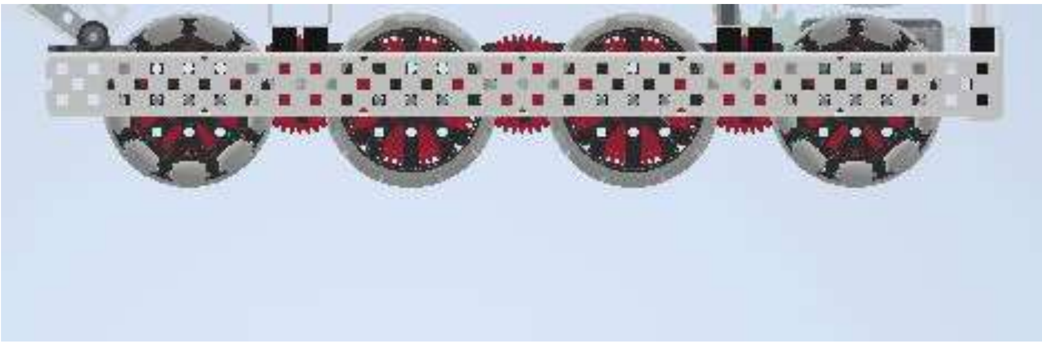
As a result, the main considerations are:

450 rpm, using **3:4** ratio on blue cartridges, **5.4 ft/s**

480 rpm, using **4:5** ratio on blue cartridges, **5.76 ft/s**

500 rpm, using **5:6** ratio on blue cartridges, **6.00 ft/s**

However, given the large size of the other gears, they actually will contact the ground instead of the wheels, which is a major issue. Furthermore, 3:4 ratio allows us to compactly gear the wheels together, allowing us to avoid large gaps between wheels, making it easier to go over the barrier. Thus, we chose a 3:4 ratio on blue cartridges. The CAD design of it is shown below.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

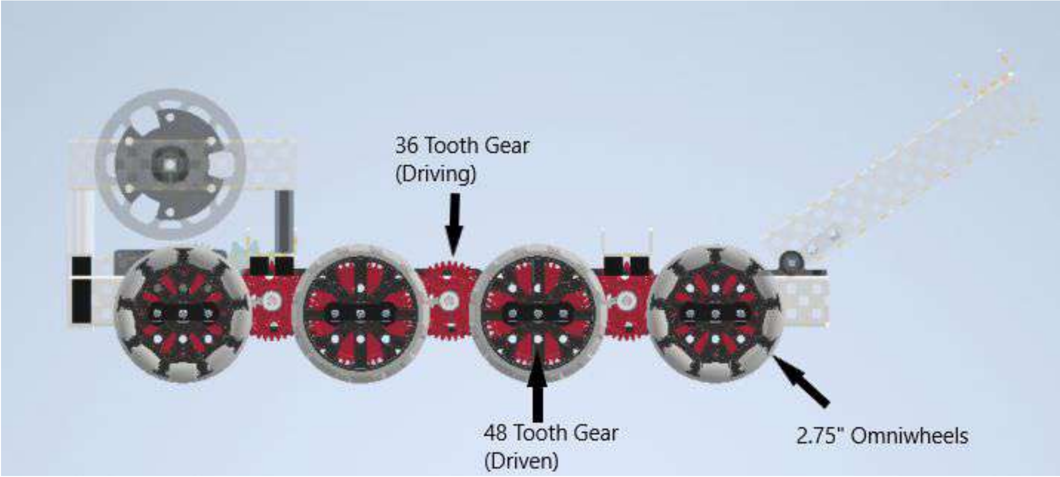
Select and Plan - Drivetrain

2024/01/6

With our combination of gears, wheels, and drivetrain type, we felt that this combination of a tank drive, 2.75” omni wheels, and a 3:4 gear ratio on 450 RPM would effectively complete our primary objectives in creating a drivetrain for our bot. There were multiple strategies and aspects we had to consider while designing this, which are the following:

- **Ability to push robots:** Having 6 motors and a reasonable speed allows us to effectively push most opponents.
- **Speed:** With our gearing and the size of our wheels, similar to our previous robot, we felt that it would sufficiently cover the speed we needed to be fast but remain some level of torque. Furthermore, 6 motors will make our robot accelerate faster, which is crucial in such a small field.
- **Sizing:** We thought that the gear ratios, wheels, and type of drivetrain used would allow us to fulfill our requirement of having a small bot to allow us to maneuver through the limited space on the field.
- **Simplicity:** This combination allowed us to create a simple yet efficient drivetrain to support our bot. It allows us to avoid stacking motors for 6 motor drive, freeing up space for other mechanisms.
- **Ability to go over barrier:** From our previous robot and testing, we found that 4 wheels, especially when smaller, allows the robot to tip less when going over the barrier, allowing it to do so smoother, which is heavily optimized with this drivetrain.

With our design in mind, we were able to start constructing our drivetrain base and prepared it for prototyping and testing.



Designed by:

Oliver Liu

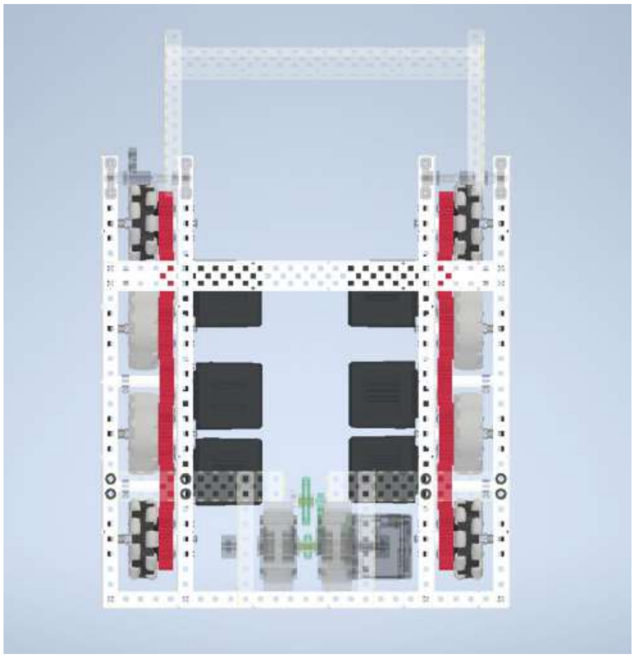
Witnessed by:

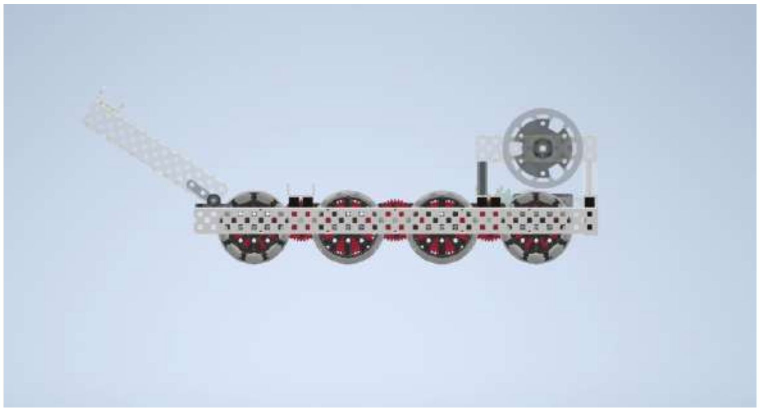
Matthew Zhang

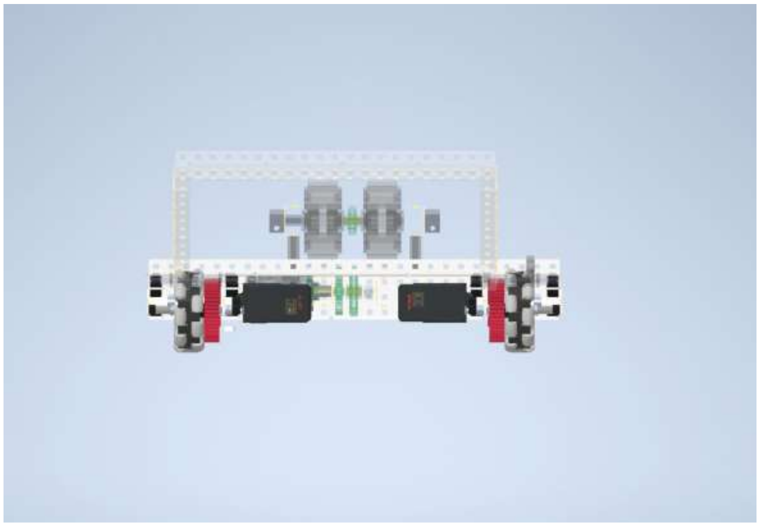
Designing - Drivetrain

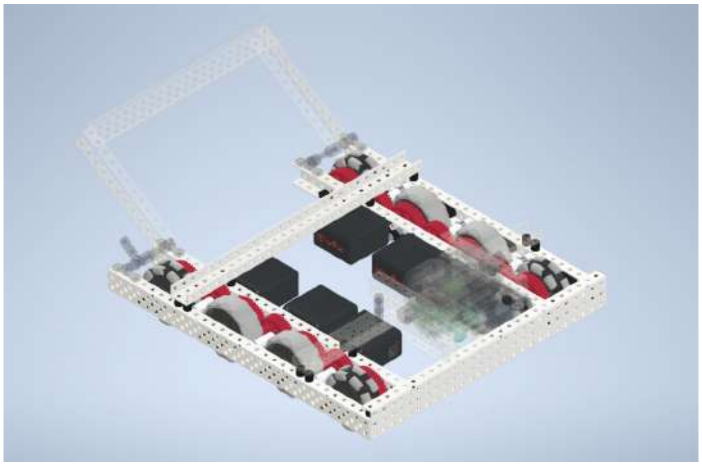
2024/01/7

Before we build our drivetrain, we used CAD to better determine the exact specifications, and allows us to quickly visualize the space we have to work with and/or any space conflicts.









Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Drivetrain - Adding traction wheels.

2024/01/8

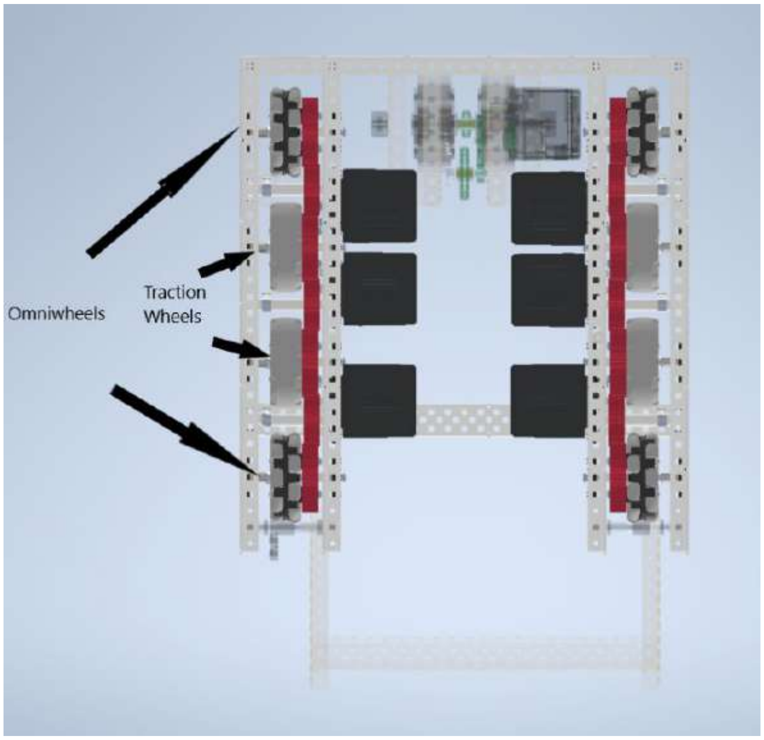
Issue:

We have noticed an issue with a lot of robots being easily pushed from the side, and also how robots have a tendency to ram into walls and objects when making fast, sharp turns due to drifting. Ramming against walls slows us down, and is suboptimal for the robot. Furthermore, we noticed with our last two robots that when we were turning to score into the goal, the robot had a tendency to slide, oftentimes hitting the sides of the nets.

For programming, we experienced small but noticeable amounts of drifting side to side in the robot, especially when it rammed against the the field elements, which made our autonomous inaccurate.

Solution:

The most straightforward and best way to stop sideways drift is through the usage of traction wheels. By placing traction wheels on the two middle wheels, it gives further amounts of grip and prevents sideways drift while also the middle wheels are close to the center of rotation so when turning, avoiding causing unnecessary friction when turning.



Designed by:

Oliver Liu

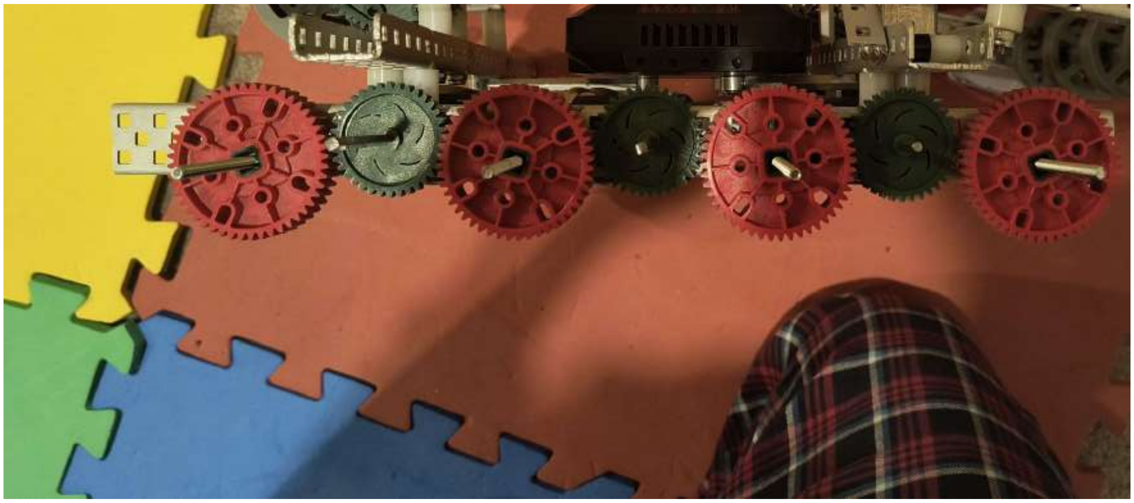
Witnessed by:

Matthew Zhang

Drivetrain - Build

2024/01/8

Due to an unexpected backorder of our wheels, we decided to work around this issue by building everything except the actual spacing for the gears/wheels, to save time for when the wheels arrive, and allow us to work on other components in the meantime. We've also added our brain mount, which is in the middle.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Identify Objective - Intake

2024/01/8

Goal: Identify an effective solution to create an intake that best suits our bot

Problem Statement:

Create an intake that will allow us to interact with Triballs on the field quickly and efficiently.

Solution Requirements:

- Must work using only 1 motor to allocate enough motors for other systems on the bot
- Must remain fairly light in order to reduce weight on the bot
- Must be constructed completely out of VEX Robotics Competition parts
- Must be able to easily and seamlessly pick up and place Triballs into the goal
- The intake must in some way be able to fit underneath 6 inches in height, as we need it to be low enough to go under the opponents goal and descore triballs.

Solution Goals:

- Using lighter materials and removing unnecessary components to optimize weight
- Allowing the intake to move up and down to easily pick up and place Triballs
- Have enough grip, speed, and torque to allow us to pick up Triballs while almost stationary
- Ensuring the intake is structurally sound to prevent damage from other bots

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Brainstorming - Intake

2024/01/8

Having seen new intake designs by other teams, we are considering some new methods of intaking triballs that we have not yet considered.

Rubber Flap Intake

Positives	Negatives
- Compact size compared to rubber band or larger flex wheel intakes. - Less likely to get entangled. - Flap intake is light.	- Possibly less consistent than rubber band or larger flex wheel intake - Flap could fall off in intense use - Flap could fold over time and decrease consistency - Compression limited by flap - Flap is compliant which could problemificate our intake

1.5’’ flex wheel intake

Positives	Negatives
- Compact size compared to rubber band or larger flex wheel intakes - Less likely entangled when colliding with other robotics - Lighter than larger flex wheels	- Heavier than rubber band intake - Flex wheels are possibly too grippy and may put too much stress on the motor when the triball is stored.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Brainstorming - Intake Cont.

2024/01/8

Having seen new intake designs by other teams, we are considering some new methods of intaking triballs that we have not yet considered.

Rubber band intake

Positives	Negatives
- Simple and light construction due to simple usage of just two sprockets - Compliant and is able to easily hold the triball without putting too much stress on the motor. - Easy to modify and prototype with.	- Takes up more space then most intakes, as sprockets need to be reasonably big, and the rubber bands cover the entire intake roller. - Likely to get entangled. (can be mostly mitigate through wrapping it in nonslip) - Rubber bands like to break, causing issues.

Flip out intake

Positives	Negatives
- Has longer reach and better control then other intakes. - Only requires a single bar to implement, simple. - Can be powered by a single piston and no motor. - Leaves more room for more mechanisms - Easy deployment to stay in size.	- Can not tunnel - Can't push triballs outside of intake. - Susceptible to ramming, supported by a single joint whilst protruding more.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Select and Plan - Intake

2024/01/8

Focus: Build a smooth, fairly lightweight intake that will allow us to easily manipulate game objects.

From our previous brainstorming, these intakes are likely the best options for us, and we will be comparing to decide which one to use based on the below criterion.

- **Smoothness/Speed:** Is the intake able to easily pick up and place Triballs without many stops or needing to slow down?
- **Consistency:** Is this design able to consistently pick up Triballs every single time?
- **Weight/Size:** How does each design impact the overall weight of the intake and bot?
- **Strength:** Is the intake able to withstand the force of other bots without breaking?

	Smoothness/ Speed	Consistency	Weight	Strength	Total:
Rubber Bands	4	3	4	3	14
Small Flex wheel	5	5	3	5	16
Flap-Intake	3	2	3	4	12
Flip-out	3	2	3	2	9

Final decision matrix comparing all 3 types of intakes.

After some consideration, we ended up deciding that flex wheels would be the best contender for our intake. As shown in the decision matrix above, flip-outs are far too slow and inconsistent for us to consider using on our intake, since a main priority for our intake is speed. When deciding between rubber bands and flex wheels, the main factor that ended up determining our design choice was the strength. Although flex wheels are slightly heavier than rubber bands, brief tests showed that rubber bands were less consistent than flex wheels, and that the possibility of the rubber bands breaking during a match was a risk we didn't want to take. Small flex wheels also can act as a ram cushion, further reducing chances of bending/breaking anything when encountering defense. Flex wheels are also more compact, an additional factor that made them better then rubber bands.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Select and Plan - Intake

2024/01/8

Another key step to deciding our intake aside from it's type, is how fast we want it to be.

- **Grip/Torque:** Is the intake able to easily grip and intake Triballs?
- **Consistency:** Is this design able to consistently pick up Triballs every single time?
- **Speed:** How fast can this RPM amount intake Triballs?
- **Compactness:** How do the different gear ratios impact the size of the gearing?

	Grip/Torque	Consistency	Speed	Compactness	Total:
400 RPM (2:1, Green)	3	4	4	5	16
600 RPM (3:1, Green)	2	3	5	4	14
300 RPM (3:1, Red)	4	4	3	4	15
266 RPM (4:3, Green)	5	4	2	2	13

Final decision matrix comparing all 3 types of intakes.

We found that 400 RPM on a 2:1 gear ratio with green cartridges was the perfect balance between speed and torque, allowing it to consistently intake Triballs at a reasonable speed. Another factor that drove us to using this RPM amount was its compactness, as achieving a 2:1 ratio is easier compared to the other options on this table. This way, we can run a 12 tooth to a 6 tooth sprocket, and a 6 tooth sprocket is the only size that can avoid protruding out when on the same axle as the small 1 ⅝ inch diameter flex wheels.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Select and Plan - Intake

2024/01/8

One final thing when considering how we design the intake is the way we mount the motor to power it.

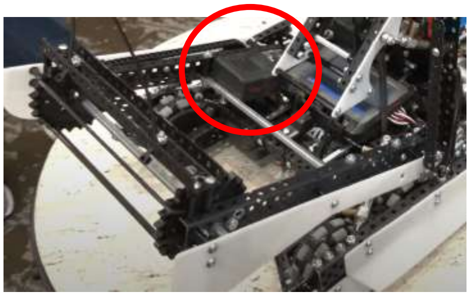
Direct Mount

A direct mount would mean a motor directly connected to the axle of the intake wheels, at the end of the intake. Although simple, and mitigates issues like chain snapping, it causes the motor itself to overhang outside the plane of the robot, making it susceptible to being rammed. This issue can be a major problem as our motor make break when encountering defense or when we are trying to push triballs under the goal.

Example from team 21417A

Staggered Mount at base of intake

A staggered mount allows us to hide the motor within the base of the intake beam, however a major drawback is that it forces us to build a longer intake beam, or otherwise, the triballs would collide with the motor and not successfully be held in the robot. Overall, although keeps the motor and the entire intake inline, it sacrifices a lot of space for other mechanisms on the robot.



Example from team 5203G

On top

By placing the motor on top of the intake flex wheels, and chaining it down, we would mitigate the issue of the motor getting rammed, while also it does not require as much space for the intake, as the motor does not get in the way of the triball in any way. One issue though is the excessive height it creates, and may prevent us from being able to fit under the goal, which is a major issue.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

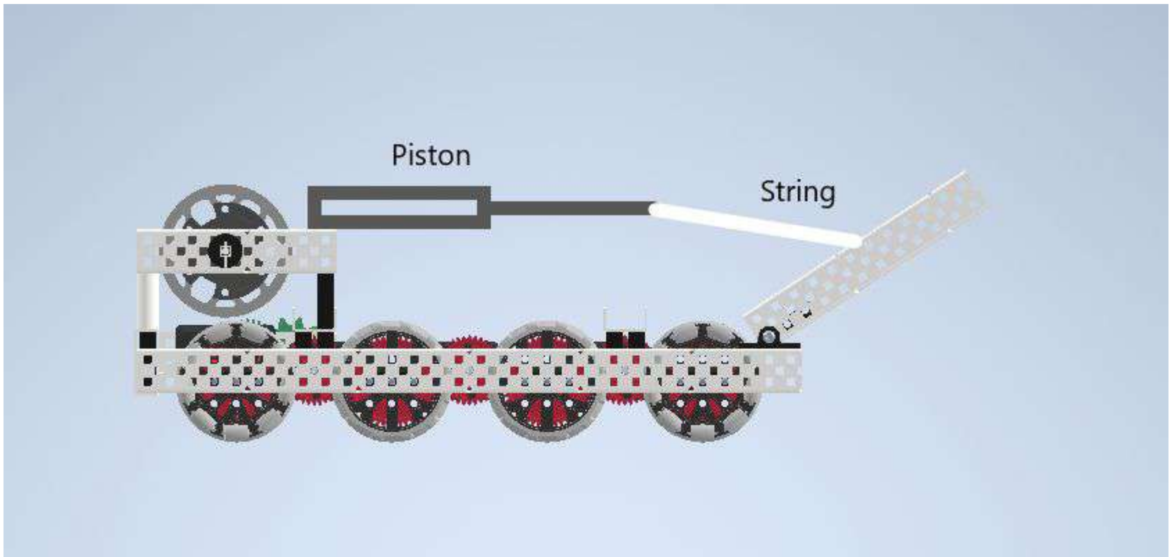
Intake Flip-Down

2024/01/8

One issue we encountered is the intake needs to be high enough to have triballs go underneath it, however, by doing so, the intake is now too tall to fit under the goal easily. To solve this problem, we decided to have the intake “drop down” when we are descoring. This way, we are able to easily go under the goal by having the intake sit at a lower resting position.

To do this, we are considering a piston that pulls the intake up so that it can be at a suitable height to reliably grab triballs. However, a direct piston mount stops the intake from going up whenever it intakes or is putting triballs into the goal. To solve this issue, we are going to use rope, or another item that is only tensioned one way, allowing us to pull the intake up into a position to grab triballs, while still having slack to allow it to move even farther up to actually score/grab triballs, and allowing it to act the same way as normal intakes do. When we release the piston, the intake will drop down low enough to fit under the goal, allowing us to descore with ease.

Below is a side view of the CAD design for our robot with the piston and string for our “drop down” intake is drawn in. When the piston is retracted, the string will pull the intake up and when the piston is extended, the string will allow the intake to drop down.



Designed by:

Oliver Liu

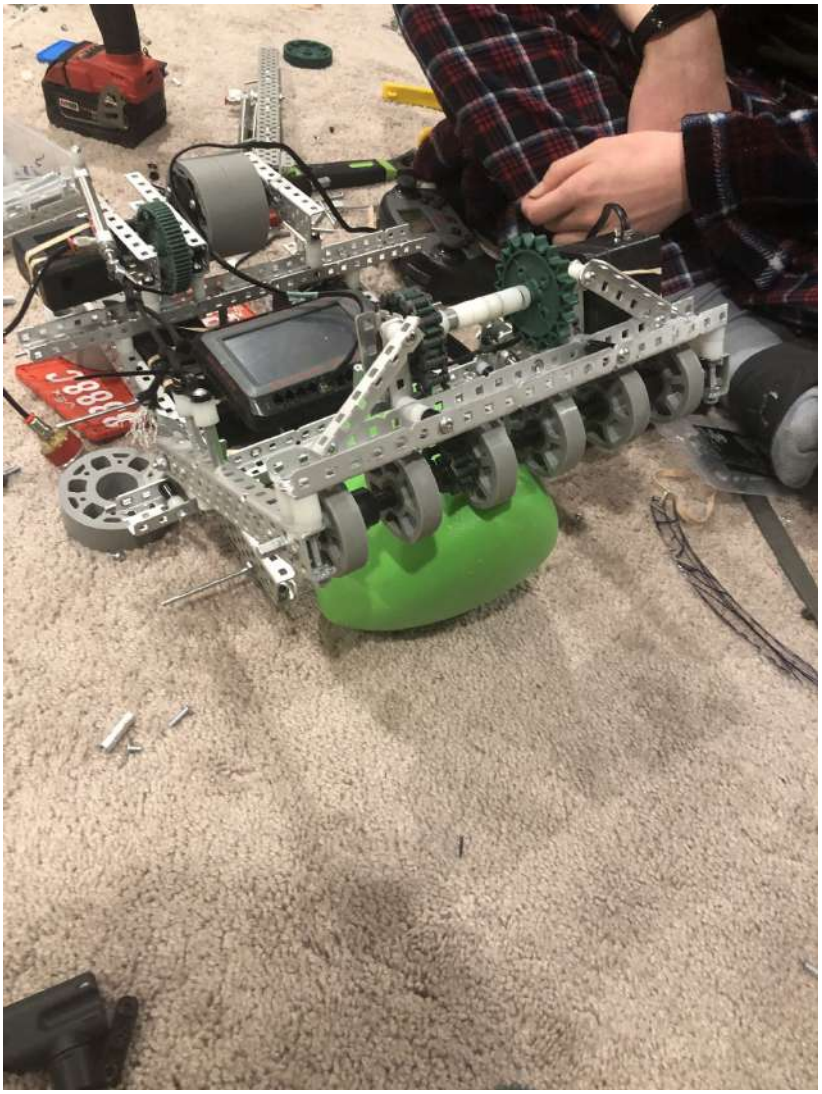
Witnessed by:

Matthew Zhang

Build - Intake

2024/01/9

To start, we decided on mounting our intake on top of 2 c-channel couplers placed on top of one of our drivetrain braces, as we figured it would be a small yet sturdy location to mount our intake. On the two couplers are 2 c-channels mounted via screw joints to allow them to freely rotate, connected by a c-channel brace on the top. We threaded our axle and flex wheels underneath this bracing and mounted our motor using vertical c-channel attached to this cross-brace. We used a 12 tooth and 6 tooth sprocket using green cartridges to achieve an RPM of 400. An image of our intake can be seen below.



Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

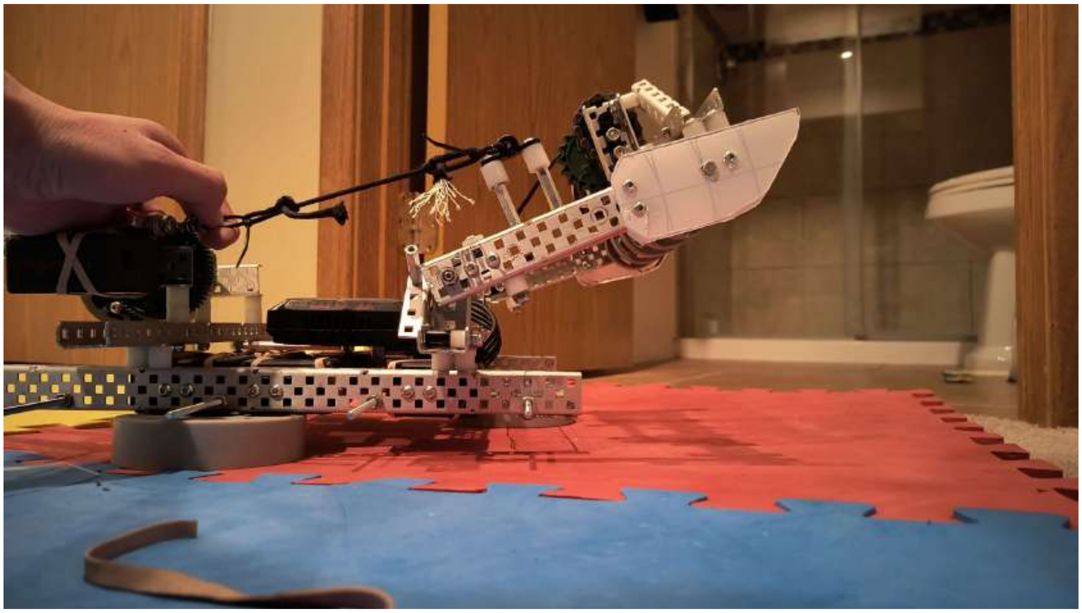
Build - Intake

2024/01/10

With our intake, an issue that we ran into was that our intake needed to go above the goal to score Triballs, but also had to go underneath the goal to allow us to still descore. To solve this problem, we needed a method of lifting the intake up and down to accomplish both of these tasks.

Since we had no spare motors left, this meant that we needed to lift the intake using only pistons. However, if we had just mounted the piston directly onto the intake, it wouldn't provide it with any slack, meaning that the intake would not be able to lift up fully before it scores. We decided on connecting the piston indirectly using string. By doing this, it still allowed the piston to control the intake, but it also provided enough slack to allow the intake to freely move up and down. Information on the design is included on page 169.

We decided on mounting the piston near the back of the bot by our flywheel on a screw joint. We then added a pillow bearing on top of the intake, and tied a piece of string connecting the two, allowing us to control the intake. An image of the completed mechanism is shown below.



In addition to our piston mechanism, we also added some lexan sleds on the side of the intake to allow it to smoothly ride up the net to score Triballs more fluidly.

Designed by: Matthew Zhang

Witnessed by: Oliver Liu

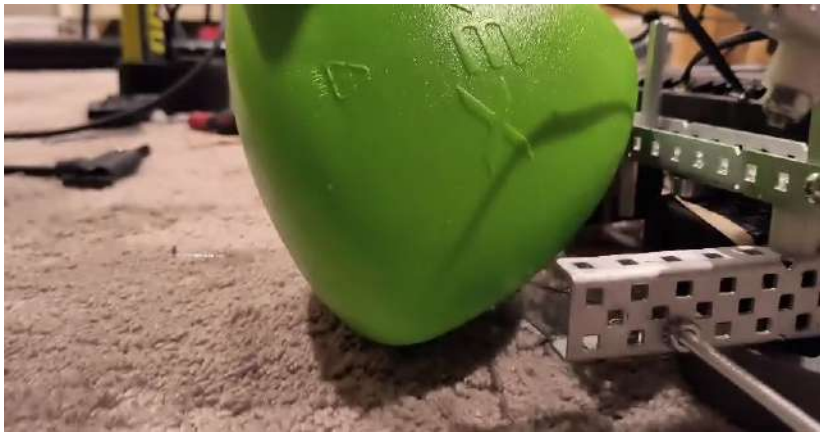
Testing - Intake

2024/01/11

When we began testing our intake, we first tried placing Triballs in different areas with different orientations to ensure the intake could consistently grab Triballs no matter where they are placed. Initially, testing was going smoothly, as we found that it was able to pick up Triballs almost all the time. One issue we found, however, was that if a Triball is placed on the far ends of the intake, Triballs could sometimes ride up the side of the intake and cause it to lift the intake rather than being stored within the bot.

The main issue we found was that depending on the orientation of the Triballs when it is intaked, it could sometimes not be fully held by the lexan beneath it, causing the Triball to drag on the ground, which could reduce consistency and cause the Triball to fall out.

We believed that, to fix this, we could increase the area of the lexan holding the Triball up, allowing the Triball to be fully supported instead of half of the Triball being supported, which is what we have now. We could also figure out a way to create a sort of backboard to re-orientate the Triball into a more favourable position. To do this, we thought of bending a piece of lexan to create a curved surface, like we did in our V1 bot, or by placing standoffs to try and wedge one of the corners of the Triball into a good position.



During this time, we also began testing our piston to elevate our intake. With a bit of tweaking of the string, we were able to consistently lift of our intake up and down while allowing it to still freely swing. We found that, even with low PSI, we were still able to lift our intake.

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Testing - Intake

2024/01/11

With our intake, we also tested out different holsters to contain the Triball. We started out with a curved, thin piece of lexan (illustrated on the left) to contain the Triball. We believed that this shape could help hold the Triball more securely, but due to a lack of space, we did not find this happening. In addition, due to its thin shape, it made it much easier for Triballs to slip out.

For our second iteration, we decided to go with a simple rectangular shape (illustrated on the right). We hoped that this would help increase the surface area, preventing Triballs from slipping out as easily. Although we did find an improvement with this design, Triballs were still touching the ground occasionally due to a lack of space. In the future, we could potentially move the holster further forward to prevent it from touching the ground.

Designed by:

Matthew Zhang

Witnessed by:

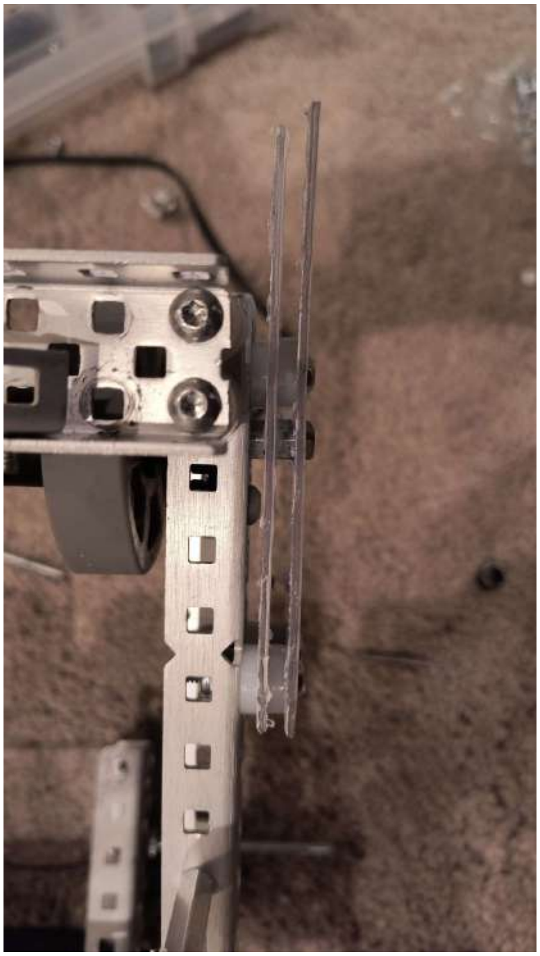
Darien Ng

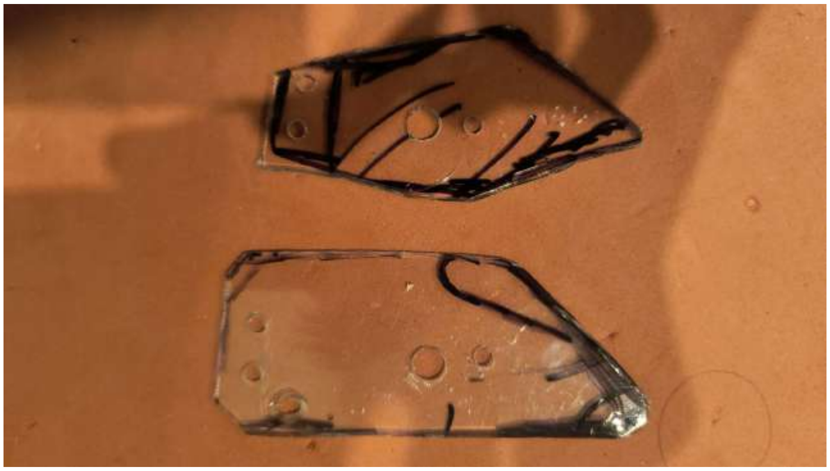
Testing - Intake

2024/01/11

While testing our intake, we also tested the sleds used for riding up the net. As seen from the picture below, we tried out two different shapes for our sleds. When testing the two out, we saw that the shape on the bottom was more consistent, as the part that was contacting the net was longer, allowing it to more consistently impact and then ride up the goal.

In addition, we initially tested our sleds with only one layer of lexan. During our testing however, we realized that this piece of lexan could sometimes bend if we impacted the net too hard. To fix this, we simply doubled the thickness of the polycarbonate, preventing it from flexing in the future.





Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Intake - V2

2024/01/12

Today we brought the robot to the field to test, and quickly we found some structural issues with the intake.

1) The intake mount was too forwards, such that it was the foremost of the robot when the intake was in the “dropped” state, which meant when we drove into things, the unbraced c channel motor mount took the impact, causing it to bend inwards, jamming the rollers.
2) The intake C-Channel that connected the two sides across was unboxed, and also began to crumple inwards from external forces such as ramming.

To fix these issues we decided to first triangle brace the front connecting c channel, as it better distributes the load of any forces, and prevents bending and increases the strength of the intake. Also, we decided to box the connecting c channel, to help prevent crumpling and damage.

Another thing we noticed was that the motor mount when in the dropped state, would overhang past the connecting c channel, meaning the motor mount took the force of ramming, which is something we do not want. As a result, we staggered the mount back more by a quarter of an inch, and thereby protecting it with the now boxed and braced front connecting c channel.

When testing it at the field, we found that it held up without a problem and we are quite satisfied with it.

Designed by:

Matthew Zhang

Witnessed by:

Darien Ng

Identify Objective - Delivery

2024/01/9

Goal: Identify an objective for our robot so that we can build an effective triball delivery mechanism

Problem Statement:

- Build a mechanism to to launch triballs from matchloads to the offensive zone for rapid scoring.

Solution Requirements:

- Must be constructed completely out of VEX Robotics Competition parts
- Must fit onto the robot in a way that it fits within 18” x 18” in length and width, while also being under 6” in height to allow descoring.
- Must work using at most 1 motors. We require 6 for the drivetrain and at least 1 motor for the intake.

Solution Goals:

- Consistently send triballs with high accuracy.
- Launch triballs far enough that they end up in our offensive zone.
- Be fairly lightweight
- Be able to fit under the horizontal bar and the goal.
- Leave space for the intake mechanism and other components.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Brainstorming - Delivery

2024/01/9

Goal: Brainstorm different methods and configurations to successfully make a delivery mechanism.

Given that the current strategies focus on avoiding match loading due to the fact that match loads can be easily pushed to the other side, it is not a priority to have a delivery mechanism that is unblockable, as chances are, we will be simply tunneling or grabbing them one at a time. Instead, delivery mechanisms are more so for convenience and advantage against weaker opponents, and more importantly, for being able to quickly and effectively scoring all 44 match loads during skills. As a result, we are prioritizing consistency and space, since we need our robot to fit under 6” for descoring.

Kicker

Positives	Negatives
- Relatively compact size - Prevents risk of imparting force into triballs when match loading - Able to place in a consistent spot, allowing for possibly more consistent shooting - Lightweight	- Requires layering of gears, which may take up a lot of space - Requires strong bracing due to forces of the kicker.

Flywheel

Positives	Negatives
- Does not require too much gearing due to lack of slipgear. - Simple and overall does not require too much space asides from the flex wheel itself. - Able to have different shooting arcs by placing the triballs in different places.	- Flex Wheels are rather heavy - Requires more space for the wheel itself - Possibly inconsistent in matchloading due to minor variation each time when matchloading.

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Brainstorming - Delivery Cont.

2024/01/9

Catapult

Positives	Negatives
- Capable of securely holding triballs when launching, making it hard for opponents to defend against via ramming. - Consistent shooting arc. - Capable of very high arc shots.	- Takes up a lot of space - Slightly harder to match load into. - Rather heavy. - More susceptible to breaking then Kickers, due to the amount of weight from the catapult itself as it moves.

Puncher

Positives	Negatives
- Compact size - Lightweight - Possibly decent arc if implemented well.	- Slow drawback - High friction due to VEX linear slides - Weak power may not consistently allow triballs go over the barrier. - High tendency to break.

Turbine(similar to flywheel except it's a stick that hits the triballs instead of a flex wheel.)

Positives	Negatives
- Fast - Lightweight - Compact storing, capable of resting in a slim profile position.	- Inconsistent due to chaotic nature of mechanism. - Dangerous - Requires a lot of space for the turbine to rotate.

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Select and Plan - Delivery

2024/01/10

Goal: Determine a method that allows us to deliver matchload triballs.

- **Speed or shooting**
  - How fast can it shoot
- **Size factor**
  - How much space will it take on the robot
- **Consistency/accuracy**
  - How can the robot shoot accurately and how well does it repeat this task
- **Strength/Reliability**
  - How strong/how likely is it to not fail or break.

Ranked out of 5, higher is better quality

	Speed	Size Factor	Consistency/ Accuracy	Strength/ Reliability	Total:
Flywheel	5	3	3	5	**16**
Catapult	2	2	4	3	11
Puncher	2	4	3	2	11
Kicker	4	3	4	4	15
Turbine	5	3	2	2	12

Final decision matrix comparing all 5 shooting mechanisms

Based on our findings from the chart, we have concluded that the Flywheel is the most suitable delivering mechanism for our robot. Kickers require more complicated gearing, something that is not favourable in our robot, which needs to fit under 6 inches, ie, it is very compact. Although flywheels are slightly worse in consistency, it is possible we make some sort of ramp or aligner that allows us to place the triballs consistently each time, allowing for consistent arcs and thus, more consistent grouping.

We will be going with a 3 inch flex wheel, as from our previous two robots, is the most consistent/compact.

Designed by:

Matthew Zhang

Witnessed by:

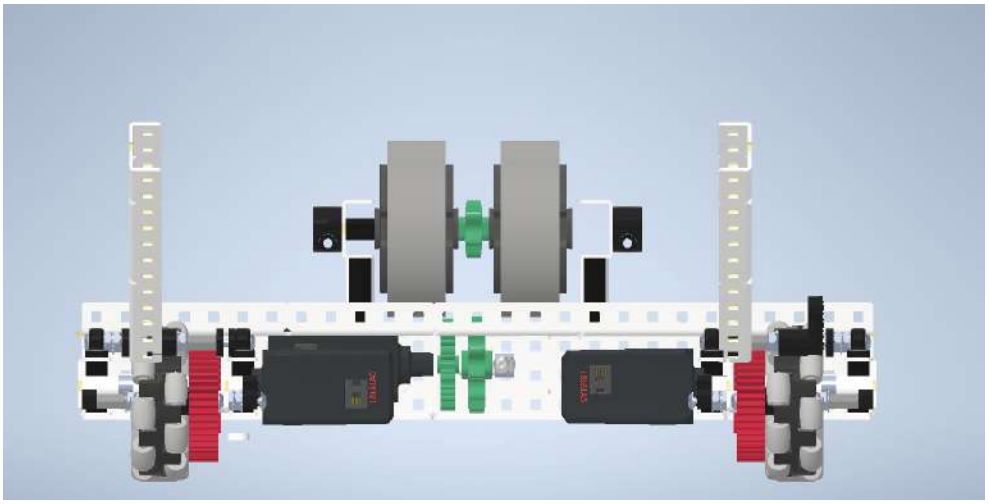
Oliver Liu

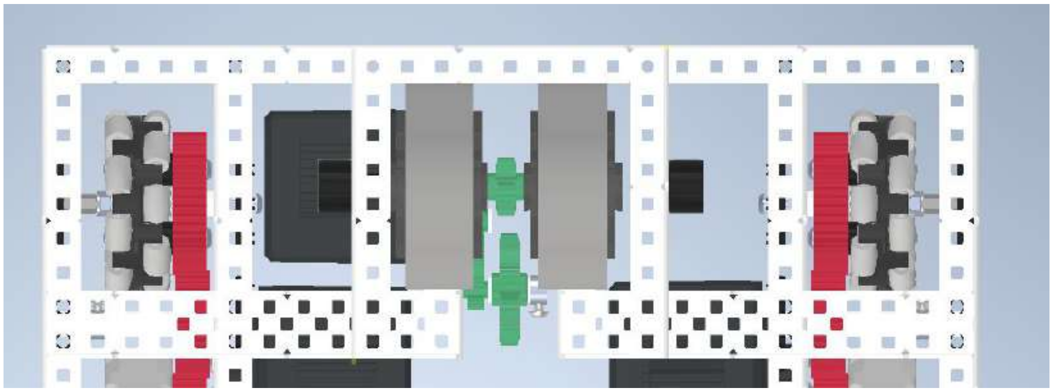
Designing - Flywheel

2024/01/10

The flywheel for our robot will be done using a 1:3 ratio through chain, compounded with an additional 1:2 ratio by sprocket, giving a total 1:6 ratio from a blue cartridge at 600 rpm, resulting in a total rpm of 3600 rpm on a 3 inch 45A wheel. This combination should give us enough speed, and by compounding it, it will allow us to easily save space for other mechanism in our small size constraints.

The CAD drawing of it is shown below.





Designed by:

Oliver Liu

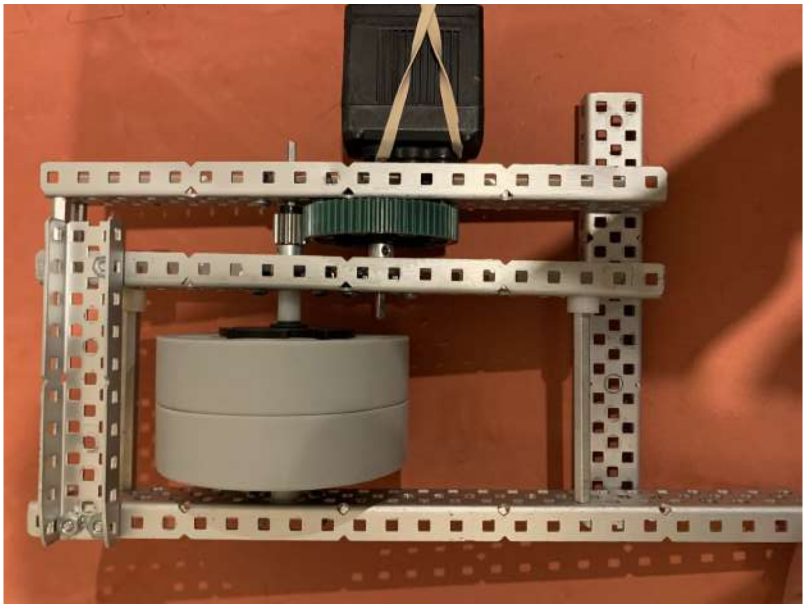
Witnessed by:

Matthew Zhang

Building - Flywheel

2024/01/12

One issue we found when we were building the design was the lack of overall structural rigidity to the robot, as one of its major braces was split down the middle. Furthermore, the space for the chain to fit through is very tight, and may cause high amounts of friction. Lastly, the mechanism as a whole takes up a bit more space then we would like, as a result we actually prototyped a more simple mechanism separately.



In the above design, we have a separate layer, allowing us to easily stagger the gearing, this way, we only require two gears and a overall more simple and structurally stable design for the flywheel. Working from this prototype, we will be adding a more compact version of it to the robot.

We also changed the gearing down to a 5:1, as it is slightly slower, but the exact rpm as our previous two robots, and from prior experience, 3000 rpm is able to consistently clear the middle barrier, whilst also not being too powerful, which is good, as it helps conserve energy.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Building - Flywheel

2024/01/12

In the image below, we have managed to fit the flywheel onto the robot, at the back, leaving space for the intake and other mechanisms. Additionally, the motor does not overhang over the plane of the robot, as the wheels/outer braces are not yet in place. Also, we now have space below the flex wheel and flywheel mount for other mechanisms, or our pneumatics, including our reservoir.

We have also wired up the flywheel, and ran it to 3000 rpm. The torque and power draw charts showed that the flywheel was relatively low on friction, which was likely due to our method of constructing it. We used high strength axle on the flex wheel itself, as it does not bend at all, and is able to be near perfectly straight, reducing wobble and friction, especially at 3000 rpm.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Flywheel Testing

2024/01/14

Since we had already built a flywheel for both of our previous bots, we were fairly confident in the abilities and potential of a flywheel shooter. Especially, with our testing on Pages **63-67, 83**. Along with the three full tournaments and one league qualifier, where in all of those, we extensively and consistently used the same type of flywheel. Regardless, we decided to test it out, as our flywheel was mounted much lower and could interfere with Triballs consistently crossing the barrier.

For our testing, we created a setup that replicated the dimensions of an actual field. We placed our bot around 3 tiles away with a PVC pipe in the middle, representing the barrier. After a bit of practice, we achieved the results shown in the bottom picture. Each spacer represents where the Triball landed, not where the Triball ended up after rolling around. After this test, we found out that our flywheel was able to shoot over the barrier almost every time with high accuracy.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Identify Objective - Wings

2024/01/8

Goal: Create a mechanism that will act as an extension of the robot to allow us to push in Triballs into the net and over the barrier more effectively

Problem Statement:

- Build wings to attach on the side of our robot that can flip out to push Triballs in more quickly and effectively

Solution Requirements:

- Must remain in the horizontal expansion limit of 36”
- Must be completely powered by pneumatics
- Must be constructed out of legal VRC parts
- Must be rigid enough to withstand the force of Triballs and potentially other robots
- Must remain fairly light
- Must be able to flick Triballs over the barrier

Solution Goals:

- Adding pieces of lexan angled upwards to help push Triballs over the barrier
- Using lighter materials to help reduce weight
- Using pistons to swing out and retract wings
- Giving the wings a slight amount of give to allow it to flick Triballs more effectively

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Designed by: Oliver Liu

Witnessed by: Bolo Wang

Select and Plan - Wings

2024/01/8

Goal: Determine a suitable design for our wings that allow us to push Triballs over the barrier and into the net.

- **Pushing Triballs into the net**
  - How well does this design push Triballs into the net to score them?
- **Pushing Triballs over the barrier**
  - How well does this design push Triballs over the barrier?
- **Simplicity**
  - How simple is this design to build?
- **Spacing/Compactness**
  - How space efficient or compact is this design?

	Net	Barrier	Simplicity	Spacing/Compactness	Total:
Vertical Wings	5	3	3	4	15
Front Wings	3	5	4	5	17

- **Spacing/Compactness**
  - How space efficient or compact is this design?
- **Effectiveness**
  - How effective can this design be?
- **Weight**
  - How will each design impact the overall weight of the bot?
- **Simplicity**
  - How simple is each design to build?

	Spacing/Compactness	Effectiveness	Weight	Simplicity	Total:
1 Set of Wings	5	2	5	5	17
2 Sets of Wings	3	5	4	4	16

Designed by:

Oliver Liu

Witnessed by:

Bolo Wang

Select and Plan - Wings

2024/01/8

Goal: Determine a suitable design for our wings that allow us to push Triballs over the barrier and into the net.

- **Pushing Triballs into the net**
  - How well does this design push Triballs into the net to score them?
- **Pushing Triballs over the barrier**
  - How well does this design push Triballs over the barrier?
- **Simplicity**
  - How simple is this design to build?
- **Spacing/Compactness**
  - How space efficient or compact is this design?

	Net	**Barrier**	**Simplicity**	**Spacing/Compactness**	**Total:**
Locking Wings	5	4	3	5	17
Non-Locking Wings	3	5	5	5	18

Based on the 3 decision matrices, we decided that having 1 set of non-locking front wings would best suit our bot. Since we wanted to put more emphasis on pushing Triballs over the barrier rather than scoring them, we wanted to ensure that the design we chose could accomplish this. Having non-locking flip-out wings is the best for this, as the slight give it provides can actually help flick Triballs over rather than a sturdy wing.

In addition, we decided on only having 1 set of wings. On our previous bot, we rarely found ourselves utilizing both sets of wings. However, due to us having a descore bot, we needed to efficiently use our space, leading us to decide against having two sets of wings. This is also partially why we were against vertical wings, as to mount them, you would need towers to mount them on. Since our bot needed to stay under 6 inches to descore, having vertical wings was something we could not do on this bot.

Designed by:

Oliver Liu

Witnessed by:

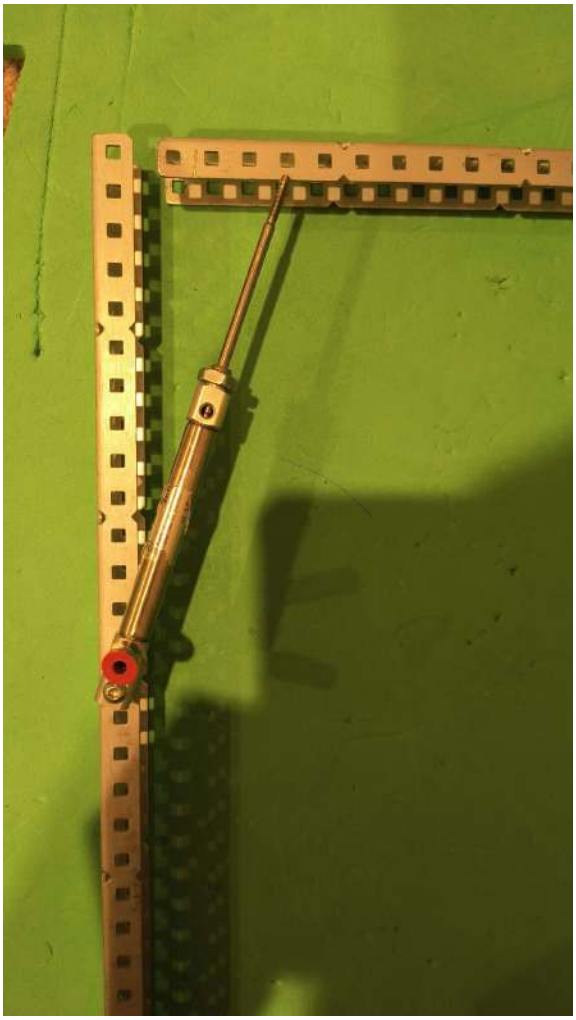
Bolo Wang

Design and Build - Wings

2024/01/12

When creating our first iteration for our wings, we decided on mounting the piston on a screw joint on top of the drivetrain, with the wing hinging around a custom piece of lexan. This mounting is quite similar to our first bot. However, we were afraid that the lexan could eventually snap if used extensively.

Regardless, we began constructing this design, mainly to learn improvements for the future as well as to test out the strength of non-locking wings.



When we built this design of wings, we noted down the spacing needed to ensure that the wings extend to 90 degrees to avoid double possessing. We also tested out the strength of the wings, and found out that they were more than strong enough to push Triballs over the barrier and score them into the net.

Designed by:

Oliver Liu

Witnessed by:

Bolo Wang

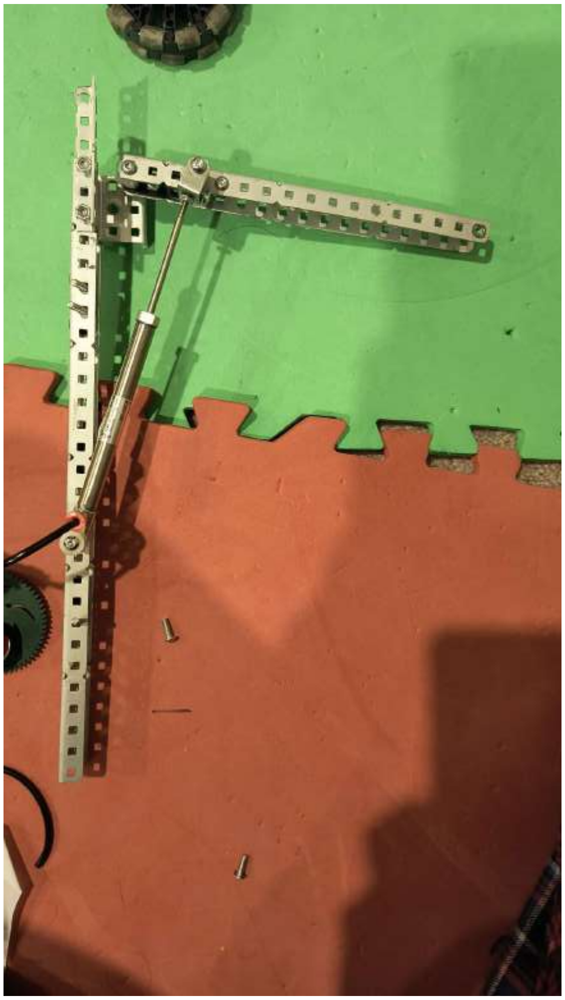
V2 - Wings

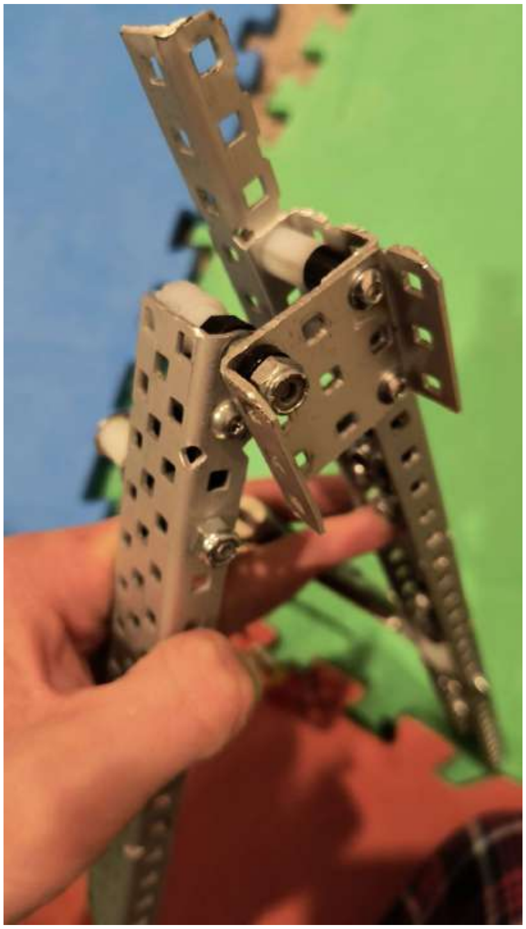
2024/01/15

For version two of our wings, instead of mounting it on a piece of lexan, we decided to use a 3-wide c-channel mounted underneath our drivetrain to place our wings. With the information gathered from our previous iteration, we were able to create wings that were straight, collapsed neatly within the bot, and extend to a perfect 90 degree angle.

With these new wings, we found that it was able to resist multiple Triballs, and when adding a custom piece of curved lexan, it was able to push Triballs over the barrier consistently.

When building the wings, we mounted the piston and the point the c-channel hinges around using screw joints to reduce friction. We also drilled out and added pieces of lexan onto the wings to help with pushing Triballs over the barrier. Images of one of the wings during the build process is shown below.





Designed by:

Oliver Liu

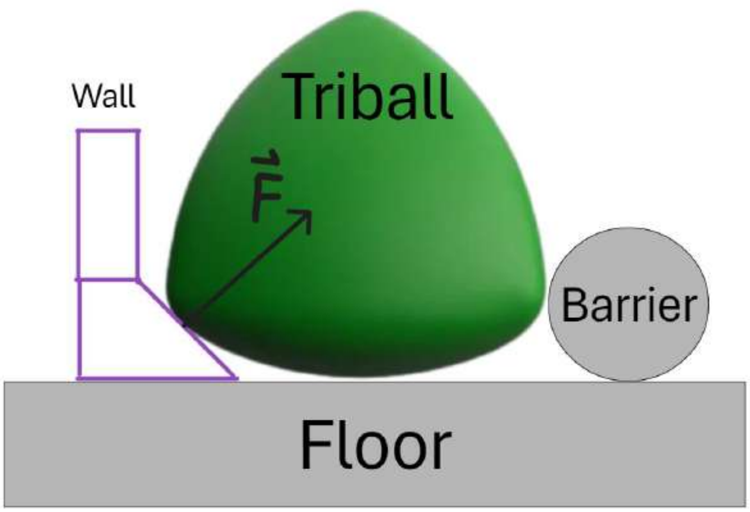
Witnessed by:

Bolo Wang

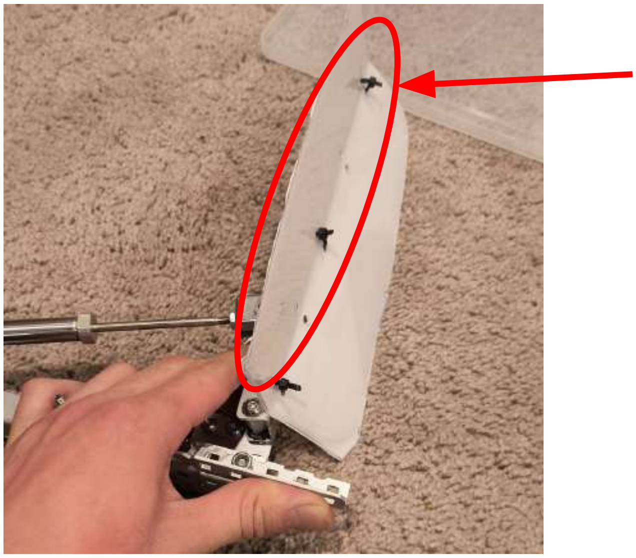
Testing - Wings

2024/01/15

From the knowledge we gained from our previous robots, we decided that having curved lexan allows us to effectively flick triballs over the barrier, while also allowing us to still push triballs into the goal. The below diagram, referenced from page 130, explains why have an angle at the bottom is necessary for it to easily push triballs over the barrier.



Furthermore, we also added a “wall” on top of the wing, as from testing with our previous iterations from our previous robot, we found that sometimes triballs would go over the wings, instead of getting pushed by them. The wall top portion increases the height and should mitigate this problem.



Additional wall part at the top.

Designed by:

Oliver Liu

Witnessed by:

Bolo Wang

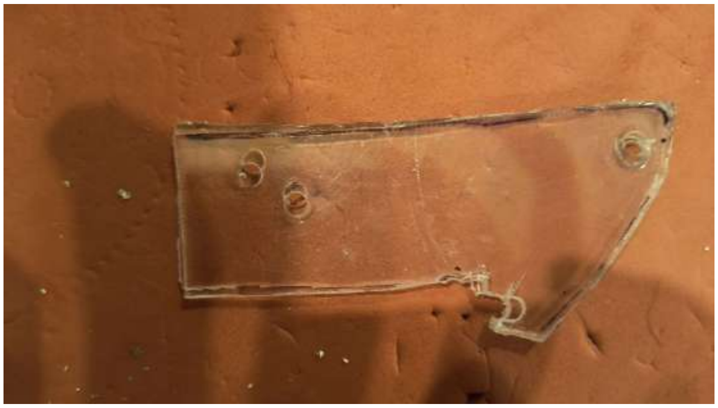
Sleds - Going over the barrier

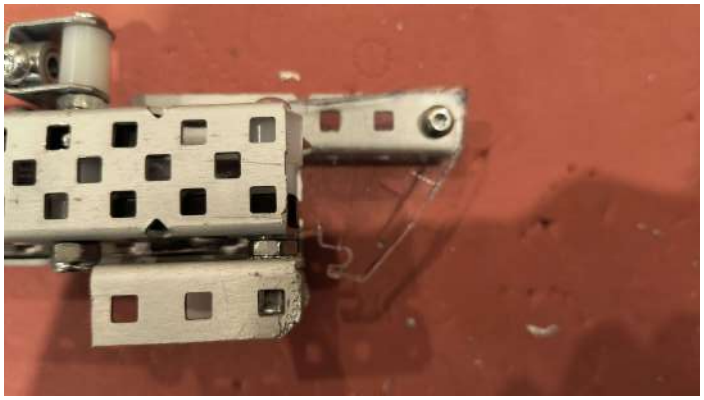
2024/01/15

Our team believed that being able to go over the barrier was extremely important in a game like this, where much of the field is restricted by barriers. It greatly increases the amount of movement options for our bot, being able to score and defend faster and go to the other side even if both sides are being blocked.

To go over the barrier, we needed a way to initially bring the bot up for it to be able to drive over the pipe. To do this, we used a curved piece of lexan, similar to the ones on our intake. These sleds allow the bot to ride up the PVC pipe, and with some momentum, is able to push the majority of the bot over. From there, once the center of gravity is over the pipe, it allows the bot to tip over and land on the other side.

We decided on mounting this on either side of the drivetrain on the front, where the center of gravity leans towards. By drilling holes and mounting multiple layers onto either end as seen below, we were able to cross the barrier with a bit of momentum.





Designed by:

Matthew Zhang

Witnessed by:

Darien Ng

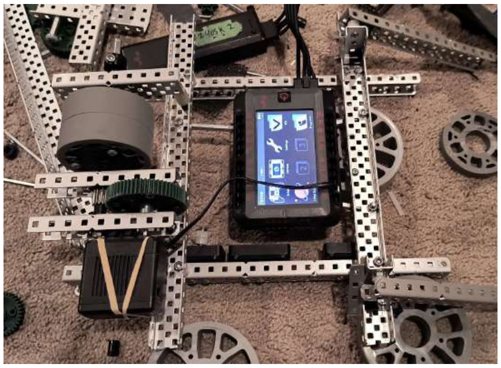
Placements

2024/01/16

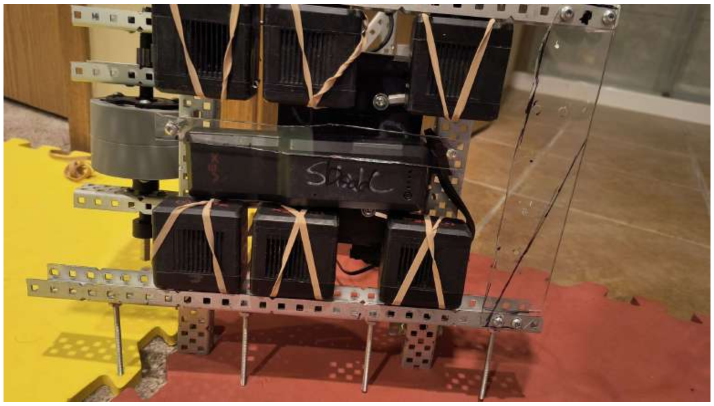
Goal: Determine placements of the Brain, Battery, and pneumatic reservoir for optimal space/CoG.

For our placements, we wanted to lower our Center of Gravity as much as possible, as that helped us not only get over the barrier, but also avoid getting flipped over. Also, when going over the barrier, from our testing, we found that having the Center of gravity near the middle, or a bit towards the front where the sleds where is preferred. This way, less than half the robot needs to tilt upwards onto the barrier before it's center of gravity allows it to naturally rotate forwards, letting its front wheels touch the other side and quickly cross.

To do this, we placed the brain in the middle, as it was accessible and fairly low.



Additionally, since the battery was relatively slim, and was rather heavy, we decided that fitting it between the motors would lower our CoG as much as possible, and save space on top of the drivetrain for other mechanisms. We used lexan to hold it due to its compliant nature, allowing for easy battery replacements.



Designed by:

Oliver Liu

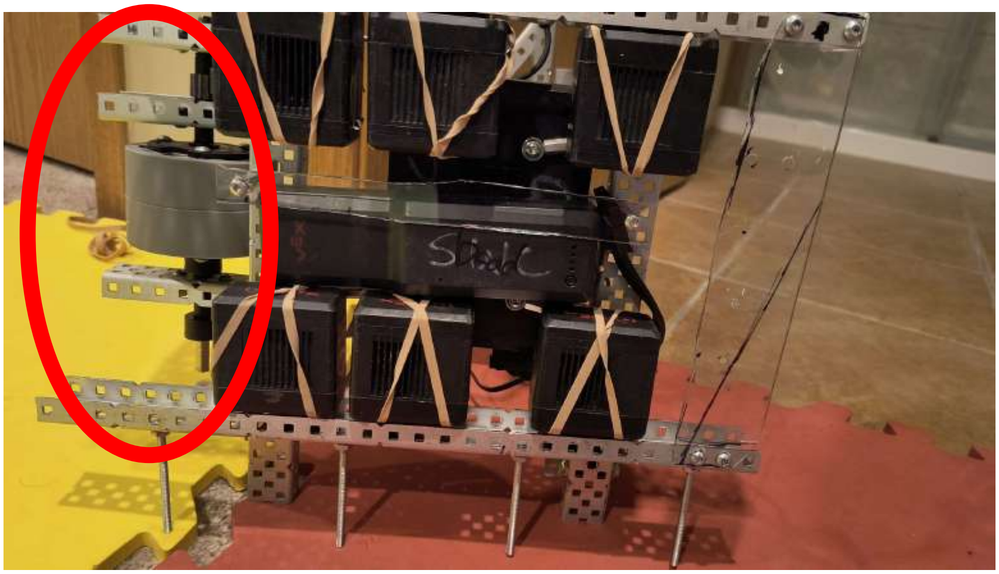
Witnessed by:

Matthew Zhang

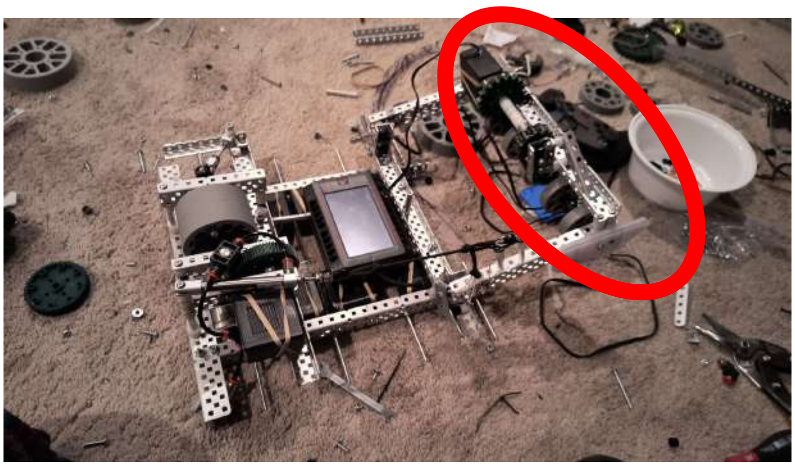
Placements Cont.

2024/01/16

For our pneumatic reservoir, we currently have it installed below the flywheel, underneath the robot, as indicated below.



However, due to the fact that it is at the back of the robot, it may cause our center of gravity to be too far back to easily go over the barrier. We have planned an alternate mounting point at the front, indicated by the red circle below. By putting it on the intake, it will significantly shift our CoG forwards, as center of mass is linearly proportional. We chose not to for now due to our priority in lowering CoG as much as possible.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

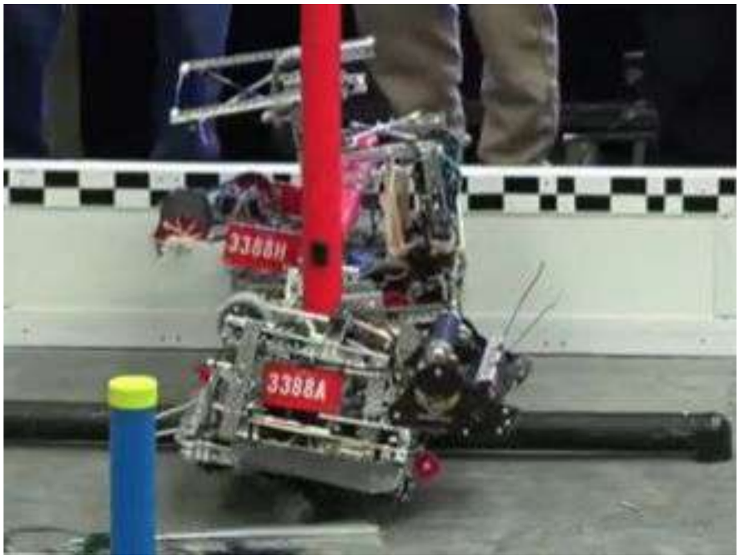
Brainstorm/Strategy - Climb

2024/01/17

Climbing was something that our team wanted to focus on. In our previous bots and tournaments, we found that our hang often won us a match that would have otherwise been lost. Paired with another bot that is capable of hanging, it can score up to an additional 40 points within seconds. These points were emphasized by the fact that match loading is becoming less common, since many of the match loaded Triballs are pushed back. Since the total number of points scored has decreased on average, our team wanted to focus on getting those extra 40 points.

Generally, in order to accomplish this, one team needs to hang off the horizontal pole and one needs to be able to climb by balancing on the barrier. Our team observed that the majority of teams are using the horizontal pole to climb, which usually only has space for 1 bot. Because of this, our team has decided on doing a side climb in order to compliment these bots, as many teams do not have a side climb, causing them to miss out on a double hang.

To perform a side climb, you first need to be able to cross the barrier. Then, you also need some mechanism to balance against the vertical pole in order to count as being elevated. To accomplish this, we decided on having a flip-out mechanism powered by a piston that is aligned with our center of gravity to allow us to balance against it.



Example of 3388H and 3388A performing a double hang during our STEM Tournament.

Designed by:

Oliver Liu

Witnessed by:

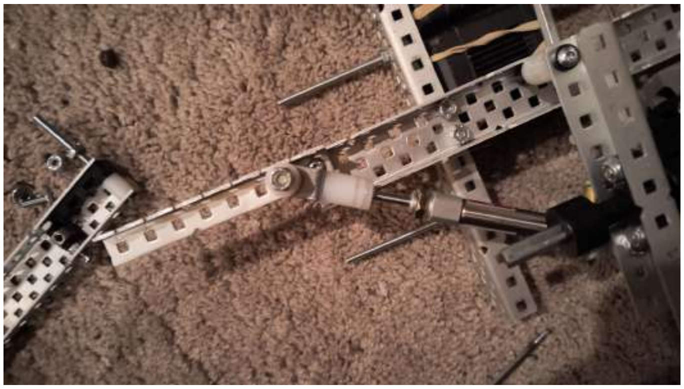
Matthew Zhang

Climb - Build/Test

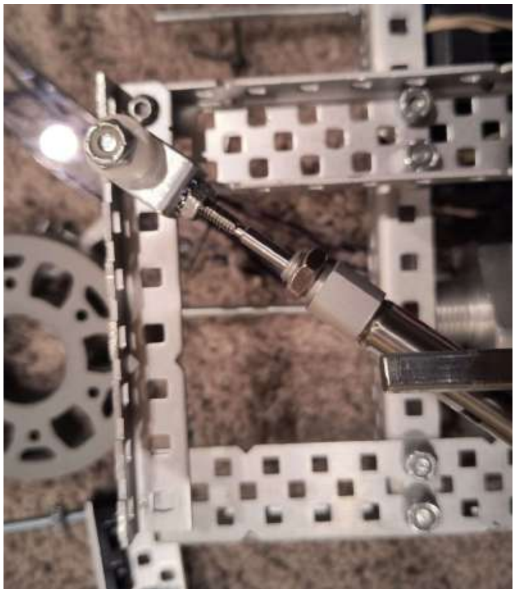
2024/01/17

For our first prototype of our climbing mechanism, we wanted something that could compactly open up, and simply help hold the robot against the vertical beam as the robot itself will be resting near its center of gravity, reducing the force needed by the actual climb mechanism to hold against the vertical pole.

To do this, we used a small piston, because of it's short and compact size, and mounted it on the back, to the flywheel mount, via screw joints. This method is strong enough, while also slim enough, for our needs.



On our second iteration, we moved the piston slightly back by two holes, and removed the spacers, to increase it's stroke and leverage, giving a slightly stronger hold against the vertical beam, which is better, as sometimes we may be very low on air (below 50 psi), due to extensive use of our wings during matches.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Climb V2

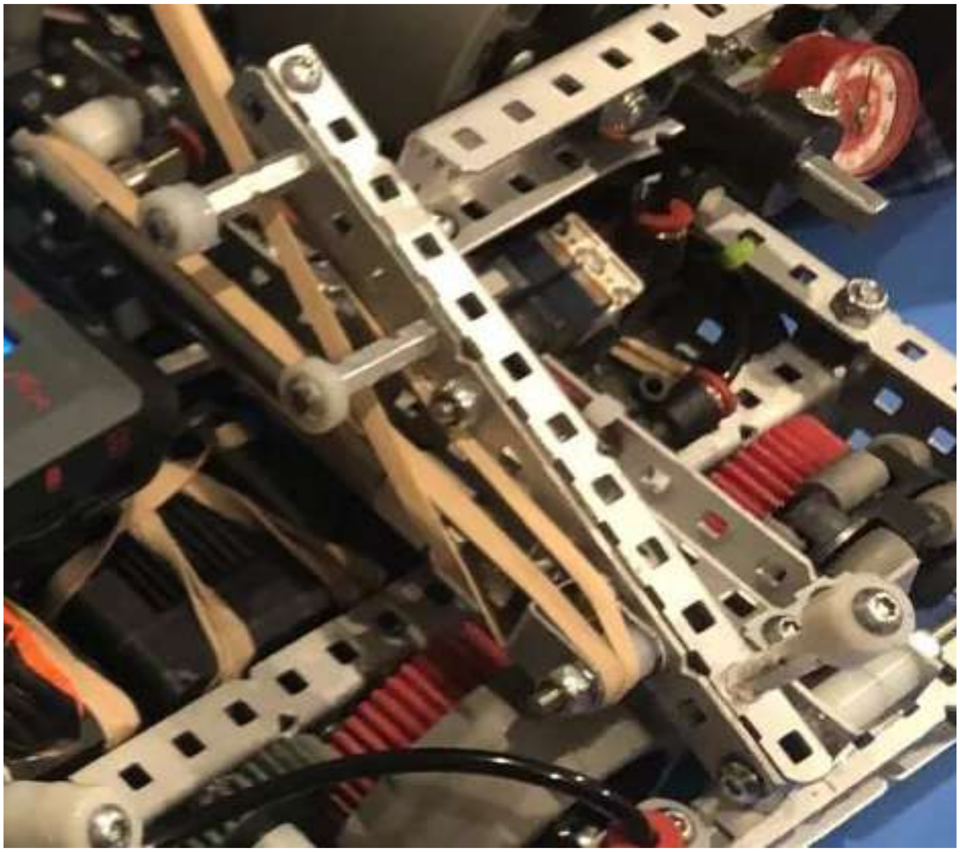
2024/01/19

Here, we are redesigning our climb mechanism so that it will function better as well as being able to function as a descoring mechanism, getting the triball out of the matchload zone during the autonomous period, opening the opportunity for us to gain an autonomous win point in matches.

For this iteration of our climb, we are making a vertical flip-out system located in a similar position as our last climb mechanism: on the side of our robot near the center of gravity. We are still powering this system with a single pneumatic, as we are out of motors and pneumatics create a simpler system with just a pivot point.

One problem we encountered while testing this mechanism was that it sometimes extended without us wanting it to. This can cause problems in a game scenario as it increases our width by a considerable amount. Thus, we are using some rubber bands that pull the mechanism back when it is not in use.

An image of this final system is shown below. The main bar of this mechanism is in the center of the image and the pneumatic powering it is situated slightly below it.



Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

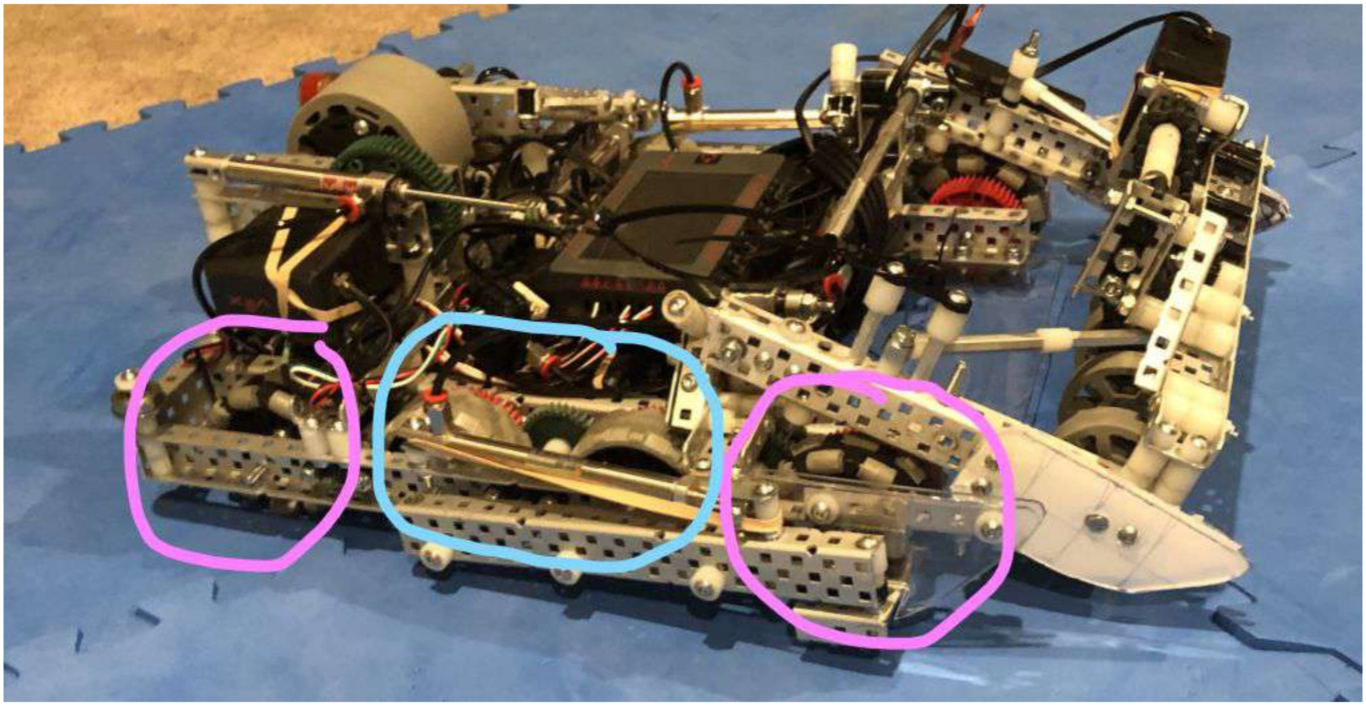
Adding Wheels

2024/01/19

Today, the wheels that we ordered for our robot have arrived, and we have promptly installed them on our robot so we are able to get started with drive practice right away.

We are running with an 8 wheel drive. The 4 outer wheels are omni-directional wheels while the inner 4 are traction wheels. The omni wheels help us with maneuverability while the traction wheels are vital for us to be able to get enough traction to cross the barrier and to be able to have enough traction to stay on the barrier at the end of a match when we elevate.

An image of one side of our robot with the wheels on is shown below. The omni wheels are circled in pink while the traction wheels are circled in blue.



Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Programming

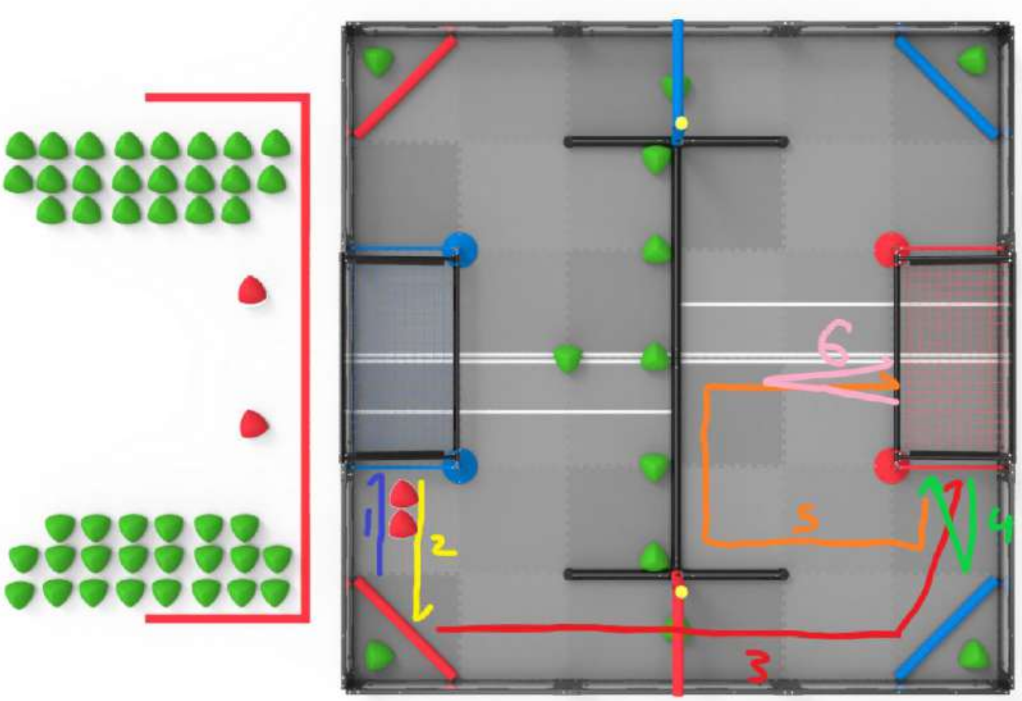
2024/01/17

Reference page 145

Since our last program was successful, we decided to use the same program as before with some minor adjustments to the tuning to optimize it for our new bot. We plan on using the same autonomous paths, as our descorer/climb mechanism is in the same utilization position as our previous robot's descore mechanism. Also, with traction wheels, we believe that a odometry pod for measuring sideways drift is not necessary, as movement will rarely drift.

Furthermore, the modularity of ez template, and the way we set it up for our robot, with clear, modular variables, we will be able to easily wire up all the motors/pneumatics, and also, quickly make any adjustments to our robot's autonomous paths as needed, via coordinate system.

We have also included a skills route which is shown below



1: Push two team coloured triballs into net
2: Return to matchload bar and turn towards the enemy net. Match Load for 30 seconds
3: Pushtriballs under climb bar and triballs on the side of the net into the goal
4: For redundancy, back up and push triball again 5 times to ensure that most of the triballs make it into the net
5: following orange path, attempt to sweep as many triballs from the sides to in front of the net, then open walls to push as many triballs as possible in
6: For redundancy, back up and push the triballs again 5 times, shifting locations slightly every iteration to ensure that most of the triballs enter the net

Designed by: Austin Ma

Witnessed by: Oliver Liu

Robot Testing

2024/01/22

Today, we tested all aspects of our robot that we are using throughout the course of a game. Most of our systems worked well, though some systems and aspects had a few problems. The two main problems we encountered will be described below.

Climb Mechanism

FIrstly, we noticed that our climbing mechanism worked well, but we also noticed that it seemed to bend a little bit whenever we went to hang, especially if we hit the elevation pole at a significant speed with the climb mechanism. Since we are unable to get onto the barrier when travelling too slowly, we will need to brace this mechanism, most likely through boxing, as it is the most space efficient method for this task.

Descoring Issues

One big issue we found with our robot when we tested it was with descoring triballs from the opponent's goal. We found that many of the triballs we pushed did not go out of the goal, but rather on top of our robot. To fix this, we are mounting a small sheet of bent lexan on the back of our robot, which is the part that we are mainly using to push triballs when descoring. This piece of lexan will be used to keep the pushed triballs on the floor, so that we are actually able to push them out of the goals.

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Mecha Mayhem - Analysis

2024/02/11

The following picture from VEX Via shows the results of our matches during the Mecha Mayhem signature event.

Practice #5	Feb 2nd at 7:08 PM	45519C	**3388H**	38	9181S	9364D	130
Qualifier #1	Feb 3rd at 9:16 AM	**3388H**	9594A	122	221Y	2088X	37
Qualifier #22	Feb 3rd at 11:39 AM	1290A	3565X	75	**3388H**	1010A	88
Qualifier #36	Feb 3rd at 11:52 AM	9364B	20315C	29	2084K	**3388H**	108
Qualifier #53	Feb 3rd at 1:39 PM	**3388H**	9594M	72	9181S	2088V	85
Qualifier #76	Feb 3rd at 3:11 PM	20785C	**3388H**	67	86744A	82855G	40
Qualifier #87	Feb 3rd at 3:57 PM	12145C	3388F	10	**3388H**	5327K	57
Qualifier #104	Feb 3rd at 5:40 PM	**3388H**	2088S	150	221E	27455B	36
Qualifier #121	Feb 3rd at 6:53 PM	6030M	604X	77	**3388H**	3388A	136
Qualifier #138	Feb 4th at 8:38 AM	3300D	27455F	14	**3388H**	45519C	93
Qualifier #157	Feb 4th at 9:50 AM	5760E	**3388H**	51	7842A	3300B	55
QF #3-1	Feb 4th at 2:17 PM	2084K	3565X	87	**3388H**	3388A	62
R16 #6-1		**3388H**	3388A	94	5760H	9409Y	57

Rank	10
WP / AP / SP	20 / 56 / 441

Although we did not win any award from Mecha Mayhem, we believe that we had a fairly strong performance overall during the event, as we performed very well during the qualifiers. The systems on our robot also performed well without many major problems.

Designed by:

Darien Ng

Witnessed by:

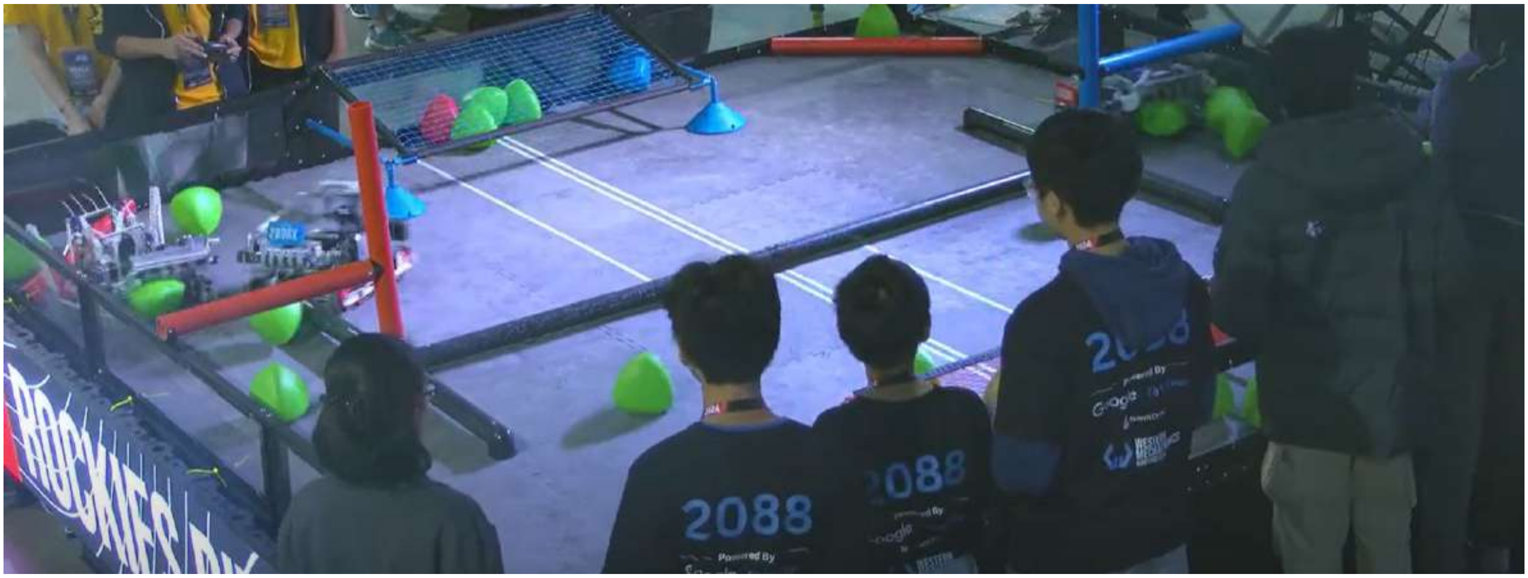
Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/11

Qualification 1

This qualification match was a strong start for our team, albeit with some issues. With our alliance partner, we were able to get the 8 point autonomous bonus, though we did miss out on the autonomous win point as our robot was unable to touch the elevation bar. The start of the match was fairly slow, with both sides scoring few triballs. Towards the middle of the match, one of our opponents started matchloading triballs across the field. However, we were able to take advantage of the situation, and both our team and our alliance partner were able to push the match loaded triballs to the tunnels and we then pushed them straight into the opponent's goal, gaining us massive points. The rest of the match was fairly uneventful, and although we were unable to get onto the barrier for elevation at the end, we still won the match with a final score of 122 to 37.



This is a photo of part of our match where both us (top right) and our alliance partner (far left) were able to push massive amounts of triballs through the tunnels and into the goal, netting us lots of points.

Designed by: Darien Ng

Witnessed by: Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Qualification 22

This match was a chaotic match for both alliances. At the start, we were able to win the autonomous bonus by a marginal amount. Throughout the game, few triballs were introduced and most of the triballs were intake and scored by bring it to the goals. We did get an opportunity to descore some triballs during the match, but it went badly for us as we did not anticipate that the goals on the fields were bolted down so hard, as the fields that we had practiced on we screwed on tightly, but not so tight as the fields used during Mecha Mayhem. Overall, this was a low scoring game, but we were able to get the better edge from a double elevation and we won the game with a final score of 88 to 75.

Qualification 36

This match went very well for our alliance, and we had some very strong plays throughout the game. We started off strong with winning the autonomous bonus. At the start of the drive control, we did have a little problem where our robot wouldn't run, but we eventually got it working. Our alliance partner was able to get in a push battle with one of our opponents in the tunnels, leading to our opponents to double zone. WE were able to take advantage of the situation and descored a large amount of triballs from our opponent's goal, scoring them into our own. In the end, we were also able to double elevate, leading to a win with a final score of 108 to 29. Below is a picture of our robot descoring some triballs from our opponent's goal.

Designed by:

Darien Ng

Witnessed by:

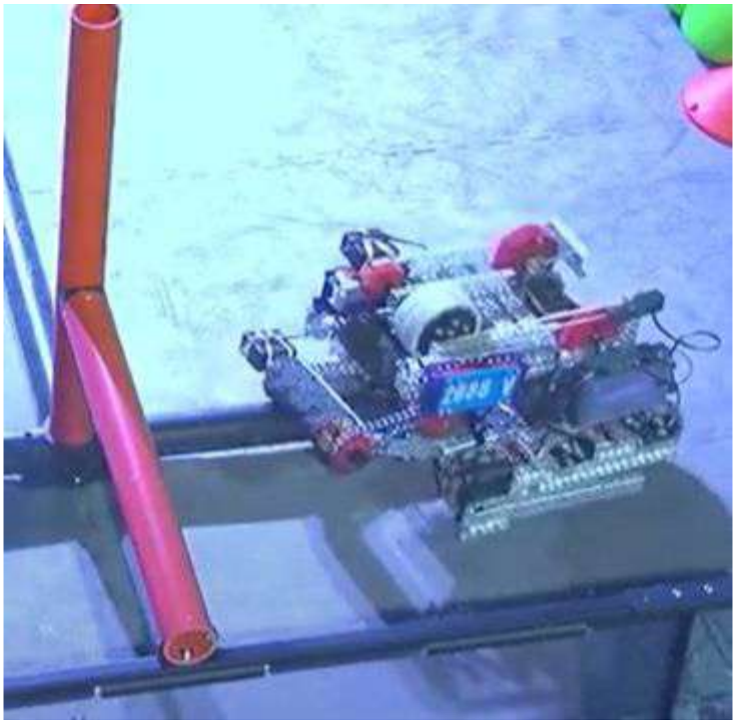
Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Qualification 53

This match was pretty chaotic, and we found ourselves struggling at times. To start, we unfortunately lost the autonomous bonus. Our tunneling was decent, though we did get a few warnings for reaching too far into the field when matchloading. Although this is not a hard rule, it is a safety concern for some people and we had to pull ourselves farther back when matchloading in the future. Unfortunately, one of our opponents was able to tunnel faster than us, and they also had the elevation at the end of the game while our alliance partner fell down right at the end of the game, resulting in a final score of 72 to 85 in the opponent's favour. However, the other robot in the opponent's alliance got stuck on the short barriers on our side, blocking us from elevating, so they were disqualified and we still got the win points. Below is a picture showing how one of our opponents got stuck on the short barriers, blocking us from elevating at the end of the game.



Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Qualification 76

This game was also a fairly strong game for our team, albeit with some flaws. To start, we were unable to secure the autonomous bonus and our robot went just a bit too far to gain the autonomous win point. During the match, our alliance partner was able to play amazing defence against our opponents, stopping them from matchloading and tunneling very effectively. Meanwhile, we were able to tunnel a few triballs across into our goal as well as grabbing some stray triballs around the field. Something we noticed while doing this was that we were going a bit fast, and some of our triballs ended up getting pushed into the opponent's matchload zone instead of the goal. Towards the end, we were blocked from elevating, but our opponents were also unable to elevate, giving us the win with a final score of 67 to 40.

Qualification 87

Although we won this qualification match, some unfortunate circumstances led our robot to perform poorly during this match. We had a good start with winning the autonomous bonus, but after scoring a few triballs, one of our opponents somehow got under our robot. This was very bad for us, and our battery cable got pulled out, and three of our motors got yanked off, rendering us useless for the rest of the match. Luckily, our alliance partner was still able to play, and we ended up winning the game with a score of 57 to 10. However, this match served as a wake up call for us, and we immediately made sure to reinforce the rubber bands that we used to hold our motors and used zip ties to hold them down where it was possible.

Designed by:

Darien Ng

Witnessed by:

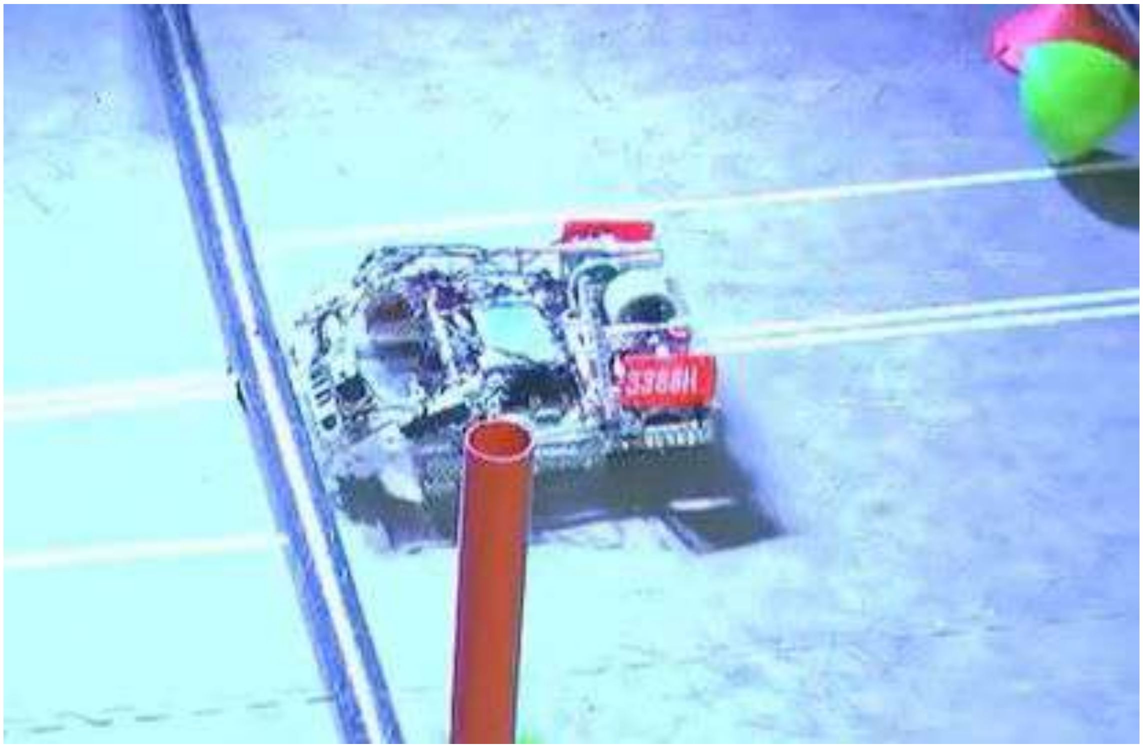
Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Qualification 104

This qualification match went decently for us. To start, we were able to secure the autonomous bonus, and we were able to get a significant amount of triballs in the goal as we were going over the barrier while our alliance partner tunneled. As we were going back to defend against our opponent's tunneling, we noticed that our drop down intake stopped working, and we had to go around the barriers as our intake stopped us from going over the barrier. Although we took a lot of extra time in going in to defend, we were still able to stop most of the opponent's attack while our alliance partner kept tunneling. Towards the end, our partner also elevated themselves, giving us the win with an overall score of 150 to 36. After this match, we noticed that the problem was an air leak somewhere in our pneumatic systems, so we had to work to try to fix it before the final match of the day. An image showing how our intake stopped us from going over the barrier in that match is shown below.



Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Qualification 121

Although we were unable to locate the leak in our air system, we still had a good match overall. We started off strong as our autonomous was working well, resulting in us winning the autonomous bonus by a huge amount. Throughout the match, our alliance partner tunneled while we mainly played defence against our opponents. This allowed us to score triballs in the goal much faster than our opponents throughout the entire match. At the end, we were also able to double elevate, giving us the win with a score of 136 to 77.

Qualification 138

Preparing for this match was a struggle, but due to some luck, we still emerged victorious. This match was quite early on the final day of the Mecha Mayhem event, and our alliance partner failed to show up on time, despite attempts to contact them through other teams from their school. Luckily for us, our opponents also showed up late, just 3 seconds after the autonomous period started, resulting in our match being a 1v1. We were also able to locate the air leak in our pneumatics and fixed the problem. We started off strong with our autonomous code working very well, winning us the autonomous bonus. At the start of the driver control period, we were able to quickly matchload a decent amount of triballs and pushed them into the goal. Our opponent also matchloaded, but we were able to take advantage and push the triballs right back across the barrier and into the goal. Eventually, we did get entangled with our opponent, but we were able to get out in time answer were able to secure an extra 20 points from a last-second elevation. The result of this game was a win for us at a final score of 93 to 14.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Qualification 157

This match was a big struggle for us, and we actually ended up taking a loss. To start, our robot hit the goal during the autonomous period, resulting in many triballs bring missed and losing the autonomous bonus to our opponents. We were able to get a couple triballs in the goal at the start, but as the match progressed, we started facing heavy resistance. Our alliance partner was also playing quite slow unfortunately throughout the match. Towards the end of the match, we were also getting distracted by our alliance partner and communication issues led us to lose valuable time and our elevation at the end of the game, losing the game with a score of 51 to 55. Although we lost, our qualification matches went quite well with 9 wins and only one loss, guaranteeing our spot into the elimination portion of the event. From this match, we learned that we had to find a better way to communicate between our drive team members, and this match also served as a reminder for us to ensure that we pick good teams to work with, if we are not the ones to get picked. Below is a picture towards the end of this match where our robots hit each other, leading us to lose the elevation at the end of the round.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Eliminations - Round of 16

For the eliminations, we were hoping to get chosen by 2084K, as we had a very good qualification match with them, and our robots synergized well. However, they opted to pick another team instead, so we chose to alliance with 3388A. Although they were farther down the rankings as they got disqualified a few times for illegal matchloading, we knew them well and made sure they got the idea of matchloading better in the future.

The round of 16 went decent for us, and we were able to come away with a victory. We started off with an amazing autonomous period, getting 7 triballs into the goal, easily winning us the autonomous bonus. Unfortunately, as the drive control started, the directions for our control seemed to flip, causing us to only be able to wiggle around the field. However, our alliance partner was able to tunnel massive amounts of triballs into the goals while we did what we could do to block our opponents. Our alliance partner was also able to get a last-second elevation. We won this match with a final score of 94 to 57.

Designed by:

Darien Ng

Witnessed by:

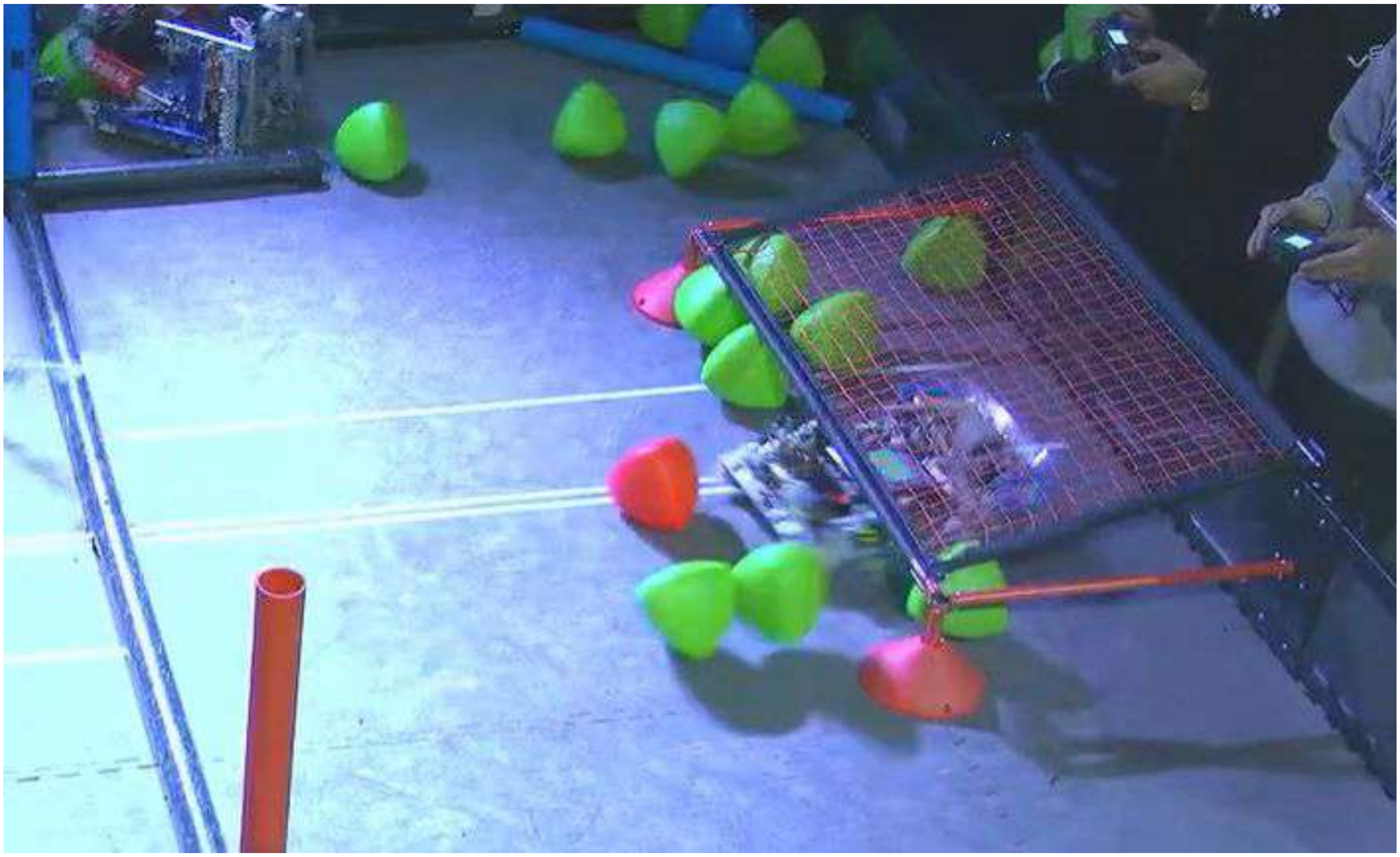
Matthew Zhang

Mecha Mayhem - Match Analysis

2024/02/12

Eliminations - Quarter finals

We were worried about this match and we were right to be worried, as this match was a huge struggle for us. We started off poorly, losing the autonomous bonus by 2 points. Throughout the match, we got shoved around quite a bit, leading to us not being able to score many triballs in our goal while our opponents were able to take whatever opportunity they had to score. In the middle of the match, we had a huge opportunity to descore triballs, and we took it, descoring over half the triballs in the opponent's goal. Unfortunately, we were unable to get enough of the descored triballs out onto our side of the field and most got pushed right back into the goal. We also missed the double elevation at the end, leading to us getting eliminated from the tournament with a final score of 87 to 62. Below is an image showing the moment when we were able to descore from our opponents.



Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Mecha Mayhem - What We Learned

2024/02/13

From analyzing our matches in the Mecha Mayhem signature event, we have come up with a list of key lessons/takeaways that will help us continue improving and help us prepare for the provincial championships in March. These key points are discussed below.

Communication between team members

The first key takeaway for us us to work on improving communication between our team members, especially those on the drive team during a match. Without communication, our driver needs to focus on way more than they need to, so callouts are important. From the strategy we have adopted, this means that drive team members should be calling out double zoning. Time callouts are also important. The need for good communication was evident in qualification 157, where we actually lost as we were unable to call out time and double zoning, leading us to miss the elevation and losing the game.

Another aspect of communication was between members of the entire team throughout the event. During our time at Mecha Mayhem, there were instances where parts were needed in a very short timeframe, so having someone running from the pits to the robot rather than having people run back to the pits and then to the robot can make a big difference. This is especially important in larger venues. We have recognized this going into the event, and we had phones on most team members to facilitate quick communication. However, there were still instances where we were a bit slow with communication and moving around, leading to valuable time lost which could have been spent running an extra skills run or continuing to refine drive skills at the practice fields. To reduce these delays in the future, we will be discussing and brainstorming better ways to communicate between members of our team.

Picking good alliance partners

Throughout the entire event, we have been thinking of who wo alliance with for the elimination portion of Mecha Mayhem in order to increase our chances of success. We have done some reaching out to other teams but with the teams higher than us already having picked their alliance partners, we were forced to think relatively quick on our feet as we would have to pick our own. Here, we settled on alliancing with 3388A. For reasons aforementioned above, we have learned that it is important to choose an alliance partner that we can communicate with well and one that synergizes with our team and robot. We also noticed the importance of looking at the qualification matches when choosing an alliance partner, as these matches can be a good representation of the team's skill in the event. As we move towards the provincial championships, we do have a few teams in mind for potential alliance partners, but we will be watching during the qualification matches to see how they do.

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Mecha Mayhem - Strategies

2024/02/13

Here, we will be discussing some of the strategies that we saw throughout the Mecha Mayhem signature event, mostly focusing on ones that we will most likely find ourselves following for the foreseeable future. We will also be thinking about how we can play along with these strategies as well as how we can play against these strategies. This will help us react effectively to these playstyles when we see them in the future, especially during the provincial championships in early March.

Tunneling

Tunneling was extremely prevalent throughout many of our matches in Mecha Mayhem. Tunneling involves matchloading a few triballs right in front of the robot, and pushing them through the sides of the field under the elevation bars and into the goal. We have noticed that this is a very effective way to get triballs scored as it prevents many of the triballs from getting pushed right back over the long barrier into our side of the field. We have also adopted this strategy throughout our matches, and it has worked very well for us. We have also noticed that it is very hard to play against this strategy, with only 2 viable counters to this style of gameplay.

The first way to stop our opponents from tunneling is by rushing to the tunnels where our opponents are making their play, and physically blocking them. This stops them from continuing to push the triballs into their goal. However, this puts us in a tug-of-war situation, where we are fully occupied with blocking our opponents, leaving us reliant on our alliance partner to stop the other robot in the opponent's alliance.

Another way to stop tunneling is to push the triballs into the matchload zones in the corners of the field. This effective takes the triballs out of play, as triballs in the matchload zone are not worth any points for either team. One advantage that this tactic has is that it is quick and effective; however, this can only be done a few times before the match load zone gets filled up with triballs and we are unable to push any more in.

Double Hanging

Double hanging is when both teams in an alliance are able to elevate themselves simultaneously at the end of a match. Usually, one team elevates on the horizontal elevation bar while the other team gets high-centered on the barrier to get off the ground. This strategy is quite strong, and can make the difference between a win and a loss as a double elevate can be worth up to 40 points, which is massive with the lower-scoring games that we have seen after the new year. One of the advantages of double hanging is that it cannot be stopped by the opponents, as they are not allowed to stop anyone from elevating at the end of a match. One thing we noticed about double hanging is that it is more effective in the elimination rounds, as teams are able to pick their own alliance partners. This allows them to make sure that the overall alliance can double hang while this is not guaranteed in qualification matches due to the random matchups.

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Mecha Mayhem - Strategies

2023/02/13

Descoring

Descoring is when one team is able to push triballs out of the opposing alliances' net when the opponents are double zoned on the same side of the field. We have also followed this strategy, and it is a way to heavily punish our opponents when they are double zoned. Being able to descore is something that has to be decided in designing the robot, as the goal is less than 6 inches tall, blocking the vast majority of robots from entering. Through our matches, we have found that an effective way to follow this strategy is to primarily play defence, so that we are able to quickly descore the opponents' net when given the opportunity. Sometimes, we would also sit near the net when we anticipate that our opponents will double zone. This is what we refer to as "camping." Because our opponents are unable to double zone when we are able to descore their goal, we effectively force them to play in a certain way, heavily restricting their strategies throughout a match.

When playing against robots that can descore, we also have to be extremely careful, as all our hard-earned points can be gone in a matter of seconds. Here, we have to make sure that we are never double zoning in a match, so that our opponents never get the opportunity to even enter our goal.

Wing Usage

Throughout Mecha Mayhem, we noticed that most teams had wings on their robots to push triballs around, but these were not used very often throughout the course of a match. One reason why this is the case is because using the pneumatics of the wings does lose some air each time they are activated, and many teams use pneumatics in some sort to lift them off the floor at the end of a match, so air needs to be conserved. Another reason is because there aren't many opportunities to use the wings in the first place, as much of the gameplay now is dominated by tunneling and starving the opponents. Without mass amounts of triballs, it just isn't worth it to use the wings that often. This is one of the changes that we saw compared to earlier months where gameplay focused on matchloading massive amounts of triballs and scoring them into the goal all at once using a set of wings. We won't have to worry so much about getting stopped by our opponents' wings when trying to score triballs, though it doesn't impact the overall gameplay too much.

One place where we still see significant wing usage is during the autonomous period, as it give teams more room for errors that arise from weird triball movement and errors in their autonomous code. Something that we have occasionally seen is teams flinging triballs with their wings to save time. This was quite intriguing to us, and we may look into possible ways we can implement this into our autonomous paths if we have time for that.

Designed by:

Darien Ng

Witnessed by:

Oliver Liu

Select and Plan - Drivetrain RPM

2024/02/15

Goal: Determine the optimal drivetrain RPM to achieve a large enough momentum to descore effectively

- **Speed**
  - How fast the bot can get across the field.
- **Torque**
  - How much force the bot can exert while pushing
- **Acceleration**
  - How long it takes to reach the max speed

Scoring: Higher is better

Drivetrain RPM	Speed	Torque	Acceleration	Total
450 RPM	3	7	4	14
600 RPM	6	4	5	15
800 RPM	5	2	6	13

Based on the decision matrix, we decided that having a 600 RPM drivetrain would best suit our bot. Since we wanted to put more emphasis on descoring effectively, rather than pushing other bots, we wanted to ensure that the design we chose could accomplish this. The increase in momentum from the faster speed would greatly improve our descoring potential. Having a 600 RPM drive is the best for this as the, as it has a good balance between speed and torque and it gives us a good momentum.

Additionally, a faster drivetrain allows us to score triballs one-by-one or through tunneling a lot faster, enabling us to cycle faster and outscore our opponents.

Designed by:

Austin Ma

Witnessed by:

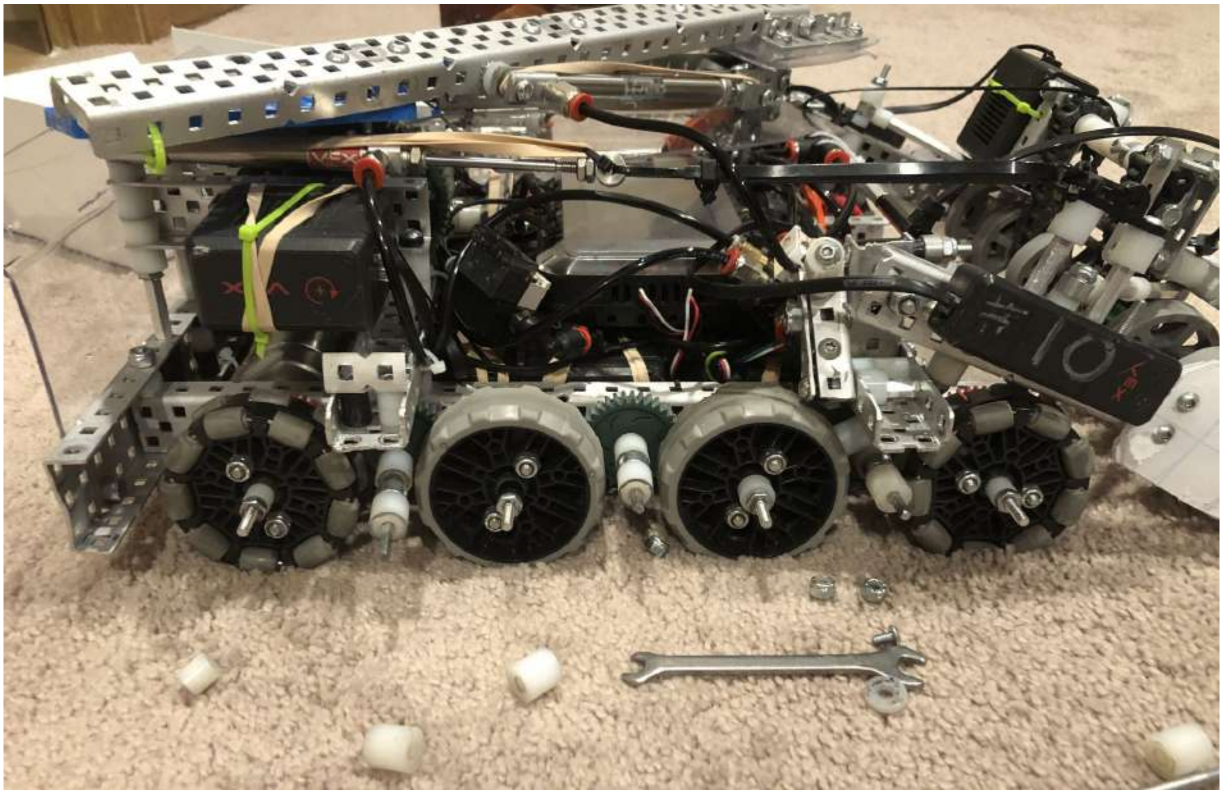
Darien Ng

Drivetrain V2

2024/02/15

Due to the nature of our drivetrain c channel mountings, we were able to relatively easily take the outer C-channel sides off, as we kept in mind to avoid building subsystems that were required to mount on both the in and outside c-channels for any possible drivetrain issues in the future. As a result, we were very quickly able to swap screw joints and move the motor positions.

Another thing to note was that since 48T gears and 36T gears do not mesh unless one gear is dropped-down or up, we decided to shift everything up a whole and forwards, so that the motors can still fit within the c channels.



Designed by:

Oliver Liu

Witnessed by:

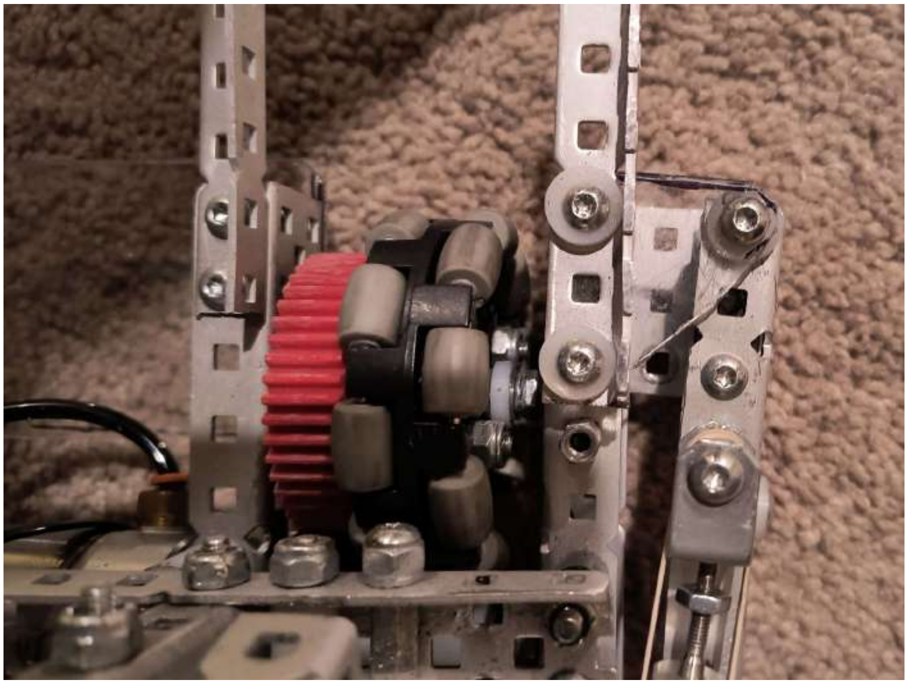
Matthew Zhang

Improving Wings - V3

2024/02/15

During our testing, we noticed that our wings were bending when we applied too much force to it. We realized that the cause of this was because our wings were cantilevered. We also realized that our wings sometimes got stuck on the sides of our drive which was due to the wings dropping and being caught on a screw.

To fix these issues, we cut a piece of lexan and placed it on top of our wing connected to our drivetrain which helps support the three wide on the bottom which strengthen our intake and non cantilevered our wings. We also boxed our wings which increase their strength and prevented them from getting stuck on our drivetrain.



Designed by:

Austin Ma

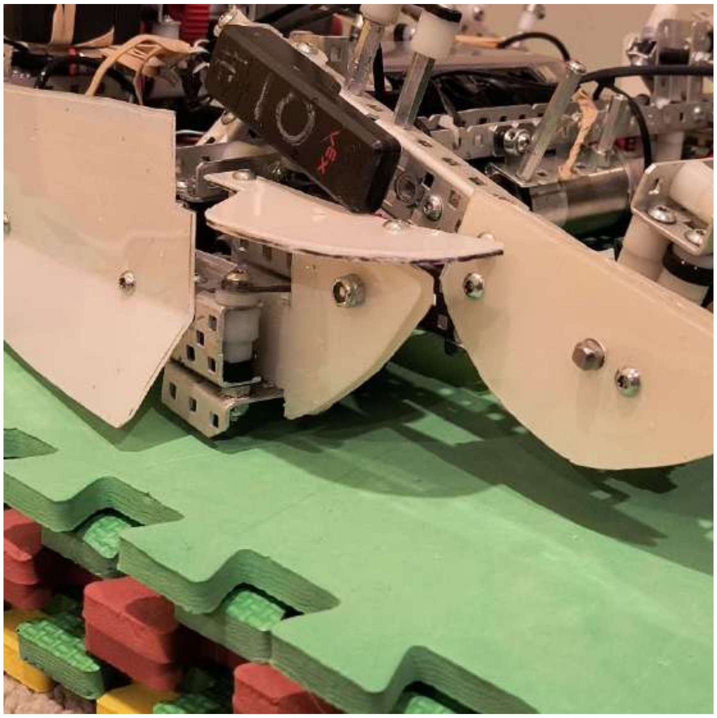
Witnessed by:

Bolo Wang

Improving Sleds - V3

2024/02/15

After raising our drivetrain by 1 hole, we had to increase the length and height of our sleds in order to maintain a high enough clearance to cross the barrier. We first increased the length of the half-cut holding the sleds to the drivetrain by 1 hole so that the sleds are farther forwards allowing them to contact the barrier earlier and thus allowing for a shallower slope. Additionally, we increased the height of our sleds in order for the top of it to be over the top of the barrier as our bot is lower to the ground now. Finally, we moved the screw that was supporting out sleds forwards by one hole, this was done as having the support be closer to where the most force is applied will have greater strength when hitting the barrier.



Designed by:

Austin Ma

Witnessed by:

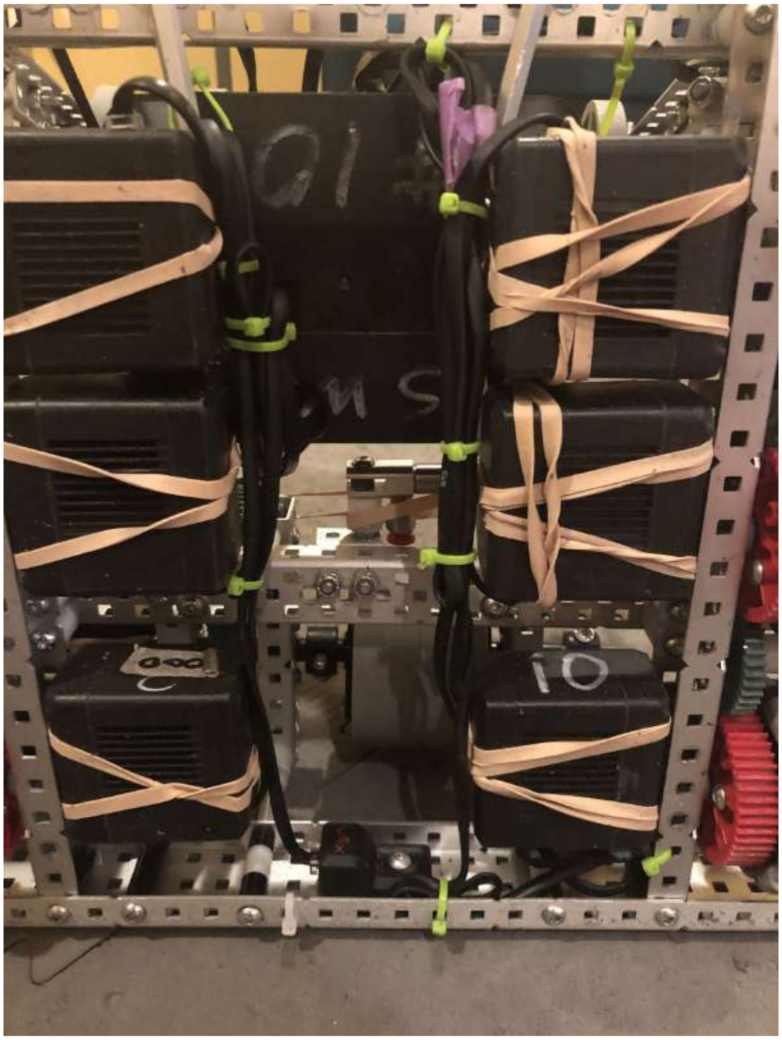
Oliver Liu

Fixing Wiring

2024/02/16

After Mecha Mayhem, we noticed that our wires were often tangled up and that it was difficult to determine which wire was connected to what device when we were troubleshooting. Thus, we rewired our motors solenoids and pneumatics to ensure a cleaner wiring so that it will be easier to troubleshoot when necessary.

We did so by bundling them with zip ties, and then have them run parallel across c-channels, making it stay tightly against the robot and preventing the wires from getting caught on anything on the robot or other robots. We also routed them underneath the robot, as in general, that helps keep the wires from getting caught and easier to access.



Designed by:

Austin Ma

Witnessed by:

Matthew Zhang

Top Loading Intake - Strategy

2024/02/16

Here, we will discuss one of the new strategies that we will be attempting to implement in building our robot. We will call this a “top loading intake” or a “top load intake.” The main advantages of such a system will be discussed in the points below.

Easier Matchloading

One of the key ideas behind a top load intake is to allow for easier matchloading during matches with a lower risk of matchloading illegally, especially with our strategy of bowling which we will be sticking with for the provincial championships. A top load intake allows for us to introduce matchloads though the top of our robot directly into our intake, while will be moving the matchloaded triballs in front of the robot, allowing for multiple matchloads in succession without overposession. This is especially important with the rules of not being able to introduce matchloads with any horizontal momentum. With bowling by matchloading on the front bar of our robot where the triball will fall off, there is a much higher chance of adding momentum to the triballs, especially with the added stress from the game environment.

We also got warned a few times about reaching too far into the field when matchloading, as we were reaching out more than one field tile. Although this is not explicitly stated in the rules, we did have to obey what we were told. A top load intake will also help with this problem, as the intake spot is not at the very front of the robot but a little farther back, as the intake will move the triball the rest of the way to the front.

More effective bowling

With a top load intake, the intake will move the triball to the front of the robot much more reliably than if we were to introduce matchloads on the front bar of our robot as we had done during Mecha Mayhem. This more controlled motion prevents triballs falling and rolling off to the side towards the center of the field where we are unable to push it through the tunnels quickly. Triballs that roll off to the center of the field are also unable to be defended well, and are much more vulnerable to getting in the opponent's’ possession.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Identify Objective - Topload Intake

2024/02/16

Goal: Create a top loading intake that is effective at both top loading and regular intaking.

Problem Statement:

- Build an intake to attach to the front of our bot which is effective and can also topload.

Solution Requirements:

- Be able to intake triballs effectively
- Be able to top load effectively
- Must be constructed out of legal VRC parts
- Must be rigid enough to withstand the force of Triballs and potentially other robots
- Must remain fairly light
- Intake must be able to rest vertically at the beginning of matches

Solution Goals:

- Be easy to top load quickly
- Be able to keep intake triballs inside intake when being rammed and moving
- Be fast and efficiency when intaking and outtaking

Designed by:

Austin Ma

Witnessed by:

Bolo Wang

Select and Plan - Top load

2024/02/16

Goal: Determine the benefits and drawbacks of top loading compared to having a regular intake

- **Simplicity**
  - How simple is this to build
- **Compactness**
  - How much space does this take up on the bot
- **Effectiveness**
  - How effective is this in helping us achieve matchload
- **Mass**
  - How the mass impacts the overall performance of bot

Scoring: Higher is better

Drivetrain RPM	Simplicity	Compactness	Effectiveness	Mass	Total
Top loading	6	4	7	5	22
Regular Intake	7	5	4	5	21

Based on the decision matrix, we decided that having a topload capable intake would best suit our bot. Since we wanted it to be easier to matchload effectively, we wondered whether it was worth having a top loader intake for our bot. Using a topload capable intake is the best for us as it will decrease the time and coordination needed to match load, especially when being defended by the opponent. Additionally, being able to top load decreases the chance that we accidentally drop triballs onto the field and getting them scored on us instead as we can make sure that the triball ends up in our intake.

Designed by:

Austin Ma

Witnessed by:

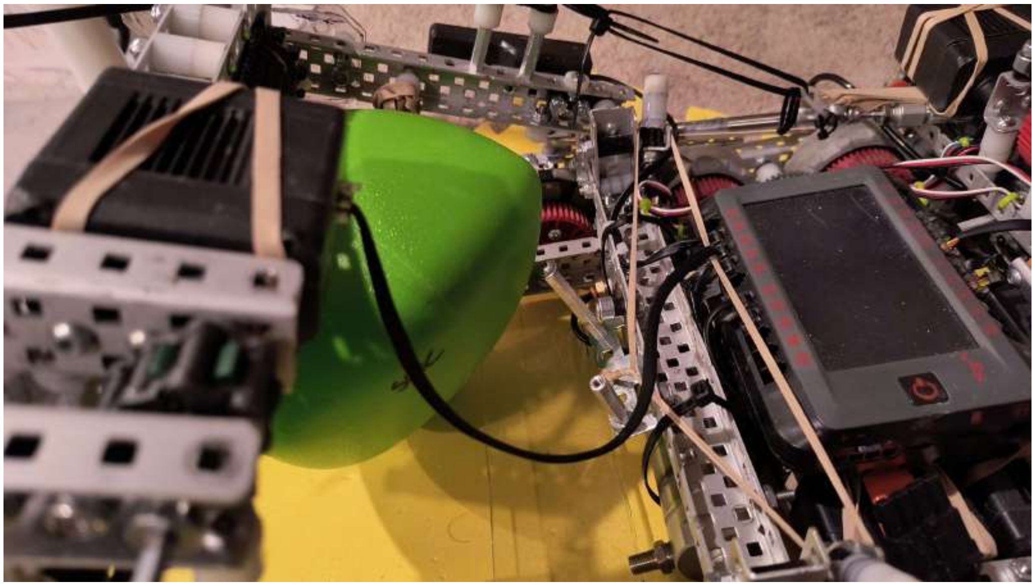
Bolo Wang

Design/Build - Topload Intake

2024/02/17

Goal: To design and build a intake that fits the requirements and capabilities stated prior.

Firstly, we realised that our previous intake was too short and that we need to make the intake beams longer in order to even fit a triball into the intake. We also removed the back bar on the intake base, as it also prevented us from fitting a triball through the top of our intake. We also realised the original way we mounted our motor go into the way of the triball, so we decided to move it to the side, and mounted it horizontally to reduce height. From these changes, we were able to build our intake, and with quick preliminary testing, it seemed to do what we wanted.



Designed by: **Witnessed by:**

Battery/Tank placements

2024/02/17

Due to struggles with our placements on our last bot iteration, we decided to move them around to ensure the best fit and access on our bot. We have decided to move our battery down and our air tank to the front of the bot. These adjustments help with maintaining the bot's centre of gravity as well as making it easier to access the tank and replace the battery when needed.

Designed by:

Austin Ma

Witnessed by:

Oliver Liu

Testing Intake Heights

2024/02/17

Goal: Test intake height to determine most effective height to grab triballs and topload.

Since we could easily adjust the height the intake rested at when in the “Up” position via adjusting the tightness of the zipties, we found through testing that the height it rested at greatly affect how easily it could pick up and hold triballs.

Test 1:

When the bottom of the intake roller rests around **>1 Inch** Under the topmost part of a triball, we found it could relatively easily grab triballs at low speeds, however, when the robot was driving into triballs at approximately 50%+ power, it would knock the triball away, this is likely due to the intake having to move so high each time, that before it even can, the momentum of the robot pushes it away. Furthermore, it was impossible to topload into the intake at this height.

Test 2:

When the bottom of the intake roller rests right on top of the topmost part of a triball, it was able to grab triballs at both high and low speeds, but, we found that the triball when inside the intake, easily slipped out. Furthermore, when trying to test toploading, sometimes the triballs would just roll out of the intake, which is not what we want, and these results show that this is too high.

Test 3:

When the bottom of the intake roller rests around **~.75 Inch** Under the topmost part of a triball, it was able to grab triballs at both high and low speeds, as it was high enough that minimal force was needed for the triball to lift up the intake to be intaked. Also, at this height, the band roller provided enough room to successfully topload into the intake, which is why we wanted to go approximately this height.

Designed by:

Matthew Zhang

Witnessed by:

Oliver Liu

Intake Holster

2024/02/17

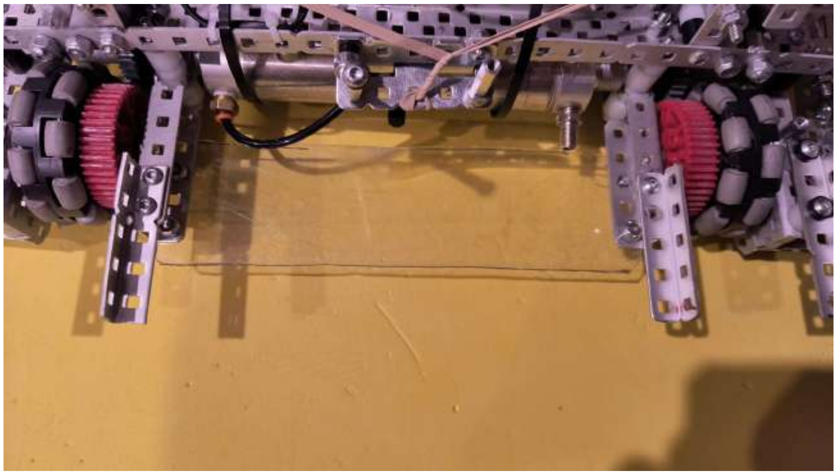
Goal: Determine the optimal design for the bottom holster for the intake.

For our intake holster, we are considering multiple designs, using lexan or rubber bands, as described below. Due to the simplicity of these different designs, we are simply going to build and test each one and find the most optimal solution.

The rubber bands often were too weak to properly hold the triball up, causing the triball to often scrape the ground as the robot moved, and slipping out of the intake. Also, rubber bands have a chance of getting caught or entangled, which is also not something we want.

The thin lexan strip although was able to keep the triball in the intake without falling out, we found that it was rather weak and when we tried crossing the barrier with the triball, oftentimes the triball would get knocked out of the intake, which is suboptimal, as we want to securely move triballs to score or bowl.

From our testing from above, we tried a larger lexan sheet, in hopes that it would provide much more surface area to hold onto the triball/keep it secure. From testing, we found that it successfully did hold the triball securely, and despite our initial doubts that it may be too big and interferes with our ability to score into the goal, it actually had no problem doing so.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

Intake Latches

2024/02/17

Goal: Build a latch system that allows triballs to be top-loaded into the intake but to not have triballs go through the intake and on to the robot.

We noticed a major issue that triballs could easily just go through the intake, especially when we intake triballs whilst moving forwards, causing the triballs to go through the intake and sit on top of our robot, which would get stuck. To prevent this issue, we tried adding Lexan latches, as they were compliant mechanisms, allowing us to easily put triballs into the intake one way, but help hold in the triballs in the intake and not go backwards and on to the top of the robot.

We tried to bend the intake latches downwards, to create a more of a "ratchet", making it much easily to slide and bend the lexan from the top so that triballs can easily be top-loaded, while being at an angle that made it harder for triballs to push upwards. An image of this prototype is shown below.

Designed by:

Oliver Liu

Witnessed by:

Darien Ng

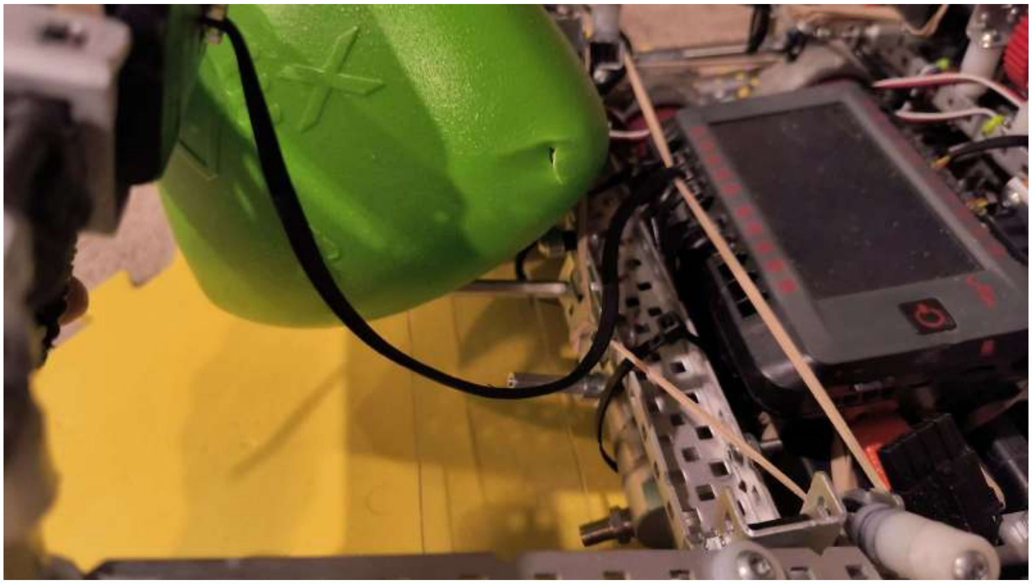
V2 - Intake Latches

2024/02/19

Goal: Build a latch system that allows triballs to be top-loaded into the intake but to not have triballs go through the intake and on to the robot.

After testing, although we saw a significant improvement in mitigating the issue, triballs still occasionally would still push past the lexan tabs when with sufficient force, such as when we rammed into a pile of triballs or a robot.

We decided to utilize a hinge instead of lexan tabs, as although a hinge is not a compliant mechanism, it still permits rotation, and we can simply limit which direction and how much it can rotate, so that we can have triballs go in one way(top down), but not the other(bottom to upwards).



We noticed that the motor mount would often cause triballs to end up moving more to the right, away from the mount, so we decided to add a longer standoff on the other side to compensate. We utilized a very weak band to keep the hinge up, so that when a triball goes into the intake, it hits the hardstop and does not ride up, but still weak enough that the weight of a triball depresses it, and allows the triball to sit in the intake. Through testing, and with minor changes to the spacing of the hinge standoffs, we were quite satisfied with the result, and has proven to be simple, compact, and reliable.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

V2 - Moving the intake piston

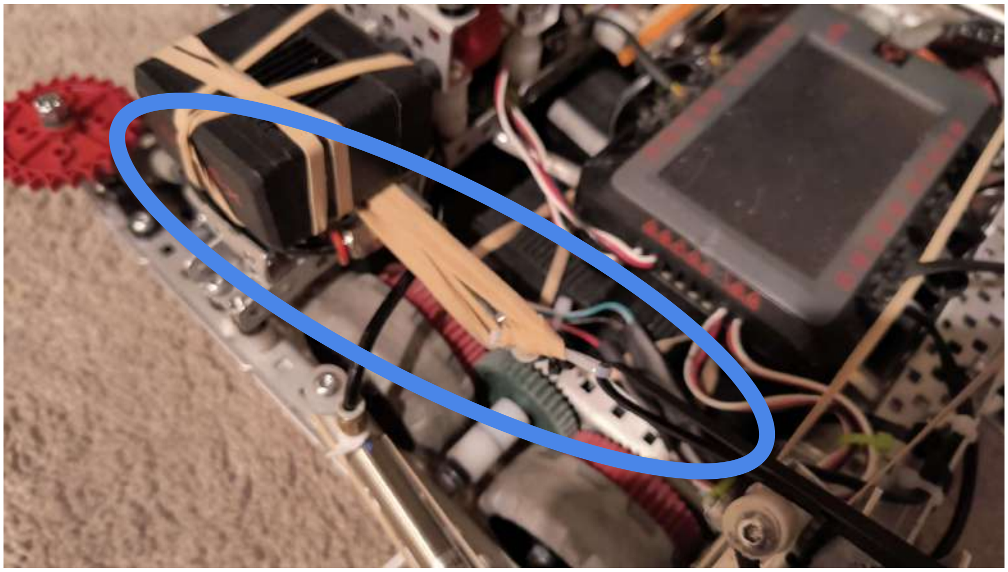
2024/02/18

From our experience at Mecha, we had an issue where unless we ziptied the license plates down with extreme force, the plates sometimes would get caught with the goal poles when we tried to descore, and jamming us as a result. We wanted a more easily mountable way to put our plates, instead of having to cut and redo zip ties every match, especially as Provincials will have considerably less time between matches.

We could put our license plates on our intake, but it would get in the way of both our radios and it may make the intake too tall.

Another consideration we came up with was to simply move the intake piston down, underneath the flywheel c-channels, which would give us space to mount both our plates, and reduce the chances of the intake lifting mechanism from getting entangled with other robots or the net.

We tried this out and it had no issues or difference in pulling the intake up, and are satisfied with this new mounting position.



Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

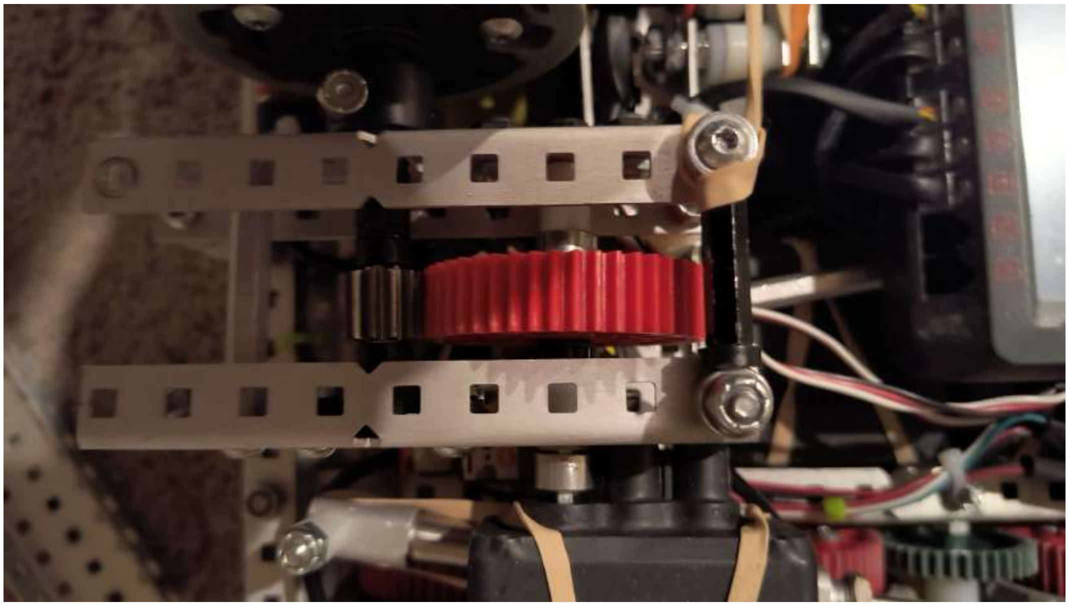
Changing Flywheel Speed

2024/02/22

Goal: Improve the performance of our flywheel and it’s drop off time.

When utilizing our flywheel in practicing, we found that the time it took for the flywheel to spin back up to speed after we just shot a triball was roughly one full second, which is considerably slower then what we want, as we need to match load all 44 triballs in skills in just under 30 seconds to allow for time to push. From checking the rpm of the motor on the brain, we saw that it only reached approximately 70 percent of its total capable speed, and decided to try reducing the gear ratio from **5:1** to **4:1**, which should increase the torque and decrease the time it takes between shots for the flywheel to go back up to speed.

Additionally, we tried to add two standoff braces, to reduce friction and wiggling of the two c-channels holding the gears, as the slack causes bad alignment and friction.



From testing, we found that we were able to considerably decrease the drop off time to approximately 0.5 seconds, which was much better.

Designed by:

Oliver Liu

Witnessed by:

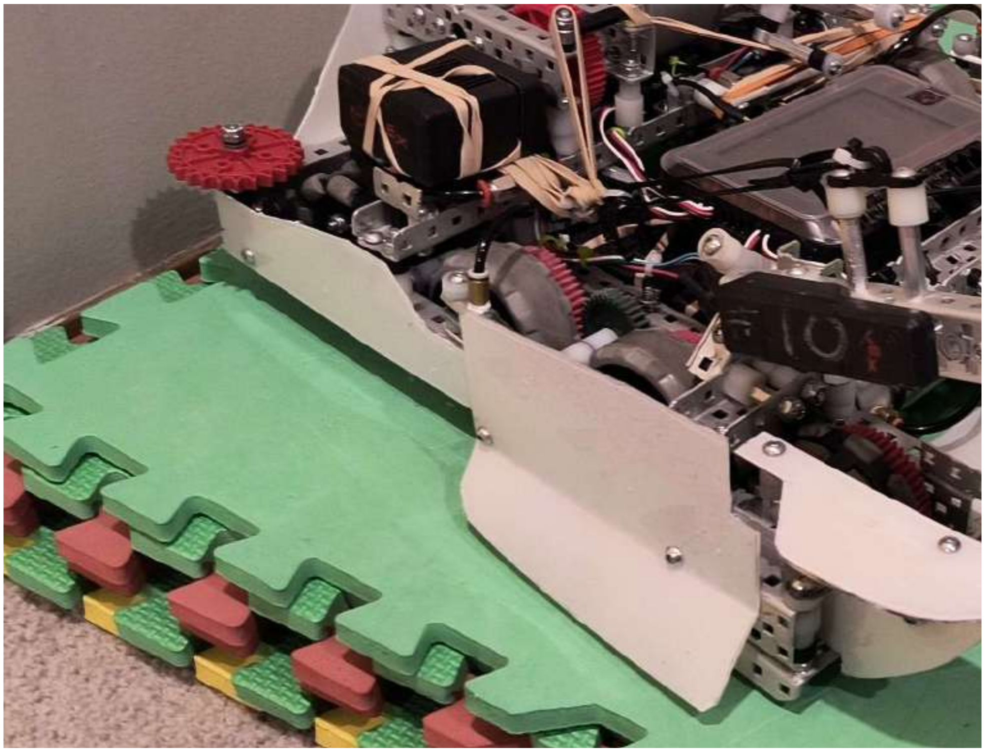
Matthew Zhang

V4 - Wings

2024/02/22

From testing recently, we tried to extend one of our wings via separate solenoid control, in an attempt to push the triballs through the tunnels without having any being missed on the sides, and significantly increasing our efficiency. However, we found that even with one wing extended, it was still too wide and would cause the robot to get caught with the sides.

To fix this issue, we decided to try cutting our wings to make them shorter in order to much more efficiently push multiple triballs under the tunnels. Even though smaller wings would mean it would push triballs overall, this isn't really prevalent in matches as almost nobody match loads large amounts of triballs. However, for skills, we recognized that it may be an actual concern. We calculated the length with shorter wings and it didn't seem to be too extreme, at 4 inches shorter in width over the 35 inches overall, and as a result, we have decided to build them and test in a actual scenario to see it's effects.



Designed by:

Matthew Zhang

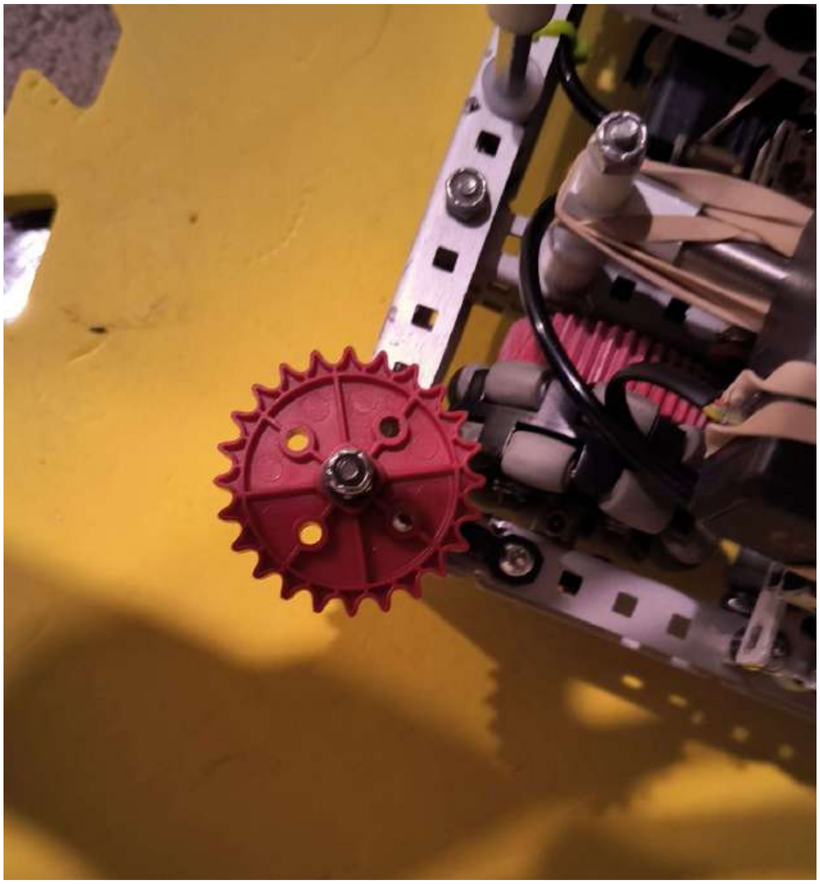
Witnessed by:

Bolo Wang

Front/Back Wall Riders

2024/02/23

From testing, we found that our robot oftentimes scrapped against the walls when driving, and because of the sharp corner of the drivetrain, it oftentimes results in the robot to get caught with the walls, and slows down our ability to go back and forth quickly. We decided to try and utilize small sprockets as a method of helping reduce friction and allow our robot to move quickly. Furthermore, these sprockets are wide enough that it helps prevent the wings getting caught on things from the back as well, and overall has significantly increased our ability to quickly move through the field.



Designed by:

Matthew Zhang

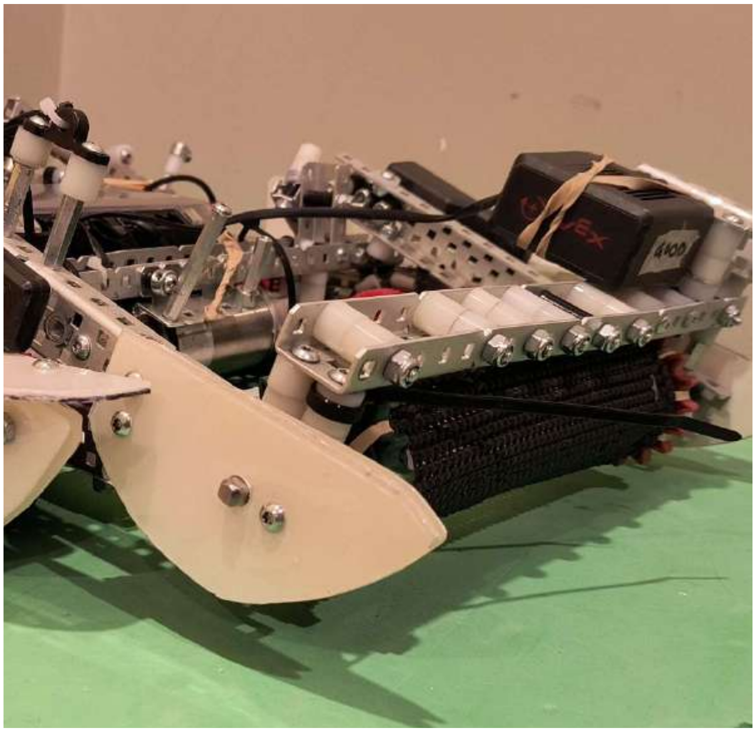
Witnessed by:

Oliver Liu

V5 - Intake

2024/02/23

We noticed that sometimes during driving and testing that the sleds would actually go underneath the goal, causing the intake to get stuck and inhibiting us from scoring our triball in our intake. To fix this issue, we wanted to make sleds that were slightly taller, preventing this issue. Also, we made the back portion smoother in order to allow for the intake to more easily to slide off the intake pole.



Also, we ran into an issue when driving and scrimmaging with our wiring sometimes interfering with the triballs, and decided to wire it tightly against the intake beam to prevent this issue.

Designed by:

Oliver Liu

Witnessed by:

Matthew Zhang

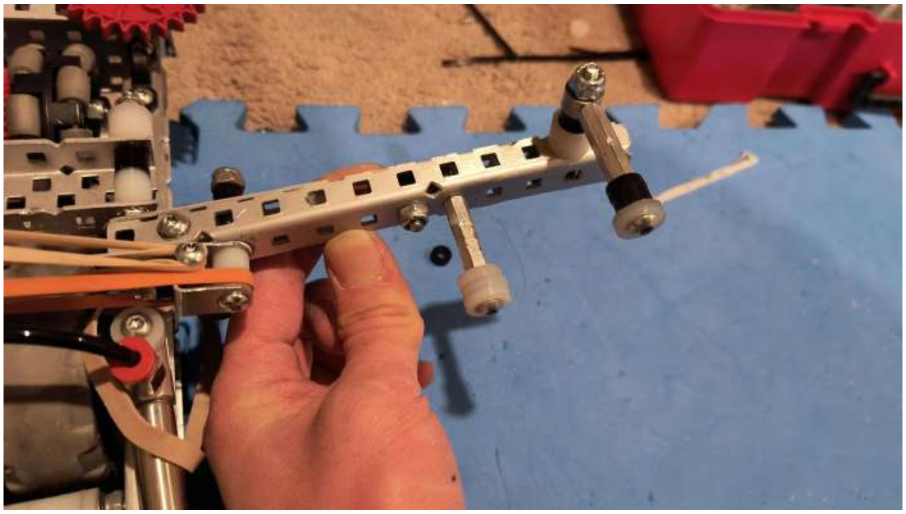
V4 - Climb/Descore

2024/02/24

Goal: Improve the consistency and tolerance needed to successfully do a side climb using our mechanism.

From testing and our experience from Mecha Mayhem, we found that oftentimes it would take over ten seconds to get ourselves off the ground, as we often failed once or twice before we could get it. We realised that due to the height of the mechanism, it had very bad mechanical leverage to counter the force of rotation of the robot wanting to tip forwards when it was on the barriers. As a result, the robot often would reach it's climb position, and then the side opposite of the climbing mechanism would slide off the barrier.

To fix this, we decided that by having a standoff beam that increases the height of contact, it will help stabilize and give the climb mechanism a better mechanical advantage to counteract the force of rotation. We tested it on a field and at multiple angles, and found that became much easier to do so. Although this standoff beam does cause the climb mechanism to slightly protrude out more then before, it still had plenty of tolerance and space between it and the height of the goal(6 in), and does not interfere with our ability to descore. Overall, we are quite happy with this change, and will continue to put it in further testing.



Designed by:

Oliver Liu

Witnessed by:

Austin Ma

Autonomous Strategies

2024/02/23

Mid-Triballs

From Mecha Mayhem, we have realized how important it is, especially for defensive side autons, to be able to quickly disrupt and grab the middle triballs, and preventing the opposing team from not only scoring them, but also getting the autonomous bonus. To do this, we want to possibly create a exclusive autonomous function for elims for the defensive side to disrupt middle triballs.

AWP

Seeing the rankings at Mecha Mayhem, we realised that most good teams will have a similar win loss ratio, and as a result, it comes down to the people who get more win points from autonomous that are able to rank higher and get a better advantage for alliance selection. Similarly, we want to focus on getting Autonomous win points with a specific route that reliably does so during our qualification matches. We also noticed that it was much more reliable to drive against the middle barrier and have a ziptie touch the colored pole, rather then have the robot stop underneath the tunnel, and possibly cross over and lose autonomous.

Skills:

We noticed in skills that people often go under a tunnel for programming, as going over the barrier can be quite inconsistent, since your wheels are drifting and the robot is unable to know properly where it is. Also, we have seen that other teams, such as *229V,* that push from all sides, and tends to be the most consistent and reliable way to score. Oftentimes, this means 1-2 pushes from one side, then pushing twice down the middle, before one last push on the other side.

Designed by:

Austin Ma

Witnessed by:

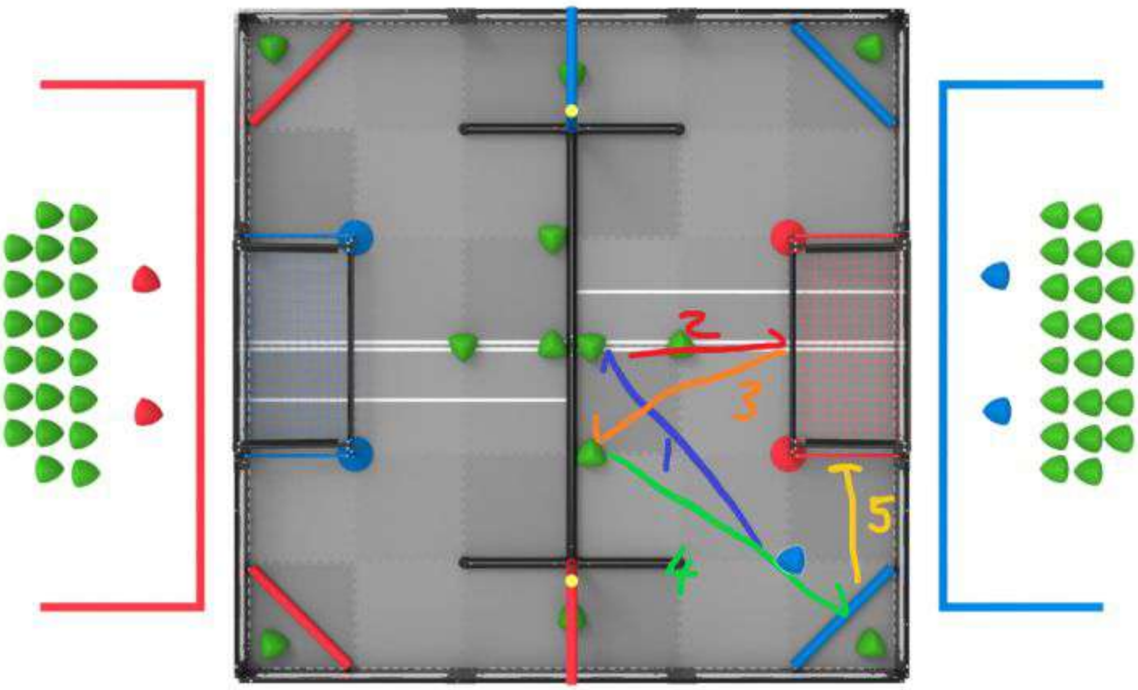
Matthew Zhang

Program Autonomous

2024/02/23

Offensive Side: 5 Balls Auton (25 points)

Due to some struggles with timing and the speed of our autonomous programs, we have decided to go for a 5 ball auton instead as it is easier to implement and will be faster and much more consistent. Additionally, we have opted to rush the middle two triballs as our opponents might try to interfere with our auton by pushing those triballs over the barrier which Is why we want to get to them first.



1. Turn on intake, follow the blue path
2. Turn around, follow the red path, open wings, push triballs into net
3. Follow orange path, turn on intake, intake triball
4. Turn around follow green path, turn so that the back is facing the net and the bot is parallel to the matchload bar, open descore mechanism, reverse until triball leaves match load zone.
5. Close descore mech, turn around, push 3 triballs into the net.

Designed by:

Austin Ma

Witnessed by:

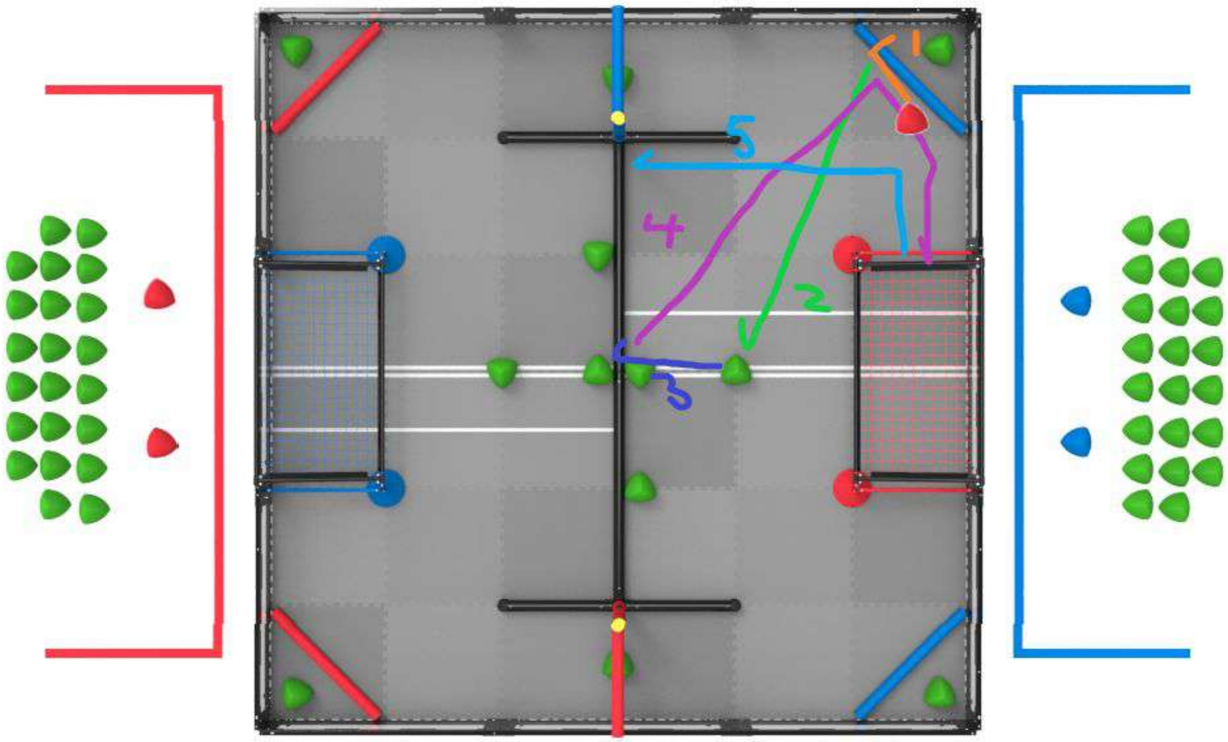
Darien Ng

Program Autonomous

2024/02/23

Defensive side: Autonomous Win Point (9 points, AWP)

Due to wanting to mid rush to interfere with the opponent's autonomous, we have decided to create a new route that prioritizes the middle triballs before scoring.



1. Orange path, open descore, remove triball from match load zone
2. Close descore, Green path, rush to middle, intake triball
3. Open walls and follow blue path to push triballs over the barrier
4. Close walls, follow purple path to push the preload into the net
5. Follow blue path to touch the elevation bar with a zip tie

Designed by:

Austin Ma

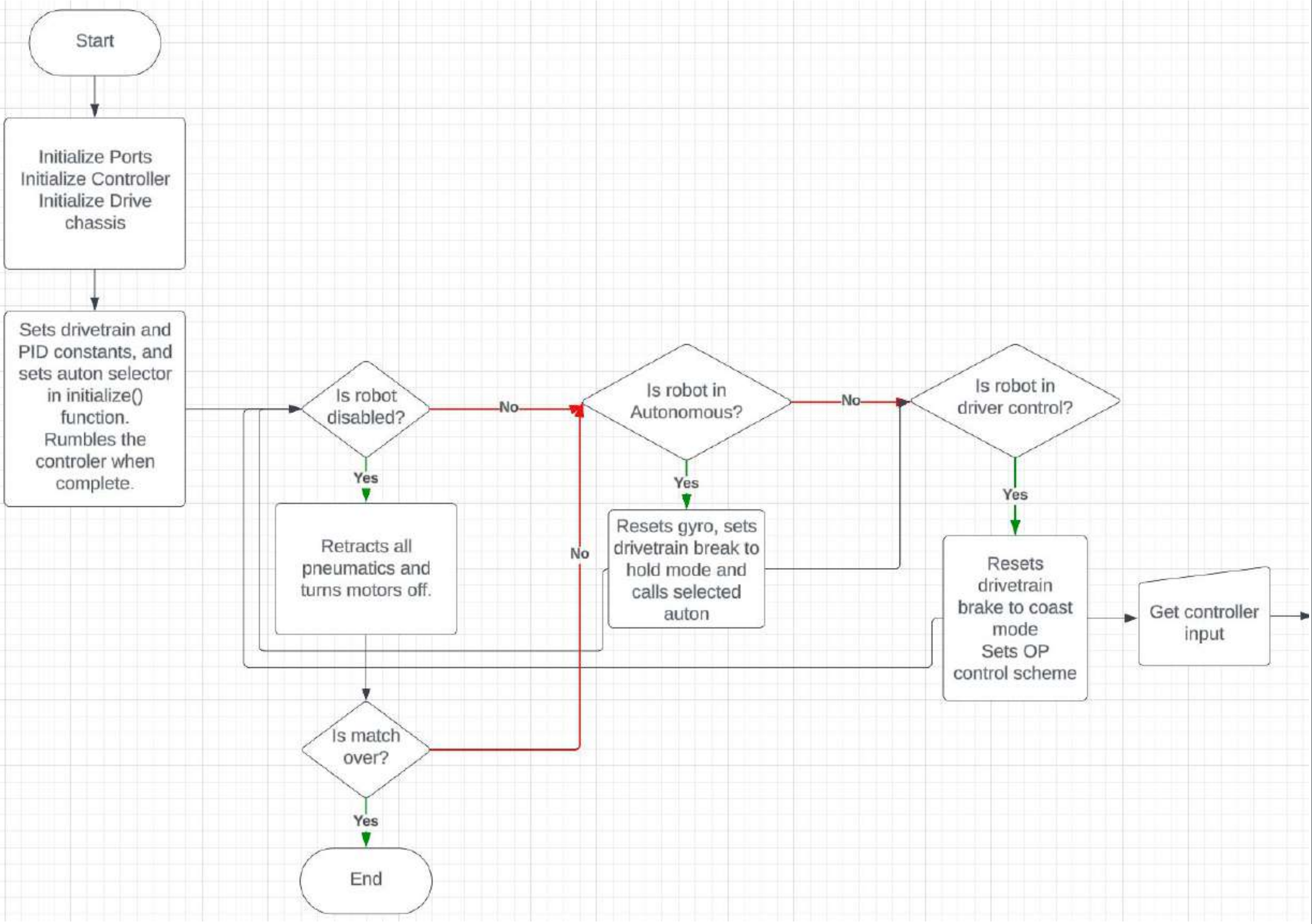
Witnessed by:

Darien Ng

Programing Full Breakdown

2024/02/28

Programming Overview Flowchart



Designed by:

Austin Ma

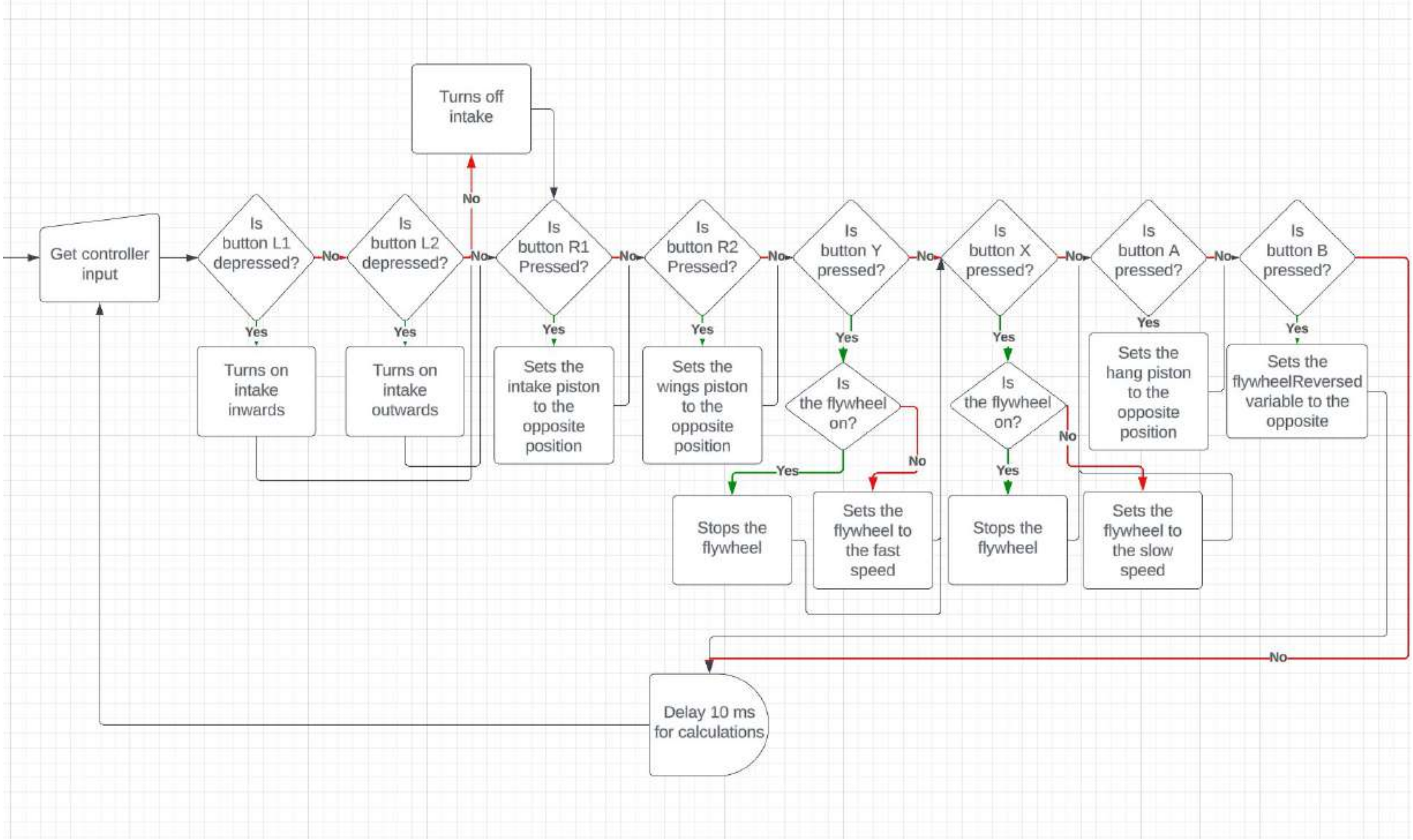
Witnessed by:

Bolo Wang

Programing Full Breakdown

2024/02/28

Programing Overview Flowchart Continued.



Designed by:

Austin Ma

Witnessed by:

Bolo Wang

Programing Full Breakdown

2024/29/02

The programming for the robot was completed using VEX PROS in Visual Studio Code. The programing language used was C++ and we used EZ Template as a starting point for our code. For our driver control period, we used an split arcade drive allowing for control of the forwards and backwards drive on the left joystick and the turning on the right joystick. For our autonomous period, we used a PID program to ensure accurate and consistent autonomous runs. Lastly, we attempted in creating a pure pursuit program which will be more efficient during autonomous as it follows curves instead of driving in straight lines which will reduce the time it takes for the robot to stop and change directions.

Designed by:

Austin Ma

Witnessed by:

Matthew Zhang

Alberta Provincials - Analysis

2024/03/05

On March 3, we competed in the Alberta Provincial Championships in Calgary. This event went extremely well for us, and we were able to walk away with a tournament champions award as well as a World Championship qualification. All the parts of our robot were working very well and we had very little issues with any of our subsystems, with only a few disconnections in our morning preparation and during our skills challenges. The following image from Robot Events show our scores in our matches.

Qualifier #4	Mar 2nd at 10:36 AM	99197A	3300D	55	3300F	**3388H**	106
Qualifier #18	Mar 2nd at 11:41 AM	**3388H**	45519D	69	27455F	210T	90
Qualifier #30	Mar 2nd at 1:29 PM	99197T	**3388H**	109	3388B	9409X	57
Qualifier #42	Mar 2nd at 2:44 PM	3388F	**3388H**	97	3388N	3388S	57
Qualifier #50	Mar 2nd at 3:18 PM	221E	27455D	87	**3388H**	6659E	102
Qualifier #62	Mar 2nd at 4:10 PM	210Z	221X	121	5760A	**3388H**	73
QF #3-1	Mar 2nd at 6:57 PM	9409Z	9409X	59	**3388H**	3388C	102
SF #2-1	Mar 2nd at 7:25 PM	**3388H**	3388C	105	210Z	3388B	97
Final #1-1	Mar 2nd at 8:28 PM	3388A	210T	92	**3388H**	3388C	120
R16 #6-1	Mar 2nd at 6:35 PM	**3388H**	3388C	115	221E	3388Z	85

Designed by: Darien Ng

Witnessed by: Matthew Zhang

Alberta Provincials - Match Analysis

2024/03/05

Qualification 4

Qualification 4 was a good start to the provincial championships. We started off strong with an autonomous win point and we were able to bowl large amounts of triballs into the goal at the start of the drive control period. We were also very quick at grabbing triballs that were scattered around the field, gaining us more points while preventing those triballs from getting into our opponents' possession. Midway through the match, we noticed that a triball got stuck in our drop-down intake, and we were unable to get it off for a while. Eventually, we figured out that spinning the robot was a good tactic to get rid of this stuck triball. Our callouts were also quite strong throughout this qualification, and we had a decent amount of time to elevate at the end of the match. We won with a final score of 106 to 55. An image of the triball that got stuck on top of our robot is included below.

Qualification 18

This math was a struggle for us, combining our lacking callouts with an unlucky team matchup resulted in us losing this match. We started off with a strong autonomous period, as we were able to earn an autonomous win point as well as the autonomous bonus. Throughout the drive control period, we found ourselves facing heavy defence from one of our opponents, and they were actually able to stop our bowling by rushing over the barrier and in front of us before we got to their goal. We were also quite slow in blocking our opponents, and they were able to bowl triballs consistently into their goal throughout the course of the match. Towards the end of the match, we missed a few time callouts between our drive team, and we were unable to elevate ourselves. Overall, we lost with a final score of 69 to 90. Although we did lose this qualification match, this was a wake up call for us to make sure we improve our callouts in the future.

Designed by:

Darien Ng

Witnessed by:

Matthew Zhang

Alberta Provincials - Match Analysis

2024/03/05

Qualification 30

We were quite concerned about this match due to the matchups, but we were able to perform quite strongly throughout this match and ended up winning by a decent margin. We started off strong with the autonomous bonus, and we were able to push a good amount of triballs scattered around the field into our goal, securing extra points for our team. Our teammate also defended very well while we were slowly moving triballs into our goal. Midway through the match, our opponents had the advantage, but they accidentally double zoned and we were able to descore a few triballs from the goal, and eventually pushing them into our own goal. Towards the end, both sides had one robot elevated, and we took the win with a final score of 109 to 57.

Qualification 42

This match overall went quite well for us, though it was closer to a skills match since both our opponents happened to face disconnection issues. We lost the autonomous period, but we were able to quickly recover by getting a huge amount of triballs in our net. At one point in the match, we double zoed, giving our opponents the opportunity to descore our goal. However, their robot faced disconnection issues when they tried to descore, basically keeping them stuck inside our net for the rest of the match. Meanwhile, our other opponents also faced disconnection issues with a battery falling out after getting defended from our alliance partner. We also noticed that the team who got stuck in our goal blocked us from scoring triballs without going around to the front of the goal. This was also a reminder to our team to be more careful about double zoning in the future, as this could have easily swayed the tides to our opponent's advantage. We won this match with a score of 97 to 57. The image below shows our opponents who got stuck inside our goal.

Designed by:

Darien Ng

Witnessed by:

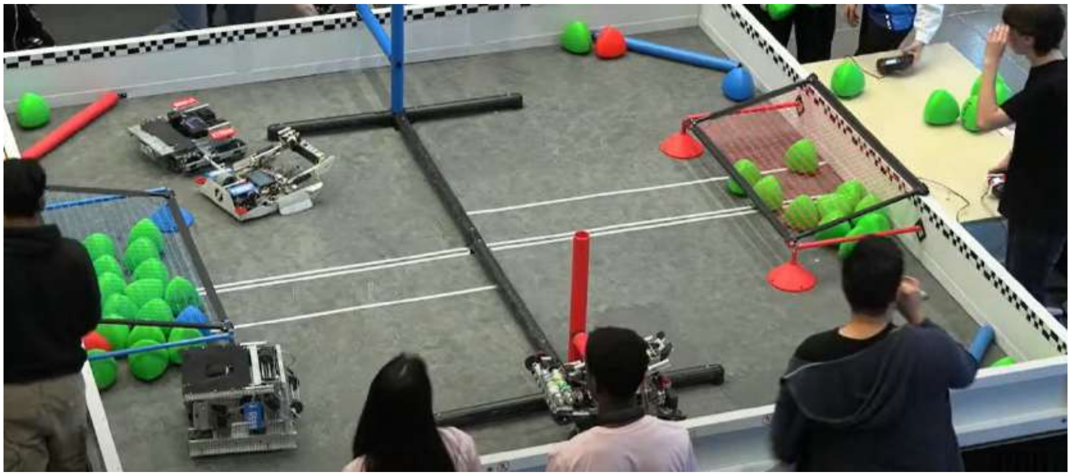
Oliver Liu

Alberta Provincials - Match Analysis

2024/03/05

Qualification 50

This match was one of our closest matches, and it could have gone either way. We started off a bit weak as our teammates' robot was touching the triball they scored in the net during autonomous. This made enough of a difference that the other alliance was able to win the autonomous bonus. Throughout the start of the driver control period, we were able to bowl a few triballs as well as get many of the triballs scattered around the field, pushing us into a huge lead. Towards the end, our team was ahead in triballs, but our opponents were able to pull off an amazing elevation while we were unfortunately unable to elevate. This was a close match, but we ended up winning with a final score of 102 to 87. Below is an image of the final state of the field after our match. We are the blue robot near the top left. One of our opponents (bottom) was able to elevate well, closing the score gap, though we still won.



Qualification 62

This match was a pretty big struggle for our team. To start, the matchup was not ideal as we were going against two of the best teams in the competition. We lucked out in the autonomous period since our opponents had a mishap with using the wrong autonomous code. In the drive control period, we faced heavy defence throughout the match. Although we were able to push many triballs around, we were unable to get the triballs cleared into our side of the field so they got pushed right into our opponent's goal. Our opponents also pulled off a strong elevation at the end of the match, and we lost the game with a final score of 121 to 73, ending our qualification matches with 4 wins and 2 losses as well as 11 win points, putting our final ranking for the qualifications at 8th place.

Designed by: Darien Ng

Witnessed by: Matthew Zhang

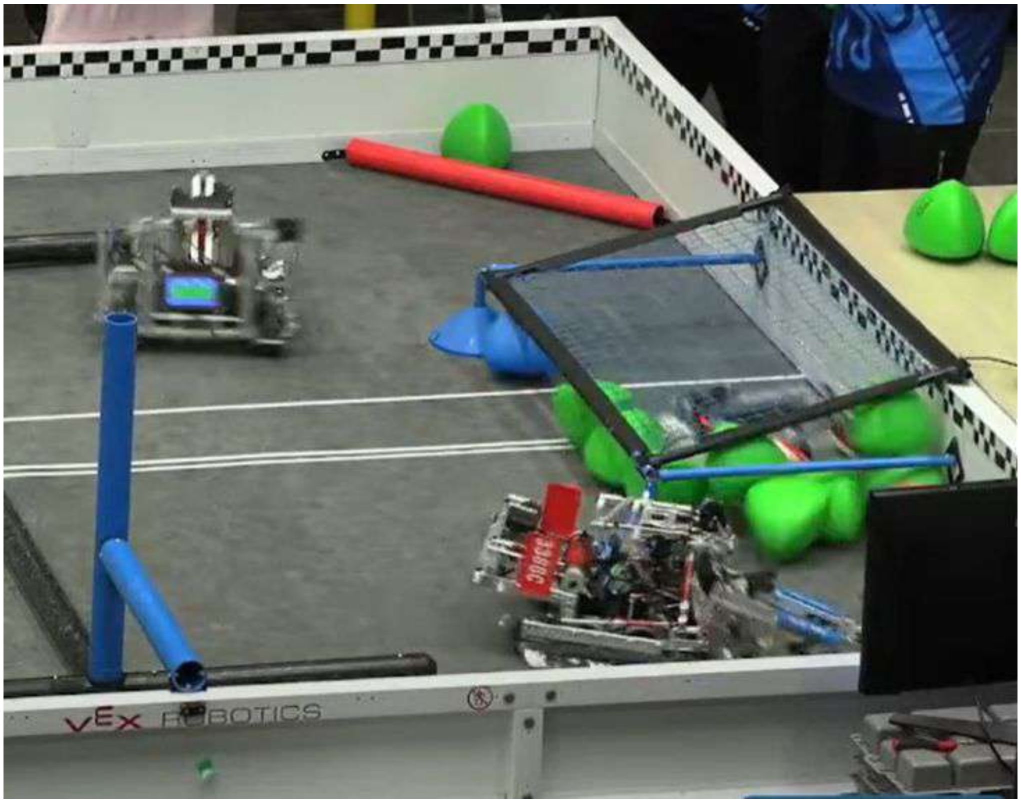
Alberta Provincials - Match Analysis

2024/03/05

For the elimination portion of the provincial tournament, we have chosen to alliance with team 3388C, as they were the best option out of the remaining teams that we could pick and most of the other teams that were able to synergize well with were already in an alliance of some sort. We are also quite familiar with 3388C as they are from the same school as us and we have seen each other in almost all the events that we have been to.

Round of 16

Overall, this round went well for us, and we were able to walk away with a win, advancing us to the quarter finals. We started off a bit slow since we did not have a good plan for autonomous in place, leading to our opponents winning the autonomous bonus. The driver control period went very well though, as our alliance partner played extremely good defence while we were able to bowl a good amount of triballs into the goal. Midway through the round, we were also able to get a descore in, removing a couple triballs from their net. With help from our alliance partner, we were also able to get these triballs into our own net, gaining us a good amount of points. At the end we were also able to get some elevation points as our alliance partner was able to elevate. This firmly secured our win with a final score of 115 to 85. An image showing the moment we descored our opponents is shown below. Our robot is the one in the goal.



Designed by:

Darien Ng

Witnessed by:

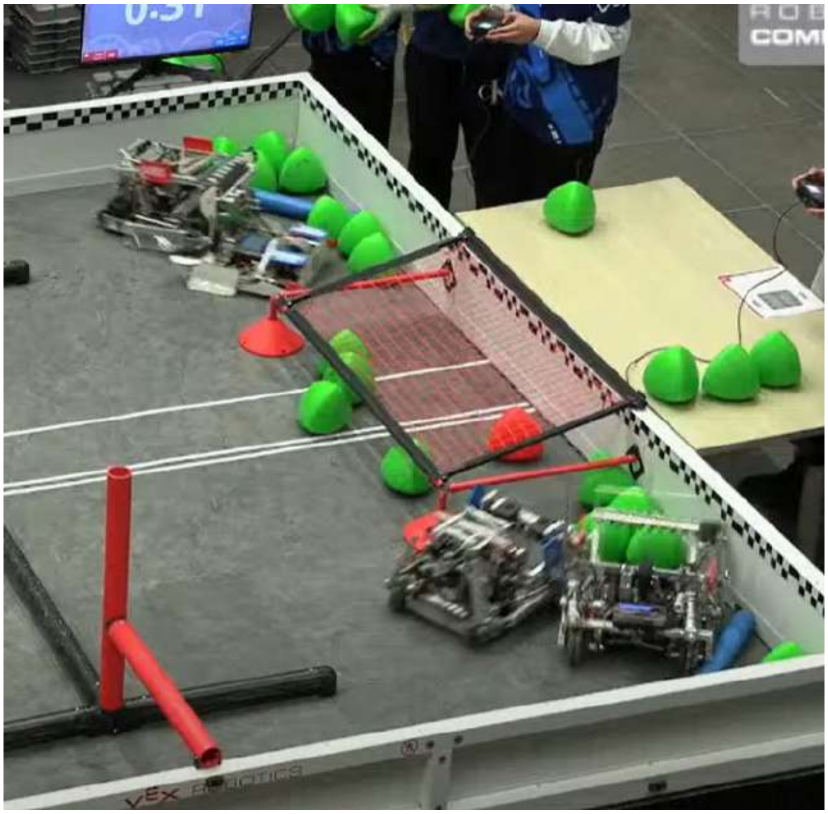
Matthew Zhang

Alberta Provincials - Match Analysis

2024/03/05

Quarter Finals

This was a fairly strong and simple match for us, even when compared to some of our qualification matches. To start, we were able to secure the autonomous bonus and immediately knocked another 3 triballs into our goal the second that driver control started. Unfortunately, our alliance partner got pushed onto the middle barrier, and we faced heavy defence while trying to get them down. Once we got them down, they were able to defend our opponents while we tunneled triballs and got a few triballs scattered around the field. We were also given the opportunity to descore while we were getting pinned to our opponents' goal, and we were able to take advantage of it, descoring a decent amount of triballs and getting them into our own goal while escaping our opponents' pin. Towards the end of the round our alliance partner was blocked from elevating for a while, but we still got the win with a final score of 102 to 55. A picture showing our opportunity to descore our opponents' goal is shown below. Our robot is in the top right, unable to escape due to the red robot. In addition to descoring the triballs present in the goal, we were also able to stop our opponents in the bottom right from scoring triballs into their goal.



Designed by: Darien Ng

Witnessed by: Austin Ma

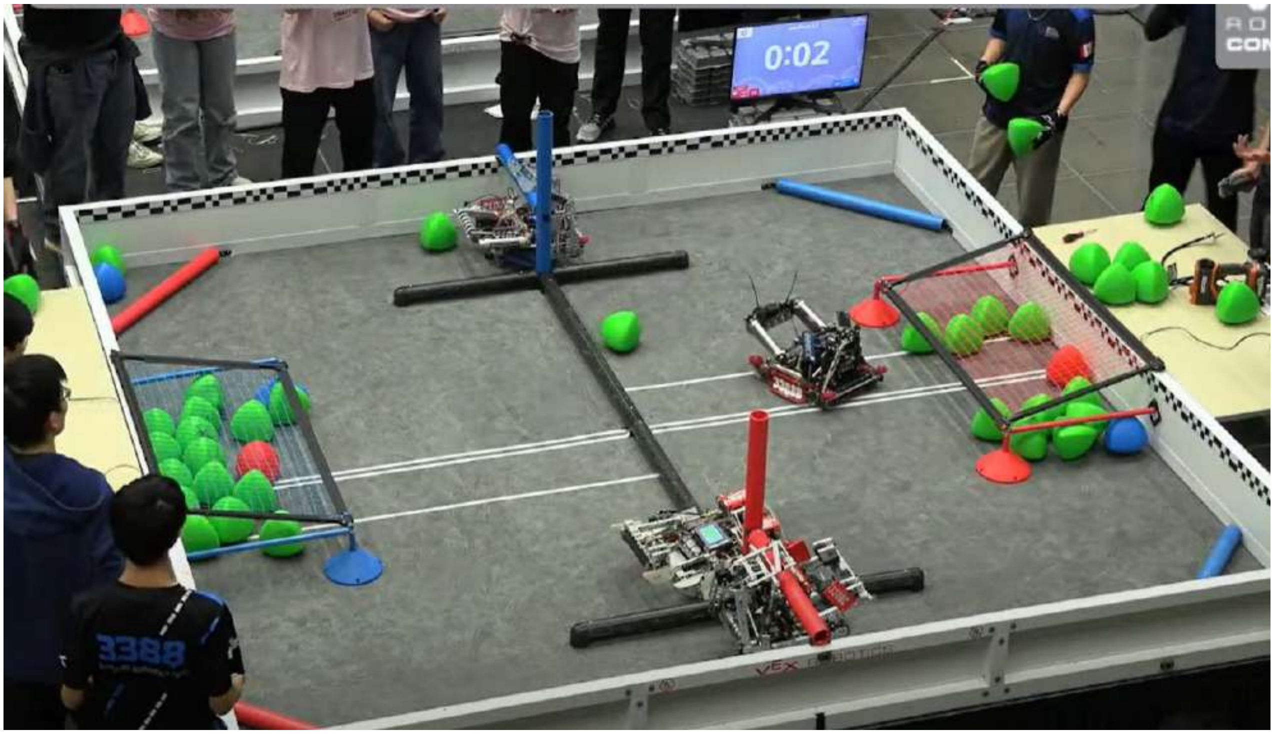
Alberta Provincials - Match Analysis

2024/03/05

Semi Finals

The semi final match was an extremely close game - only an 8 point difference between our final scores. We were able to win the autonomous bonus by a marginal amount. During driver control, we had significant difficulty in scoring, and our opponents were able to bowl many triballs across while our alliance partner was only able to get one triball across every once in a while. Midway through the match, we were given the opportunity to descore and we descored around five triballs. It was not too much, but enough to make a difference in the final score. At the end of the round, we were able to get a double elevation while our opponents only had one team elevate. The extra elevation gave us the win with a final score of 105 to 97, advancing us to the finals.

A picture showing the final state of the field is shown below. Our alliance is the red alliance in this match. With the difference in the amount of triballs in each goal, everything that we did to score points influenced the result of the game.



Designed by: Darien Ng

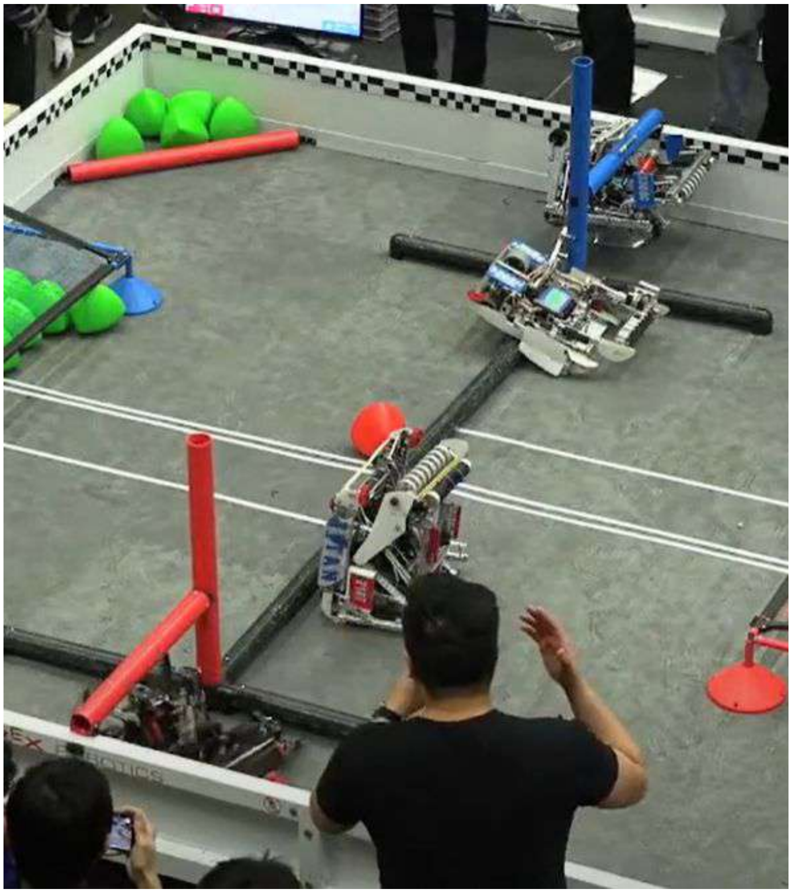
Witnessed by: Matthew Zhang

Alberta Provincials - Match Analysis

2024/03/05

Finals 1

Going into the finals, we were not optimistic, knowing the teams that we were going up against both placed top 3 in the qualifications and also held seat one in the eliminations. The autonomous period went about as expected for us, we got completely demolished due to our opponents' autonomous code getting to the triballs much faster than ours. As the driver control period started, we were off to an explosive start, and we were able to both tunnel at the same time, catching our opponents off guard (our alliance partner had a free path to the goal). However, our opponents were also able to get just as many tribal;ls into their goal. In the last 15 seconds, we lucked out, as one of our opponents flipped onto their back while crossing the barrier. Our other opponent was able to elevate, but fell off in the last few seconds with no time to get back up. On the other hand we were able to get some elevation in, bringing the final score to 120 to 92 and giving us the win for the first round of the finals. Below is a photo showing all of our robots at the end of the round. At the very top, our alliance partner was able to safely elevate while on the bottom half of the image, our opponents were touching the floor at the end of the match. Our robot (near the top, below our alliance partner) was unfortunately unable to elevate at the end of the match.



Designed by:

Darien Ng

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Matthew Zhang

Alberta Provincials - Match Analysis

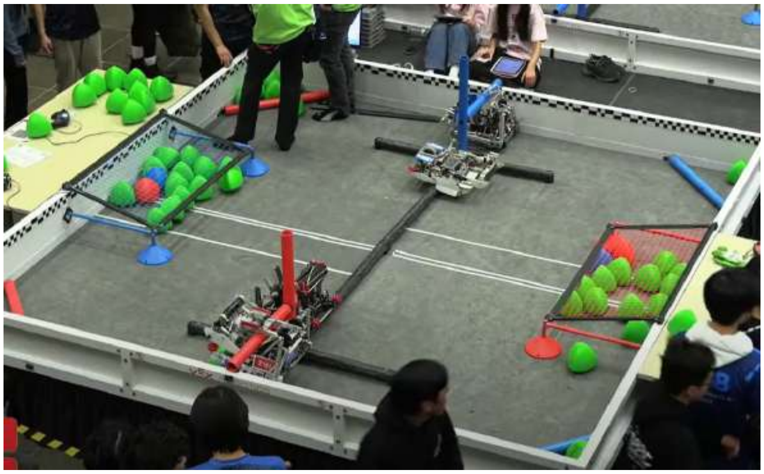
2024/03/05

Finals 2

This round was a struggle for us, as our motors were getting quite hot, resulting in slower gameplay from our alliance while our opponents were able to take advantage of it to beat us this round. We lost the autonomous bonus by a massive amount, giving our opponents a huge lead going into the drive control period. During the drive control period, we faced extremely heavy defence from one of our opponents, effectively blocking us from doing much other than slowly moving triballs across when we are given the opportunity. Our alliance partner was also getting heavily defended, and all the triballs that they loaded into the intake of their robot was quickly stolen by our other opponent, giving our opponents much more triballs to work with much closer to their net. As a result they were able to score triballs faster than us. At the end, our opponents also got a double elevation while our alliance only got a single elevation, giving our opponents the win with a final score of 114 to 97.

Finals 3

The last round of the finals was a chaotic game, and it was an extremely close game. To start, the autonomous period went the same as the first where we lost by a miserable amount. We faced extremely tough defence throughout the match, though both sides had the opportunity to tunnel some triballs into the goals. Our alliance partner got entangled with one of our opponents stopping both robots for about 30 seconds. Eventually, they were able to get free. We were able to get a double elevation this match while our opponent was only able to get one robot elevated. After the scores were tallied, we barely got the win with a final score of 109 to 100, giving us the win in the final round. Below is a picture showing the final state of the field after our match. Like all of the finals matches, this was an extremely close game, and anything that could have gone differently would have been match affecting.



Designed by:

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Witnessed by:

Matthew Zhang

Climb - Strategy

2024/03/6

Here, we will discuss one of the new strategies that we will be attempting to implement in building our robot. We will call this a "climb" or a "hang." The main advantages of such a system will be discussed in the points below. We will be discussing two types of climbing mechanism. A horizontal bar climb and an ace climb.

Less time needed for elevation

One of the key ideas behind a horizontal bar climb is to allow for easier time climbing and to achieve double elevation during matches with a shorter time required to climb. This is especially useful with our strategy of bowling which we will be sticking with for the world championships. A horizontal bar climb is especially useful for this strategy as it will maximize the time we have to bowl by minimizing the amount of time needed to set up our elevation. This is especially important as it can help us score a few extra points uncontested while the enemy is elevating, then a last second hang to compete with them for the elevation points.

More points in elevation

With a horizontal bar climb, we are able to elevate much higher than with a barrier ride hang as we have done in the past. With the horizontal bar climb, we are able to achieve a C tier elevation, and with an ace climb, we can achieve a D tier elevation, which would be much more competitive as compared to an A tier elevation. The increase in elevation tier would help us achieve more points during the end game and we can be much more flexible on how we elevate depending on what our teammate can do.

Designed by:

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Matthew Zhang

Identify Objective - Climb

2024/03/09

Goal: Create a climb that is efficient and able to reach a high tier

Problem Statement:

- Build a climb that will be attached to our bot which can perform both a horizontal bar hang and an ace hang

Solution Requirements:

- Be able to hang on the horizontal bar
- Be able to perform an ace hang
- Must be constructed out of legal VRC parts
- Must be rigid enough to withstand the force of our bot
- Must remain fairly light
- Must be able to fit under 6 inches

Solution Goals:

- Be able to elevate quickly
- Be able to quickly switch which mode of elevation it is using
- Be able to get a high tier

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Austin Ma

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Bolo Wang

Select and Plan - Climb

2024/03/09

Goal: Determine the benefits and drawbacks of the different types of elevation mechanisms

- **Simplicity**
  - How simple is this to build
- **Compactness**
  - How much space does this take up on the bot
- **Effectiveness**
  - How effective is this in helping us climb
- **Tier**
  - Which tier the climb is capable of reaching

Scoring: Higher is better

Drivetrain RPM	Simplicity	Compactness	Effectiveness	Tier	Total
Barrier riding	6	7	3	1	17
Horizontal bar climb	5	5	6	3	19
Ace climb	3	5	7	4	19

Based on the decision matrix, we decided that having a climb that is capable of both a horizontal bar climb and an ace climb would best suit our bot. Since our past climb was inefficient and inconsistent, wondered whether it was worth building a higher and more efficient elevation mechanism for our bot. Using a horizontal bar climb that can double as an ace clim will greatly boost our overall potency during the endgame phase of each match. Additionally, having many different elevation strategies allows us to be adaptive and compliment our teammate during the endgame periods of each match.

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Bolo Wang

Design/Build - Climb

2024/03/10

Goal: To design and build a intake that fits the requirements and capabilities stated prior.

Firstly, we realised that our previous climb was too inconsistent and that we need to make the our climb higher and more consistent. We removed the flywheel from our bot to mount our new climb mechanism as we believed that the flywheel is not as useful in this game. We realized that the original way we mounted our flywheel motor would be too tall for the climb, so we had to move a piston and the motor to the side so that we can mount our climb in the centre of our bot. From these additions, we were able to build our climb, and with some preliminary testing, it seemed to do what we wanted.

Designed by:

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Witnessed by:

Darien Ng