ISB HS Robotics

The Tutorial of Things You Need

Version 2025

Second Revision · April 6, 2025

William Pan
Class of 2026

VEX V5

I hope someone will be interested in this one.

Table of contents

Prologue

Thank you for reading this “Tutorial”. I do not expect this will pass on for a long time, but I hope this can guide some of the new ISB Robotics member in the next **five** years. I expect the general rules of VEX V5 will still work, such as the build limit.

In order to make it a little bit more easy-to-read, I will attempt to include more pictures than texts to explain. I hope my experience will help you to better understand this system.

This tutorial is intended to not just teach new members about all the items in ISB Robotics but also provide a first aid on the field when competing and troubleshooting malfunctions. I will also include some guides for new team leaders to manage their team.

In the Second revision I reduced a lot of unhelpful information and summarized them into logic chains, so you can easily know the reason and the benefits.

Again, I hope this can be more of interesting but not some random piece of paper.

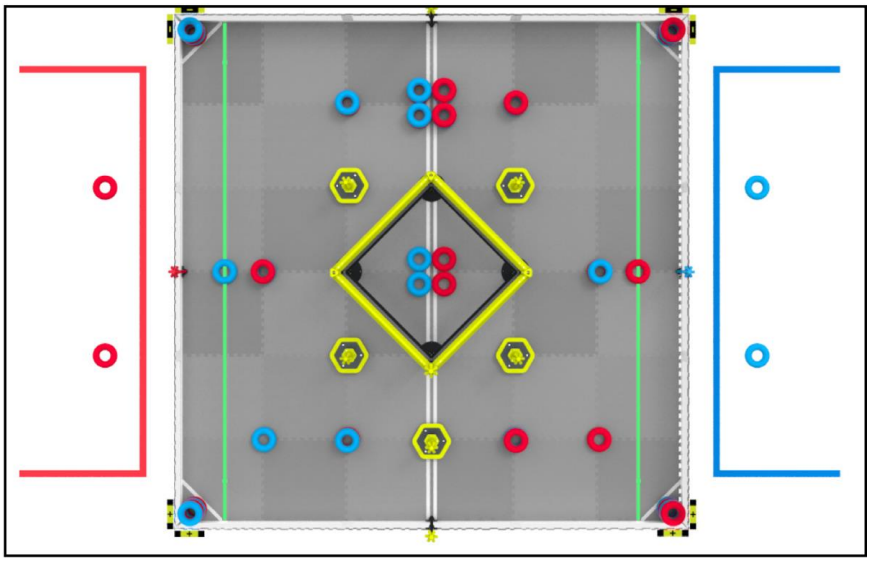
Part I: Fundamentals of VEX V5

1.1 The Basic Design of V5 System

V5 is antagonistic, because two different alliances are in the same field. If you already know V5 systems, Skip it.

➔ You have one (1) alliance, and two (2) opponents, which means the game is 2 VS 2 (teams).

The alliances start at two sides of the field (or arena), with size of **12*12 feet (365.7 cm)**. For example, in 2024-2025 game High Stakes, the start position looks like this:



Where the green line is the start line.

➔ You can see the position can be important; a good starting place is important, because it can increase your efficiency in the first few seconds, so you can win easier.

➔ You will randomly go to Red of Blue in different matches, so prepare two (2) plans for starting[1].

- V5 includes robots bumping and ramming to other bots. Teams are responsible for their own robots; intentional ram and collision is common.

  ➔ Your robot needs to be stable, or in other words, "Robust" (*Resistant to change from exterior factors*), it cannot just get broken after several collisions.

[1] Note that four total robots also mean 4 total possible starting points.

- V5 allows teams to cut the materials but not completely modify them.
  - ➔ Cut the metals and stuffs when you need, but you can't melt it and form into another shape.
  - ➔ Don't make your build debatable, because it will waste your time arguing with the judges, therefore measure and assess whether your robot is legit.
- V5 Changes their game manual and modifies rules after some month, after the publish of the Season game.
  - ➔ Pay attention to the competition's specifications, because they might not use the most updated version of the manual.

1.2 The Game Elements

This is a short section: The game elements are where the robot will contact and move around, will be design in shapes where you need to secure it.

If you design a flat piece and just want to push them, they may not listen to you and go anywhere you don't want them to go.

- ➔ Design something that holds the element to prevent other robots from stealing it.

- You basically have to move the score item onto/into a goal. This design occurs for all of my contributing years, 2023 and 2024 (Over Under and High Stakes). Over Under wants you push a ball to the goal; High Stakes wants you to put a donut into a stake.

Basically: **take it, move it, place it.**

- This is all you need in the match. You need to design:
  - ➔ A mechanism that takes the object (intake).
  - ➔ A *Drive Train*[2] that moves the robot around.
  - ➔ A mechanism that places the object to the goal (Deliver System).

1.3 Other Rules

Motors

There is limit for Motors usage. It limits you can have no more than **88 Watts** of total power. **Big motor**

[2] Drive Train (底盘) is the basic part of the robot. If you don't understand, it is like the wheel, engine and backbone structure of a car (while other parts like intake, is the light bulbs of it.)

costs 11 Watts and **small one costs 5.5 Watts**. Therefore the limitation is no more than 8 Big motors, or some other stupid combinations.

Safety

This part sounds like some common boring rule, but in Vex things can actually get dangerous. If you intentionally eject a part of your robot, that is violating the rules, and your robot will get disabled due to safety reasons. For example, (although it is stupid and no one will probably do), my robot eject a spear in order to hit another robot. Well, that spear can go somewhere else and may hit someone. Don't do things like this, we all know.

Building Limit

The limit is 18 inch * 18(in) * 18, translation: a 45.72 cm cube. Everything of the robot must be folded in this cube area when you start the game. However, the reason I say fold is because you can extend then over the limit after the game started.

- Maybe you think 45 cm should be enough, but when you are actually doing it, it's always not enough, because Vex element designs are ineffective and chubby. Brain, Battery, pneumatics canister, motors and all other stuffs all need a home to be placed.

  ➔ Therefore, measure when your team is building and designing. This is more of a hard limit, no within size limit = no right to join the competitions[3].

Teachers can't help much

The role of a teacher is highly restricted in Vex V5. They can't directly help you build, program, or be on the field when matching. Not to be mentioning that our ISB Robotics doesn't really get supports by adults! The only people you can rely on are your teammates, experienced senior players and the execs.

Holding Rules

"Holding" is specified in the game manual (for basically every year), it limits what your robot can do to other robots in a game.

- (Trapping) If you block an opponent that they can't move or escape anywhere, you can only do that

[3] There will be an inspection before every competition. There will be referees that really takes a look if you are not getting the rules obeyed. If you don't obey, they don't let you pass. So please treat it carefully, don't think that "1cm over is ok", it is not ok, and you won't pass.

for 5 seconds[4]. (If the opponent is not trying to go anywhere it doesn't count)

- (Pinning) You are trying to stop an opponent (robot) from scoring, getting a field element, or touching other robots.

  ➔ This pinning is hard to judge whether you did it intentional or it wasn't on propose. But keep in mind that people have common sense, it would be obvious if you do it intentionally.

My advice for "Holding" is you don't even try to do that. It's not worth it, you can use that time to do your robot's job.

It really (and only) depends on what you have been done

Sometimes we wonder why my team leader is our leader but not doing things. This can be the case, everyone must've had some kind of bad leaders. But don't worry too much, because in this Engineering field, what matters is how much work you have been done, not your title. You can be a normal team player, but you work a lot, even more than all the leaders. Or you organize the team enough that you are in fact the "actual" leader. So please don't pay too much attention on those titles, the most important thing is not about that. You should believe in yourself. Show your results generously to others and tell them that **you actually did a lot**!

[4] This 5 second rule is manually counted by referees, and it works only when that judge counts. I have seen that some students think they are being pinned so they started to count by themselves. That won't work, you can actually just yell holding to drag ref's attention, rather than counting yourself. Also, that 5 seconds is not by a stopwatch, but ref counts manually, so the exact time will fluctuate. Also (also), if you hold opponent and release, there will be a 5 second cooldown, where in this cooldown time, if you hold them again, the time will resume from the last time you hold them. Also (x3), I think the entire team shares the countdown. So if Robot A traps, then Robot B continues to trap, the countdown will just resume (in that 5 sec cooldown). Don't argue to them, **because all I mentioned here are in the rules.**

Part II: Designing

2.1 Drive Train

The Drive Train is the base of your robot. This is the most important part, because if the Drive Train suffers from anomaly, you will stop moving and can't do shit.

Speed: Motor and wheel size selections

Remember, Your Drive Train's efficiency determines a lot. Because the more effective you complete works, the more score you will have, therefore winning the game easier.

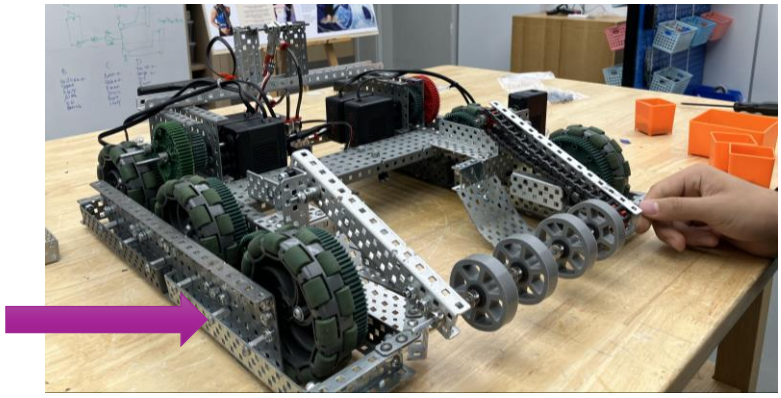
But every year this design will need to be different. For some season, more defensive robots are better. Fast bot is not always the best. Ask yourself before the build:

- ➔ Are we making the robot defensive or offensive, why?
- ➔ Is there any game element that requires us to move around quickly / hold in a position?
- ➔ Will we miss score opportunities if we are too slow / too fast?
- ➔ How will the system on the Robots gets affected by the speed?

Remember, the Drive Train carries all other systems for scoring. The last question is very important:

- If the scoring system gets wobble or unstable, not only fix the scoring system, but also think whether the Drive Train is too fast / too slow that also contributes to the instability.

Material Selection



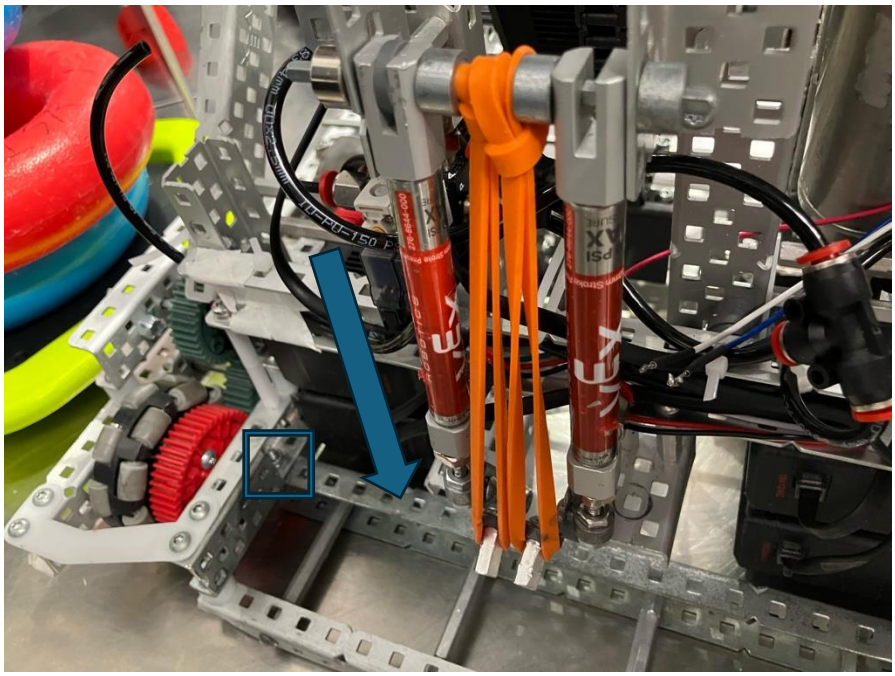
Check out this robot my team made in 2024 High Stakes season. This is made of mainly stainless steel; it is denser than aluminum therefore heavier, therefore the main purpose of this robot is defense due to low speed.

The speed and weight highly depend on robot's duty. Here's the advantage v. disadvantage chart:

	All/Most Steel	Only the backbone structures	All Aluminum
Robustness	High	High	Med
Weight	Heavy	Med	Light
Modify easiness	Hard	Easy	Easy
Replace damage parts chance	Low	Generally Low	Med
Pushing Power	Med	Med	Depends
Camping Power	High (Hard to get push)	Med	Low (Easy to push)

My advice:

- Use steel for only the base structures, e.g.:



This steel c-channel is a **basic supporting structure**. Previously, we removed it and replaced to aluminum for weight considerations, but then the entire drive train was wobbly. In this example you can see – although in the recent season, fast bots are good (that means overall aluminum), but steel is still critical for some components. This channel connects to two drive train sides (or wheel assembly), so it is very important and must hold them together, also resist the ram forces.

- Use aluminum for non-critical supportive parts. Less weight means more acceleration. The reason of more acceleration will be mentioned later.

  Remember: Aluminum is more prone to **deformation upon impact**, while steel is usually less so. Detect where the robot will suffer from collision and use steel to improve.

Torque and Wheel sizes [Heavy Calculations]

The definition of Torque is basically "How strong" is the motor, it is very related to friction but only some. The most popular in V5 building is 4-motor or 6-motor drive train (All in big ones, so each cost 44/66 watts).

The torque is proportional to power and spin speed, e.g., if you have a red (MAX 100 RPM) cartridge, it creates 3.0 Nm of torque. Also, the 5.5 Watts small one gets 0.5 Nm and 200 RPM MAX. Maybe confused, here's chart.

	Red Ct	Green Ct	Blue Ct	Small Motor
Max RPM	100	200	600	200
Torque (N*m)	3	1	0.5	0.5
Power Output (W	11	11	11	5.5

- Typically, you need at least 22 watts of power for mechanisms. Therefore, maximum of 66 Watts on Drive train is recommended.

  ➔ Gear down (Less final RPM) should add you some torque; therefore, gear up should reduce the torque.

  ➔ If you think you need more power, reduce the power of drive train (you have no other choices, sadly) to make sure things work.

Also, Physics tells us that the torque is proportional to the distance of the center[5]. ($\tau = F * r$) That means, the diameter of the wheel can also affect the acceleration of your robot. **The torque exerted by the motor is a fixed value.** That says, **in order to maximum out the linear force, the distance to the center must be smaller**. i.e., smaller wheels creates faster linear acceleration.

Before we dive into the calculations, and if you are reading this with a device (and you got a VPN), get into this link to see all the possible combinations of gear, wheel sizes, and motor cartridges. **This is the results you can get from my demonstration later.** Thanks to Andrew Elfman who made this chart.

https://docs.google.com/spreadsheets/d/1S0xQm0eDGq3fbDsam8x4ZP_xMLXirXvMVMGXvjNWbxc/edit?gid=0#gid=0

[Contains heavy Physics calculation. If you don't have time, skip it and simply click/type the link.]

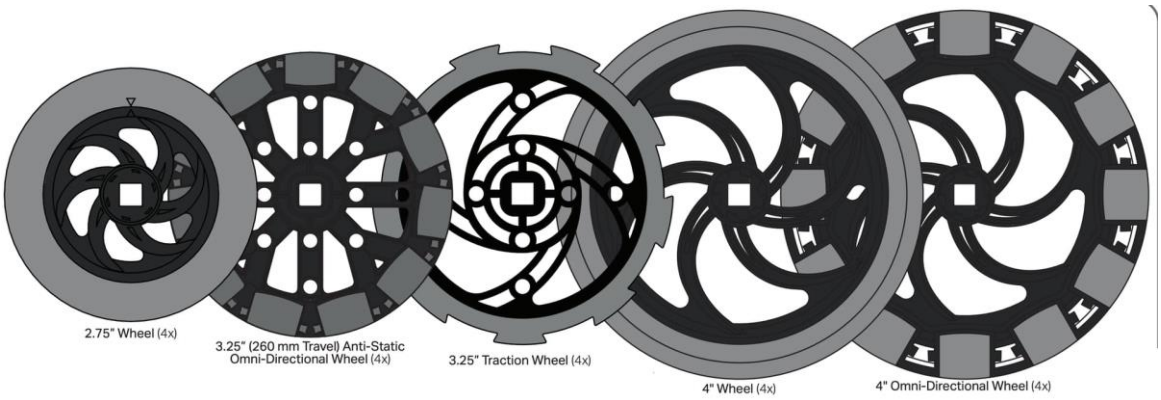
Here, I want to demo you a calculation to determine your robot's acceleration, and maximum velocity, so you can know how fast your robot is.

Wait, why is this important and we must learn all of that? **If you know your robot more, you can get**

[5] Enjoy if you are studying IB Physics HL. This is Rigid Body Mechanics

more strategies around it. You can know how fast your robot can run to the goal, to the object, and the performance of pushing other robots.

There are three sizes of Vex wheels (diameter): 2.75, 3.25, 4 inch.



(Image source: Lauren Harter, vex.com)

Let's assume your robot has a 6-motor drive, Blue Cartridge (600RPM // 0.5Nm Torque), geared down to 450 RPM, and has a mass of 5 kg.

First, you need to know how much torque you have. $(6 * 0.5) * \frac{600}{450} = 4\ Nm$

Where 6 is the amount of motor you have, 0.5 is the torque each motor has, 600 is the maximum RPM of the motor, and 450 is the geared final RPM of the wheels. Now, we can convert that to force.

$$\tau = F * r, \qquad 4 = F * \frac{\frac{2.75}{2} * 2.54}{100}, \qquad F = \frac{4}{0.034925} = 114.53N$$

Where tail (τ) is the total torque exerted by the motors, F is the total linear force exerted by the motors, r is the radius of the wheels, 2.75 is the diameter of the wheel, divide by 2 is the radius of the wheel, times 2.54 is the conversion to centimeters, divide by 100 is the conversion to meters.

The acceleration can be calculated:

$$F = m * a, \qquad a = \frac{F}{m}, \qquad a = \frac{114.53}{5} = 22.9ms^{-2}$$

Where F is the total force exerted by the motors, m is the mass of the robot, a is the acceleration of the robot.

That means your robot accelerated 22.9m/s in a second, quite fast. Now we want to calculate the angular velocity of the wheels, so we can know linear velocity (which is what we want).

$$\omega = \frac{\theta}{t}, \qquad \omega = \frac{450 * 2\pi}{60} = 47.124rad/s$$

Where omega (ω) is the angular velocity, theta (θ) is the revolutions it travels in a minute, 2π is the conversion from revolutions to radians (1 revolution = 2pi), divide by 60 is the conversion from minutes to seconds.

Now we can know the velocity of our robot.

$$v = \omega * r, \qquad v = 47.124 * 0.034925 = \mathbf{1.6458 m s^{-1}}$$

In the real condition, you have to replace the mass, RPM of wheels and torque by motors to the real value or your robot, and you can measure all of them. It is not super difficult to calculate, just substitute the value.

https://www.desmos.com/calculator/jzuyyrzbhh This is my calculator if you are tired of inputting your own formula. Instructions are all in the link.

Friction

Friction can be a big factor when building Drive Train. E.g., If the drive train used too many gears to connect, it may get a lot of friction because the gears are touching each other and wastes some power.

- Friction is inversely proportional to the torque you can have to run the robot. That means the **more friction, the less torque**.
  - ➔ Before attaching the motors, check if the wheels can freely roll at the ground. Test how much distance the system can travel with a small push by the hand. If it barely travels and immediately stops after you released your hand, you need to do the next step.
  - ➔ **Try use your hand to turn the wheels**. If you feel you need less "power" to do that, then it is good, that means the friction is reduced. If you need to use a lot of force turning those wheels, that is not good.
- The more *transition* of the power, the more friction you may get (e.g., gears, chains).
  - ➔ Less use of gear should help a bit. Also, if the shaft (that connects the wheels) contacts to some materials (e.g., Aluminum channels), that will also increase the friction.
  - ➔ If you use a chain system or similar, the friction is expected to be higher, because **some energy will be consumed by the chain.**
- You can always add a layer of washer to decrease the friction.
  - ➔ Make the wheels assembly not too tight when attaching them. It needs some space to spin around!

Compatibility

After figuring out all the motors and wheels, check if there is still enough space.

➔ It is recommended to not attach the brain and battery before you know where to put your *devices* (i.e., Scoring Mechanisms).

➔ Also recommended to have a test before attaching anything yet. I usually like to use some zip-ties to tie the brain and battery temporarily and see how much speed we got.

Also, you can always **learn from your opponent's / other teams in ISB.** Don't feel bad to learn from others, only feel shame when you are copying. **Think:**

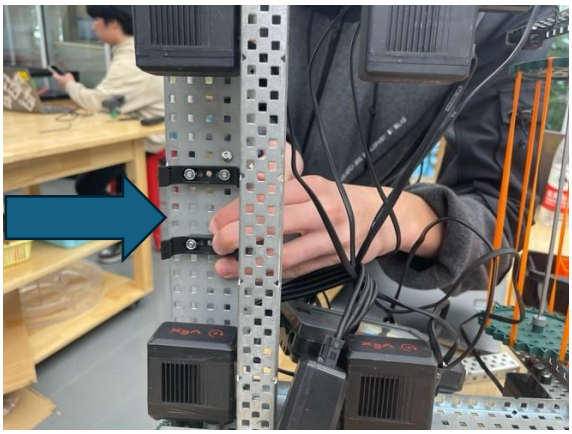
➔ What is the average speed made by other teams, and why they want it to be slow / fast?

➔ What devices they have up their drive train, and how these devices might change their decision of the speed?

➔ How much space they still have left, and why / why not they are reserving spaces for more devices?

- Remember, the drive train *serves* the devices. If you used all the space to figure out how to attach your gears and motors for drive train, there will be no space for other devices.

Check this, in Over Under, my team made the battery to an awkward place, this is because there is no other good place to mount.



The battery is upside-down. That means each time we want to switch battery, we have to flip the robot. Although that is surely inconvenience, but this must be done, in order to leave spaces for the catapult and intake.

➔ Sort out where you want to put the intake and delivery system first. [6]

2.2 Intake System

The intake system is one of the devices attached on the robot, and it needs to be able to contact with

[6] i.e., reserve at least 35x35x30 cm of space as my personal suggestion.

game elements, requires significant amount of space.

➔ The robot must have an open area where the intake is allowed to make contact or close to the foam pad ground. (ideal)

Efficiency

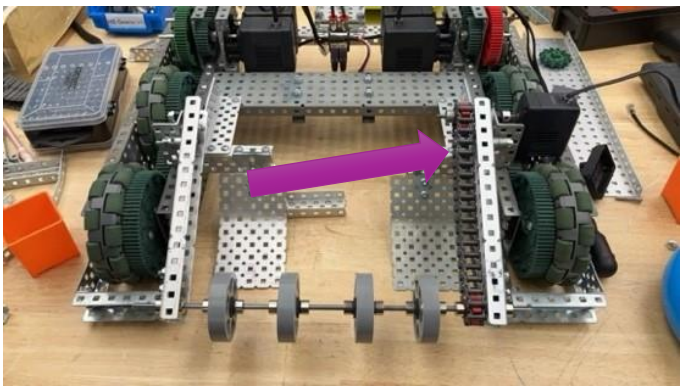
The intake efficiency is not just the faster the better. You must also consider if the process system (it collects the game element and redirects it to the goal) can handle the speed.

- The intake does not have to be the fastest, since the game elements always weights, there are torque requirements.

  ➔ If you use a Blue Ct and even gear it up, any type of intake method will not work, the game element will stop upon intact with the robot due to lack of torque. I suggest you reserve at least 0.5 Nm of torque for intake.

  In ’23 Over Under game, my team used a green motor for the intake, because the triballs are big so we want more torque to secure. For ’24 High Stakes game, my team used a 5.5W motor for the intake (and later chained a 11W blue motor for both intake and belt). Because the donuts are smaller and lighter.

- Still, the intake in High Stakes is still troublesome. It does not have much torque therefore more chance of overheat.



Look at the right-hand side, one small motor and a chain that transfers the power. This chain later caused several problems, both in torque and consistency.

➔ I suggest you make the power transfer distance shorter and avoid **too much** use of chain.

Consistency

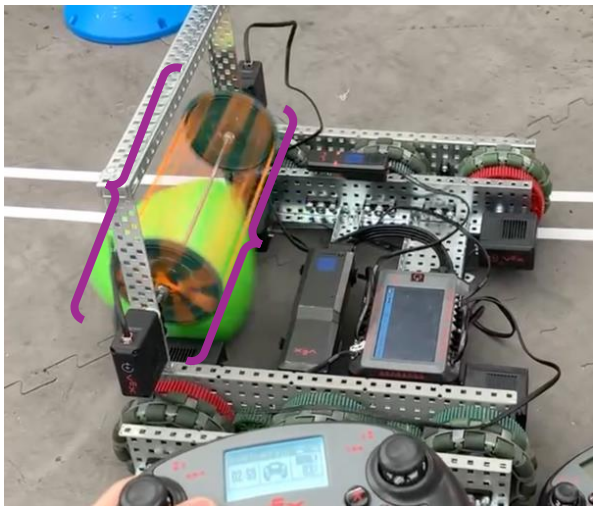
The consistency of the intake is sometimes more important than the speed.

➔ But make the consistency close to 100%. The consistency is actually the more the better.

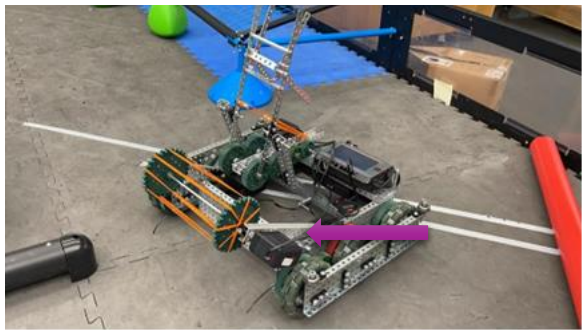
Sometimes, instable build can really affect this part. For example, if my intake got rammed[7] by a robot, the intake can be slanted if poorly made, therefore causing malfunctions, therefore decreases the consistency.

Resistance

This part is also highly related to the consistency. The intake has the most chance of break apart, because it is exposed to outside. The intake might wiggle around if you want to add more efficiency. Like in Over Under:



This is the first version made by my team. It is not good is because the distance. Sometimes if the intake is broken and it lift up a little bit, it won't be able to even touch the triball. So later we did this:



Now we can see it seems more bended and have an angle. This is because when it intakes, the ball will naturally make the intake lift up due to fitting the size. After releasing the ball, the intake naturally goes back to the original position due to gravity. Free source of power!!

- We attempted to use gravity to help us.

  ➔ Good intake tends to have this feature for the recent years.

[7] Some may say avoiding ram will work. But Sorry, there is no way of avoiding and ram is partially the reason why V5 is made of metal.

➔ Don't make the intake that stays in one position.

- Now it seems if the intake can move around, that means it is not mounted or screwed hard to anything.

  ➔ This means the connect joints will need to be strong, because upon collision to other robots the joint will suffer the most.

- This intake looks like a *bulge* that sticks out the main structure. As I mentioned, it's going to get bump and ram. However, because the building quality went well, I witnessed the intake got very bended on the field, but it is still functionable. This is the exact explain of term "robust", as it still works under extreme circumstances.

2.3 Deliver System

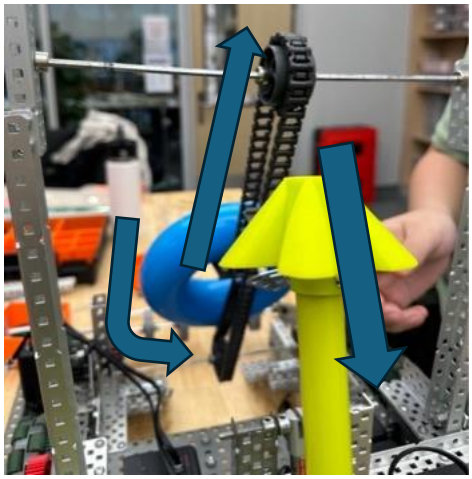
The deliver system delivers the game element to the goal. Sometimes it is a conveyor belt, sometimes it is just the intake itself, sometimes it can be a catapult.

Compatibility

The Deliver system is in charge of passing the game element from the intake.

- If you only have a deliver system but you never try it with the intake, it will not work.

  ➔ Make sure the Delivery system actually gets feed by the intake (not your hand) so it simulates the real situation.



In this picture the delivery system did not feed from the intake, this is a flaw made by us. Normally the steps look like this:

Step 1: Intake the donut.

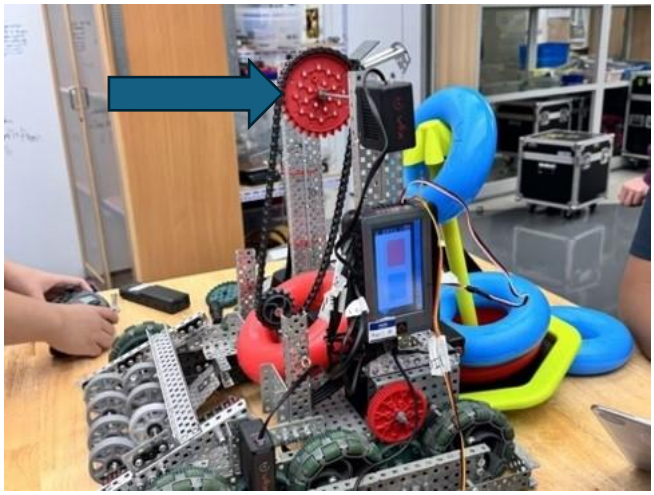
Step 2: Donut transfer to a wait position and belt lifts it up.

Step 3: Belt releases the donut and “smash” to the stake.

Because we directly put donuts on the belt, we missed step 1. This is a mistake.

Stability

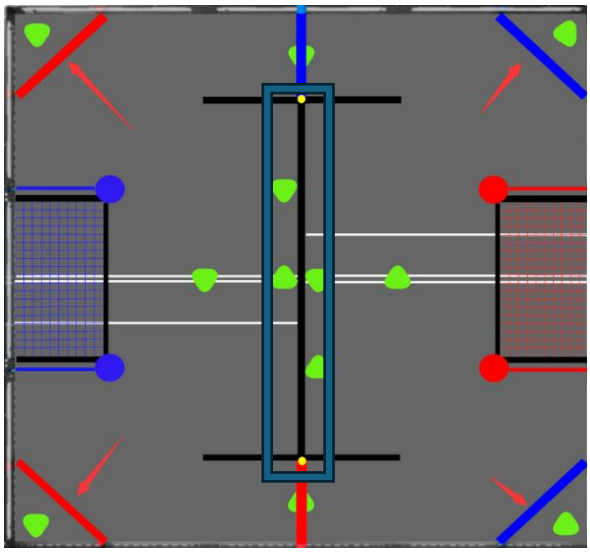
The stability of the Deliver system is the key. It could cause a single point failure. Although the Deliver system normally should be protected by the robot, but that doesn’t mean it can be fragile.



As seen in this picture, our Deliver system in ’24 High Stakes is that belt at the center of the robot. But at the first time we developed it, it is such wobble that it just wiggles when we are moving.

The minimum requirement for the delivery system is not wobbly. Fail to do that will lead to failure of the system.

In ’23 Over Under we had a catapult for match loading (people manually put a game element on the robot), because we want it to shoot to the other side. There was a bar at the middle preventing you directly push the triball, so it has to be passed through air.



For the red arrows, there was other bars in the corner. In that year some triballs often got stuck so I marked them out.

- Due to poor aerodynamic shape, the triball never gets accurate and it only shoots to a near place where we aim.
- You almost always need to *process* the game element and do other interactions to the element. For Over Under you have to push the triball, it won't get into the goal by itself, nor the power by the catapult (wasn't enough). For High Stakes you need to redirect the donut precisely into the stake, while shooting it is not possible due to precision issues

  ➔ Throw the game element is sometimes a bad idea, if you don't communicate with teammates, it can get stolen.

Speed

This can play a big role in some deliver systems. In '24 High Stakes, the deliver system will require some kinetic energy to push the donut into stake, because the tip of the stake is slightly bigger than the inner diameter of the donut.

If you do nothing, it stuck there; so there must be a force applying to push it down.

If you think you want more stability, if you try to achieve this by reduce the speed, it may work even worse, due to lack of energy.

- We need to find a balance point between too fast/low stability and too slow/high stability. Also, the stability is not always inversely proportional to the speed. A good design can both achieve speedy and stable.

2.4 Let's Talk about Pneumatics

Pneumatics Kit is an advanced system that uses gas as the source of power. So, it works like an impulse when it extends. Also, the instant force exerted by the piston is much higher than the motor.

- If your design needs a power that needs to be switch from a position to another and needs strong power, pneumatics works very well.

Know the Parts

First you have the core, tank, or canister, whatever you want to call it, it looks either this:

(Legacy Tank, might become illegal after years, still legal in 2025)

Or this:

(New Tank, all source from VEX Library)

This canister is basically the gas storage. It can suck in gas by your air charger and also output to your valves. The maximum allowed pressure is 100 PSI, or 6.8 times of normal air pressure that you breath. You can charge more than 100 PSI, but get ready of being caught by the judges, or a rapid unscheduled disassembly (explosion), because they designed to tolerate no more than 100 psi ☺.[8]

[8] Well, in fact, no one will try to argue with how much psi you charged. But just be careful when it is beyond the design limit.

This one is from Vex Store, that's what you'll get form a full pneumatics kit (300 dollars or 2100 RMB).

Take a look at the **green-squared item**, they are officially called "Stroke Pneumatic Cylinder", well, I'm going to call it **piston** for ease, because it works like a piston, retract and extend. In the newer kit, Vex gives you different extend lengths. The more long one gets 75mm, then 50mm, then 25mm.

Now check the **purple-squared one**, they are called "Double Acting Solenoids". Um, let's call it **electric valve**, because it works like a valve but controlled by the brain. A three-port wire (as the purple arrow points at) controls it open and close the valve (extend and retract the piston). You must use this to control the piston.

One of the other critical parts is the **orange-squared** small things. They are called "Straight Male Fittings". The fitting must be mounted to all other components, otherwise will lead to a air leak.

Just keep in mind that you need **all** the parts I mentioned.

Another not 100% needed part is the blue-circled, that is a manual valve.

Now you can identify the important parts, but still don't know how to assemble. A video is all you need.
https://www.youtube.com/watch?v=lc4lmRpYIpI

Thank you, 44252A, for making the video.

2.5 End game

End game is an element for every year. For most of the time, it's about lifting up the robot.

Important before you keep reading: After game ends, the field controller will **disable all the motors** but not release pneumatics! So, if your mechanism can't keep the position without power, **use pneumatics**[9].

Here's three methods I knew until 2024:

	2022 Spin Up	2023 Over Under	2024 High Stakes
Method	Expand as much as you can in the field, count for score	Hang or attach on a wall, making sure the robot is off the ground will work	Hang at a ladder, level 1=3pts, 2=6, 3=12.
Difficulty	Everyone can make one	Mid / Easy depends on your goal	High
Ability to score more	A lot. The more you expand, the more you get. No limit.	Depends on others, if nobody elevated, you got a lot.	Higher climb more score, but get the most point is nearly impossible (~110cm off the ground)
How many teams did it (early season)	(Basically) Everyone (> 90%)	30-50%	Almost nobody (< 10%)
How many teams did it (late season)	Everyone	~40%	Some (~30%)

The likelihood of having an end game mechanism is:

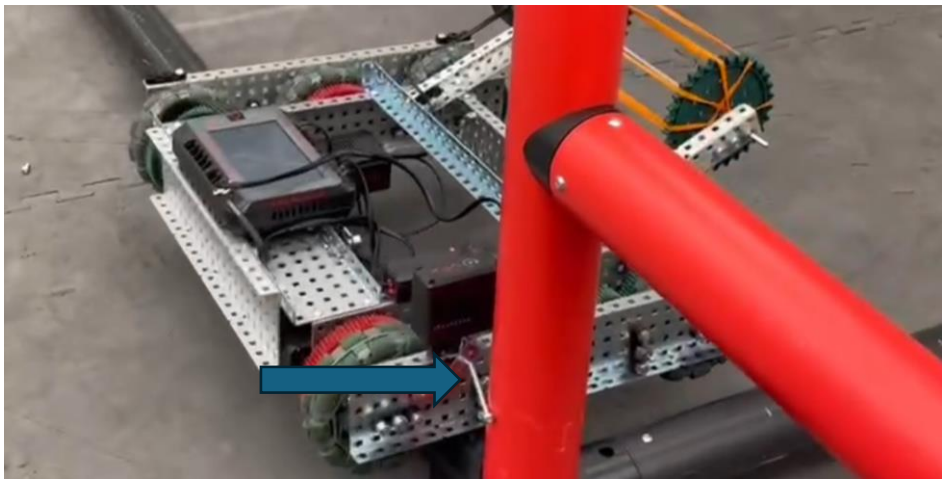
a. Proportional to how much score you can potentially get. (More score, more likely)

b. Inversely proportional to the difficulty. (More difficult, less likely)

That says, sometimes you don't want to spend time on end game design. For example, in 2024 High Stakes, my team didn't really make an elevation. The reason is because it worths too little yet consumes too much time.

Another example is from the '23 Over Under game. My team got no end game in the early season because there were no good ideas generated. However, as we had a better understanding to the game, I realized that I could make an easy mechanism that hooks the robot from the ground. It is very hard to explain, so here's a picture.

[9] Some may say the solenoids will be disabled, thus leading the release of the pistons. But that is not the case, in fact, the solenoids will lock themselves after an operation, so it won't be affected.



The elevation is made by a screw and a blocker at the right side. After some check I found the criteria for the end game is just "the robot should not contact the ground". That means it is legal to stay at the middle pipe, the only thing I need to do is balance the robot, so it prevents from getting off the pipe.

- Notice the 30 points potential for this movement. In Over Under, you award 5 points by pushing the triball to the goal, took about 5 seconds to go and push. For the elevation, you need 15 seconds to go[10], get in and lock on. You see, this award drives me to design this mechanism.

  ➔ This is also one of the reasons why there are more complains in '24 High Stakes, because people think the very strategic end game is gone due to high difficulty.

Get some CAD first before the real one

https://www.vexforum.com/t/vex-cad-fusion-360-parts-library-2-0-0-release/120228

Go to this link. Get some Vex CAD parts, build it via fusion so you can know every part and screw before you start to build, and thus less time figuring out what type of screw you might need.

The reason why we need CAD design is you can simulate your robot before you build anything, so you spend less time messing up in the robotics space (remember, we have **very limited build and test time**, **but a lot of design time on your own.** The advantages of CAD are:

➔ Eliminate "bad" ideas that you want to try (so you won't waste time).

➔ Knowing the distance, building specifications before the build.

➔ Knowing how to connect all the parts together, instead of wasting time trying around.

➔ Knowing the robot will be oversized/big/small before you have it so you can make changes before everything is built and it is too late.

Yes, if you CAD, your entire team will benefit from it. It is like a blueprint, and when you build, you just

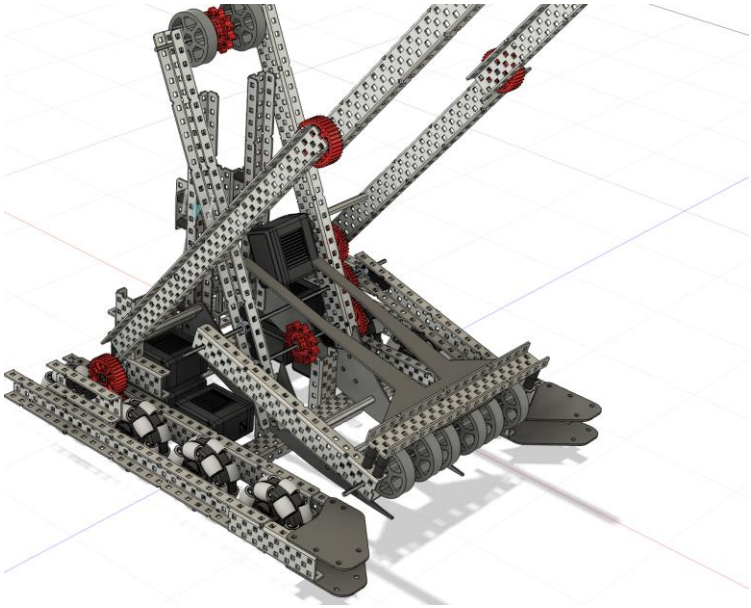
[10] OK, we were bad at it. Some experienced people can make it in 5 seconds, so there is a lot of potential for this end game.

follow the steps you made in CAD. Therefore we can see the efficiency spending in the Robotics space increased by a lot, that means more test time and drive time.

My recommendation is you at least have one people who is mainly working on CAD, and the rest of the design team should be familiar with CAD software. Yes, you will gain advantage from CAD your robot and design more.

You even need to CAD your custom nameplates. So, if you want to be cool, learn this one.

Fusion is typically the most you'll need, and Blender is for rendering. Take a look:



This is what you can get via fusion. (Model by Eddie Xu)

This is Blender. You won't use this a lot but know it, so you may use this in the future.

Don't know how to CAD? This is not a problem. Check Mr. Walton's video here, and there are thousands of videos that teaches you fusion 360. Please, if you want to master this skill, learn to search instead of making the social media platforms deliver you videos to your face.

https://www.youtube.com/watch?v=BNCcJyaHRiE&t=5s (Mr. Walton's video)

If you are reading it with a printed version, please just search up "DCB SE21" in YouTube so you can find Mr. Walton's old channel.

Blender tutorials? If you do read and write Chinese, get this one from KurTips.

https://www.bilibili.com/video/BV14u41147YH

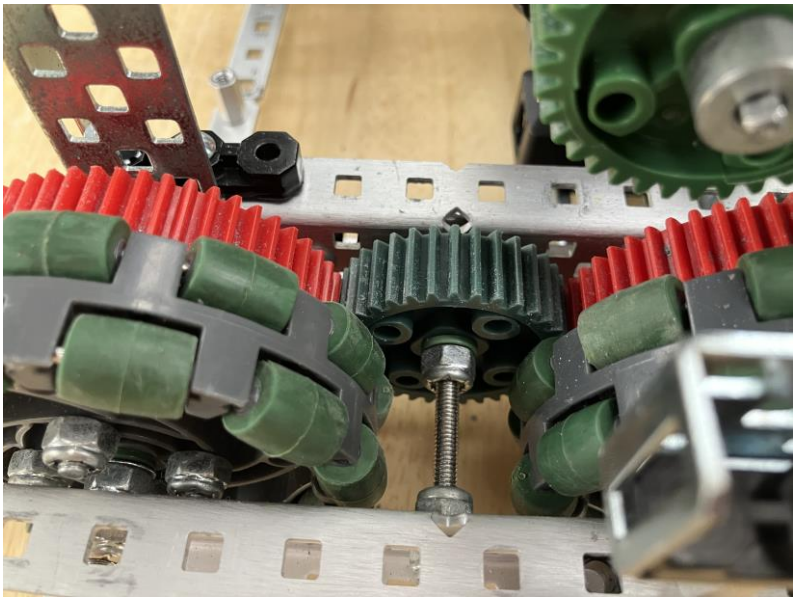
Part III: Building

In this part I will be talking about how you build (as the title said), and my experiences dealing with the materials. Builders need to pay attention on some fragile materials, they may seem to be OK, but when you use it, it is bad. I only talk about the basics, but you can examine whether I am correct by doing some experiments.

Screw and Nuts

Screws and nuts are basically the most important parts among all the materials. They function as connectors, sometimes joints. We all know the basic function of screw and nut, so here is a trick:

An advanced drive train build strategy is to use a 2.5-inch (longest possible) screw to be the shaft of the wheels.



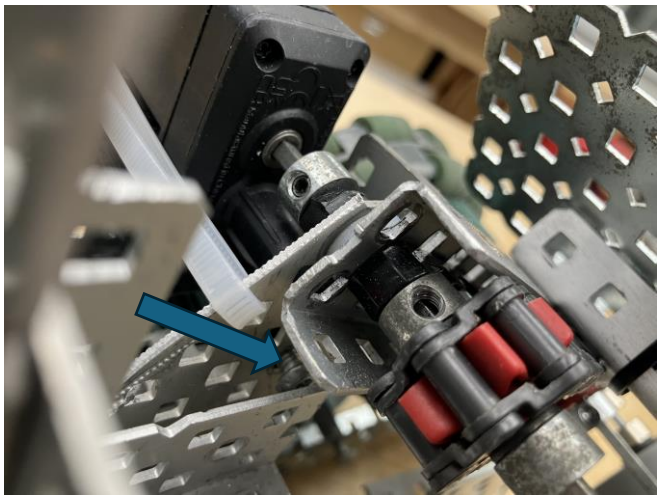
This is made by Team A in September 2024. As you can see, they used a screw but not shaft. **The screw won't spin while the wheels and gears are spinning**, therefore reduces the friction, because the screw no longer creates friction to the aluminum channels, because it does not spin.

Tighten the motors

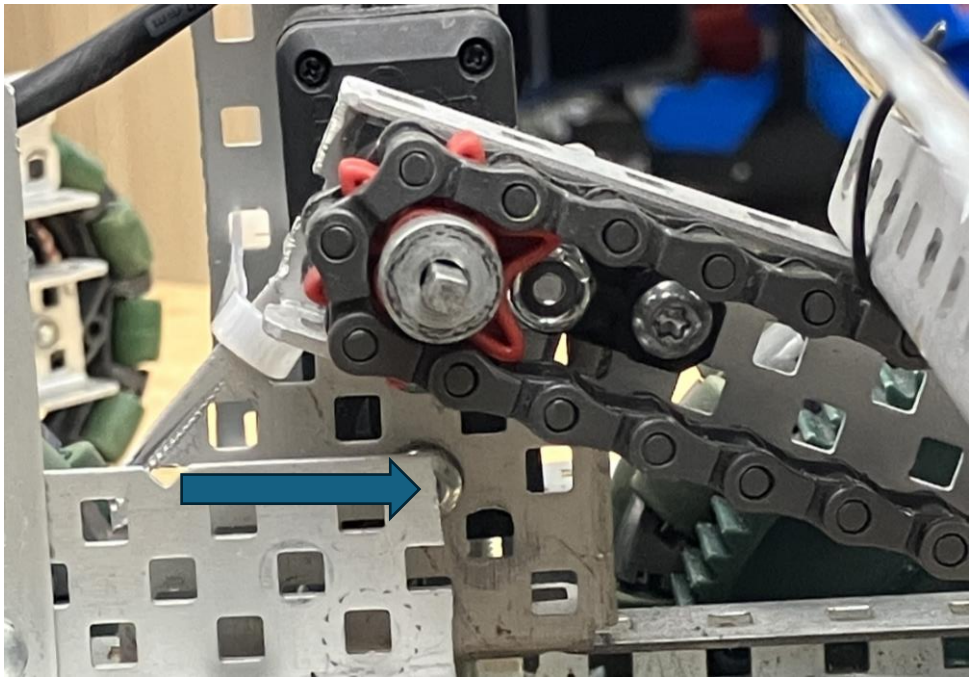
Motors really runs fast; they **vibrate** when running. If there is vibration the screw will be loose, and unfortunately the only mounting way for motor is two screws.

You have a motor cap that can connect one shaft and two screws. The motor core is connected to four smaller screw that are secure not going to have trouble.

➔ Leave space for motor screws so you can screw them back if they are loose.

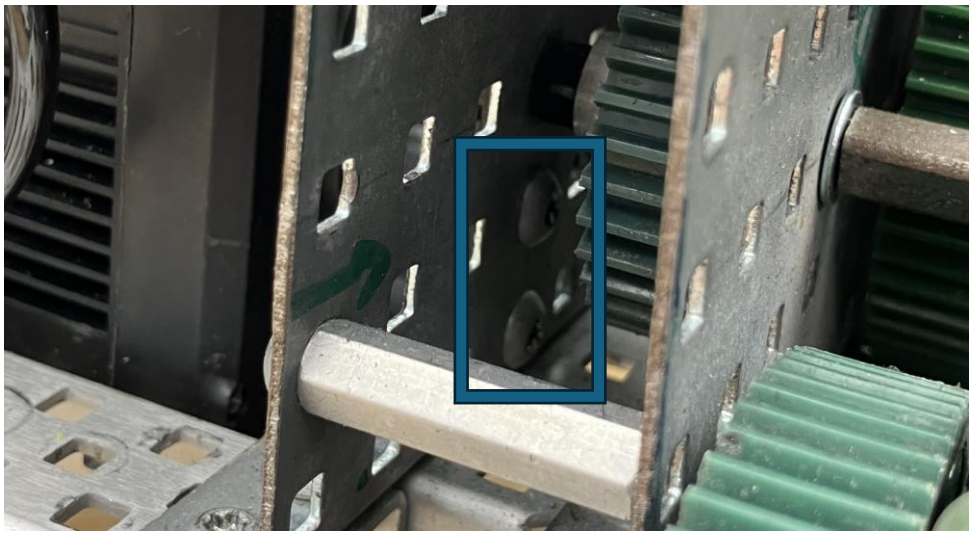


This gives you a bad example. You can clearly see a screw that we can never screw it back in because it got blocked.

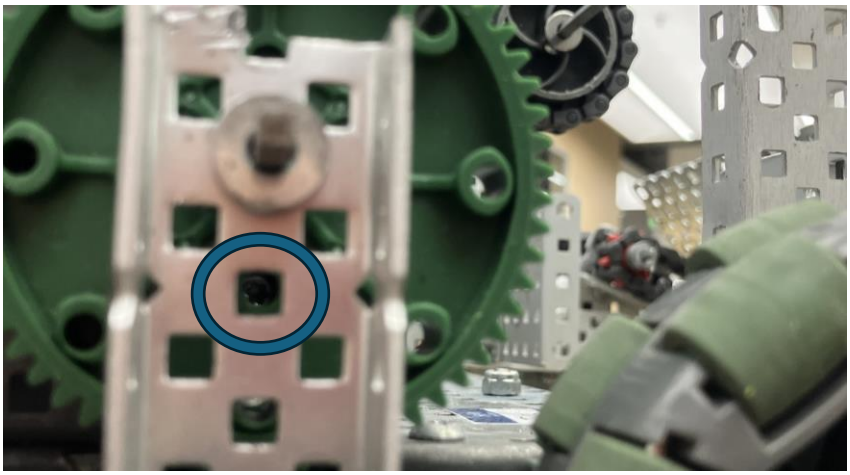


Don't do this as you don't want to disassemble other things only to screw the motor back.

There are some special cases where you have to make the motor screw to be somewhere difficult to screw back. However, still give it a little space. I made a tricky design.



It **seems like it doesn't really have any space to insert the screwdriver** or the Allen key. However, if we take this in another way:



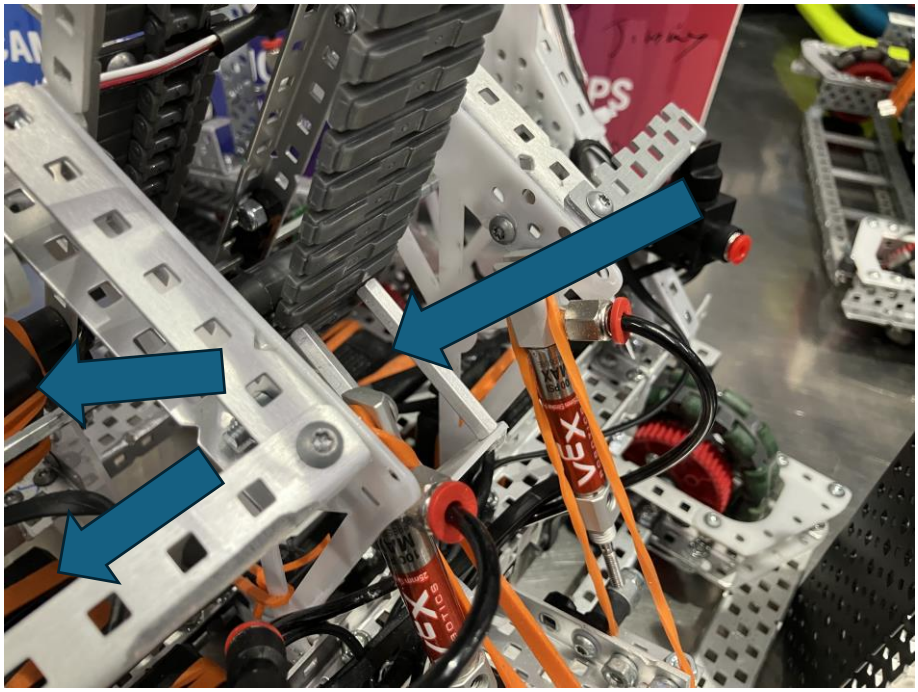
If you check it closer there is a small screw head, you can see from the holes of the c-channel and a gear. So, it still allows the screwdriver to "penetrate" all of those and screw the motor. Still, this would not be recommended, it is such difficult to find the correct "angle". You will certainly swear in the field because it is a waste of time.

The other good solution is a Loctite.

A type of glue that strengthens your screw. But Loctite also makes you have difficult time disassemble the motors when you need to repair.

Hot Swap

Hot Swap motors are made because people don't want overheated motors. The way you do a hot swap is unscrew the four small screws on the motor cap, and use rubber band to secure the core and cap.



(Yes, this is a bad picture. Sorry I couldn't find any better)

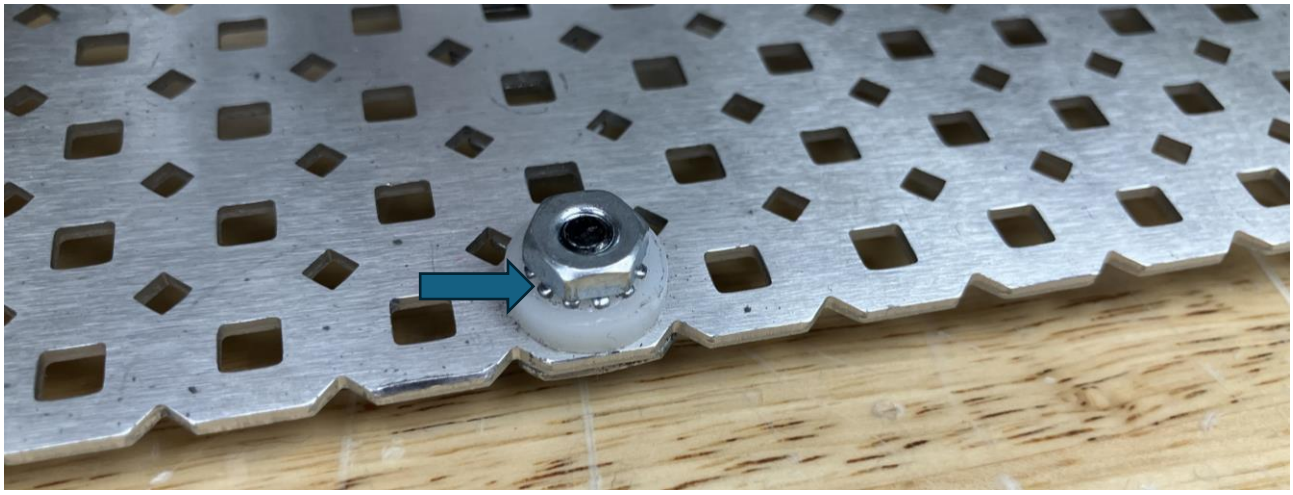
There will be drawbacks. The rubber band can snap; if you do hot swap unproperly, the rubber band can be loosened and causing the motor to detach. I personally don't use hot swap because I cannot be bothered to switch the rubber bands. My suggestion is if you have a robot with motors being easily overheated, use hot swap, and prepare spare motor cores in order to replace.

Different types of nuts

Nuts have three different ones. The **Normal**, the **Crown**, and the **Nylock (Nylon lock)**.

- Typically, we don't use the normal nut, because it is such slippery that it will be loose after a little bump. Not recommended.

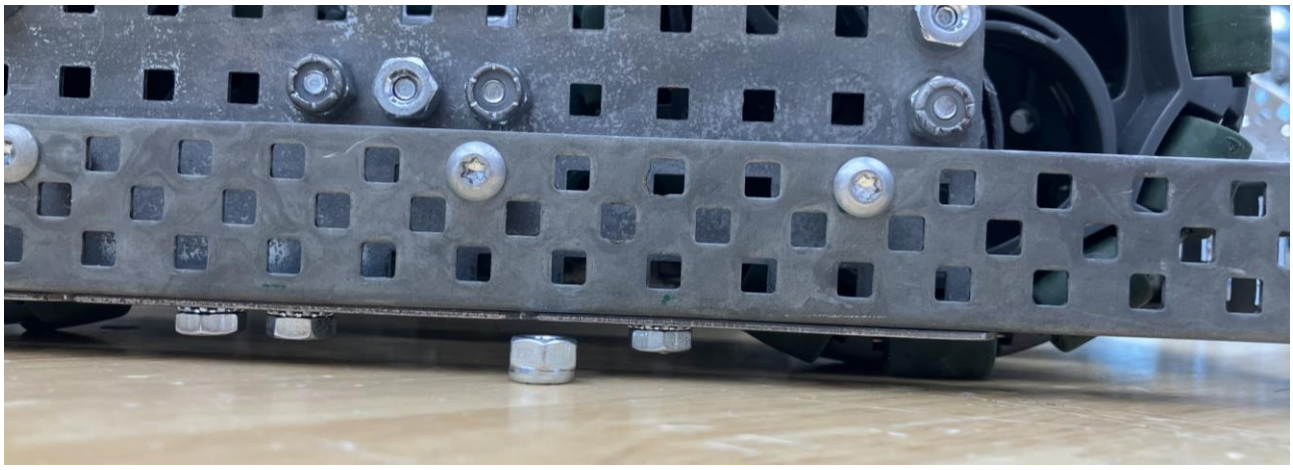
- Crown nuts are a bit "chicken rib" (Not too valuable but also can't throw away), they don't really loose after bumps, but it is risky because you never know when it will be loose.



This one is from Team A ’24 High Stakes’ ramp. To reduce the bump of the donut, they want a lower design, so that is what they used. You can also see the reason why it’s called crown nuts – there are small crowns underneath the nut sections, which means adds friction and is resist of loose (but not as stable as nylock).

- ➔ Crown screw is for quick attach, or for places where you ran out of space.
- ➔ You normally don’t need a wrench for crown because they lock by themselves via friction.

I have this scenario for you to see some of the desperate position where you have to use crown screws.



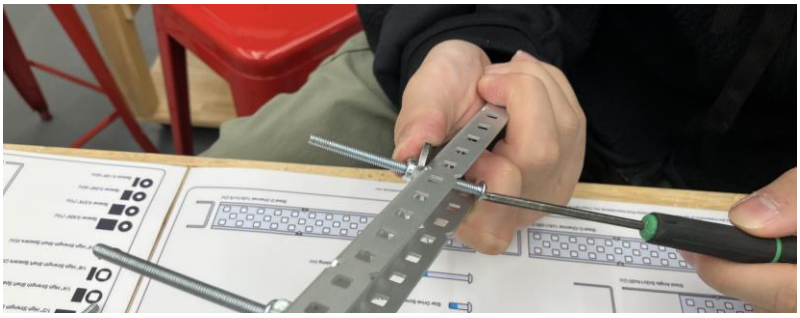
You see. If I use a nylock, it will be very close so it might touch the field, causing damage. So, we got no choice.

You can also see some of the nylocks at the top of where I make the drive train’s wheel assembly (the screw that connects the gear and the wheel). There is a bearing flat to make sure the screw is stable and less friction. In that case using nylock would be a good choice. The screw on the other side would be non-reachable because the build must continue and the other C-channel will be installed, thus blocking anything.

- ➔ My team must make sure this bearing flat is durable; we won’t have a chance to fix it unless we want to disassemble the entire side. Make sure you screwed it hardly (because the nylock is very

tight compare to other nuts).

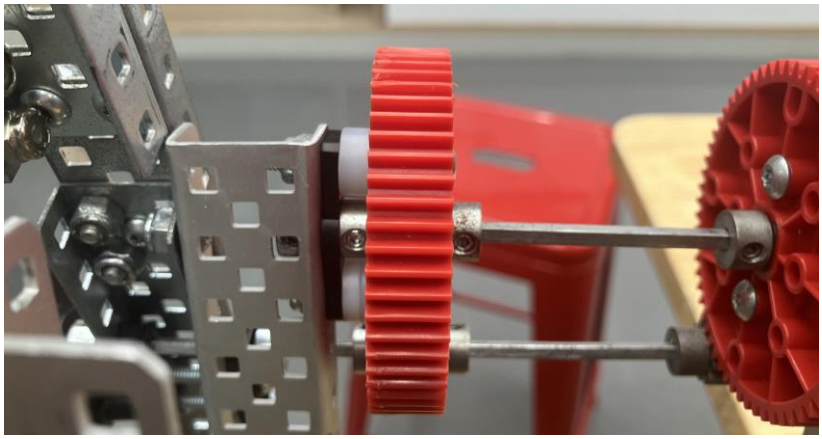
➔ If you are making a Nylock passing a long distance (i.e. see the picture below), Maybe use a powered tool (drills) because both your hand and time will be wasted.



(Painful moments! Aiden Kim, our builder, spend five minutes on this.)

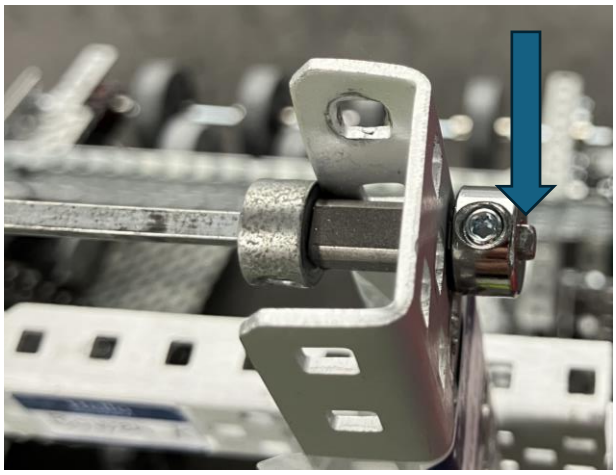
Shaft and Shaft Collars Family

When speaking of this combination, I will have to say you need to prepare a lot, the shaft family are so important, but also fragile at the same time. Shaft collars is just a part that mounts and keeps the items on the shaft stay in the same place. Enough yapping, here's example:

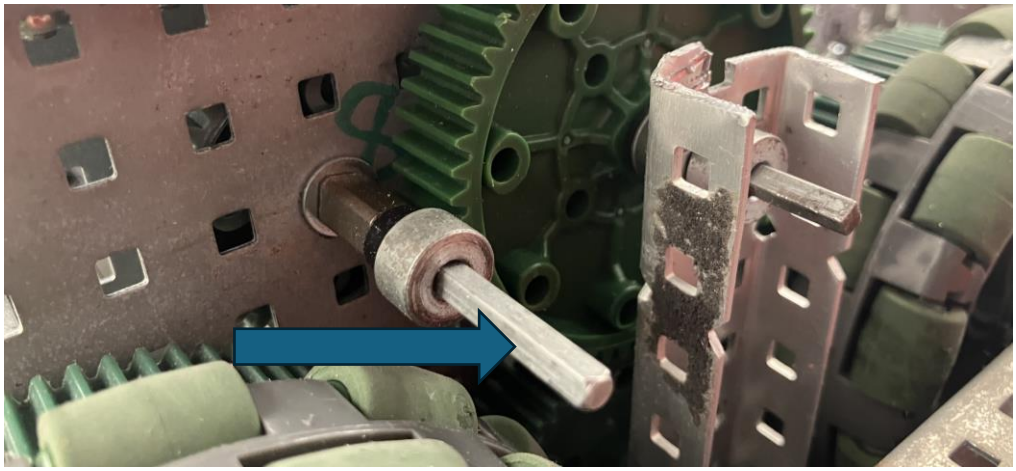


If there are no shaft collars, the gear would've move around, and that is not what we want.

When selecting shafts, the length also matters. Typically, you want it to be longer to prevent this from happening:



This is almost not enough to connect the shaft collar at the end. So keep in mind that you should always get a longer one, and it typically shouldn't block anything. Like this one:

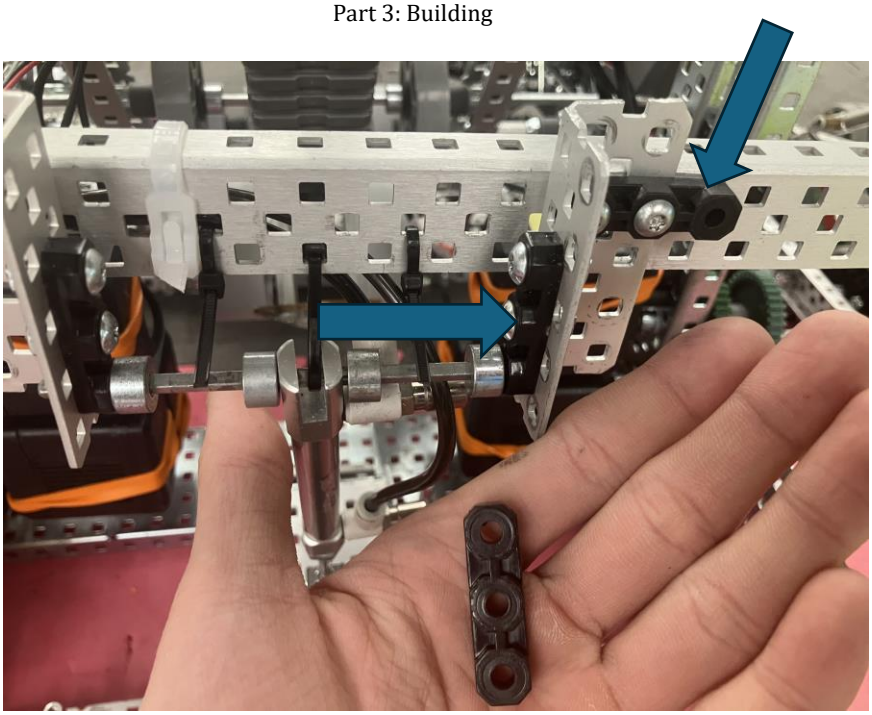


This shaft is longer than what we need, so we decided not to change or modify it shorter. I mean, it requires more work and is a waste of time. As long as it doesn't make trouble we shouldn't waste more time on it.

- ➔ You shouldn't waste too much time picking the right size of the shaft, for most of the scenario just pick about the length you want.
- ➔ After you have the shaft, it would be hard to change it because a lot of stuff will get on the shaft. So select a relatively new one.

Bearing Flats

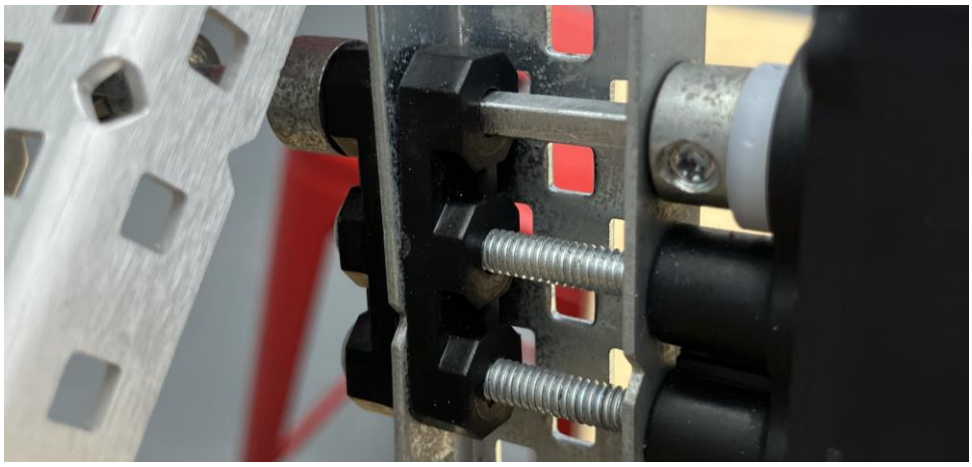
This is a terrible name, so I need to give a picture first:



As shown in my hand, these are bearing flats. They are the contributor to shaft stability, and you can see them in basically every shaft, because it adds a lot of stability and prevents the shaft from bending.

- You use more bearing flats when you need the shaft to be stronger (and resist to bend).

  ➔ However that doesn't solve the fundamental issue, if the force applied on the shaft is so much.



In this example, we added two bearing flats because the shafts bended so much, we were concerned and the gears were "clicking". I will talk about this specifically in the Gears part.

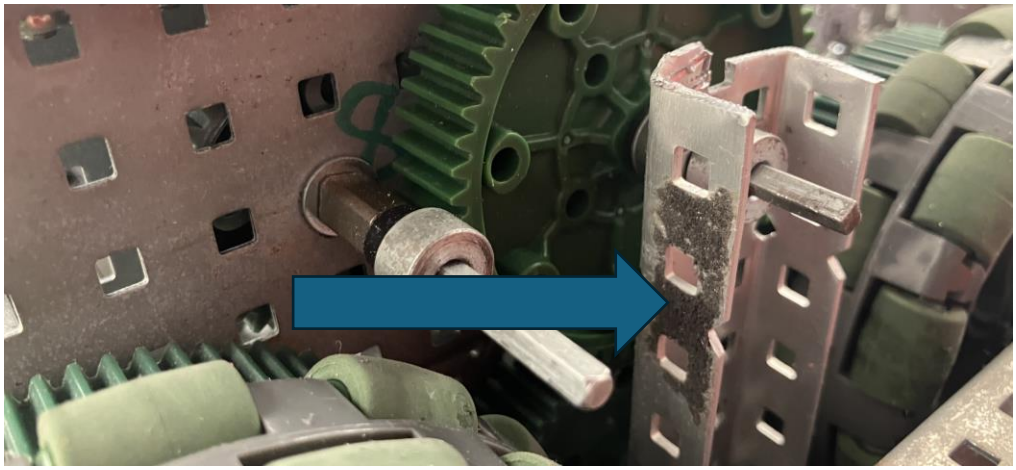
Gears

Gears might be the most annoying part that you must deal with. I will show you several examples:

The first example is you are using the gears in a high force situation. Just like my team's arm.

- When experiencing a great force, the shaft will bend. This is because newton's third law (there will be a counter force for every force), the gears are pushing each other in the other direction, causing clicking (the sound means the **gears got detached, the contact is no good**).

We had this headache issue also on our drive train.



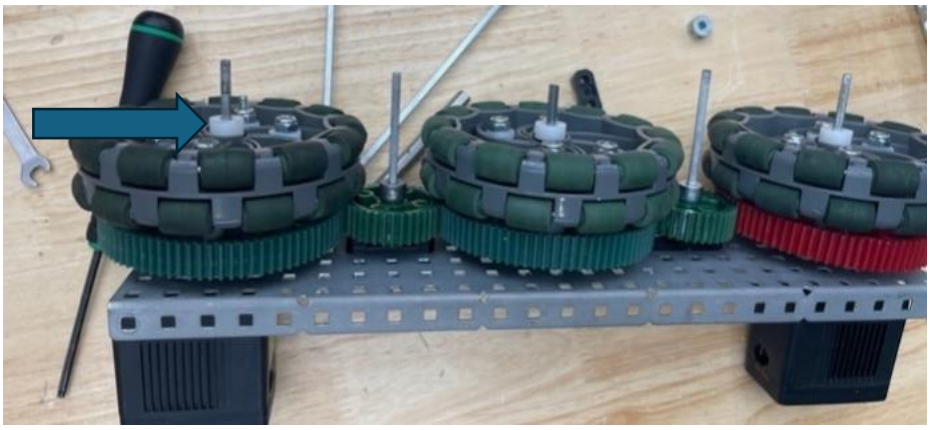
This is the reason why there is a c-channel. It prevents the shafts from bending too much, because it just blocks the pathway to do so, by connecting the two shafts. However, you won't always find this chance to connect the two gears by another strong material.

- ➔ Make sure you treat the gears a bit more gentle than other materials. Although they are not fragile, but their feature makes them unstable, they can get easily disconnected (from other gears).
- ➔ Shaft collar is the best friend of the gears. Make sure they are tight, so the gears won't move.
- ➔ Add some stiffeners (like the c-channel above) to improve the stability.

The gears are more like a single point failure (Again, that means *if it doesn't work, everything won't work*), I suggest you perform more checks before it is on the field.

Spacers and Washers

These two items also make the shaft family. If you need to give an item more space or just to make it less frictional, use a spacer/washer. This is most likely seen on drive trains.



Pay attention to the white spacers. We could've directly added another shaft collar there as their function

are similar, but we decided to go with the spacers. This is because spacers can have slightly better control in the distance, while shaft collars have only one thickness, which is not always the thickness you wanted. In this situation, if we add another shaft collar here, the shaft length will be barely long enough.

Also, some may say why can't we just mount without anything there. Welp, the issue is we had the "locked omnis" mechanism, and the wheels would collide to the channels if we don't get a spacer. Another advantage for the spacer is it would provide less friction than the shaft collar. Although we used a conventional direct shaft connection (as in picture), still, the friction is not as big as we thought due to the existence of those spacers.

- However, if you abuse the spacer, it won't be helpful, because it is going to take too much space.

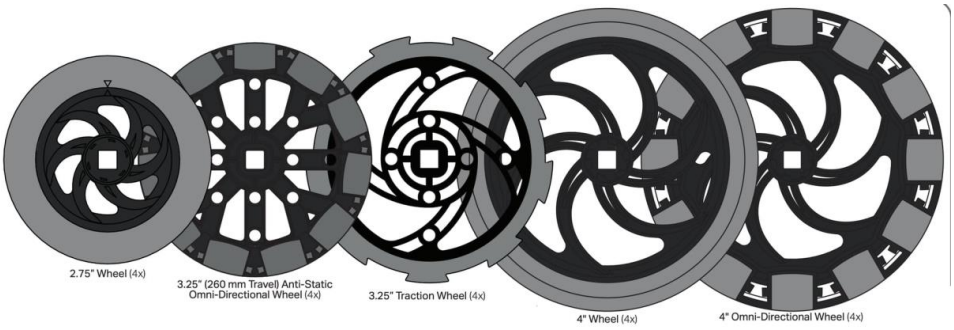
  ➔ Washer can sometimes work for shorter spacers if you need a more precise control of distance (washer is much thinner).

Wheels

There are three types of wheels, let's call back what we learned from the designing part.

Type	Omni	Traction	Mecanum[11]
Overall Rating	Very Good	Good	Poor
Anti-Push (side Axis)	Make it worse	Very Good	Some
Easy to Turn	Good	Slightly slower	No Change
Construction difficulty	Easy (new Ver.)	Easy	Medium
Sizes (Inches, diameter)	2.75, 3.25, 4	2.75, 3.25, 4	4.15

And, one notice for the wheel would be: the new wheels always looks more white, the old versions are all green-ish.



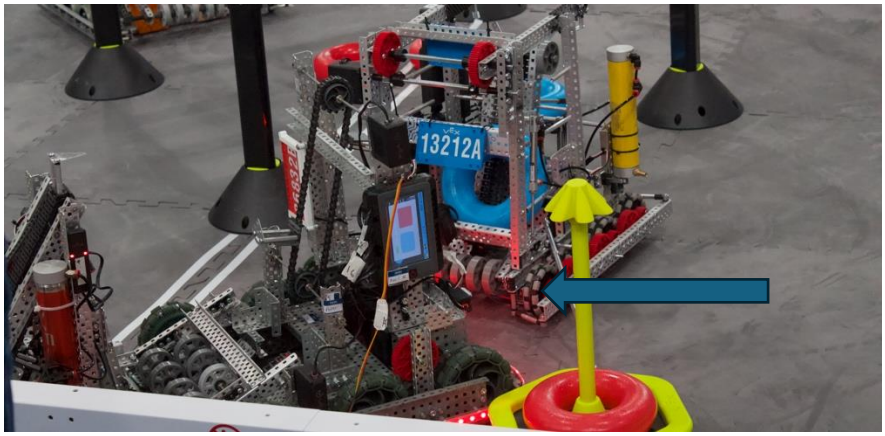
(Callback from the design part, note the color difference)

Omni Wheels

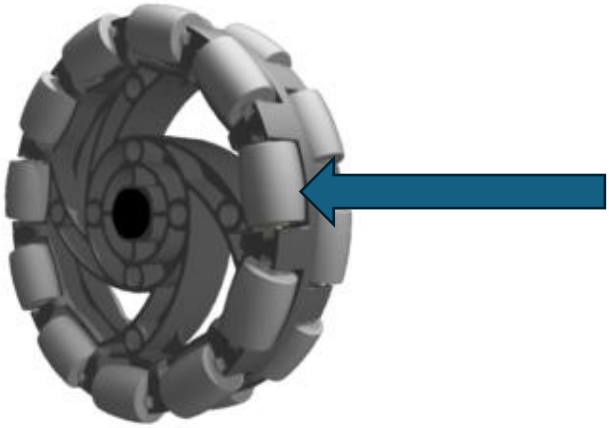
This is the wheel that we liked the most. It gives better turning efficiency. However, this feature also

[11] Take a look: https://www.youtube.com/watch?v=rgkQvIEf2II

makes the wheel incapable of resisting the pushing force.

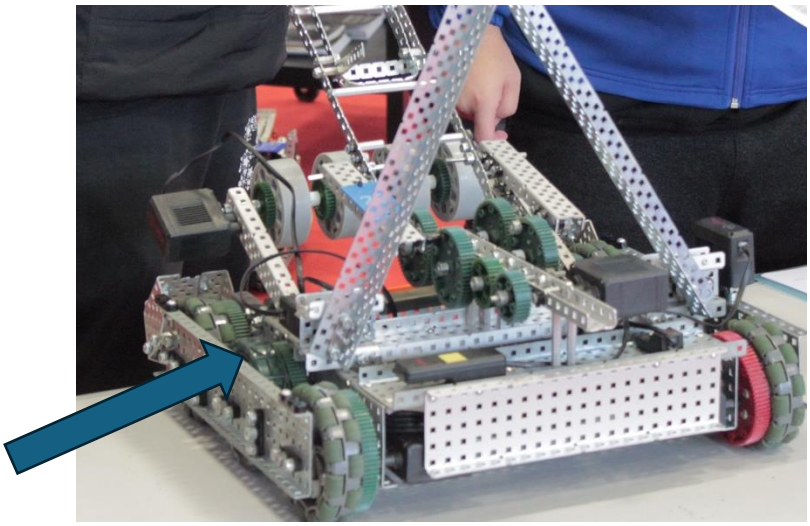


(picture taken in High Stakes APAC)



(Picture Credit: SIGBOTS Wiki)

This small wheel is free spinning. So it cannot resist side-pushing forces.My suggestion for this wheel would be use a combination of wheels. I mean:



This is from ’23 Over Under, TIS challenge. If you pay attention, you may find out **the middle wheel is a traction**. This is what I mean. It is a **balance** between turning and anti-push.

- If you have a 4-wheels drive train side, then the middle two wheels are recommended to be traction, but the outside two can be omni.

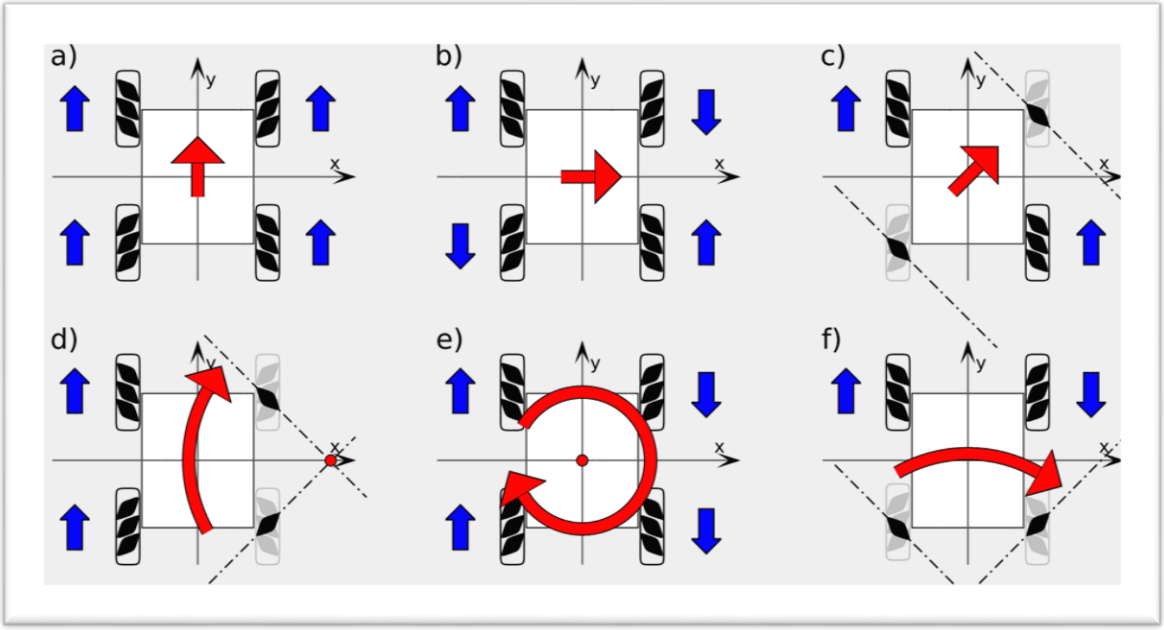
Traction Wheels

If you want your robot to be more tank, use this wheel. It creates a lot of friction, making the opponent unable to push you. But as I mentioned in omni wheels part, I suggest you put only half the wheels as traction wheel, or your robot may have problems from turning.

Mecanum wheels

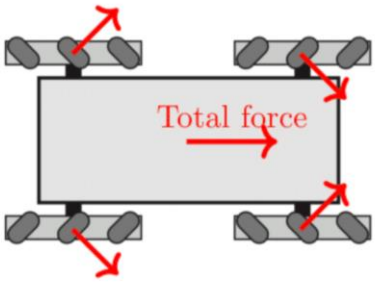
Although from the first look this may be a cool wheel because the robot will be capable of moving omnidirectional (全向移动), but it turns out it is not effective. I will explain the reason.

This wheel is suck in VEX, because the motors are suck, not proving enough power.

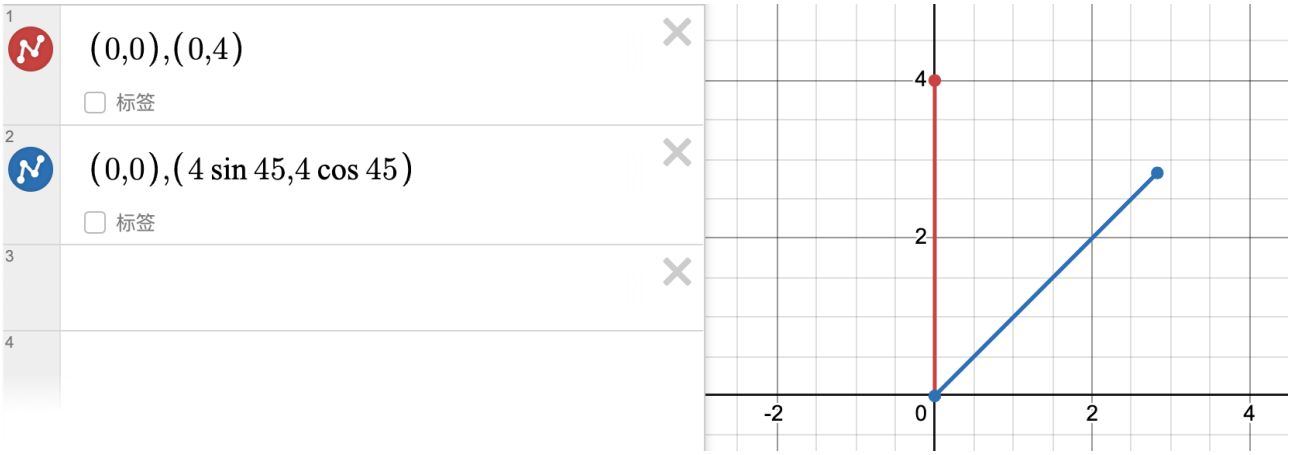


(Credit: Wikipedia)

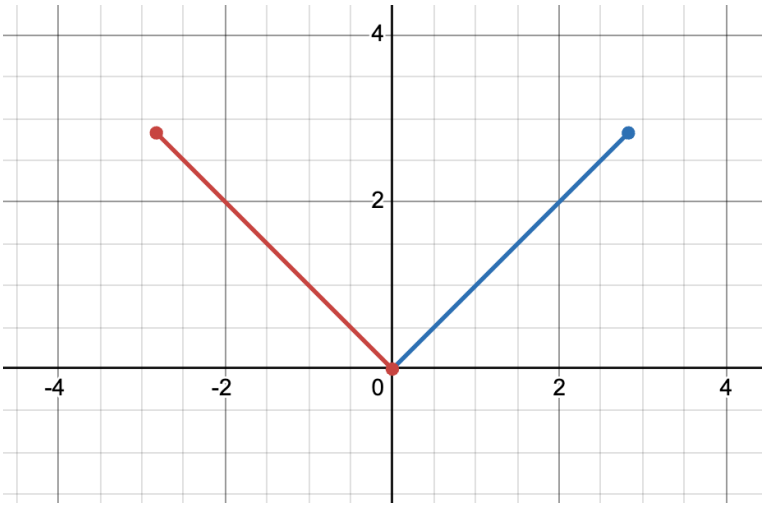
You can see, mecanum wheel can (theoretically) make the robot move anyway it wants. Well, in cars, it is a super cool design. But as I mentioned, it requires a lot of power because it wastes some power to cancel out some vectors.



I don't want to make it like Math class, but (again) it is important to know why Mecanum wheels are wasting power so you won't waste your time trying to build this.



I did this in Desmos. In this example the length of the lines are all 4, which means the power output by the motor. But for Mecanum wheels, it is not directed forward. Well, sadly, the rule of trigonometry tells us this fact: $x \sin\theta$ can't be larger than x (because $\sin\theta$ can't be bigger than 1). And for Mecanum wheels, the degree will be around 45 degrees. This means the actual power will be multiplied by a factor of $\frac{\sqrt{2}}{2}$ (0.707). If the normal robot exerts force of 4 forward, Mecanum wheels can only get 2.828. Other forces got canceled by the other wheel, who exerts the force in the perpendicular way:

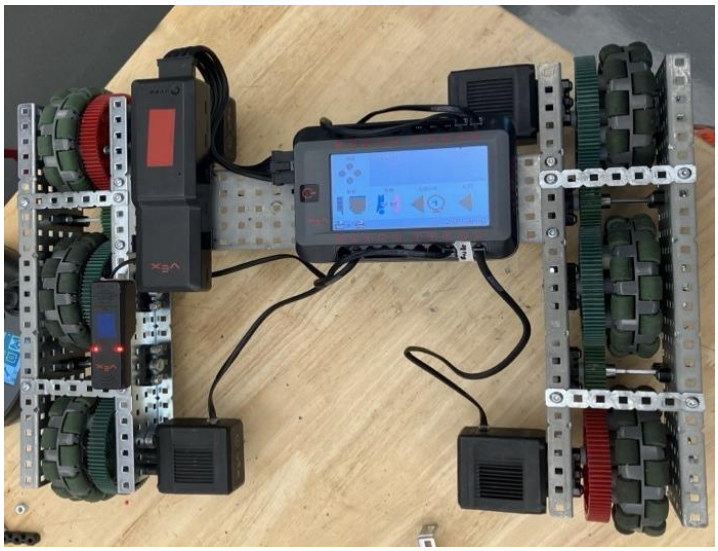


The red line is the force made by another wheel. You see, these x-axis force got canceled. This is why it

is good for powerful cars but bad for weak Vex motors.

Metal Channels and Plates

This is a tough part. Different metals and types of the channels can significantly change the robustness and stability of the drive train (and other stuffs). First, I want to show you with this example. If you are experienced builder, you can think in your mind about what we did wrongly.

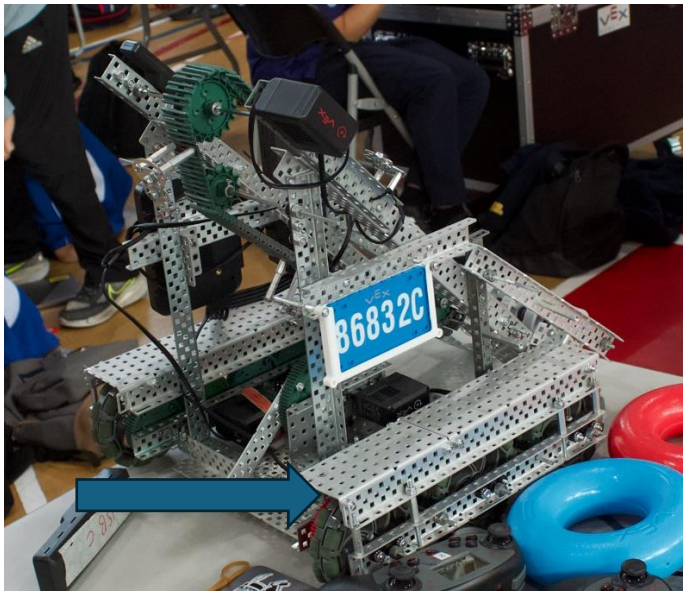


This is a picture taken from ’23 Over Under, while that time, my team suffer from drive train instability. So, what we did is I added some stiffeners on the sides. You are not wrong, they are the 7 units long, one unit tile. Although I intentionally picked steel as the material, still, with no vertical support, this tile is still fragile, and it only contributes little. I neglected the fact that this piece will suffer some horizontal stretch. My suggestion is only use tiles when the component will not suffer from bumps and rams.

C-Channels

C-channels makes the bulk of your drive train. It is so far the (theoretical) most robust part of the Vex. However, their size is sometimes a trouble. The C-channels are recommended to build:

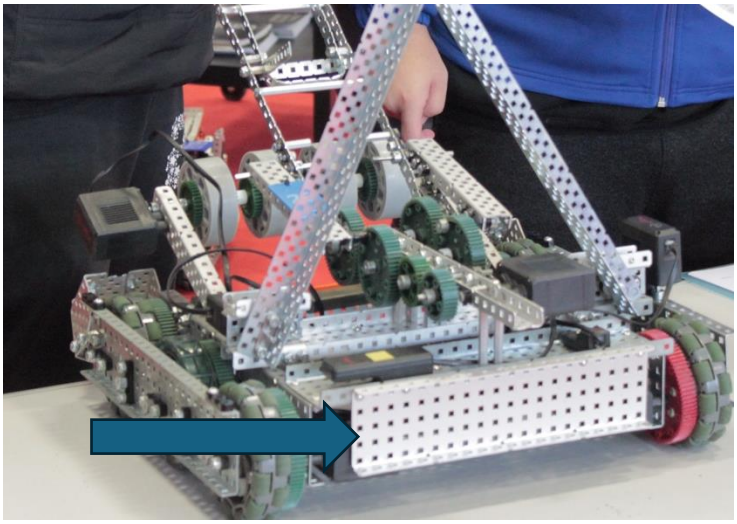
- Your drive train core parts.
- Key strengthen components.
- Anywhere that may experience a bump from other teams / the field.



This is team C's (first) robot from '24 High Stakes. As you may see, they used a lot of C-channels in order to protect the wheels. Although I would argue that they can replace the standoffs with channels, but they had limited resources. Still, I never seen their drive train malfunctions, because the protection went well.

- I am not suggesting your wheels protection should also be like that, I would say that is slightly overkilled.

Check another example:



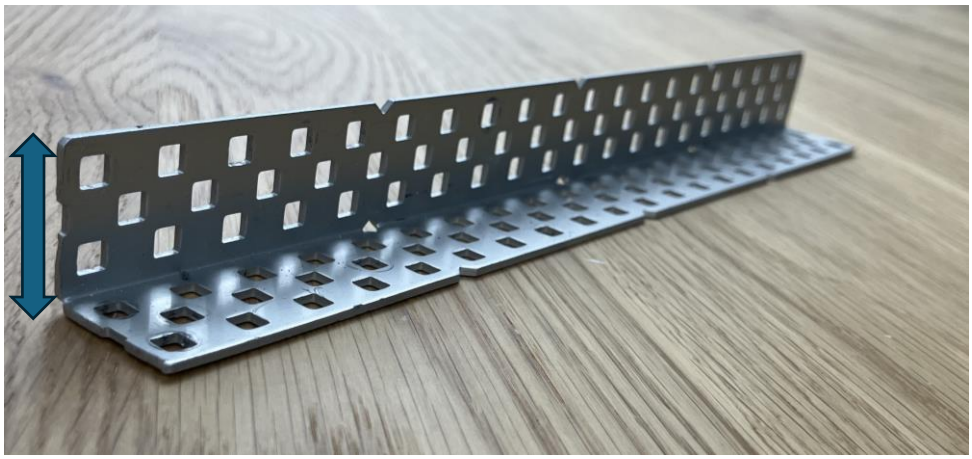
This picture is back, but now I am focusing on the back C-channel. This part is not connected to any critical parts, we can remove it. However, what behind it are the motors. I don't want to risk the motors been bumped by other teams, it is fragile, and critical, so this protection is created. Like a car, you know, it's got the rear bumper (保险杠).

L-Channels

The L-channels can be considered as a mutation of the C-channel. This channel type is not as that much

of useful than the c-channel, but they are still helpful.

For example, when you need to connect two parts in 90 degrees angle, all you need is the L-channel. Although you can certainly use C-channel, but their "other side" is 1 unit, the L-channel is 2 units, that creates more stability. Um, it sounds confusing, I know, so here's the picture.

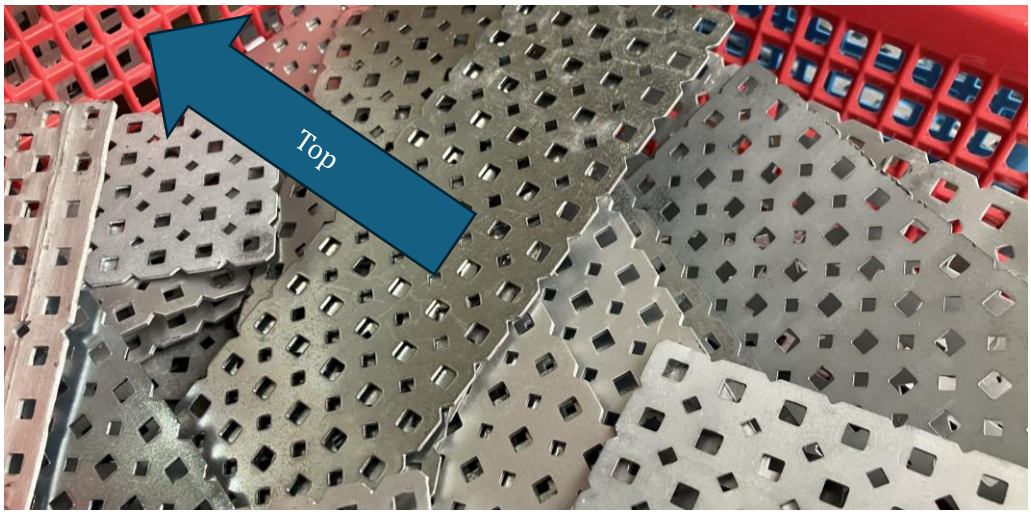


So, it certainly has a limited use scenario, but it may save you in several cases like the one I mentioned above, where you need 90 degrees mount.

- If you are picking between C-channel and L-channel, if they both can be used, I suggest you pick the C-channel, because they are slightly stronger.

Plates

Plates are the most love-and-hate part. They are easy of modifying, but also fragile as hell. Specifically for aluminum plates, they are just too bad in resisting the "top" side of force.



Due to this specialty, plates can be used as a ramp to help with the intake, but that would be all it can do. If you are using this as the main structure, you will regret, because it is unstable.

Tiles

Tiles is one of the… unpopular part. This is because they are more fragile, and there's usually better parts to use than the tiles.

As you can see, they have only one unit for width. Same as plates, it is same easily bendable from top. This makes them have a restricted amount of use. However, if you want something to be a specific angle, this may help, but you still need to be careful about its strength.

- Don't attach tiles to anywhere it may get bump, or the tile is just useless, again, they bend easily.

Standoffs

This is a part which it is high risk but high reward. Upon the right use of the standoffs the building would be easier, and the location of each part can be determined and mounted quickly (Sorry for the yapping, but I have to explain a little).

- My suggestion is you only use the standoffs when you don't need it to be robust. i.e., it shouldn't be bumped.
- Otherwise, when the use of standoffs is your only choice, then go ahead. Still, I personally don't recommend the team use too much of standoffs.

In order to secure the connection of the standoff, he is back.

If you don't use Loctite or similar glue, when the robot vibrates, the standoff will be shaken off a little, and that loose will sum up.

Custom Parts

Custom parts sound very cool, isn't it? But it has limited amount of use, and they are made of, well, basically plastic.

+The advantage of those custom parts is they can be whatever the shape you want them to be.

➔ You can only laser cut or cut it by hands. 3D printing is illegal for useful parts (but the nameplates are OK).

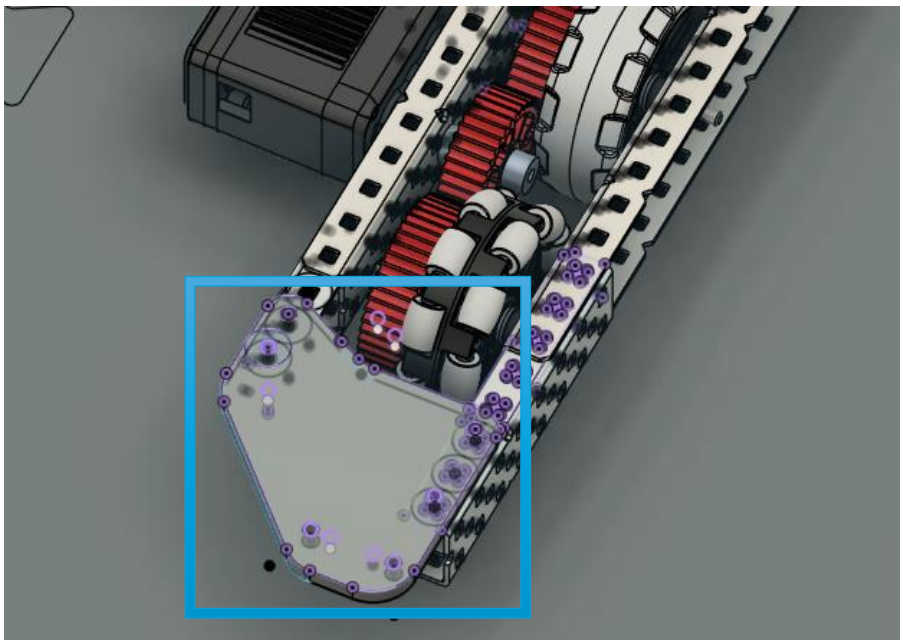
-On the other hand, the disadvantage of them would be too fragile if you don't design them well.

➔ The thickness is very limited to **0.07 inches (1.77 mm)**, that is like a piece of paper.

- **Size limit!** Everything must fit into a 12*24-inch plate (**30.48*60.96cm**), It means that if they give you a that size of sheet, you must be able to cut all your pieces from it.

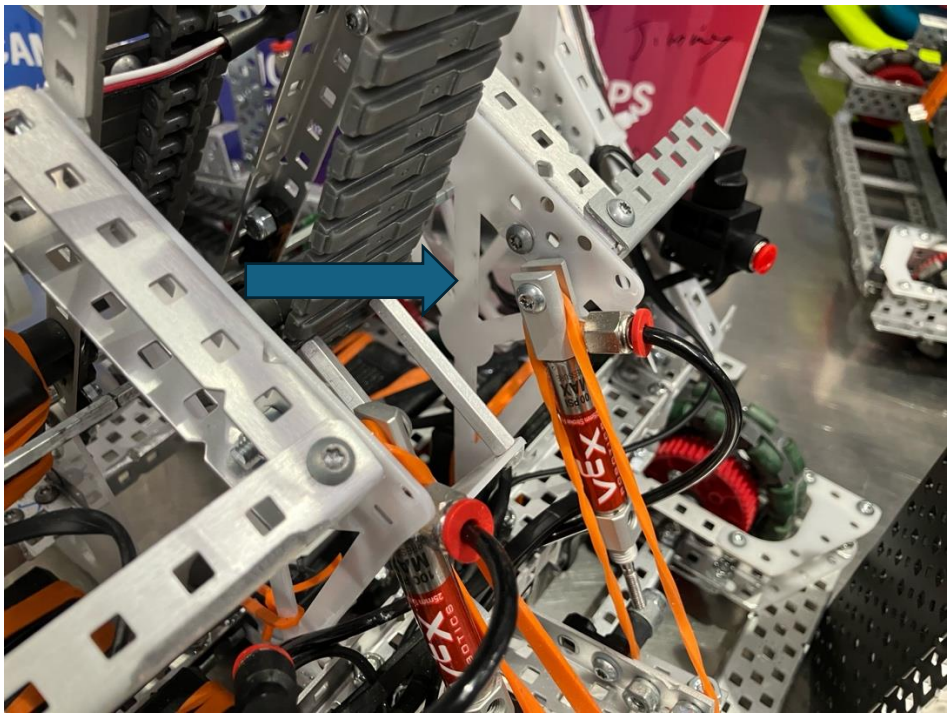
For materials, you need to follow the instruction by vex. Basically, if the plastic is brittle can break easily (like acrylic), it is illegal. I suggest you use **Polycarbonate (PC,聚碳酸酯)**, **Polyether ether ketone (PEEK,聚醚醚酮),** or **Polyoxymethylene (POM,聚甲醛)**. Some PC sheets are transparent, PEEK sheets are mostly "beige" looking (yellow but closer to white), POM is white and slightly translucent.

It is (highly) recommended to CAD the entire shape you want. Well, to do that, you might have to cad the big structure of your robot to determine where the holes are (so you can screw them onto your robot).

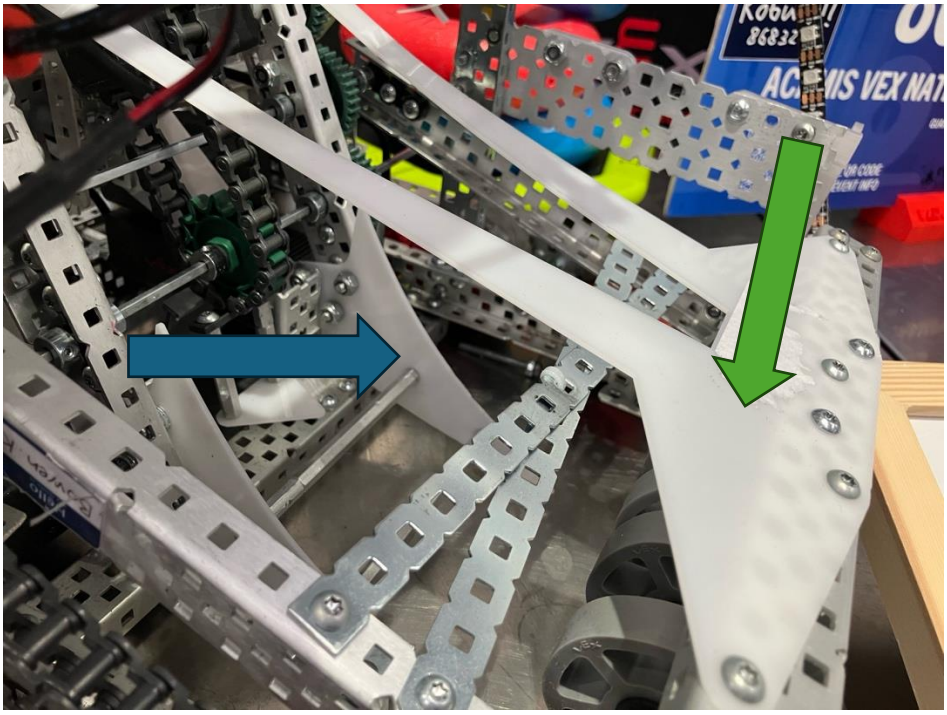


Example: Eddie's guidance system

Check what Eddie did, he made a good job. He modeled our robot's main structure so he knows the shape it should be. Then we asked design center teachers to start-up the laser cutters.



This is (part of) Leon Zhu's Robot in the High Stakes season (He's Class of 2025), and he used POM for his belt and the clamp (see the white skeletal part). This is a very effective design since it **reduces the weight** and provides a **specific angle** that Leon have already designed in his CAD, which, no Vex materials can make this angle. Although Leon used it for a main supporting structure, but it is quite durable, since he also used metal to help strengthen it. This designed belt angle makes the Mobile goal score system run smoothly than before.



This is the later version of Team B robot in High Stakes season. We used POM on our intake slope (blue arrow) and an anti-stuck mechanism (green arrow). You can see, no other Vex components can make it just as compact. Therefore, in this scenario, use plastic parts.

All of those examples can make you think of the scenarios you want to use custom plastic parts. My suggestions are:

Use:

- ➔ When you need a specific angle of the slope.
- ➔ When you need a smooth transition.
- ➔ When you need to make a funnel that concentrate things.

Don't use:

- ➔ When you want a support structure that provides the base of a mechanism.
- ➔ When you need a critical connection component (e.g., standoff).
- ➔ When you need a "armor" to prevent things from ram.

Test your build (Very Important)

This is the most important part of the section. **If you don't test, you never know if the mechanism**

works (even if you already CAD-ed, it does not 100% simulate the real world). So, make sure you know it is working by testing, and then proceed to the next building phase.

- It is not recommended to build too many things and the test them together. It would be too late, and you have a higher chance of failing to determine which part went wrong. Build 1 test 1.
- Never think test wastes time. It will teach you what you did wrongly. Better than you never test and then cry on the field.
  - ➔ The easiest way to test a structure's stability is just use your hand and try to move it. If it doesn't even shake, then it is good.

Before you start testing, you must have a goal, or an expectation. For example, if I am testing a drive train side, I would expect this: If I turn the joystick forward, it goes forward; if I turn the joystick left, it turns left……

This is only a vague example, and the real one should be specified. Like "the motor must increase the velocity to y, as I am pushing the joystick position to x", in your mind.

The test is likely to go wrong in the first few trials. Don't worry, that should happen, as nothing is perfect, nor you can make everything the best at the first time. Then, for example, when I say turn left, it turns right. That is a malfunction, but you should be able to tell what went wrongly, e.g., I messed up the values of the velocity in the program. Therefore, I must now revise me program.

- I may be yapping a little bit here, anyways, the knowledge I want you know is you shouldn't do something like this: Check the intake but the drive train is having issue. I mean, that shouldn't be happen, but just be careful to not waste time.

Stress tests

The stress test is you test something to the expected limit. For example, a drive train normally would run entire 2 minutes (15s Auto, 1:45 min Driver). If you want to make sure that the drive train can sustain 2 minutes, maybe do a 3-minute test.

- The most common stress test I did would be making the robot turning for 3 minutes at one direction.
  - ➔ The disadvantage is it does not simulate the real competition's accelerations. For this "stress" test, the robot's motor is simply keeping up the velocity, but not accelerate from 0 to maximum, where accelerate will use more torque.
  - ➔ Therefore, I suggest you accelerate every 5~10 seconds, keep at the speed, and stop, and repeat acceleration.

Similar tests can also be on intake, e.g., make it continuously intake 30 donuts for '24 High Stakes (there

are total 48 donuts, you are probably not going to pick more than 30 since there is only 24 donuts with your color).

The coolest, also most helpful way is to continue test until something malfunctions. For example, I just keep the drive train turning until the motor gets overheated.

- After doing the limit test, I just knew the drive train's limit, if that number is more than 5 minutes, it means it just qualified to have a back-to-back game (The team immediately have a next game after finishes one match) without any cooling methods.
  - ➔ If drive train's overheat time is less than 2 minutes, then that would be problematic, because it means the robot would 100% malfunction before the match ends.
  - ➔ When overheating, the driver will feel that they asked the robot to go forward straight, but it typically doesn't do so, because one side is overheated and outputted less power, thus less RPM.

For the Pneumatics system it is more of a durability test. We know that the canister has limited amount of air, so there is limited amount of use for those pistons. Example:

In High Stakes, we use pneumatic piston to drive our clamp. OK, then count how many times it can clamp, before it is too weak that its angle will not support the donut to get in. You press it multiple times, count the number out loud, and one time you will see it act differently than the previous one, like the mobile stake got tilted, that means after this count the piston would stop working, and needs to recharge. So, you know the limit of the robot, so you won't use it extremely in the real matches. Well, Boi, Sun Tsu once said: 知己知彼，百战不殆 (Know yourself and the enemy will let you fight without defeat)。

Part IV: Driving

I was a driver back in Over Under, but I wasn't good. So there are better people that drives now.

Practice, Practice, Practice

The title stated the bullet point I need you to know. If you don't get time to practice before the real one, You 99% will get confused in the game, and lose them.

- I suggest the team push the build speed faster and **get one week for driving** before the competition, so there is time to practice driving (and also troubleshoot).
  - ➔ The meaning of Push means the team must done with first step troubleshoot and the overall performance of the robot is guaranteed. I mean, it should withstand the 2 minutes of consecutive driving, for example.
  - ➔ If it overheats even before the match ends, well, that should be solved prior the last week before the competition.

Simulation Driving [Important for a driver]

Simulation Driving means you really just simulates the competition status, like the 1:45 time limit, and you may grab another robot (and another driver), making them to be your opponent. Think about what you can do under your area and what things your opponents can do in order to annoy you, practice together.

- Talk with another team's driver and discuss what they observed while you drive or just ask your teammate, about what went wrong & what went well.
- The aim of the simulation driving is also to discover the possible faulty issues. Try to discover more problems as you can. It is not a bad thing to know there are problems.
  - ➔ Make sure you know how to solve the problems you found. Ironically those **very rare problems will actually show up in the real competitions**. It indeed obeys Murphey's Law[12] (i.e., *if there is a chance of going wrong it will happen*).
  - ➔ If you discovered some low chance malfunctions, try out multiple possible solutions in the simulation driving, then you will be able to handle them on the field quickly.

[12] This is not a joke. In 2025 ACAMIS Nationals Competition, I spotted a very rare, 1 in 20 malfunction chance bugs. And it happened during the competition. I don't think it is going to happen, so I didn't tell Eddie (he's also driving). Fortunately, he attempted to fix the problem. But let's not pray with luck.

Find something to work with

Sometimes you will see that your alliance teammate and opponents are all cooking, but you have no job to do, and you weren't able to gather any game elements. It seems like the thing you can do is just stay put, but the fact is you can still contribute.

- Remember you always have a drive train. You can always move around and attempt to stop your opponent from scoring (but don't be too aggressive), AKA, push bot.
- If the game wants the team to hold some object, then discuss with your alliance driver to ask if they want you to keep the object and let them find more game elements to score.

You can certainly have two ways to do work – stop your opponent / help your teammate. It sounds like helping teammate is sweet, but V5 is a quick game, and it might be too late to contact for helping (and my experience told me that there is barely "teamwork" like robot A grabs a game element to robot B). So, my suggestion is you will focus most of the time stop your opponent.

Personal Suggestion: Make an Ethical move

In the field, when we are competing, the real judgement of whether a move is legal is "if the judge sees it". So, it really becomes stupid when your opponent does an illegal move, but the judge didn't see. In this situation, two teams would start to yap, and delaying all the upcoming rounds. I really want all of ISB Robotics people do a more ethical move, simply stop arguing because you won't get too much.

The basic definition of "ethical move" would be not "edging" the rules. Sometimes it is a tactical to block your opponents from scoring, but you cannot, e.g., stuck them in a corner, that is edging the rule.

I mean, play nicely, or at least don't make anyone to find debatable/unethical points of your driving.

Make it easy: Communication is the key

Always remember that you have an alliance, you are not making it alone, you won't be able to make it alone. Here's some suggestions I have when you are trying to teamwork.

- ➔ Before the Game, know their robot well, especially the part that are likely to malfunction.
- ➔ Understand the Murphy's Law. (again) If it has a chance of malfunction, it might. Don't blame if opponent is not doing super well.

It will be clear that some robots are fast while some are slower. Therefore we can say that faster robots should go offense and collect the game elements, because they are just faster, right? The slower ones, on the other hand, should be more capable of defend. Such these discussions can be happen so everyone knows their main goal when on the field.

- ➔ If you have a slower defensive bot, then make sure you inform your alliance clearly that they must cook harder in offense.

➔ If you have a faster bot, then also make sure… they are in charge of defending the game elements after you finished collection.

Crisis management

First possibility: 1 VS 2 and you're the 1

During all three competitions from my experience, the chance of getting a "bad" team as your alliance is basically unavoidable. We must understand for every competition there will be some poor teams and some cook teams. If you are playing with a poor team (for example they only had a drive train), it's sort of a big deal.

Another possibility led to a crisis is your alliance's robot malfunctions and stopped working. Maybe some parts fell off or the wires got disconnected.

Anyways, two situations lead to the same crisis, which means you are doing 1 v 2 the rest of the game.

In 1 vs 2, you must pay extra attention, as now the opponent can target all around you. They can be 2 times annoying, so I suggest you don't think about winning the game, but to defend what you have so far.

➔ Your other teammates on the field can observe the opponent's movements.

➔ Tell your opponent to be the push bot – interrupt the opponent, if they can still move.

➔ If the alliance's robot is incapacitated (cannot move), also ask the alliance people to tell you the opponent robot's position and if they are near your robot. This would be the most unfortunate situation, there is nothing you can do with your alliance.

Second possibility: Your robot malfunctioned

There are more possibilities in this section, but here I will mention three major malfunctions.

The first one is probably the most common one, which is **your intake/deliver system stopped working**. It could be either too much ram, or the game element got stuck. Anyways, now the robot **still moves, but it can't do other things.**

- A very good approach would be you talk to the teammate, and see if there is anything you can defend on.
- An okay, not the most ethical way would be you just harass your opponents, just be a push bot.

The second is your drive train can't drive. Well, in this situation, you are more cooked. Even if your intake and deliver system still works, you still can't do nothing. In this case simply support your alliance by informing where are the opponent's position, and what they are doing.

The third would be **you can't drive in some direction.** This is common when you have a ramp, and it gets too low that touches the ground, which means when you drive forward, it shoves the ground, causing damage and prevents the robot from moving (We call this 铲车).

- This is still savable. This is equivalent to your intake got disabled, but harder control. Still, communicate with alliance, and see if you can **defend an object.**

Third possibility: Inconsistent Mechanism

This is likely to a malfunction on the intake/deliver system, but it is less hazard, because this case the system didn't broke, but they become inconsistent, like:

Your intake should take 3 seconds to take the game element, now it needs 5, sometimes 10 seconds. This is what I meant by inconsistent rather than malfunction.

- The decision whether you still use it really depends on:
  - ➔ If your teammate can't do the job of the inconsistent mechanism's job, you got to put a bold face on it and continue.
  - ➔ If your teammate can just do all the job of that problematic mechanism, then abandon the mechanism for this match, and start your push bot journey, or simply release the end game early.

Part V: In-Field Logistics and Troubleshooting

Aa a member who will go to competitions, this part has the chance of saving your team when there are multiple issues, but you also have no time to get it done by yourself.

I: Confirm that everyone has a job

Check-in with teammates

At the beginning of the competition, just ask the teammates if they know what to do, or they are in charge of what. For example, if the robot has got a pneumatics, then someone must go charge gas it before the match begins. Make sure someone is doing such nessacery work.

Eyes is all you need

After each competition, you may be checking your robot's status, like what got bumped, and what needs to be fixed, right? Make sure you spend one minute looking at other teammates, do they stare at the robot? If yes, tell them what they can do. Here's example:

- If you need something, tell them, they can talk with other alliance and maybe borrow them shortly.
- If you need a tool, ask, some free teammates can help you grab that.
    - ➔ If members really have no job, make them contact with the future alliances, or scout the opponents and the teams on the top of leaderboard.

II: Work separately

If you have more than 5 people in the competition table, then consider make at least one people go out and scout. It is not possible that all people can fix together, the robot is small (not like FRC where they have huge, human-size robots).

Scouting

As I said, make at least one people be the scout, make them grab something they can record on. Now, as they are close to other team's table, record:

- **The feature the robot has**. e.g. " √ Intake"
- **Their possible weakness**. E.g. "center of mass is too high".
    - ➔ How can you tell the weakness? Well, check the material and weight distribution. You know steel is heavier, and other things like brain and battery will also contribute.

- Potential to be in the Elimination round. This basically means they are overall “good”. Good means they are better than most other teams in the competition.
- Will they match with your team. If they will be your alliance, don’t hesitate to talk with them. If they will be your opponent, also don’t hesitate to talk, I mean, you don’t have to talk about your robot, just yap and gather information.

Driver’s talk and strategy brainstorms

When a game ends, I suggest the driver in the team listen to a debrief from their teammate’s observations of:

I. What happened, what was the major milestone to determine the win / loss of the game.

II. What malfunctioned and can be improved.

III. What was a helpful strategy and saved time / has a high efficiency.

IV. Approximately how many seconds did our team driver do nothing or confused.

After the discussion with teammates (or anytime available for a member), find the alliance team and contact with them. Ask these, since they are critical to the game:

I. What mechanism they have.

II. What is the drive train speed when driving.

III. Is there any malfunction potential in a game (includes overheat, inconsistent mech, etc.)

IV. What is there driving strategy and game understanding (i.e. What they want to do).

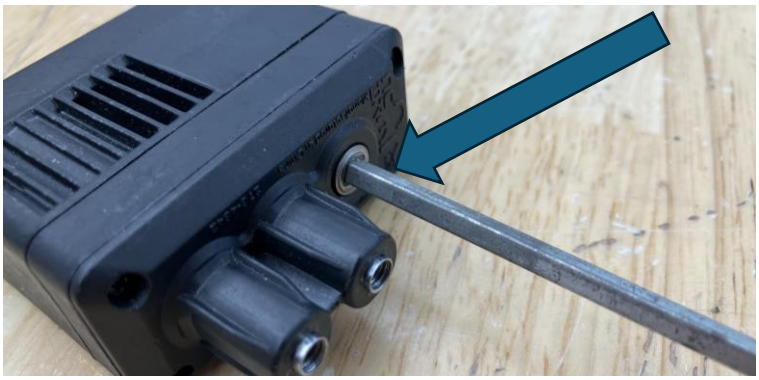
Just like normal scouting to other robots, but you are knowing more.

III: Troubleshooting Ideas

The Drive Train malfunctioned

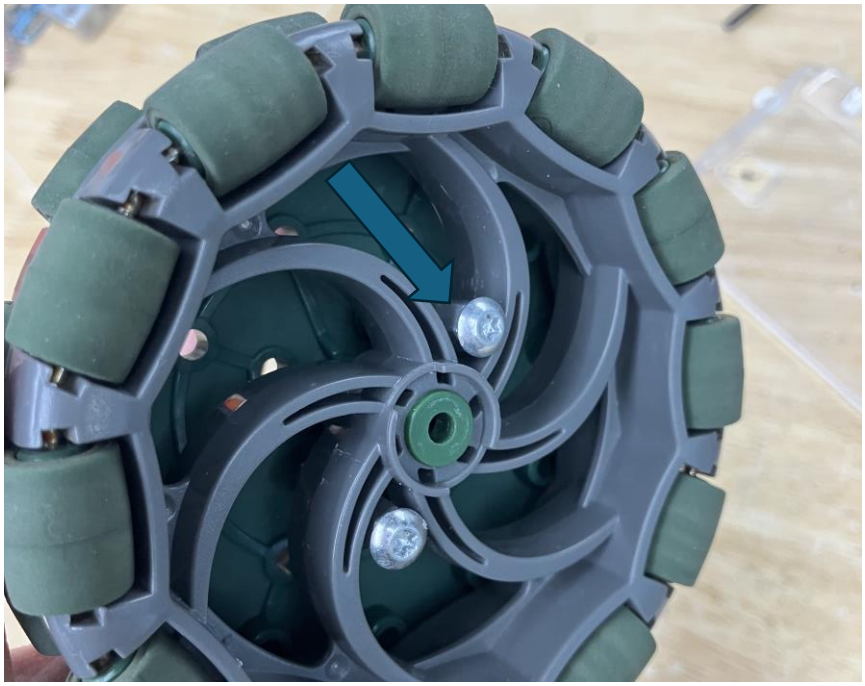
Attempt to drive on the field. Record what you witnessed, and see if they can be categorized to any of these:

- If you hear clicking sound, the gears got disconnected, you will need some strengthener to enhance the connection of the gears. See building – gears (P.27).
- If you hear the motors are spinning, but the drive train didn’t do anything, the shaft must’ve fell off from the motor insert.



➔ Use a shaft collar to mount them, make sure screw hard so this won't happen again.

- If the gears are all working, no clicking sound, but the wheels aren't spinning, check if your are using the old "locked wheels" method:



➔ In this case, there is nothing too much you can do in regard to its stability, just screw the connection joints hardly.

- When you tell the drive train to drive forward, but it turns somewhere slightly. This is a little bit complicated, the drive train can be:

  i. One side is having more friction.

  ii. The power output for two sides is not equal.

  iii. Something is overheated.

  For 1, this shouldn't be happening because you should test it prior to the competition. However, this can still happen in the field, and the only possibility would be something rammed to your robot, causing bend in the drive train, thus causes friction.

➔ Check if the drive train is slanted, it should be obvious. If there are no slanting issues, check the shaft, it may be bended.

For 2, This can happen if one motor malfunctioned. It is possible that:

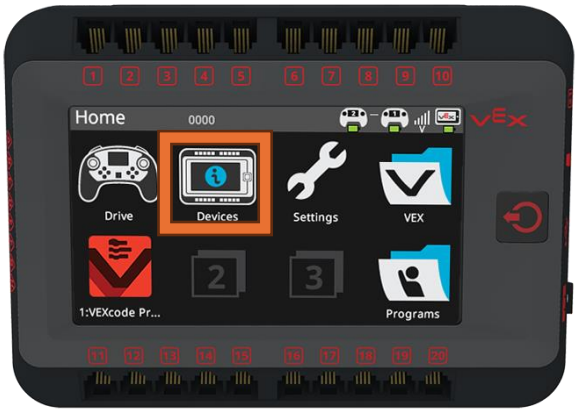
i. The wire got disconnected randomly.

ii. The motor itself is broken (possibly due to huge amount of torque)

iii. The cartridge of the motor is broken (rare).

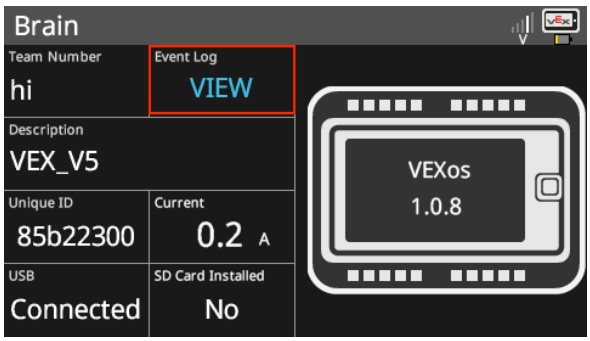
My suggestion is you get rid of the motor and run a sperate test to check.

For 3, overheat can be check via your brain.



Go to devices -> The brain icon.

Go to event log.



(All image credit goes to VEX Library, kb.vex.com)

Intake / Delivery System malfunctioned

If your parts didn't fell apart, then you got lucky. If that happens, your team needs to identify the parts that fell off and find the exact same part to replace.

- I suggest the team check if the system is bended (again), because this is the most common issue. Sometimes the gears other things would malfunction, if they are blended hardly. The channels are indeed very stiff therefore there is no chance of breaking, but possible of bending. And the real problem, for 90% of the time, is the connect joints, like a screw, they may seem stiff yet still possible of bending.

  ➔ If there is only one screw mounting two things, like the intake channel to the main channel, this joint is fragile since there are no other supporting things.

For most of the time the Intake is robust. But the problem is they can get slanted (again! Common issue). For example, in APAC High Stakes, my opponent rammed onto the intake and caused damage. Although it seemed that no parts have been falling off, but it malfunctioned, because we used a chain to connect the intake roller to the motor, and with the slant, it would not spin anymore.

➔ Although it sounds funny, but you need to remember the intake's original looking. This can help with fixing the slant, so you will be known where to bent back in order to fix.

Delivery system will be more complicated than intake, almost always. Sometimes the gear insert (that converts original high-strength shaft to low) will disappear (likely because a shaft collar fell off).

(image source from vex.com)

Another approach: shake your robot. If you hear something like there is a separate part falling off and left behind somewhere the robot, locate it, do what you need. There might be something already falling off from the robot, so prepare more materials.

Driver gets confused

Don't laugh for this, the driver could've easily gotten confused, that always happens. You know the driver is confused when they were doing random things on the field, not doing a "work".

- I advise one of the teammates **record a match video** so we can analyze further when all the matches that day have ended and there is time to yap and talk about it.
    - ➔ For quick feedback, simply inform what was the issue. E.g., "You were driving without doing anything", or "You know the intake broke but you are still trying multiple times". Knowing what went wrong should be obvious.

Although it may sound aggressive when talking such feedbacks to the driver, but again, we have to know that mistakes are normal, shouldn't be blaming them or anyone.

Drivers, know your goals when you are driving. **Don't drive randomly like you don't know what to do. Find a job.** Even annoy your opponent is better than wander around.

Part VI: Team Management

Team Leaders, I know some of you may be headache about how to manage your team well and make sure all of them are doing something. Well, don't you worry. You must know the reason why you are the Team lead, although it is a bit brutal. *You are smarter than others, so you have to tell them what to do.*

Theories that May Be Helpful (Contains **Heavy Yap!**)

Skip this part if you are tired of me teaching you because you are already smart.

Maslow's Hierarchy of Needs

I have to apology that this part looks like a business management course but understand this would be important in regard to leading a team.

I will make you understand what the relationship is. If you got lazy, here's one sentence:

If you can't even guarantee a teammate that they won't be kicked, how can you expect them to fully contribute to teams, and even likes Robotics?

You must understand this fact: Most people come here is not likely because they like Robotics (in level 4: Self-Esteem), but it's for their college app, or their parents & friends want them to come (level 3 or 2).

OK, why is that then?

We must know the needs are in ways of hierarchy, in order words, if you want 2, you first need to have the first 1 locked in.

For example, if you can't make sure that you will keep being in the team, you will think that your contribution may disappear because one day you have a chance of leaving, therefore less work you will make. But when there is guarantee, you will feel that "now I won't have any issue with getting kicked, which means all my contribution will stay there, and continue, people will know and acknowledge." And when they contributed a lot, they may feel they started to like Robotics, not because there is pizza party, or free food on the weekend sessions, or their parents; they would start to feel a deeper meaning in Robotics.

Another example, if the previous one got confused. Just like some Gym boys in the school, they go to gym is not because girls will like them if they become buffed, but because they feel it is meaningful deep inside their heart, they feel like this has meanings to their life. This is called self-esteem.

I don't want to make this as another philosophy class, but we sometimes really need to think about what the meaning of life is. Some would say for money because they want to live better like bigger housing or good food, that is in level 1, for human's basic needs. Some others would say for contributing human's advancement, they are in some between level 4 and 5. Although I can't give a very clear reason, but everyone can tell the dream about "making human life better" is a higher level of goal.

Please, I hope all the team leaders can be less egoism or bureaucracy. I hope they know why they are the team leader but not others.

If you ask me what the reason is of writing this tutorial while the busiest year of my High School Life, I will answer: Not for my college app, nobody asked, my parents don't care. This is only because I want to make the club just a little bit better, and hopefully someone will reach to this part.

(Possible) Steps of making teammates feel more self-driven

Before you attempt it, ask them the reason why they are in Robotics.

1. Tell them they won't have any chance of getting removed (sometimes helpful).
2. Assign work that they know what to do.
3. **Teach them more skills**.
4. Make them understand that the team needs them.

After this step, observe if they are trying to change, to be more productive, or to attempting not to chat with their friend too much[13]. Then you can again ask the reason why they are still coming to work at Robotics after probably few weeks. If they are now more feeling the fact "they like Robotics", then their work efficiency will increase by a lot, because their motivation changed (hopefully).

[13] It is so normal to chat with others, but you can't use like 75% of the time in the space just to chat around but not doing work at the same time.

Matthew's effect

Matthew's Effect is basically:

The people who did good will be even better; the people who did poorly will be even worse.

Applying this effect into Robotics, it is likely that the people who have knowledge continues to lead the team and did better, the people who just joined with no knowledge will know nothing. Therefore, when the smart people left, the only thing that the club can do is to **hope there will be few people who already had some basic knowledge, they learn more by themselves, they join and save the club.** According to my observations, this happened basically every year throughout the last few years. I want to stop this but pass more experience.

Let's be honest. This is just like me, I knew a lot of engineering knowledges prior to my join. So, I continued to be better, I got Lead Engineer in the second year of my join, and I might continue to be an executive. But how about those who just joined with no knowledge? You can see, they don't have a motivation, they don't know anything, so they cannot participate and shove their hidden talent.

It would be very sad that this is happening, numbers of people have the talent to Robotics, but they never found it, use it, and enjoy it.

This became the final reason of writing this tutorial. I want more people can find their talents in this field, not just stayed and confused of what to do. The main idea is to first let several people know more, and they spread to others. (If you know Deng Xiaoping, you can find a similar point – "先让一部分人富起来")

I don't expect everyone will read this too long 16000-word tutorial (like how and why someone would waste their time on this, it is so long!), but if even one people reached here, I achieved my goal.

So as what you can do: You teach, and some who have talents will understand quickly and be better, yet don't expect everyone will listen to you.

Four Phases of Team collaboration

OK, now, I assume in the start of the year, your team members don't really know what do to, there are newbies[14]. That is ok (and normal), every year there is people joining, and you need to teach them from the beginning. I know it is already hard being a team leader, not to speak about teaching (and some don't want to listen) … But something is always better than nothing, if you teach more people, there is a chance that they will continue to be better and eventually be the next-gen leaders. I will provide you some steps as the team develops their skills.

[14] Hopefully not all of them. Still, for the new ones, this should work. For the experienced members, assign them work at the start of the year, then let themselves work on their own items (as they should know what they must do in the later season)

Phase 1: You do, they watch.

Phase 2: You tell, they do.

Phase 3: They do, you ask.

Phase 4: They do, you watch.

Now, I will talk about each phase and what you should guide your teammates.

Phase 1: You do, they watch

In this phase, your team is probably at first few weeks from the start. In this phace, you will find your teammates won't do anything, when you work, they normally stare at the robot or what they are doing. **Don't blame them, they don't know what to do, they have barely any knowledge of Vex.** How can we get this going then? I suggest you **don't just straight in talk about all of Vex**, there is too many things, it's an information overload. (therefore this "tutorial" is actually for the experienced people because there is too much)

- Just as the title says, you do the main work, teammates observe, and you tell them the reason behind it.
  - ➔ Don't tell them too much in one time. All knowledge takes time to absorb.
  - ➔ After some teaching, ask them some questions about what you told them. If they can't answer, that is OK! Tell them again.

Phase 2: You tell, they do

Now, the teammates should witnessed how do did your job. Now, you may want them to contribute little bit more, by starting to assign them work and supervise them. In this phase, they will certainly make a lot of errors, that means they are just in the first stage of learning. It is normal.

- While watching them work, you can ask why they are doing this (a specific movement). I suggest you only tell them to do a task but not inform how to make it done. This can be a good time to see if teammate have actually learned from observation (and a good practice).
- If the teammates encountered an issue and they got stuck, don't just say nothing, repeat what you told them (about this issue), and make them try again.

Typically, this phase will cost the most time than other 3 phases. It may seem like this is repeating an idea is stupid, but it could be helpful to understand better. don't hesitate when they need help, they are not fully trained yet.

Phase 3: They do, you ask

After long time of practicing, I am sure some teammates' skill will eventually climb high enough that they can started to do work by themselves. In this phase, you no longer need to tell them what to do, but they

will know what should be done. Now, teammates are still likely to make mistakes, but that is still normal, if you spot some potential problem, point it out **by the way of asking them questions.** For example, £ is attaching a c-channel but they used the wrong nut. I might ask them:" £, Are there better ways to mount this?" If they can't think of one, that is okay, point it out. If even you cannot tell a specific better way, admit it, there is no shame for that. You are there to help solve the problem, not to show-off your skills.

Phase 4: They do, you watch

This is the final and most unlikely phase that any team might go, which is that you don't need to do anything, and the teammates can completely run by themselves. However, if the team really get into the phase, then congrats. This is because you just trained them who are now eligible of being the leaders.

I really have to say, before joining this club, I thought the competition of the executives are intense. However, as I got deeper into the club, I found barely anyone actually wants to be an exec. So, by training the teammates on your team for good, I will say, I hope, they are very likely to be an exec and continue the club to be running on hot.

Teach others, completing our mission

This is probably the most stupid section, but in order to pass my experience, I will get some bullet points.

- ➔ If you don't allow others to make mistake, they will have no chance of improve.
- ➔ If teammates don't ask you questions, that means you did hands-on jobs for too much. Give them opportunities to work by themselves (So they will naturally have questions because they are still learning).
- ➔ (In later stages) If teammates still staring at the robot for a long time, that means they still don't know what do to. Guide them to make them think about the robot and what can be improved.

Common Issues in the Team / Club

"They act normally when we do good, they run when we do bad"

My father (Who was a Founder of a company) once said to me: In my entrepreneurship years, the most significant mistake that I made was I thought my teammates are all fine with their job. I thought my relationship with them are good and they are satisfied. But when we had a failure, they immediately start to blame others. I never knew they already had resentments.

This is a common issue after one competition, when you did poorly (which is normal). Maybe you didn't notice some disagreements already occurred in the team, but anyways, some people just like to blame it on you, the reason of that might be those (not all of the possibilities, but the most common ones):

1. You took too much work in ordinary days and **suddenly disappeared in the competition**, just to

"test" how your team is doing without you. But this is not responsible.

2. You took very little work in daily life and **suddenly asks the teammates to do everything**, while they actually had no skill.
3. You had **bad luck getting alliances**, and the driver gets confused because **lack of practice**.
4. You had no tests nor stress tests before the actual competition happens, leading to a bunch of malfunctions during the match, and there is no way you can fix is in the time.
5. They don't agree with your ideas and strategies, but they just don't want to say in the normal days, because they can't find a good point. Now, since your team did poorly on competitions, they have an excuse of blaming you.

Let's be straightforward. For 1-4, it's mainly your issue, for 5, it's the teammate's problem. Example 1-4 is more of a not-to-do when you are a team lead.

Example 1 and 2 makes the teammate had no way to understand anything, they are the extremes. **I suggest you gradually letting go, you teach them a lot, then you start to let go a little, just like the 4 phases I mentioned.**

Example 3 and 4 is also more of your issue. **I recommend that you get a plan before everything happens and set a bunch of hard major milestone deadlines.** Not just that, as a team lead, you should also know there will be required testing, because nothing will become perfect in the first trial.

To be fair, in '24 High Stakes APAC, I did example 1. So, it is reasonable that I got blamed. Although I attempted to gradually letting go of things, but the speed of letting go was done poorly, due to my lack of experience. It seems like that I teaches so much before the competition, then just suddenly silenced. It's not a very good approach, I should've gone on the field with my teammates, since the practice isn't enough for our driver. I could've provided my experience of crisis management, but I didn't. So yes, **don't change things too quickly**, humans are naturally resistant to change, you are too.

Later in ACAMIS North regionals, with the previous two competition experience, I sometimes let my teammates on the field, I said I want to train their skills on the field, explicitly. They have done a good job.

Maybe you can quote from Biden: "You can't love your country only when you win; you can't love your neighbor only when agree." So you can't leave them only when you feel like they are OK, but they might not be there yet.

"Public welfare organization"

The fundamental of our club is really like a public welfare org. That says, all teammates' join & leave is uncontrollable. If this is a company, you can certainly kick the people who did poorly or don't award them salary. But in this club, you can't. People come and go, there's nothing you can do. You can

encourage people to behave better but it depends whether they accept your suggestion. ☹

- Realize this fact of our club. The only thing you can do is to perform like a leader and make people like their job, so they will continue to work. (as I mentioned the 4-steps)
- Unless someone did really badly (like safety issues), you can't punish them. So you have to educate them why was their behavior not good.

Do what you can do! Don't be blame yourself if you can't change anything. There are a bunch of stupid restriction that we have no way to change because a bigger organization will tend to be more conservative (保守), so there will be more rules in order to keep people "safe".

Epilogue

I can't believe someone actually finished reading all the contents. This tutorial wasn't written on a whim, it was thought about for a long time, because I got afraid that no one will probably read it (so my time will be wasted), to be honest. It is always difficult to read a lot, especially reading all of this "has nothing to do with my college app", as some of you might think.

However, there is still hope around. I mean, I know, there will be only few Robotics enthusiasts, willing to read it. I hope the future of this club can be slightly better when I am writing this part. It's April of 2025, the club just got a little attention, but majority of the people still don't really know or care that we went to APAC or TIS or ACAMIS, unless they had some friends who participated in Robotics; We still had no right to build without supervision, although the Vex parts aren't dangerous or will kill anyone; every time we need to buy new parts, there's always too much pushbacks in time; Our core member is still little and only few people cares about the club, although it looks like a lot of people joined.

I never participated in Performing arts and only little season sports, but I do wonder and got slightly jealous about their daily life. They always get noticed by the entire school, well, it's popular. I must say, getting in and stick with Robotics is a much harder road. You should expect no applauses, no supports. It's boring, it has a relatively high barriers to enter.

The tutorial might sounds like everything in Robotics are too hard and takes too much time. This is sadly my own limitations; I can't explain everything in a shorter way. Afterall, English is my secondary language.

I hope all the dedication and perseverance, and ordinary stuffs that might seem a little pointless, will eventually create something different (If you study Chinese, Mr. Zheng's room has an almost exact same quote). It doesn't matter whether it's good or bad, if people are actually learning something from here, all my time and experiences would be worth it.

I sometimes have doubts about continuing Robotics, even about the meaning of life, like, everything will be demolished after a long time, nobody will remember your contributions after the last person knows it dies, so what is the purpose of doing things if one day they will all disappear, something like that. But later I no longer think like this. Because I guess my life also needs some robustness.

中文后记

2025 年 4 月 5 日

这部分算是我个人的一些想法，仅仅是记录在这里，就当做随手记了。应该不会有人读到这吧？毕竟又不是小说，这篇教程其实枯燥得很。

我个人有一些无病呻吟的问题。我过着舒适的生活，但是我又却焦虑地认为不知道这种生活哪一天会结束。毕竟这种生活有点是竭泽而渔，当我们的父母离我们而去，我们要自己想办法活下去的时候，还能继续如现在一般活得自由自在吗？我们的未来是怎样的呢？我以后做什么工作，会有什么感兴趣的东西？没人告诉我，人们告诉我要学习。我上小学就问这问题。爸妈说：为了上初中做准备。初中我也问这个问题。爸妈说：为了上高中做准备。高中我居然又荒谬地问一遍，却没有总结出什么。爸妈说：为了上大学做准备，然后你就可以找一个好工作养活自己。

大家都是这样吗？上学，学习，考试，然后做一些莫名其妙的东西丰富自己的简历，然后工作，也许升职，然后退休。很多人应该都知道，我是一个喜欢做一些不一样事情的人，这种行为奇怪到明明有更简单的方式，我却还是为了这“不一样”去走一个更难的路。所以我就很慌张。我不知道这种“平庸”的生活是不是我想要的。

这种焦虑的情绪在我撰写这篇教程的时候同样存在。我有太多莫名其妙的无病呻吟。我就想着“如果没人会感兴趣阅读我的东西，为什么写？”我尝试安慰自己：“发表之前谁知道？也许大受欢迎。”然而，这种所谓的安慰实际上有点不现实。后现代的我们已经太过沉沦于那些给你提供瞬时情绪的东西，因而有“脑腐”(Brain Rot)这一说法——就像是，你看了几小时推荐的视频，但是感觉什么都没学到，好像就完全浪费了。我不知道是否还能有人愿意在他们业余的时间里不去看那些能给他们产生共鸣和强烈情感的视频，而是来这里啃一个很莫名其妙且难懂的教程。

我观察着身边人的生活，他们看上去很幸福。一些人们和朋友出去玩，一些人去欣赏美丽的风景，虽然我知道大家只会给别人展示他们比较美好有趣的一面，但是这难免不会造成影响。不幸的是，我本人实际上只是一个窝在自己家里的一个怪人，还做着各种奇怪的事情，而这完全是我自己的选择，人话就是活该。我无数次提醒我自己随波逐流并不代表是好的东西，也不应当片面的通过人生活的一个切片来判断他们是否活得开心，然而这种同伴的压力还是难以克服。

实际上，这个后记部分，甚至整篇教程，可能也最终会是我个人的无病呻吟。大家其实不需要这些信息，只是我自己自作多情了。当然，这些写在这里的抱怨也完全没有用，因为人人皆可抱怨，但是能想出解决办法的人的抱怨才真的有用。因此后来我想了想，这篇教程石沉大海我也无所谓了，因为我应当先和自己和解，先走出这种莫名其妙焦虑的状况...通过做一些不一样且实际上有可能帮到别人的事情，同时仅仅是出于自己的考虑，而不是什么该死的大学申请。

我已经做了太多违心的事情，因此总该给自己放个假了。


循此苦旅，以抵星辰