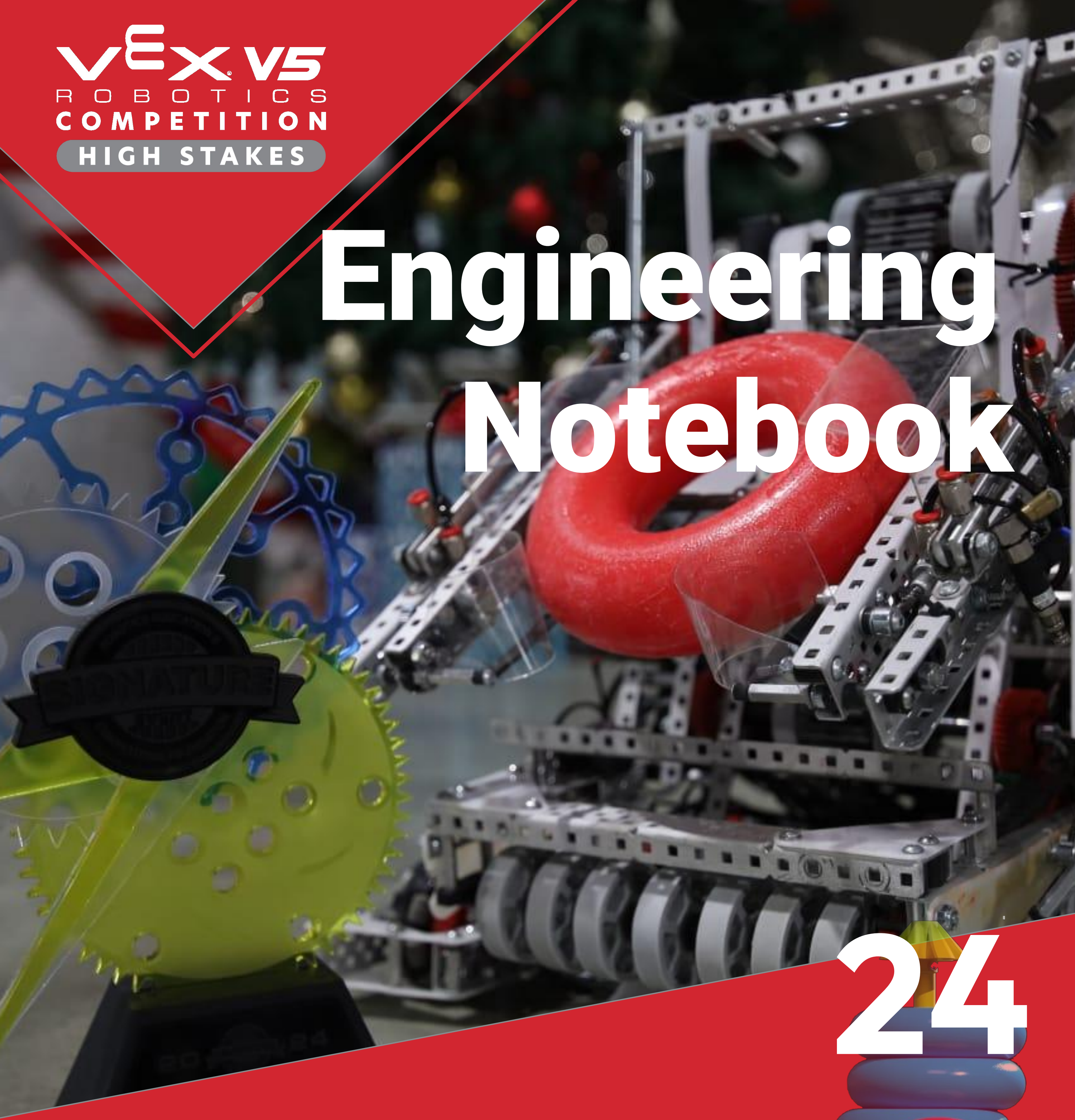
VEX V5 ROBOTICS COMPETITION
HIGH STAKES



Engineering Notebook

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86254B

Book 1 (Introduction)

Team Name
CAPMI1

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INTRODUCTION

TEAM BIOGRAPHY

Ryan Chu
Builder / Driver / Programmer / Notebooker
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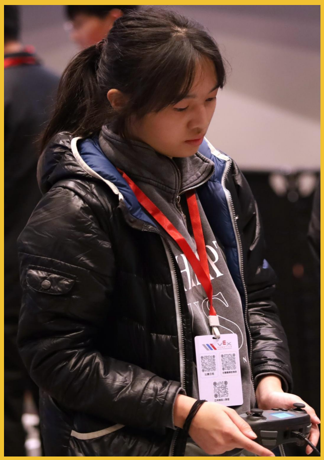

Ramie Kwok
Promotion Officer / Strategist
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*We participated in the VRC under team 39400A in Spin Up and Over Under

project Team Biography name Michael date 30/4/24

INTRODUCTION

TEAM GOALS

01 Learn to use PID and odometry to program

- This will allow us to proceed our robot to destinated position will higher accuracy and effectiveness
- Along with efficiency and accuracy, odometry programming also enable our robot to move using curved path, which increases the complexity of the path and ultimately improve our total point score in head-to-head autonomous period and robot skills challenge.

02 Utilize all scoring elements of the game

- We will consider all aspects of the gameplay when designing our robot, which allows us to perform different driving strategies in response to different potential opponents and alliance partners

03 Rank top 10 in the World Skills Ranking

- In the global world skills standings, reaching the top ten means we will be better than 99% of teams globally in terms of autonomous programming and driving in skills.
- It would be challenging but the resources used to achieve the top ten score will be used in our tournament autonomous program and driver training.

HOW TO READ THIS NOTEBOOK

TITLE	This font will be used for project titles
— SUBTITLE —	This font and format will be used for subtitles.
LABEL	Labels for diagrams,sketches,etc.will be all capitalized.
Section Heading	A box around words will indicate a section heading
Normal	Most other text will be written in this standard type. Some changes to this font are anticipated and acceptable.

ENGINEERING DESIGN PROCESS

Identify Problem

- Understanding the reason we need to solve this problem
- Problem description with words and pictures
- Solution Requirements & Goals

Brainstorm Solutions

- Possible solutions with advantages and disadvantages
- Labeled diagrams with drawings
- CAD prototype of possible solutions
- Citations from outside sources

Select and Plan

- Testing steps for prototype solutions
- Result tables of test results
- prototype analyzing
- CAD model of solution

Build Solution

- Steps to build the Solutions
- Record of the problems encountered during building
- Completed assembled build

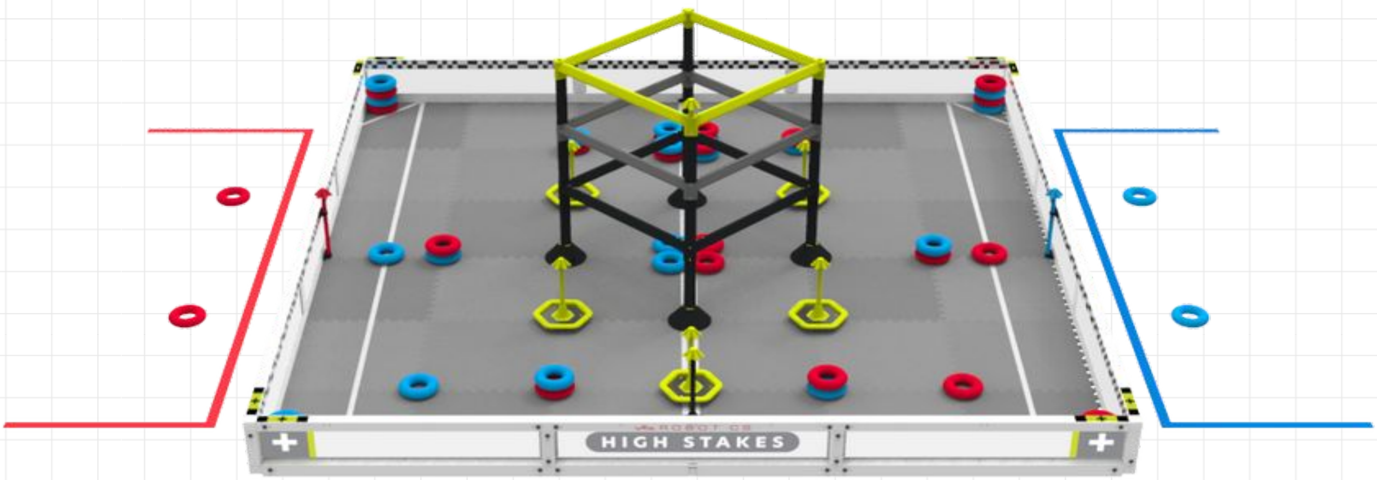
Test Solution

- Diverse testing criteria for solution evaluation
- Graphs and tables for test results
- Conclusion and reflection based on results

IDENTIFY GAME PROBLEM

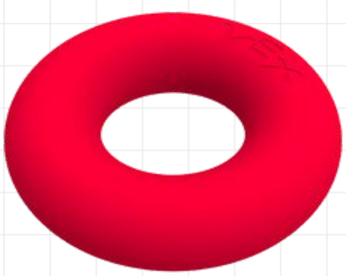
Goal

We will analyze VRC “High Stakes” so that we can better understand this year’s game.



Field elements

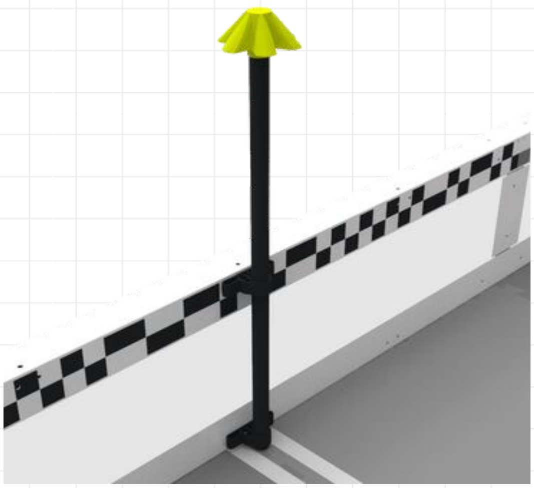
- Total of possible 48 rings in play, 24 colored rings per alliance
- 44 rings start on the field
- 2 preload rings per alliance (put on the field or robots before match starts)
- Outer diameter: 7” (177.8mm)
- Inner diameter: 3” (76.2mm)
- Thickness: 2” (50.8mm)
- 3 pts each for top ring in a stake
- 1 pt in a stake when not classified as top ring



Rings

Mobile goal

- 5 in the field
- Neutral for both alliances
- Hexagonal base
- Base maximum diameter 10” (254 mm)
- overall height of 14.5” (368.3 mm)



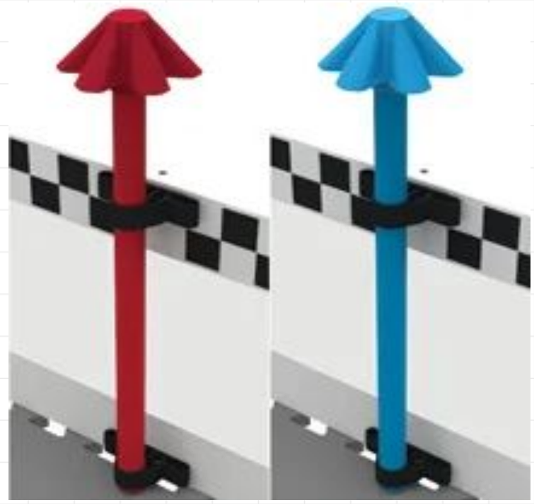
Neutral Wall Stake

- 2 in the field
- Neutral for both alliances
- 25.09 inches tall

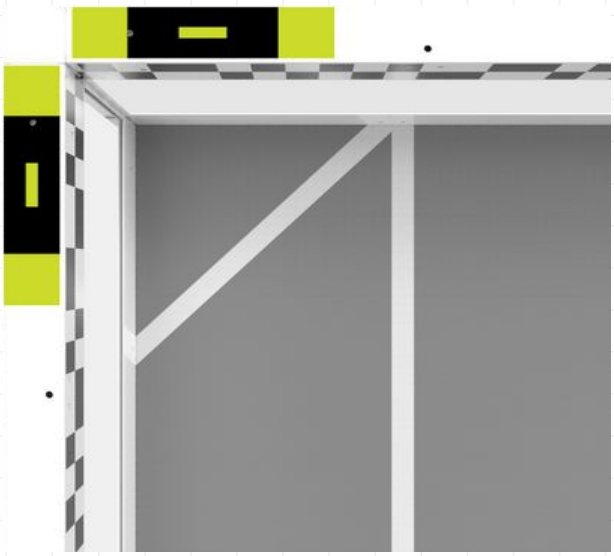
High Stake

- 1 in the field
- Located on the top of the Ladder
- Neutral for both alliances
- 49.89 inches tall

Alliance Wall Stake



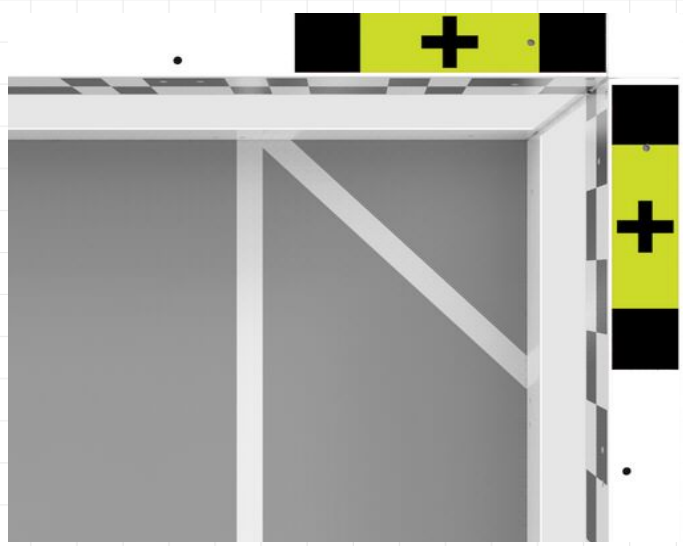
- 2 alliance wall stakes total (1 per alliance)
- 16.72 inches tall
- Located on field walls parallel to Alliance Stations



Negative Corner

- 2 in the field, on the same side of the field
- 12 inches x 12 inches triangle area
- has two “minus” sign on top for indication

Positive Corner



- 2 in the field, on the same side of the field
- 12 inches x 12 inches triangle area
- has two “plus” sign on top for indication

Ladder

- 46 inches tall
- 36 inches wide
- 36 inches long
- has 3 sets of horizontal rungs at 18” (457.2 mm), 32” (812.8 mm), and 46” (1168.4 mm)

Autonomous Line

- A pair of white tapes separating both alliances
- Robots that cross the line during the autonomous period lost the 6 point bonus to the opposing alliance

Alliance Starting Line

- Parallel to the alliance stations
- Marks the starting positions for robots

Important terms

Game objects

- Scored - A ring status, the ring is encircling the stake
- Top ring - A ring status, the furthest Scored Ring from a given Stake's base
- Placed in a Corner - A mobile goal status, the mobile goal is touching the ground, breaking the plane of the corner and a portion of its top is higher than the top edge of the field wall
- Possession - A robot status. A robot can only possess up to 1 mobile goal and 2 rings

Match Play

- Autonomous period - 15 second period at the beginning of each match without driver input
- Driver Control Period - 1 minute 45 second time following the autonomous period with driver input allowed

Important terms

Violations

- Entanglement - A Robot status. A Robot is Entangled if it has grabbed, hooked, or attached to an opposing Robot or a Field Element.

- Trapping - A Robot status, Robots that constrict another to a small space (roughly the size of one field tile) are considered Trapping. Robots that are Trapping for longer than 5 seconds are in violation of this rule.

- Match affecting - A Violation that changes the winning and losing Alliance in the match.

- Minor Violation - A Violation which does not result in a Disqualification. Usually minor violations are accidental and/or momentary.

- Major violation - A Violation which results in a Disqualification. Usually match affecting and intentional violations qualify as major.

UNDERSTAND GAME RULES

Goal

We will understand the game rules of VRC “High Stakes” to develop strategies

SG1

Standard rule explaining the legal robot setup

1. Robots stay within their respective alliance lines
2. Robots may not touch any field elements or game elements other than their preloads and perimeter
3. Robots may not be contacting with other robots
4. Robots start within an 18"x 18"x 18" cube

SG2

Rule that limits robot’s horizontal expansion

- Robot can never exceed overall size of 24” x 18”
- Only one “X/Y” horizontal direction from the robot’s perspective can be expanded to at most 24” during match

SG3

Rule that limits robot’s vertical expansion

- Robot can expand vertically after match begins
- Robot can never break 2 planes of the ladder at the same time
- The vertical size limit does not rotate with the robot

SG4

Scoring objects should be in the field

Violations of this rule are considered major violation when:

- a team removes 3 or more opponent’s ring from the field
- a robot removes a mobile goal from the field

SG5

Rule that allows robots to hold up to 1 Preload before the match

- Preloads can contact no more than one robot
- Preloads cannot be contacting or encircling a Stake or any other Scoring Objects
- Preloads has to contact one robot of the same alliance colour as the preload

SG6

Possession is limited to 2 rings and a mobile goal

- Rings on a state does not count to the ring count of possession
- plowing one mobile goal while possessing the other is a violation to this rule

SG7

Standard rule disallowing teams from crossing the autonomous line

- A robot is considered across the line if it contacts the foam tiles, rings, or mobile goals of the opposing alliance
- The mobile goal and wall stakes on the autonomous line are exempt from this rule

SG8

Rule that remind teams to carefully engage with the autonomous line

- Crossing the line will not be punished only when both robots are interacting with the same element

SG9

Rule that protect climbed robot

- driving directly into a climbing robot will result in a minor violation at least
- A higher and more firmly attached robot will have “benefit of doubt” when collisions happened between two climbing robots

SG10

Rule that only allows robots to interact with their own alliance stake

- Opponent’s ring that scored on alliance stake will not count

SG11

Rule that protect positive corners during the endgame period

- Robots cannot touch mobile goals placed in a positive corner and rings scored in it during the last 15 seconds of a match
- Any violation of this rule will be a major violation

GAME STRATEGIES

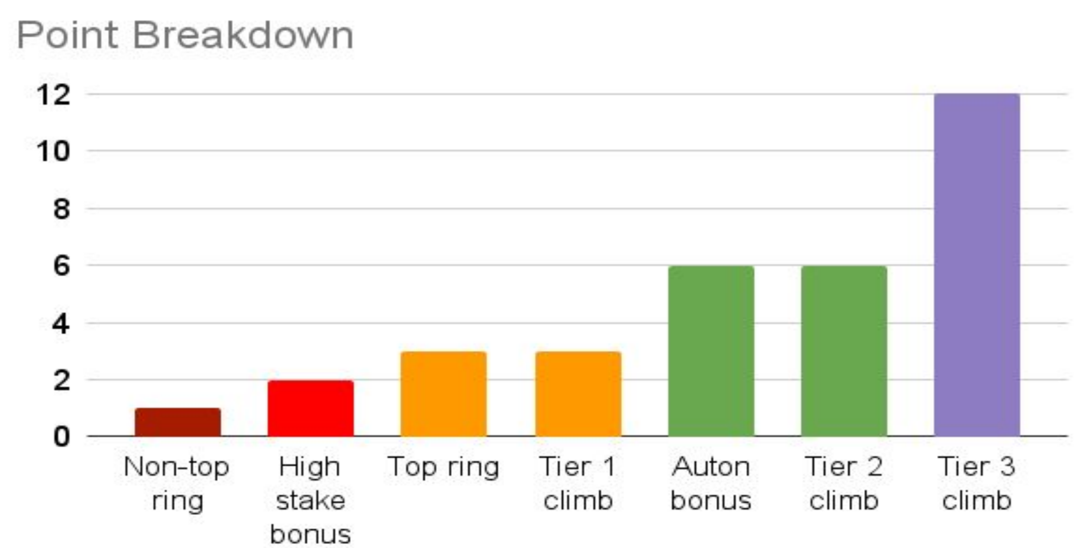
Goal

we will develop strategies for this year's game so that we can be more effective in playing the game

Scoring prioritization

Scoring method points:

- 1 point for each ring scored in stakes
- 3 points for each top ring scored in stakes
- score doubled for each mobile goal in positive corners
- 3,6, or 12 points earned for climbing
- additional 2 points for each alliance robot climbing scores after scoring the High Stake
- 6 points for autonomous bonus

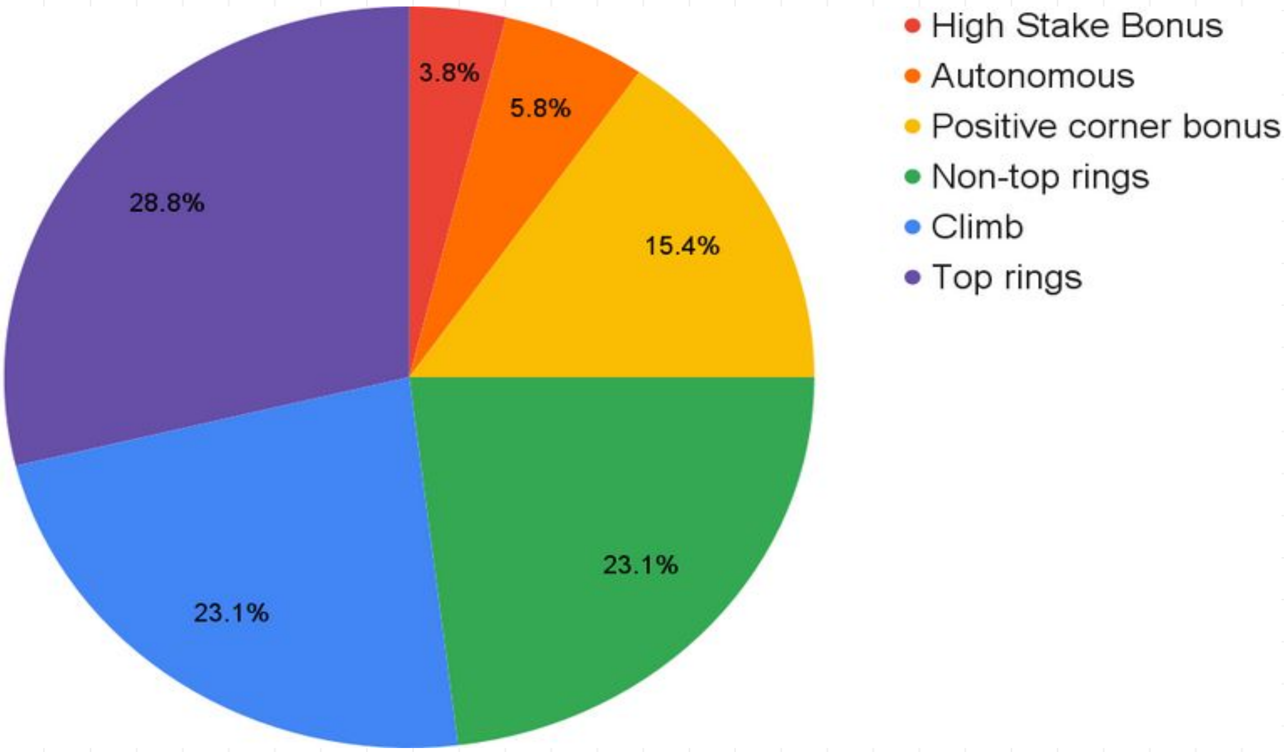


Observation

- Tier 3 climbing is worth the most points but is the most time-consuming
- Scoring non-top rings worth the least points but it can be completed very quickly
- Stakes in positive corners can be removed by the opponents
- Top ring are the best scoring option all-rounded considering score and time balance

Total points

- 24 points can be scored from non-top rings for each alliance
- 30 points can be scored from top rings
- 6 points can be scored from auton bonus
- Up to 14 points can be scored from climbing
- At most 16 points can be scored from positive corner



Observations:

- Top rings are the task that worth the most total points
- Autonomous bonus is the task worth the least total points
- Top ring and autonomous bonus value roughly doubled since claiming it descores point from opposing alliance
- Climbing fluctuates depending on design of robot

Offensive strategies

Fill up a full mobile goal

Positives	Negatives
• Top rings are secured • Easy to score • Can be put in positive corner to gain additional 8 points	• Will lose a 16 point difference if the mobile goal is put in negative corners • Limited to score at most 4 full mobile goals a match

Scoring Wall Stakes

Positives	Negatives
• Very hard to descore • Can be scored anytime	• Time consuming to score • Easy to be contested

Scoring High Stakes

Positives	Negatives
• Can gain up to 7 points	• Very time consuming to score • Has to specifically design mechanism for this • Easy to fail

Score a full mobile goal in autonomous period

Positives	Negatives
• Have huge initial advantage at the start of driver period • High chances of winning autonomous bonus	• Requires high precision and accuracy for the robot movement control • May score opponent's ring in auton period if the program failed

Climb to tier 3 during endgame

Positives	Negatives
• Can gain up to 12 scores directly • Protected by rules from being obstructed	• Very time consuming • Need to leave a mobile goal on the ground

Scoring alliance wall stakes

Positives	Negatives
• Cannot be descored by opponents • A secured top ring	• Limited to scoring two rings • Hard to score

Defensive Strategies

Push opposing robots when they are trying to score wall stakes

Positives	Negatives
• Preventing them from getting 3 point from top ring • Protects our alliance's top rings	• May cause damage to our robot • May cause our motors to overheat

Defend positive corners

Positives	Negatives
• Preventing them from getting 3 point from top ring • Protects our alliance's top rings	• Prevent us from scoring additional points

Flip our mobile goal

Positives	Negatives
• Can prevent our rings from being descored or put in negative corners • to grab an extra mobile goal	• Have to design a mechanism to consistently flip mobile goal • 1-2 rings may fell our during flipping

Putting opponent's mobile goal into negative corners

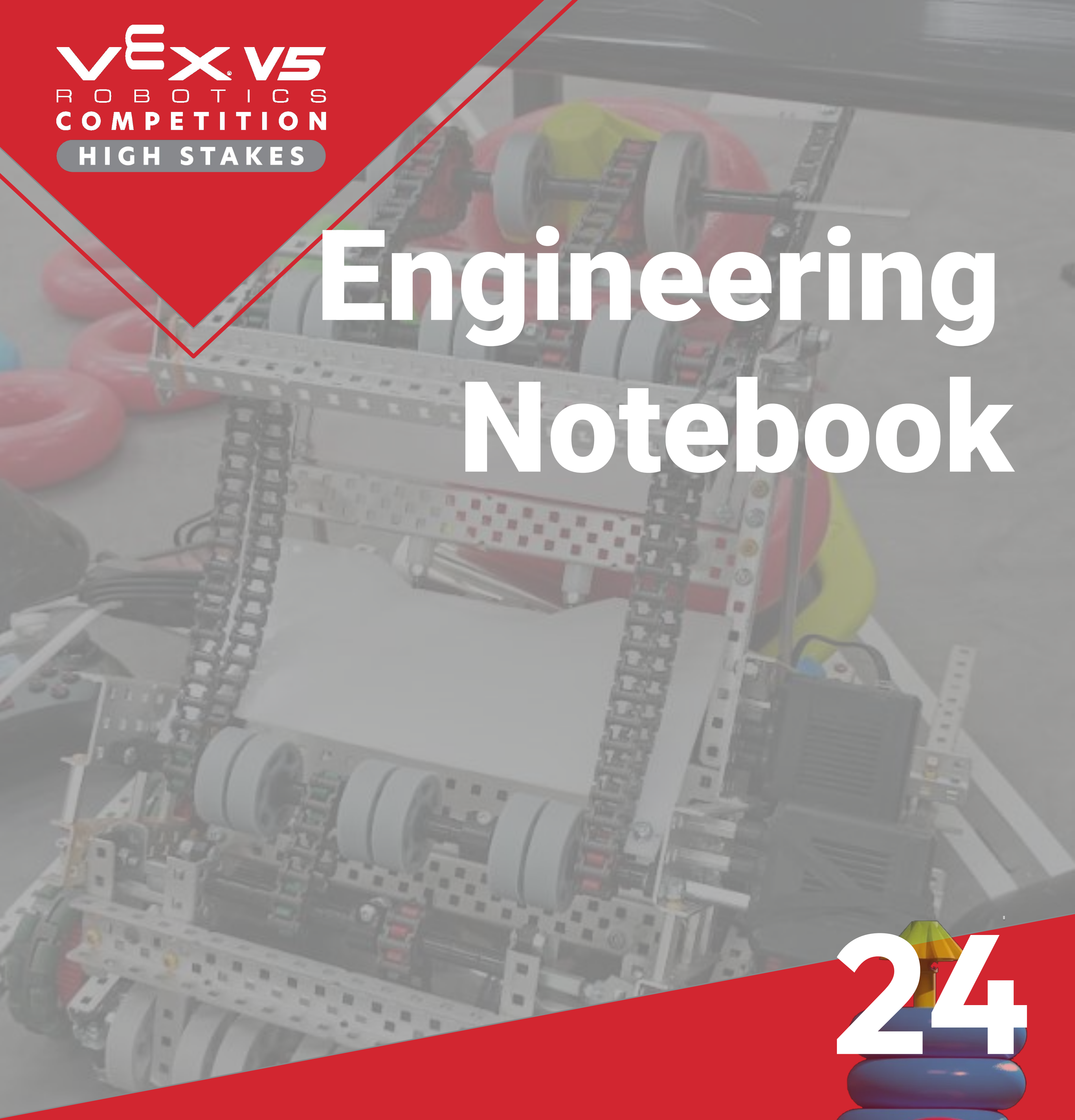
Positives	Negatives
• Value up to 16 points • Forces the opposing alliance to change their game strategy	• Easily to be interrupted

Climb to tier 3 during endgame

Positives	Negatives
• Can gain up to 12 scores directly • Protected by rules from being obstructed	• Very time consuming • Need to leave a mobile goal on the ground

VEX V5 ROBOTICS COMPETITION

HIGH STAKES



Engineering Notebook

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Book 2 (Generation 1&2, Pre-season to September)

Team name
CAPMI1

Robot name
BattleBot

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Robot Generation 1

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ROBOT GENERATION 1

project Drivetrain name Michae l date 27/5/24

DRIVETRAIN

project Drivetrain name Michael date 27/5/24

IDENTIFY PROBLEM

DRIVETRAIN

Goal

We will identify an objective for our robot so that we can address it and build an effective drivetrain

Problem Statement

We need a mechanism to move around the field so that we can interact with the game objects

Solution Requirements

- Must only use legal VEX Robotics Competition parts
- Must fit within 18”x18”x18” cube for starting size limit
- Must work using no more than 6 motors

Solution Goals

- Travel from a positive corner to the other one in less than 3 seconds
- Turn 360 degree in less than 2 seconds
- Travel from a corner to an diagonal corner in less than 5 seconds
- Running in the field continuously more than 6 minutes without overheating

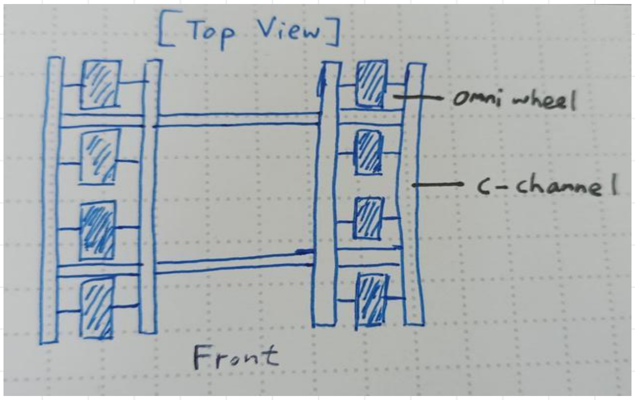
project Drivetrain name Michae l date 27/5/24

BRAINSTORM SOLUTION

DRIVETRAIN

Goal

We will brainstorm possible solutions for our drivetrain so that we can select the best one for our design

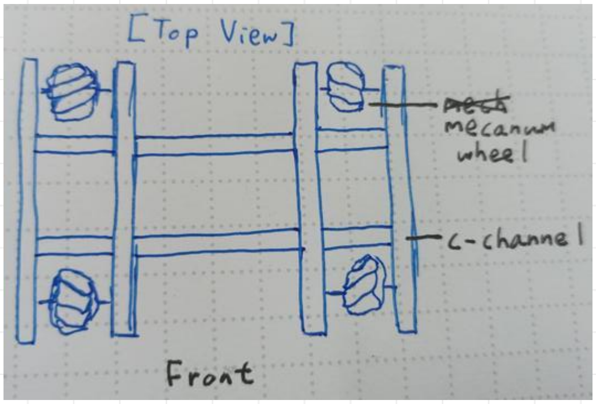


Possible Solutions - Drivetrain type

Full Omnidirectional wheels

- Omnidirectional wheels setup in a tank-drive orientation
- Most common drivetrain type

Positives	Negatives
• Fast • Easy to turn • more prolonged before overheat	• Low traction • Moves in only 2 directions



Mecanum wheels

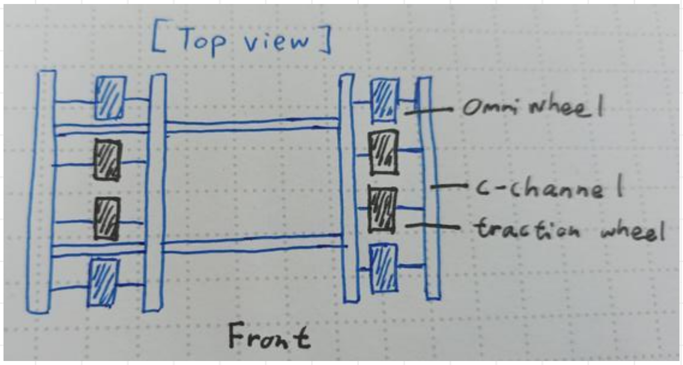
- Specialized wheels designed to allow movement in all directions
- Set up in a tank-drive orientation

Positives	Negatives
• All directions movement • Simple	• Less accurate in auton period due to four independent wheels • Slow when moving horizontally

project Drivetrain name Michael date 27/5/24

Omnidirectional and Traction Wheels

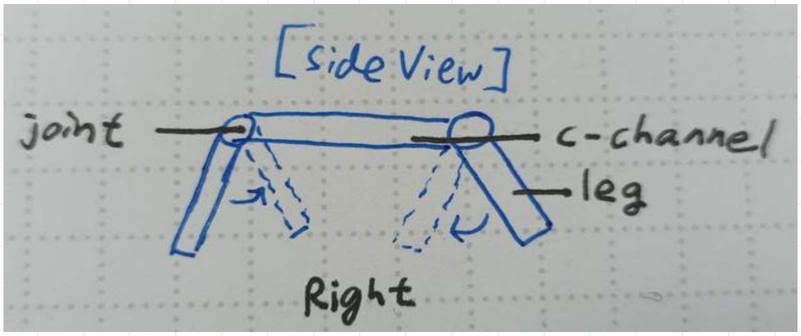
- Omnidirectional wheels and traction wheels set up in a tank-drive orientation
- Two omnidirectional wheels and two traction wheels per side



Positives	Negatives
• Good Traction • Movements can be precised controlled by driver	• Slow • Slow turning

Walking mechanism

- Use motors and arms to simulate walking movements
- Has two legs per side



Positives	Negatives
• Unique • Tall	• Extremely slow • High center of mass • Does not turn • Easy to flip • Huge usage of compressed air

Possible Solutions - Wheel Size

4” Omnidirectional/Traction Wheel

- Biggest wheel type allowed in official VRC parts
- Most common wheel size

Positives	Negatives
• Very fast • Familiar wheel size	• May stuck on rings • Easy to tip due to high center of gravity

3.25” Omnidirectional/Traction Wheel

- Middle size wheel type

Positives	Negatives
• Thin • Balanced speed and strength	• May be pushed easily

2.75” Omnidirectional/Traction Wheel

- Small size wheel type

Positives	Negatives
• Great center of mass • Highest torque • Will not stuck on rings • Fastest acceleration time	• Slower compared to other options

Possible Solutions - Cartridge Type

Red Cartridge

- Spins up to 100 RPM
- Usually used for mechanisms requiring extra strength such as lifters

Positives	Negatives
• Highest torque and strength • Least acceration time	• Extremely slow • Loses a lot of energy to friction inside the cartridge

Green Cartridge

- Spins up to 200 RPM
- Usually used for mechanisms requiring a balance of torque and speed

Positives	Negatives
• Has a good balance between speed and torque	• Loses some speed to friction in the cartridge

Blue Cartridge

- Spins up to 600 RPM
- Usually used for mechanisms requiring high speed

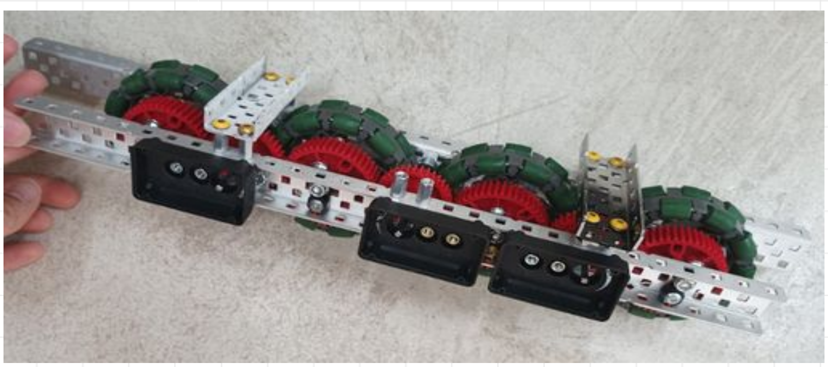
Positives	Negatives
• Very fast • More prone to overheat due to less friction	• Weak in terms of torque

Prototyped solutions

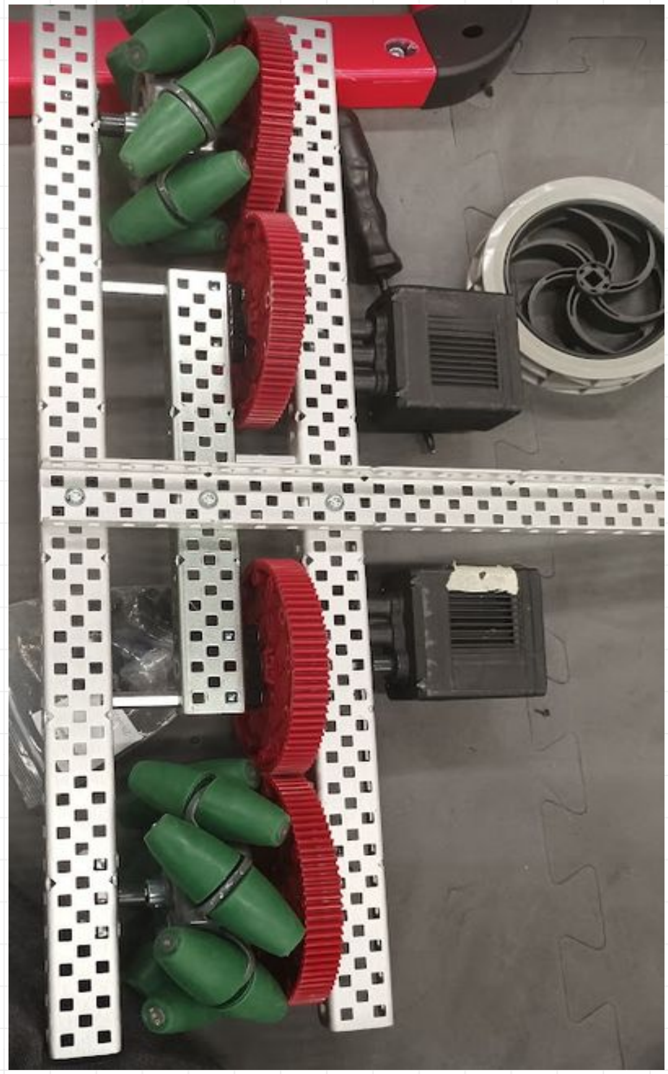
We have decided to prototype the 3 most common drivetrain types to get the most accurate information

- This will help us understand how these drivetrains will compare under our priorities

[Half Omni Drivetrain]



[Full Omni Wheel Drivetrain]



[Mecanum Wheel Drivetrain]

SELECT AND PLAN

DRIVETRAIN

Goal

We will select the solution that is best for our team so that we can plan how to build it

Prototype testing

- Test 1: Speed
- Test Procedures
- Place Prototype so that the back contacts the field perimeter wall
- Move prototype forward using joystick and start stopwatch
- Stop stopwatch when the front of the prototype hits wall
- Record results

Test Results:

Time Taken to Travel the Length of the Field					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Full omni	2.93	3.03	3.07	3.06	3.0225
Mecanum	4.23	3.98	4.16	3.98	4.0875
Omni-traction	3.64	3.7	3.65	3.69	3.67

Fastest: Full omni drive

- Test 2: Corner mobility
- Test Procedures
- Place prototype on a corner
- Start drive program and start stopwatch
- Drive prototype to each adjacent corner
- Stop stopwatch when the prototype touches last corner
- Record results

Test Results:

Time Taken to Travel across the corners					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Full omni	19.16	18.91	19.06	19.07	19.05
Mecanum	27.64	27.81	27.59	27.52	27.64
Omni-traction	24.58	24.62	24.57	24.75	24.63

Fastest: Full omni drive

- Test 3: Push
- Test Procedures
- place two different types of drivetrain prototypes in the middle of the field
- use joystick to drive the two prototypes to push towards each others
- Stop and record the results when one robot hits wall
- Record results

Test Results:

	Full omni	Mecanum	Half omni
Full omni	/	Full omni	Full omni
Mecanum	Full omni	/	Half omni
Half omni	Full omni	Half omni	/

Winner: Full omni drive

Decision Matrix - Drivetrain type

Speed	How fast the design moves at its max speed
Acceleration	How fast the drivetrain accelerates
Rotation	How quickly the design turns
Strength	How high is the torque of the drivetrain

	Speed	Acceleration	Rotation	Strength	Total
Full Omni	4.5	5	5	4	18.5
Half Omni	4.5	3.5	4	5	17
Mecanum	3.5	3	3.5	3.5	13.5

We will use 6 motor full omni drivetrain becasue of its high overall score on our prioties. Now our design is sured, we will find the right wheel size for the drivetrain.

Decision Matrix - Wheel type

Speed	How fast the wheel moves at its max speed
Acceleration	How quick the wheel accelerates
COG	How low the wheel places the center of gravity of the design
Strength	How high is the torque of the wheel
Overheat	How long the wheel can run before overheating

	Speed	Acceleration	COG	Strength	Overheat	Total
4" Wheel	5	2.5	3.5	3.5	3	19
3.25" Wheel	4.5	4	4.5	4.5	4	21.5
2.75" Wheel	3	4.5	4.5	4.5	4.5	21

We will use 3.25 inch omnidirectional wheels with the 6 motor standard tank-drive as it has the highest overall score on our priorities. Given both of these decisions, we will find the right motor cartridge type for the drivetrain.

Decision Matrix - Motor Cartridge

Speed How easy the wheel spins

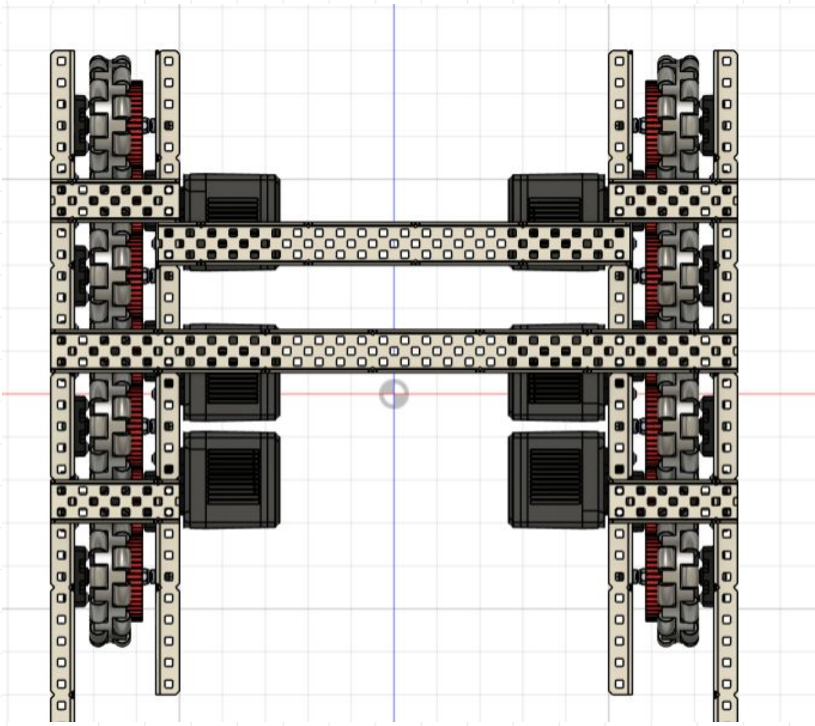
Acceleration How quickly the wheel accelerates

Strength How strong the wheel is

	Speed	Acceleration	Strength	Total
Red	1	5	5	11
Green	2.5	4.5	4	11
Blue	5	4	3	12

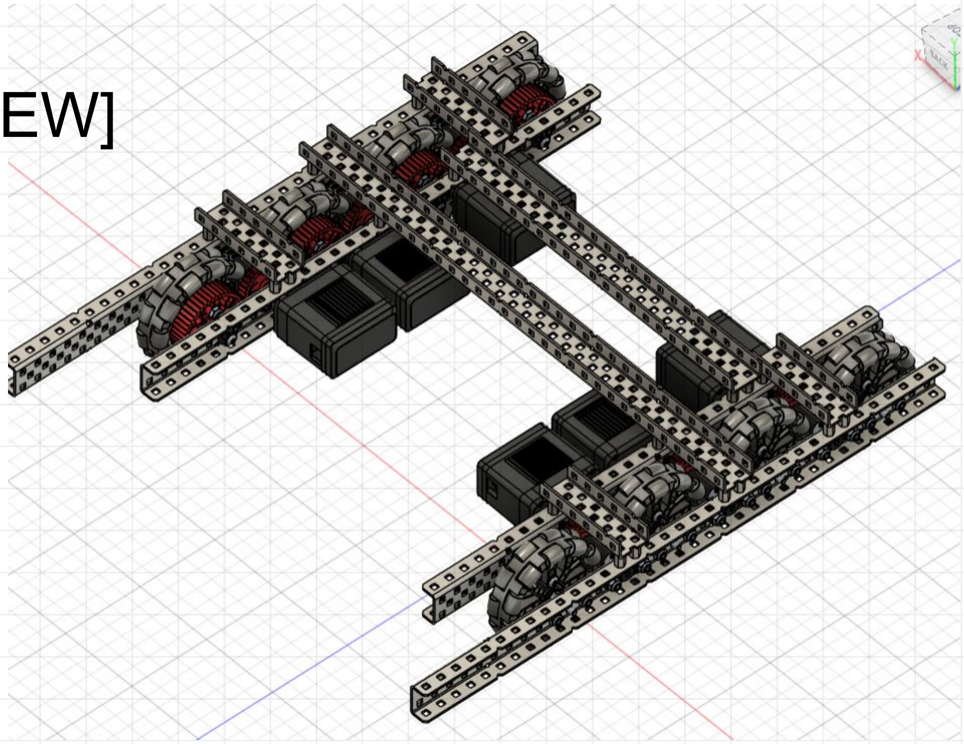
We will use 6 motors with blue motor cartridges on a 3.25 inch omnidirectional standard tank-drive drivetrain using 360 RPM because of its high composite score on our priorities

CAD model of solution

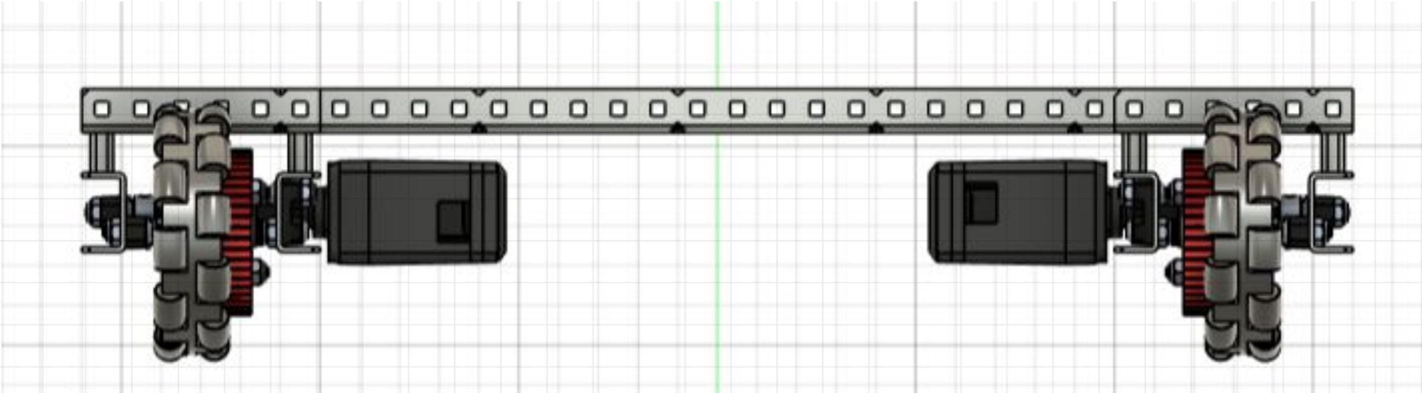


[TOP VIEW]

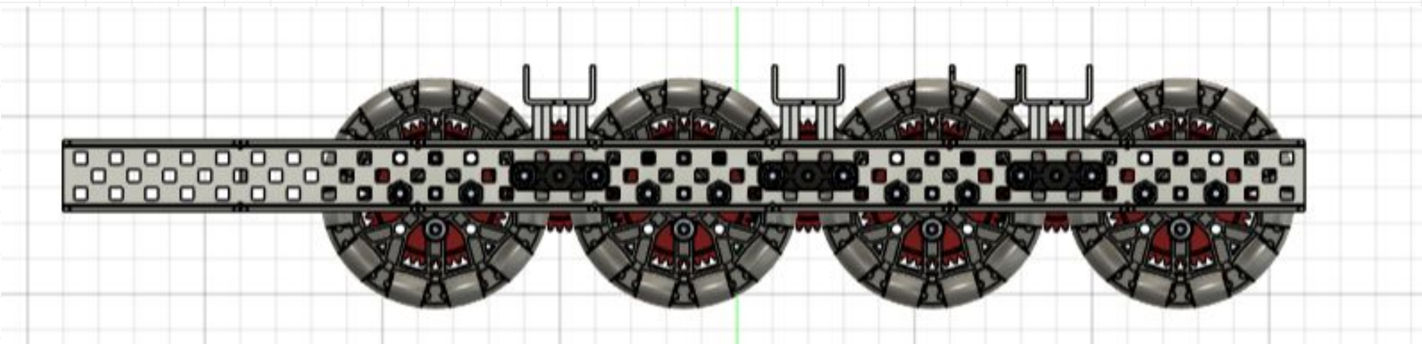
[ISOMETRIC VIEW]



[FRONT VIEW]



[SIDE VIEW]



We decided to add our tracking wheels to our base on CAD. We planned to use odometry and pure pursuit this season which requires the use of tracking wheels. On the next page, we will explain our tracking wheel setup and measurements that we will need in order to tune odometry.

Tracking wheel setup

In order to increase the accuracy of our auton program, we decided to use tracking wheels to track the global position of the robot.

The working principle of tracking wheel is a rotation sensor connecting to a wheel which is not powered by motors, which measures the movement of the robot in that direction.

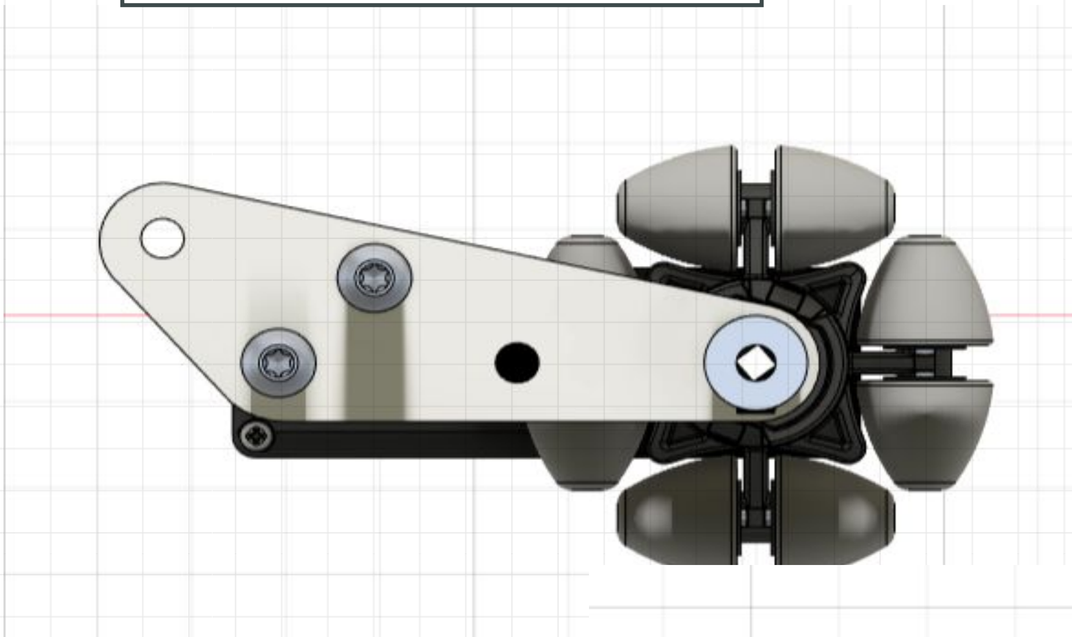
In order to get the global position of the robot, we need tracking wheels in horizontal and vertical direction, which is required by odometry algorithms. We will talk more about our odometry program in the later programming section of this notebook.

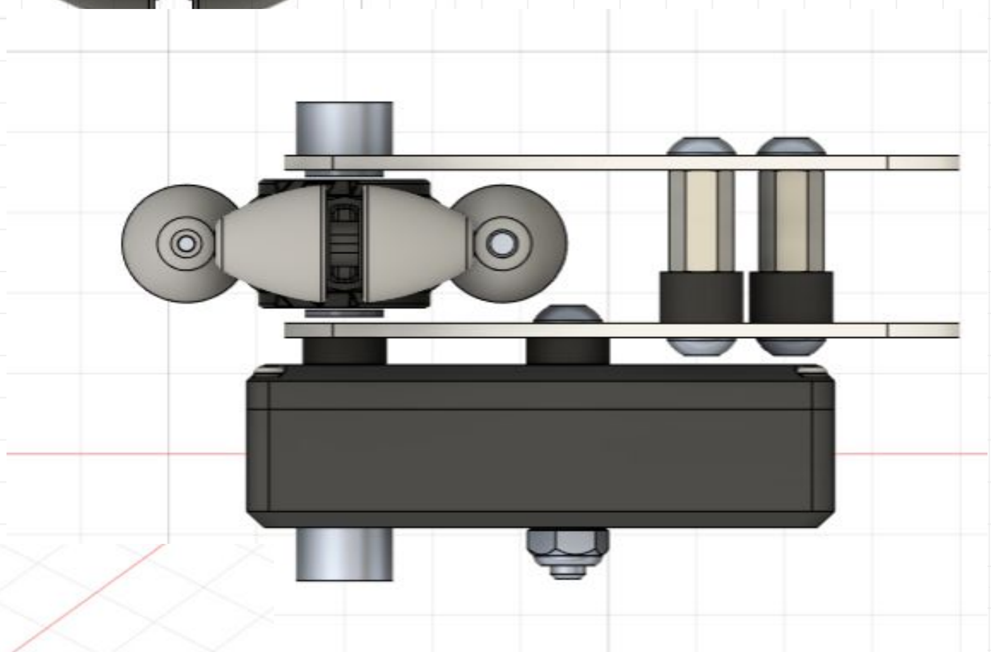
Tracking wheel plans selection

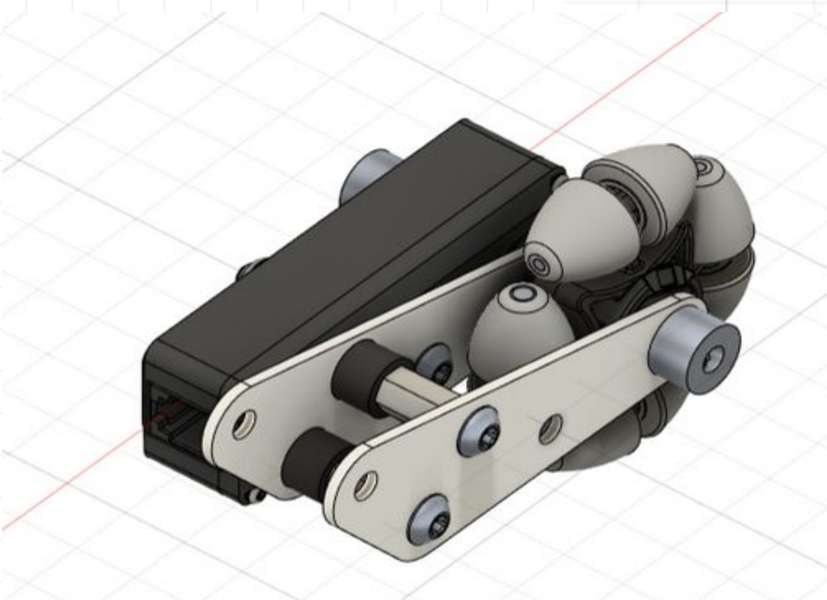
In order to make our drivetrain more compact, we aimed to build our tracking wheels as small as possible. There are two main types of materials for tracking wheels: Plastic or C channel

We CAD and built the two solutions out to have better understanding of their advantages and disadvantages

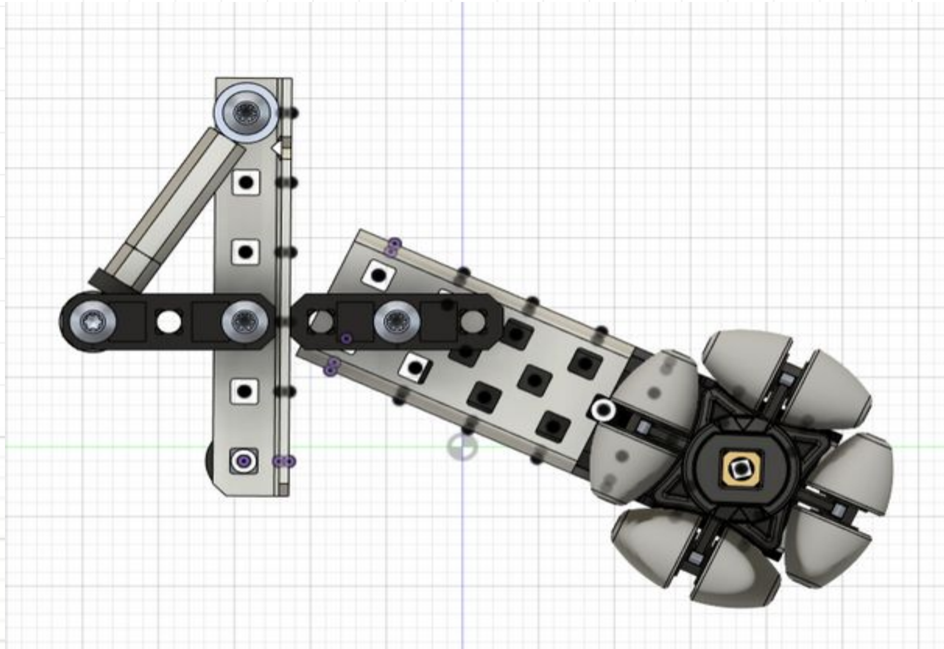
Plastic Tracking wheel

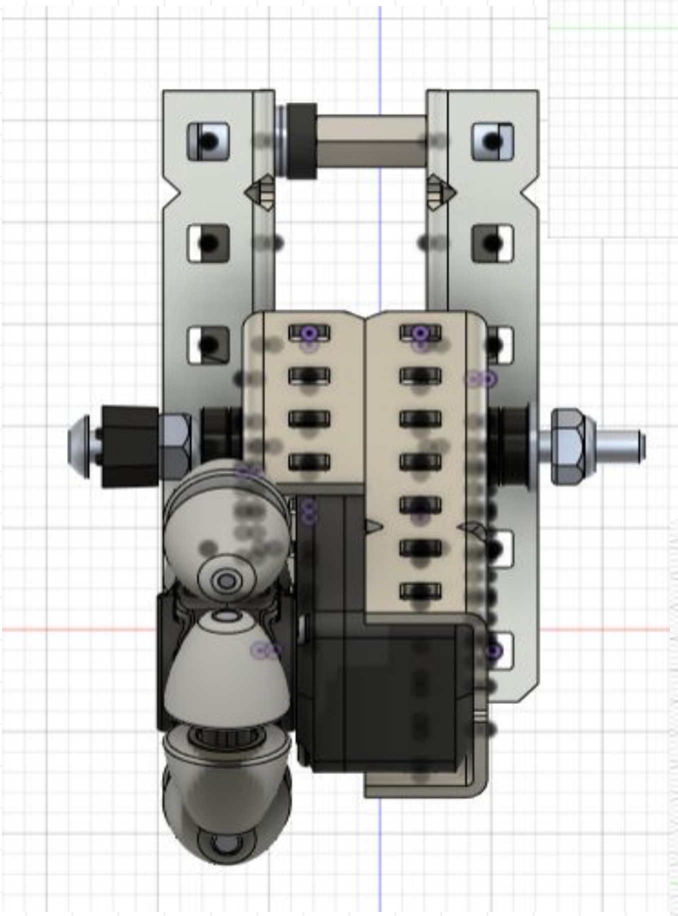


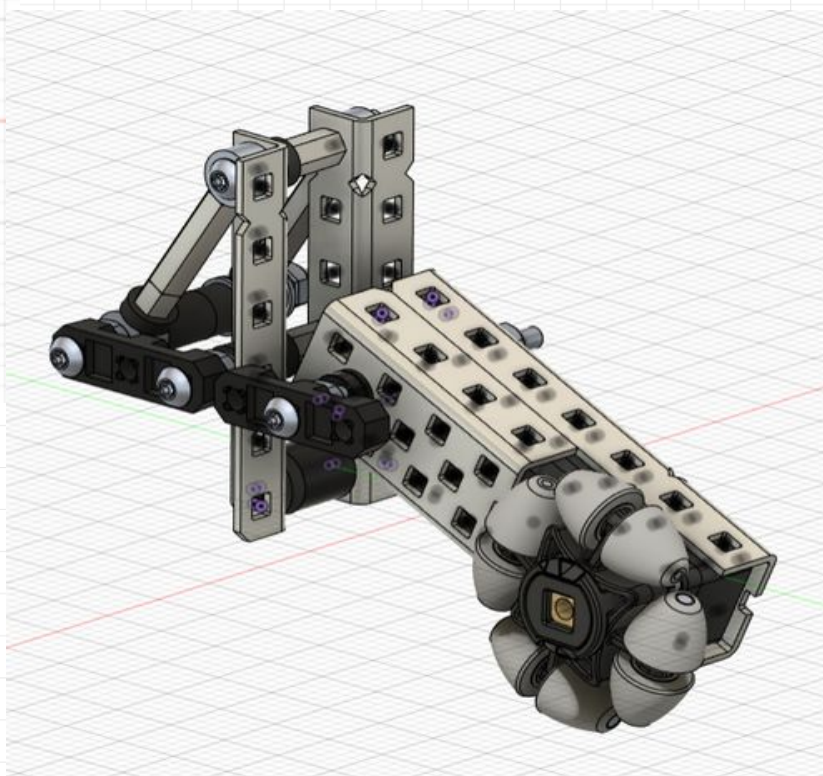




C channel Tracking wheel







Decision matrix - Tracking Wheel

Size	How compact the design is
Stability	How solid is the design
Weight	How heavy is the design

	Size	Stability	Weight	Total
Plastic Tracking Wheel	4.5	2.5	5	12
C Channel Tracking Wheel	4	5	3.5	12.5

We decided to use C channel tracking wheels as it provides the best accuracy, which is the most important aspect of an auton program setup.

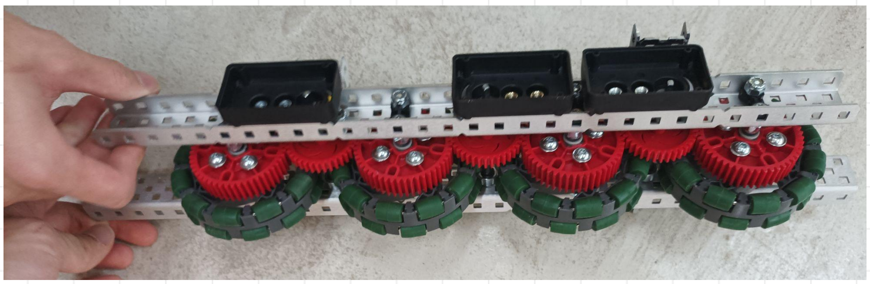
BUILD SOLUTION

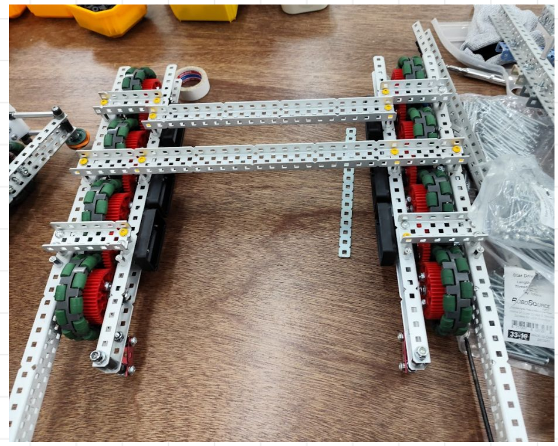
DRIVETRAIN

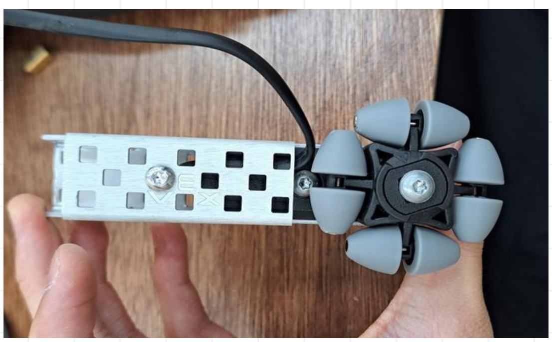
Goal

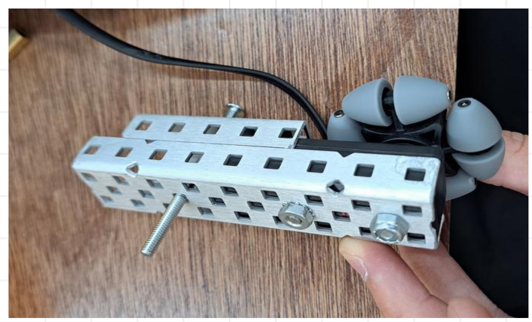
We will build our planned solution according to the CAD so that we can test its performance

Assembled Build









Above are the completed 6 motor full omni drivetrain and tracking wheels. Building this was simple and fast as all the work and planning was done beforehand by CAD and decision making. We directly followed the planned model to assemble this build.

The drivetrain used a geartrain to connect wheels on each side. This ensures the wheels are spinning at the same speed at anytime. Compared to software methods of controlling velocity in direct motor drive, this geartrain setup syncs the wheels in a mechanical way and thus provide a higher accuracy in the robot's movement control.

project Drivetrain name Michae l date 10/6/24

TEST SOLUTION

DRIVETRAIN

Goal

we will test the solution so that we can see if it meets our requirements and goals

Solution Goals

- Travel from a positive corner to the other one in less than 3 seconds
- Turn 360 degree in less than 2 seconds
- Travel from a corner to an diagonal corner in less than 5 seconds
- Running in the filed continuously more than 6 minutes without overheating

Test Results

- Travel from a positive corner to the other one in less than 3 seconds - Used 2.77 seconds ✅
- Turn 360 degree in less than 2 seconds - Used 1.13 seconds ✅
- Travel from a corner to an diagonal corner in less than 5 seconds - Used 4.6 seconds ✅
- Running in the filed continuously more than 6 minutes without overheating - Takes 10 minutes to overheat ✅

project Drivetrain name Michae l date 10/6/24

INTAKE & DELIVERY

project Drivetrain name Michae
l date 10/6/24

IDENTIFY PROBLEM

Intake & Delivery

Goal

We will identify an objective for our robot so that we can address it and build an effective robot.

Problem Statement

We need a mechanism to gain possession of rings and maneuver them within the robot so that they can be transferred to the mobile goal scoring mechanism to be scored during a match.

Solution Requirements

Must only use legal VEX V5RC competition parts

Must fit within 18”*18”*18” cube

Must work using no more than 22W motor watt

Solution Goals

Move a ring into the scoring position in less than 1 second

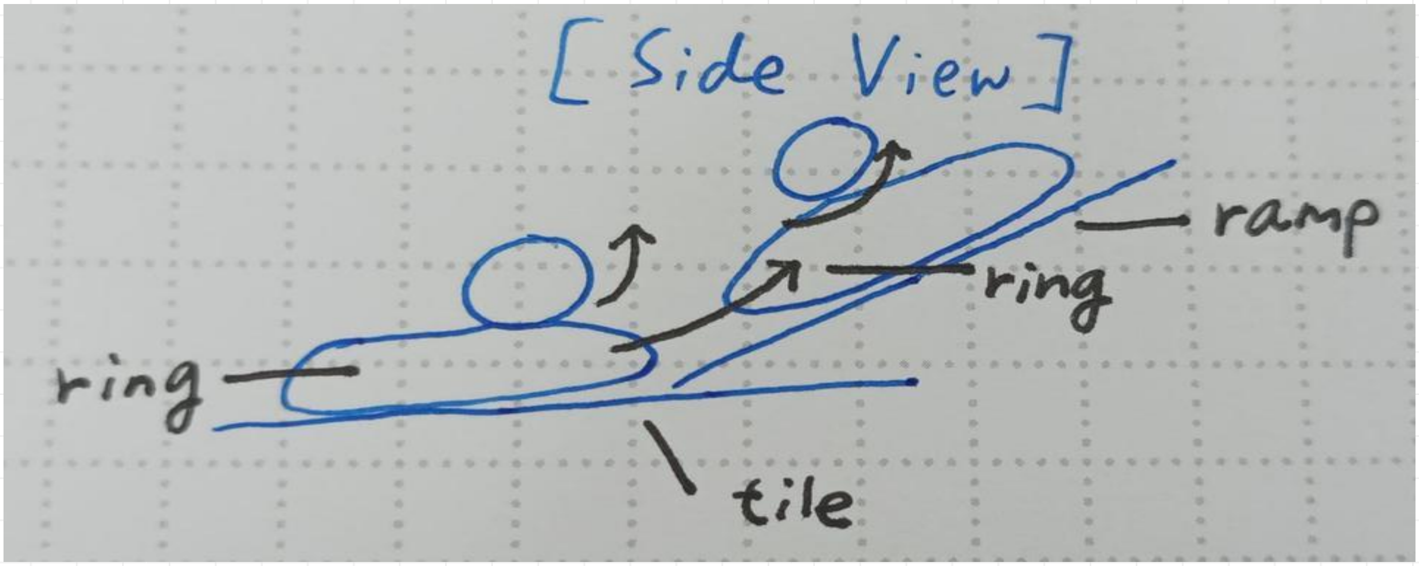
Move 6 ring into the scoring position within 8 seconds

Move 24 ring into the scoring position without overheating

Possible Solutions - Intake mechanism

Flex wheel roller

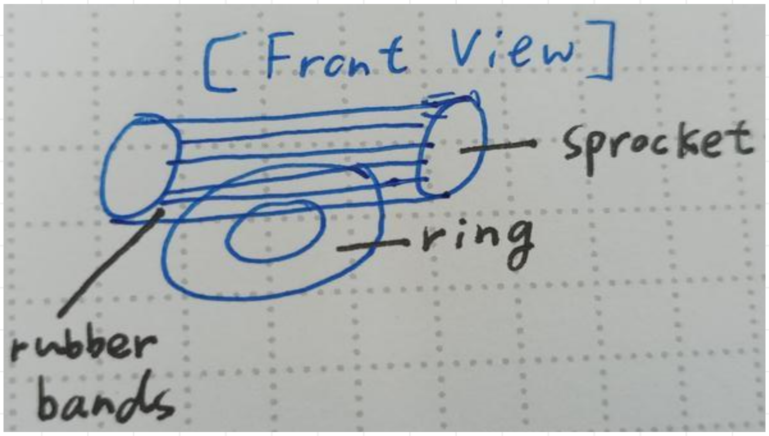
- A row of flex wheel connected to an intake arm
- The arm is connected to the drivetrain by a free spin rotational pivot
- The row flex wheel is powered by the same motor as the scoring mechanism



Positives	Negatives
• Very fast intaking • Consistent	• Limited intake range • Easy to bend

Band Sprocket Roller

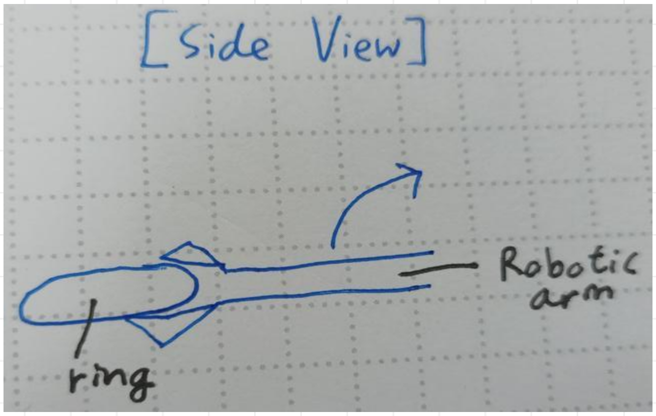
- Two sprockets connected using bands horizontally
- The roller is connected to the scoring motor
- Similar to intakes in VRC Over Under



Positives	Negatives
• Light weight • Very consistent	• Slow • The bands easily break

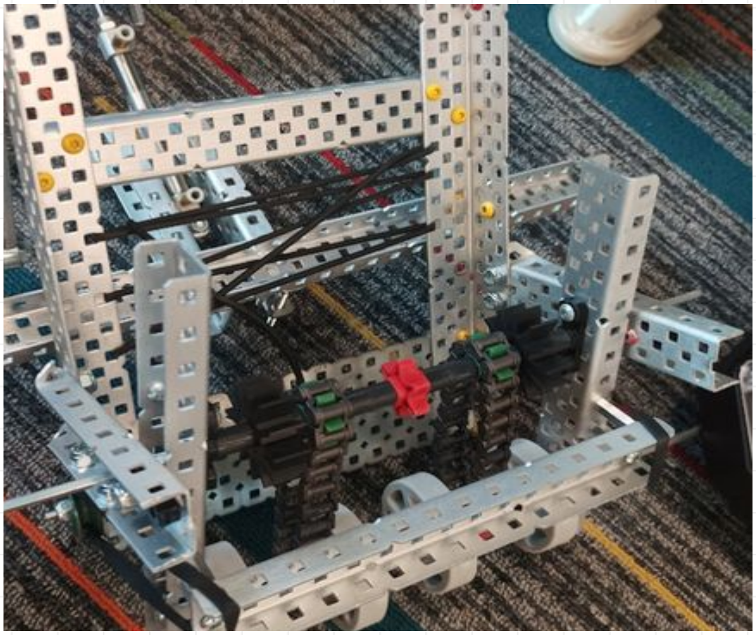
Robotic Arm

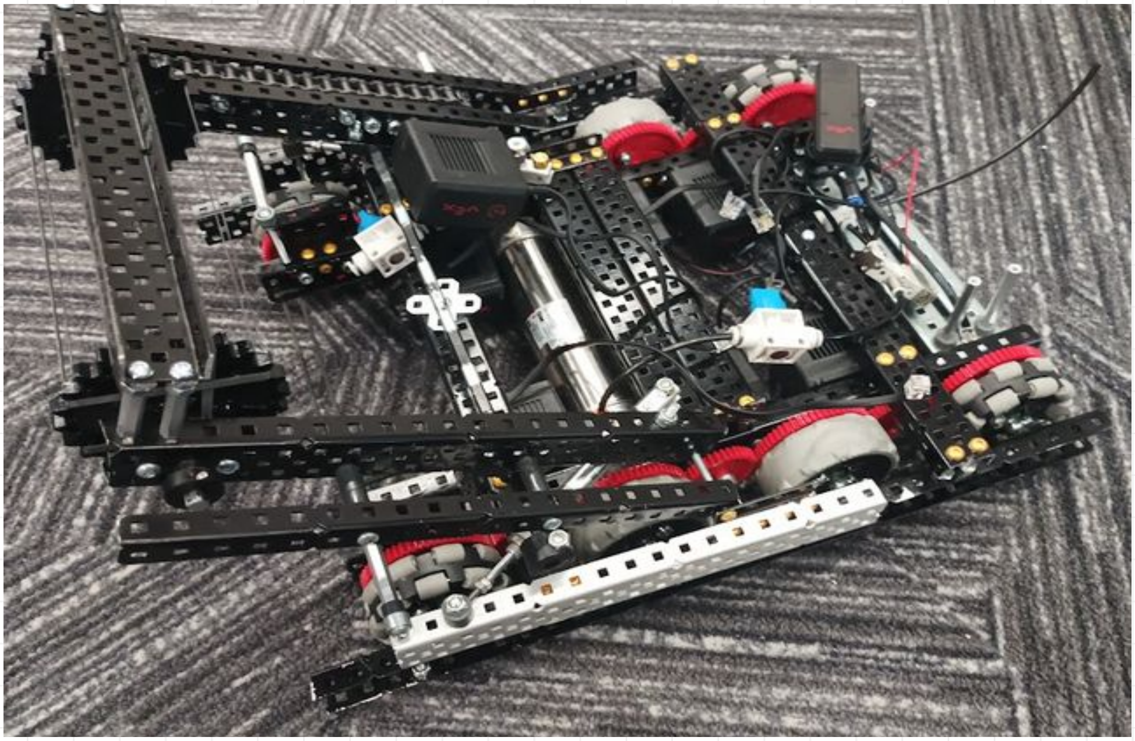
- Same mechanism as the possible solution of scoring
- Use an arm to grab and score the ring directly
- A motor is used to directly control the arm
- Pistons are used to grab the ring tightly



Positives	Negatives
• Wide grabbing range • Can perform different actions freely	• Very slow • Difficult to tune • Long recovery time

Prototyped Solutions - Intake





For the band roller intake, we simply build it using our old VRC Over Under parts to save time

SELECT AND PLAN

Prototype Testing - Intake

- Test 1: Speed
- Test Procedures
- Place one ring on the tile and power the mechanism's motor using controller
- Contact the ring with the mechanism and start stopwatch
- Stop stopwatch when the mechanism finishes intaking that ring
- Record results

Test Results:

Time Taken to intake one ring					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Flex wheel roller	1.07	1.13	1.17	1.05	1.105
Band Sprocket Roller	1.89	1.75	1.88	1.83	1.8375
Robotic Arm	2.86	3	2.82	2.89	2.8925

Fastest design: Flex wheel roller

- Test 2: Consistency
- Test Procedures
- Place 6 rings on the tile and power the mechanism's motor using controller
- Use the mechanism to continuously intake the rings and start stopwatch
- Stop stopwatch when the mechanism finishes intaking all the rings
- Record results

Test Results:

Time Taken to intake 6 ring					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Flex wheel roller	8.12	8.08	8.1	8.08	8.095
Band Sprocket Roller	11.08	11.07	11.13	11.17	11.1125
Robotic Arm	22.17	22.07	22.08	22.18	22.125

Most consistent design: Flex wheel roller

- Test 3: Overheat
- Test Procedures
- Place a number of rings on the tile and power the mechanism's motor using controller
- Use the mechanism to continuously intake the rings and start stopwatch
- Stop stopwatch when the motor reaches overheat level 1
- Record results

Test Results:

Time taken to overheat					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Flex wheel roller	559.8	565.98	503.65	543.79	543.305
Band Sprocket Roller	459.99	434.25	430.26	404.37	432.2175
Robotic Arm	266.72	226.92	243.45	207.71	236.2

Most long-lasting design: Flex wheel roller

Decision Matrix - Intake

Consistency	How consistent is the intaking
Speed	How fast is each intaking
Overheat	How long it can run before overheating
Recovery	How quickly the design prepares next intaking

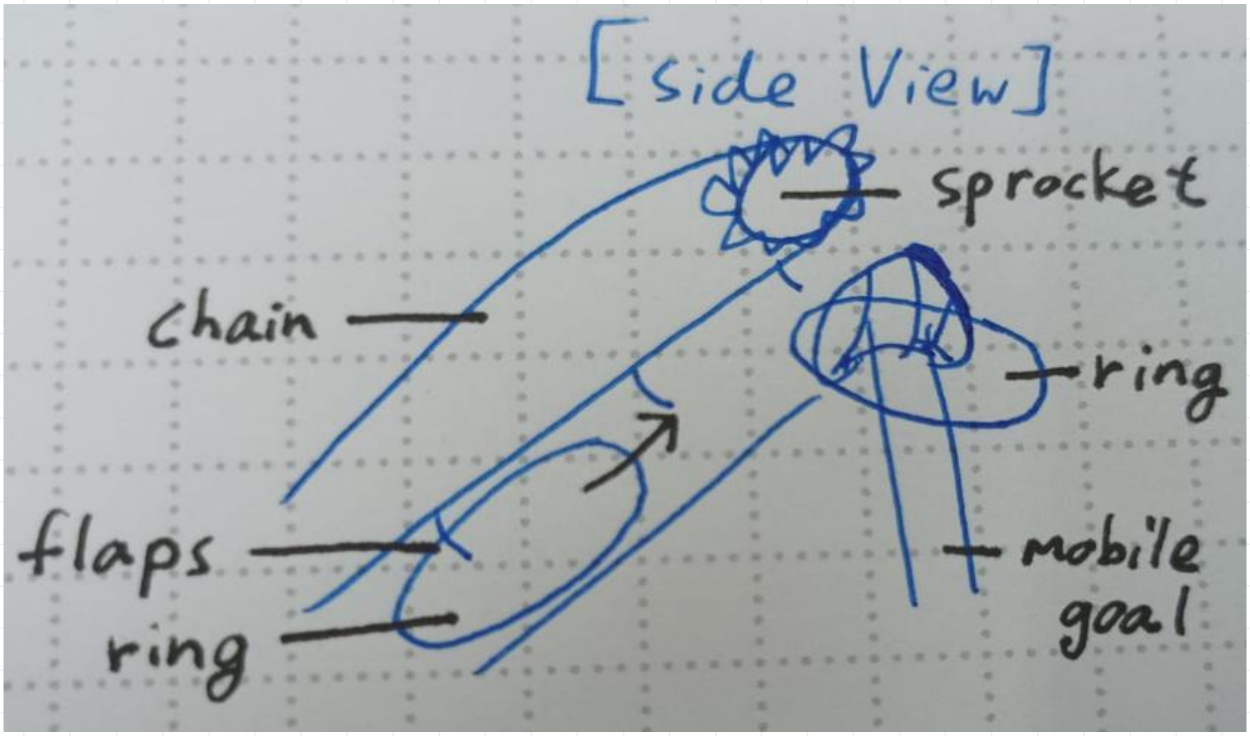
	Consistency	Speed	Overheat	Recovery	Total
Flex Wheel Roller	5	5	5	5	20
Rubber Band Roller	4.5	3	4	4.5	16
Robotic Arm	5	2	3	1	11

We will use the Flex Wheel Roller mechanism because its high composite score on our priorities.

Possible Solutions - delivery mechanism

Conveyor Belt

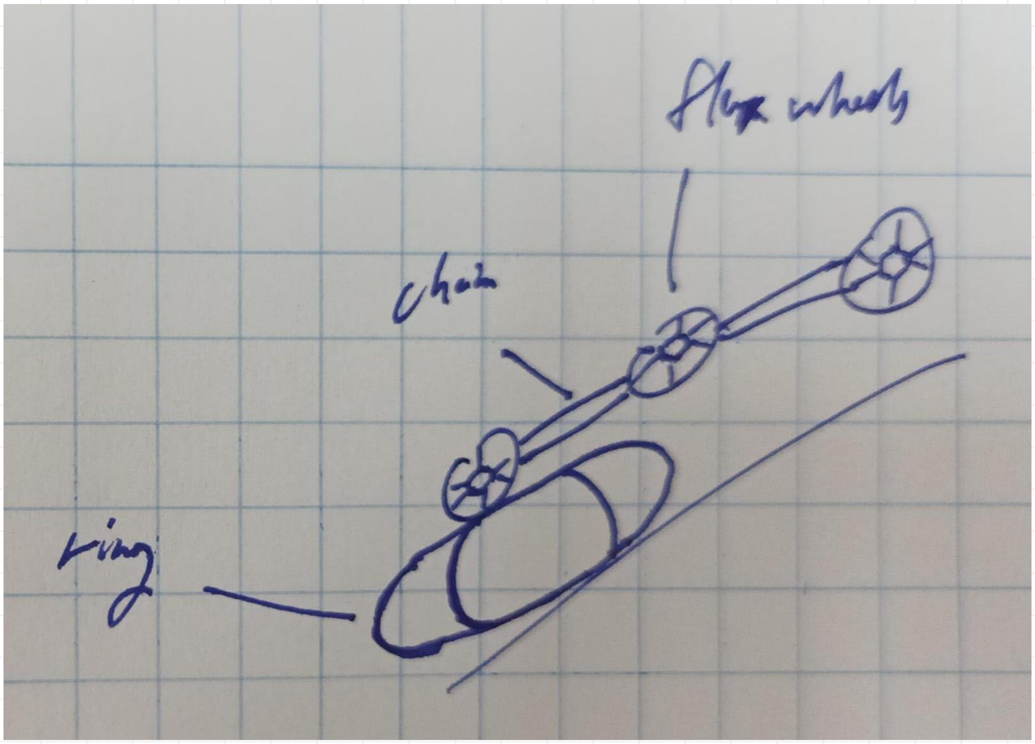
- Conveyor belt with flaps is used to move the ring upwards
- A track is located under the ring so that the flaps can constantly contact the rings



Positives	Negatives
• Easy to build • Light weight	• Inefficient scoring (slower) • More stress on the motors, higher chance of overheating

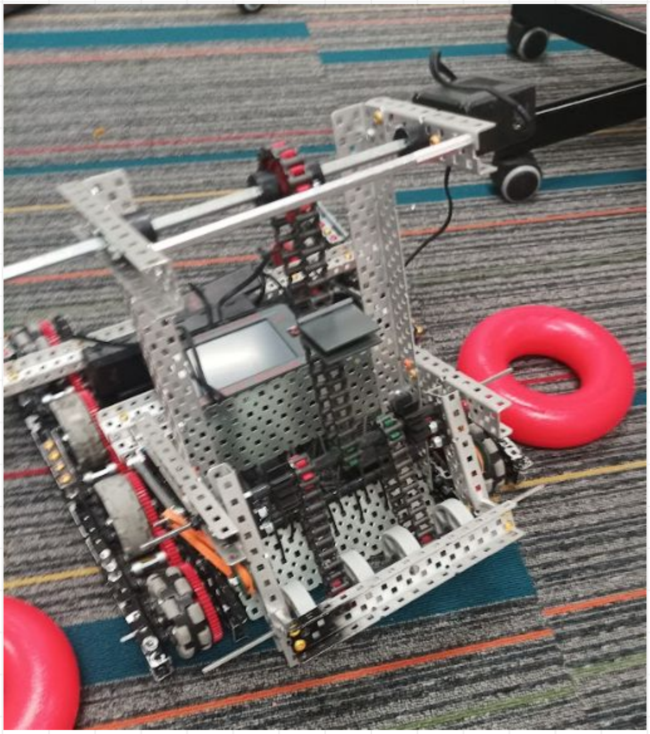
Flex Wheel Chain

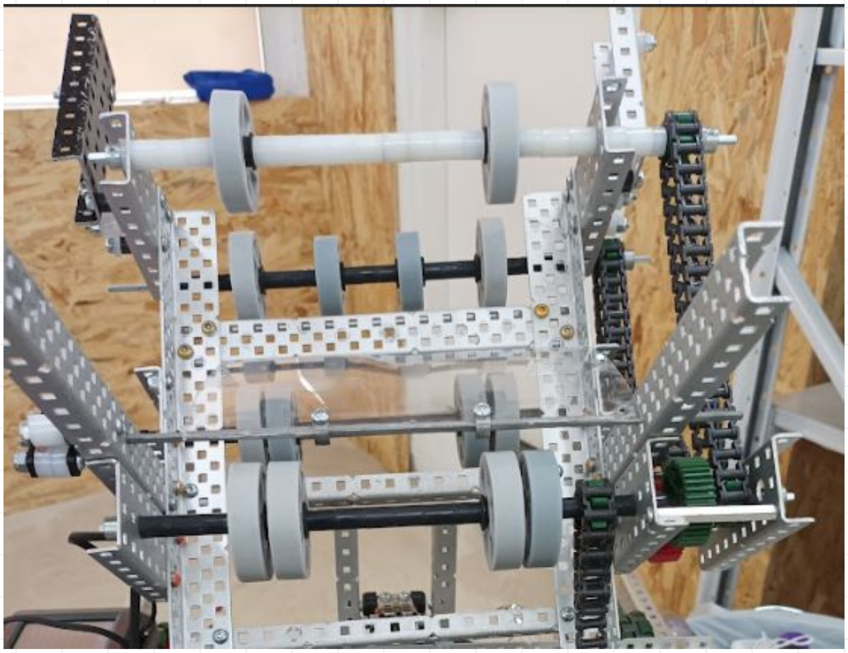
- 3 rows of flex wheels are installed along the delivery path
- The flex wheels contact with the rings to bring them up the delivery path



Positives	Negatives
• Faster • Less prone to overheat (if made carefully)	• More difficult to build • Tuning the distance between the flex wheels and the rings is time-consuming If the position of flex wheel is too low such that it touched the ring with too large reaction force, it would exert a lot of torque to the intake motors which will cause serious overheat.

Prototyped Solutions - delivery





We build the delivery system independent from our prototype intake mechanism so that we can have a more accurate test data

Decision Matrix - Delivery

Consistency	How consistent is the delivery
Speed	How fast is each delivery
Overheat	How long it can run before overheating
Recovery	How quickly the design prepares next delivery

	Consistency	Speed	Overheat	Recovery	Total
Conveyor Belt	3.5	3.5	4	3.5	14.5
Flex Wheel Chain	4.5	4	3	4.5	16

We will use the Flex Wheel Chain mechanism because its high composite score on our priorities.

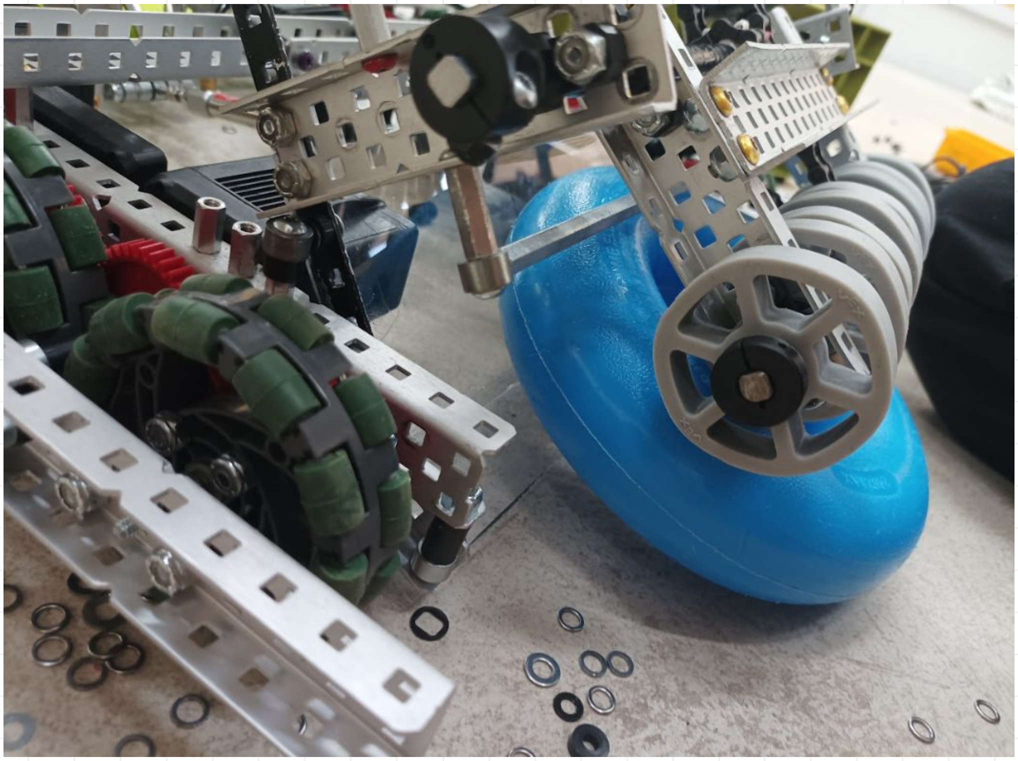
BUILD SOLUTION

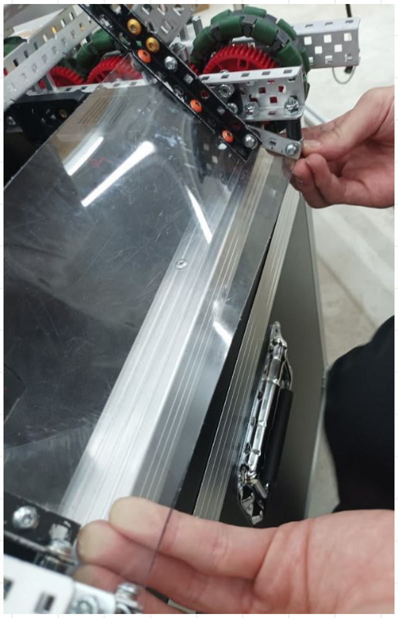
Intake & Delivery

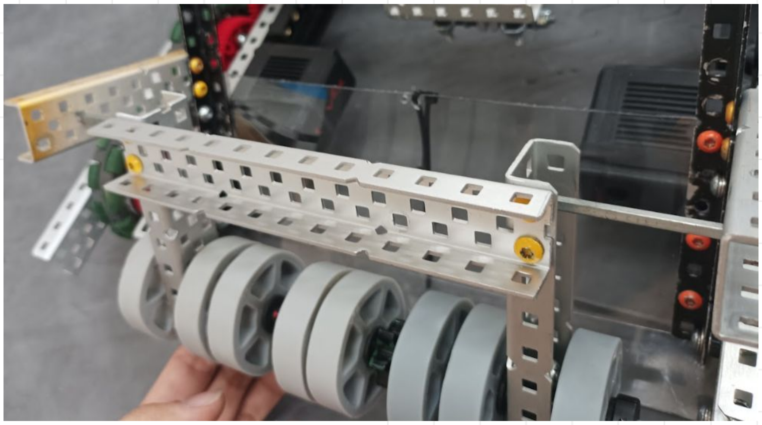
Goal

We will build our planned solution so that we can test its performance

Implemented Solution - Intake







Implemented Solution - Delivery

Implemented solution: Flex Wheel Chain

We chose the flex wheel chain due to the following reasons

1. It is more efficient (faster)
2. It is more durable (less likely to fail during a match)

TEST SOLUTION

Intake & Delivery

Goal

We will test the solution so that we can see if it meets our requirements and goals.

Solution Goals

Score a ring into mobile goal in less than 1 second

Score a full mobile goal within 8 seconds

Score 4 full mobile goal without overheating

Test Results

Move a ring into the scoring position in less than 1 second - Used 0.54 seconds ✅

Move a ring into the scoring position within 8 seconds - Used 7.55 seconds ✅

Move a ring into the scoring position without overheating - ✅

MOBILE GOAL GRABBING MECHANISM

IDENTIFY PROBLEM

MOBILE GOAL GRABBING MECHANISM

Goal

We will identify an objective for our robot so that we can address it and build an effective mobile goal grabbing mechanism

Problem Statement

We need a mechanism to be able to grab mobile goals and carry it around with the drivetrain

Solution Requirements

- Must only use legal VEX Robotics Competition parts
- Must fit within 18”x18”x18” cube for starting size limit
- Must not require motor to work

Solution Goals

- Grab a mobile goal within 2 seconds
- Release a mobile goal in 2 seconds
- Rotating the robot with mobile goal grabbed without it falling out for more than 20 seconds
- Can be activated and deactivated at least 15 times in a match (in the case of pneumatics)

BRAINSTORM SOLUTION

MOBILE GOAL GRABBING MECHANISM

Goal

We will brainstorm possible solutions for our mobile goal grabbing mechanism so that we can select the best one for our design

Possible Solutions

Claw

- A claw with two arm on the two sides of the mobile goal
- Powered by a piston, allowing it to open or close

Positives	Negatives
• Wide range • Fast • Less amount of pressurised air needed	• Very inconsistence grabbing position • Loose

Clamp

- Use a piston to grab the mobile goal in vertical direction
- Two standoff is used in both sides to grab the mobile goal in all directions

Positives	Negatives
• Can grab in all directions • Fast	• Hard to aim • Large amount of pressurised air needed

project Mobile goal grabbing mechanism name Michael date 2/7/24

Gate

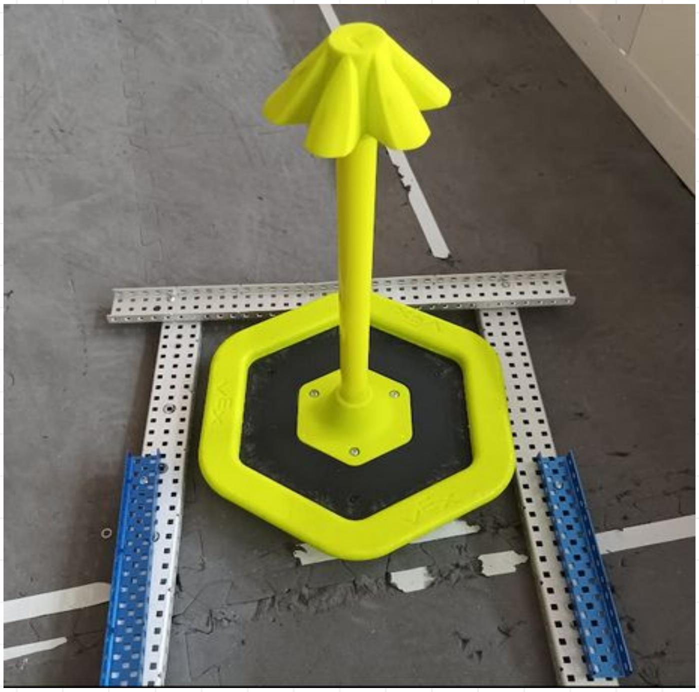
- A wide space in the back of the drivetrain allowing the mobile goal to go in
- A piston activates to close the gate, trapping the mobile goal inside

Positives	Negatives
• Wide range • Easy to aim	• Slow • Very inconsistent grabbing position

Prototyped Solutions

We built prototypes of the three possible solutions to test their preformance.

Claw



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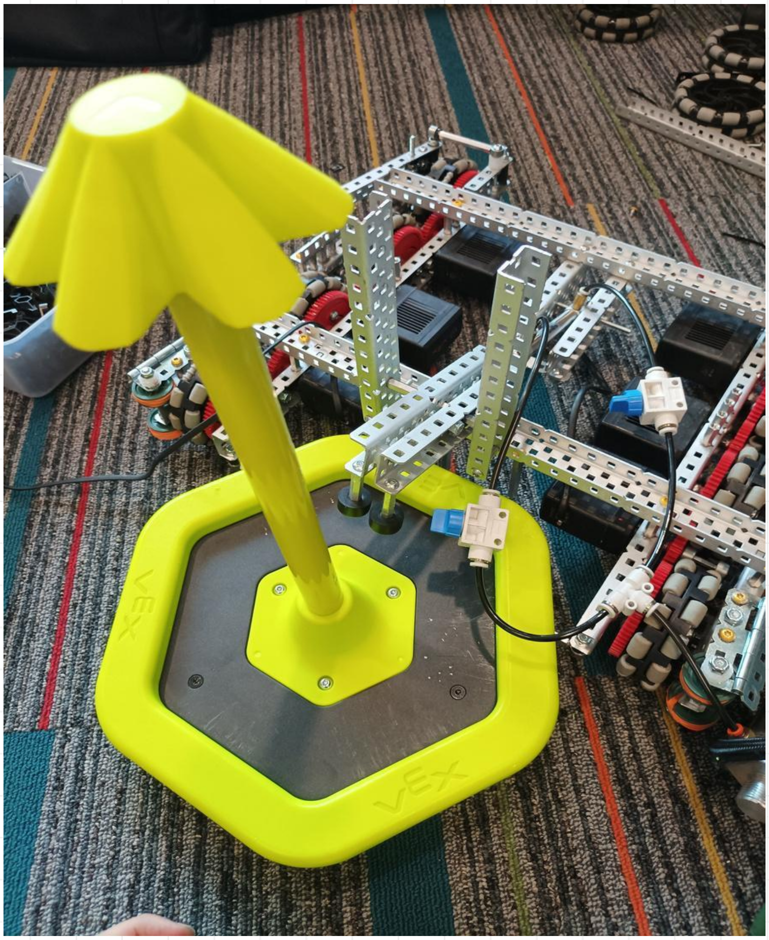
Prototyped Solutions

Clamp



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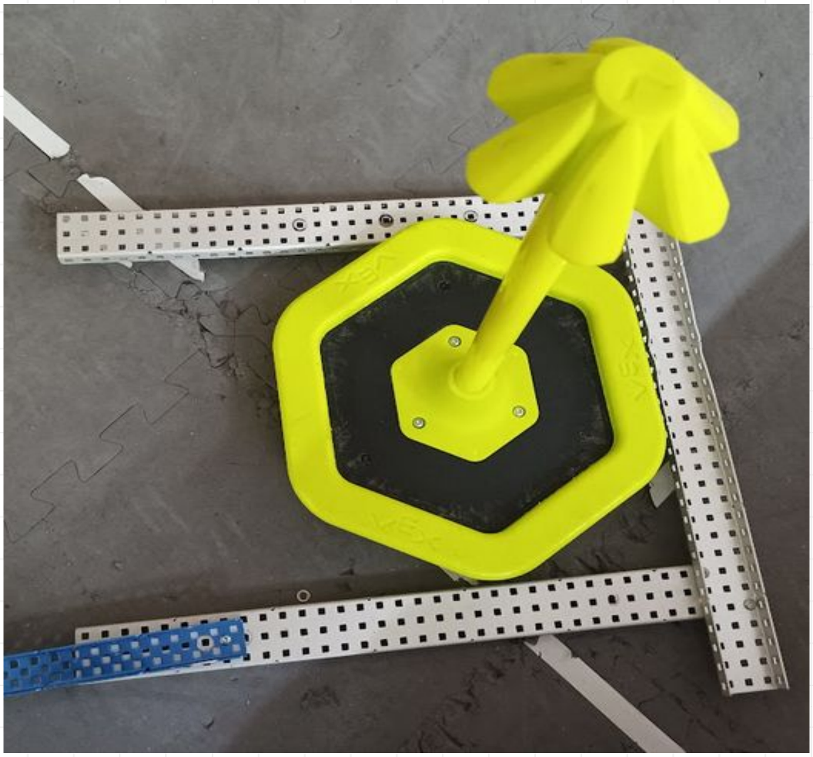
Prototyped Solutions

Gate



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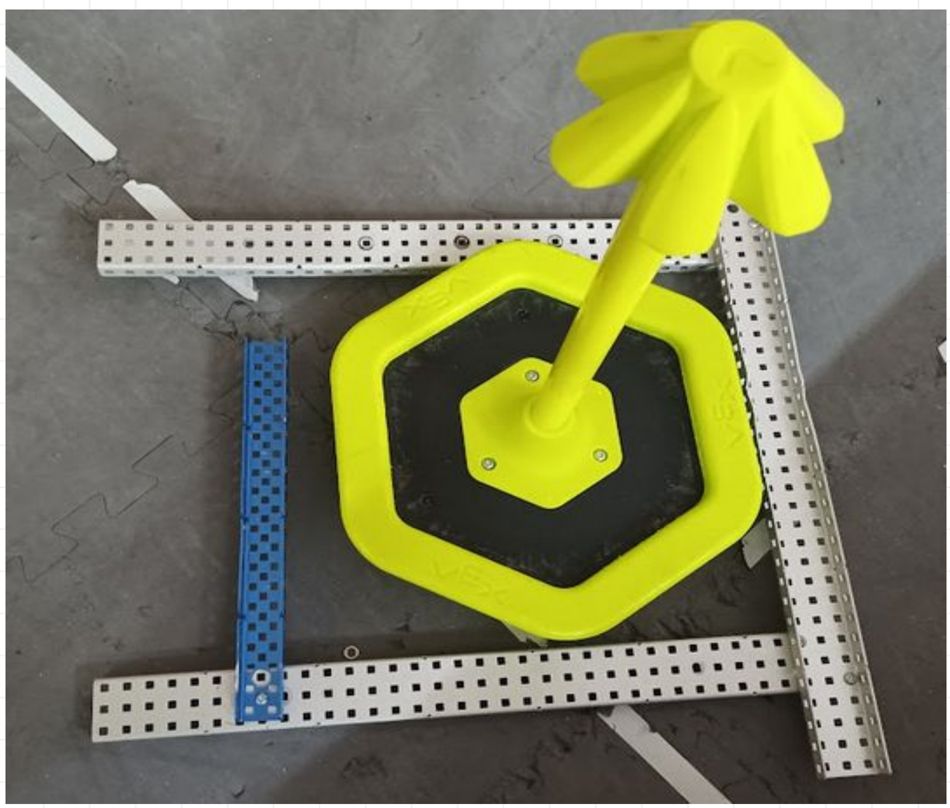


SELECT AND PLAN

MOBILE GOAL GRABBING MECHANISM

Goal

We will select the solution that is best for our team so that we can plan how to build it

Prototype testing

- Test 1: Speed
- Test Procedures
- Place Prototype so that it is in front of the mobile goal
- Move prototype forward, activate it and start stopwatch
- Stop stopwatch when the mobile goal is grabbed by the prototype
- Record result

Test Results:

	Trial 1	Trial 2	Trial 3	Trial 4	Average
Claw	1.46	1.17	1.48	1.48	1.3
Clamp	1.11	1.04	1.12	1.16	1.14
Gate	1.06	1.11	1.07	1.09	1.21

Most consistent: Mogo clamp

- Test 2: Force
- Test Procedures
- Put a mobile goal into the mechanism and activates it
- Try to move the mobile goal by hand and observe the mobile goal
- Record and compare the results

Result: The clamp mechanism holds the mobile goal with the greatest force gate

Decision Matrix

Speed How fast the design grabs mobile goals

Consistency How consistent is the grabbed mobile goal position

Force How tight is the mobile goal grabbed

Air usage How much air is used in one grabbing action

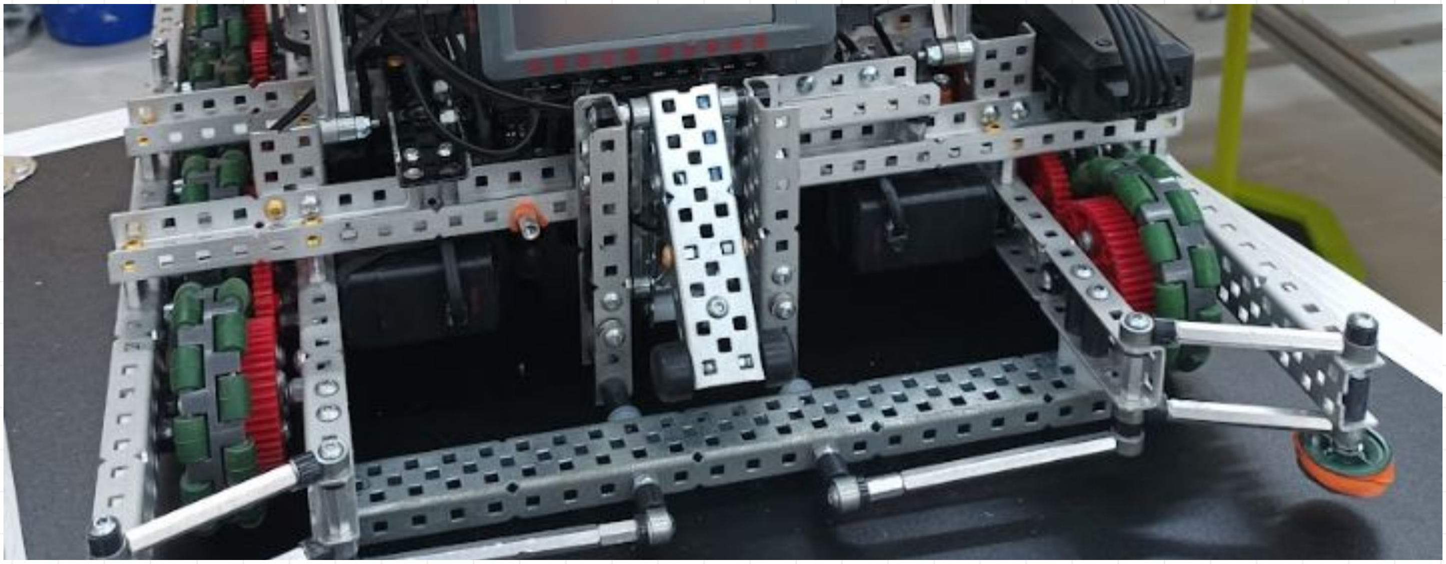
	Speed	Consistency	Force	Air usage	Total
Claw	5	5	5	4	19
Clamp	4	3	3	3	13
Gate	4	1	1	5	11

We will use clamp for grabbing mobile goal because its high composite score on our priorities.

BUILD SOLUTION

MOBILE GOAL GRABBING MECHANISM

Assembled Build



TEST SOLUTION

MOBILE GOAL GRABBING MECHANISM

Goal

We will test the solution so that we can see if it meets our requirements and goals.

Solution Goals

- Grab a mobile goal within 2 seconds
- Release a mobile goal in 2 seconds
- Rotating the robot with mobile goal grabbed without it falling out for more than 20 seconds
- Can be activated and deactivated at least 15 times in a ...e of pneumatics)

Test Results

- Grab a mobile goal within 2 seconds - less than 1 second ✅
- Release a mobile goal in 2 seconds - less than 1 second ✅
- Rotating the robot with mobile goal grabbed without it falling out for more than 20 seconds - ✅
- Can be activated and deactivated at least 15 times in a match (in the case of pneumatics) - can be activated and deactivated 27 times ✅

MOBILE GOAL SCORING MECHANISM

IDENTIFY PROBLEM

MOBILE GOAL SCORING MECHANISM

Goal

We will identify an objective for our robot so that we can address it and build an effective robot.

Problem Statement

We need a mechanism to score rings into the mobile goal after the ring has been transferred to the top of the robot by the delivery. This would be our main scoring method in the match.

Solution Requirements

Must only use legal VEX V5RC competition parts

Must fit within 18”*18”*18” cube

Must work using no more than 22W motor watt

Solution Goals

Score a ring into mobile goal in less than 1 second

Score a full mobile goal within 8 seconds

Score 4 full mobile goal without overheating

BRAINSTORM SOLUTION

MOBILE GOAL SCORING MECHANISM

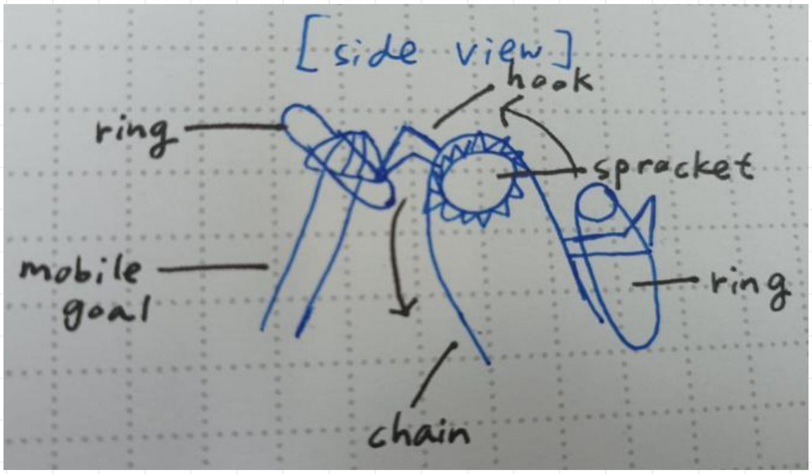
Goal

We will brainstorm possible solutions for our scoring and I taking mechanism so that we can select the best idea for our team

Possible Solutions - Scoring

Hook

- Blue cartridge directly connected to a spinning chain belt with hook-shape materials attached on it
- Rings are scored onto mobile goals by rotating around the flex wheels
- Flex wheel is used on the top of the chain to allow more stable and consistent rings locus

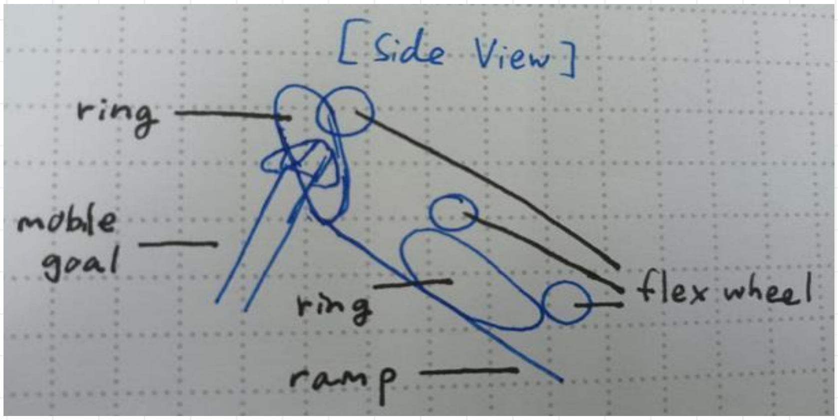


Positives	Negatives
• Easy to tune • Fast scoring time • Less prone to overheat • Light weight	• Scoring may fail due to robot momentum changes • Require a large unusable area for the hook to pass through

project Mogo scoring name Michae l date 21/7/24

Hood

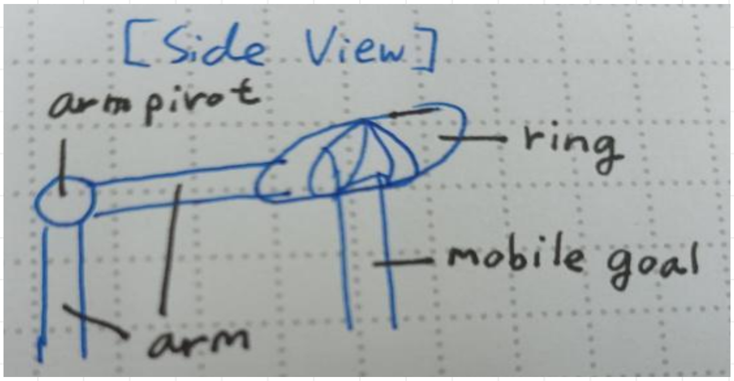
- Blue cartridge connected to multiple rollers of flex wheel rollers
- A track is on the bottom of the rollers to guide the rings upwards
- Flaps are installed on two sides of the end of the track



Positives	Negatives
• Very fast scoring • Scoring very consistent • Allows two rings to be scored at once	• Wide • Easy to overheat • Preformance easily affected by little bending of shafts or channels

Robotic arm

- Arms connected by multiple rotational pivots
- Use chain and sprockets to rotate and move the arm
- Piston is used to grab the ring and score into mobile goals

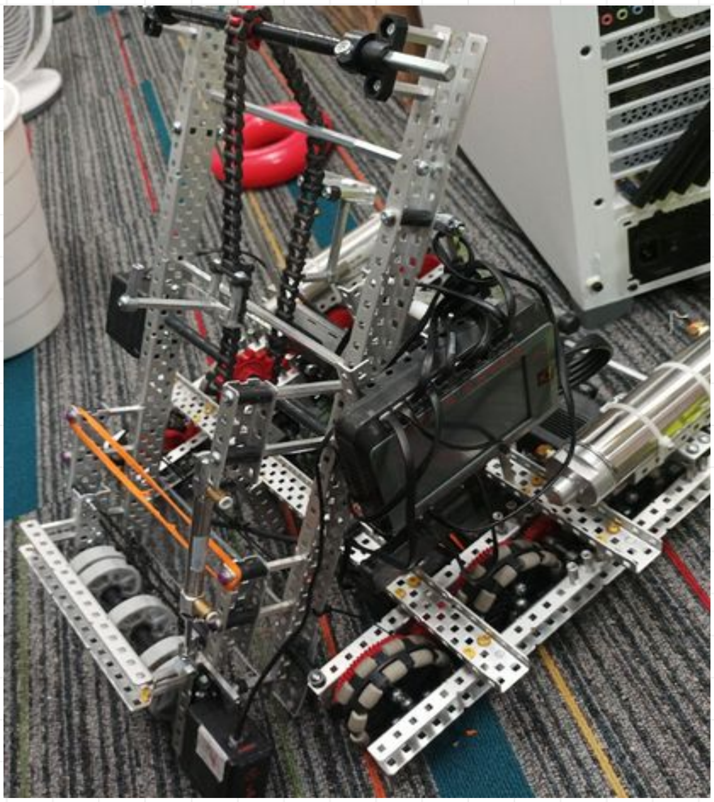


Positives	Negatives
• Unique • Can preform precise actions • small and compact	• Slow recovery time • Very easily overheated • inconsistent

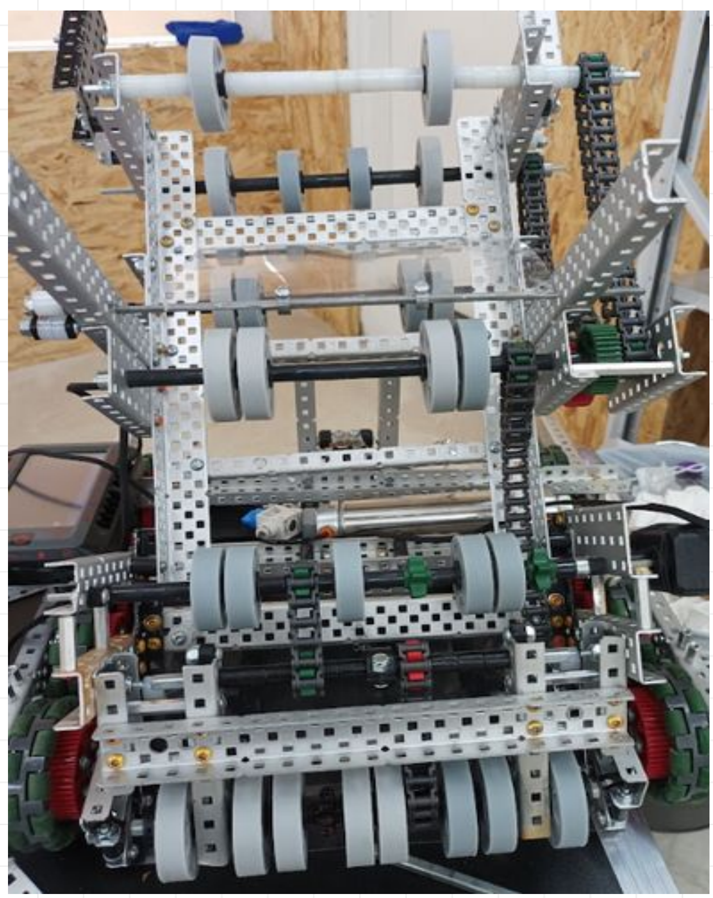
Prototyped Solutions - Scoring

As the solutions require drivetrains to build on for supporting, we used our VRC Over Under drivetrains for the prototypes supporting

Hook



Hood



SELECT AND PLAN

MOBILE GOAL SCORING MECHANISM

Goal

We will select the solution that is best by testing the mechanism's ability to score rings into mogo from intake

Prototype Testing - Scoring

- Test 1: Speed
- Test Procedures
- Place one ring into the intake
- Power the mechanism's motor using controller and start stopwatch
- Stop stopwatch when the mechanism finishes scoring that ring
- Record results

Test Results:

Time taken to score 1 ring					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Hook	0.85	1.07	1.17	1.18	1.0675
Hood	0.89	0.77	0.97	1.06	0.9225
Robotic Arm	5.56	4.68	5.97	3.86	5.0175

Fastest: Hood

- Test 2: Consistency
- Test Procedures
- Place 6 rings into the intake one by one
- Power the mechanism's motor using controller and start stopwatch
- Stop stopwatch when the mechanism finishes scoring all 6 rings
- Record results

Test Results:

Time taken to score 6 rings					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Hook	6.65	7.55	7.4	7.94	7.385
Hood	6.11	6.91	6.91	6.78	6.6775
Robotic Arm	18.02	25.58	19.95	27.65	22.8

Fastest: Hood

- Test 3: Overheating
- Test Procedures
- Continuously place rings into the intake one by one
- Power the mechanism’s motor using controller and start stopwatch
- Stop stopwatch when the motor reaches overheat level 1
- Record results

Test Results:

Time Taken to overheat					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Hook	177.26	147.47	151.05	158.21	158.4975
Hood	341.89	267.22	303.26	306.32	304.6725
Robotic Arm	92.76	79.65	97.35	82.7	88.115

Longest time until overheat: Hood

Decision Matrix - Scoring

Consistency	How consistent is the scoring
Speed	How fast is each scoring
Overheat	How long it can run before overheating
Recovery	How quickly the design prepares next scoring

	Consistency	Speed	Overheat	Recovery	Total
Hook	4	4	4	4	16
Hood	5	5	3.5	5	18.5
Robotic Arm	4.5	1	1	1	7.5
Conveyor Belt	3.5	3.5	4	4	15

We will use the hood mechanism because its high composite score on our priorities.

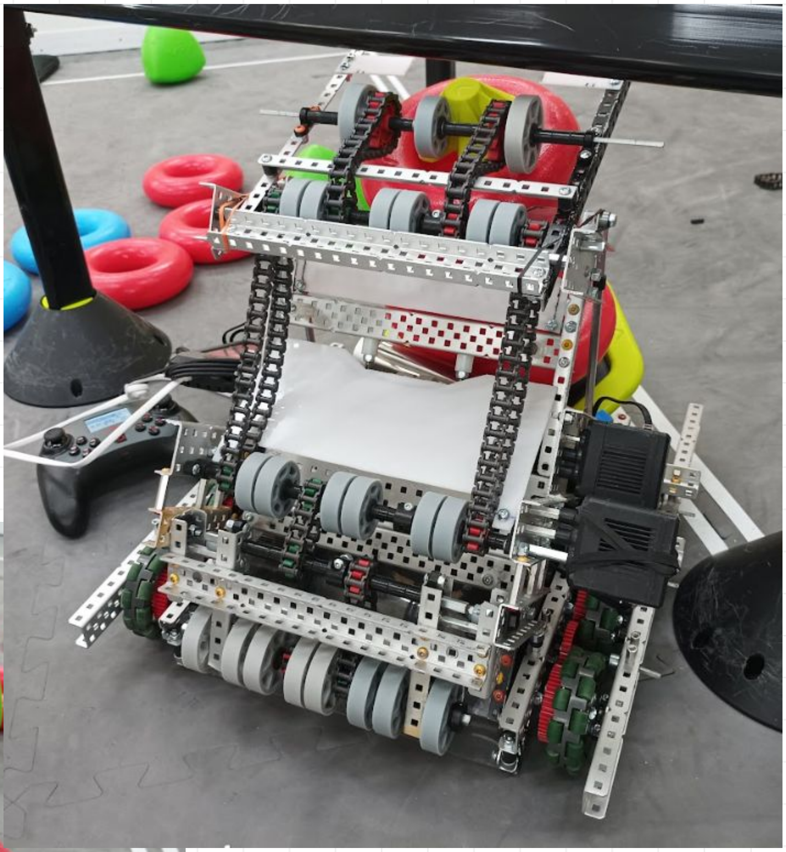
BUILD SOLUTION

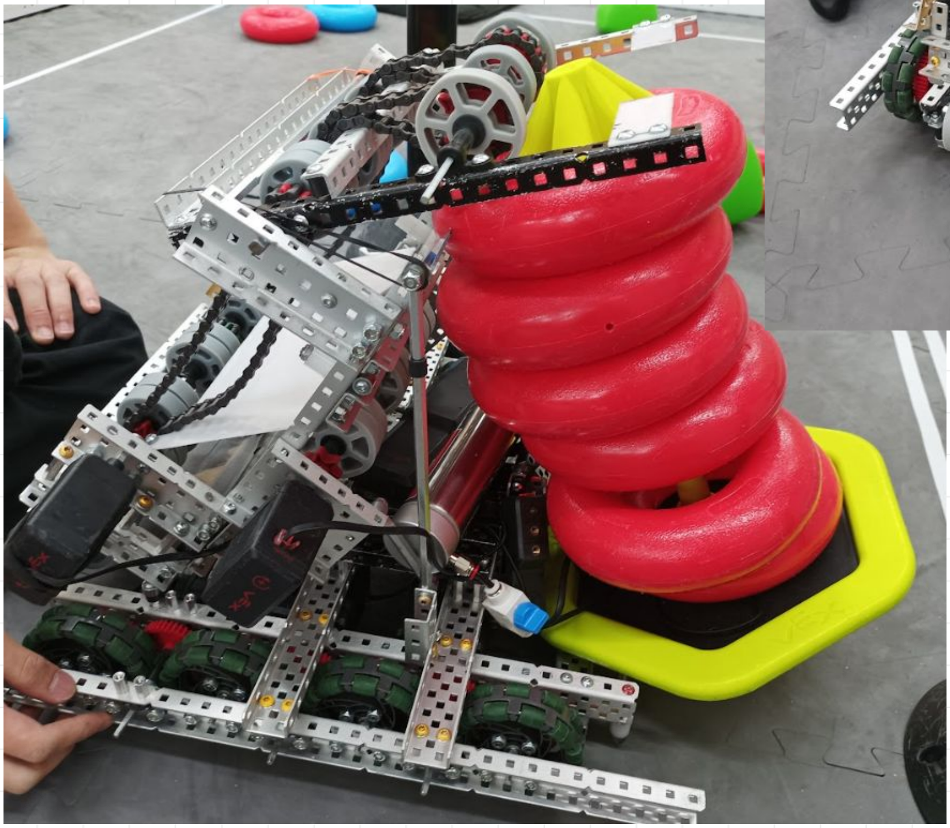
MOBILE GOAL SCORING MECHANISM

Goal

We will build our planned solution so that we can test its performance

Assembled Build - Final





project Mogo scoring name Michael date 31/7/24

TEST SOLUTION

MOBILE GOAL SCORING MECHANISM

Goal

We will test the solution so that we can see if it meets our requirements and goals.

Solution Goals

Score a ring into mobile goal in less than 1 second

Score a full mobile goal within 8 seconds

Score 4 full mobile goal without overheating

Test Results

Score a ring into mobile goal in less than 1 second - Used 0.74 seconds ✅

Score a full mobile goal within 8 seconds - Used 8.35 seconds ✅

Score 4 full mobile goal without overheating - ✅

WALL STAKE SCORING MECHANISM

project Mobile Goal Scoring Mech. name Michae
l date 1/8/24

IDENTIFY PROBLEM

WALL STAKES SCORING MECHANISM

Goal

We will identify an objective for our robot so that we can address it and build an effective wall stakes scoring mechanism

Problem Statement

We need a mechanism to be able to score wall stakes effectively and consistently

Solution Requirements

- Must only use legal VEX Robotics Competition parts
- Must fit within 18”x18”x18” cube for starting size limit
- Must require at most 1 motor to work

Solution Goals

- Intake a ring from the ground to the wall stakes scoring mechanism in 2 seconds
- Score wall stakes in 2 seconds
- Score a full wall stakes in 30 seconds

BRAINSTORM SOLUTION

WALL STAKES SCORING MECHANISM

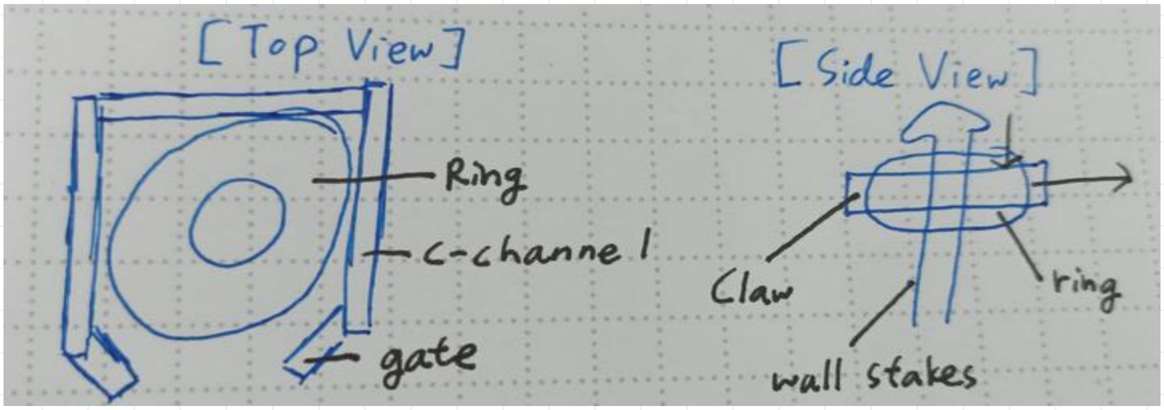
Goal

We will brainstorm possible solutions for our wall stakes scoring mechanism so that we can select the best one for our design

Possible Solutions

Up-and-down Claw

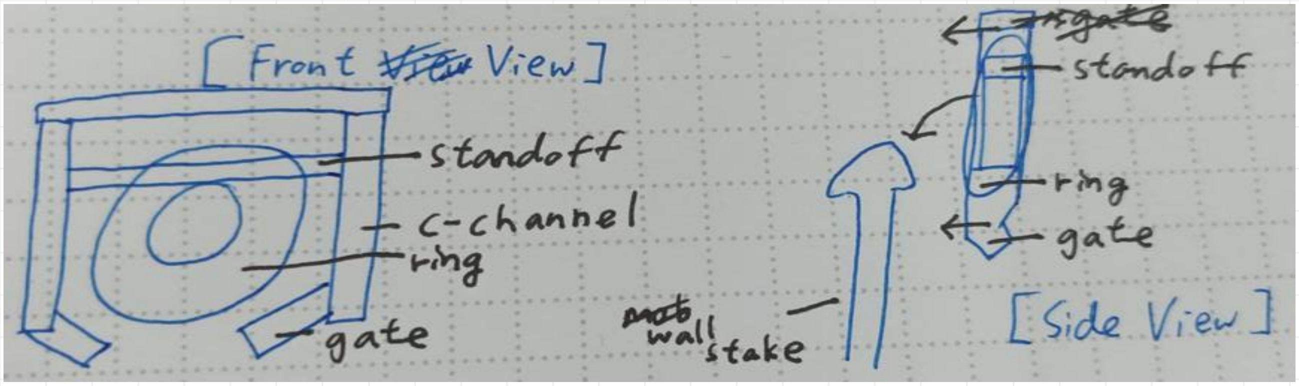
- A claw with two arm on the two sides of the ring to grab it
- The ring was scored vertically downwards by 4-bar linkage



Positives	Negatives
• Wide range • Fast • No amount of pressurised air needed	• THe ring holding maybe loose • Hard to aim

Collision Claw

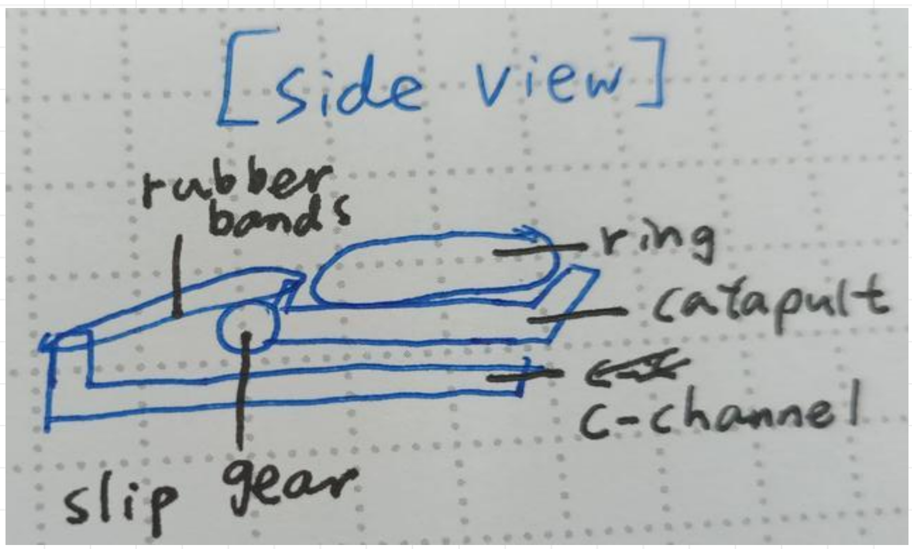
- The short arm holds the ring vertically
- The ring will be rotated into the wall stake when the robot runs into the wall stake



Positives	Negatives
• No amount of pressurized air needed • Fast	• Hard to aim • Depends on the momentum of the robot

Cataput

- Multiple bands are pulled by motors
- Ratchet is used on the motor gear to protect the motor
- The ring is then shoot onto the wall stakes

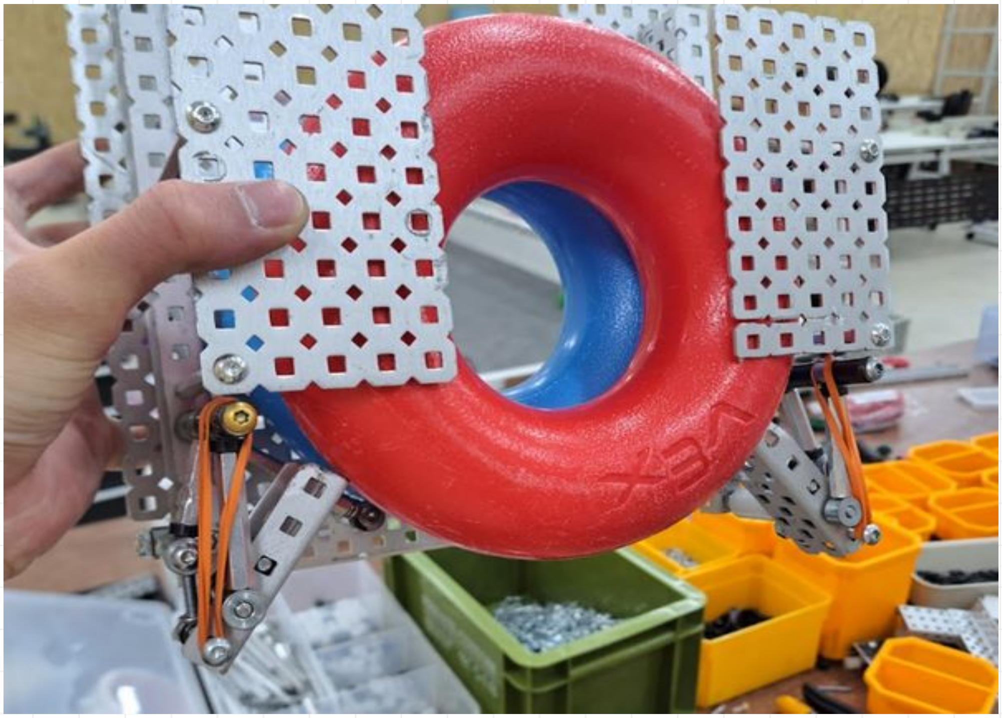


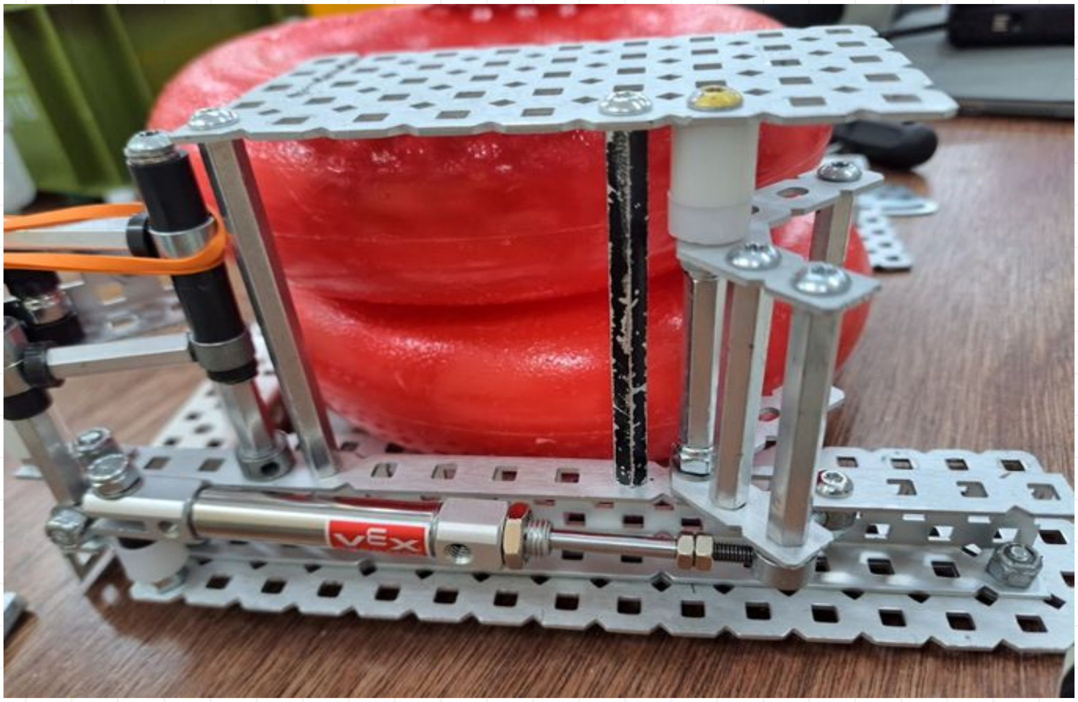
Positives	Negatives
• Wide range	• Slow • Very inconsistent

Prototyped Solutions

We built prototypes of the two possible solutions to test their performance.

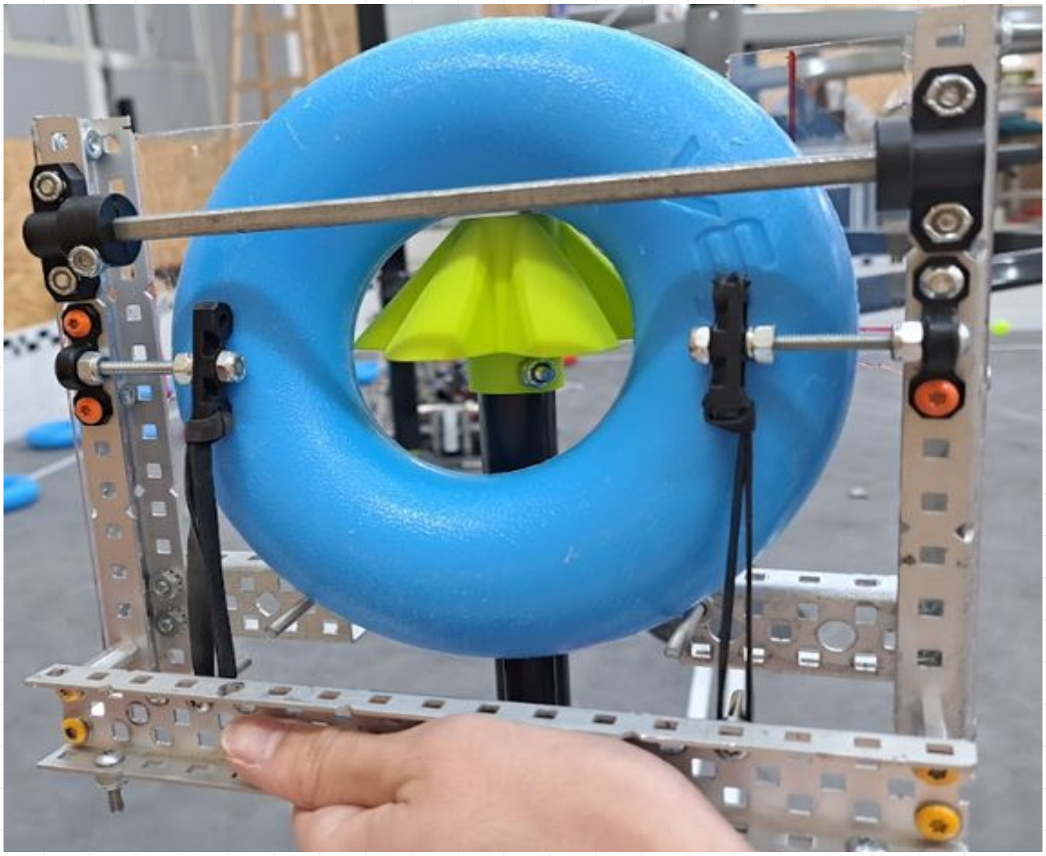
Up-and-down Claw

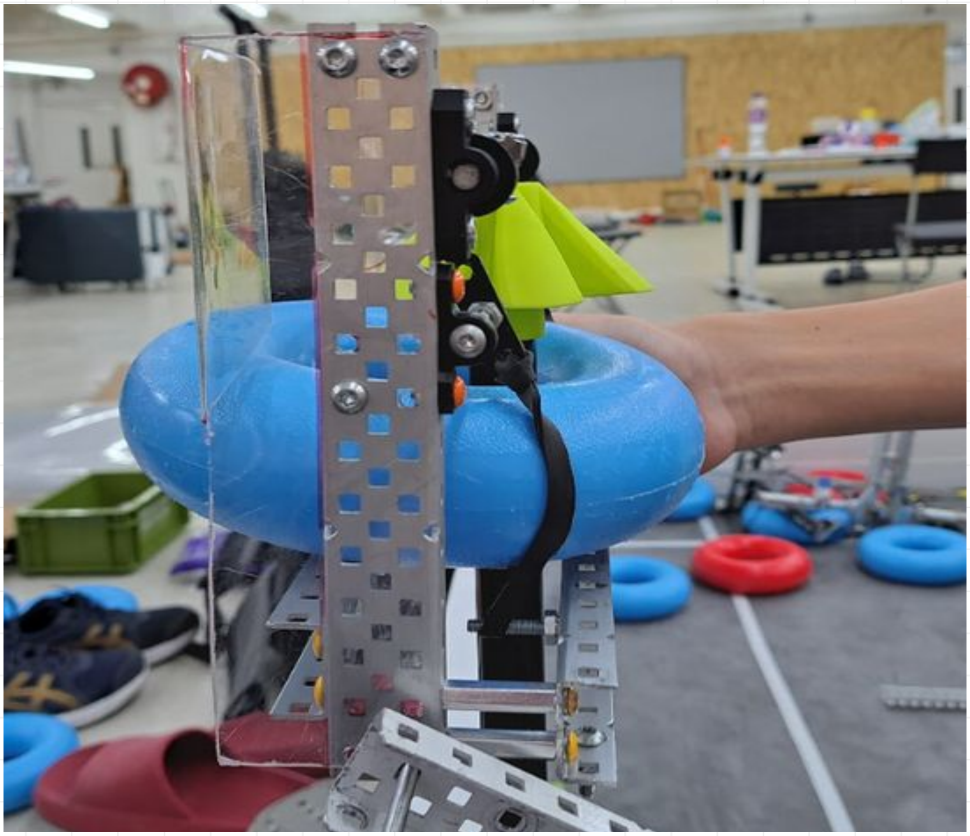




Prototyped Solutions

Collision Claw





SELECT AND PLAN

WALL STAKES SCORING MECHANISM

Decision Matrix

Speed How fast the design scores wall stakes

Consistency How consistent is the design scoring wall stakes

Air usage How much pressurized air is used in one scoring action

	Speed	Consistency	Air usage	Total
Up-and-down claw	4	5	4	13
Collision claw	4.5	4	3.5	12
catapult	5	1	5	11

We will use the up-and-down claw mechanism for wall stakes scoring because its high composite score on our priorities.

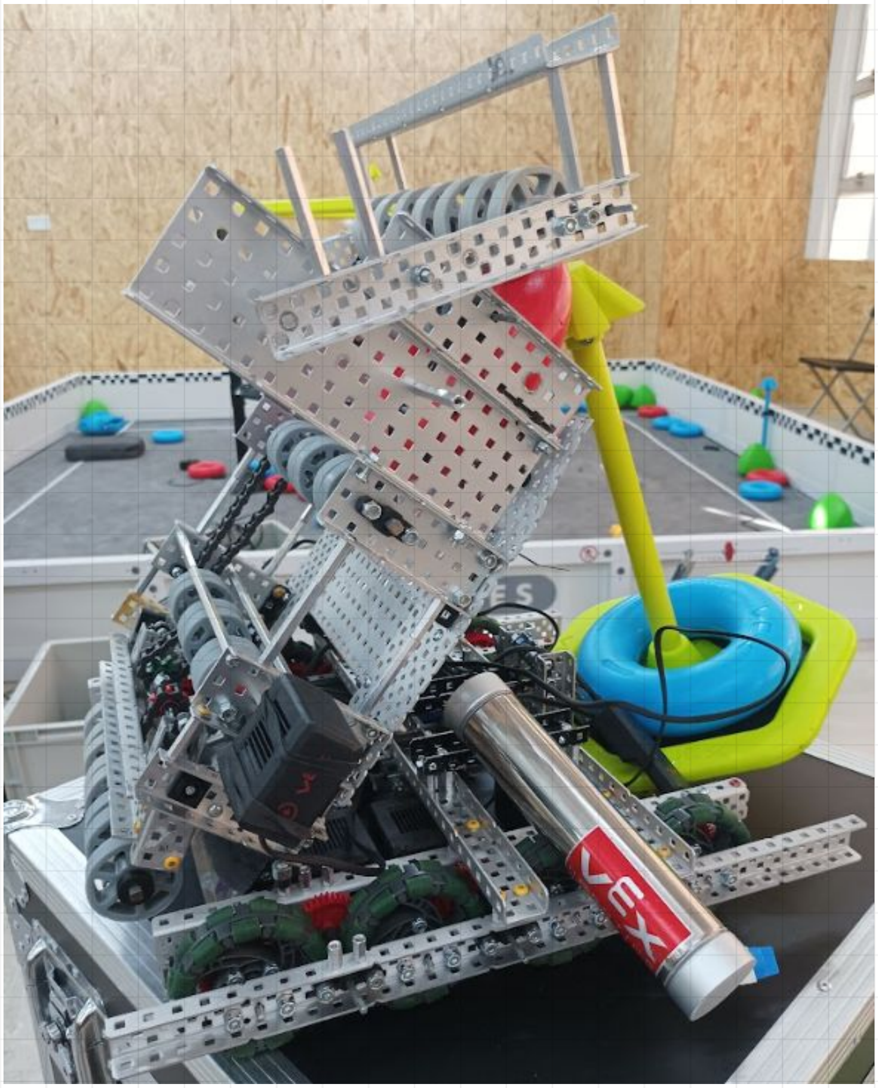
BUILD SOLUTION

WALL STAKES SCORING MECHANISM

Goal

We will build our planned solution so that we can test its performance

Assembled Build (Failed)



However, during the build process, we discovered that the wall stakes scoring mechanism will exceed the size limit of the robot, thus resulting a failure of this design

TEST SOLUTION

WALL STAKES SCORING MECHANISM

Goal

We will test the solution so that we can see if it meets our requirements and goals.

Solution Goals

- Intake a ring from the ground to the wall stakes scoring mechanism in 2 seconds
- Score wall stakes in 2 seconds
- Score a full wall stakes in 30 seconds

Test Results

- Intake a ring from the ground to the wall stakes scoring mechanism in 2 seconds - used less than 1 second ❌
- Score wall stakes in 2 seconds - used less than 2 seconds ❌
- Score a full wall stakes in 30 seconds - used 27 seconds ❌

ROBOT GENERATION 2

project Drivetrain name Michae
l date 14/8/24

REFLECTION ON GEN 1

Evaluation of robot performance

Flaws

1. There is no wall stake scoring mechanism
2. The friction in mobile goal scoring mechanism is high
3. The intake and delivery use 2 11W motors which is unsatisfactory

Improvement areas

- Redesign the mobile goal scoring mechanism
- Do some minor change to the intake and delivery so that it can use one 11W motor or less
- Build a wall stake scoring mechanism

IMPROVEMENT
INTAKE & DELIVERY

project Drivetrain name Michae
l date 15/8/24

IDENTIFY PROBLEM

Intake and Delivery

Goal

We will identify the current flaws of the current intake and delivery mechanism

Flaws

1. The mechanism uses 2 11W motors, which results in no motor left for our wall stakes scoring mechanism
2. The ring sometimes are stucked inside the delivery due to insufficient contact of flex wheels due to bent shafts
3. The pivot of intake roller is bent, lowering the rpm of whole mechanism

Improvement areas

- Redesign the mechanism so that it works with one 11W motor
- Use CAD to calculate the correct position of the flex wheel roller of delivery to avoid bending of shafts
- Redesign the intake pivot using stronger shape

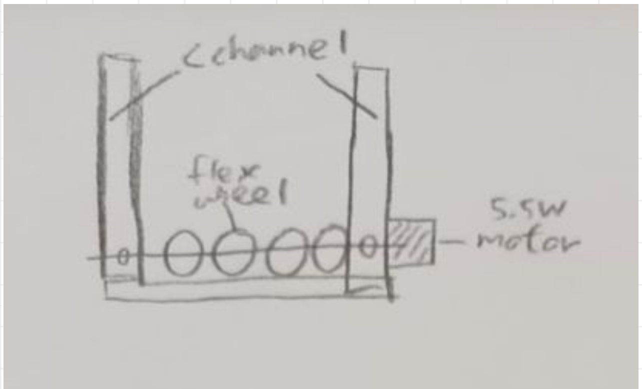
BRAINSTORM SOLUTION

Intake and Delivery

Goal

We will brainstorm possible solutions for our intake & delivery so that we can select the best one for our design

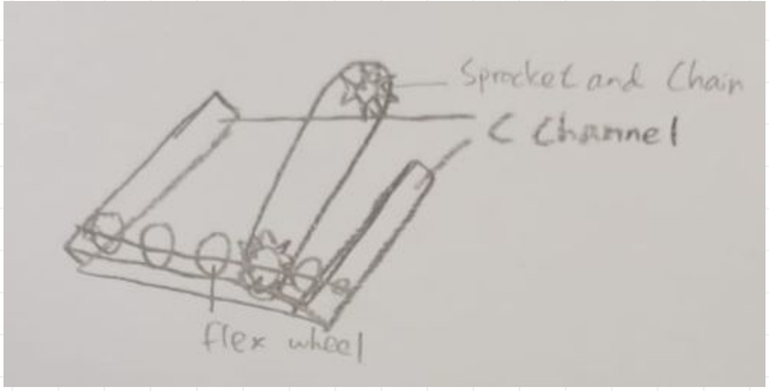
Possible Improvement- Intake & delivery



5.5W independent motor intake

- Use one 5.5W motor to power the intake roller independently

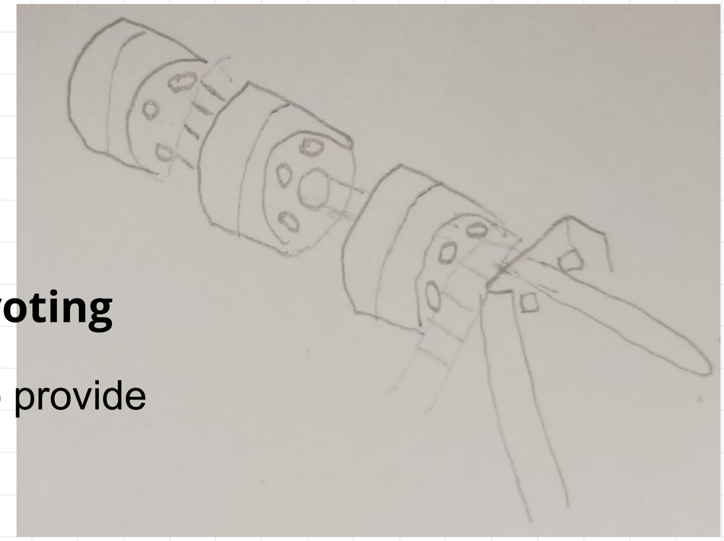
Positives	Negatives
• Less friction • Use less power • more prolonged before overheat	• Low torque • May be too slow



Chain powered intake

- Use chain and sprocket to power the intake roller by connecting with the delivery

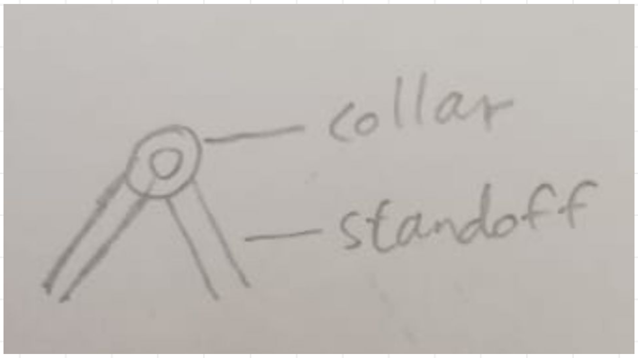
Positives	Negatives
• Fast • High torque • Simple	• Use more power • More friction



C Channel structure delivery pivoting

- Use standard holes in C channels to provide pivot for the delivery roller shafts

Positives	Negatives
• Very fast • Familiar wheel size	• May stuck on rings • Easy to tip due to high center of gravity



Bearing structure delivery pivoting

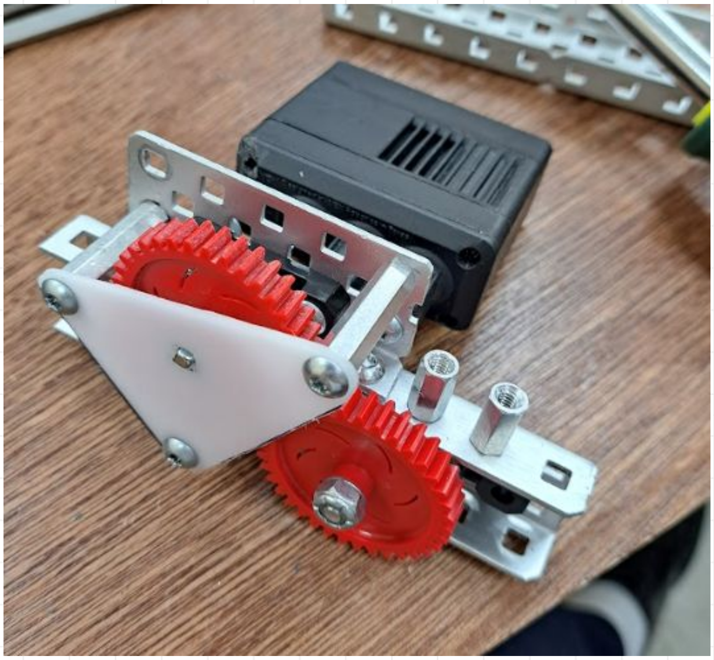
- Use standoffs and pillow block bearing to provide pivot for the delivery roller shafts

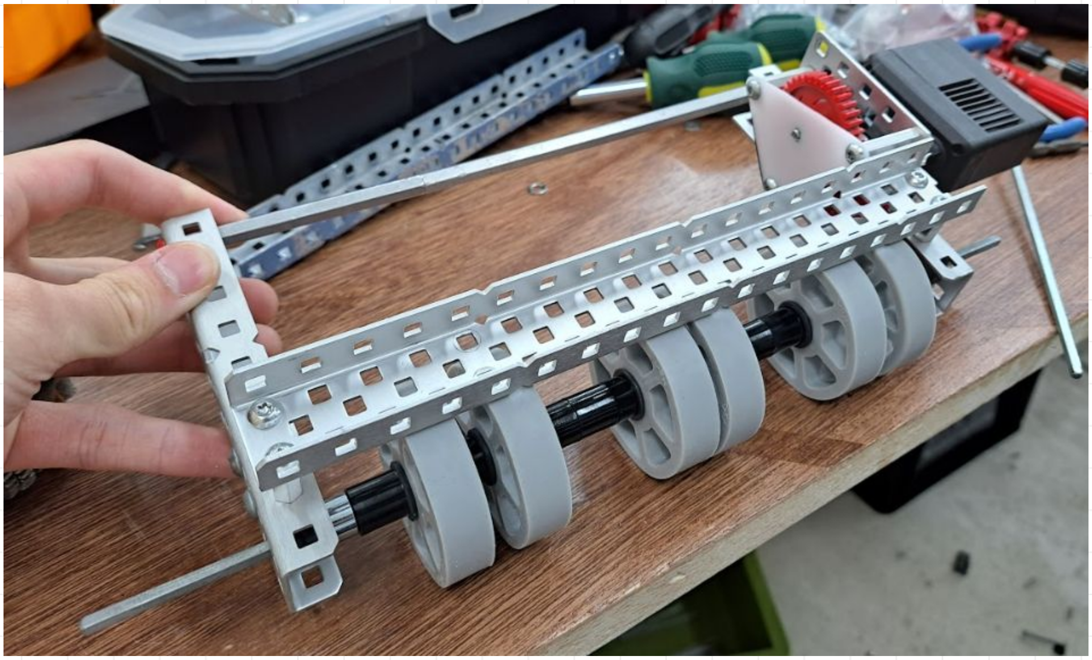
Positives	Negatives
• Great center of mass • Highest torque • Will not stuck on rings • Fastest acceleration time	• Slower compared to other options

Prototyped solutions

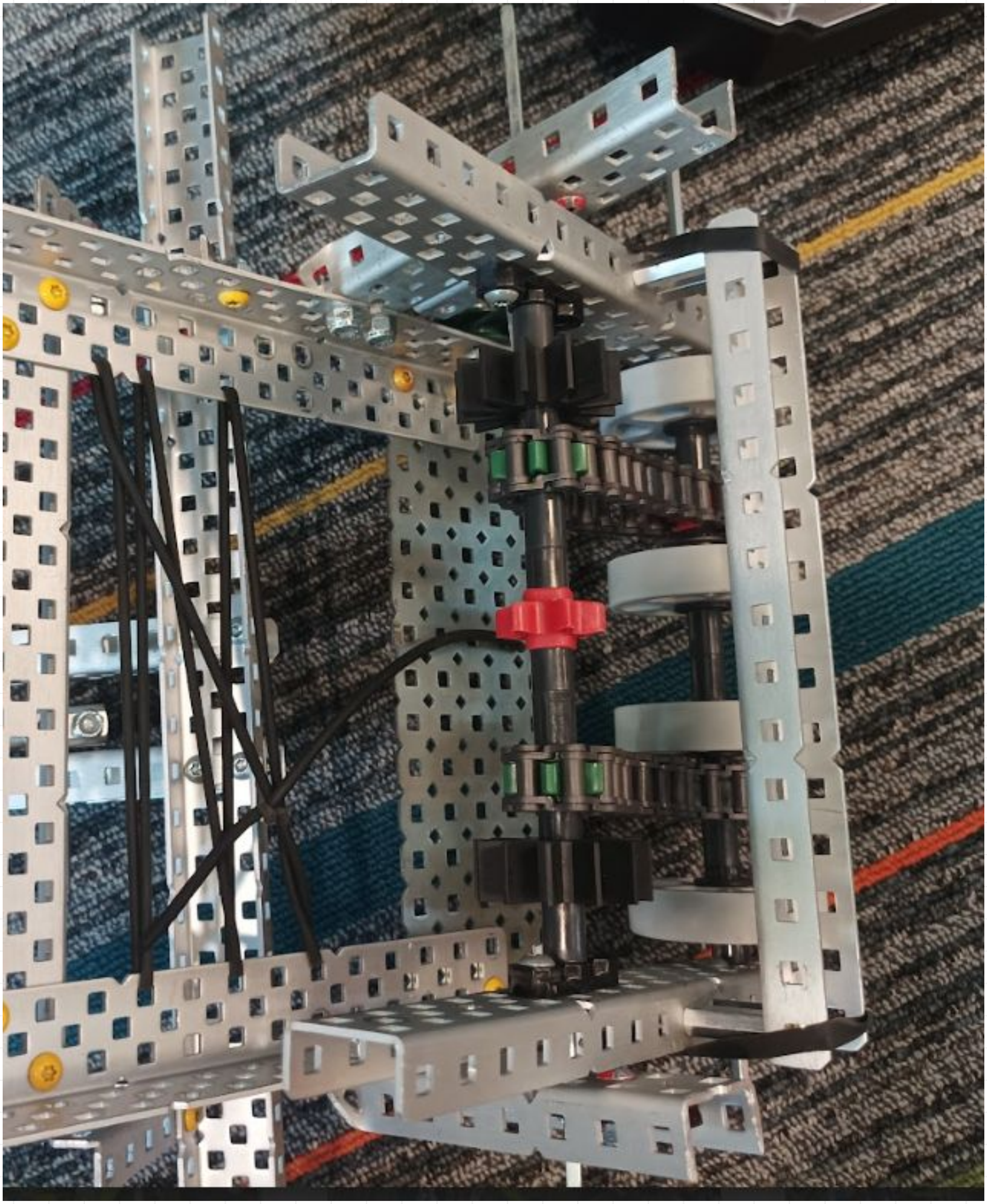
We have decided to prototype the 2 most common intake solutions for testing, so that we can select the best design

5.5W Motor intake

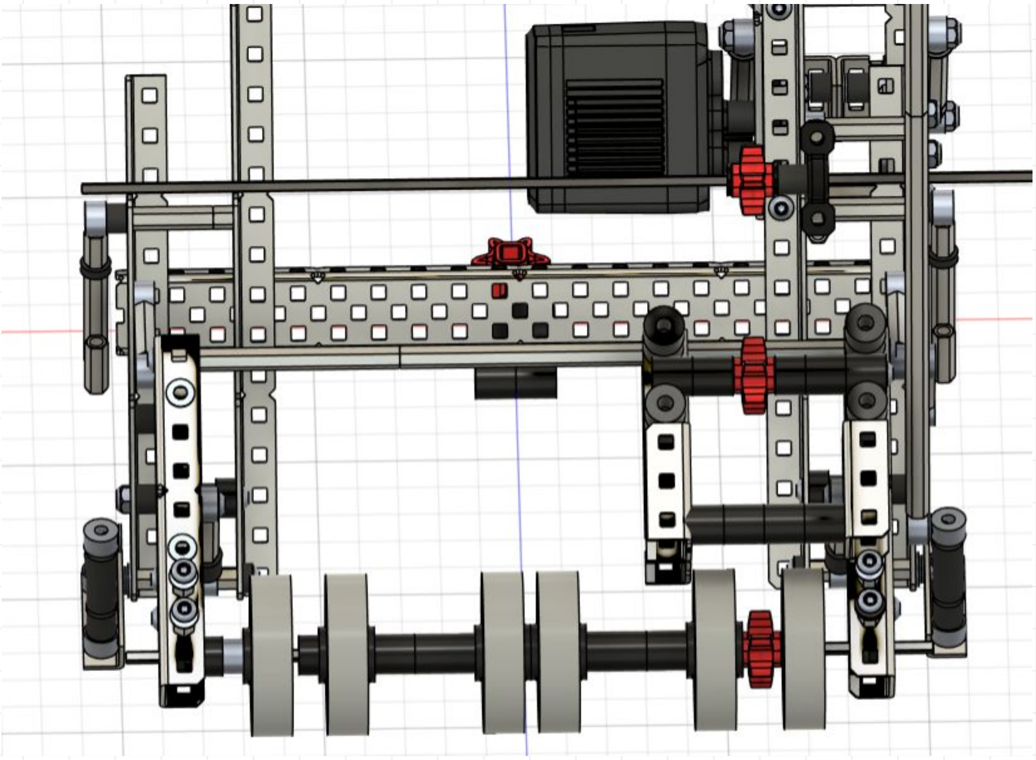




Chain intake

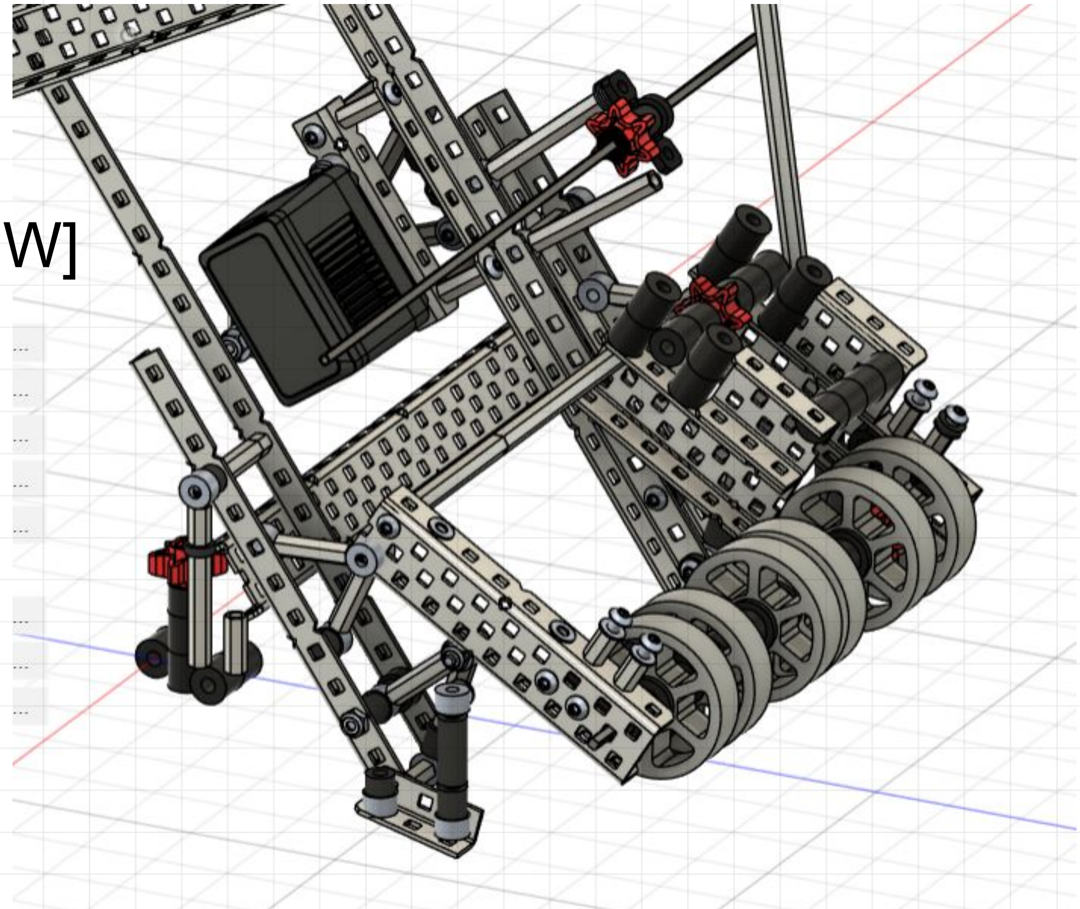


CAD model of solution



[TOP VIEW]

[ISOMETRIC VIEW]



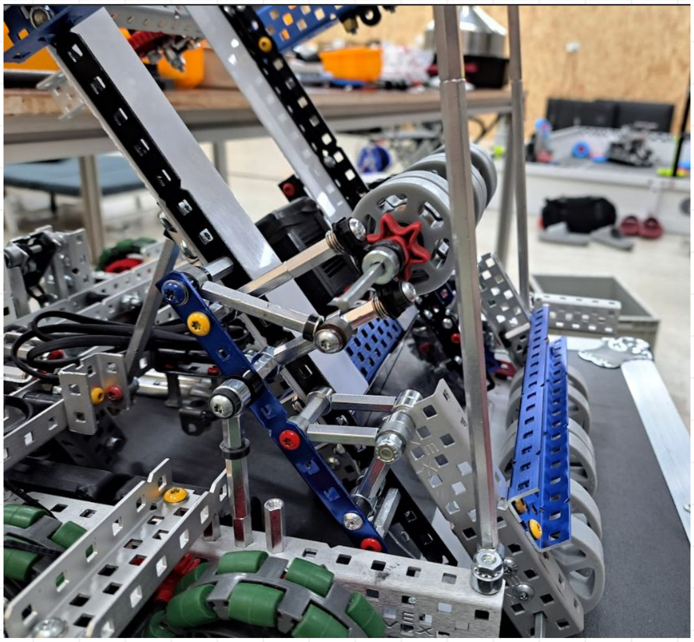
BUILD SOLUTION

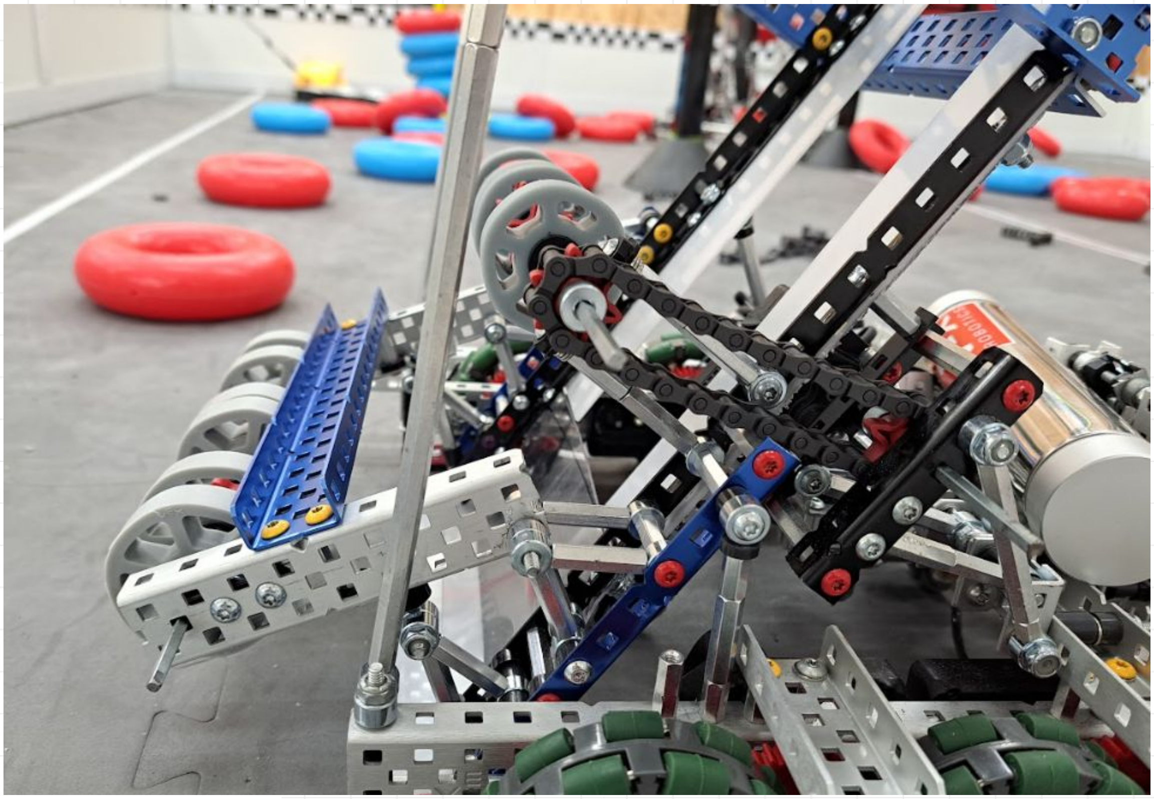
INTAKE AND DELIVERY

Goal

We will build our planned solution according to the CAD so that we can test its performance

Assembled Build





project INTAKE AND DELIVERY name Michael date 30/8/24

TEST SOLUTION

INTAKE AND DELIVERY

Goal

we will test the solution so that we can see if it meets our requirements and goals

Requirements

- Redesign the mechanism so that it works with one 11W motor
- Use CAD to calculate the correct position of the flex wheel roller of delivery to avoid bending of shafts
- Redesign the intake pivot using stronger shape

Final performance

- Redesign the mechanism so that it works with one 11W motor✅
- Use CAD to calculate the correct position of the flex wheel roller of delivery to avoid bending of shafts✅
- Redesign the intake pivot using stronger shape✅

INTRODUCTION OF
WALL STAKE SCORING MECHANISM

project Intake & delivery name Michae l date 31/8/24

IDENTIFY PROBLEM

WALL STAKES SCORING MECHANISM

Goal

We will identify an objective for our robot so that we can address it and build an effective wall stakes scoring mechanism

Problem Statement

We need a mechanism to be able to score wall stakes effectively and consistently

Solution Requirements

- Must only use legal VEX Robotics Competition parts
- Must fit within 18”x18”x18” cube for starting size limit
- Must require at most 1 motor to work

Solution Goals

- Intake a ring from the ground to the wall stakes scoring mechanism in 2 seconds
- Score wall stakes in 2 seconds
- Score a full wall stakes in 30 seconds

BRAINSTORM SOLUTION

WALL STAKES SCORING MECHANISM

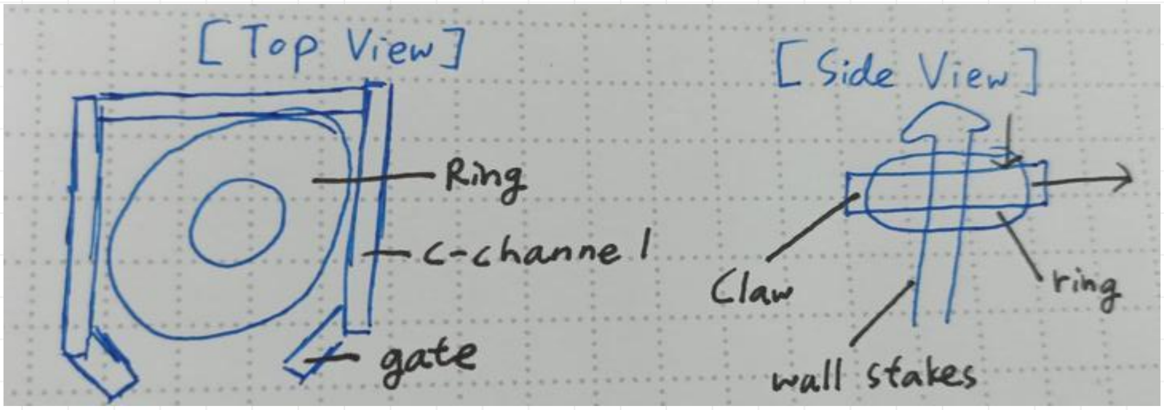
Goal

We will brainstorm possible solutions for our wall stakes scoring mechanism so that we can select the best one for our design

Possible Solutions

Up-and-down Claw

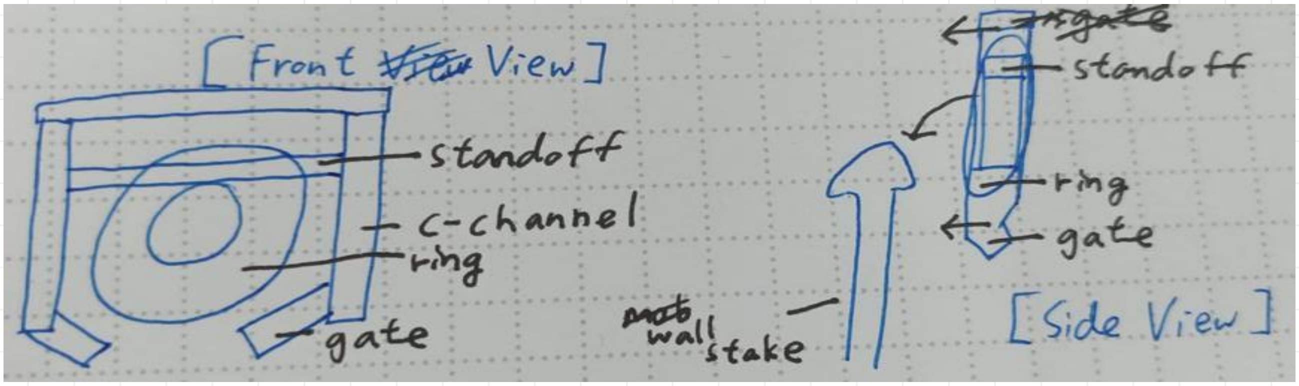
- A claw with two arm on the two sides of the mobile goal
- Powered by a piston, allowing it to open or close



Positives	Negatives
• Wide range • Fast • Less amount of pressurised air needed	• Very inconsistence grabbing position • Loose

Collision Claw

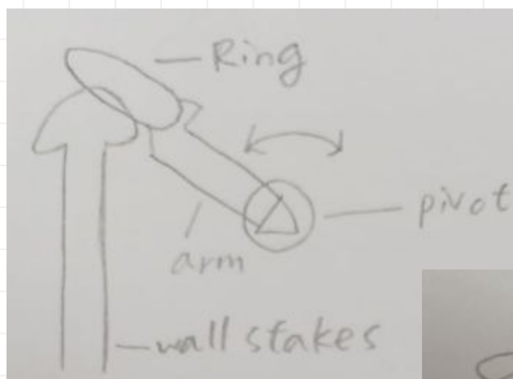
- Use a piston to grab the mobile goal in vertical direction
- Two standoff is used in both sides to grab the mobile goal in all directions

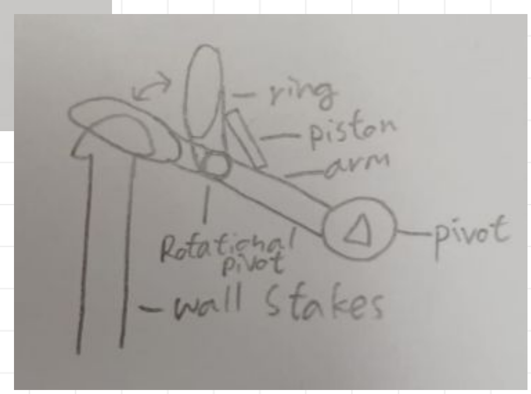


Positives	Negatives
• Can grab in all directions • Fast	• Hard to aim • Large amount of pressurised air needed

Flipping claw

- A short arm that holds the ring
- A long arm that holds a pivot for the short arm to spin and score the ring into the wall stakes



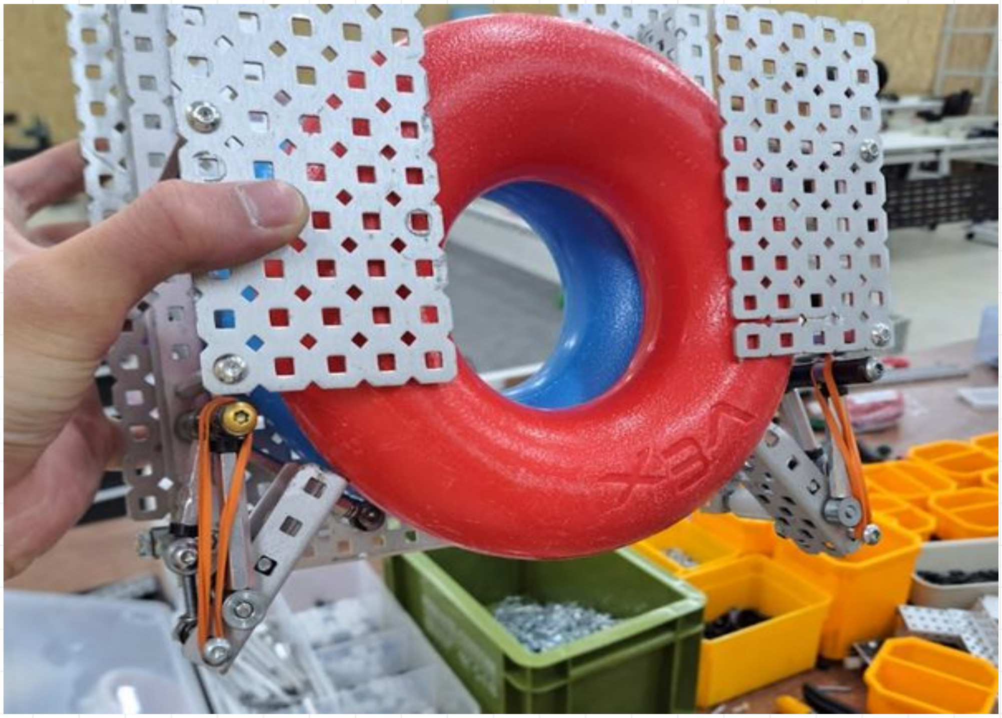


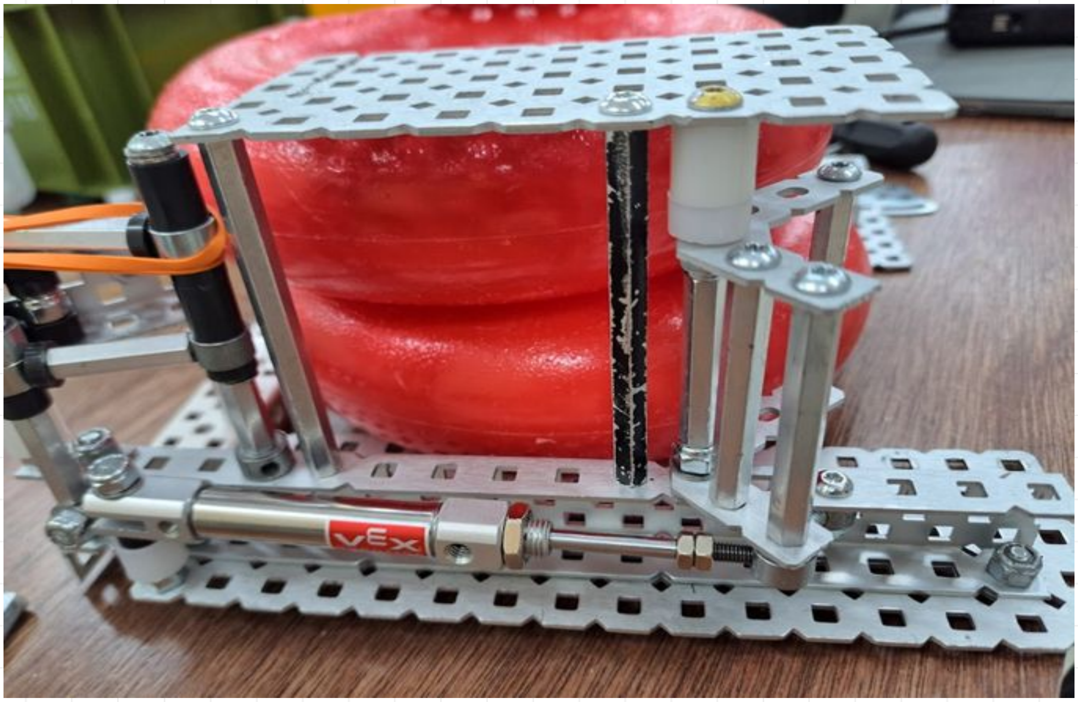
Positives	Negatives
• Fast • Easy to aim • Can score in all directions	• inconsistent grabbing position

Prototyped Solutions

We built prototypes of the two possible solutions to test their performance.

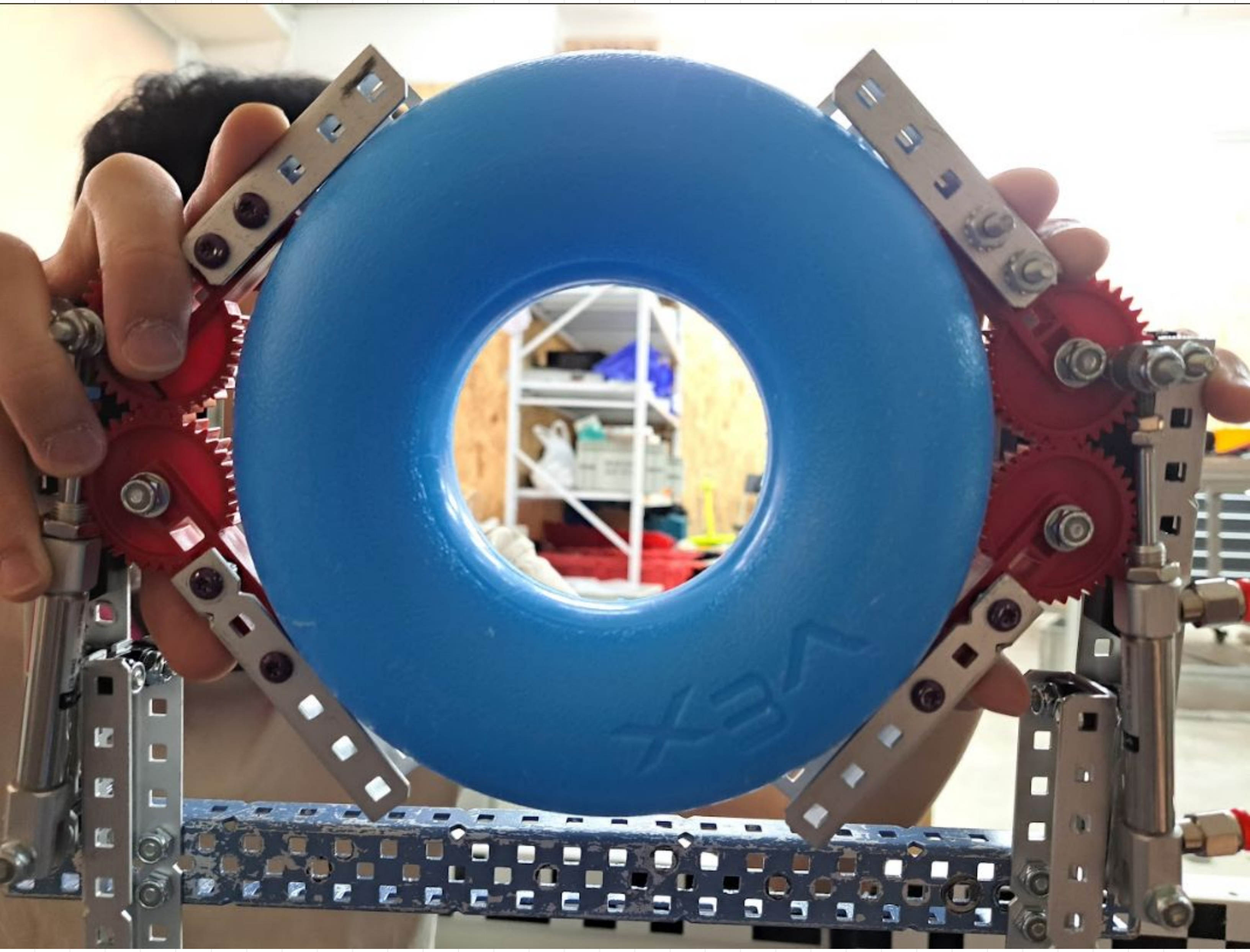
Up-and-down Claw





Prototyped Solutions

Flipping Claw



SELECT AND PLAN

WALL STAKES SCORING MECHANISM

Decision Matrix

Speed How fast the design scores wall stakes

Consistency How consistent is the design scoring wall stakes

Air usage How much pressurized air is used in one scoring action

	Speed	Consistency	Air usage	Total
Up-and-down claw	4	5	4	13
Collision claw	4.5	4	3.5	12
catapult	5	1	5	11

We will use the up-and-down claw mechanism for wall stakes scoring because its high composite score on our priorities.

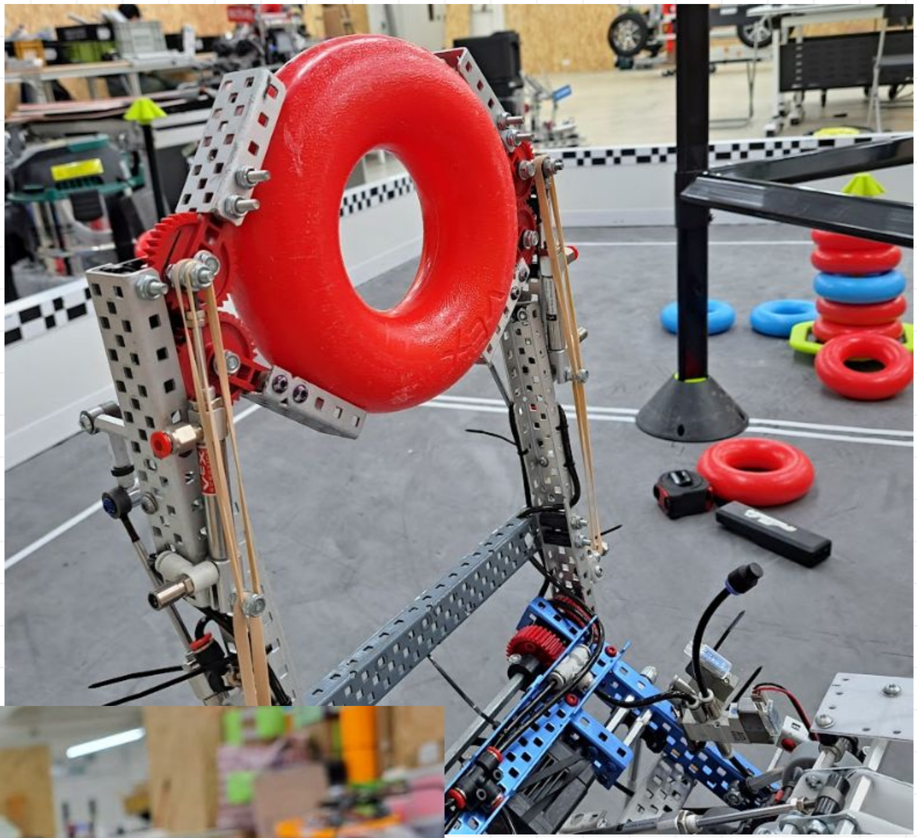
BUILD SOLUTION

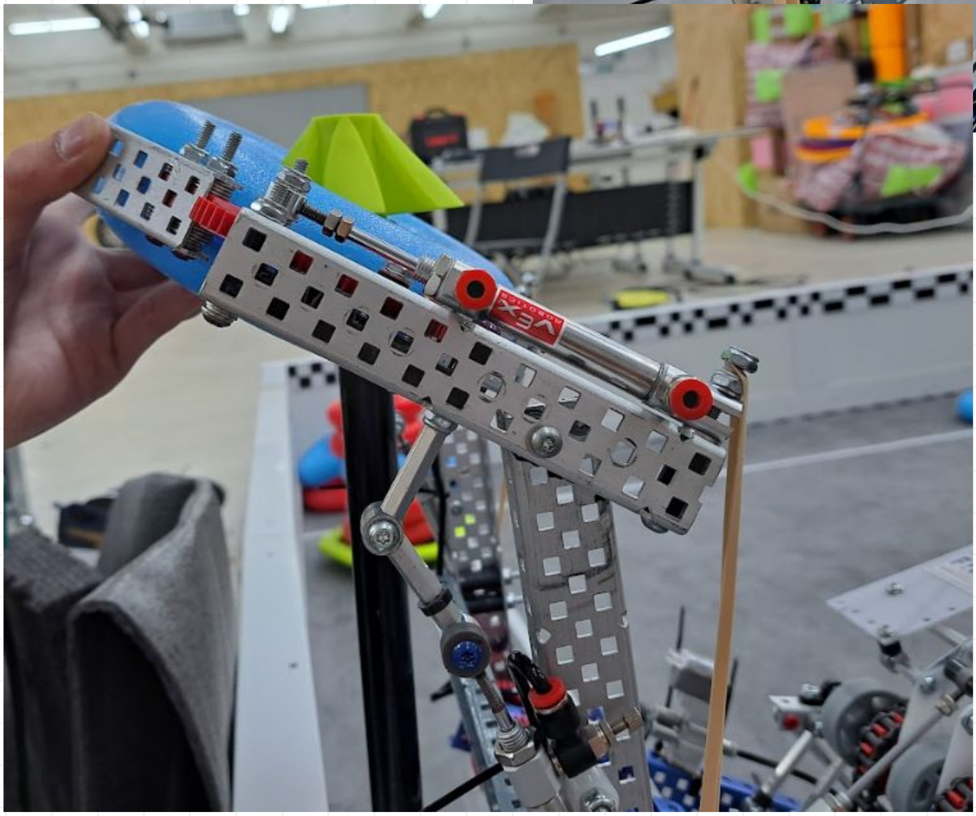
WALL STAKES SCORING MECHANISM

Goal

We will build our planned solution so that we can test its performance

Assembled Build





IMPROVEMENT
MOBILE GOAL SCORING MECHANISM

TEST SOLUTION

WALL STAKES SCORING MECHANISM

Goal

We will test the solution so that we can see if it meets our requirements and goals.

Solution Goals

- Intake a ring from the ground to the wall stakes scoring mechanism in 2 seconds
- Score wall stakes in 2 seconds
- Score a full wall stakes in 30 seconds

Test Results

- Intake a ring from the ground to the wall stakes scoring mechanism in 2 seconds - used less than 1 second ✅
- Score wall stakes in 2 seconds - used less than 2 seconds ✅
- Score a full wall stakes in 30 seconds - used 27 seconds ✅

IMPROVEMENT

MOBILE GOAL SCORING MECHANISM

Goal

We will identify a problem with our mobile goal scoring mechanism (hood) so that we can address it and have a more consistent design with less friction

Reason of changing

The robot must be able to score the ring into the mobile goal from intake with only one 11W motor, thus the friction of the scoring mechanism have to be reduced

Solution

- We redesigned the hood so that it is much smaller now.
- We changed the pivot material from L channel holes into plastic in order to reduce friction by a more accurate pivot

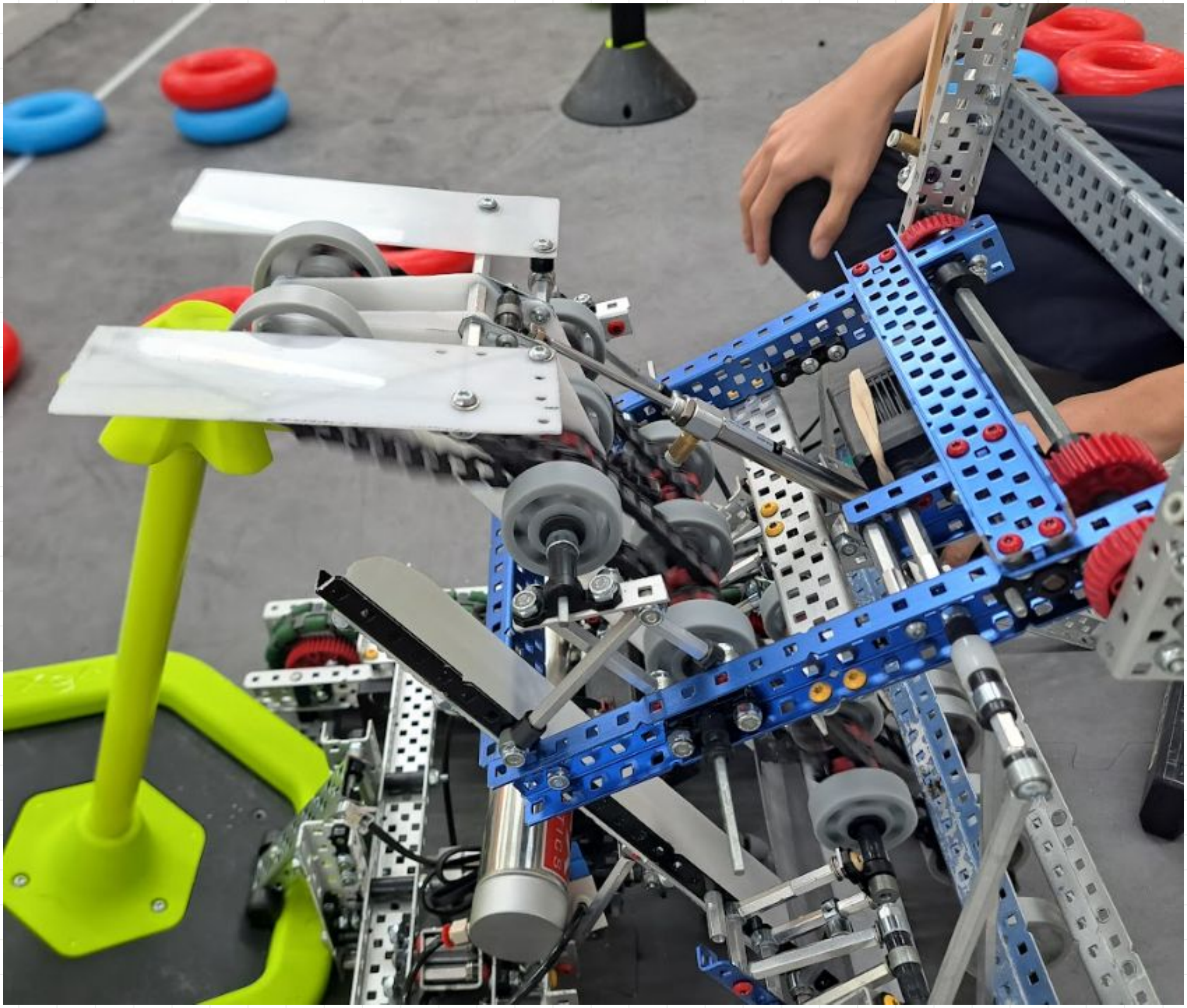
Solution Goals

- Intake a ring from the ground to the wall stakes scoring mechanism in 2 seconds
- Score wall stakes in 2 seconds
- Score a full wall stakes in 30 seconds

IMPROVEMENT

MOBILE GOAL SCORING MECHANISM

Assembled solution



IMPROVEMENT PROGRAMMING

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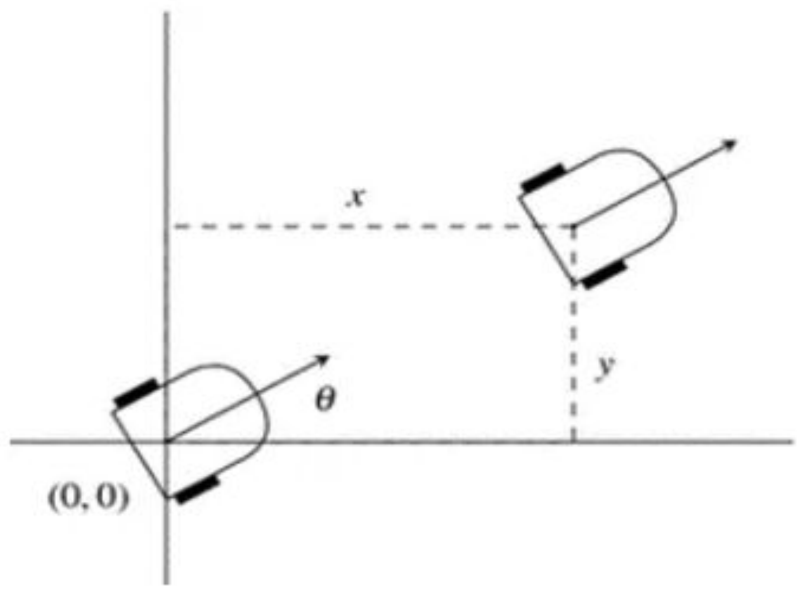
project Mobile Goal scoring mech. name Michae
l date 20/9/24

PROGRAMMING - ODOMETRY

This season, we decided to use odometry algorithm to increase our accuracy in autonomous period and autonomous skills. The way how odometry works is by recording robot's movement by measuring the readings of horizontal and vertical tracking wheels and an IMU.



In this image, we can get theta by reading the heading from IMU. The displacement of the robot can be read from the value of the vertical tracking wheel. Therefore, we can calculate the global position (x,y) of the robot relative to it's starting position.

Positives of odometry

In the previous seasons, we use linear motion (straight line and straight up heading turn). This method moves the robot to it’s designated position by referring to it’s current position relatively. Therefore, errors accumulate for each action. Letting the average error of each action by E, the total accumulated errors of the previous linear movement method after n actions would be nE.
Using odometry, each actions compares the robot’s designated position with it’s starting position. As the starting position is a constant and tracking wheel allows the robot to know it’s global position relative to it’s starting position, errors would reset each actions. Therefore, the total accumulated errors of the odometry movement method after n actions would be E, which is n times less than that of linear motion method.

PROGRAMMING THOUGHT PROCESS

Limitations

By the help of odometry, we are able to write auton movements that are a lot more consistent and accurate than before. However, as we only have our tracking wheel in vertical and horizontal direction, slight tilt and bend during turns and curve of robot's path my result in errors in the odometry algorithm. This may lead to inconsistent path execution.

Possible solution

Although errors may occur during curve paths, we can reduce the error caused by utilising more straight line movements and turning, so that our sensors won't be affected by errors. We experimented and found out three basic movement patterns that can lead to the least errors.

Basic movement patterns

There are mainly 3 basic movement functions to program the robot in order to achieve least error and more stable path.

[Move to point] is mainly used for lateral motions. [Move to point] compares the robot's current position with it's designated position globally, and find the best route for the movement.

[Turn to heading] is used to rotate the robot using its rotation center as the pivot. It reads the current heading of robot from the IMU and compare it to the designated heading. Then, it turns the robot to the designated heading using a PID controller.

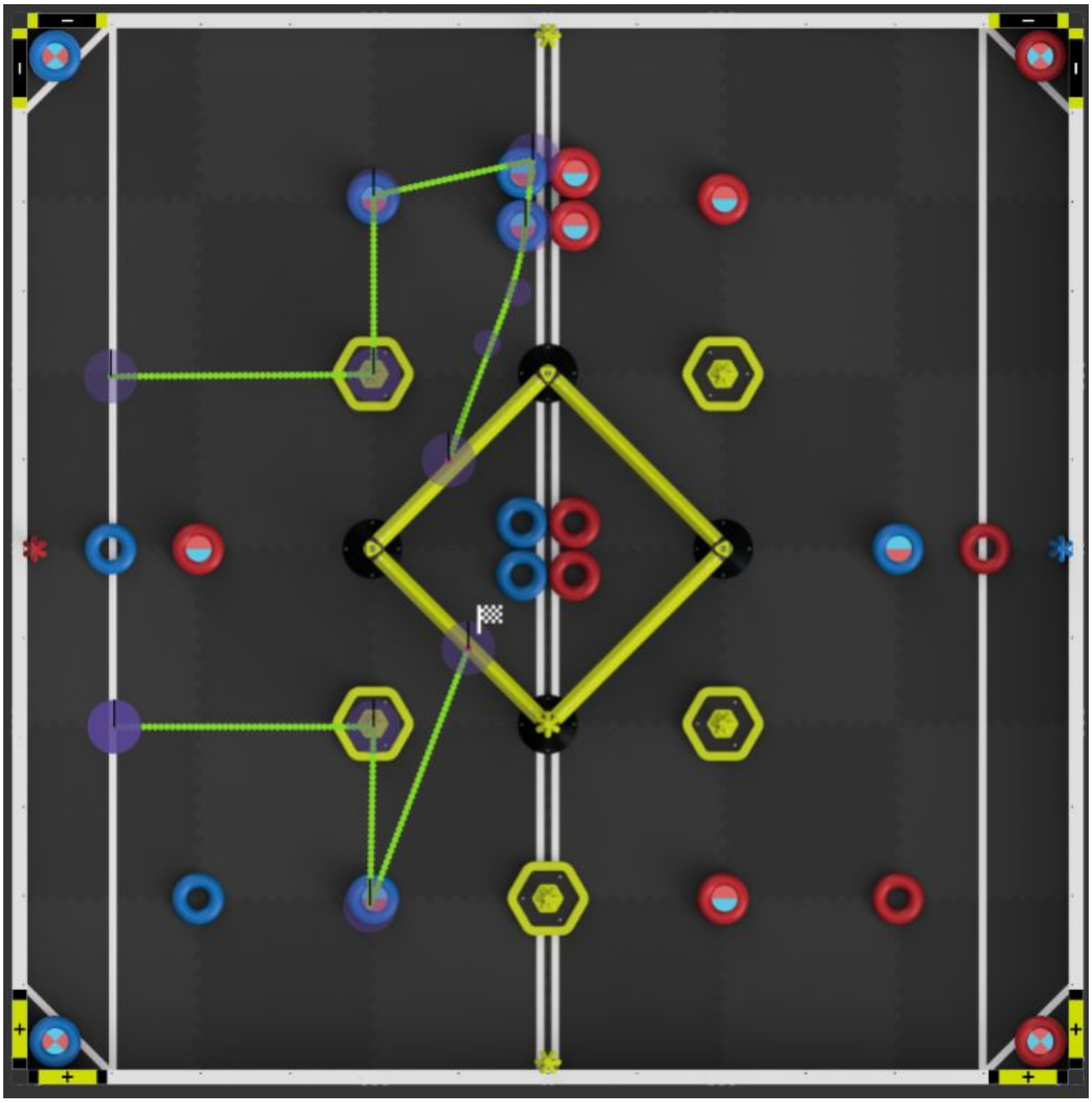
[Swing to heading] is a rather more complicated and advanced function. It locks the robot's one side of drivetrain and keep spinning the other side drivetrain until the robot reaches the designated heading.

PROGRAMMING - AUTON PATH

Goal

We aim to write the auton programs of both side of the field starting position for head-to-head matches

Solution



We used https://path.jerryio.com/ to generate images of auton paths

VEX V5 ROBOTICS COMPETITION

HIGH STAKES

Engineering Notebook

Tournament Champions

24 25

86254B

Book 3 (Generation 3 & PAS-VEX Sig.)

Team name
CAPMI1

Robot name
BattleBot

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TABLE OF CONTENTS

ROBOT GENERATION 3

project Drivetrain name Michae l date 21/9/24

SYNOPSIS

GENERAL

As the PAS-VEX Signature Event closes in, we need a major upgrade to prepare for the event from which we aim to gain World Championship qualification.

We believe that we have evolved enough from pre-season and are satisfied with previous progress, however, improvements in the following areas will need to be addressed in this major update (details will be put in respective sections).

1. Redesign the drivetrain
2. Redesign the intake & delivery
3. Redesign the mobile goal clamp
4. Introduction of the Katana
5. Redesign the claw
6. Redesign the mobile goal scoring mech.

REDESIGNED DRIVETRAIN

REFLECTION ON PREVIOUS GEN.

DRIVETRAIN

The previous drivetrain was deemed

Positives	Negatives
• Omni-configuration gives high maneuverability • Cartridge choice	• Too slow to be competitive • 3.25” wheels induces a high COG

A redesign is needed, except the wheel type, which the original design will be continued.

After competing in a few tournaments, we found out that speed of the robot is important as it helps us to get to the corners faster in order to take control of the positive/negative corners. The cog of the robot also need to be lower to prevent rings from going under the robot and stucking the drivetrain.

We will refine the scoring matrix, putting more weight on the speed of which we can achieve with the drivetrain, as well as adjusting the weighting such that smaller diameters are awarded more.

We will analyse the **same solutions we have brainstormed**.

SELECT AND PLAN

DRIVETRAIN

Decision Matrix - Wheel type

Speed — How fast the wheel moves at its max speed

Acceleration — How quick the wheel accelerates

COG — How low the wheel places the center of gravity of the design

Strength — How high is the torque of the wheel

Overheat — How long the wheel can run before overheating

	Speed (x1.5)	Acceleration	COG (x1.5)	Strength	Overheat	Total
4" Wheel	3	2.5	3	3.5	3	18
3.25" Wheel	4	4	4	4.5	4	24.5
2.75" Wheel	5	4.5	5	4.5	4.5	28.5

We will use 2.75 inch omnidirectional wheels with the 6 motor standard tank-drive as it has the highest overall score on our priorities. Given both of these decisions, we will find the right motor cartridge type for the drivetrain.

SELECT AND PLAN

DRIVETRAIN

Decision Matrix - Motor Cartridge

Speed How easy the wheel spins

Acceleration How quickly the wheel accelerates

Strength How strong the wheel is

	Speed	Acceleration	Strength	Total
Red	1	5	5	11
Green	2.5	4.5	4	11
Blue	5	4	3	12

Final decision for the redesign

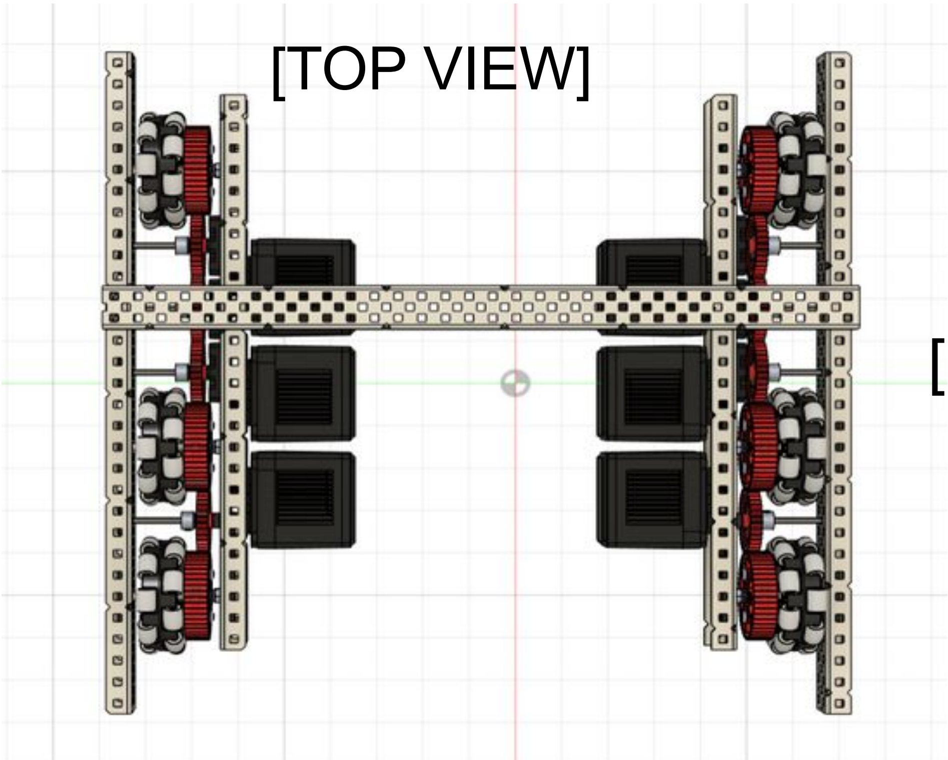
2.75” omni wheels are chosen driven by six motors equipped with blue cartridges.

To strike the balance between speed and torque, we chose to run 450RPM on the wheels **given the previous two choices**.

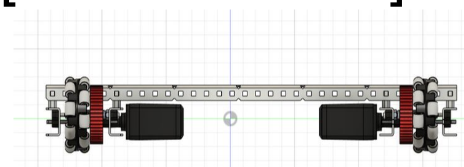
SELECTION AND PLAN

DRIVETRAIN

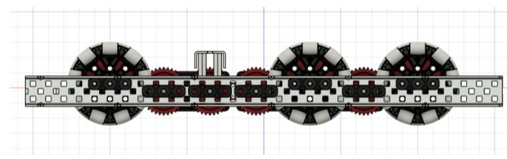
CAD model of solution



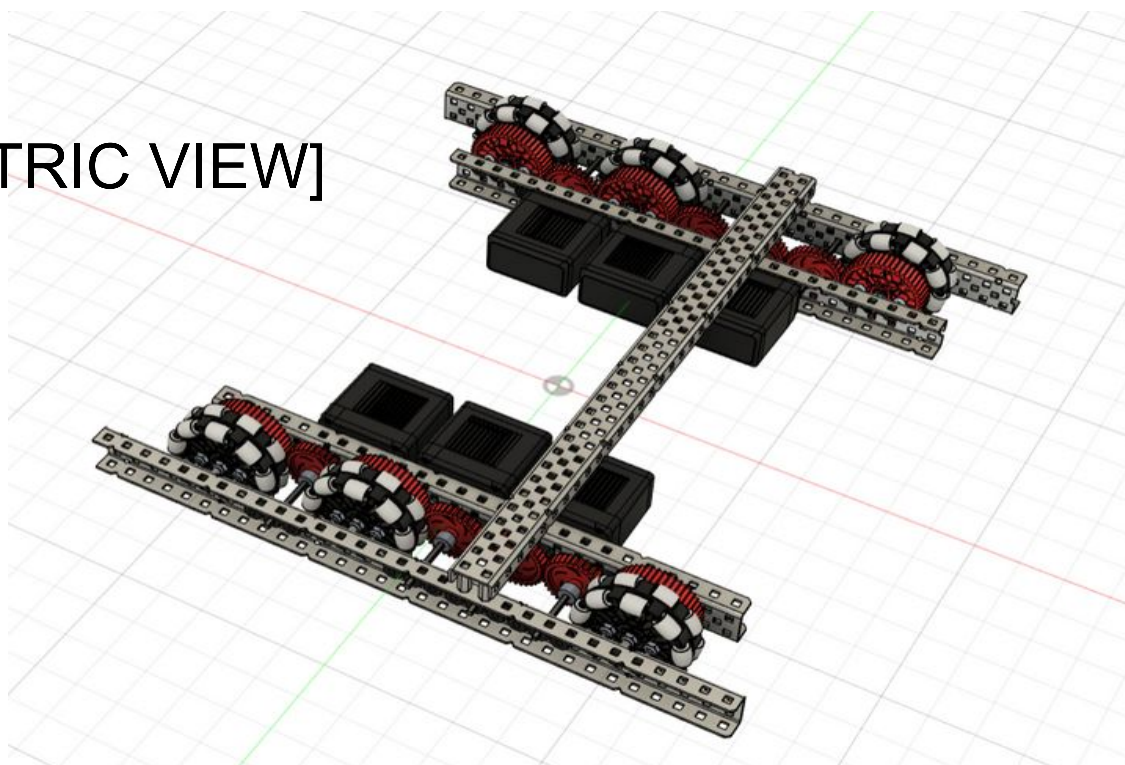
[FRONT VIEW]



[ISOMETRIC VIEW]

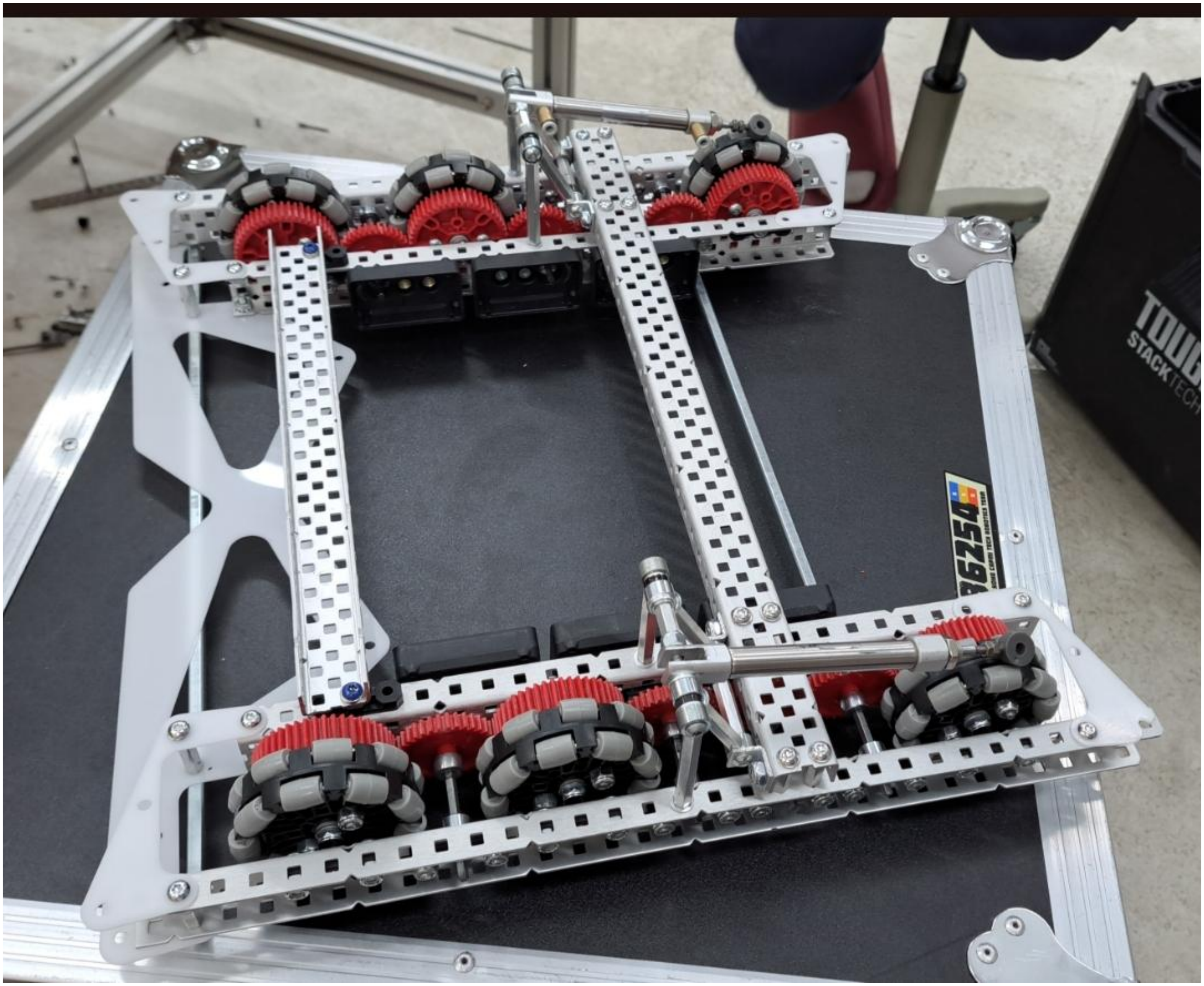


[ISOMETRIC VIEW]



BUILD SOLUTION

DRIVETRAIN



project Drivetrain name Michael date 28/9/24

TEST SOLUTION

DRIVETRAIN

Goal

we will test the solution so that we can see if it meets our requirements and goals

Solution Goals

- Travel from a positive corner to the other one in less than 3 seconds
- Turn 360 degree in less than 2 seconds
- Travel from a corner to an diagonal corner in less than 5 seconds
- Running in the filed continuously more than 6 minutes without overheating

Test Results

- Travel from a positive corner to the other one in less than 3 seconds - Used 2.43 seconds ✅
- Turn 360 degree in less than 2 seconds - Used 1.06 seconds ✅
- Travel from a corner to an diagonal corner in less than 5 seconds - Used 4.22 seconds ✅
- Running in the field continuously more than 6 minutes without overheating - Takes 9 minutes to overheat ✅

REDESIGNED INTAKE AND DELIVERY

REFLECTION ON PREVIOUS GEN.

INTAKE AND DELIVERY

We will develop the **mobile goal scoring mechanism** concurrently and parallelly with the **intake and delivery system**, this is done to create better connectivity and coherence of the two.

The previous delivery was deemed

Positives	Negatives
• Speed	• Clumsy • Prone to snapping (chains) • Time-consuming to tune

A redesign is needed, except the intake which the old design idea will be continued.

A new design to the delivery will be introduced and tested upon: the “hook” design, which has been mentioned in generation 2 as a scoring method.

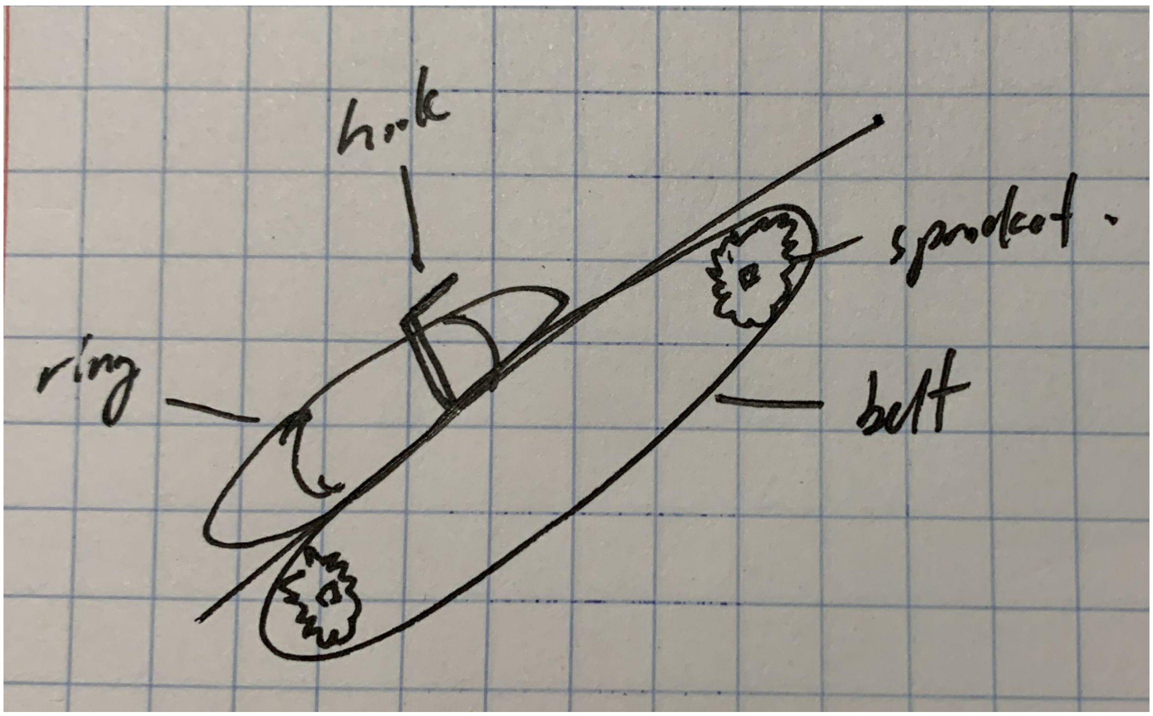
We will adjust the scoring matrix accordingly to work out a more desirable choice.

SELECT AND PLAN

INTAKE AND DELIVERY

Hook Design

- A guitar puck shaped hook will hook onto the hallow inner part of the ring and transfer it up the delivery path



Positives	Negatives
• Faster • Less prone to overheat (if made carefully) • Easy to build	• Bigger size, the operation area required as the hook moves up and down the belt is big

SELECT AND PLAN

INTAKE AND DELIVERY

Decision Matrix - Delivery

Consistency	How consistent is the delivery
Speed	How fast is each delivery
Overheat	How long it can run before overheating
Recovery	How quickly the design prepares next delivery

	Consistency	Speed	Overheat	Recovery	Total
Conveyor Belt	3.5	3.5	4	3.5	14.5
Flex Wheel Chain	4.5	4	3	4.5	16
Hook	4.5	5	4	4	17.5

We will use the new hook design because its high composite score on our priorities.

SELECT AND PLAN

INTAKE AND DELIVERY

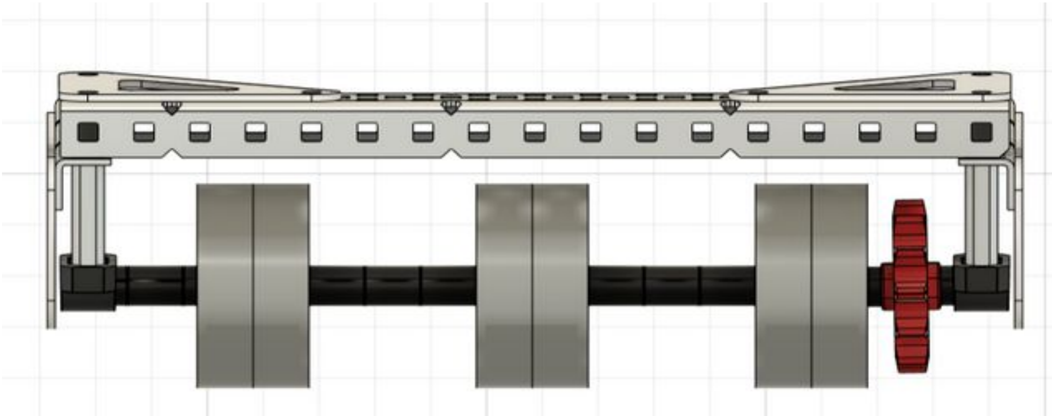
Final decision on Intake and Delivery

Intake design will be continued from generation 2, slight changes to fit into generation 3 will be made if needed.

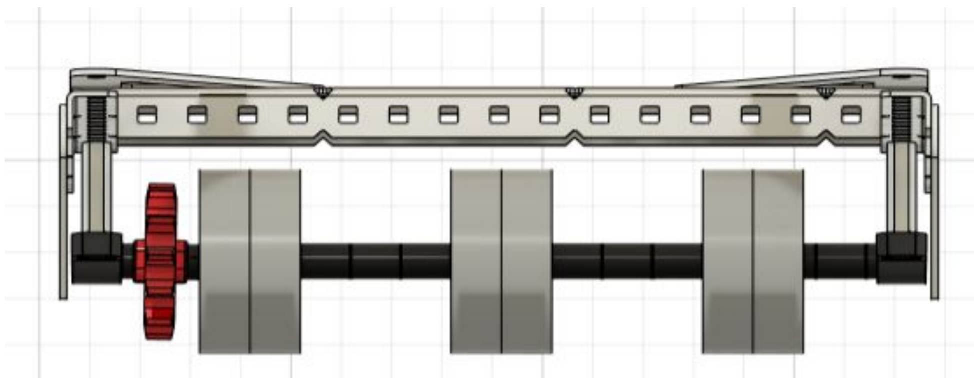
We will adopt a **"hook" design** for the delivery as it scores highest in our adjusted scoring matrix.

We observe that the hook design can be used for scoring on mobile goals as well, therefore we will evaluate the possible redesign of the **mobile goal scoring mech.** first, then we will proceed with CADing this redesign process.

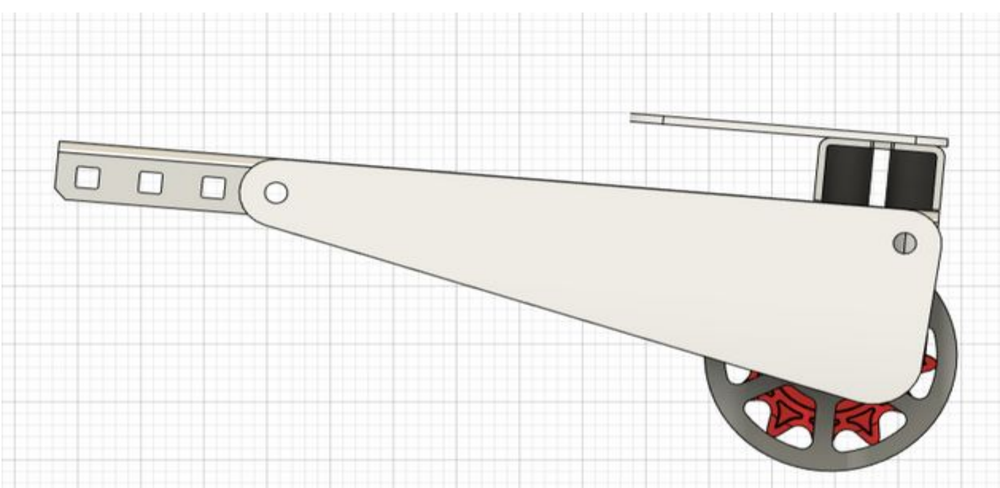
CAD Plan - Intake



[Front View]

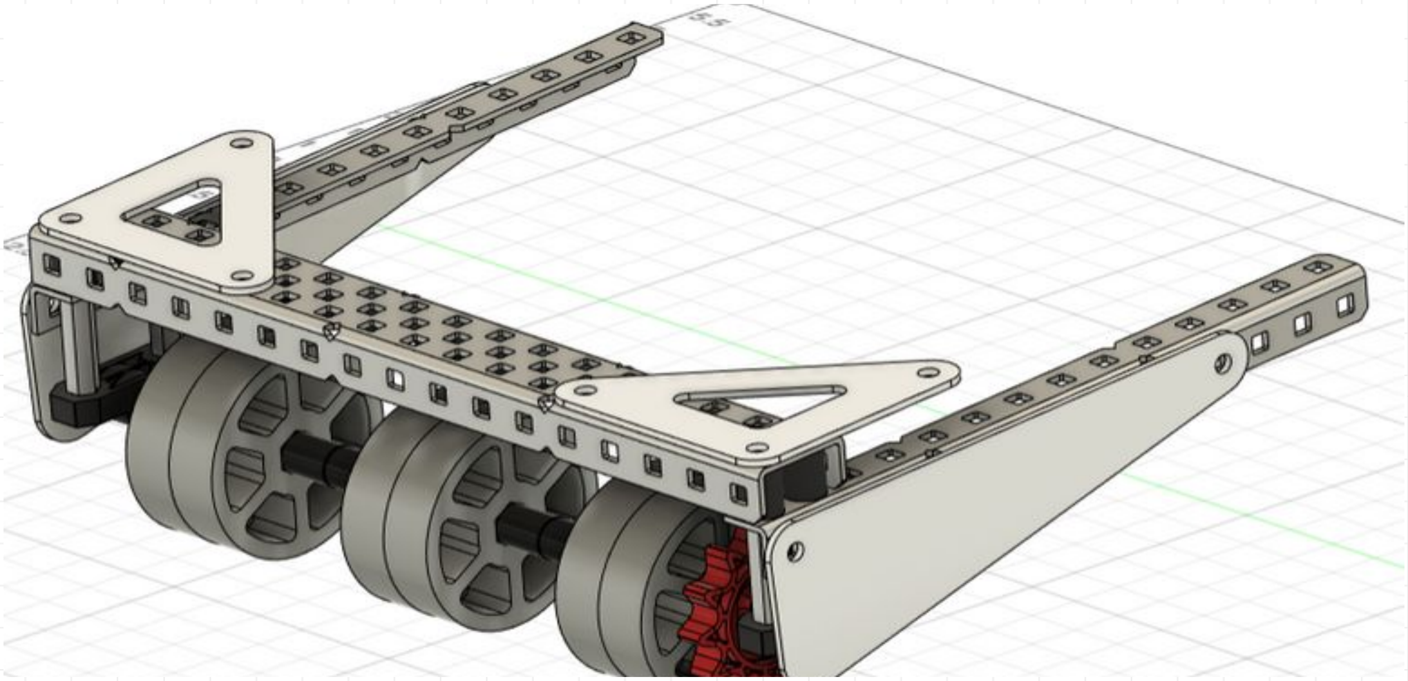


[Back View]



[Side View]

CAD Plan - Intake



[ISOMETRIC VIEW]

In order to mount the flex wheel roller, we decided to use two 14 holes L channel on the two sides to provide support for the roller. High strength bearings are mounted below the L channel by standoffs, which reduces the chance of the L channels blocking the rings as the flex wheels are much lower than the L channels. The outer diameter of ring is 7” (14 standard holes), therefore 17 holes C channel is used to interconnect the two L channels, providing enough gap for the ring to slide in.

REDESIGNED

MOBILE GOAL SCORING MECH.

REFLECTION

MOBILE GOAL SCORING MECHANISM

We will develop the **mobile goal scoring mechanism** concurrently and parallelly with the **intake and delivery system**, this is done to create better connectivity and coherence of the two.

In light of this, the previous design will be reevaluated with an adjusted scoring matrix with a new scoring factor: **connectivity with delivery**.

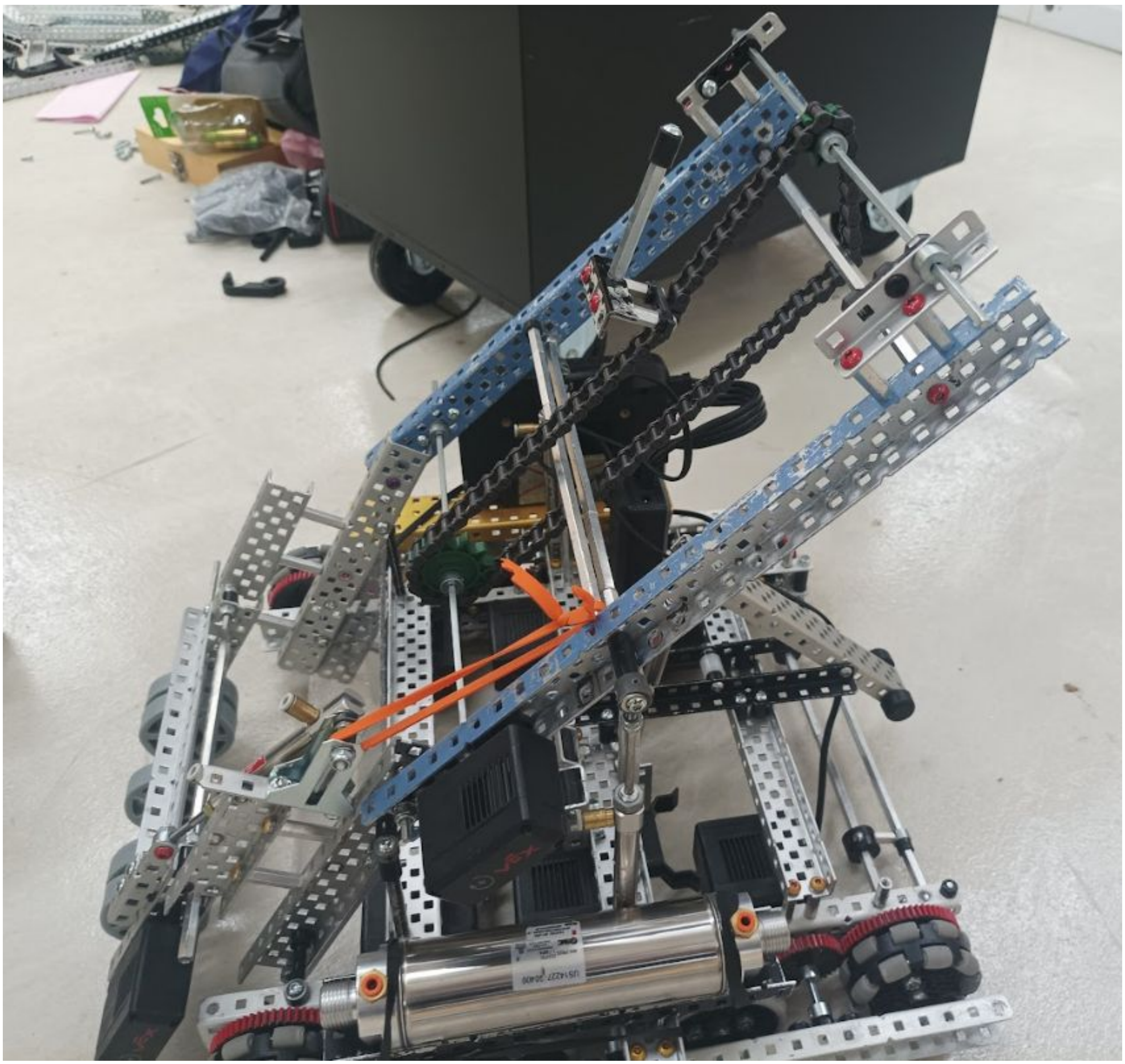
On the previous hood design for scoring on mobile goals:

Positives	Negatives
• Theoretically the highest rate of which rings can be scored is higher	• Low efficiency • Low reliability, it misses pretty frequently

PROTOTYPING

MOBILE GOAL SCORING MECHANISM

A revised version of the rough hook design will be made and it will be put into direct comparison with generation 2's hood design to give us an idea of the key values the two different designs demonstrate.
We redesigned the hook shape and improved the speed of the motor for better possible performances.



Project Mobile goal scoring mech prototyping

Name Michael Date 10/10/24 Page

SELECT AND PLAN

MOBILE GOAL SCORING MECHANISM

Goal

We will select the solution that is best by testing the mechanism's ability to score rings into mogo from intake

Prototype Testing - Scoring

- Test 1: Speed
- Test Procedures
- Place one ring into the intake
- Power the mechanism's motor using controller and start stopwatch
- Stop stopwatch when the mechanism finishes scoring that ring
- Record results

Test Results:

Time Taken to score one ring					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Hook	0.82	0.67	1.08	0.65	0.805
Hood	1.02	1.19	1.03	1.22	1.115

Fastest: Hook

- Test 2: Consistency
- Test Procedures
- Place 6 rings into the intake one by one
- Power the mechanism's motor using controller and start stopwatch
- Stop stopwatch when the mechanism finishes scoring all 6 rings
- Record results

Test Results:

Time Taken to score 6 rings					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Hook	5.59	5.76	6.28	5.7	5.8325
Hood	7.94	7.08	8.43	8.35	7.95

Fastest: Hook

- Test 3: Overheating
- Test Procedures
- Continuously place rings into the intake one by one
- Power the mechanism's motor using controller and start stopwatch
- Stop stopwatch when the motor reaches overheat level 1
- Record results

Test Results:

Time Taken to overheat					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Hook	470.77	463.6	471.3	478.44	471.0275
Hood	343.22	314.12	323.55	326.01	326.725

Longest time until overheat: Hook

Decision Matrix - Scoring

Consistency	How consistent is the scoring
Speed	How fast is each scoring
Overheat	How long it can run before overheating
Recovery	How quickly the design prepares next scoring
Connectivity	Connectivity with delivery

	Consistency	Speed	Overheat	Recovery	Connectivity	Total
Hook	5	5	4	4	5	23
Hood	5	5	3.5	5	3	21.5
Robotic Arm	4.5	1	1	1	2.5	10
Conveyor Belt	3.5	3.5	4	4	2.5	17.5

We will use the hook mechanism because its high composite score on our priorities.

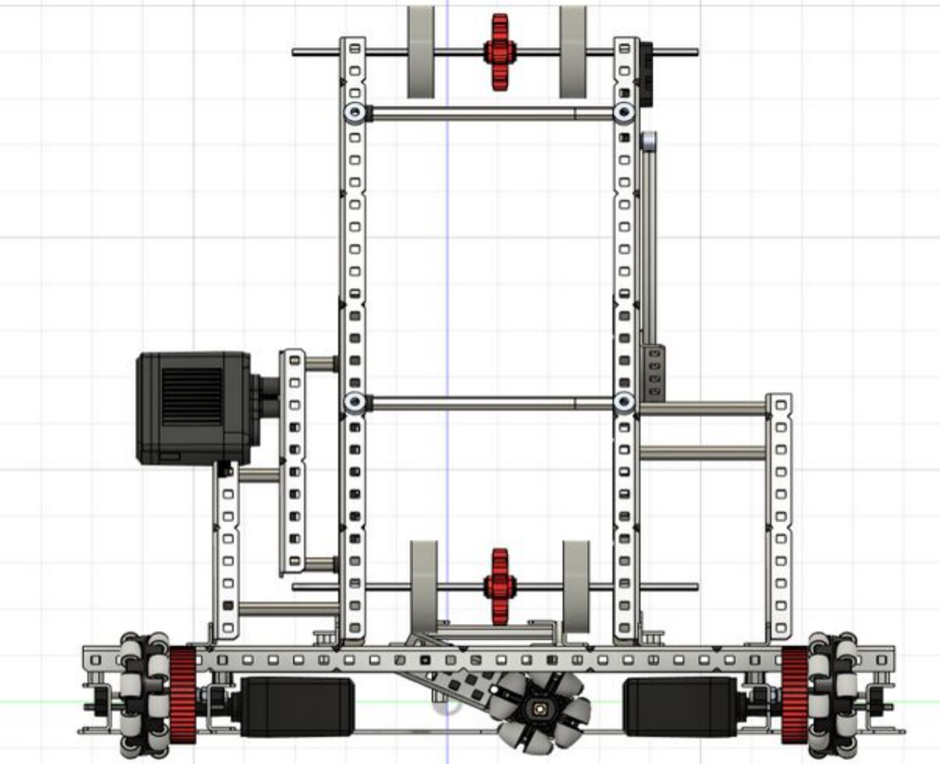
Final decision on mobile goal scoring mech.

We will adopt a **“hook” design** for the scoring on mobile goals as it scores highest in our adjusted scoring matrix.

This also means that the **delivery** and **mobile goal scoring mech.** will be **integrated**.

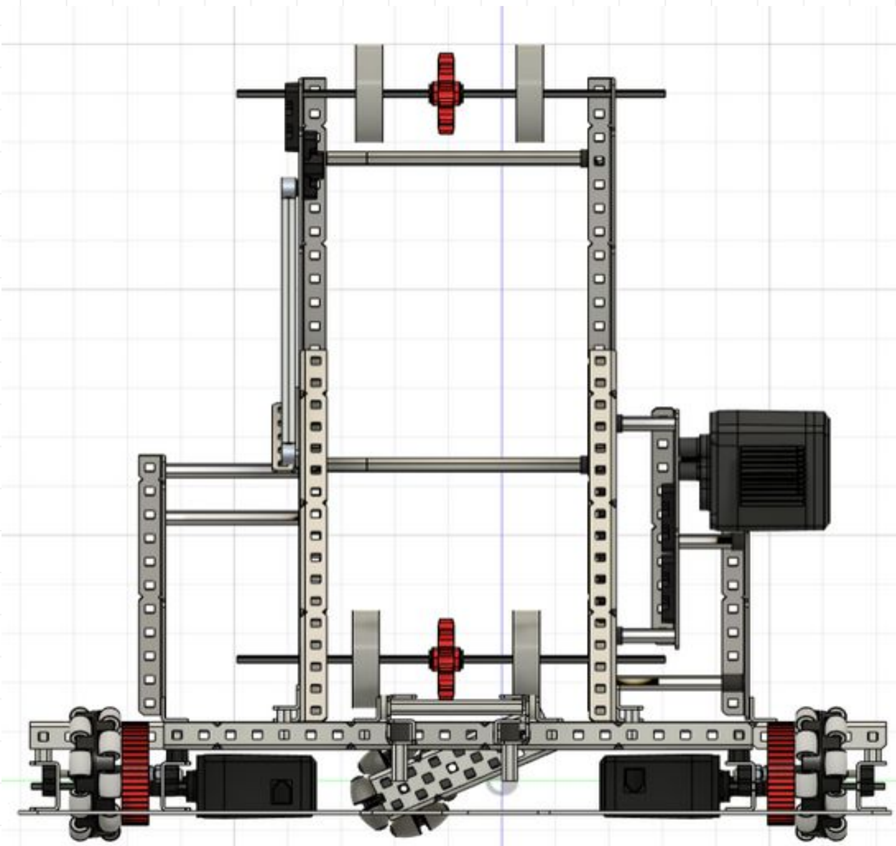
CAD will proceed this redesign process and join the two components

CAD Plan - Delivery



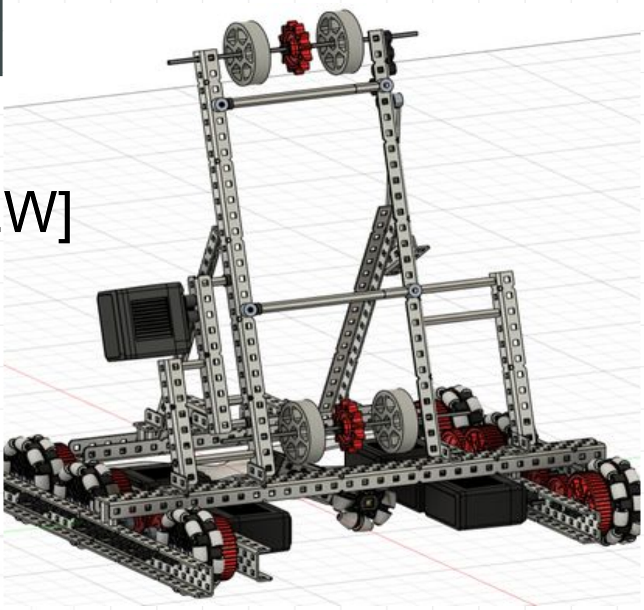
[Front View]

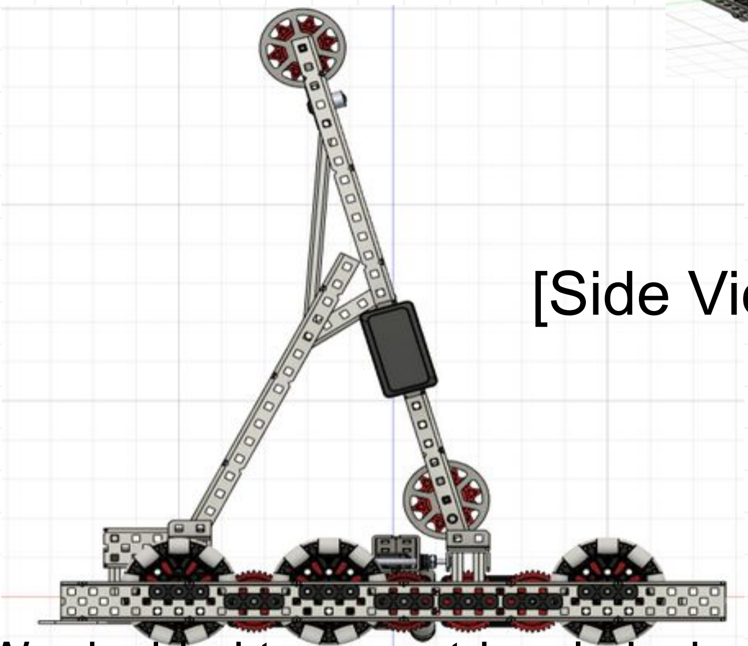
[Back View]



CAD Plan - Delivery

[ISOMETRIC VIEW]



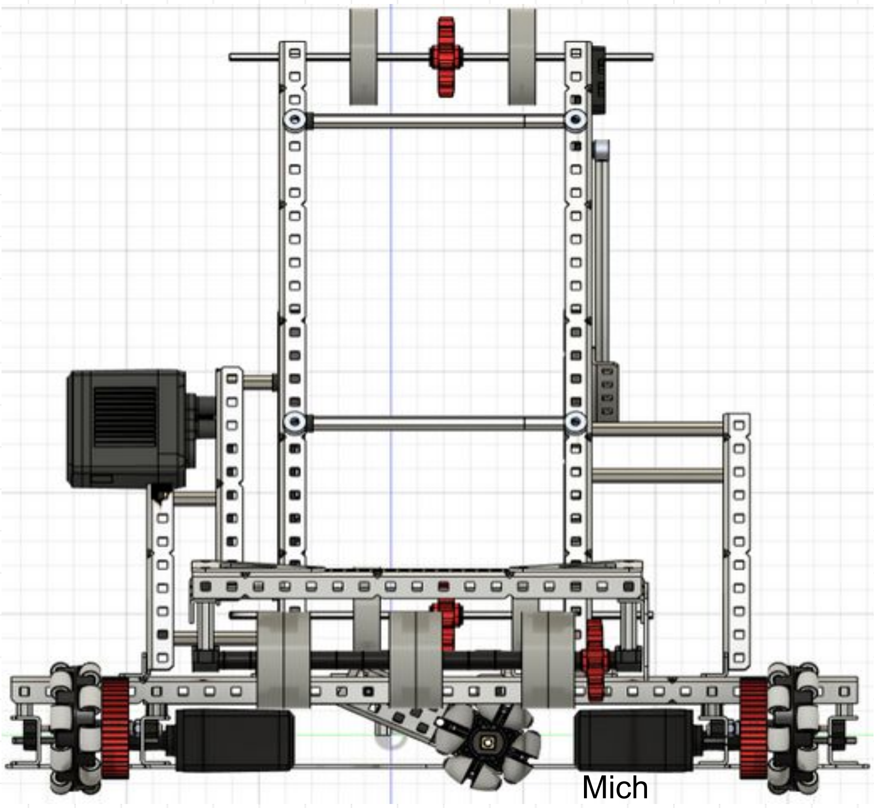


[Side View]

We decided to use a triangle L channel structure as our main supporting structure for the hook scoring mechanism. Two flex wheels are added on the bottom of the belt to provide a smoother transaction from intake to hook mechanism. We used a 600 rpm motor driectly powering the whole mechanism to ensure the rings can be scored efficiently.

Chain and hooks are not rendered in CAD as it is time consuming to CAD a realistic chain placement and not worth it.

CAD Plan - Final



[Front View]

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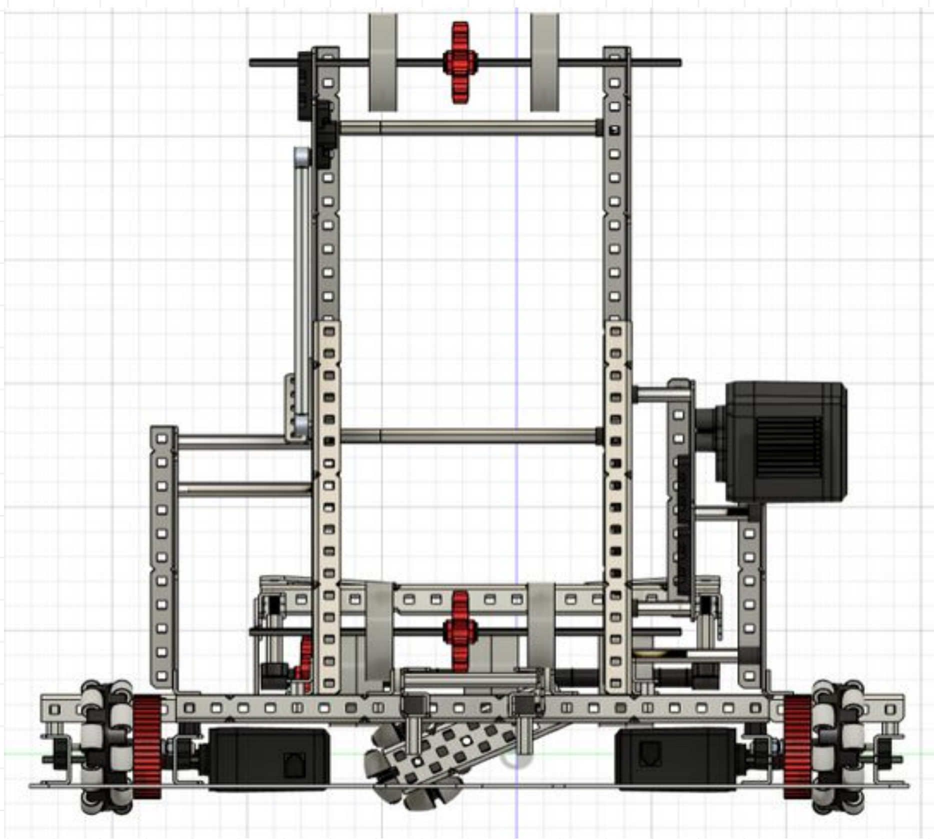
[Back View]



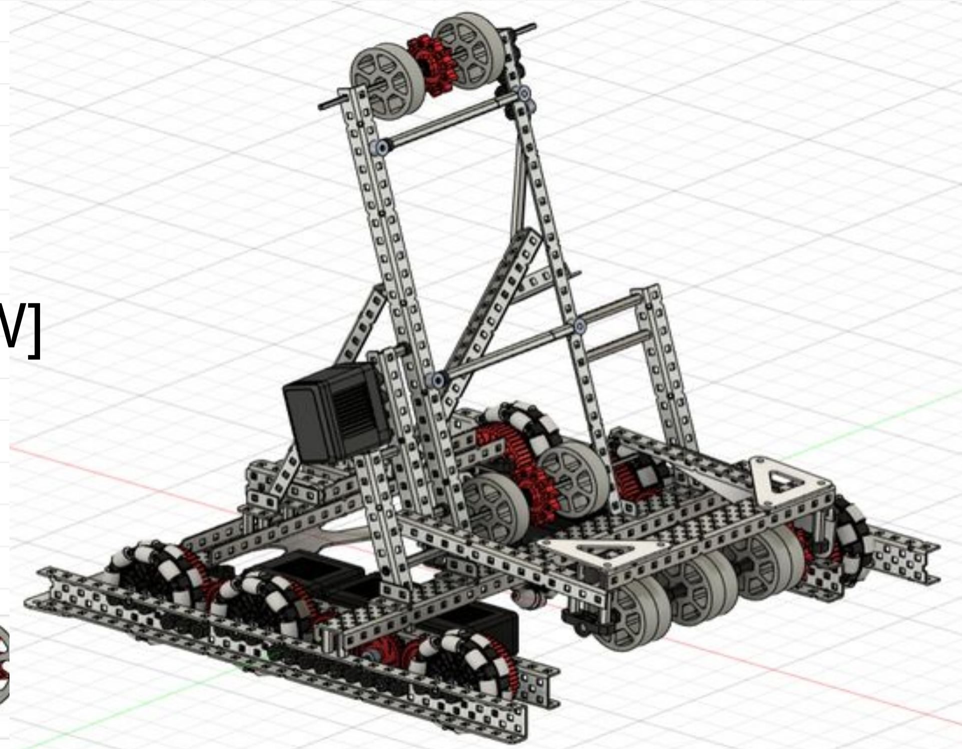
project Mobile goal scoring mech

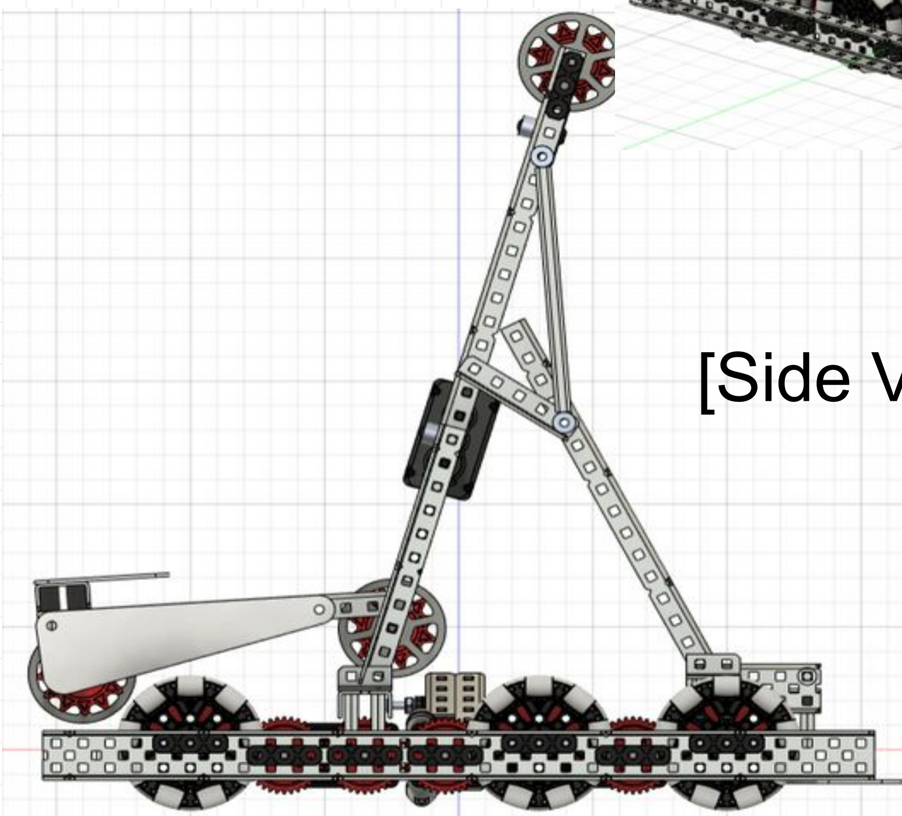
name Michael

date 20/10/24

CAD Plan - Final

[ISOMETRIC VIEW]





[Side View]

As mentioned before, we want to use a motor to power the scoring and intake mechanism. Therefore, we used gears to connect the two mechanisms, while transferring the rotation to the roller by sprockets and chains.

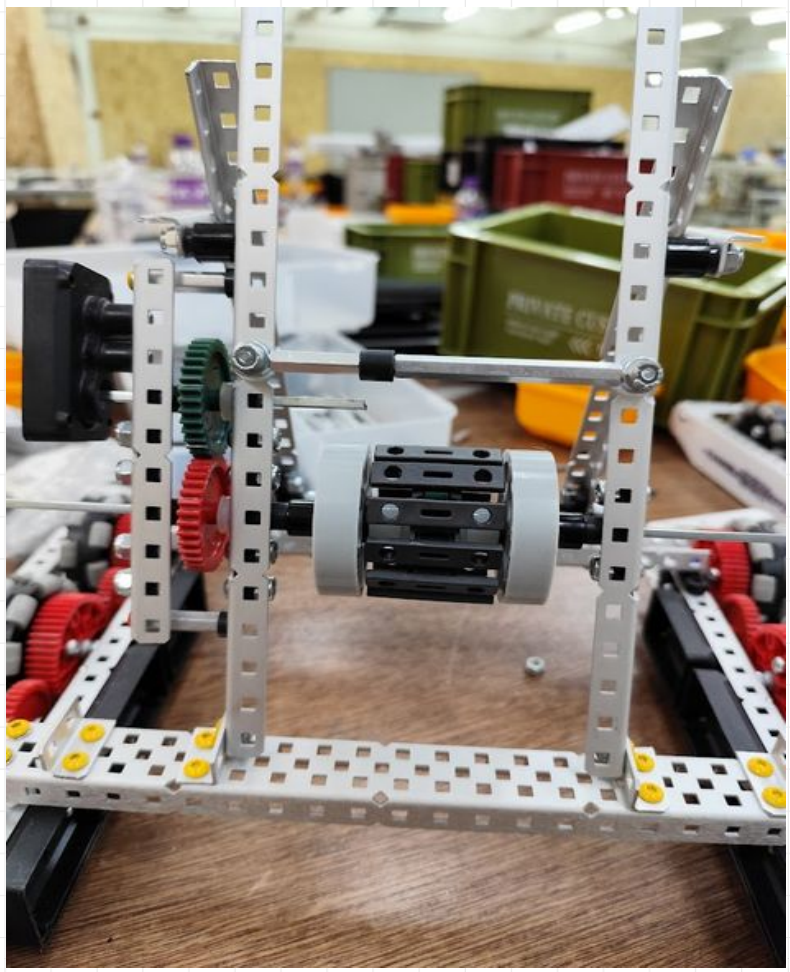
BUILD SOLUTION

DELIVERY

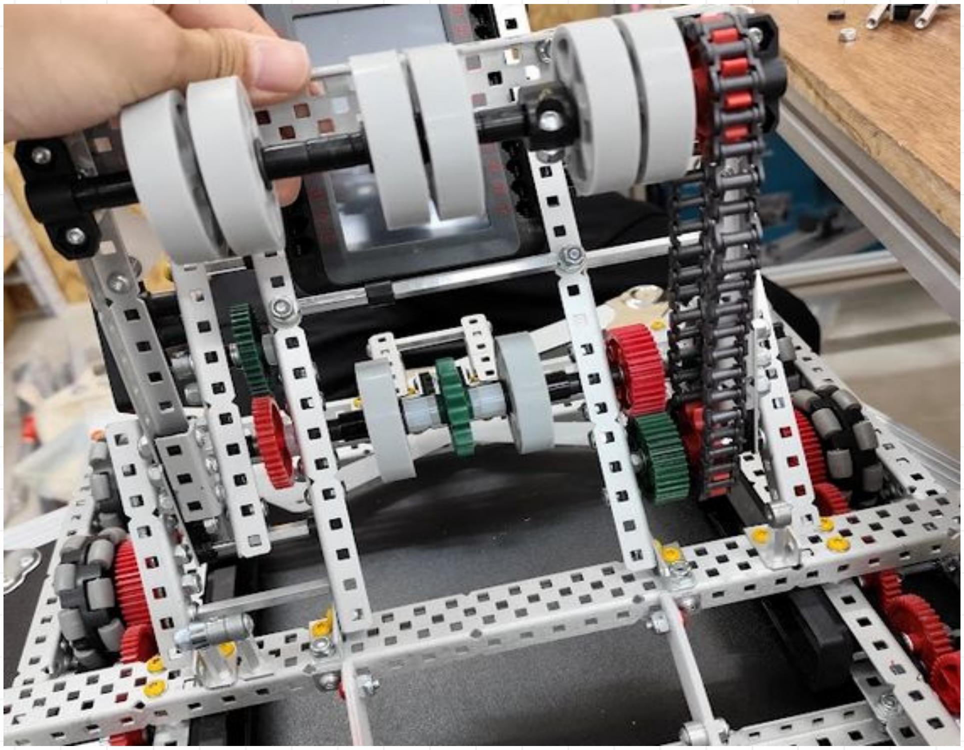
Goal

We will build our planned solution according to the CAD so that we can test its performance

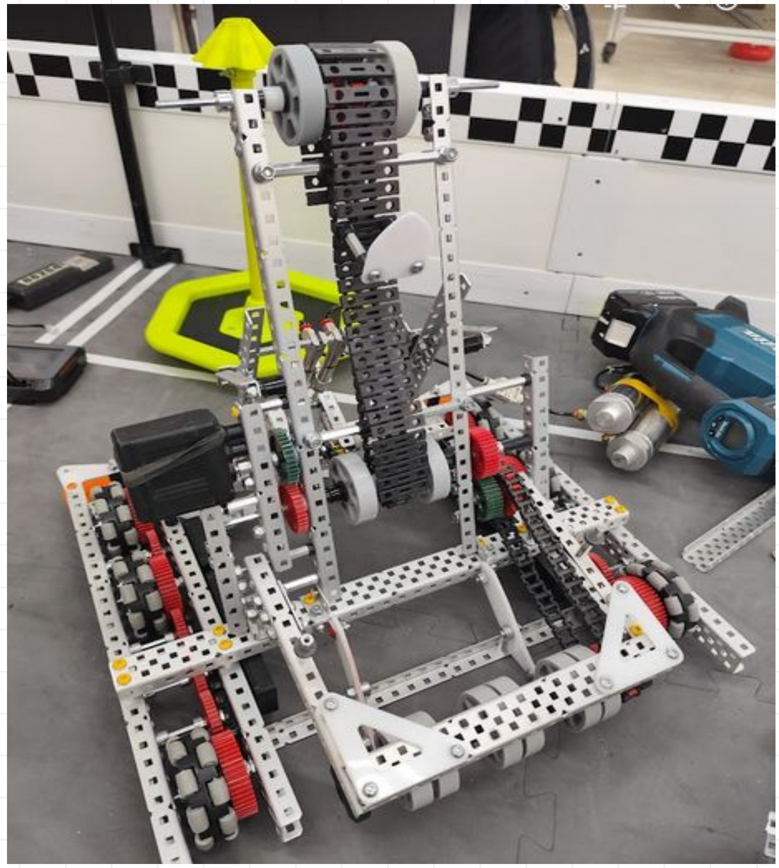
Assembled Build - Delivery

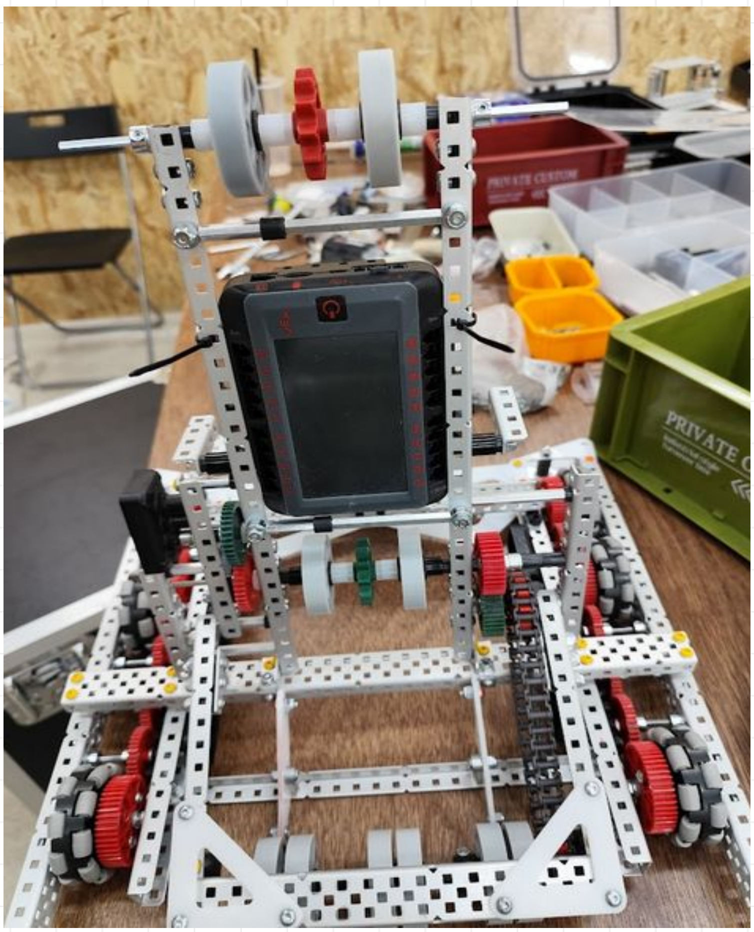


Assembled Build - Delivery



Assembled Build - Final





TEST SOLUTION

Mobile goal scoring mech

Goal

We will test the solution so that we can see if it meets our requirements and goals.

Solution Goals

Score a ring into mobile goal in less than 1 second

Score a full mobile goal within 8 seconds

Score 4 full mobile goal without overheating

Test Results

Score a ring into mobile goal in less than 1 second - Used 0.85 seconds ✅

Score a full mobile goal within 8 seconds - Used 7.84 seconds ✅

Score 4 full mobile goal without overheating - ✅

REDESIGNED
MOBILE GOAL CLAMP

REFLECTION

MOBILE GOAL CLAMP

We are satisfied with the clamp design over the others (gate and claw, which are designs evaluated in the development of generation 2).

However it is observed that the clamp is quite loose.

As a result, we aim to redesign the clamp only without considering other general mechanism to hold the mobile goal in possession to ensure tighter grip on the mobile goals.

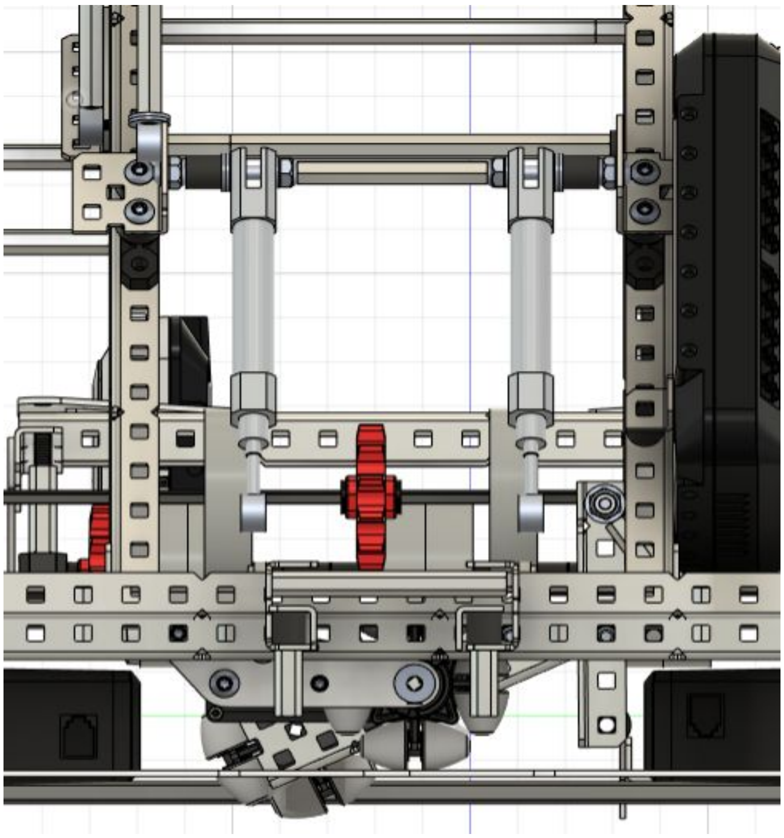
Positives	Negatives
• The general design is good and will be continued	• Loose grip on the mobile goals

In this design process, we will **start directly with CADs** and analyse the physics while creating CADs as we have decided that the **general direction of using a clamp is unchanged**.

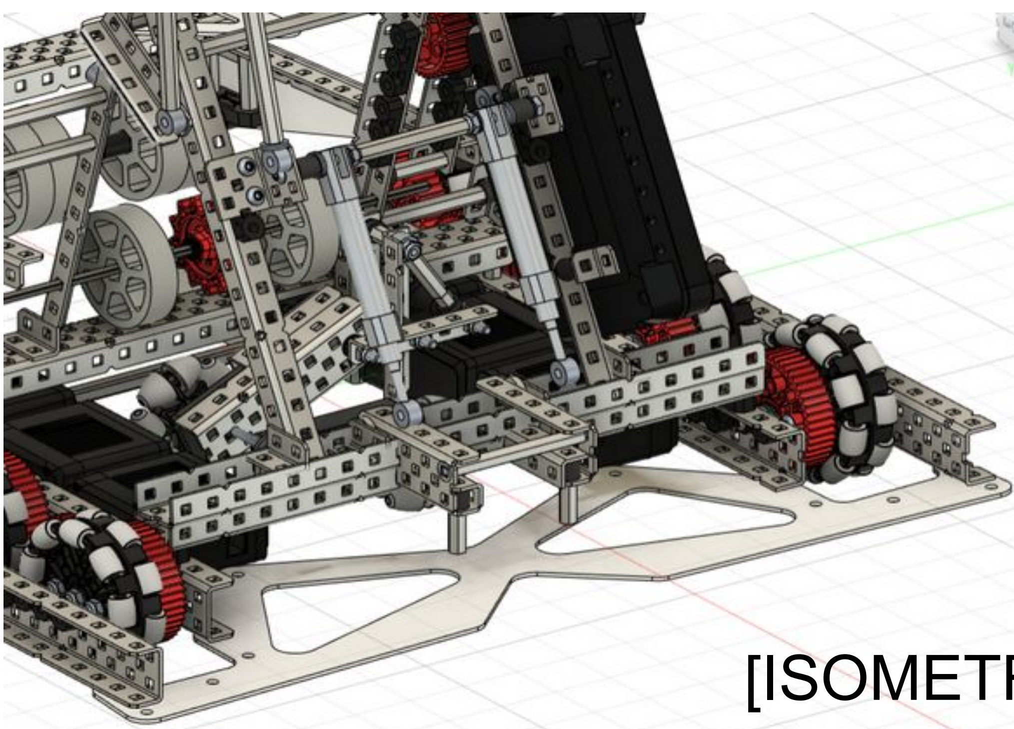
SELECT AND PLAN

INTAKE AND DELIVERY

CAD model of solution



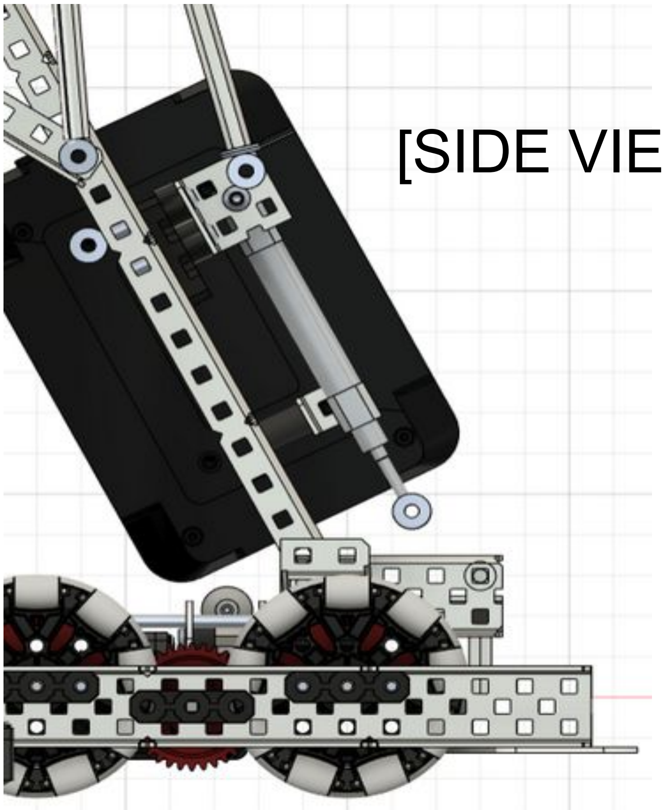
[FRONT VIEW]



[ISOMETRIC VIEW]

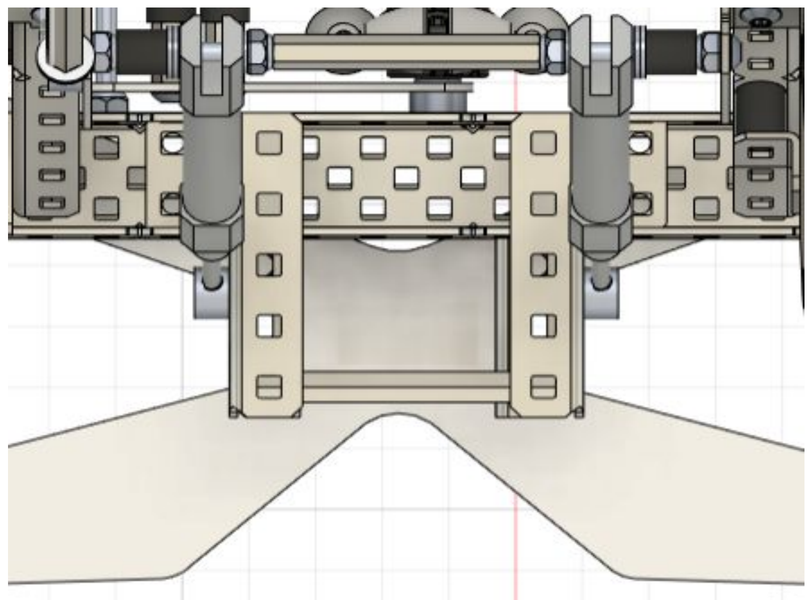
project Mobile goal grabbing mechanism name Michael date 3/11/24

CAD model of solution



[SIDE VIEW]

[Top View]



We decided to use a plastic board to support the mobile goal. When the robot moves towards the mobile goal, the plastic board lifts the goal up, which then act as a pivot point for the clamp to rotate the mobile goal anticlockwise upwards, preventing the mobile goal from touching the tiles.

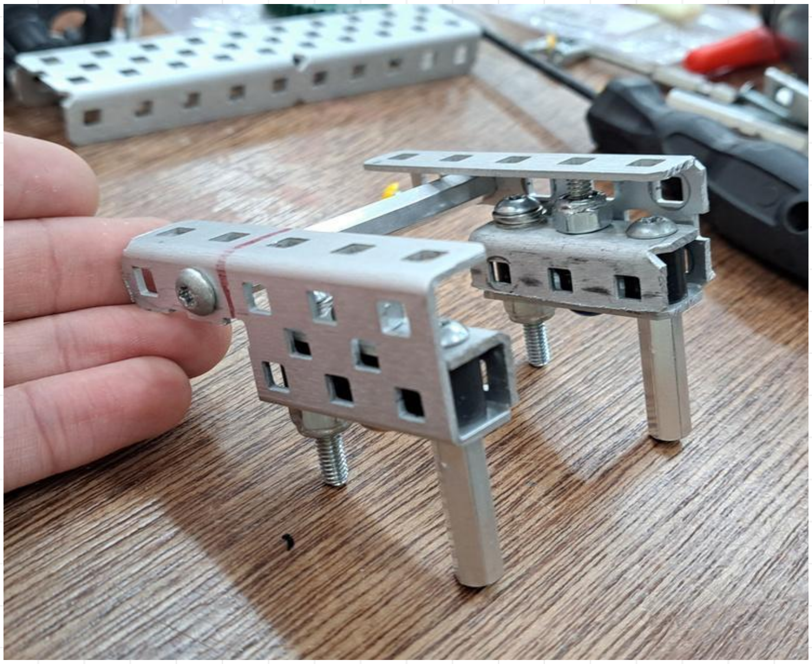
BUILD SOLUTION

MOBILE GOAL GRABBING MECHANISM

Goal

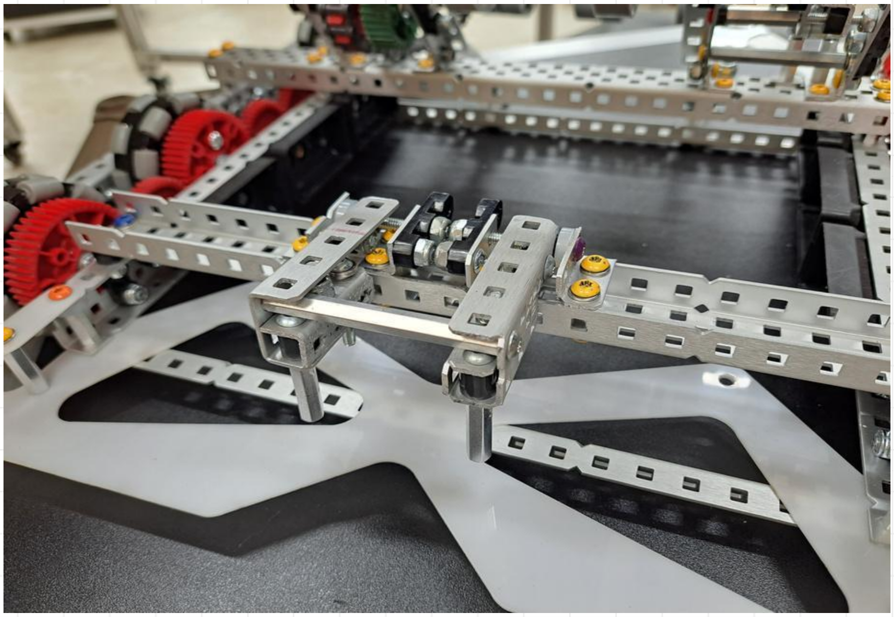
We will build our planned solution according to the CAD so that we can test its performance

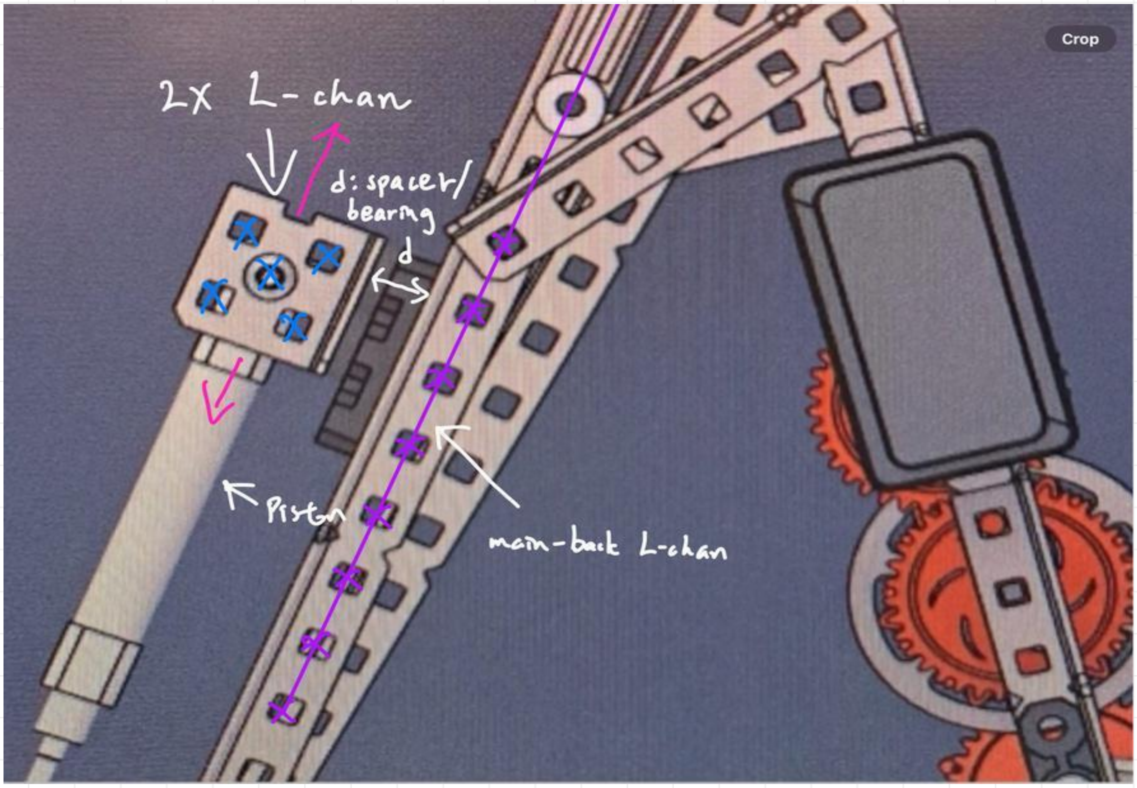
Building Process



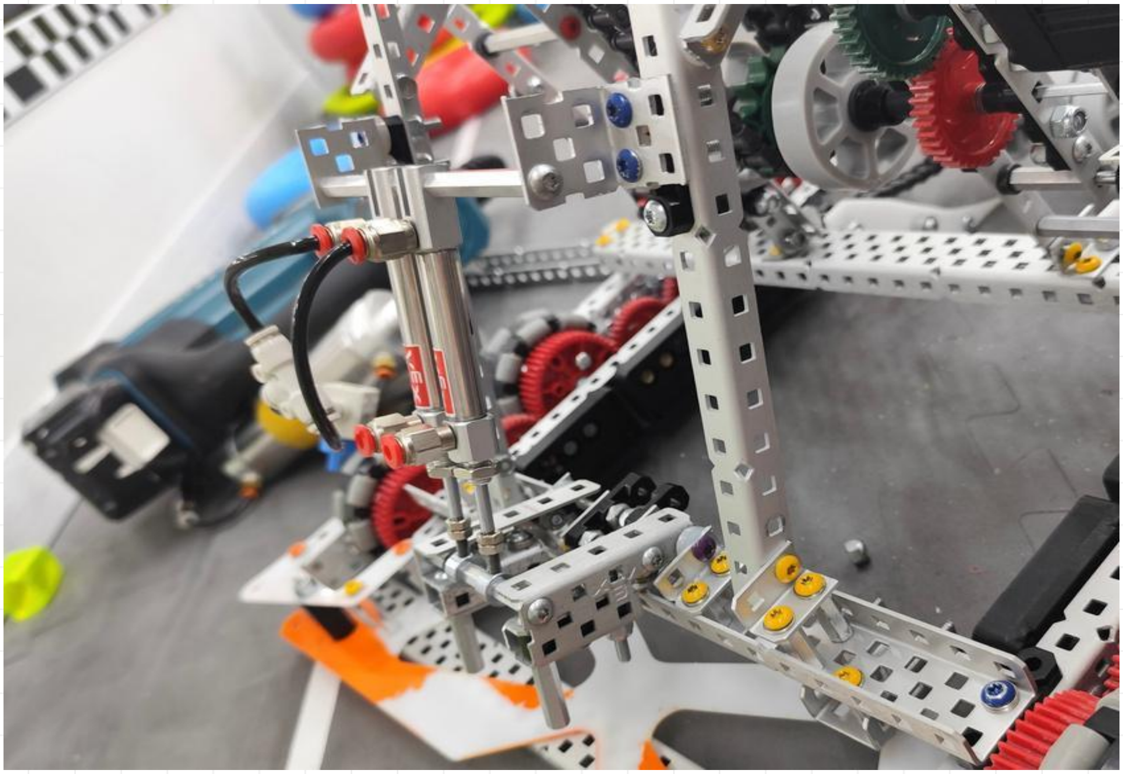
After building the clamp arm, it has to be installed on a pivot and linked by a piston.

There are two things we can adjust to tune the clamping performance and inclination of mogo.
The length of the standoff equals to the extent that the mogo is pushed down against the mogo bottom board. It has to be tuned together with the angle displacement of clamp arm so that the clamp does not under-pushed(not firmly clamping mogo) or over pushed(pushes down too much and may bend the bottom board).
The length of the screws directly determines the inclination of clamped mogo, which locks the mogo at the mogo's edges about the point where the standoffs push it down against the bottom board.



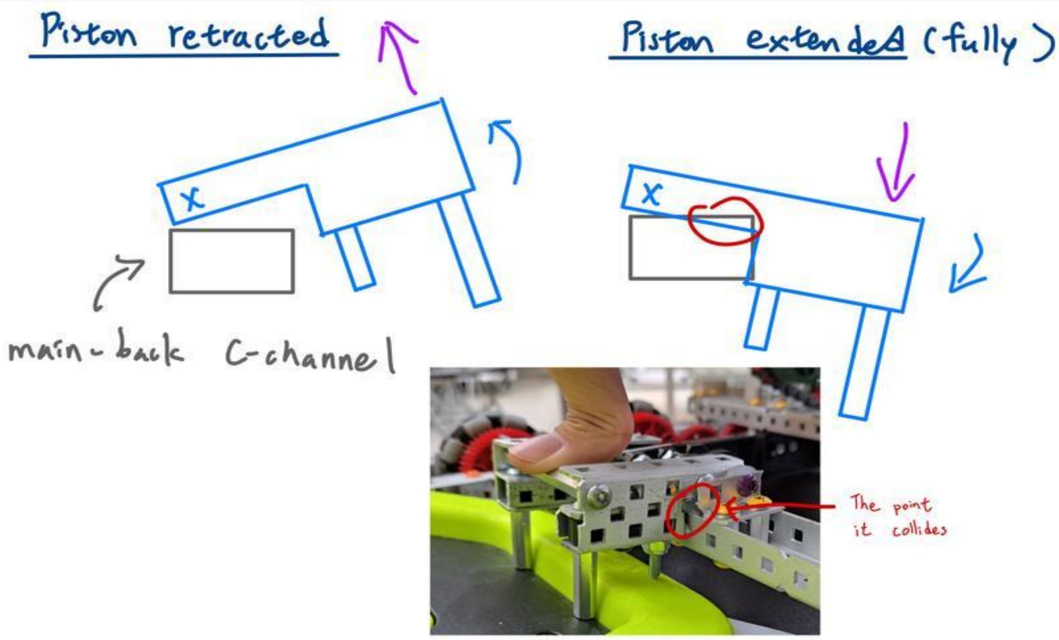


We decided to install the clamp piston onto a 2x L-channel, which is connected to the main-back L-channel. Spacing d between the 2x L-channel and the main-back L-channel can be adjusted by adding spacers and bearings in between. The 2x L-channel can be translated upwards or downwards(pink arrows) along the main-back L-channel according to the standard holes(purple line). Moreover, the piston can be installed to any one of the five holes. In this way, we can install the pivot on the main-back L-channel freely as we want.



We decided to set the preliminary piston pivot in the above position first so that we can test the hook scoring.(d = 0.125” + 0.250”) Also, we chose to use 25mm piston as its stroke length is suitable for the required angle displacement of the clamp arm.

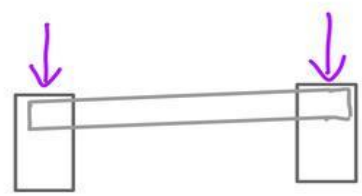
After testing with sufficient psi and powered intake and motor, the rings were scored very smoothly and we were satisfied with the performance.



However, for the current piston position, when the piston fully extends, actually it pushes the clamp arm too much and makes the clamp arm collide with the main-back C-channel.

This causes bending of the structure and will lead to more issues in the future.

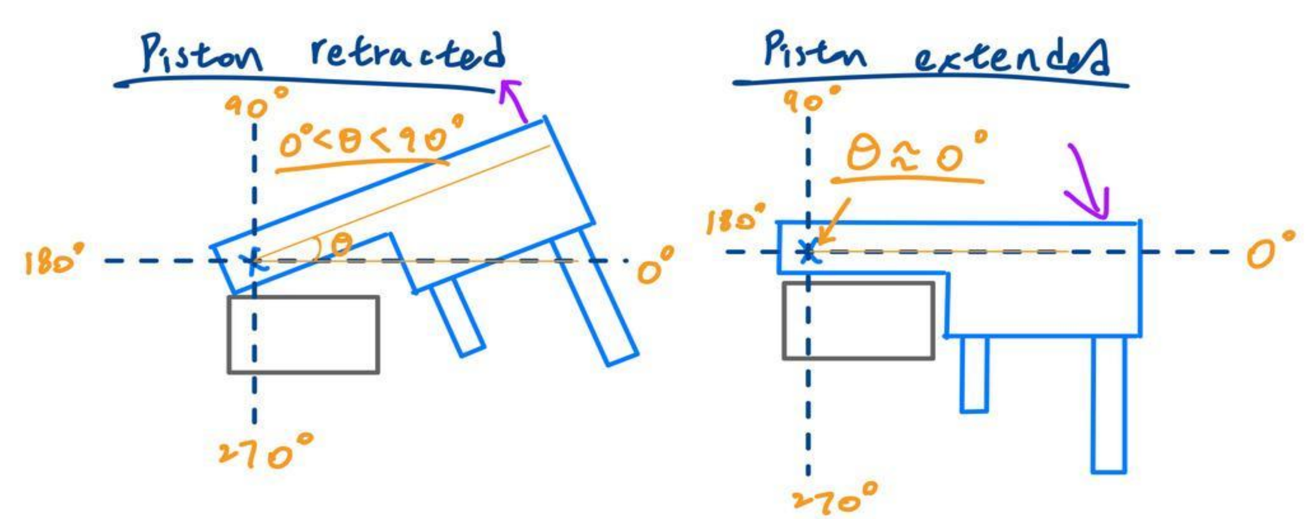
The piston position have to be adjusted.



Another problem we discovered is that when the clamp cannot perfectly grip the mogo, the 2 sides of the clamp become not aligned to each other and bend under the force acted by pistons.

Then, if the standoffs were not locked perfectly with the mogo's base, it could only clamp pretty loosely.

The current structure is no not rigid enough and will bend over usages.



In fact, the clamp only needs to be pushed to horizontal when it clamps and that will works while the structure will not be bent.

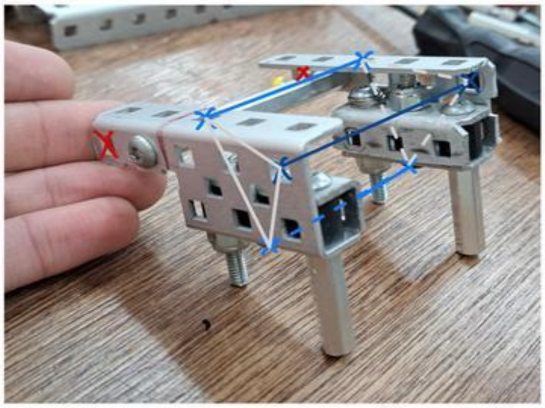
According to the above figure, let θ be the inclination of the clamp arm.

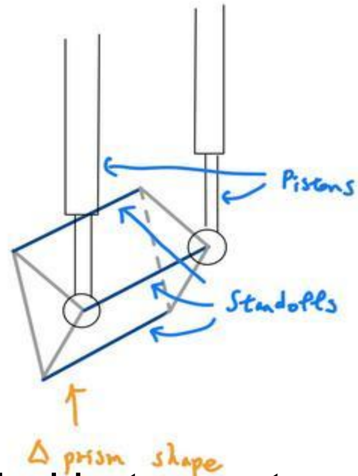
The desired θ of clamp arm when piston pushes will be 0°.

When the clamp arm opens, θ can be any value in range**(0°<θ<90°)**

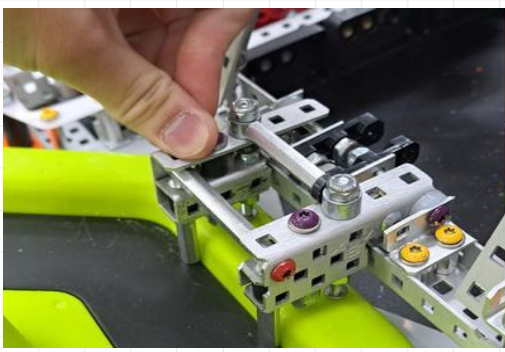
The next thing we did is solidifying the structure of the clamp arm first so that we could have a more stable clamp for future trials and tests.

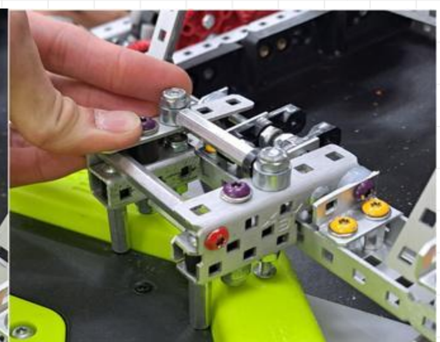
Plan:

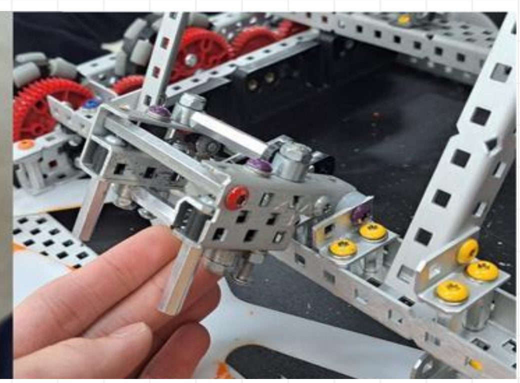




When standoffs(blue coloured lines) are added between two sides as shown in the above figure, they form a triangular prism structure. When pistons act force directly on one of the vertex of the prism, the structure can withstand the force and it will be less likely bend or deform.







After building out the structure and installing it to the original pivot position, we test its ability to grab the mogo at both its vertices and edges. It is much more rigid than before and do not deform even if we push it down very hard. Then, we can find the optimal piston pivot position without worrying about the structural issues.

project Mobile goal grabbing mechanism name Michael date 7/11/24

TEST SOLUTION

MOBILE GOAL GRABBING MECHANISM

Goal

We will test the solution so that we can see if it meets our requirements and goals.

Solution Goals

- Grab a mobile goal within 2 seconds
- Release a mobile goal in 2 seconds
- Rotating the robot with mobile goal grabbed without it falling out for more than 20 seconds
- Can be activated and deactivated at least 15 times in a
e of pneumatics)

Test Results

- Grab a mobile goal within 2 seconds - less than 1 second ✅
- Release a mobile goal in 2 seconds - less than 1 second ✅
- Rotating the robot with mobile goal grabbed without it falling out for more than 20 seconds - ✅
- Can be activated and deactivated at least 15 times in a match (in the case of pneumatics) - can be activated and deactivated 27 times ✅

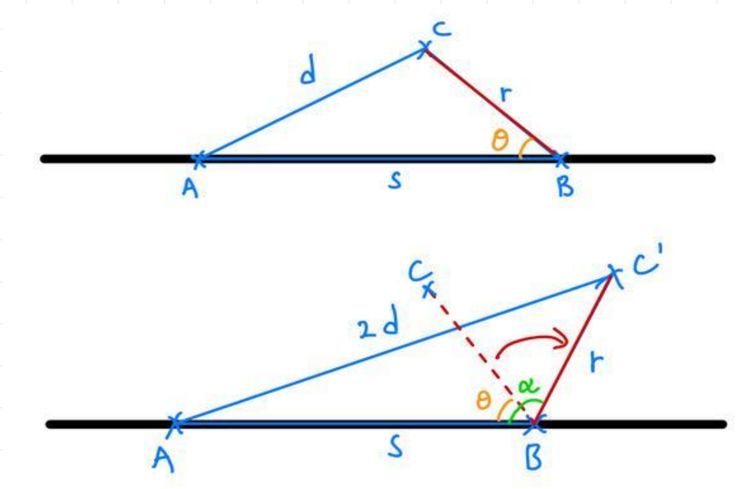
IMPROVEMENT AND OPTIMISATION

MOBILE GOAL CLAMP: LINKAGE

Locating the optimal piston anchor point(pivot)

Studying linkages involving pistons

Before moving on to the later parts, we have to understand the way that linkages move when the piston retracts or extends.



Consider a linkage, consists of 3 bars(not drawn to scale).

AB is anchored and remain stationary. Length s of AB is kept constant.

BC(red lines) can be rotated about point B. Length r of BC is kept constant.

AC can be rotated about point A. AC can be extended from d to 2d.

When length of AC increases, while s and r remain constant, BC will be rotated clockwise to BC' .

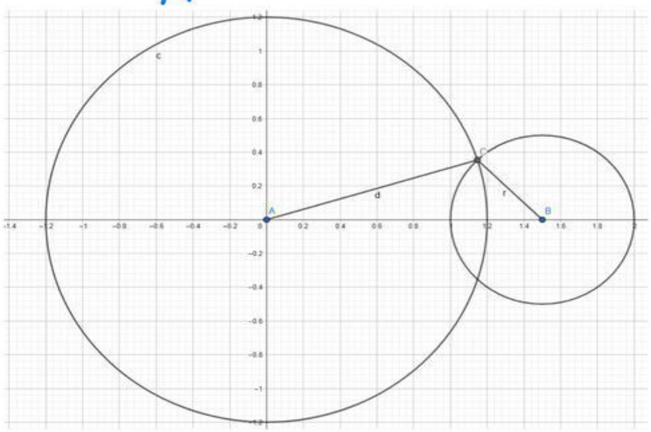
And this, is actually the geometric representation of a linkage moved by a piston.

In this case, AC is the piston in retracted retracted state; AC' is the piston in extended state.

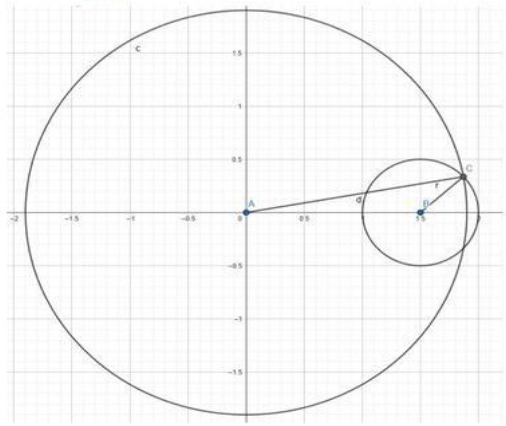
This is equivalent to when AC(piston) extends, BC is pushed clockwise to BC' .

Further studying the geometry in the above case,
the following can be found.

A



B



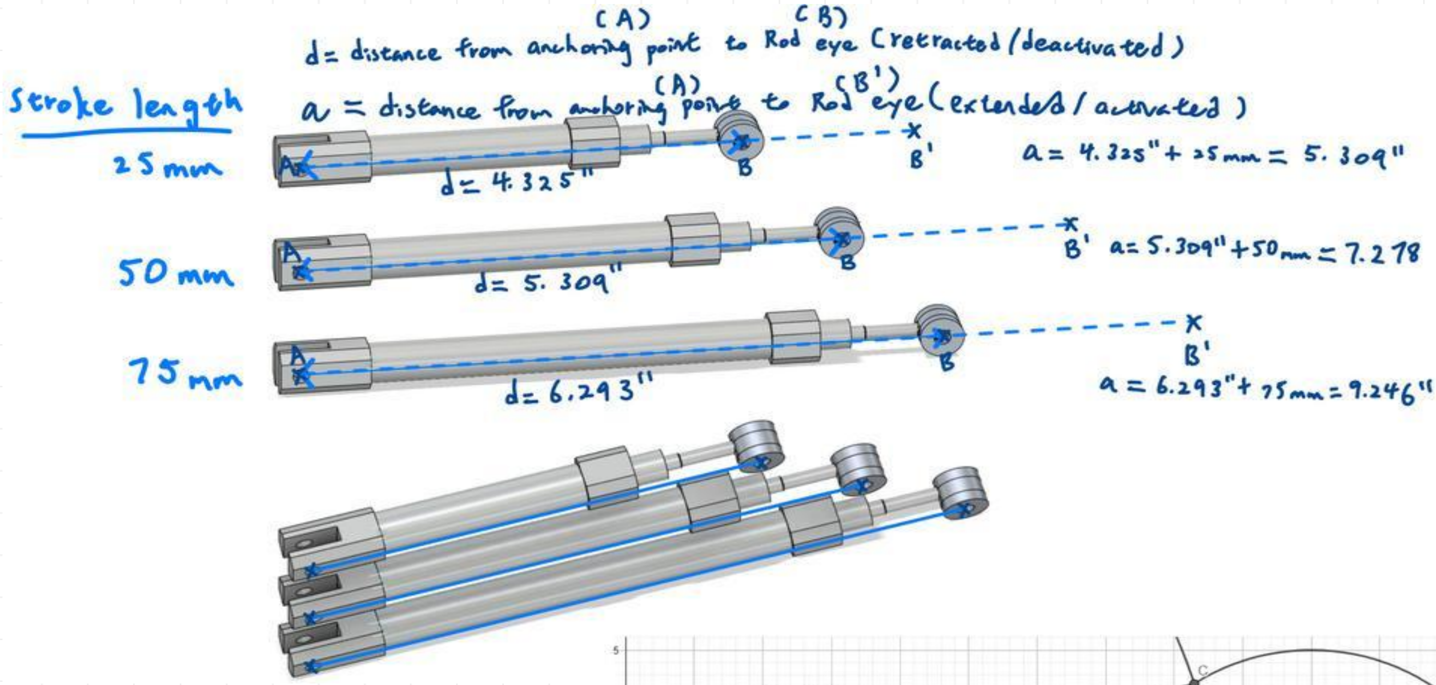
GeoGebra is used to plot the above 2 figure.

We found that a 3 bar linkage is equivalent to two intersecting circles, in which radius of one of the circle remains constant while the radius of the other one changes.

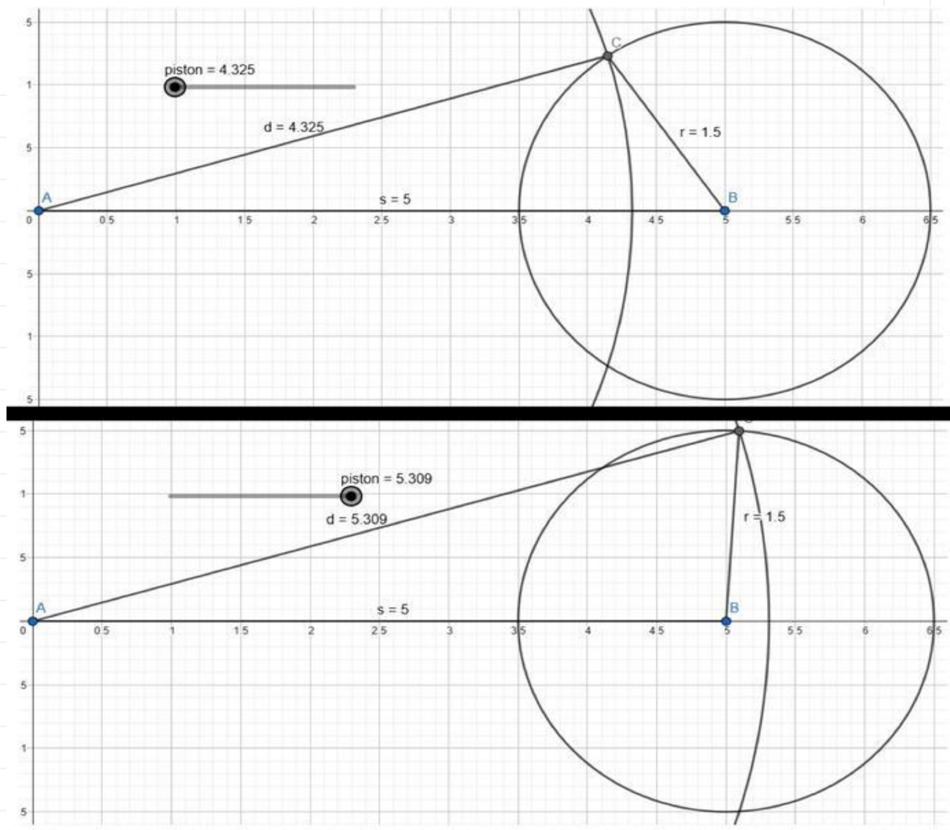
In other point of view, the shape of 3 bar linkage is always a triangle with two sides of constant length. And the change of length of piston will bring relative rotation to the other 2 sides and changes the respective angles.

The side which changes its length is equivalent to a piston.

Therefore, we can get the lengths of piston in both extended and retracted state and use them for future calculation. We used library for Fusion 360 to get the following data.



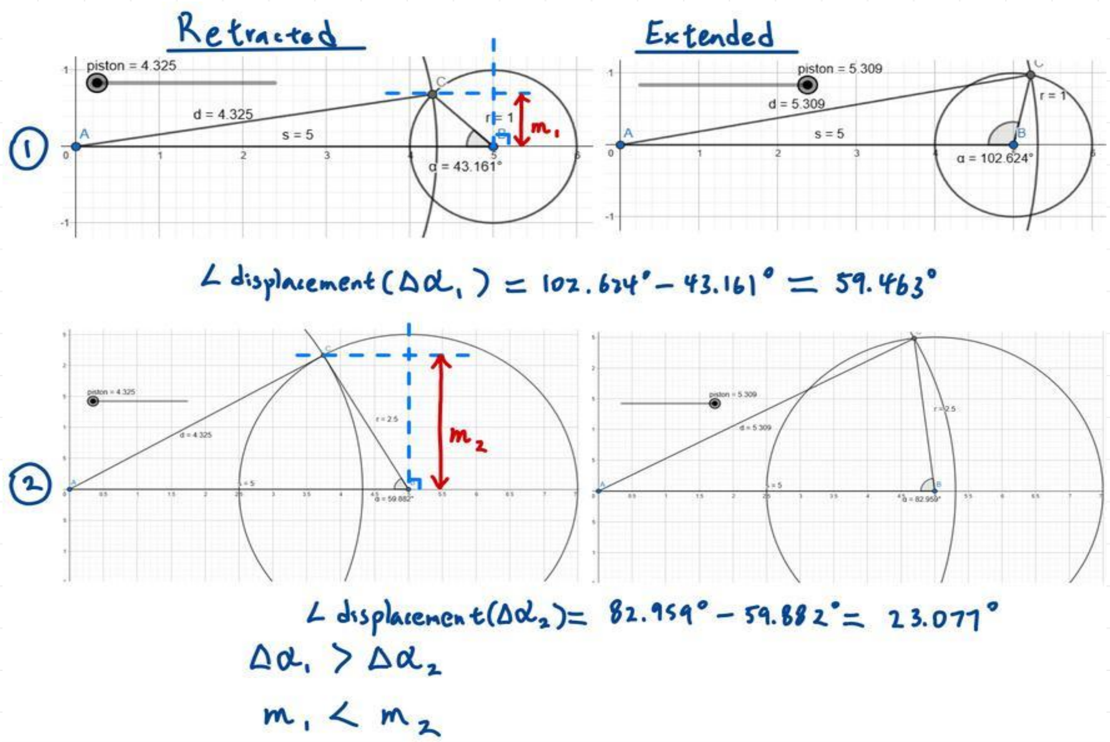
Then, we inserted the data into GeoGebra.
1 interval length = 1”
which means the unit of coordinate plane is in inch which is more convenient for VEX.



Take 25mm piston as example, we used the slider function to construct a circle which the radius can be reduced or enlarged to its respective minimum and maximum value
(min.=4.325”, max.=5.309”).
In this way, we can simulate and study 3 bar linkage involving piston in GeoGebra.

Relationship between 3 bar linkage and anchoring points/side lengths

Consider the following cases.



Case 1 and 2 both uses 25mm piston, AB is kept constant.

In case 1, length of BC=1, while in case 2, length of BC=2.5 .

Let's call BC as Arm, which also equals to the radius of the corresponding circle locus of C.

The arm length is equivalent to the distance between the connection point of piston rod eye and the pivot point of the arm.

In case 1, the arm length is shorter than that in case 2(1<2.5).

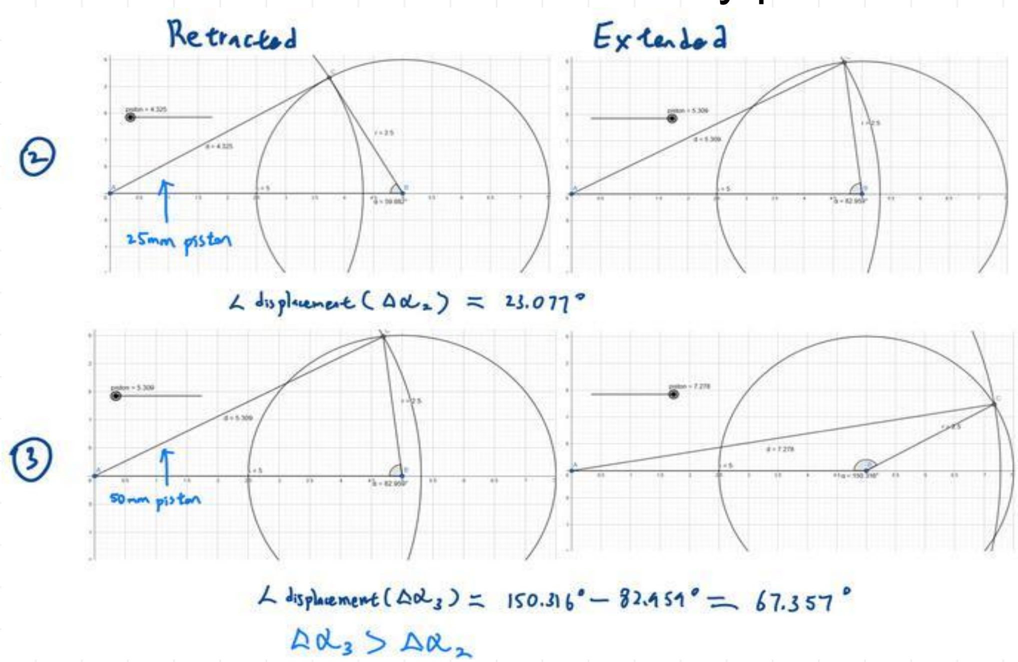
Under the extending motion of piston, arm in case 1 has a larger angle displacement than that in case 2.

In other words, piston can push an arm further which has shorter arm length.

On the other hand, the arm length affects the moment acted by the piston.

In case 1, as the arm length is shorter(the circle is smaller), point C has a shorter perpendicular distance to the x-axis than those in case 2. Therefore, the moment acted by piston in case 1 is smaller than that in case 2.

Based on the above 2 cases, the arm length affects the angle displacement of arm and the moment acted by piston.



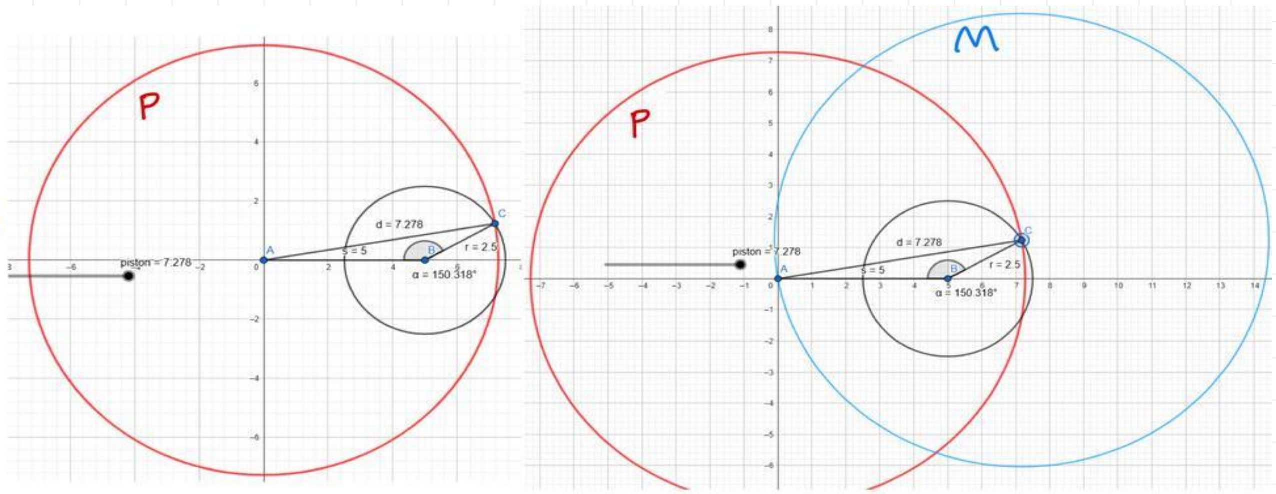
Consider case 2 and 3.

In case 2, 25mm piston is used; in case 3, 50mm piston is used.

When a piston of longer stroke length is used, it will have a larger angle displacement.

Simply saying, a loner piston can push an arm further than a shorter piston.

4



Next, consider case 4.

In the above 2 graphs of case 4, arm lengths and distance AB are the same, and both use 50mm as example. Pistons are in extended state.

Point A is equivalent to the anchoring point of piston.

AE=radius of red circle=extended piston length

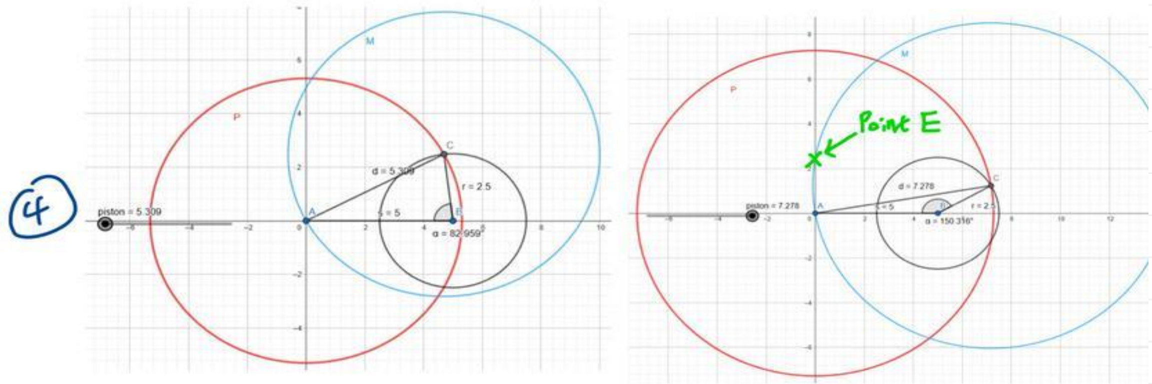
Let’s say we want to push BE to the above shown position(∠ABC = 150.318°), in which it is fully pushed.

Originally, the circle P with center A intersects with the circle M(arm BE) at point E.

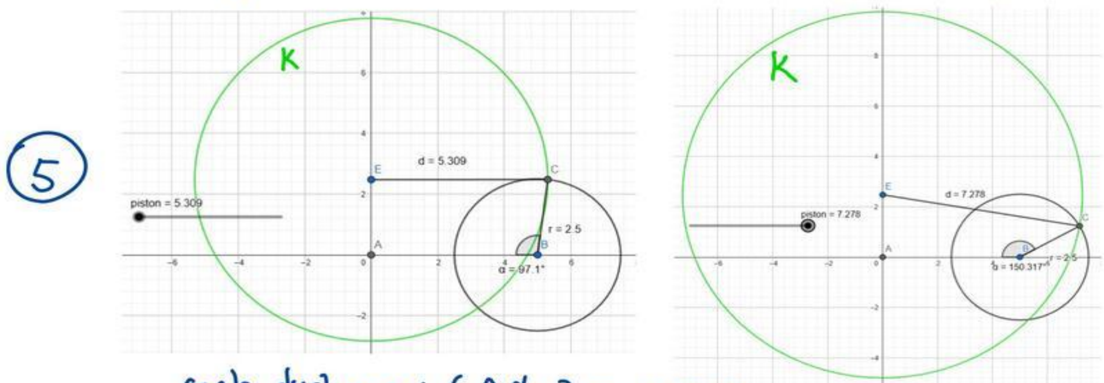
When a circle of same radius is drawn with E as the center, the circle M passes through point A, which is the anchoring point of piston.

Point A is said to be a point which pushes BE to the exact position(∠ABC = 150.318°) when it extends fully.

When a 25mm piston is installed to point A, it will push BE to the position where ∠ABC = 150.318°.



angle displacement ($\Delta\alpha_4$) $= 150.316° - 82.959° = 67.357°$



angle displacement ($\Delta\alpha_5$) $= 150.317° - 97.1° = 53.217°$

$\Delta\alpha_4 > \Delta\alpha_5$

Finally, consider case 4 and 5 together.

Both cases use same arm length and piston length, but different anchoring point coordinates.

In both cases, when piston extends, arm is pushed to the same position(∠ABC ~ 150.317°)

Point E is obtained by setting another point on circle M(blue).

In case 5, another circle F is drawn with the same radius.

Although the anchoring points of pistons are different, when they extend, then push the arm to the same position.

This means, when the anchoring point is set on elsewhere(not A, but any points) on the blue circle, the piston can still push the arm to the same position(∠ABC ~ 150.317°). Of course, the anchoring point must be reasonable so that it has sufficient force and over-center will not occur.

To sum up the above, the anchoring point of piston can be set on the circle (which its center is the end-point of arm) and the arm can be pushed to the same position(∠ABC ~ 150.317°).

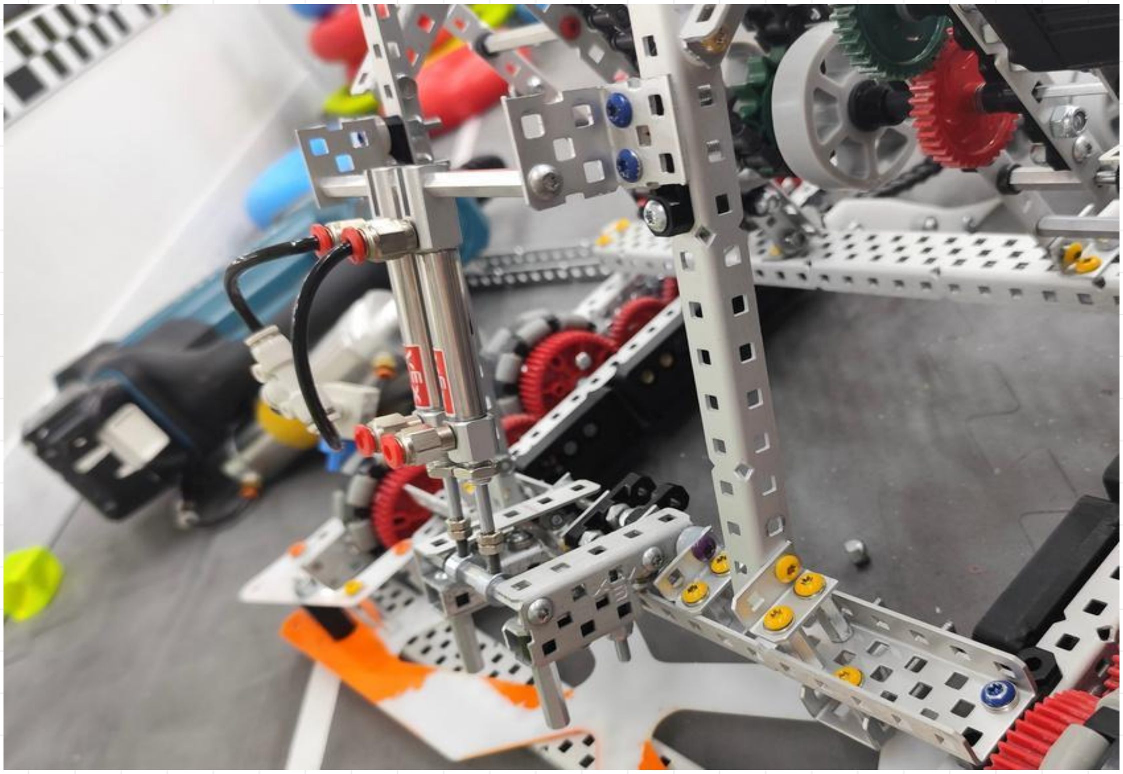
Another relatively minor thing to consider, is that the angle displacement varies as the anchoring point changes.

In conclusion, the following are the factors to be consider when constructing a 3 bar linkage involving piston:

1. Angle displacement of arm(to be moved)
2. Moment acted by piston on the arm(pushing/pulling strength)
3. other factors: whether the linkage will collide with other mechanisms

Constructing the linkage:

4. choosing suitable piston length
5. adjusting the arm length(arm length inversely proportional to angle displacement, proportional to moment)
6. finding suitable anchoring point of piston by setting up a circle at the end-point of the arm



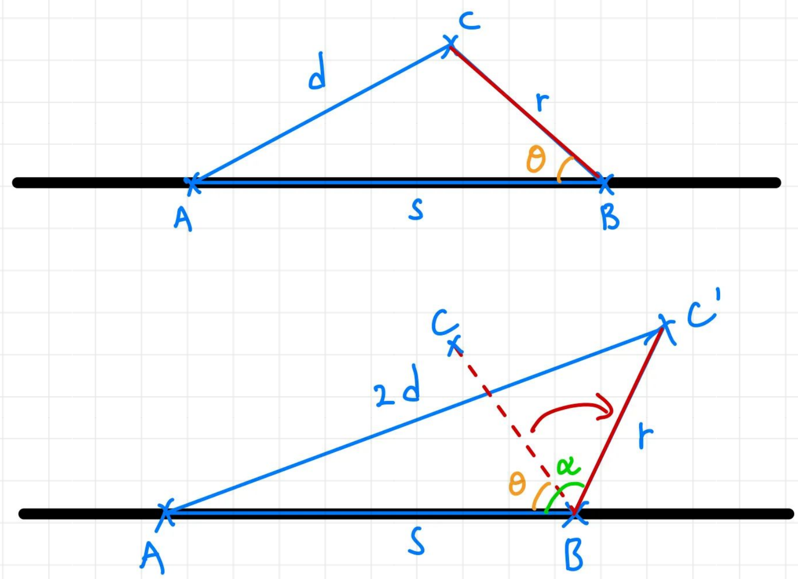
We decided to set the preliminary piston pivot in the above position first so that we can test the hook scoring.(d = 0.125” + 0.250”) Also, we chose to use 25mm piston as its stroke length is suitable for the required angle displacement of the clamp arm.

After testing with sufficient psi and powered intake and motor, the rings were scored very smoothly and we were satisfied with the performance.

Development of solution (mathematically)

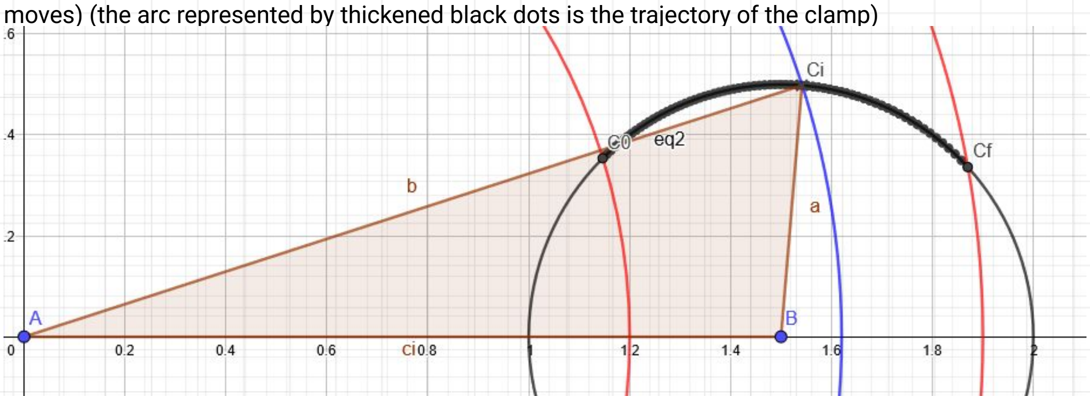
We analysed mathematically where the optimal piston pivot point is on the robot.

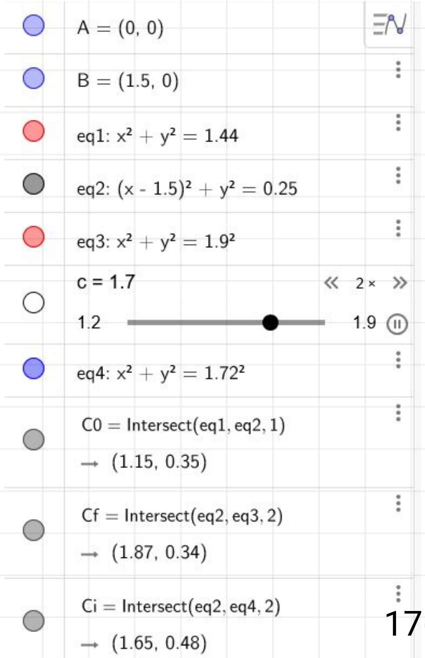
It helps with
(1) Avoiding damage caused by the clamp to other structures by colliding
(2) Ensuring a firm and rigid grip of the mobile goal.



In the diagram, AC is the piston and AC' is the piston actualized.
AB is the supporting c-channel that is fixed, and BC the clamp and its length is also fixed.

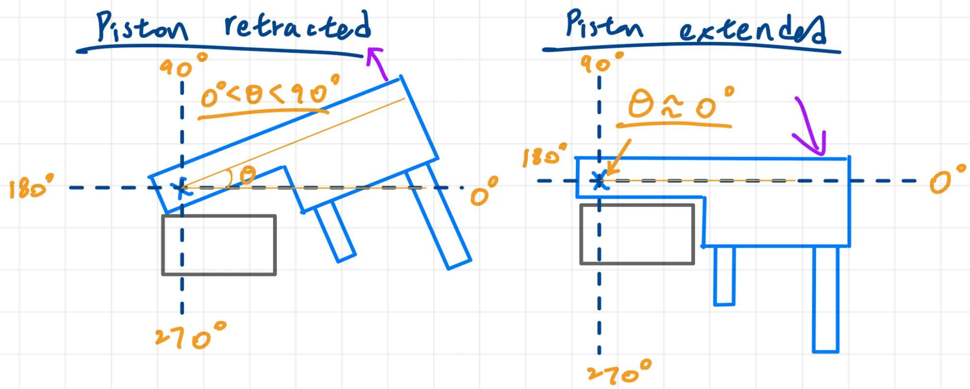
We then can model the trajectory of the piston as an arc of the Circle. (eq1, eq3 are the limits of piston extension / retraction) (eq2 is the arc where the clamp moves) (the arc represented by thickened black dots is the trajectory of the clamp)



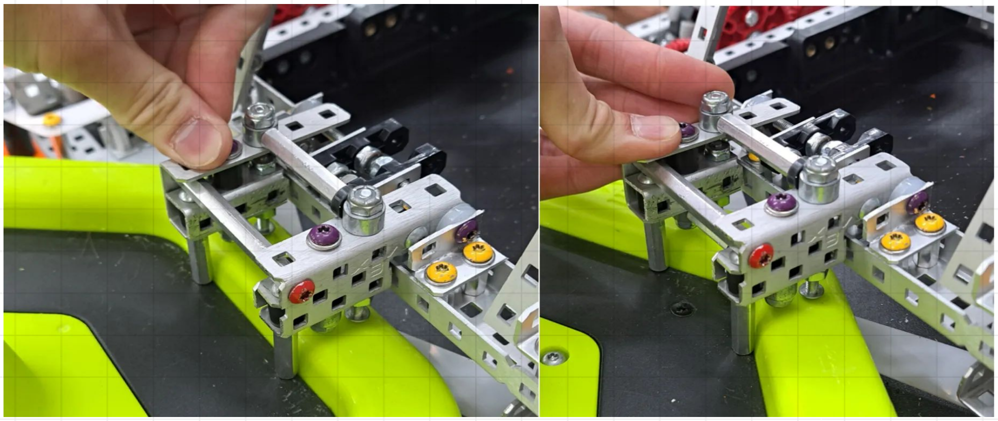


Mobile goal grabbing mechanism

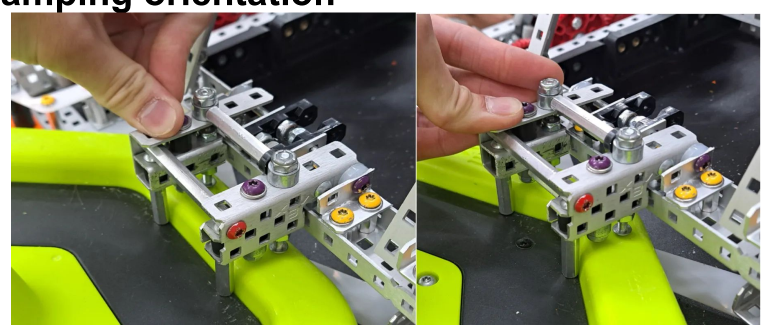
Development of solution



We then use this model to brute-force the optimal pivot point (A) of the piston would be, such that the clamp does not collide with any other structure while still pins the mobile goal down firmly.



Test solution

Target of the mobile goal clamp	How our design addresses the target
The tip of the mobile goal should end up at a similar / same position no matter what orientation the mobile goal base is	We included mobile goals into the model in the previous page, and worked out the positions of the pistons and the clamp such that the **tip ends up in the same position no matter the clamping orientation** 
Securely pin-down the mobile goal and deliberately make it difficult for the steal mechanisms	- Mobile goals will be **angled towards the core** of the robot when its clamped, it made most mechanisms that are used to steal mobile goals impossible to even touch our mobile goal. - The **high ground clearance** makes it difficult to grab onto our clamped mobile goal
The mobile goals need to be lifted up from the ground	The **high-strength shaft** below the clamp is used to lift up the mobile goal.

INTRODUCTION

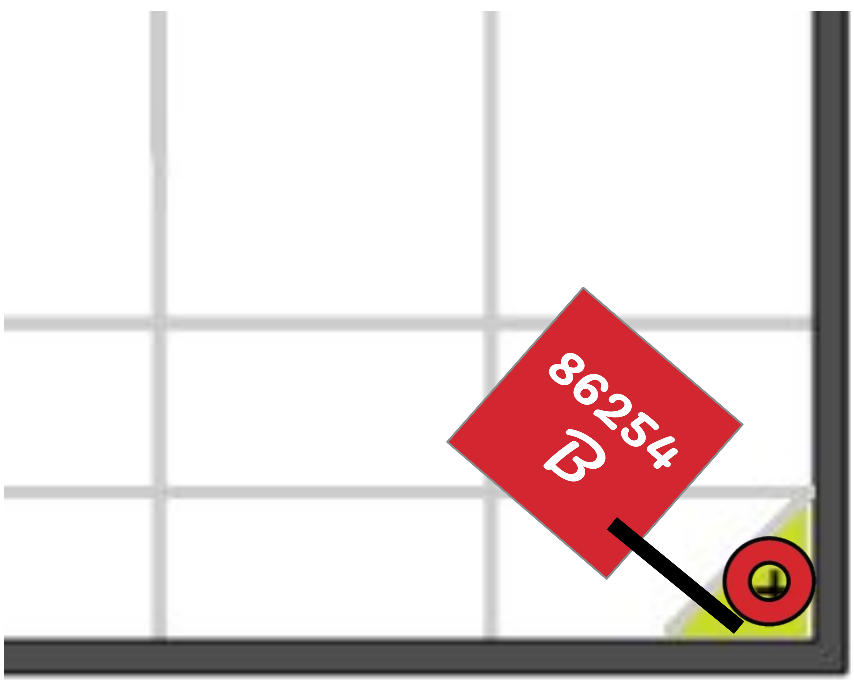
KATANA

The Katana

Identify the problem

Function 1: Move rings out from corners

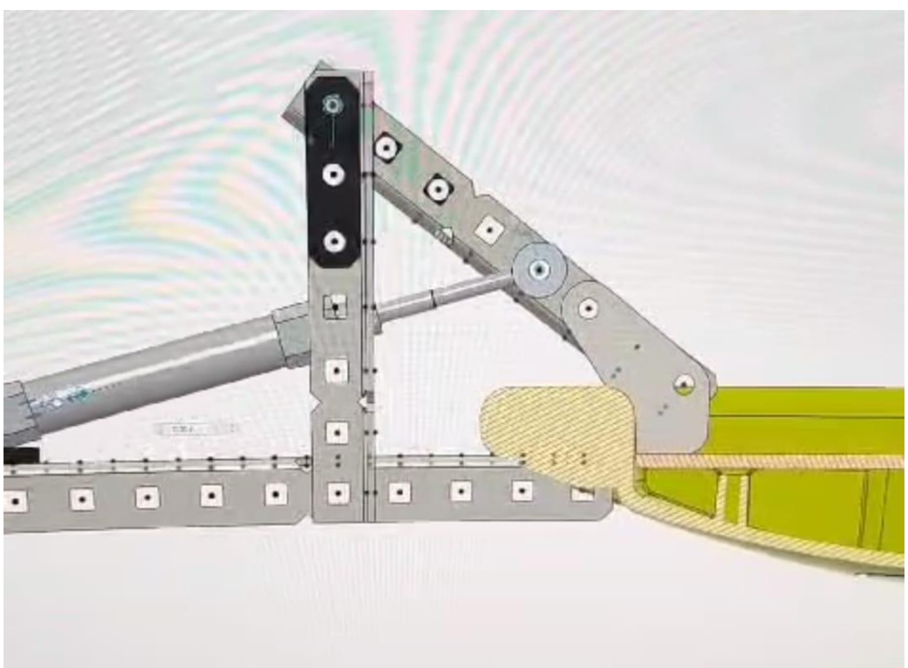
- Katanas are **extension** “rods” from the main body of the robot
- It can **reach into corners** where the robot cannot
- “flicks” rings out
- Gives us **more game elements** if needed
  -> More **diverse strategy** options



The Katana

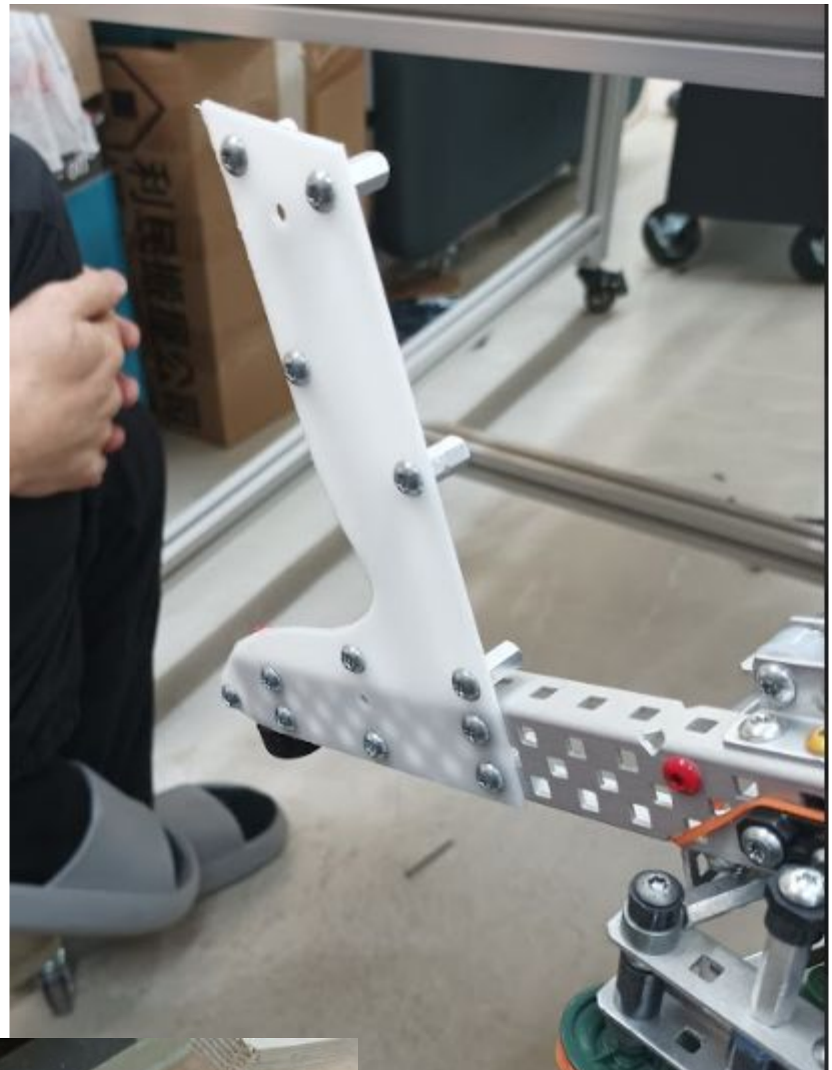
Identify the problem

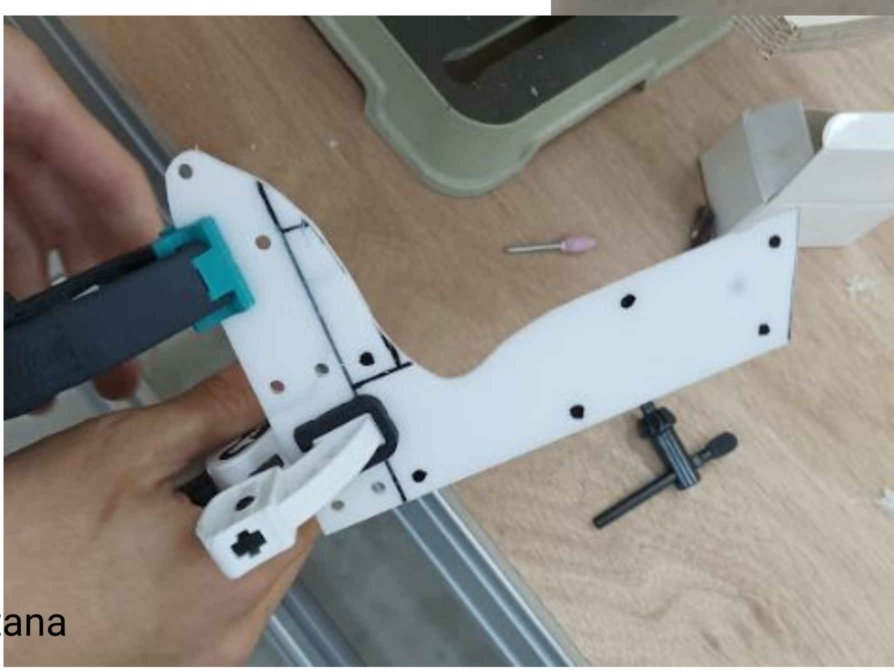
Function 2: Clamp onto mobile goals
- The 25mm piston is another clamp for mobile goals - It is used when we want to **steal opponent's** mobile goal - Used when we are **rushing to a mobile goal** as it is **positioned in front** of the robot, the driver only needs to **drive forward** to grab that mobile goal, the rear mobile goal clamp requires the driver to go in reverse - Through *Game Analysis [Section B]* and according to our *[A8] Game Strategy*, mobile goal **possession is essential** to our game, therefore during the autonomous period we will rush as quickly as possibly to have **two** mobile goals in our possession (alliance has three).



The Katana

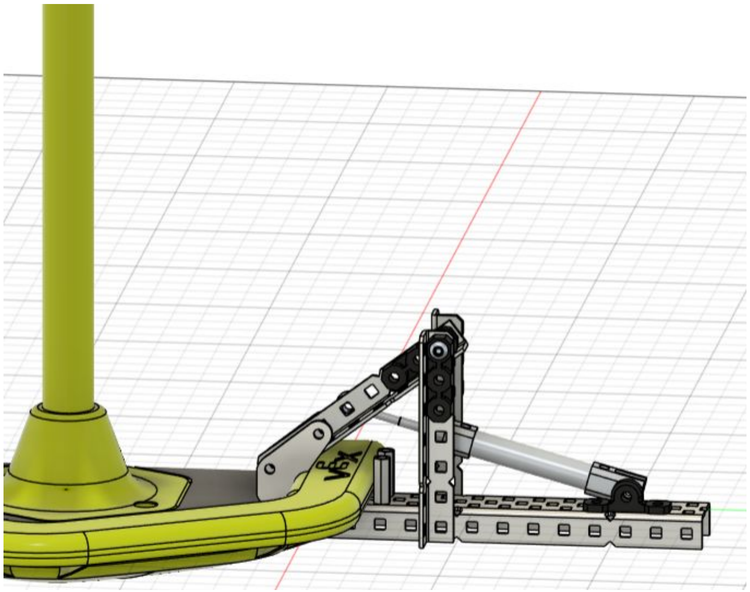
Build solution

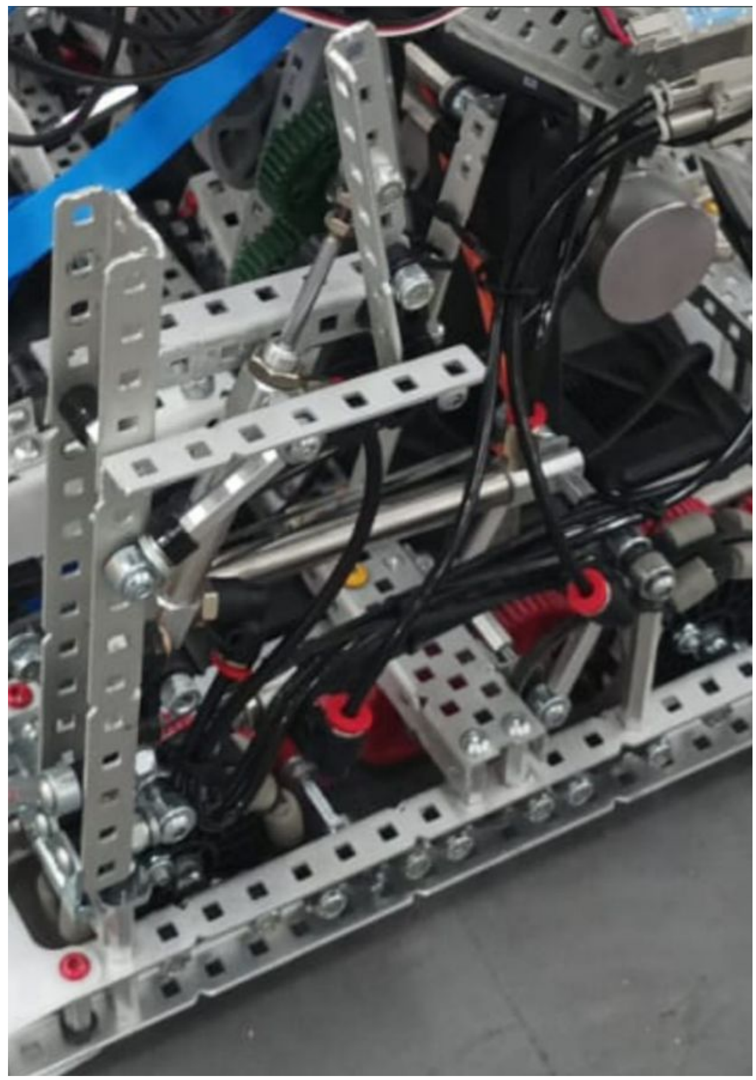




The Katana

Solution implementation





Katana

Michael

21/11/24

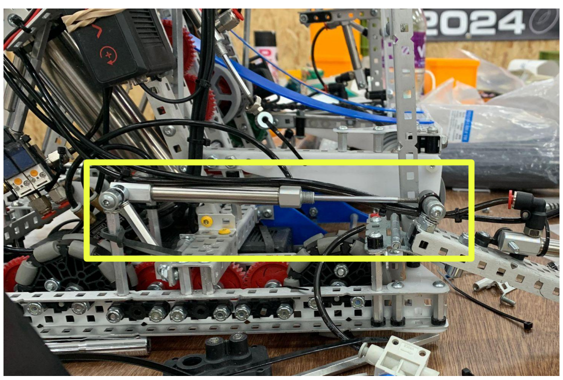
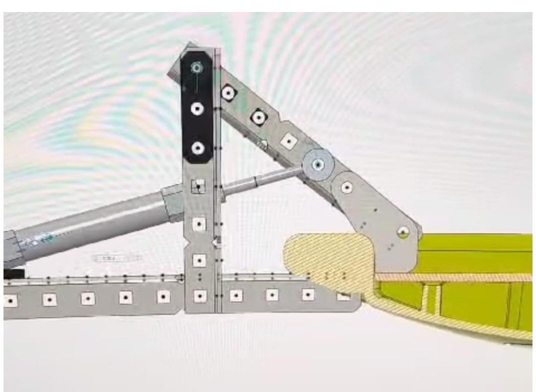
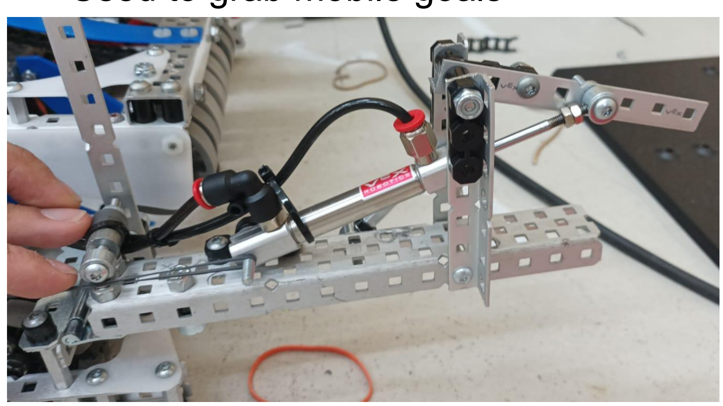
The Katana

Design process

A pneumatics-activated device installed on **both sides of the robot**. Each katana is made up of two double-acting pistons (1x50mm + 1x25mm).

Being a simple device, we decided to **directly start with CAD**, that is done to speed up the process.

Specs & Design

Component	**Use**
50mm double-acting piston 	- Extend & retract the katana from the drivetrain
25mm double-acting piston 	- Extend & retract the **arm on the katana** - Used to grab mobile goals 

REDESIGN

WALL STAKES SCORING MECH.

REFLECTION

WALL STAKES SCORING MECHANISM

We will develop the **mobile goal scoring mechanism** concurrently and parallelly with the **intake and delivery system**, this is done to create better connectivity and coherence of the two.

In light of this, the previous design will be reevaluated with an adjusted scoring matrix with a new scoring factor: **connectivity with delivery**.

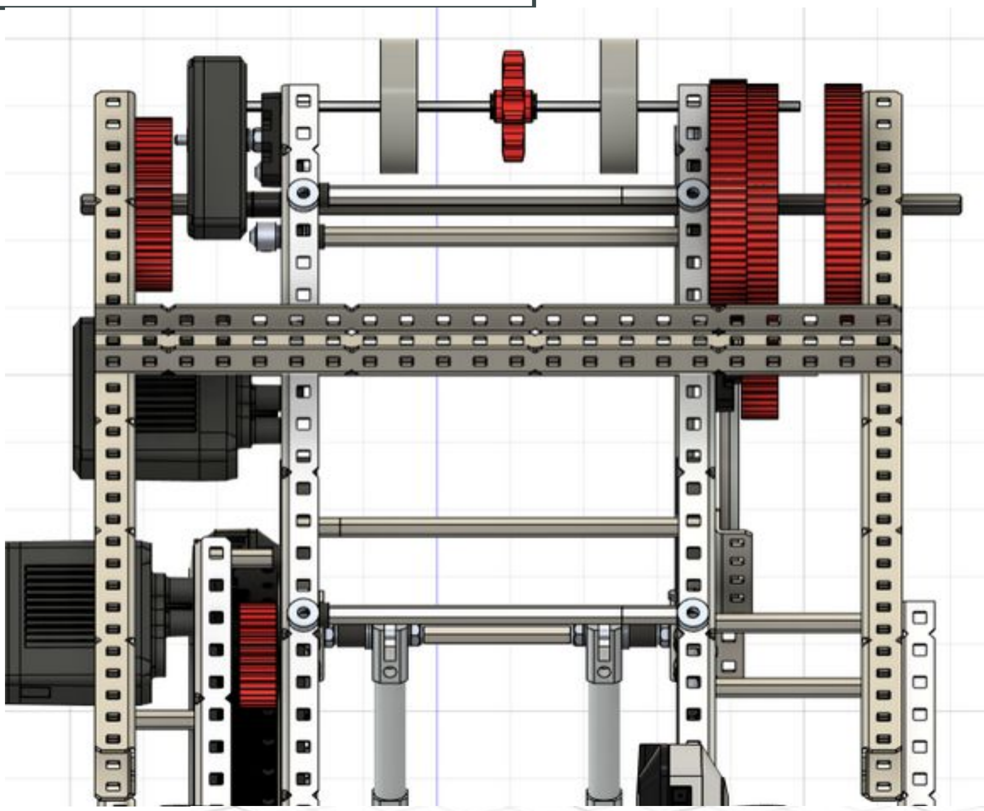
On the previous hood design for scoring on mobile goals:

Positives	Negatives
• Theoretically the highest rate of which rings can be scored is higher	• Low efficiency • Low reliability, it misses pretty frequently

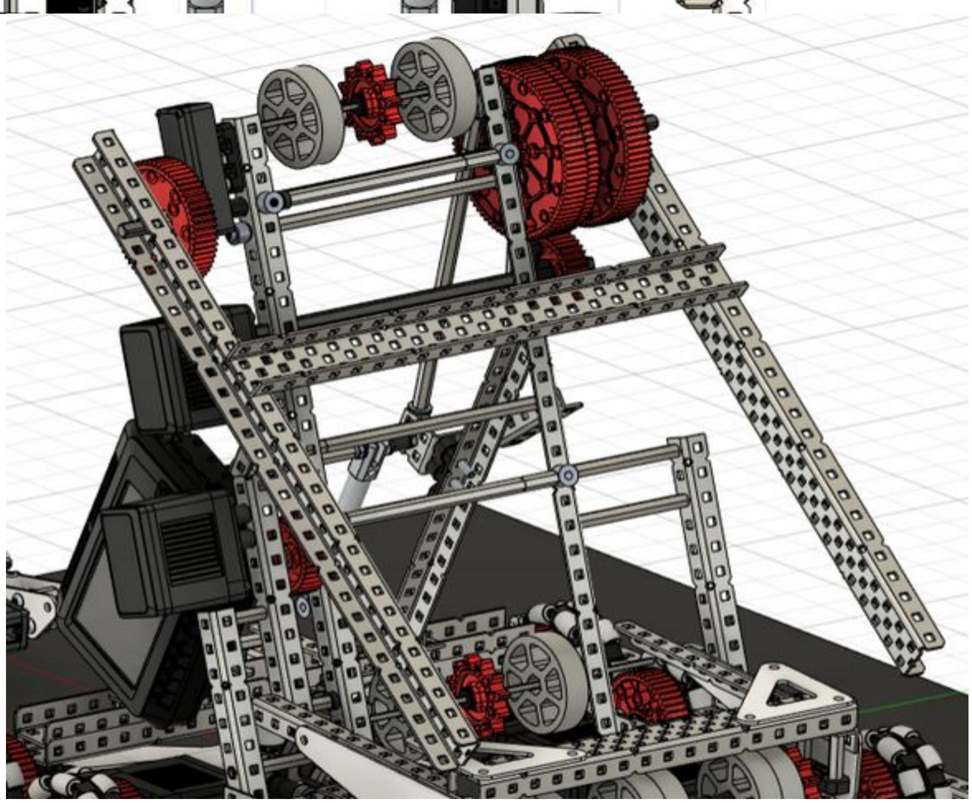
PLAN

WALL STAKES SCORING MECHANISM

CAD model of solution



[FRONT VIEW]

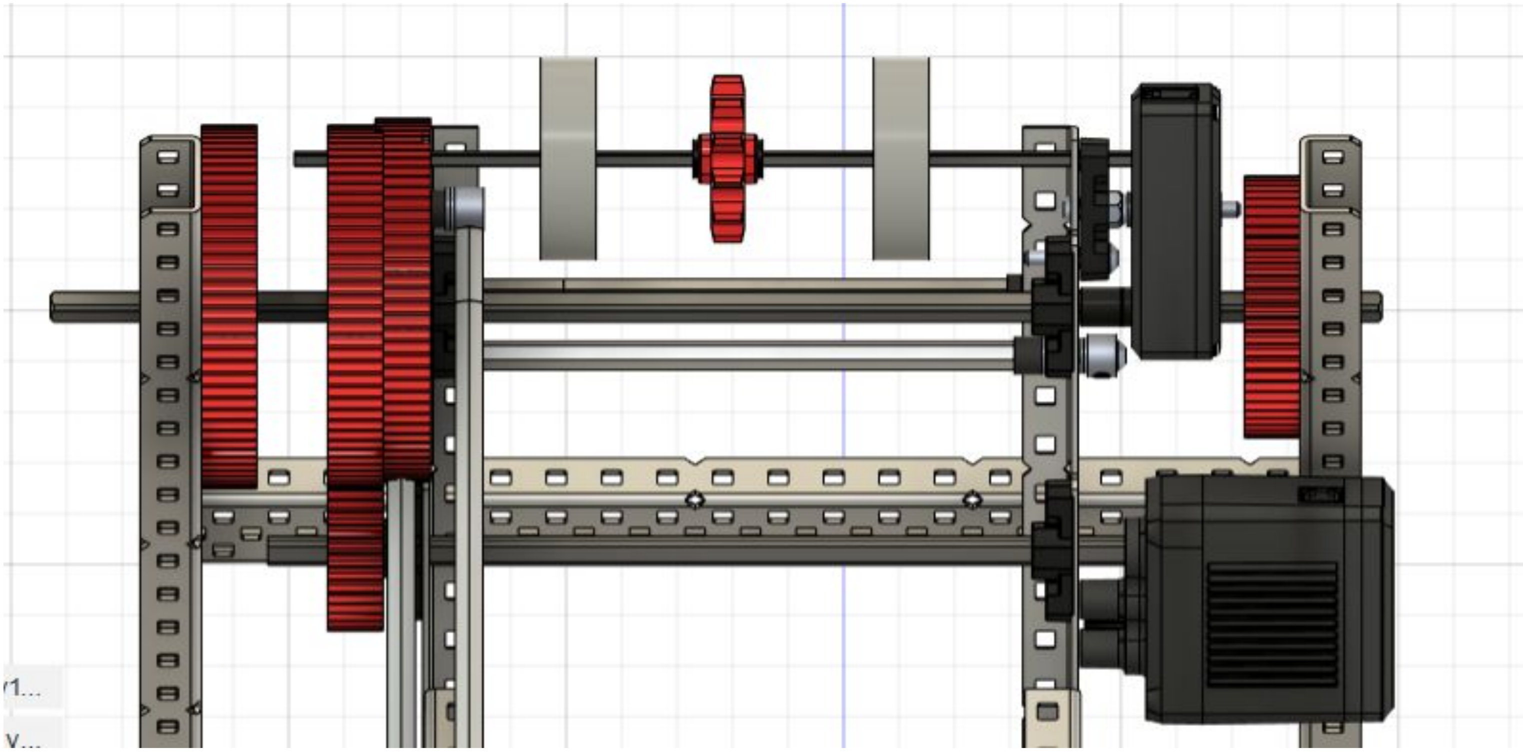


[ISOMETRIC VIEW]

project wall stake scoring mechanism name Michae l date 30/11/24

CAD model of solution

[BACK VIEW]



We decided to use a gear ratio of 36:84 for the claw arm. As the motor is powered with red cartridge, the claw arm moves at 42.8 rpm at it’s peak, which allow us to raise and lower the arm very quickly for effective wall stakes scoring.

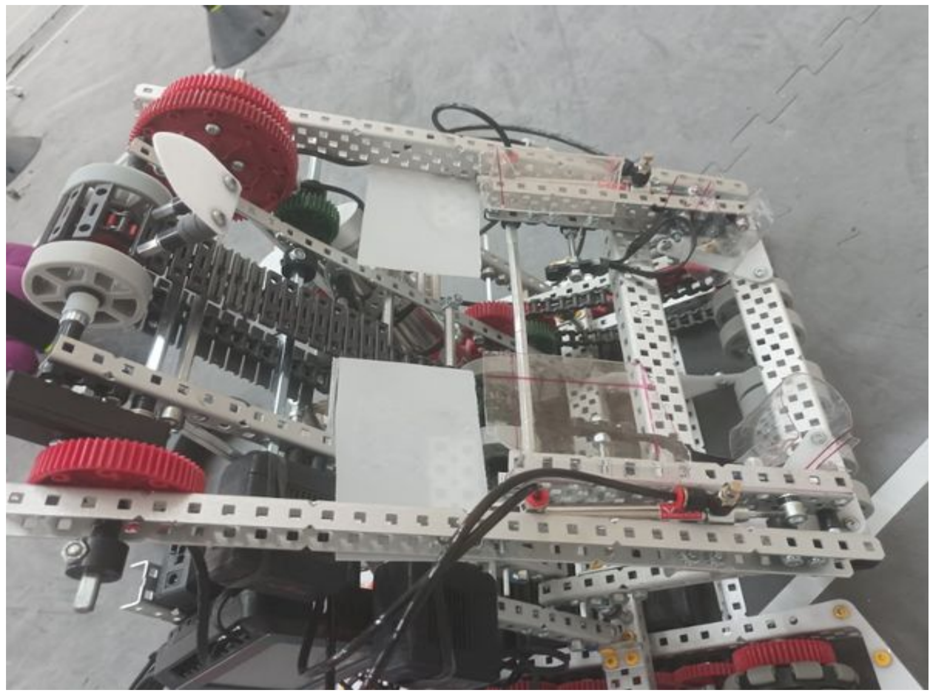
BUILD SOLUTION

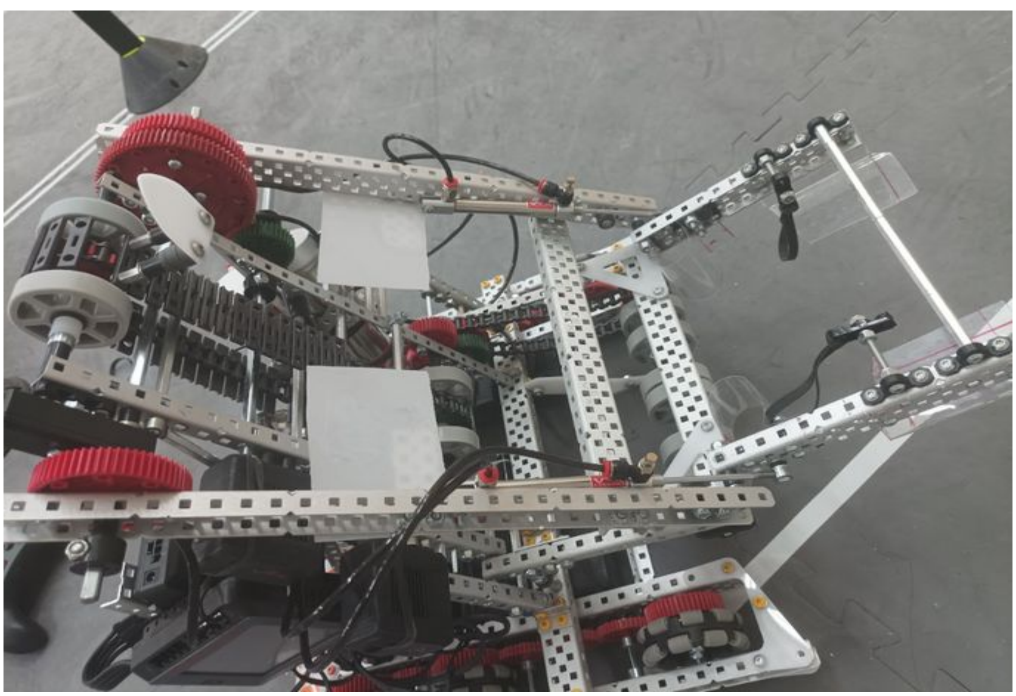
WALL STAKES SCORING MECHANISM

Goal

We will build our planned solution according to the CAD so that we can test its performance

Assembled Build





project wall stake scoring mechanism name Michael date 1/12/24

BUILD SOLUTION

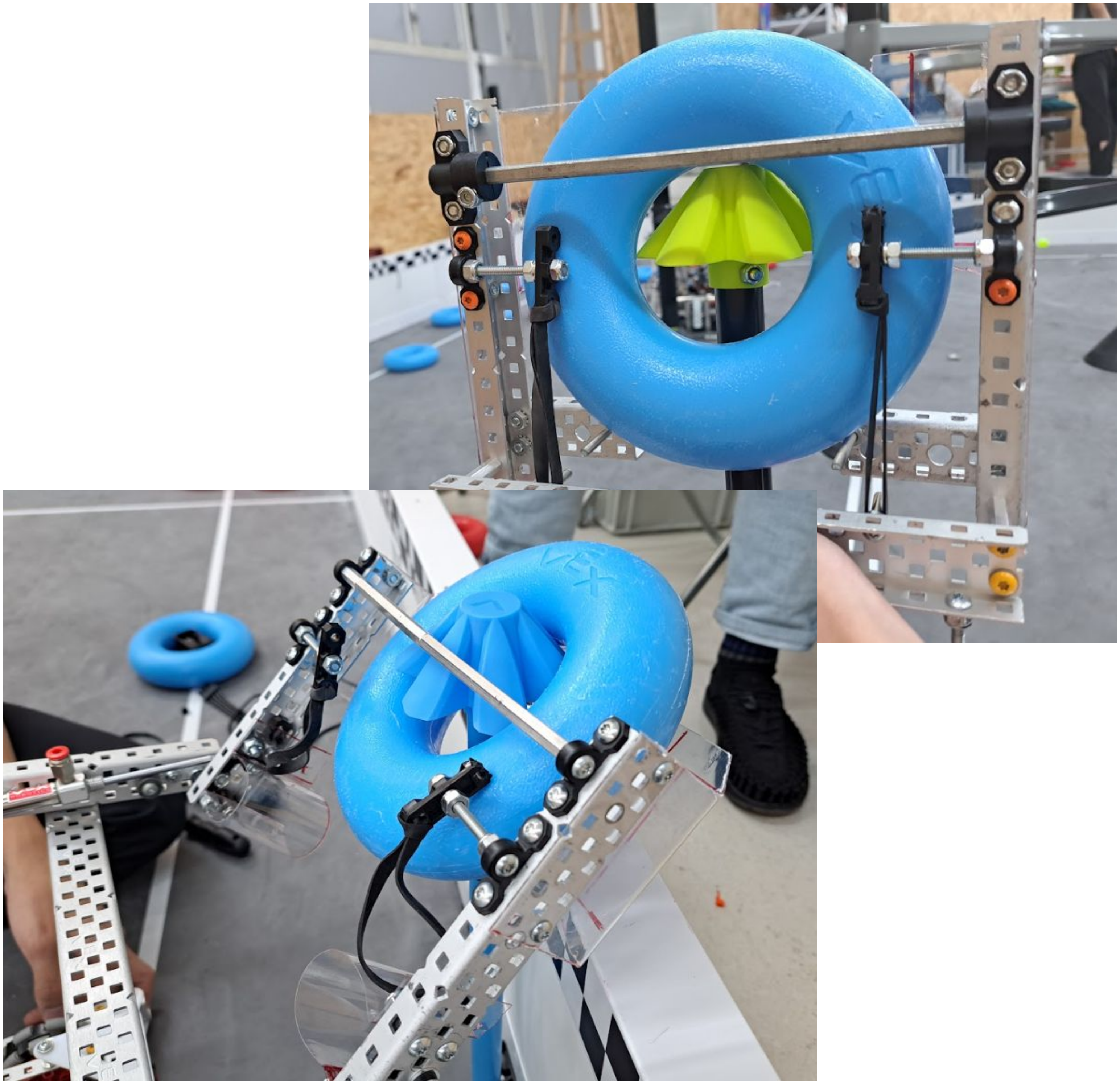
WALL STAKES SCORING MECHANISM

Assembled Build

project wall stake scoring mechanism name Michael date 1/12/24

TEST SOLUTION

WALL STAKE SCORING MECHANISM

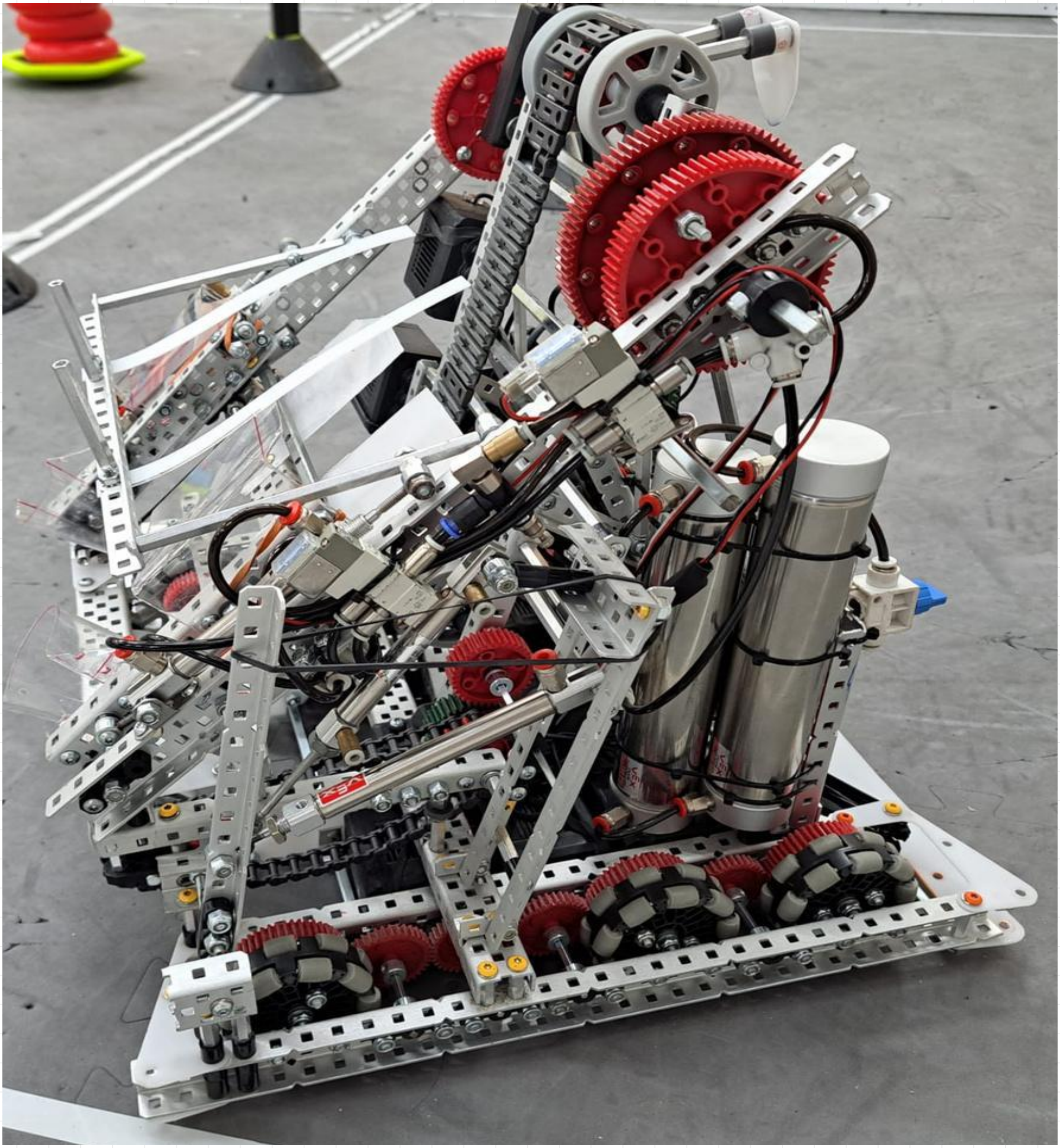


The mechanism is able to score both the neutral wall stakes and the alliance wall stakes

ASSEMBLED BUILD

ASSMEBLED BUILD

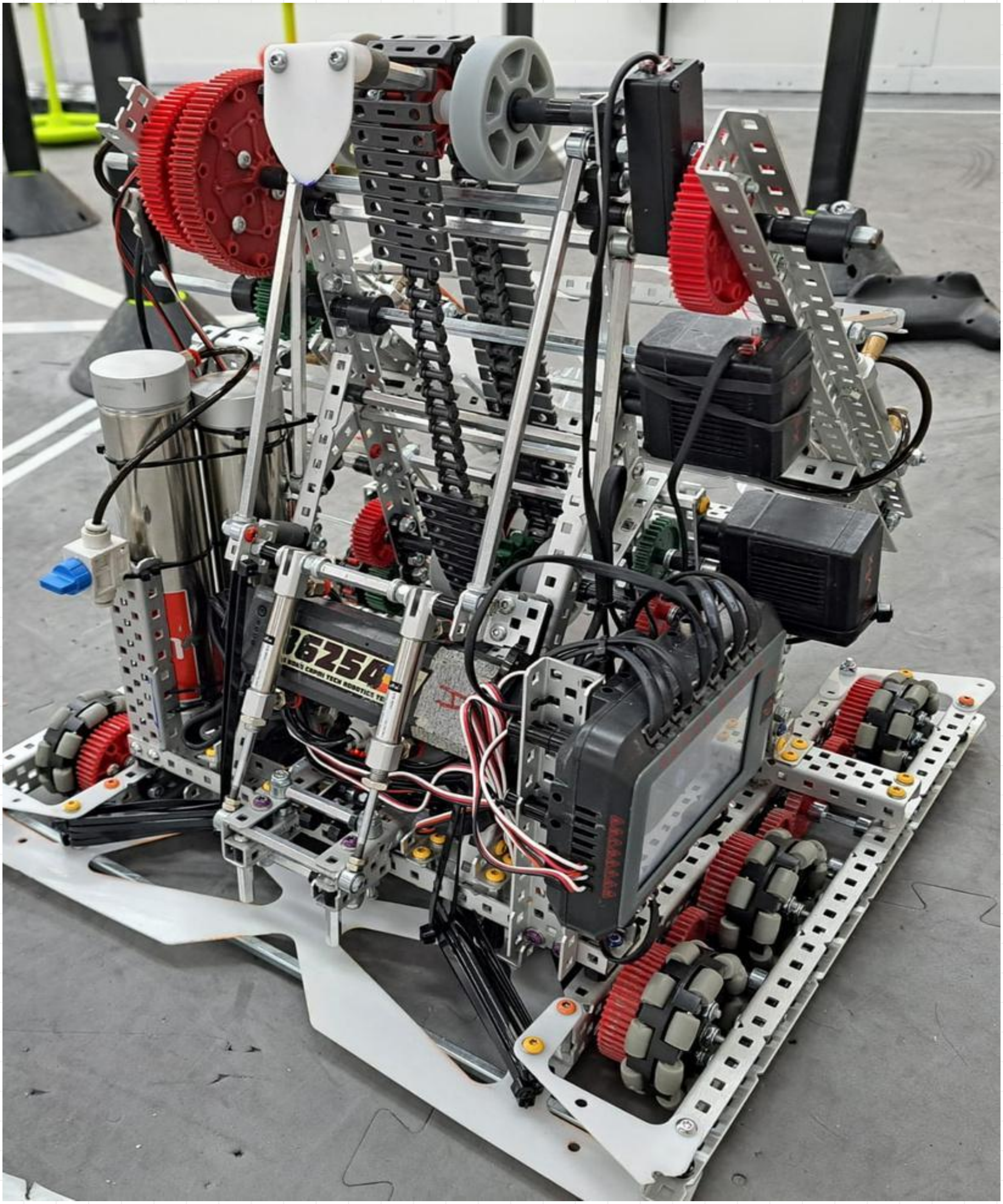
WHOLE ROBOT



project Assembled build name Michae
l date 2/12/24

ASSMEBLED BUILD

WHOLE ROBOT



project Assembled build name Michae l date 2/12/24

DRIVE STRATEGY

IMPROVEMENT

DRIVER STRATEGY

Goal

Improve our driving strategies which fit our current robot

Now we have completed our robot, we aim to design our strategy based on what our robot performs well, and maximise our advantages in the area that we perform well. To do this, we first need to identify our advantages.

Identify advantages

Firstly, our robot scores rings into mobile goal very quickly. With the speed of 1 second per ring, we can score a full mobile goal in less than 10 seconds after the driver period starts.

Secondly, our robot scores 1 ring into wall stakes very efficiently. Unlike other designs, we only need to lift the claw up and drive our robot towards the wall stakes for scoring. This allow us to score wall stakes in between scoring mobile goals as we only need to focus on our drivetrain movement.

Thirdly, our robot can consistently flip a full mobile goal. By self-spinning at max speed and releasing our mobile goal clamp, we can consistently flip a grabbed full mobile goal.

Designing Strategies - before final 15 seconds

In order to maximise our advantages, we decided to score a full mobile goal right after driver period starts. Then, we will flip our scored full mobile goal using mobile goal clamp.
At this time, it should be around 10-15 seconds into the driver period. The fifth mobile goal at the positive corner side of the field should be left aside due to our fast scoring and flipping. We would go and grab the fifth mobile goal and score 6 ring on it.
In most of the matches, both alliance should be contolling a positive corner at that time. We then will put our scored full mobile goal into the positve corner. Our alliance partner will continue protect the corner at the positive corner side of the field, where we will start scoring top rings on wall stakes.

Designing Strategies - final 15 seconds

In the final 15 seconds, positive corners are protected. Therefore, all four robots will be active in the field. At this stage, covering opponent's wall stake top will be our first priority as it values 5 points (disabling opponent's top ring + our alliance's new top ring). If both wall stakes contain our alliance's top rings, we will protect our top rings on wall stakes by standing in front of the wall stakes. Most of the wall stakes scoring mechanisms are required to be in front of the wall stakes to score. Therefore, getting in front of the wall stakes can prevent opponents from scoring them, thus protecting our alliance's top rings, as it also values -5 points if we failed to protect them.

PROGRAMMING - AUTON IMPROVEMENT

Goal

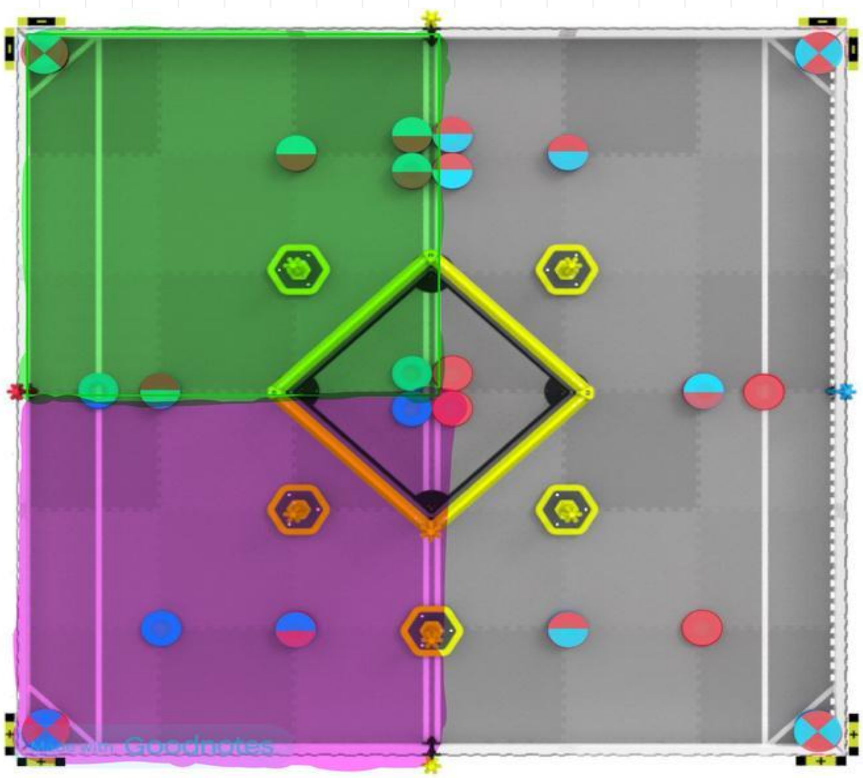
We aim to improve the auton program for head-to-head matches that by utiliting our robot’s advantage

Identify our advantages in autonomous period

- Able to grab mobile goals in any direction
- Fast mobile goal scoring
- Precise movement due to the help of odometry
- Can touch the ladder consistently by raising and dropping the claw arm

Auton sides

We devided the field into two parts, mogo side and ring side. Mogo side refers to the side with a mobile goal in the middle, while ring side refers to the side having 8 rings in the middle.



In the figure, ring side is coloured in green while mogo side is coloured in purple.

project Auton

nameMichae
l

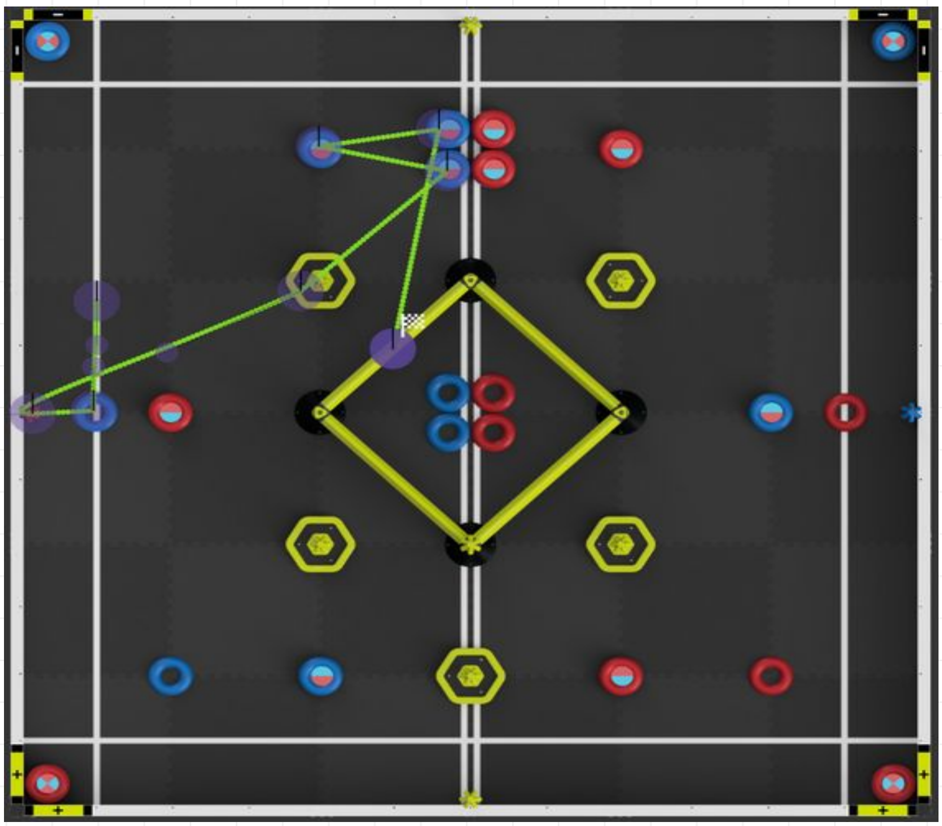
date 13/12/24

Qualification auton

In qualification matches, Autonomous Win Point (AWP) is important as it gives 1 Win Point to the alliance that completed the AWP tasks.

In order to win AWP, an alliance has to score three rings on at least 2 stakes, and touch the ladder.

As we cannot ensure whether our partner's auton program will work, we dicided to make a solo AWP program with a path that can complete all AWP tasks by ourselves, so that we can consistently get AWP without depending on our teammates.

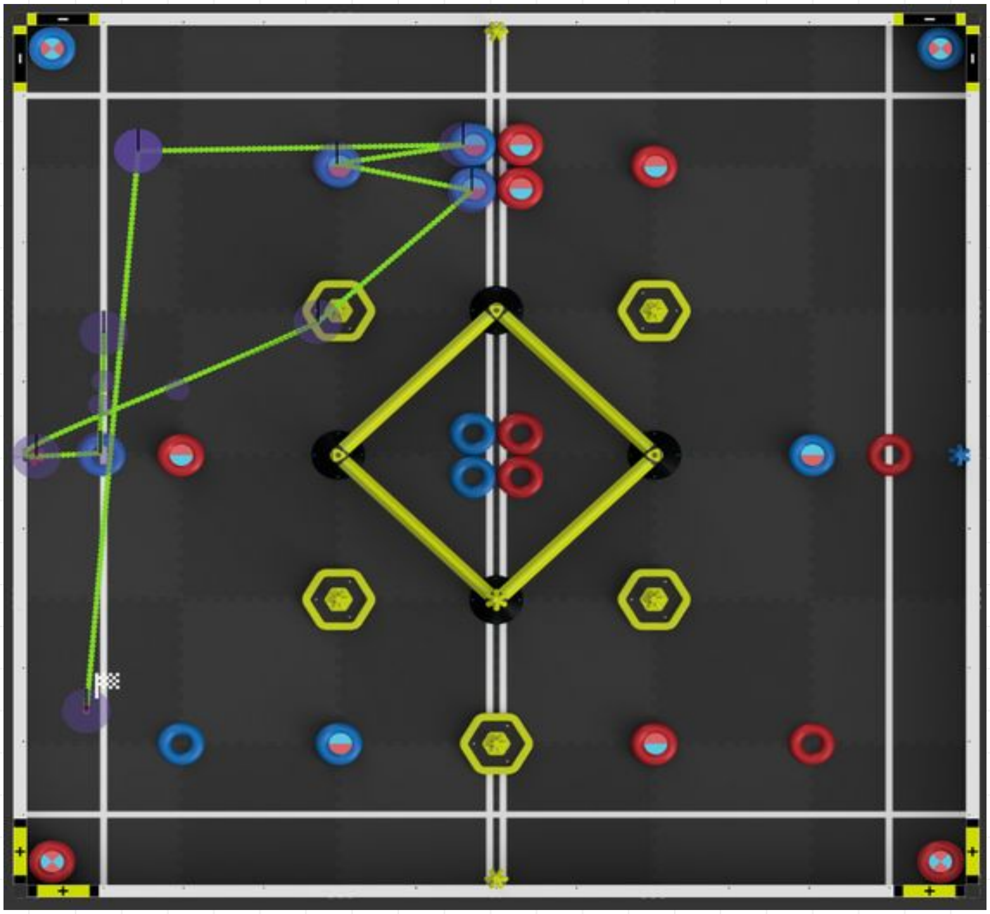


This is our ring side auton for qualification matches. In order to solo AWP, we need at least 3 rings on our side of the field. Therefore, we chose ring side for auton program during qualification matches.

The robot will first score alliance wall stakes using hook, then grab the mobile goal, and score the remaining 3 rings. After that, it will raise it's arm and touch the ladder. The arm will drop down due to gravity onto the ladder, which meets every tasks of the criteria of AWP.

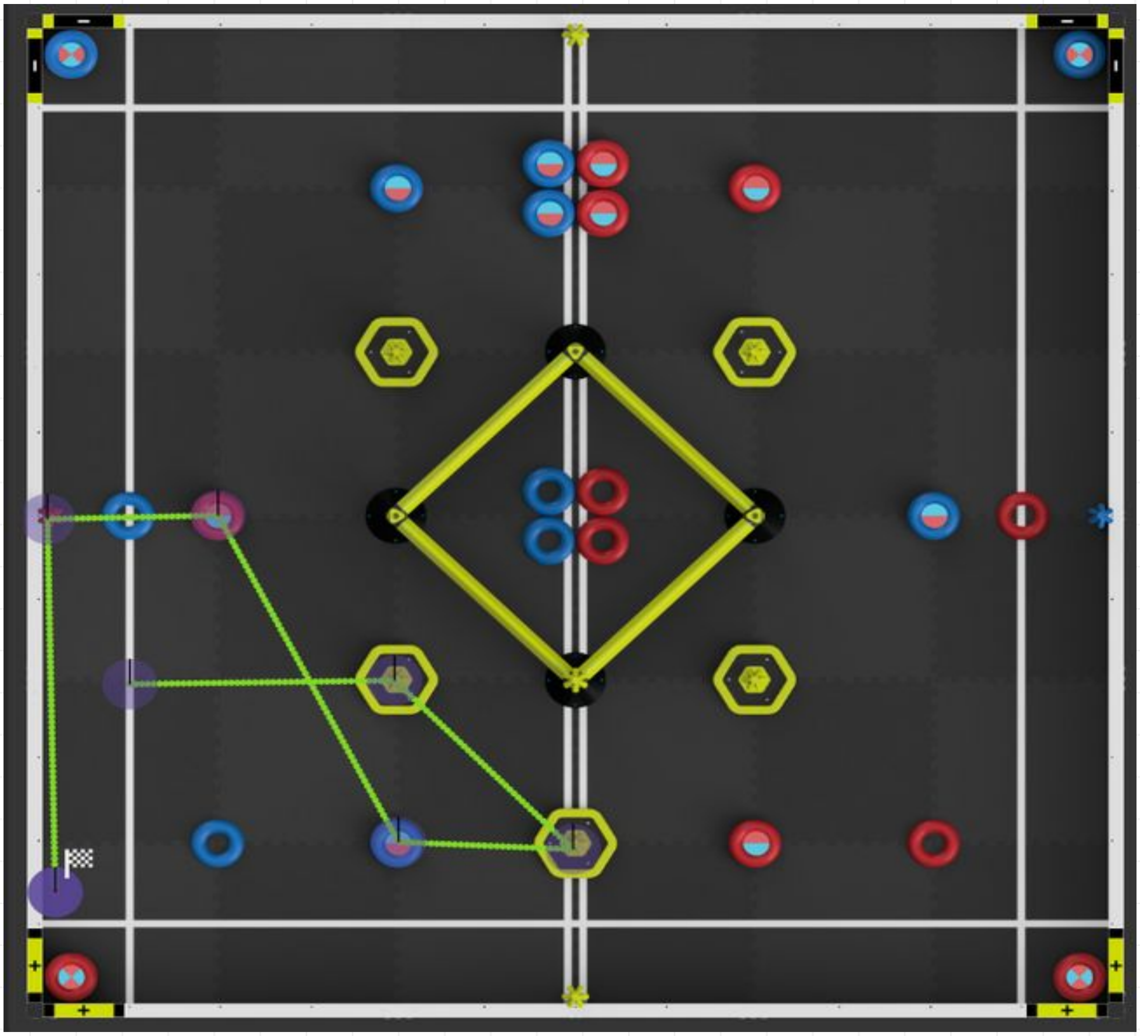
Elimination auton

In elimination matches, there is no use to win AWPs. Therefore, we can focus on purely getting the highest points possible to win the autonomous win bonus, which gives us extra 6 points.



[Ring Side]

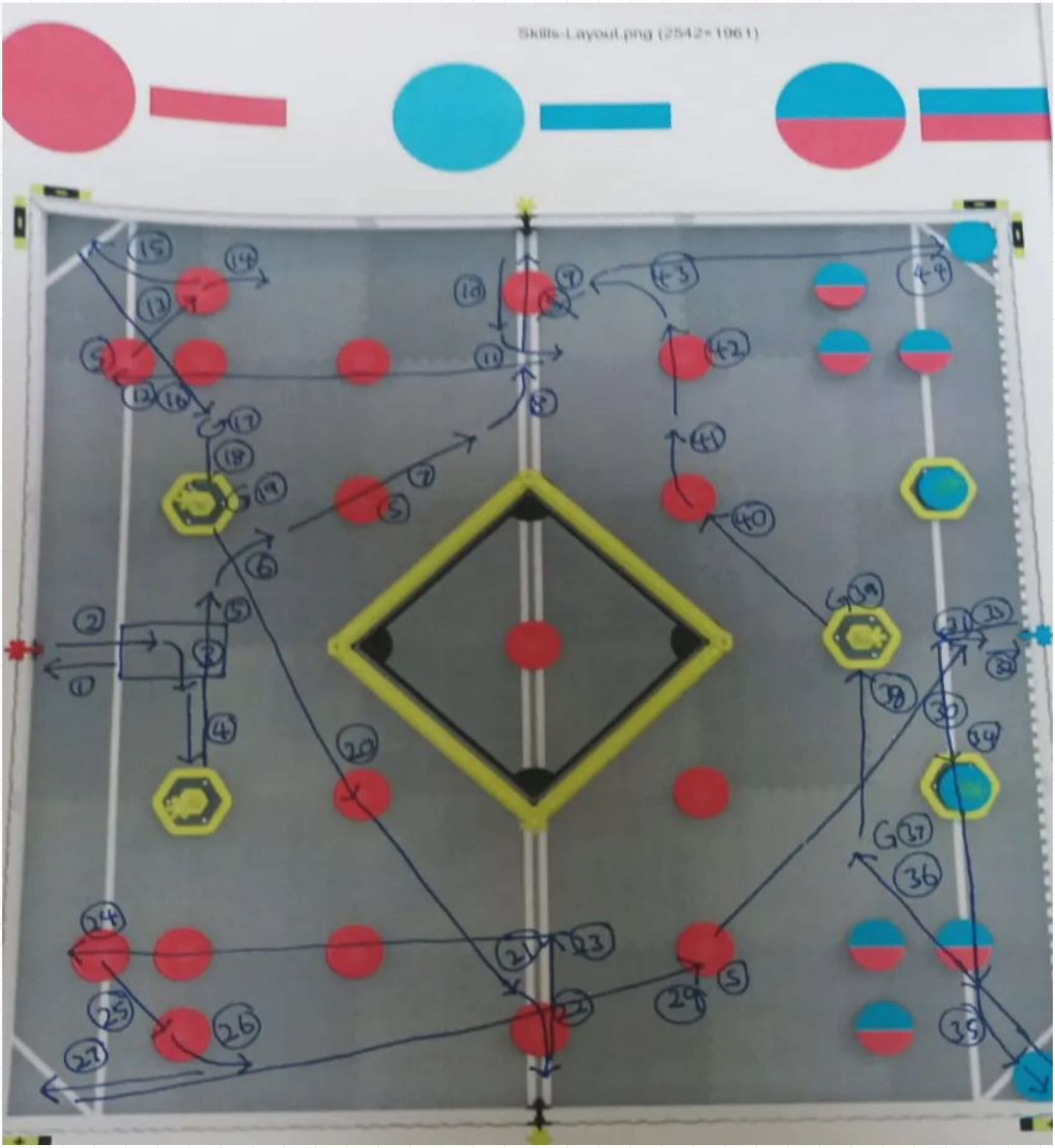
For the ring side, we slightly modified the end part of the qualification auton, changing robot's movement from touching the ladder to moving to the positive corner area at the end. This allow us to be able to quickly score a full mobile goal and put it in the positive corner, creating great advantages early in game.



[Mogo side]

For the ring side, we aim to score at many points as possible to win the autonomous win bonus. Therefore, we decided to score 1 top ring on 2 mobile goals and the alliance wall stake. This gives us 9 points. We would clear the positive corner’s stacked rings using our katana at the end to allow smoother mobile goal placement in driver period.

PROGRAMMING - SKILLS



project Auton name Michael date 17/12/24

PROGRAMMING - SKILLS

1. Move front
2. m (back)
3. sw (left)
4. m (back)
5. m (front)
6. sw (right)
7. m (front) + 5
8. sw (left)
9. m (front)

wall stakes scoring

10. m (back)
11. sw (right)
12. m (front) + 5

turn to heading

13. m (front)
14. sw (right)
15. sw (left)

corner

16. ~~m~~ m (front)
17. t
18. m (back)

mogo grab

19. t
20. m (front)
21. sw (right)

wall stakes scoring

22. sw (right)

wall stakes scoring

23. m (back)

turn to heading

~~35~~ 24. m (front)

25, 26 } str sw (~~lef~~ left)

27. m (back)

corner

29. m (front) + 5
30. m (front)
31. turn to heading
32. move forward
33. m (back) + sw (left)

24, 35 } sw (left) + m (front)

36. m (back)
37. sw (left)
38. m (back)

mogo grabbing

39. turn to heading
40. m (front)
41. sw (right)
42. m (front)
43. sw (left)
44. m (back)

corner

short - forms

c — motion chaining

s — selection

m — move with pid (back/front)

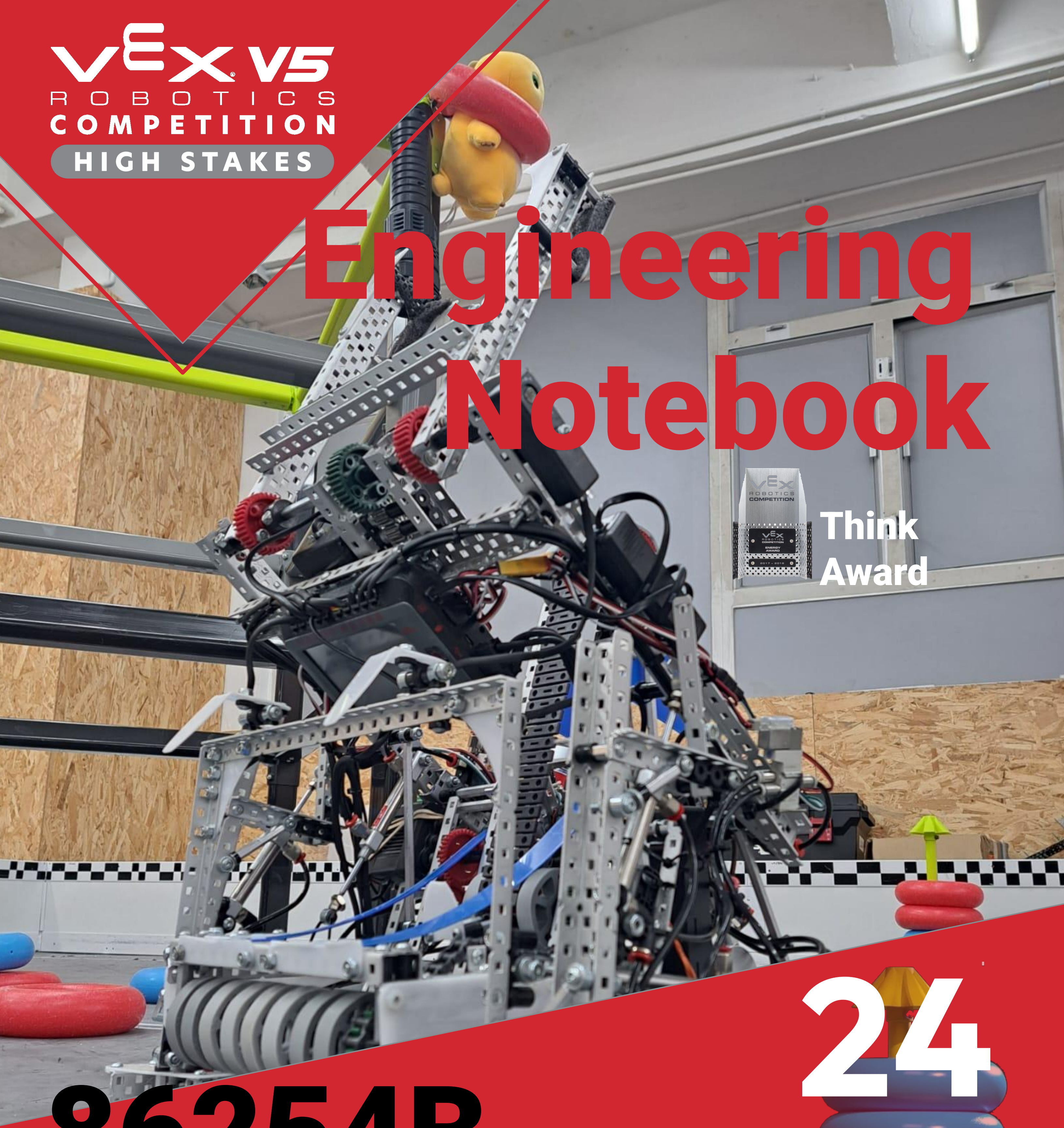
t — turn to heading

sw — swing to heading (right / left)

project Auton name Michael date 17/12/24

VEX V5 ROBOTICS COMPETITION
HIGH STAKES

Engineering Notebook



Think Award

86254B

Book 4 (Generation 4 & Hong Kong Regional)

Team name
CAPMI1

Robot name
272K

24
25

TABLE OF CONTENTS

REDESIGN

WALL STAKES SCORING MECH.

REFLECTION

WALL STAKES SCORING MECH.

We are not very satisfied with the performance of the cage in scoring Wall Stakes, hence we would like to redesign the claw mechanism to improve its performances

Positives	Negatives
• At least it can score	• Heavy and bulky • Inconsistent with low efficiency

IMPROVEMENT - Wall Stakes Scoring Mechanism

The Lady-Brown Mechanism

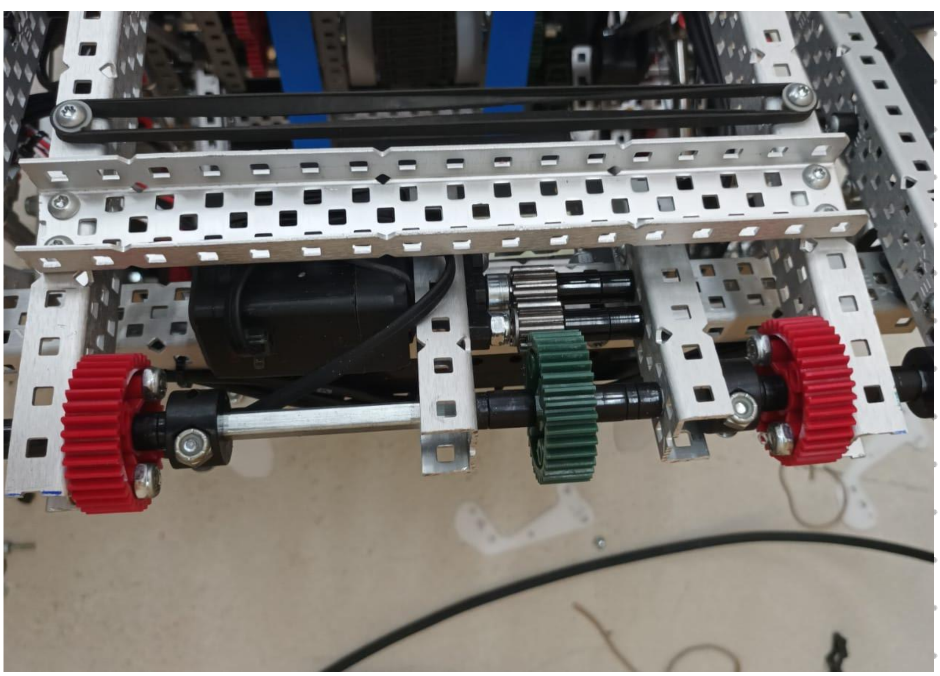
We use 11W 300 rpm motor to power the lady-brown mechanism. The motor is geared 3:1 (drive : driven) to the lady-brown arm. Giving the lady-brown mechanism a maximum rpm of 100.

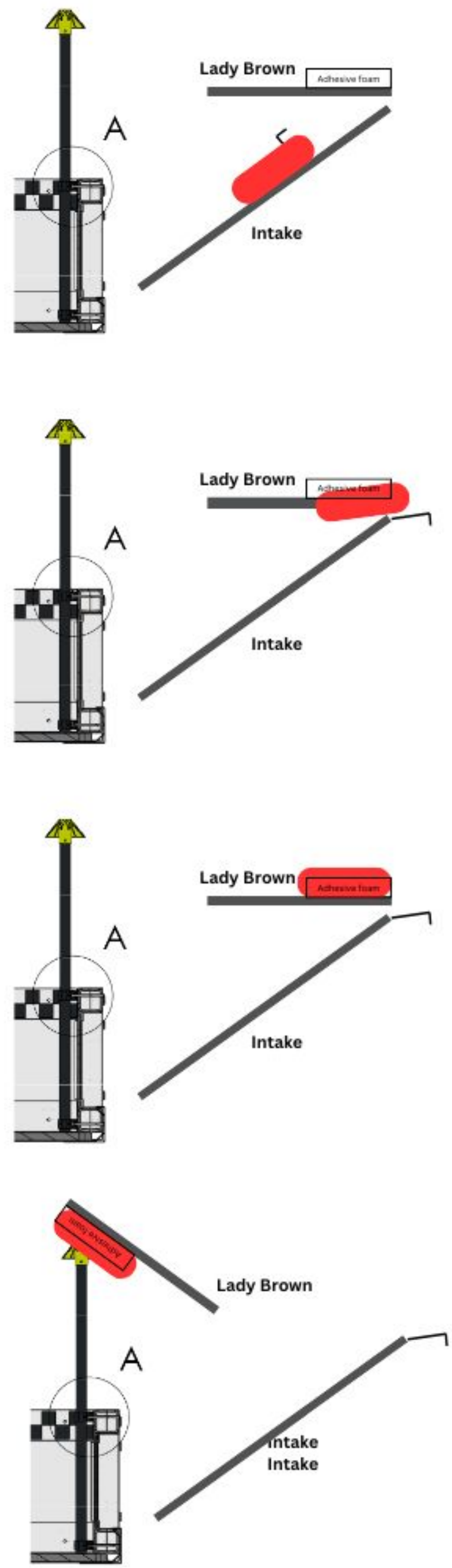
However we will not use the maximum rpm of the motor as it will be too fast for the job.

We use adhesive foam at the end of the lady-brown arm to increase grip on the rings.

The Lady-Brown mechanism basically flips the ring over to score into the High Stakes and the Wall Stakes.

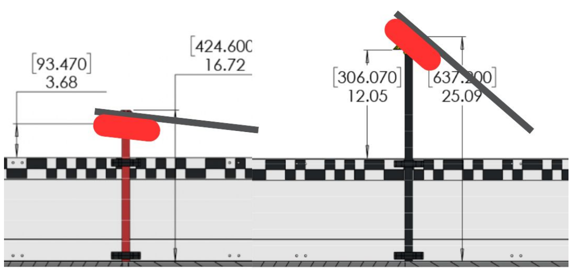
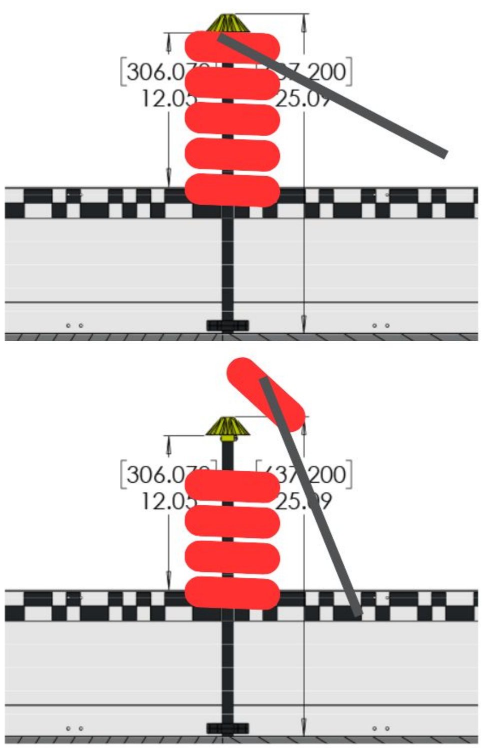
PID is used to precisely control the position of the lady-brown mechanism to achieve different functions: <u>(1) load rings</u>, <u>(2) Wall Stakes</u> and <u>(3) Alliance Wall Stakes</u>





Wall Stakes Scoring Mechanism

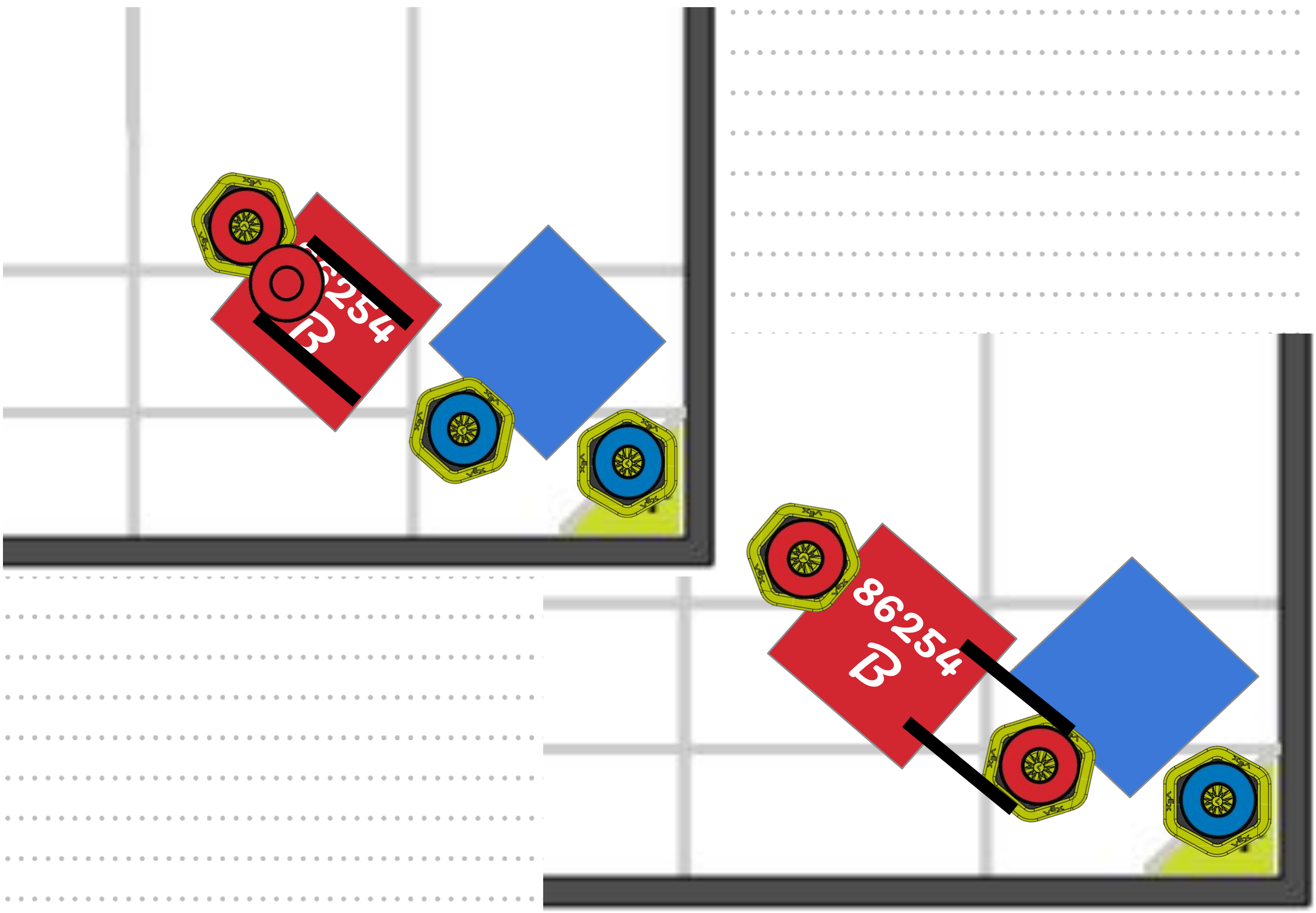
Why ours is special

Function	**What makes it special and distinguishes it from others**
Able to **score both Wall Stakes and Alliance** Wall Stakes 	- The two kind of wall stakes have **different heights** - Our lady-brown mechanism is placed after **mathematical analysis** such that it can score both Wall Stakes and Alliance Wall Stakes - **Many other teams use two separate mechanisms** to achieve what we can do with one
Descore 	- In the same way as scoring, our lady-brown can be used to descore rings in the Wall Stakes - Very important since **top rings worth 3 points while others worth only 1** - We can **remove the top ring** (and subsequent rings) and put ours on

Wall Stakes Scoring Mechanism

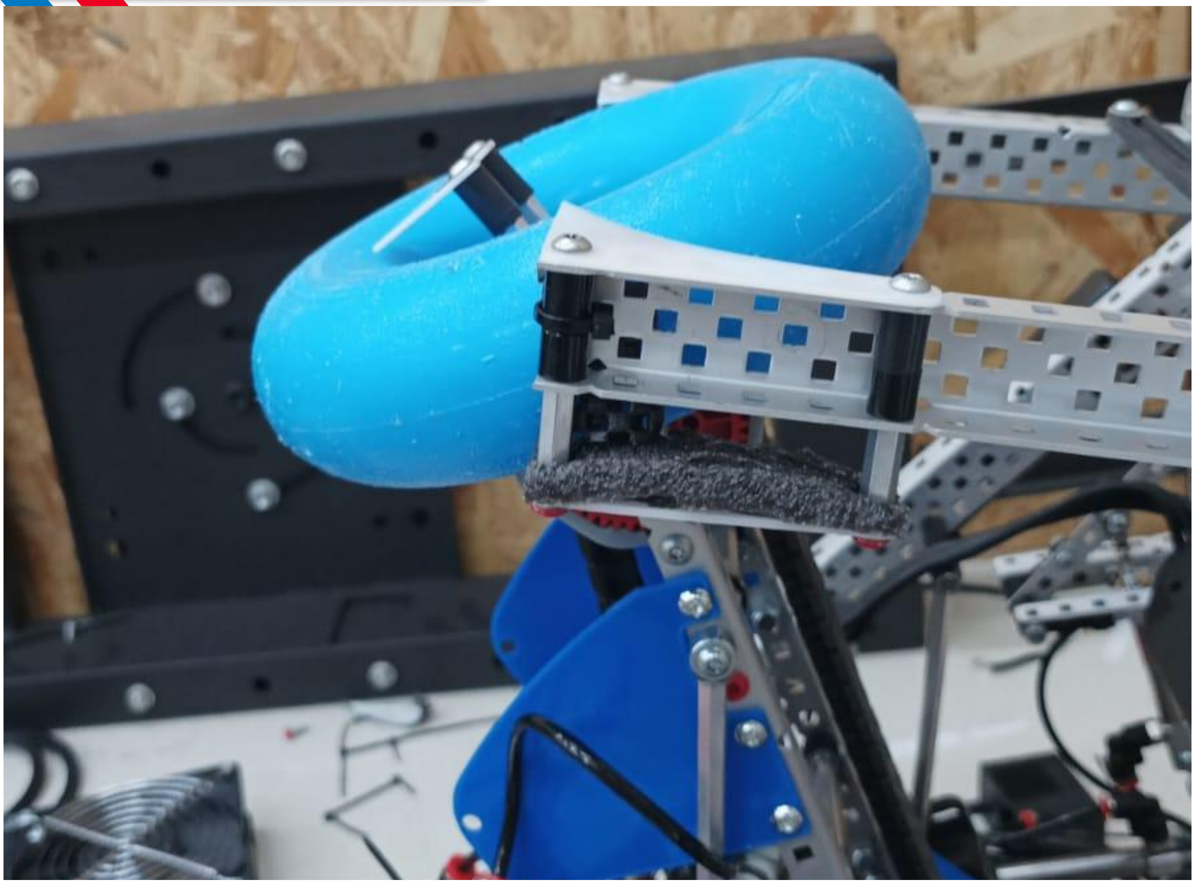
Why ours is special

Function	What makes it special and distinguishes it from others
****Score** rings onto **mobile goals**	- We often see teams "**camping**" with a mobile goal in the positive corner - Our lady-brown mechanism is designed to **score the top ring onto mobile goals** - This will give us a **significant advantage** as top ring in positive corner is worth **6 points**



Wall Stakes Scoring Mechanism

Ring Loading



(1) At idle, the lady-brown mechanism will **stay below the top of the intake**.

(2) As rings go up the delivery, the driver will press a button on the controller to **lift the lady-brown up to loading position** (controlled by PID).

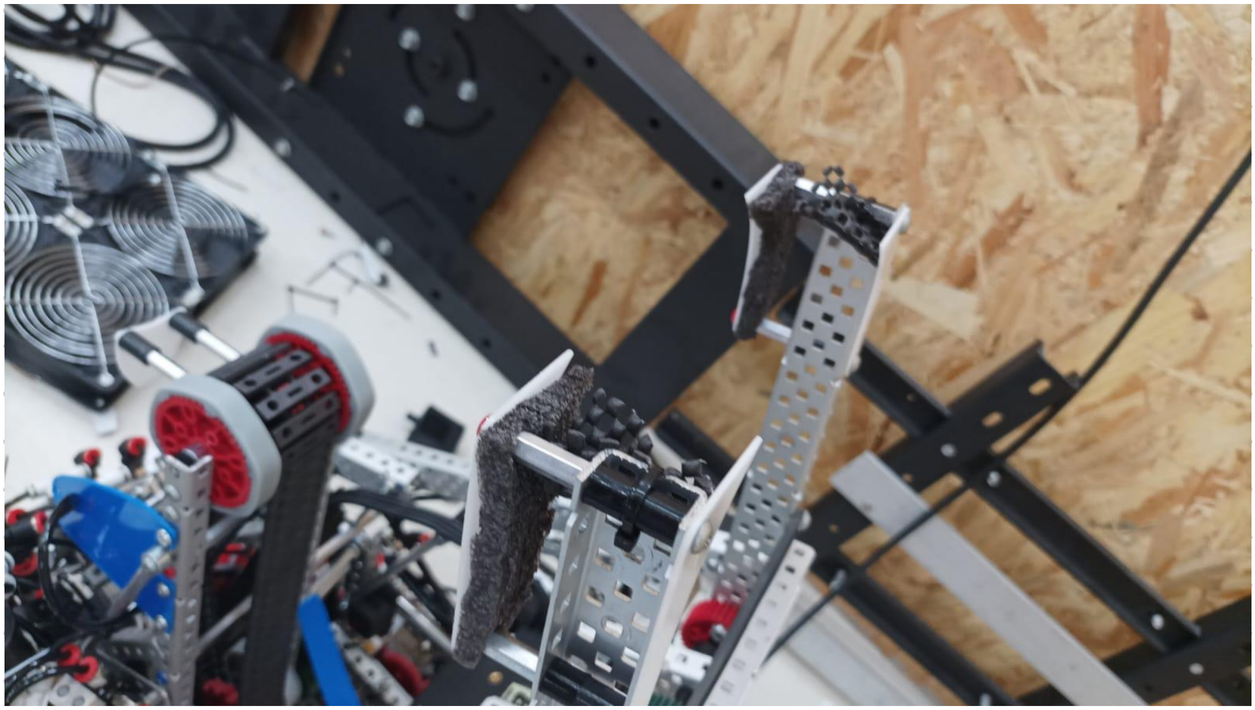
(3) The **hook will bring the ring to the top of the delivery and stop**.

(4) The ring will be **caught by the adhesive foam**.

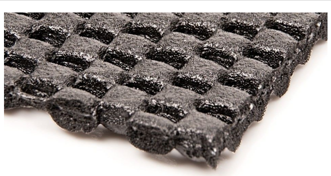
(5) The **hook will reverse back down** so the **ring will be transferred** to the lady-brown.

Wall Stakes Scoring Mechanism

Ring control

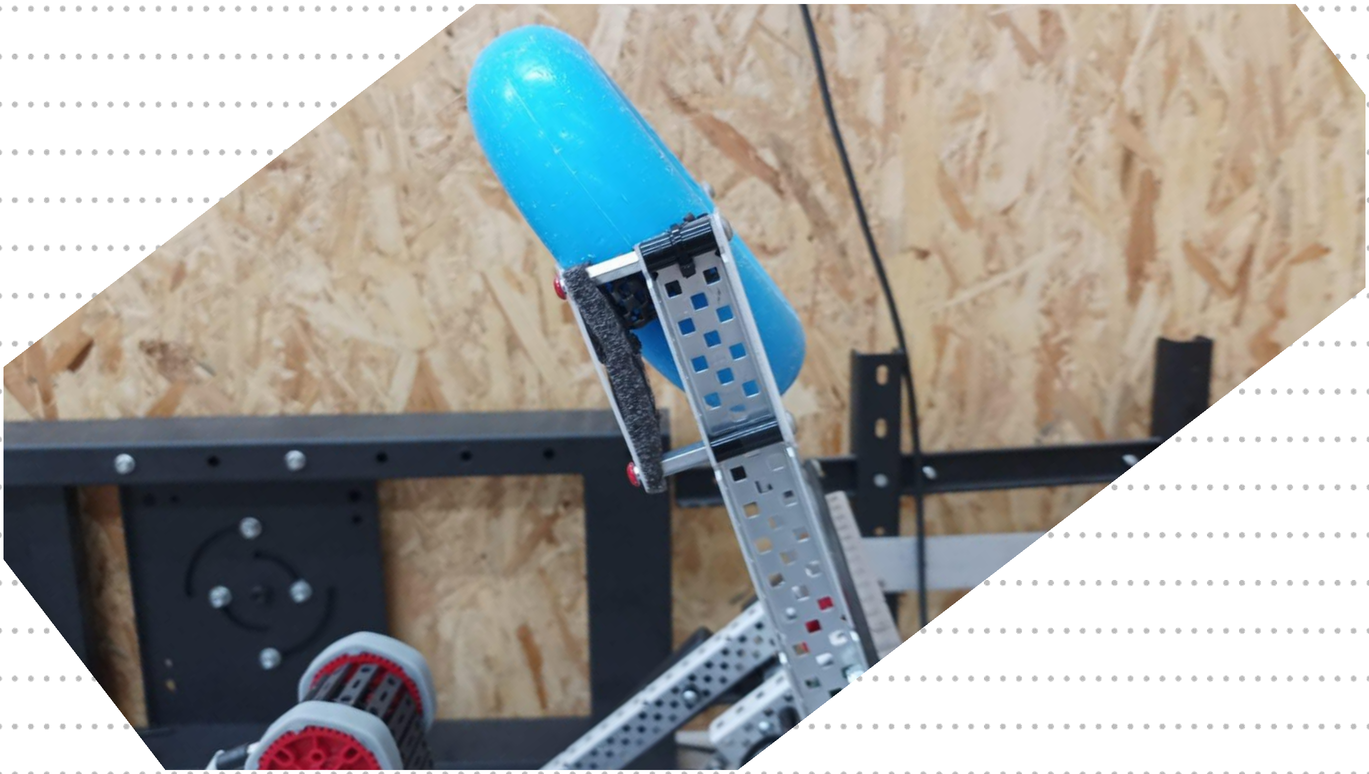


The lady-brown mechanism requires firm and tight grip on the rings. Our initial prototype of the lady-brown had issue with securing the rings in place and performed badly.

Material to make the clamp	Testing results & feedback
Anti-slip mat 	We stacked /folded layers of anti-slip mat - **Performed badly**, low grip Rings will fall out
Adhesive foam + anti-slip mat 	We added adhesive foam at the top of the lady-brown and kept the anti-slip mat - **Very satisfactory** results Rings are able to stay on the mechanism and stay there even under mild collision - **Larger contact area** -> better grip
Future: field tiles	As we try to keep improve our mechanism, **in the future** we will try to use field tiles.

Wall Stakes Scoring Mechanism

Ring control



Top: Ring held inverted by the adhesive foam

The lady-brown mechanism is **precisely controlled** by the PID (same as the one used on drivetrain).

PID is used to control the ring to four positions
(1) Idle position, below the top of the intake
(2) Load position, at the top of the intake
(3) Wall Stake scoring position
(4) Alliance Wall Stake scoring position

IMPROVEMENT - program - Colour Sort

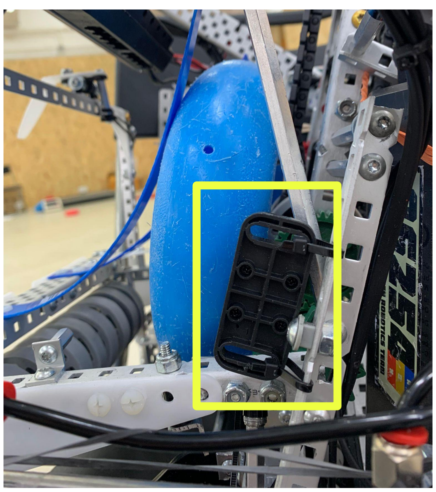
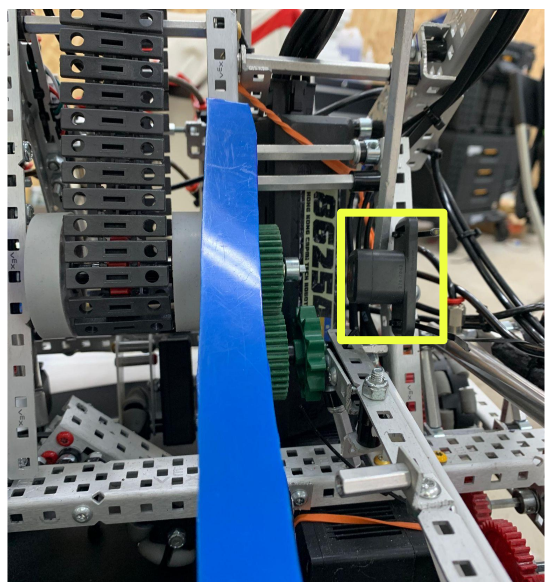
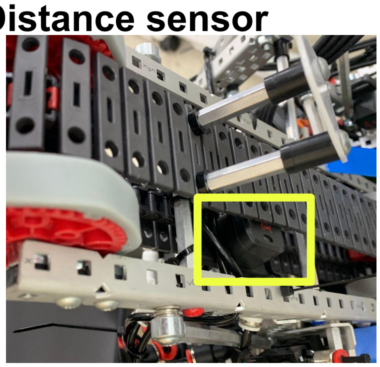
Overview

Sorting rings is absolutely essential as each point matters in High Stakes than any of the other seasons we have participated before, we cannot afford scoring the other alliance's rings.

This is a highly intensive task both mentally to our driver and also happens very frequently in the intense competition environment.

Automating sorting rings by colour greatly reduces the driver's duty and pressure.

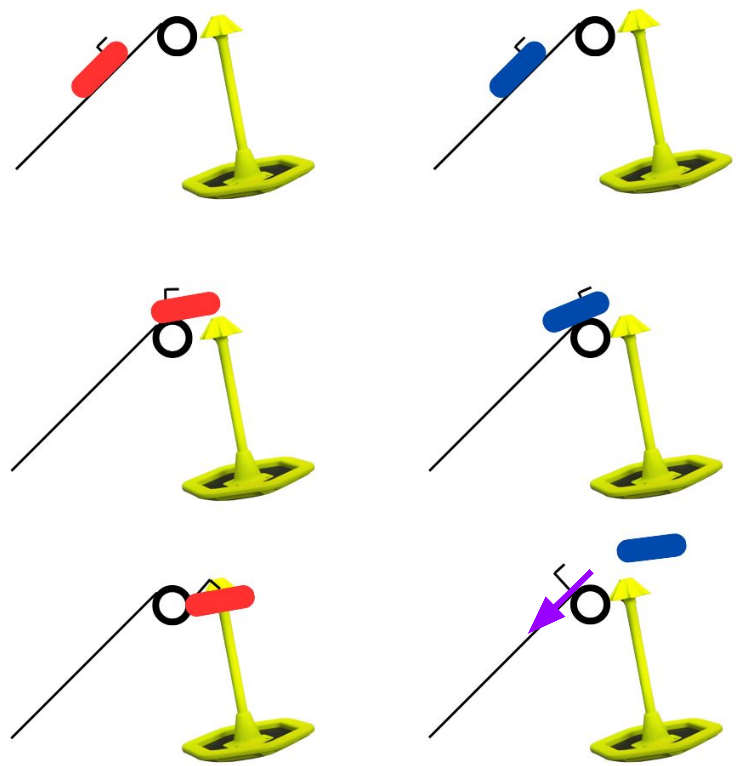
Specs

Vision sensor (colour) 	- Installed right behind the intake roller - Detects the colour of the ring 
Distance sensor 	- Installed on the delivery tread - Sends a positive return value when the ring reaches the sensor position

Working principle

The ring proceeds as normal if it is of our alliance (scored onto mobile goals / loaded into the lady-brown).

The ring is thrown off by a sudden stop of the tread.



Graphical illustration of the working principle

If a ring of our alliance is detected, the delivery tread will spin continuously and score the ring onto the mobile goal.

If the ring is of the opposing alliance, at the top the delivery tread will come to a sudden stop, using momentum of the ring to throw it away.

REDESIGN

DRIVETRAIN

IMPROVEMENT - Drivetrain Hot-swap Motors

Problem

The drivetrain motors **overheat after three-four minutes** of intensive operation. This is a dire problem especially when we need to compete in two or three matches in a row in elimination rounds.

Overheated motors significantly hinders performance by slowing down or even not generating enough torque to even move at all. No matter how good the motor is if the motor overheats it will cause a **huge toll on performance**.

If the motor is overheated after the game, if the six motors are cooled unevenly, it will affect our autonomous period causing the robot to wobble and might even fail, so using liquid coolants and fans to cool them down is risky and not a long term solution.

Hence overheating is a serious problem that has to be addressed carefully and appropriately.

Solution

“Hot-swappable” motors are used in the drivetrain. It allows us to swap the motors between matches, ensuring consistent performance.

It works by installing just the VEX V5 Motor’s cap onto the drivetrain by disassembling the motor from the four screws they have at the corner.

Rubber bands are used to hold the motor with cartridge onto the cap and connects to the drivetrain.

By doing so, we can swap used motors for fresh motors after each match. Effectively eliminating the problem of uneven cooling caused by coolants and fans.

IMPROVEMENT PROGRAMMING

IMPROVEMENT - PROGRAM - Odometry & PID

Problem

In the previous competitions our autonomous period program are very uncompetitive as we could not figure out a **way to precisely maneuver the robot using program**.

This is caused by various external factors outside of the code of the program, such as motor condition, field condition, etc. It turns out that it is very difficult to self-build an odometry algorithm that is reliable and consistent. Therefore, we decided to try the Lemlib odometry library and start learning the principle of odometry all over again.

Solution Overview

Learning from the top-flight teams around the world through their online documentaries / videos, we found out (1) odometry can be used to accurate track the robot's position in the field and (2) Proportional-Integral-Derivative (PID) control loop can make the robot travel a consistent path every time.

Odometry

Odometry is used to track the robot's real-time position on the field (x, y position and heading angle).

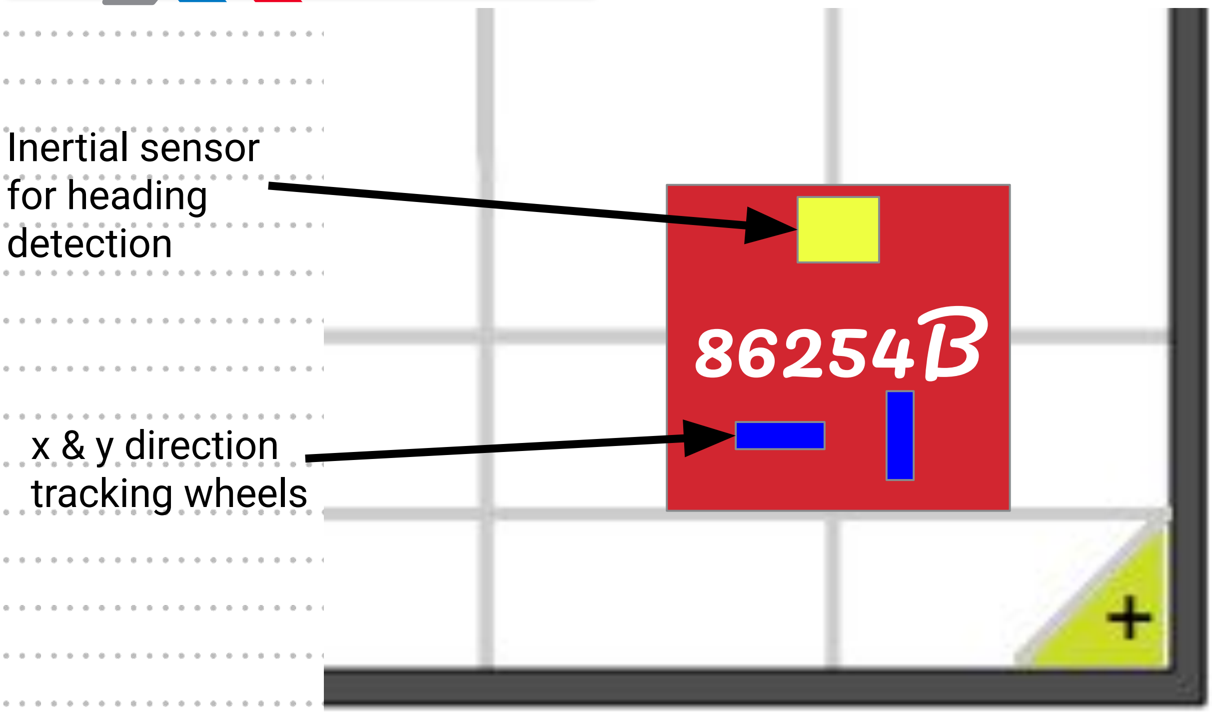
Relying on the drivetrain motor's rotational reading is inaccurate and we need dedicated instruments to measure distance travelled.

We have installed inside the drivetrain **two tracking wheels made of 2-inch mecanum wheels** in perpendicular to each other to measure the *x* and *y* distance travelled by the robot. The 2-inch wheels are used to reduce its size so that we can spare more of the precious space inside the core of the robot for other components, and mecanum wheels are used to not obstruct motion.

The wheels are connected to **rotation sensor** which are much more **accurate** in tracking position.

They are rubber banded to make sure they are constantly touching the ground to keep measuring.

Odometry



Inertial sensor are used to detect the robot's heading, it facilitates turning.

PID (Proportional-Integral-Derivative) Control Loop

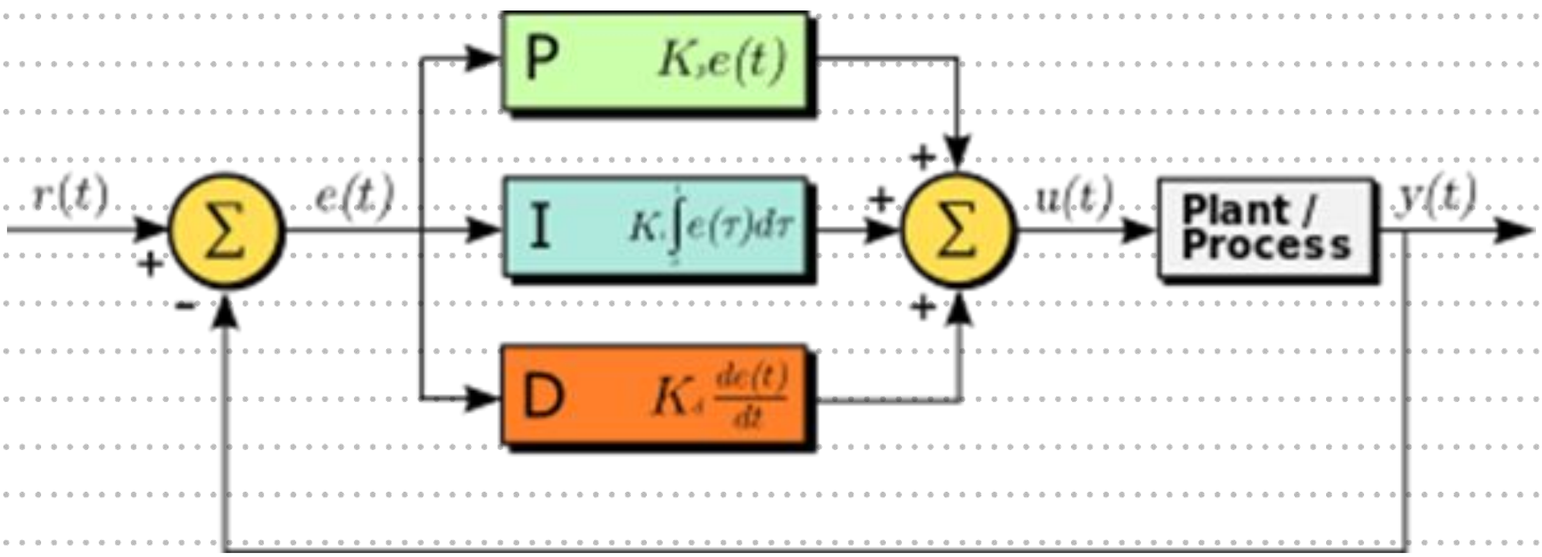
$$P \sim k_p e + k_i \int_0^{t_c} e\, dt + k_d \frac{\delta e}{\delta t}$$

P : Power output to the motors
e : Error = *target_position - current_position*
k_p : Weighting of proportional component, to be fine-tuned
k_i : Weighting of integral component, to be fine-tuned
k_d : Weighting of derivative component, to be fine-tuned
t_c : Current time
t : Time

PID (Proportional-Integral-Derivative) Control Loop

The control loop is an active feedback loop that takes the current motor readings (current output) to feed into the algorithm as input)

PID loop is a **feedback-based active control loop**, it takes in current data readings from the odometry wheels and inertial sensors and feed those sensor outputs into input to form a loop.



Introduction to PID [https://info.erdosmiller.com/blog/introduction-to-pid-control-loops]

PID (Proportional-Integral-Derivative) Control Loop

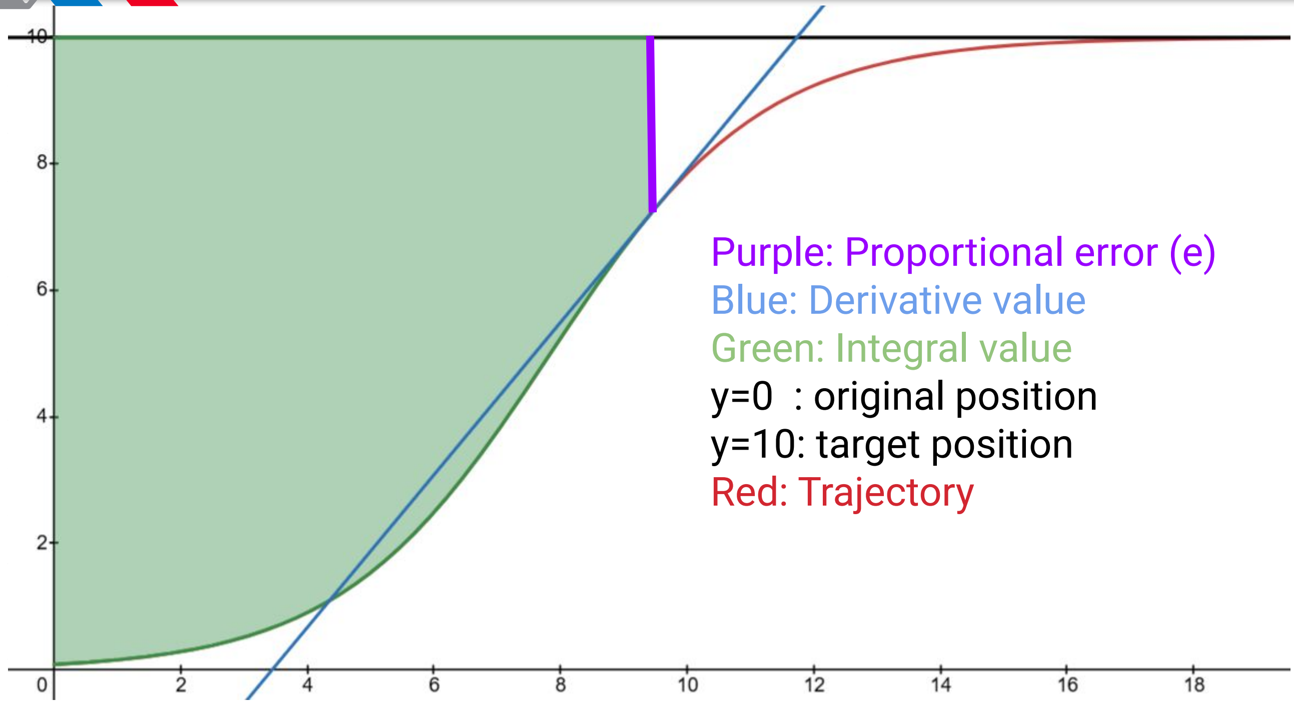


Fig. Typical Robot Movement Graph

$$P \sim k_p e$$

The **PROPORTIONAL** component provide **immediate response to the current error**, it applies more power when the robot is further away from the target and gradually reduces power output as the robot approaches the target.

$$P \sim k_i \int_0^{t_c} e\, dt$$

The **INTEGRAL** component is proportional the the error accumulated through time, it is represented as the green area between the target distance and the robot's trajectory. It aims to **eliminate the residue steady-rate error** (e.g. 0.5 cm away from target and the proportional component is so small that the robot is not moving) that might remain after the proportional component.
The integral's upper limit is the current time and the lower bound is the time when the current movement starts.

PID (Proportional-Integral-Derivative) Control Loop

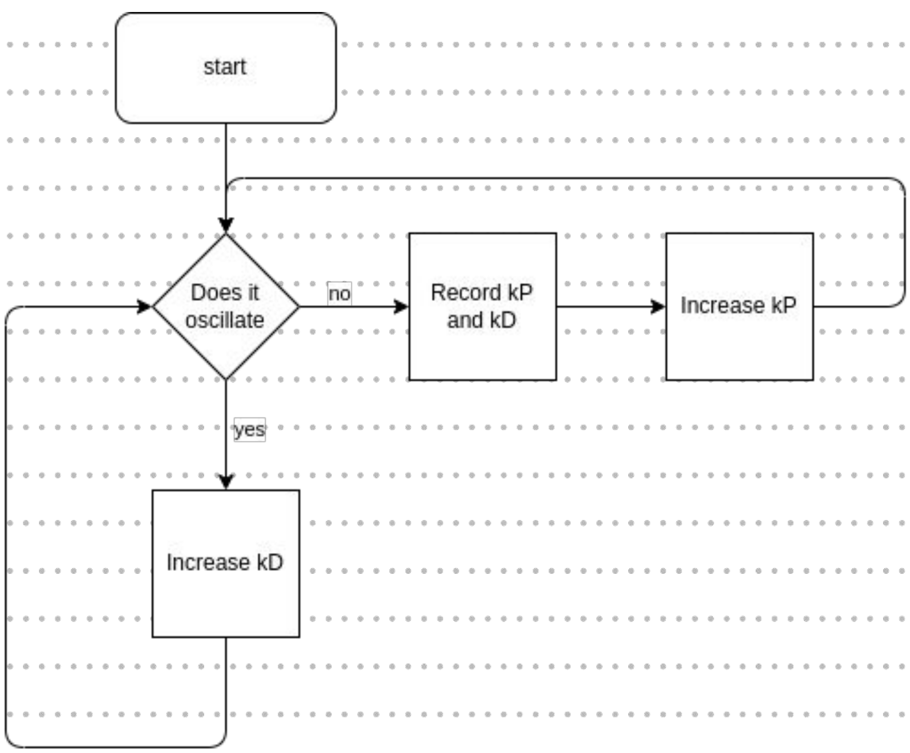
$$P \sim k_d \frac{\delta e}{\delta t}$$

In the **DERIVATIVE** component is where the power applied to the motors are proportional to the rate of change of error.
It reduces power output when the error is reducing too quick, and increases power when the error is reducing at a very slow rate.
This allows the PID loop to **prevent overshoot and oscillations by anticipating the future movement of the robot** by smoothening the robot's response.

Turning the coefficients

We use lemlib to write the PID on PROS (more to be elaborated in [*Section A9 Programming*])

We turn the PID coefficients (k_p, k_i, and k_d) according to the documentary by lemlib.



PID tuning, LemLib, https://lemlib.readthedocs.io/en/stable/tutorials/4_pid_tuning.html

PROS Programming

PROS is a lightweight and fast alternative open source operating system for the VEX V5 Brain. It allows us to write program in C++ to program our robot in a more advanced manner instead of using coding blocks in VexCode.

This allows much more **flexibility and functionality**, it makes the programming faster and also allows the robot to have a higher level of functionality.

Advantage 1: Parallel computing
PROS's capability to run parallel at runtime is a huge benefit - Run the program for **drivetrain concurrently with the intake** - **Saves us a lot of time** during the autonomous period where every second counts

Advantage 2: LGVL (Light and Versatile Embedded Graphics)
Using C++ to programme the Brain allows us to include the LGVL library - Customise the Brain screen to **show key parameters**, this is especially useful during PID tuning and runtime **debugging and logging** - Keep only the essential information on display

Advantage 3: LemLib (for PID)
LemLib is a library on PROS for PID control (details of PID has been explained in the PID section of drivetrain). - LemLib **provides ready-made PID** functions, leaving parameters such as weightings on integral, proportional and derivative components for us to tune to achieve the best PID configuration for our robot - Saves time in writing the PID on our own

Advantage 4: Programming in C++
Both Michael and Michael have participated in Informatics Olympics, we are more comfortable with C++ than Blockly in VEXCode or Python. Using our already matured programming expertise, it is easier for us to both write the program and to debug.

IMPROVEMENT -Strategy - Autonomous

Autonomous - General

Gain possession of the 5th mobile goal in between the two alliance sides as soon as possible using the Katana.
This will give us an advantage of having three mobile goals in our alliance side while the opponent has two only, the mobile goal will be released in our alliance side.
We then use our rear mobile goal clamp to grab mobile goals fill it up with rings using [A4 Intake, Delivery & Hook Scoring, P. 20].

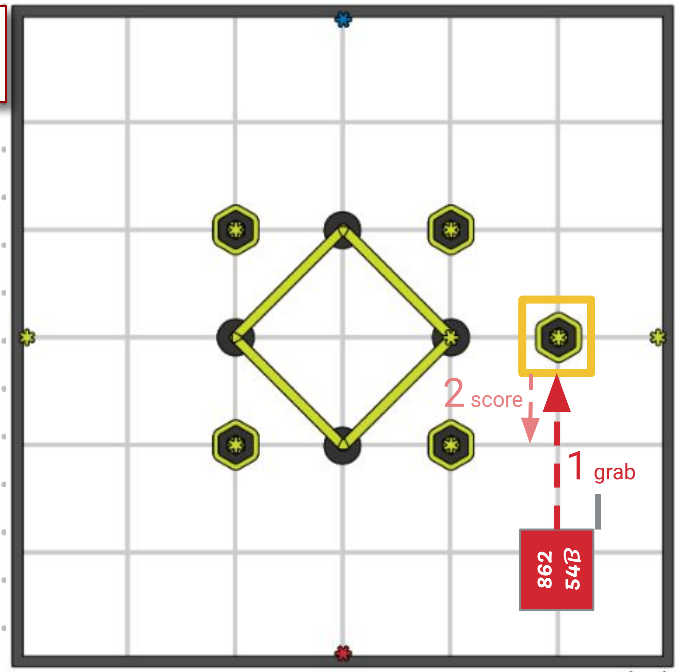


Fig 1. Start of autonomous period

Securing three mobile goals at our side, our robot will **end the autonomous period at the channel between the positive corner and the opposition half**. This is essential because we need to defend and hold onto the positive corner at our alliance side. Ending our autonomous period at the channel secures our control over the mobile goals, also prevents the opposition from stealing the positive corner (as seen in previous competitions around the world this is a common strategy across all teams).

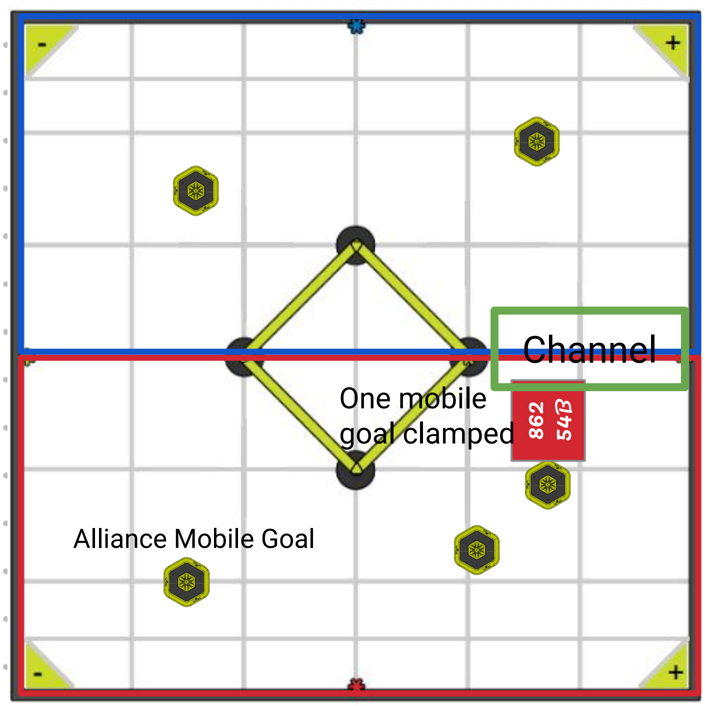


Fig 2. End of autonomous period (Top)

IMPROVEMENT - Strategy - Driver

1. Start -> Swap

We or our alliance teammate will first put the mobile goal they have already scored on into the positive corner while clamping the third mobile goal which should yet to be filled (illustrated in Fig. 1). The other member in the alliance then can freely move around the field and fill up the mobile goal clamped.

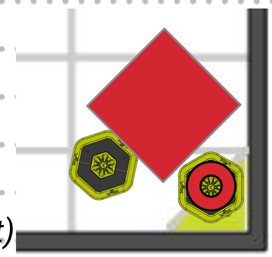


Fig 1. (Right)

After the mobile goal is filled, we will swap the two robots (ie the one originally defending the corner will come out and the other takes up the task of defending the positive corner), as illustrated in Fig 2.

The swap will allow robot 2 to fill up the mobile goal. This allows us to guard the positive corner alternatively while filling up the three mobile goals we possess. Securing points every match in a very controllable manner.

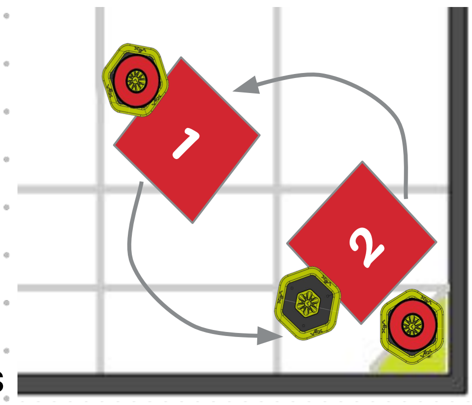


Fig 2. Swap

2. Wall Stakes

While guarding the positive corner we will observe if there are any opportunities to score on the wall stakes which is between the two positive corners, our fast drivetrain enables us to quickly score onto the wall stakes while not opening too much of a time window for the opposition to steal our positive corner.

3. End game (last 30s)

In the last 30 seconds we will mainly focus on scoring on the Wall Stakes, however it is a crucial period for our spotter, we will constantly keep a close eye on the opposition mobile goals, to grasp every opportunity to steal an opposition mobile goal and put it into the negative corner.
We have seen many teams fumbling the end-game as they have their mobile goal stolen and put into negative corner. We will put **pressure** on the opposition trying to **force a mistake under pressure** but at the same time defend our mobile goals well.

Conclusion of Robot development until Hong Kong Regional Championship

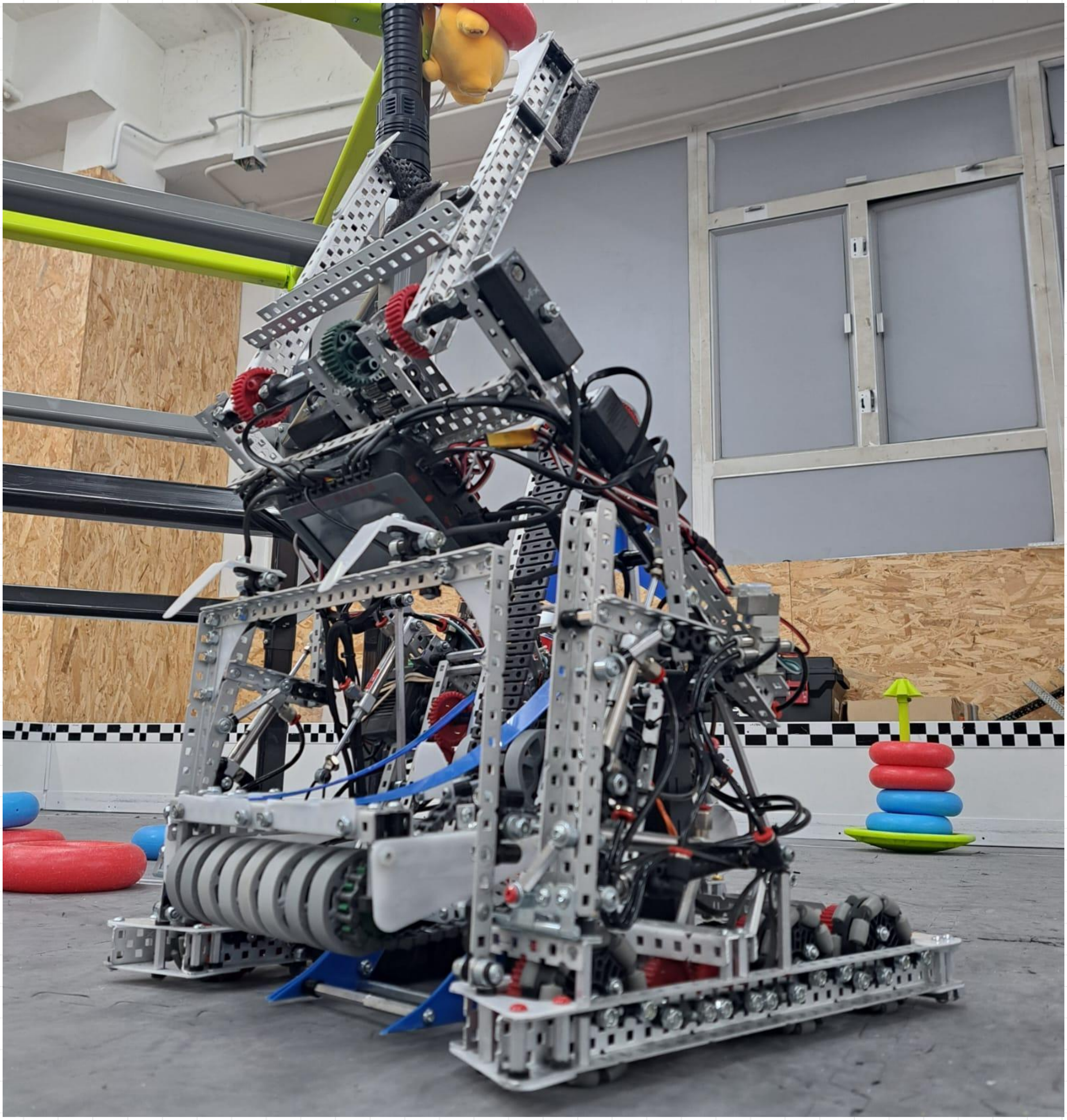
Problem 1: Wall Stakes	
Issues with generation 3	Improvements in generation 4
● Too slow to load - Requires the intake to reverse at the exact location into the cage - Depends on the hook to push the rings into the cage ● Difficult to control (driver feedback) ● Scoring depends on field condition - Momentum of robot to push the rings down the stake - Inconsistency & inefficiency Wall Stakes are becoming more important in matches than before.	**Introduction of the lady-brown mechanism** ● Loads the rings at the top of the intake - Decreases time needed to load - Eliminate uncertainties that affects loading using PID ● Simpler and lighter design makes it easier to control ● Lady-brown mechanism to score directly onto the Wall Stakes - Without external dependencies - Larger operational radius - More consistent - Higher accuracy & conversion rate

Problem 2: Mobile Goal Scoring	
Issues with generation 3	Improvements in generation 4
Efficiency is not up to our standards, there are still plenty of room for improvement and fine-tuning.	● Reworked intake & mobile goal scoring mechanism ● Fine-tuned colour sort mechanism

Problem 3: Robot condition
Issues with generation 3
Generation 3 was **heavily worn** during the PAS-VEX Signature Event 1. Intake does not work as smoothly as it used to 2. Wall Stakes scoring mechanism sometimes cannot lift up anymore

ASSMEBLED BUILD

WHOLE ROBOT



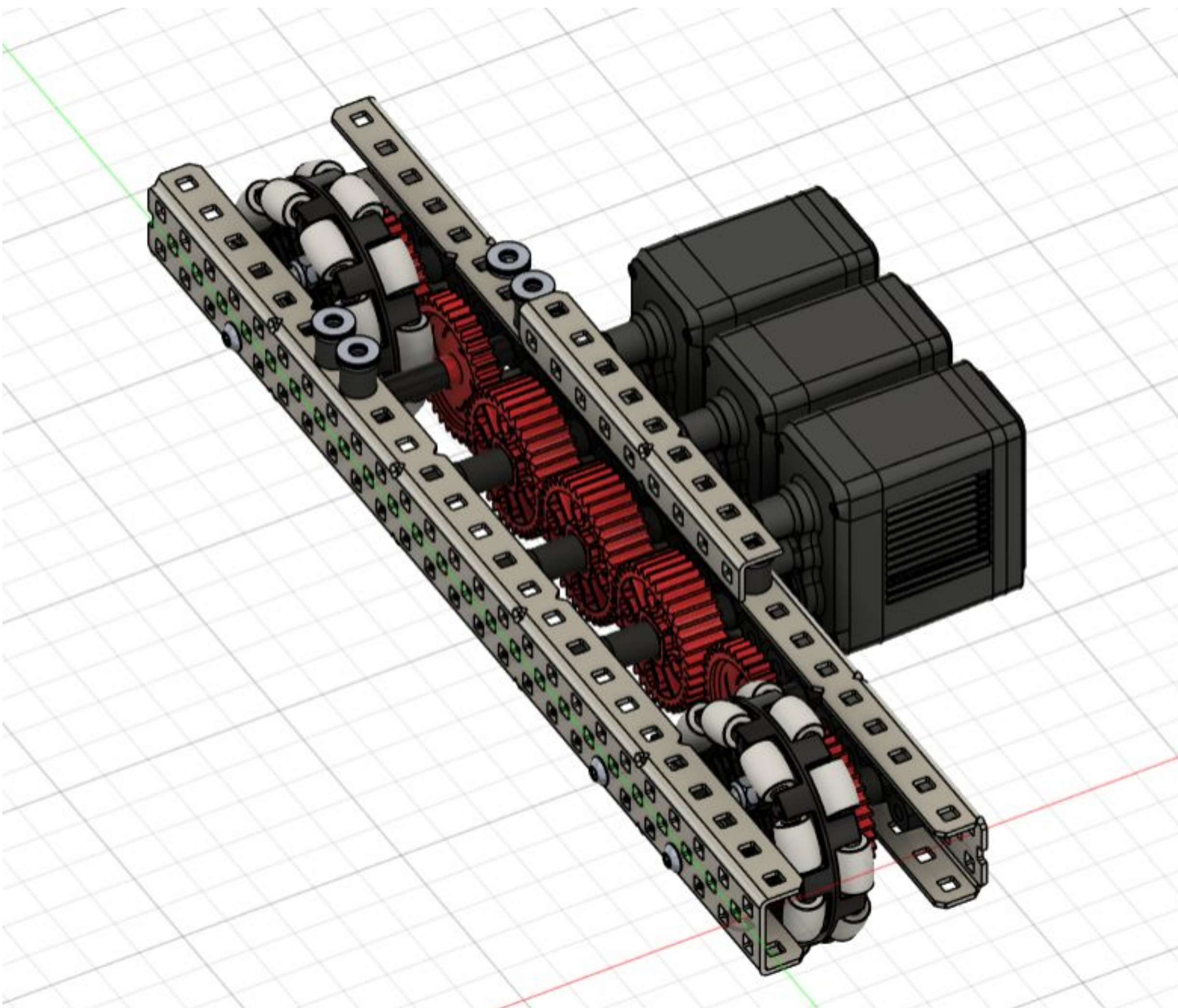
IMPROVEMENT

Drivetrain

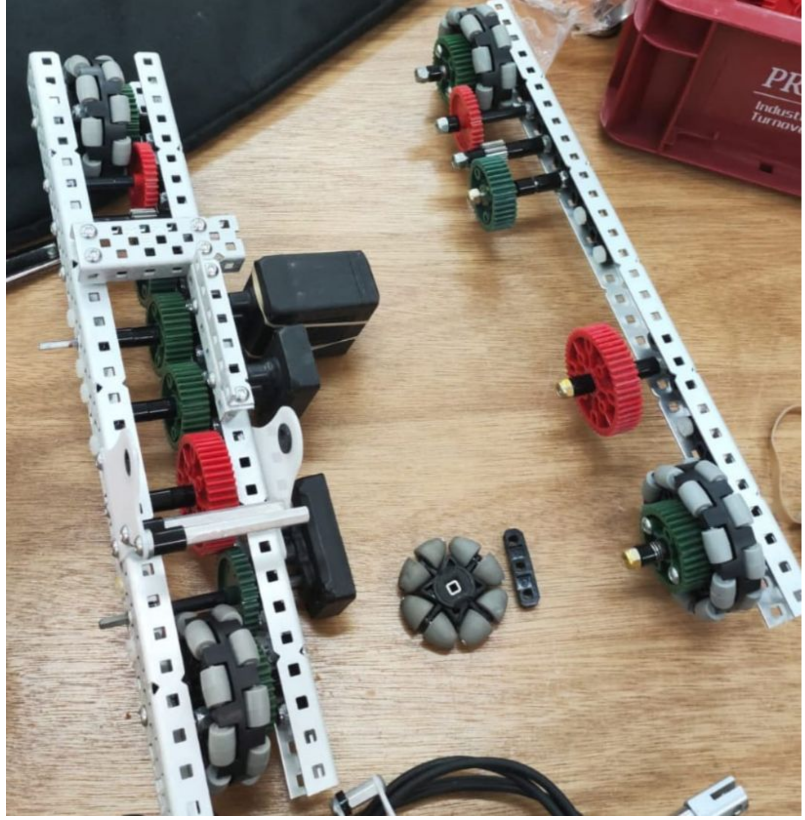
During the Hong Kong Regional Championship, we found out that the speed of our robot is not enough to compete against other teams in mobile goal / ring rush in autonomous period. Therefore, we decided to modify our drivetrain to increase the rpm.

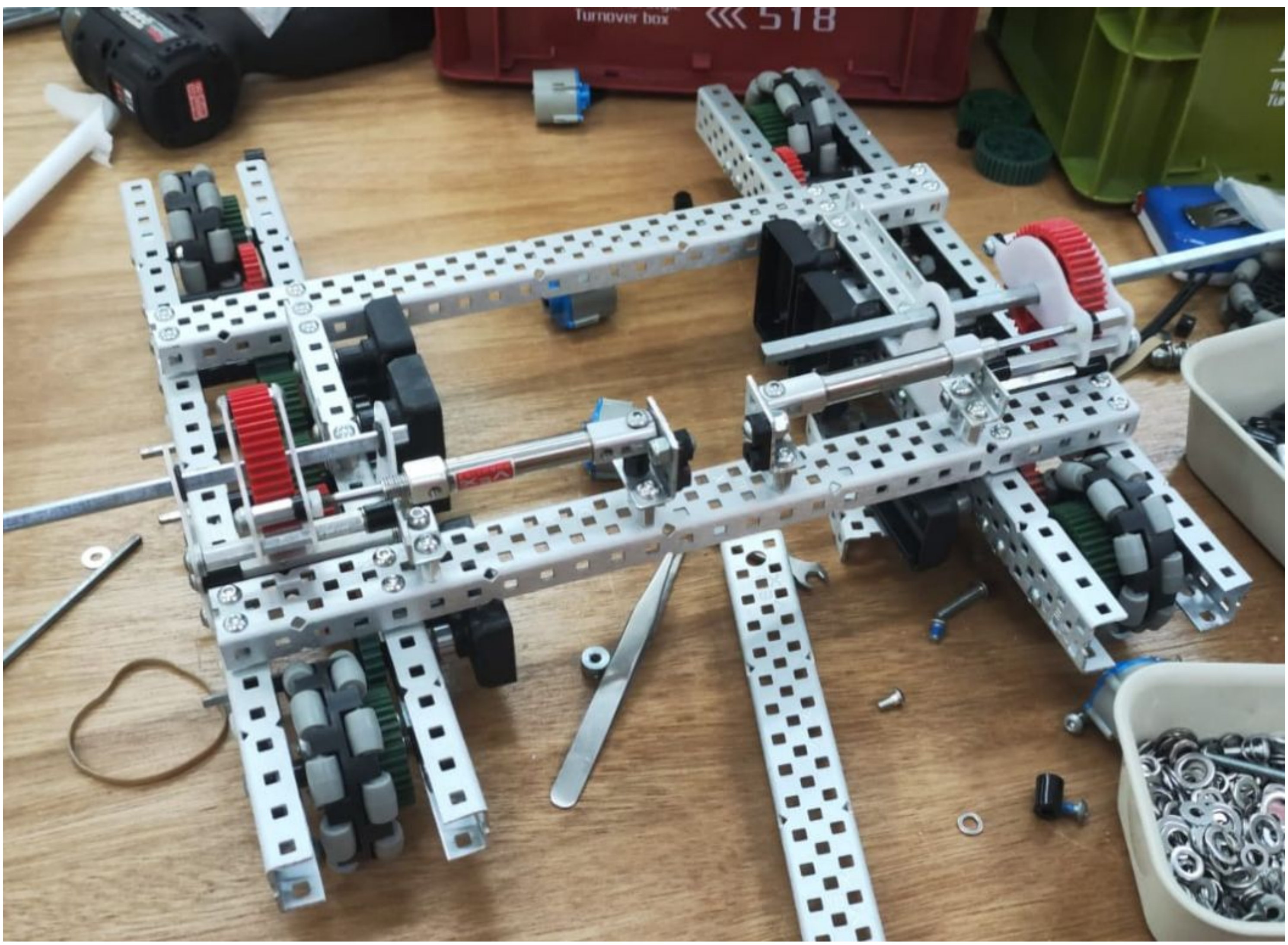
We keep the choice of 2.75 inch omni wheels but instead change the gear ratio to 1:1, meaning that we are having a 600 rpm drivetrain

CAD Plan - Final



Assembled build





CLIMBING MECHANISM

IDENTIFY PROBLEM

Climbing mechanism

Goal

We will identify an objective for our robot so that we can address it and build a Tier 3 climbing mechanism

Problem Statement

We need a mechanism to climb to the top of the ladder

Solution Requirements

- Must only use legal VEX Robotics Competition parts
- Must fit within 18”x18”x18” cube for starting size limit
- Must fit within the 24”x18”x36” expansion size limit

Solution Goals

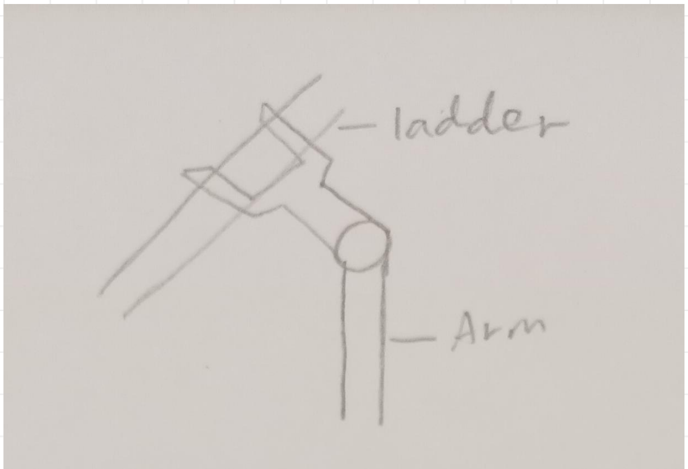
- Climb to Tier 3 ladder position in less than 30 seconds

BRAINSTORM SOLUTION

Climbing mechanism

Goal

We will brainstorm possible solutions for our climbing mechanism so that we can select the best one for our design

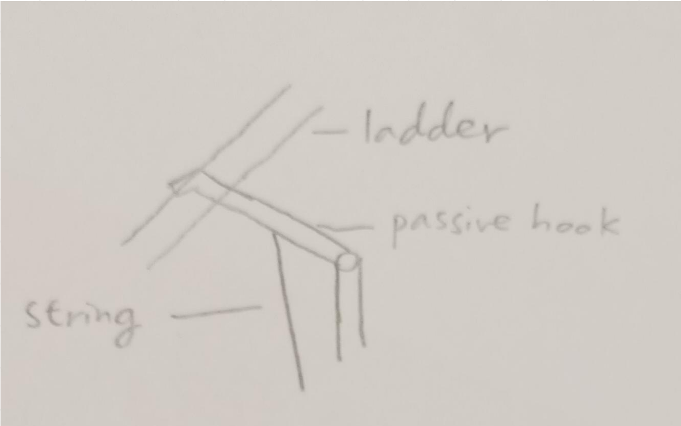


Possible Solutions - Climbing method

Robotic arm

- A robotic arm with rotation joint
- Grab the ladder and climb up by motor

Positives	Negatives
• Simple	• High torque needed • Easy to bend



String and Passive hook

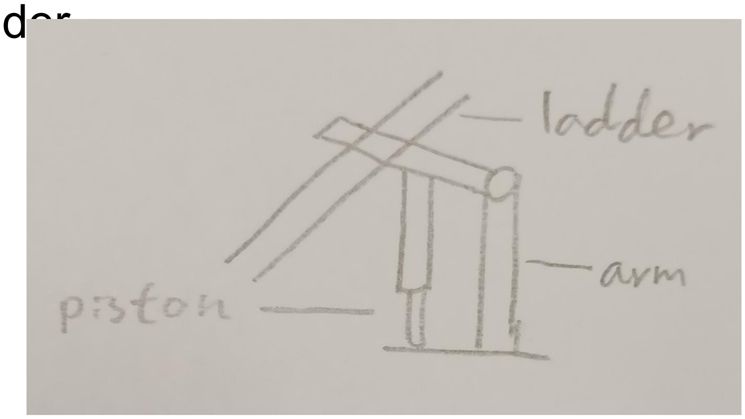
- A string connected to passive hook and motors
- The motor pulls the string and the hook down

Positives	Negatives
• Fast • Easy to aim	• Easy to bend or break due to large force at a point

project Climb name Michael date 31/3/25

Piston and passive hook

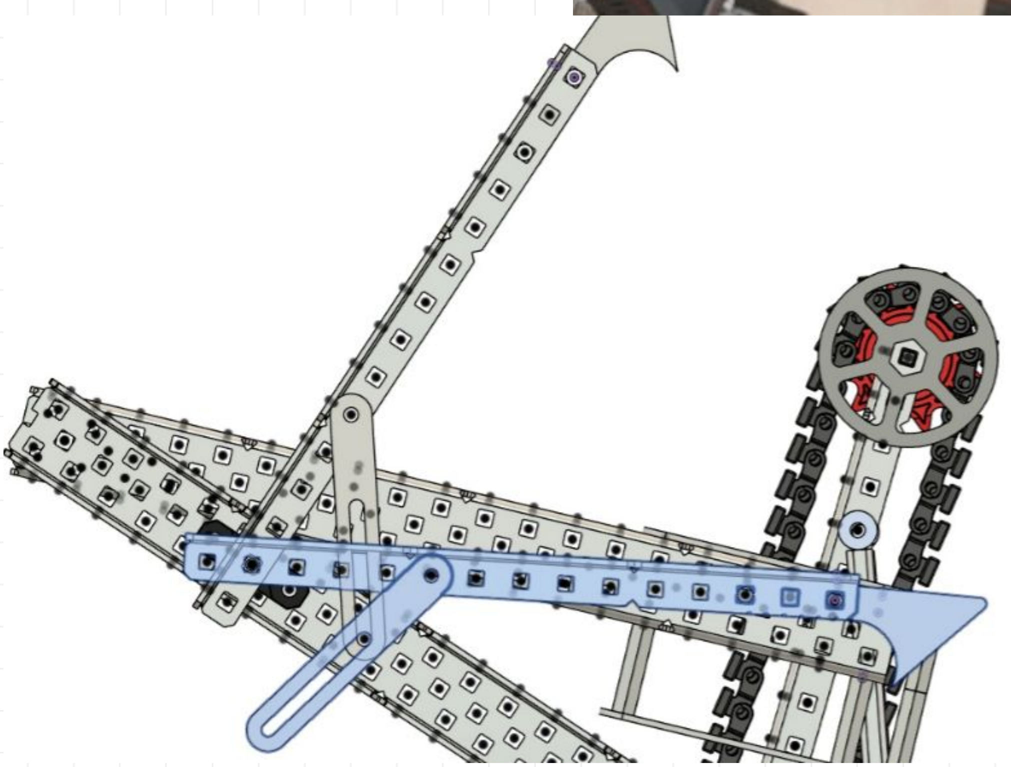
- Passive hook hangs on the ladder
- Piston pulls the robot upwards



Positives	Negatives
• Fast • Huge force can be applied	• Extremely high pressurized air consumption

Prototyped solutions

We have decided to prototype 2 possible solutions to test their performances



SELECT AND PLAN

CLIMBING MECHANISM

Goal

We will select the solution that is best for our team so that we can plan how to build it

Prototype testing

- Test: Speed
- Test Procedures
- Mount the mechanism onto a testing robot
- Start climb to the top of the ladder and start the stopwatch
- Stop the stopwatch when it reached the top record the time needed

Test Results:

Time taken to reach the top of the ladder					
	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Trail 4 (s)	Average (s)
Piston and passive hook	49.73	44.82	43.12	48.02	46.4225
String and passive hook	43.8	39.02	44.18	44.07	42.7675

Fastest: String and passive hook

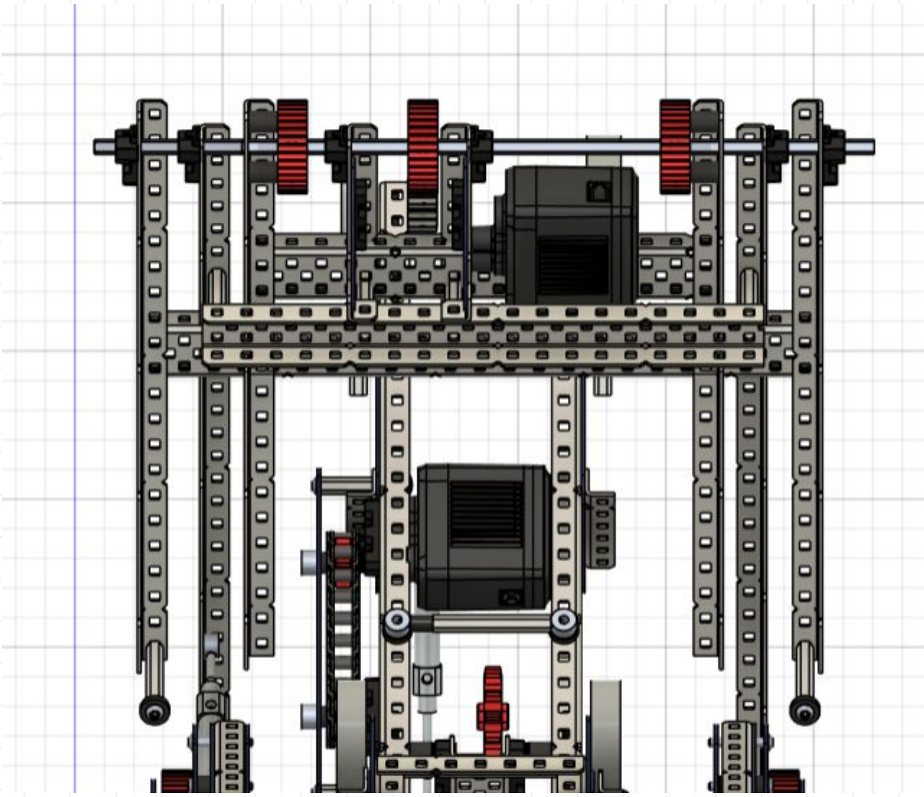
Decision Matrix - Climb type

Speed	How fast the design reaches Tier 3 ladder
Power	How energy efficient is the design
Consistency	How consistent is the design

	Power	Speed	Consistency	Total
Piston and passive hook	4	3.5	3	10.5
String and passive hook	3.5	4	5	12.5

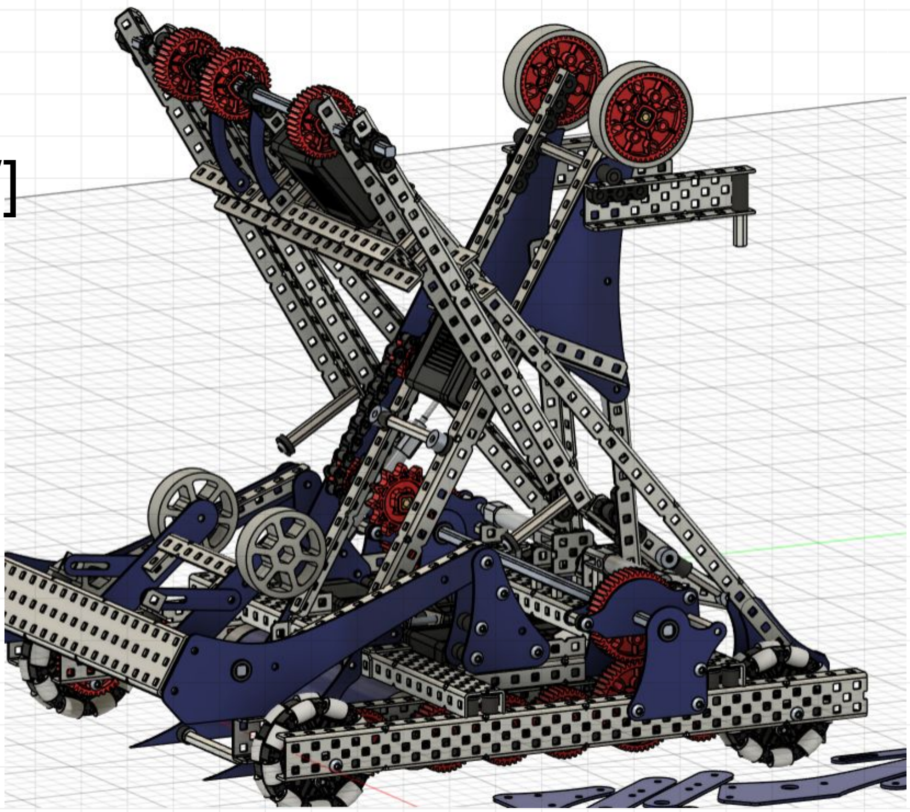
We will use string and passive hook because of its high overall score on our priroties.

CAD model of solution



[FRONT VIEW]

[ISOMETRIC VIEW]



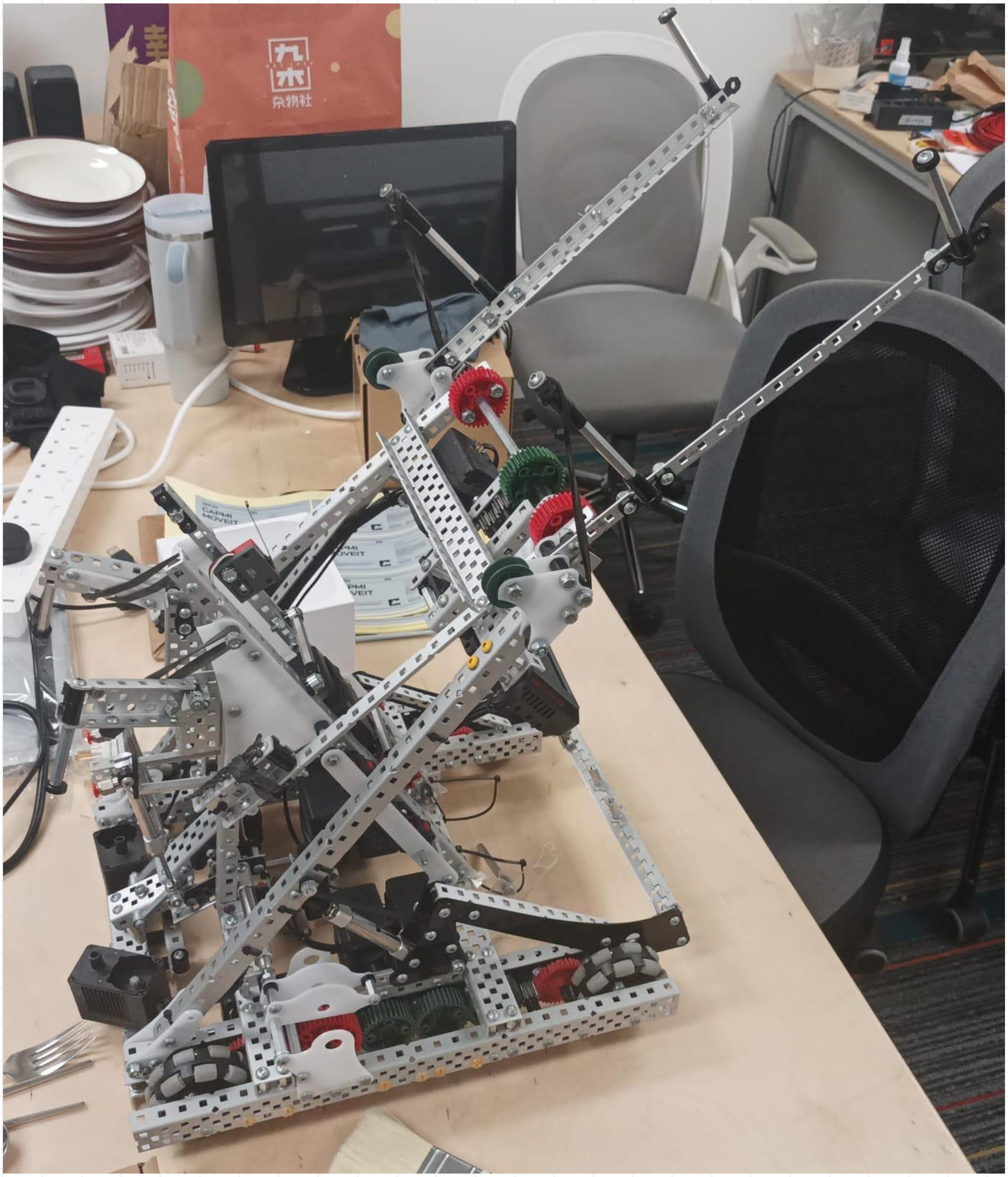
BUILD SOLUTION

Climb Mechanism

Goal

We will build our planned solution according to the CAD so that we can test its performance

Assembled Build



TEST SOLUTION

Climbing Mechanism

Goal

we will test the solution so that we can see if it meets our requirements and goals

Solution Goals

- Climb to Tier 3 ladder position in less than 30 seconds

Test Results

- Climb to Tier 3 ladder position in less than 30 seconds ✅

Solution Requirements

- Must only use legal VEX Robotics Competition parts ✅
- Must fit within 18”x18”x18” cube for starting size limit ✅
- Must fit within the 24”x18”x36” expansion size limit ✅