Drive Base (Chassis) Build Instruction Guide

6627 Daylight

KNIGHT TIME BOTS D

WORKING FROM

KNIGHT TIME TO DAYLIGHT

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Link to Youtube Video - ***LINK***

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Chassis Build Instruction

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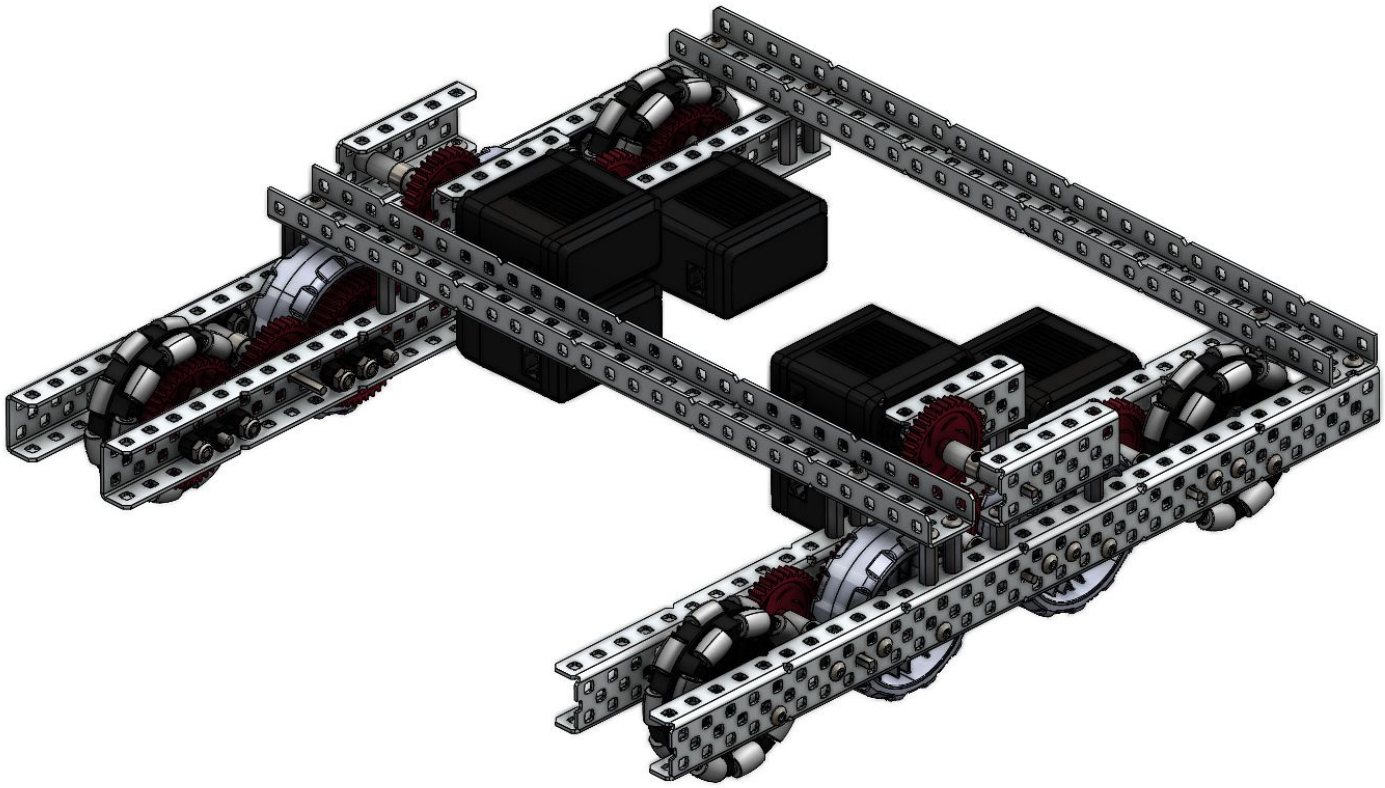
Chassis Explanation

Overview

A chassis must be designed to effectively function as it is a big part of the robot's overall capability. Having a well performing chassis is a major part in competing because without movement the robot would be unable to score.

The chassis design is an A shaped chassis with a 450 RPM, with 8 wheels, and a 6 motor drive. The chassis uses four 2.75 inch omni wheels and four 2.75 inch traction wheels. By using six motors it gives the robot better acceleration. The chassis has two cross bars for stability. Lastly, the use of 4 traction wheels and 4 omni wheels eliminates drift*, making the robot easier to drive and making programming the chassis easier and more accurate.

This chassis has screw joints and stacked motors which are more advanced techniques that helps make the robot more competitive.

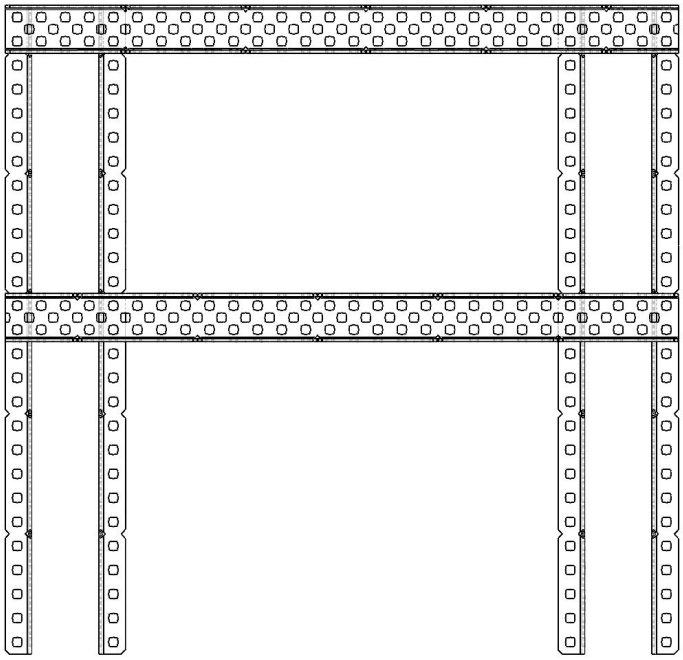


**Adding traction wheels eliminates the drift caused by omni wheels, it does not eliminate drift caused by uneven friction.*

Chassis Frame

What is a Chassis?

A chassis serves as a stable base and allows the robot to move around the field, making it one of the most important systems incorporated into the robot. Deciding which type of chassis to use is essential as it determines the positions of the subsystems, and the stability of the overall robot.



A-Shaped Chassis

The A-Chassis is similar to the H-Shaped chassis, however a bar is added on the back of the chassis for extra support. The extra bar also allows for more connection points for future subsystems.

Pros:	Cons:
- Better structure - Stable	- Extra weight

Tips for a Chassis

The chassis frame is the most important part of the robot meaning the chassis has to be structurally stable and functional. To ensure that this happens make sure you...

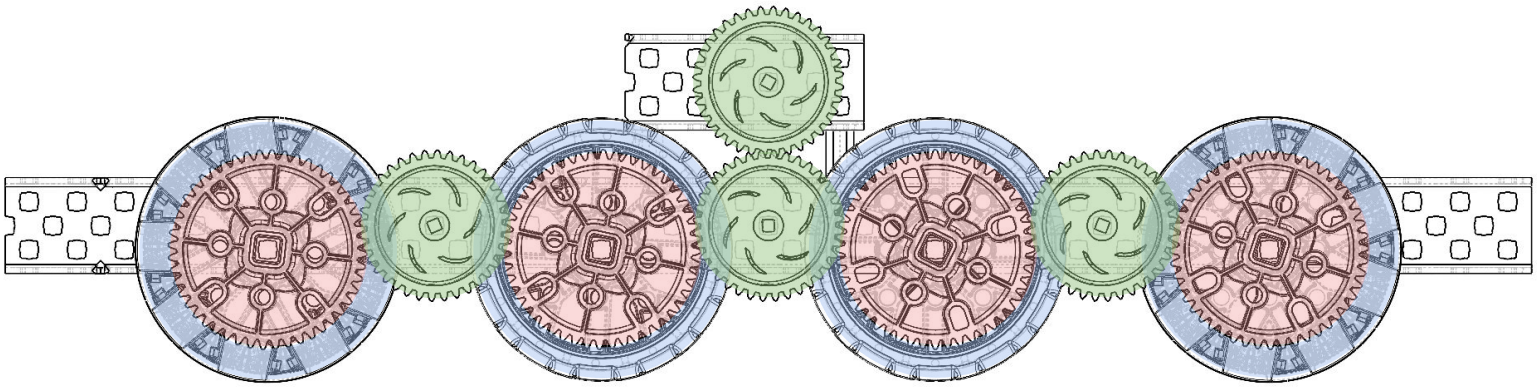
- Have at least two cross braces running from one side of the chassis to the other
- Have the wheels inside of the chassis (between two pieces of metal)
- Have enough points of contact to mount firmware as well as subsystems
- Have low friction

This is not necessary but it is very useful to have a 6 motor chassis to be a competitive team because the extra speed is necessary during the game.

Gear Ratio

What is RPM?

RPM is the number of rotations per minute which is calculated to help determine the amount of speed and torque a robot has. A faster gear ratio may be preferred for an offensive robot because it has more power and acceleration.



450 RPM (36:48)

- Runs at 57.43 in/s
- Geared down 36:48 (3:4)
- Optimized for 2.75 inch wheels but can use 3.25

Pros:	Cons:
- Very fast chassis - Robot is hard to push around	- Can be hard to control - Motors can burn out easily

Reason for Using Two Traction Wheels Instead of all Omni Wheels

- Better traction and more control
- No drift (Is beneficial for beginners but more experienced drivers may want drift)
- This prevents from being pushed easily
- Uses blue motors to increases the speed
- Good chassis for a rush*

*A rush is when a robot tries to reach a certain point/game element first, for example in the game High Stakes most teams have a rush to quickly obtain the mobile goal in the center of the field.

This gear ratio allows for a much more competitive robot because of its benefits in speed, acceleration, traction, and control.

***Color Code** - Pink = 48 Tooth Gears, Green = 36 Tooth Gears, Blue = Wheels*

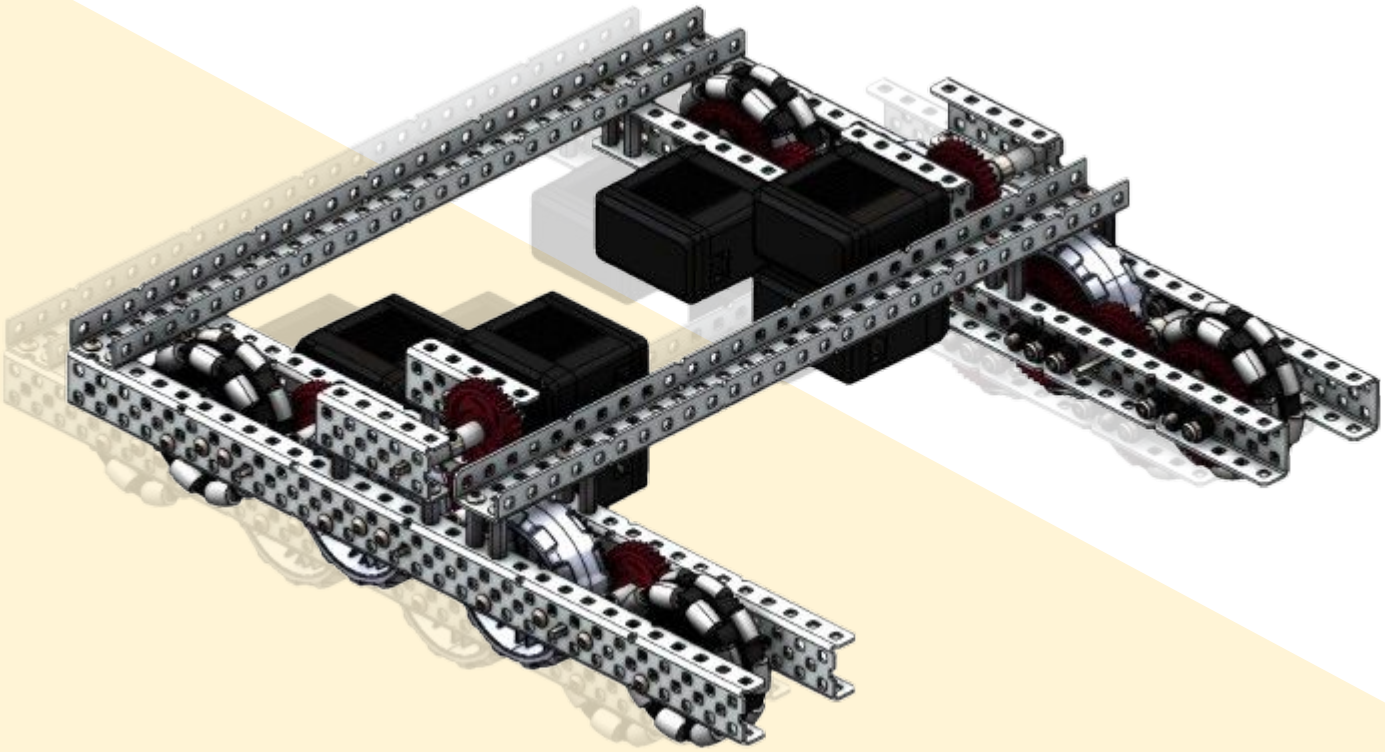
Movement

The chassis that is going to be designed runs at a 450 RPM which is a fast chassis. This type of chassis is capable of maneuvering easily but doesn't drift.

Drift happens when you have a chassis with all omni wheels because the omni wheels have cylindrical rollers which allows for a larger range of motion, causing the robot to drift in a certain direction when turning.

The type of motion that beginner teams, or someone with little drive experience wants is a chassis that doesn't drift because it is easier to control the robot. This helps teams gain experience while also having a robot that is competitive enough where the extra range of motion is not necessary.

The robot drives forwards, backwards, and side to side, which also contains any in between depending on how the controller is programmed.



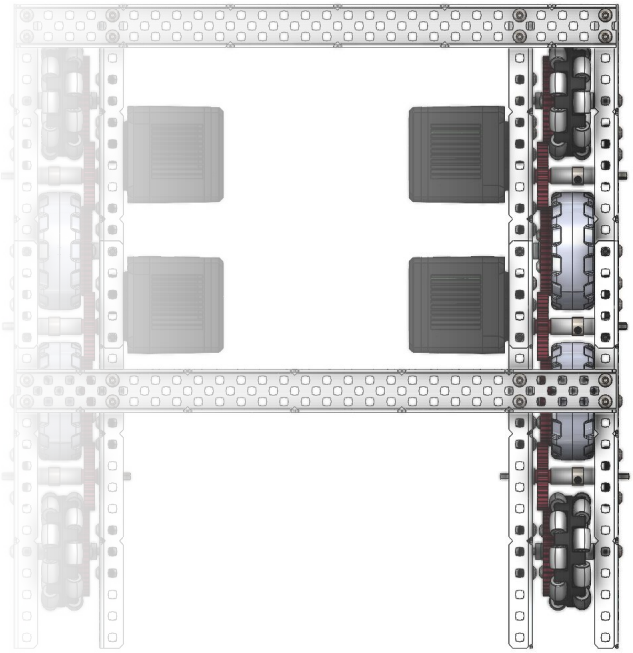
Chassis Planning

The timeline to the right is a representation of the different subcomponents this chassis is broken up into for building. This list also contains the page number of where each subcomponent starts to be built to make it easier to find.

Formating

- Each subcomponent is shown with an exploded view of the cad
- Each part is colored a different color with a key to understand what each part is
- A view of the cad will be shown to give more information about the build

Formulas, lists of tools, and lists of parts are on the following pages to get you started with building a chassis.



Formulas

Speed Formula

To calculate the linear speed of the drivetrain, the length of the wheels' radius and the angular speed (the speed of an object in rotational motion) must first be measured. The radius of each wheel is 2.75", and the angular speed is calculated using the angular speed formula below, with a result of 47.124 radians per second. Afterwards, both of these values are plugged into the linear speed formula to calculate the chassis speed in meters per second. Finally, convert this value to miles per hour.

Linear Speed = radius of wheel • angular speed

Angular Speed = 2π radians/4 seconds

The speed of this chassis, without friction or weight, would be approximately 4.32 mph. If taking weight and friction into consideration, the chassis speed would be roughly 4mph.

RPM Formula

The main factors when calculating RPM are the gear ratio on the chassis, and the RPM of the motor cartridge. Once you know the the gear ratio and the RPM of the cartridge, you multiply both values to find the RPM of the wheels.

Cartridges Types

Green Cartridge: Runs at 200 RPM, standard motor (18:1).

Red Cartridge: Runs at 100 RPM, torque motor (36:1).

Blue Cartridge: Runs at 600 RPM, speed motor (6: 1)

Formula - Motor RPM • (Input Gear/Output Gear) = RPM

The RPM of this chassis is 450 RPM

Images taken from the Vex Robotics Website

Tools List

Tools Needed

- T15 Star Drive Screwdriver
- Open ended Wrench
- T8 Star Drive Screwdriver

These tools can either be found on the Vex Robotics website or RoboSource depending on your preferences.

It is better to use a screwdriver than a star drive key because it is easier to use. For the screwdrivers, a screwdriver with a ball end will be more convenient since it can screw a screw in at an angle.

It is easier to buy individual tools off of RoboSource, and easier to buy large packs off of the Vex Robotics website.

T15 Star Drive Screwdriver - Made for screwing in standard screws (Image from Vex Robotics).

T15 Star Drive Ball End Screwdriver - Made for screwing in screws, especially at an angle (Image from RoboSource).

T8 Star Drive Screwdriver - Made for screwing in shaft collars and couplers (Image from Vex Robotics).

Wrench - Double sided, one end for tightening nylocks/keps nuts, and the other end for tightening standoffs (Image from Vex Robotics).

Parts List

Part Name	SKU Number	Quantity
1 x 2 x 1 x 35 Aluminum C-Channel**	276-2289	6
# 8-32 x 1/4" Star Drive Screw	276-4990	32
# 8-32 x 3/8" Star Drive Screw	276-4991	16
# 8-32 x 1/2" Star Drive Screw	276-4992	40
# 8-32 x 1.000" Star Drive Screw	276-4996	16
# 8-32 x 2.500" Star Drive Screw	276-8016	8
0.375" OD Nylon Spacer Variety Pack (0.125”)	276-6340	16
0.375" OD Nylon Spacer Variety Pack (0.250”)	276-6340	4
0.375" OD Nylon Spacer Variety Pack (0.375”)	276-6340	4
0.375" OD Nylon Spacer Variety Pack (0.5”)	276-6340	20
Teflon Washer (1/16”)	275-1025	12
1/2" Standoff	275-1014	8
3/4" Standoff	275-1015	8
Black Aluminum Standoffs, 7/8" Length	None	8
Bearing Flat	276-1209	6
Low Profile Bearing Flat	276-8023	8
# 8-32 Nylock Nut	275-1027	52
# 8-32 Keps Nut	275-1026	8
Star Drive Shaft Collar	276-6103	8
2.75" (220mm Travel) Omni-Directional Anti-Static Wheel	276-8106	4

* Some parts are going to be modified by cutting
**A single 35 long C-Channel can be cut to a 5 long and a 30 long to multi-purpose the metal

Parts List

Part Name	SKU Number	Quantity
2.75" (220mm Travel) Anti-Static Wheel	276-8098	4
48T High Strength Gear v2	276-7573	8
Gear Kit (36T)	276-2169	8
Shaft Add-On Kit (3”)	228-3057	8
High Strength Shaft Insert Kit	276-3881	16
V5 Smart Motor (11W)	276-4840	6
Smart Motor 6:1 Cartridge (600 RPM)	276-5842	6

Replacement Parts

Alternate to 0.875 Inch Standoffs

1/4" OD Nylon Spacer, 7/8" Length	None	8
# 8-32 x 1.250" Star Drive Screw	276-4997	8
# 8-32 Nylock Nut	275-1027	8

Alternative to low profile bearing flats

Bearing Flat	276-1209	8

Alternative to Back Brace

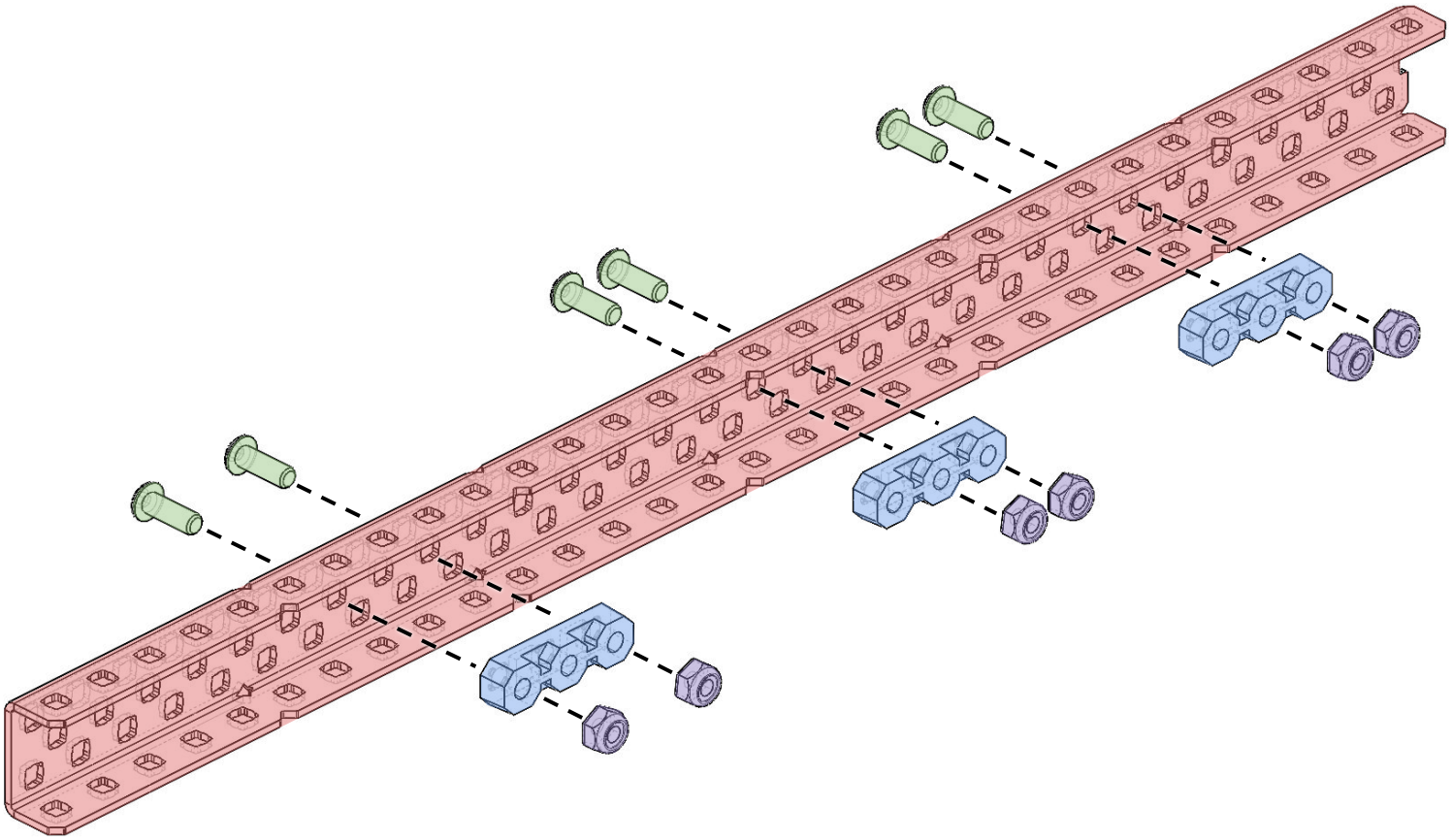
24” High Strength Shaft (Will be cut down later)	276-7465	1
# 8-32 x 1/2" Star Drive Screw (Replaces the same quantity of 1/4" screws)	276-4992	4

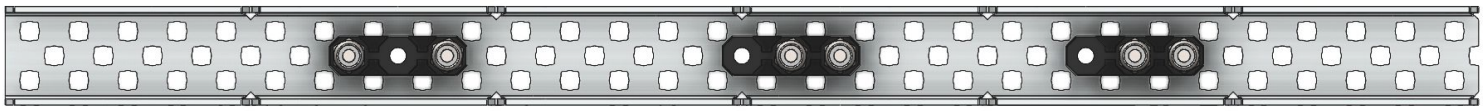
All of these parts are found on VEX Robotics except for the 0.875” standoffs and 0.875” spacers which are found on Robosource

VEX Robotics - https://www.vexrobotics.com/catalogsearch/result/?q=__empty

Robosource - https://www.robosource.net/

Step 1 - C-Channel Configuration - Outer Left Side - Part 1



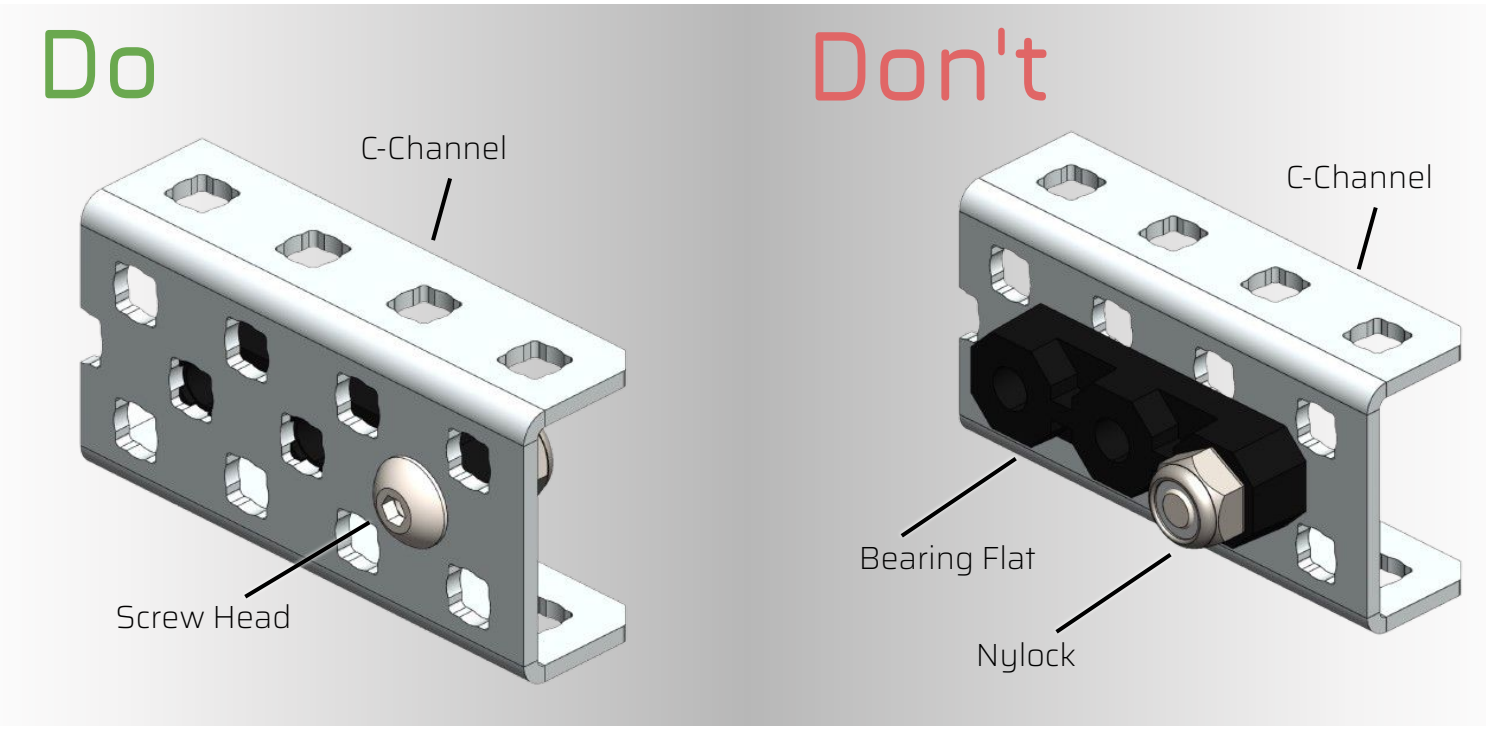


Part	Quantity (Total)	Color Code
1 x 2 x 1 x 30 Aluminum C-Channel	1	Red
0.5 Inch Screw	6	Green
Bearing Flat	3	Blue
Nylock	6	Purple

Screw Placement

One common mistake is the placement of the screw head, it is be very important especially with the chassis because the screw head has better clearance then the nylock on the end of the screw. The screw head should be on the flat side of the c-channel with the nyclock and bearing flat on the inside of the c-channel.

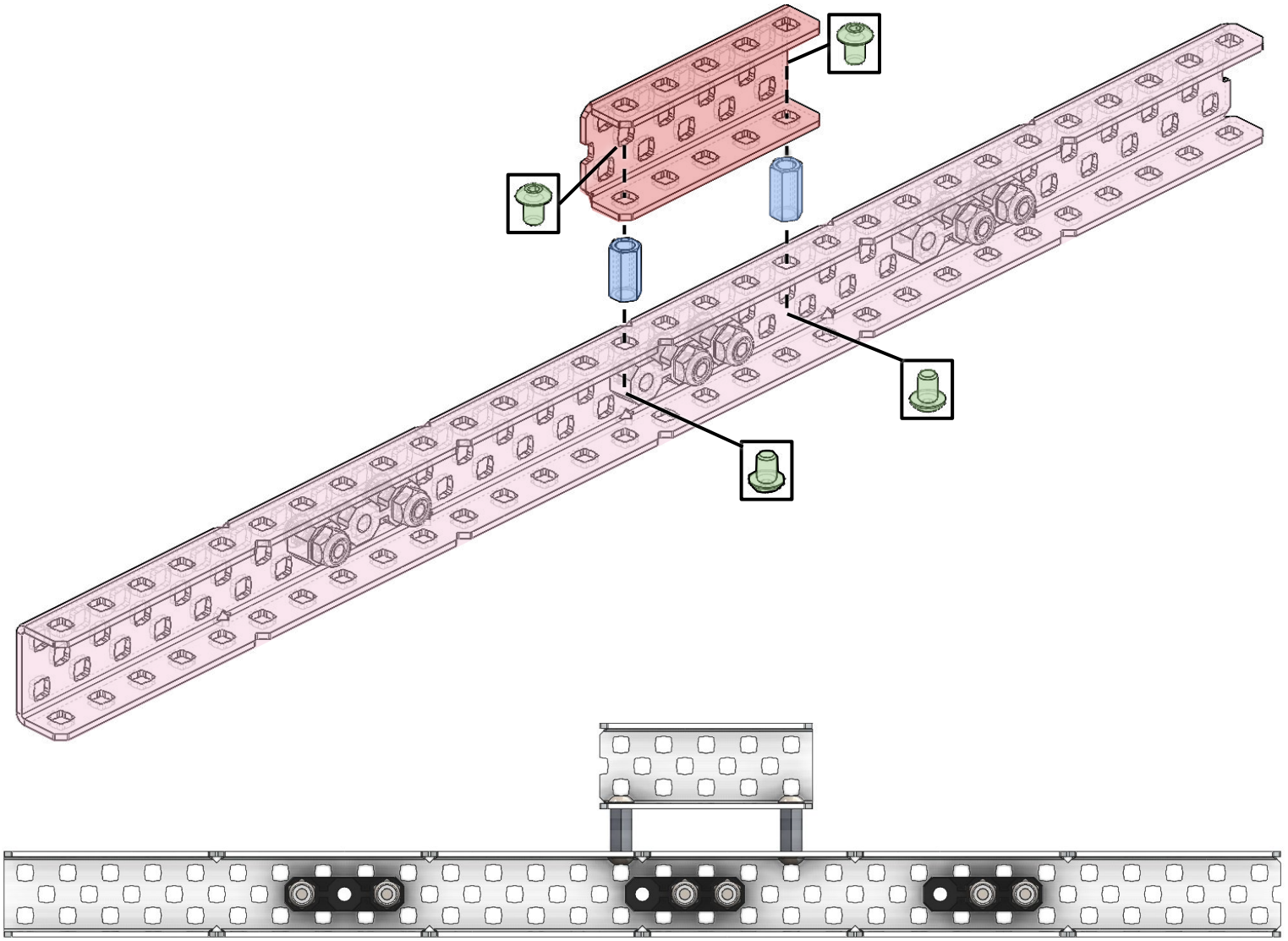
Do	Don't
- Screw head is on the flat side of the c-channel - The nylock and bearing flat is on the inside of the c-channel	- Do not have the nylock or the bearing flat on the flat side of the c-channel - Do not have the screw on the inside of the c-channel



There is more clearance with this model because the screw head is on the flat side of the c-channel. The screw head does not extrude as far outwards as the nylock or bearing flat.

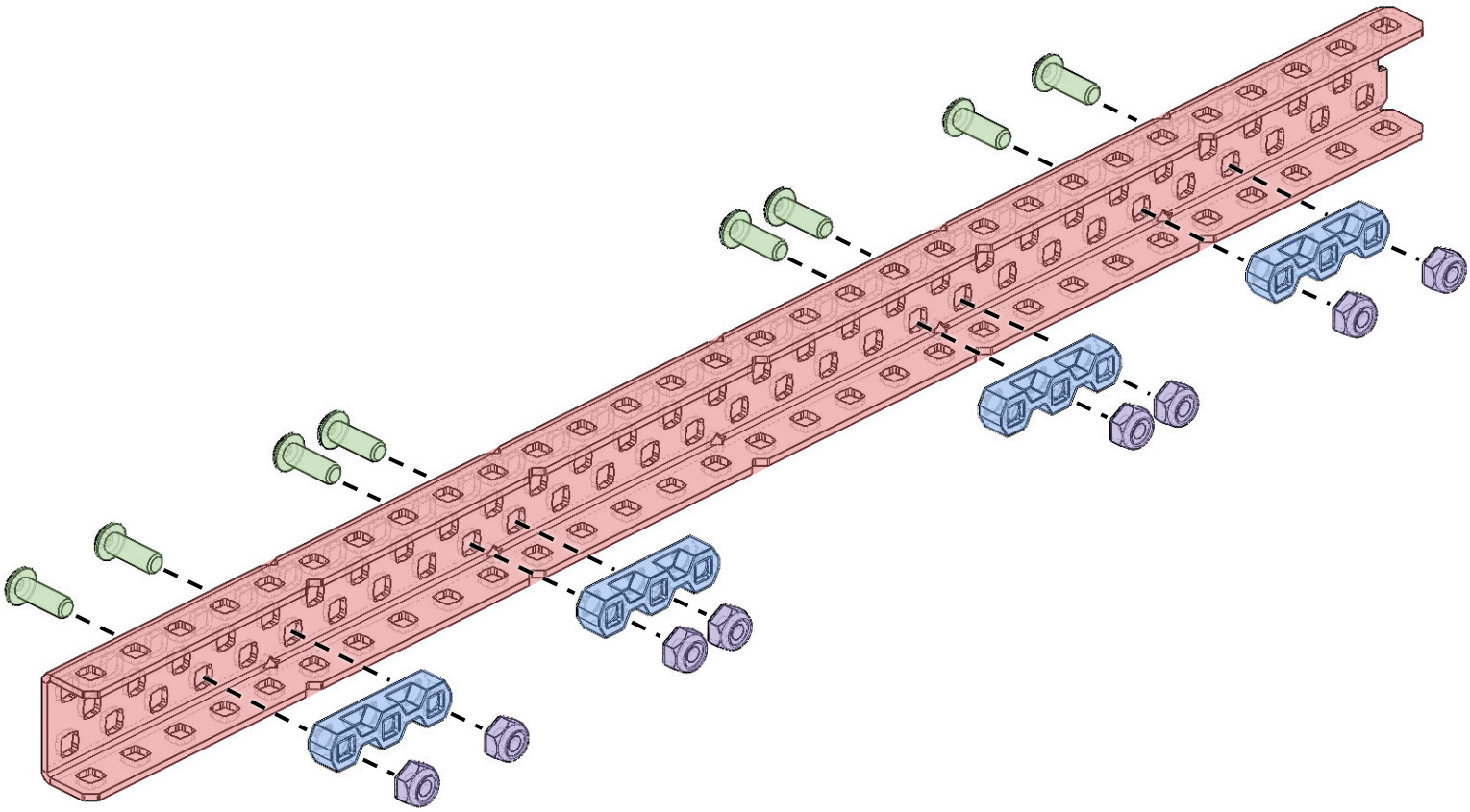
When the bearing flat and the nylock is on the flat side of the c-channel instead of the inside of the c-channel it decreases your profile (clearance).

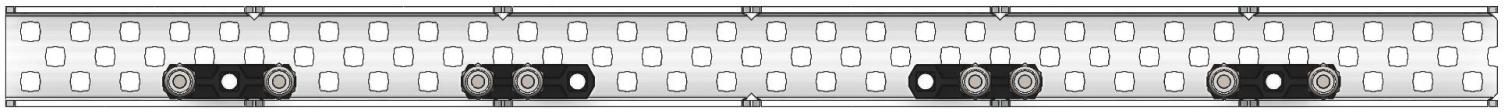
Step 2 - C-Channel Configuration - Outer Left Side - Part 1



Part	Quantity (Total)	Color Code
1 x 2 x 1 x 5 Aluminum C-Channel	1	Red
0.25 Inch Screw	4	Green
0.5 Inch Standoff	2	Blue
Part from the Previous Step	1	Pink

Step 3 - C-Channel Configuration - Inner Left Side - Part 2





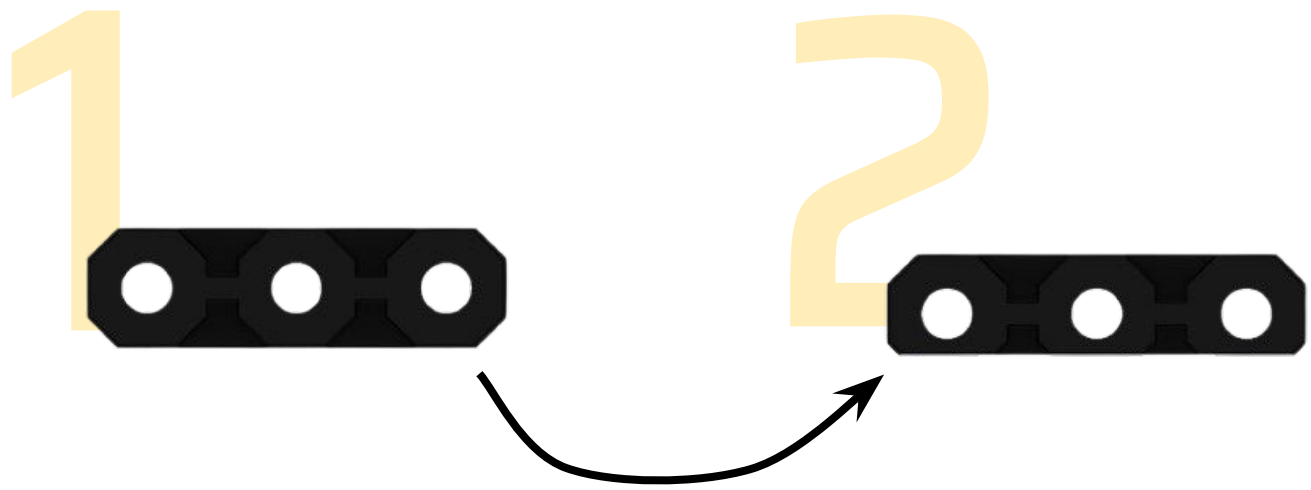
Part	Quantity (Total)	Color Code
1 x 2 x 1 x 30 Aluminum C-Channel	1	Red
0.5 Inch Screw	8	Green
Low Profile Bearing Flat	4	Blue
Nylock	8	Purple

Bearing Flats - Alternative for Low Profile Being Flat

There are certain situations where the bearing flat needs to be shaved down. This allows the bearing flat to fit on the lower part of the c-channel. Shaving down a bearing flat is necessary for certain chassis but not all; it's all dependent on the wheel and gear placement.

How to - When shaving a gear down it is important that the circles are fully intact. This allows the bearing flat to retain its proper use even when a portion of it is shaved down. It can be either done manually using a file or done by using a belt sander.

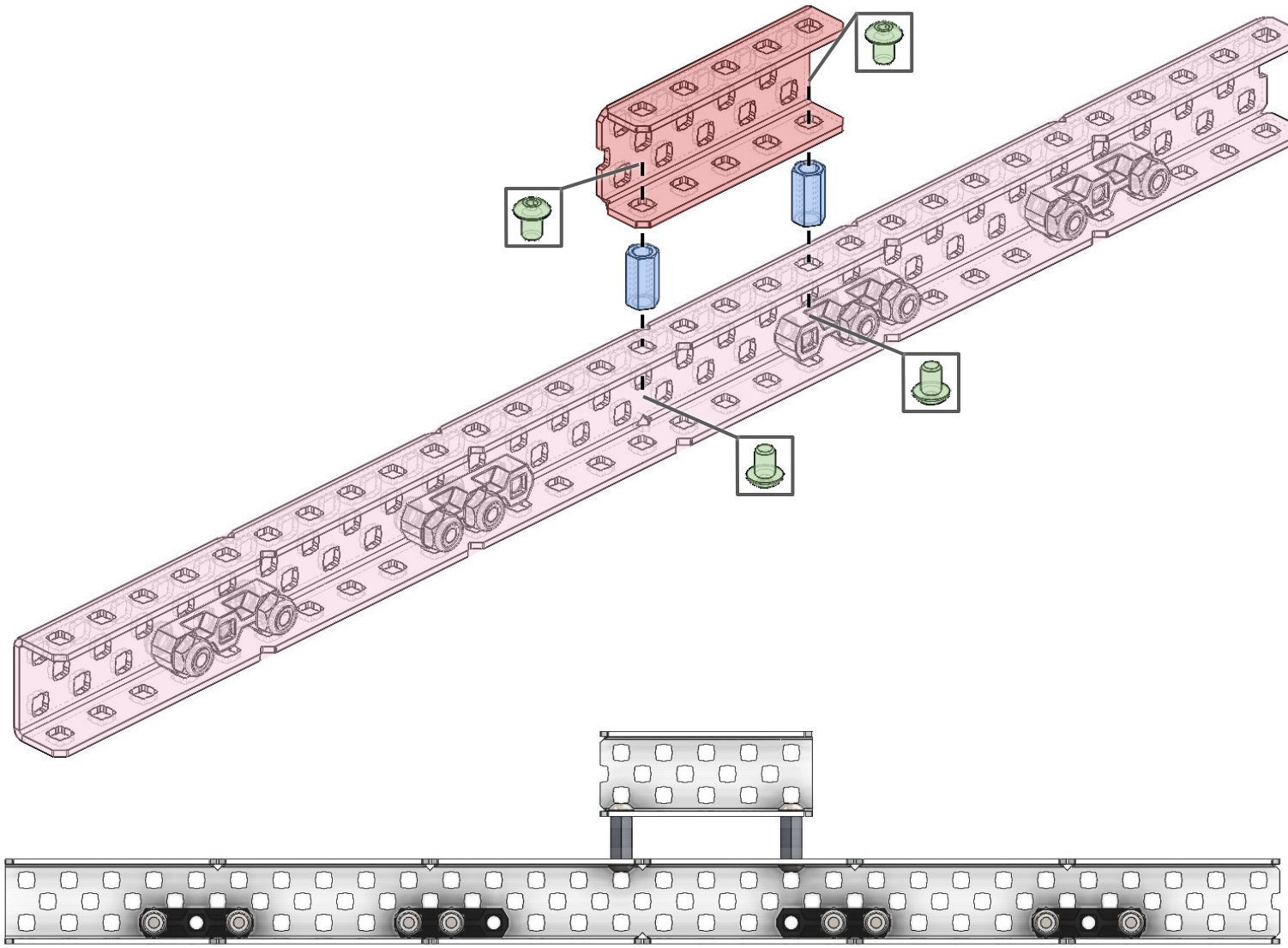
Do	Don't
- The bearing flat is shaved down without affecting the circles - The bearing flat is cut straight without any extruding edges	- The circles in the bearing flat are open, losing its use - The bearing flat is cut crookedly which makes it harder to line up with the holes in the c-channel



For this chassis either the bearing flats need to be cut or a low profile bearing flat needs to be used. This is because there is not enough room for a full bearing flat to fit on the bottom row of holes on a c-channel.

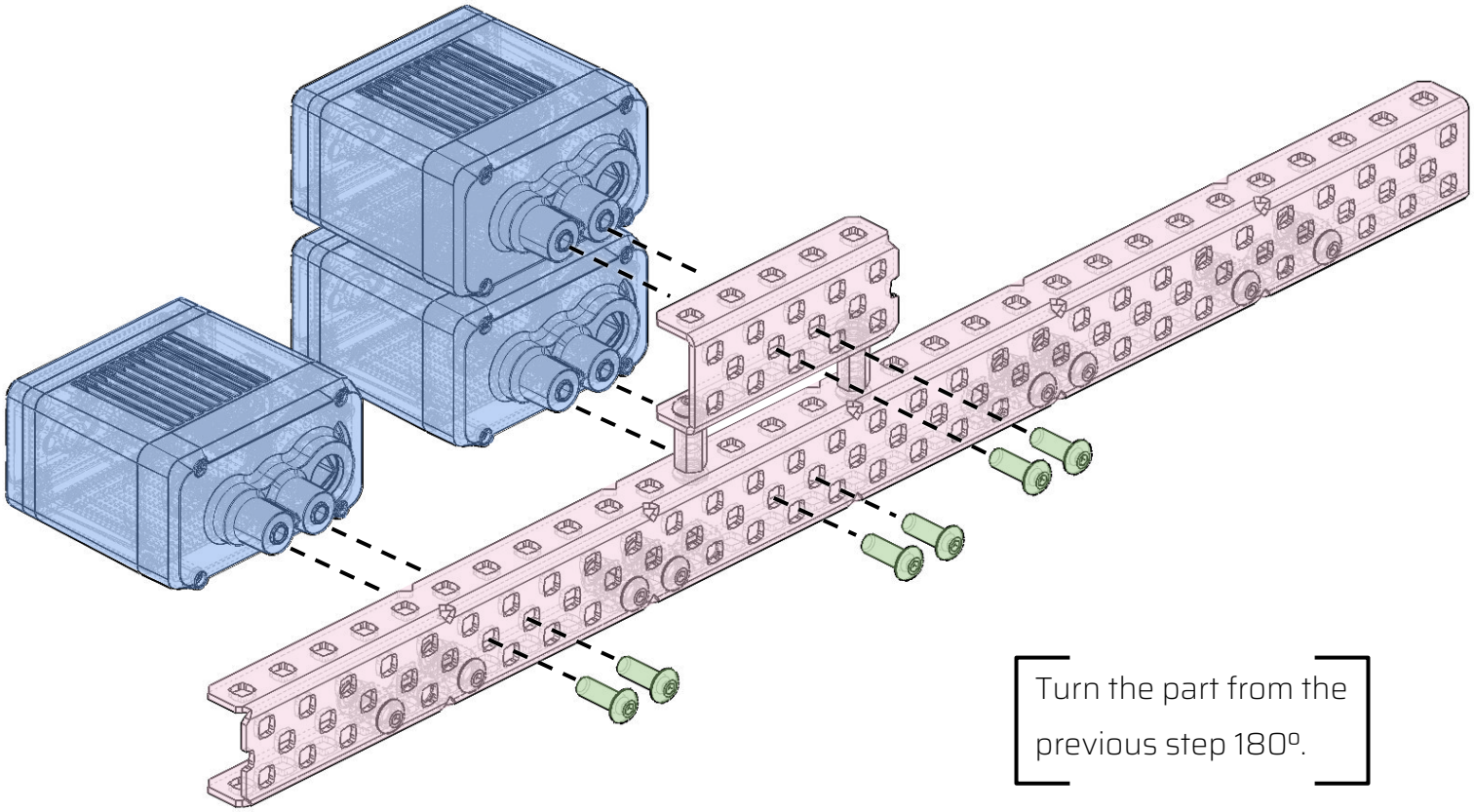
To cut the bearing flat as seen in step 2 either it can be cut, filled down or a belt sander can be used. It is important that the holes are still intact otherwise the bearing flat loses its purpose.

Step 4 - C-Channel Configuration - Inner Left Side - Part 2



Part	Quantity (Total)	Color Code
1 x 2 x 1 x 5 Aluminum C-Channel	1	Red
0.25 Inch Screw	4	Green
0.5 Inch Standoff	2	Blue
Part from Previous Step	1	Pink

Step 5 - C-Channel Configuration - Left Side Motor Placement - Part 2



Turn the part from the previous step 180º.

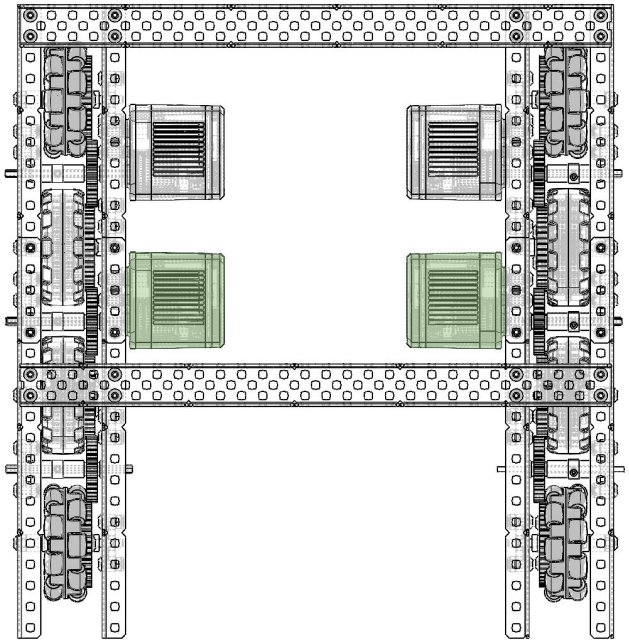
Part	Quantity (Total)	Color Code
0.5 Inch Screw	6	Green
Blue Motor	3	Blue
Part from Previous Step	1	Pink

Reason for Stacking Motors

Stacking motors decreases the amount of room being used by the chassis. By stacking motors it is more efficient spatially because it gives more room to the front of the chassis, allowing for either game elements to be capable of passing there or adding a mechanism.

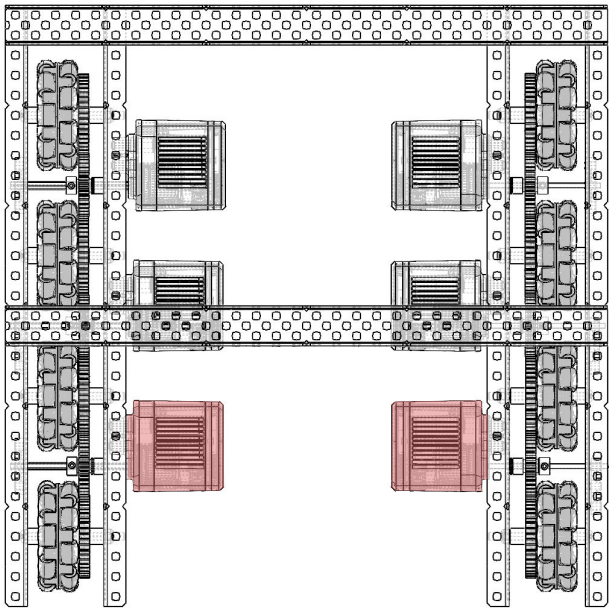
For the gear ratio of the stacked motor it is a 1 to 1 ratio to keep the speed constant at 600 RPM. If the gear ratio was not 1 to 1 then the RPM would change and that is not ideal, it is easier to keep it at a 1 to 1 ratio.

With
Stacked Motors



In this model, due to the stacked motors (colored in **green**) help give more space to the front of the chassis. This space can be used for many purposes depending on the game or the reason why the chassis is being built.

Without
Stacked Motors

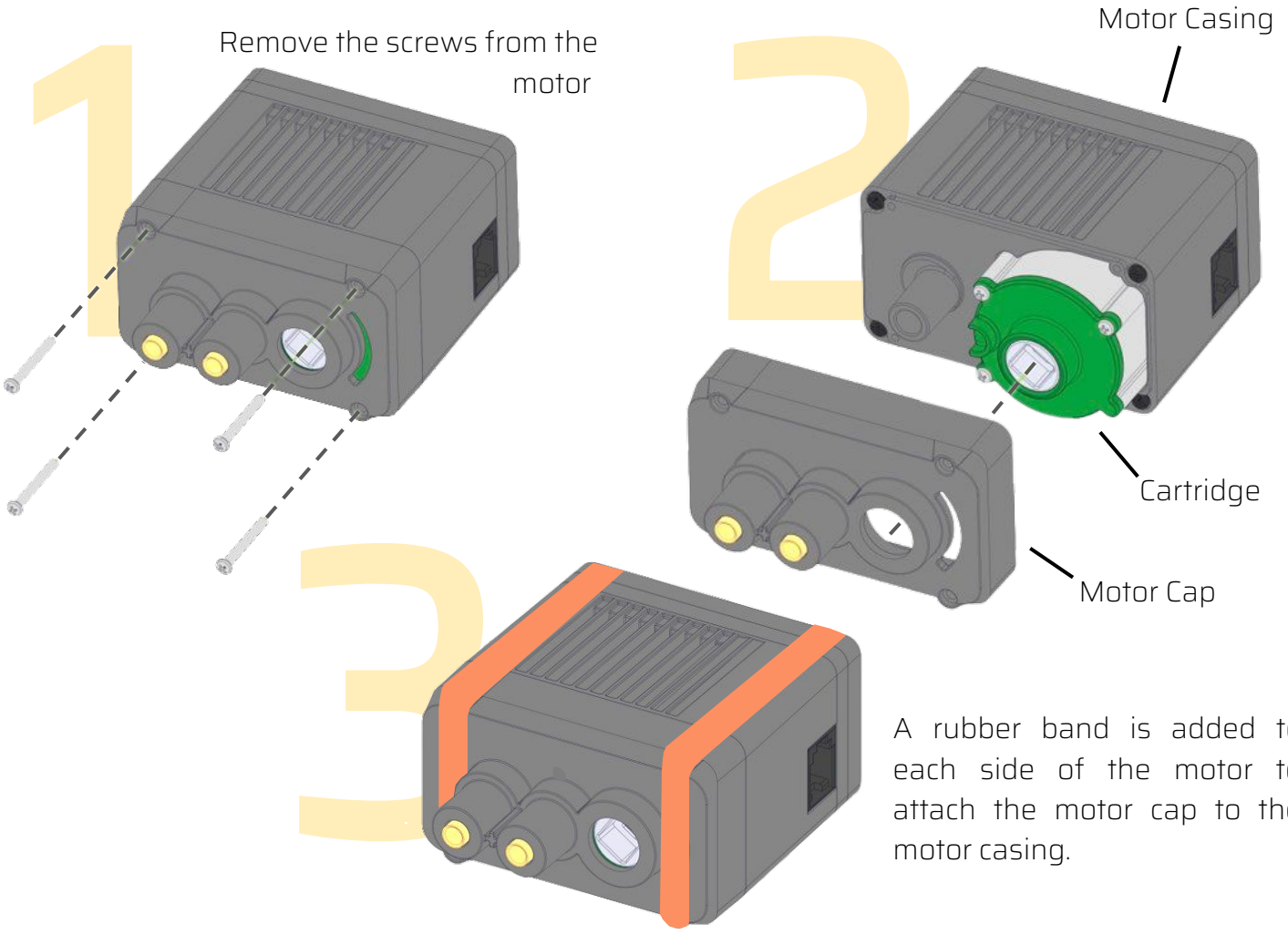


This model does not have stacked motors, instead it has a motor at the front of the chassis (colored in **red**) decreasing the amount of space found at the front of the chassis. This can be very limiting to what can be done with the chassis.

Hot Swap Motors

There is a method to make the motor easily exchangeable in case if the motor overheats. It is necessary to get a new motor if the the robot needs to continually used.

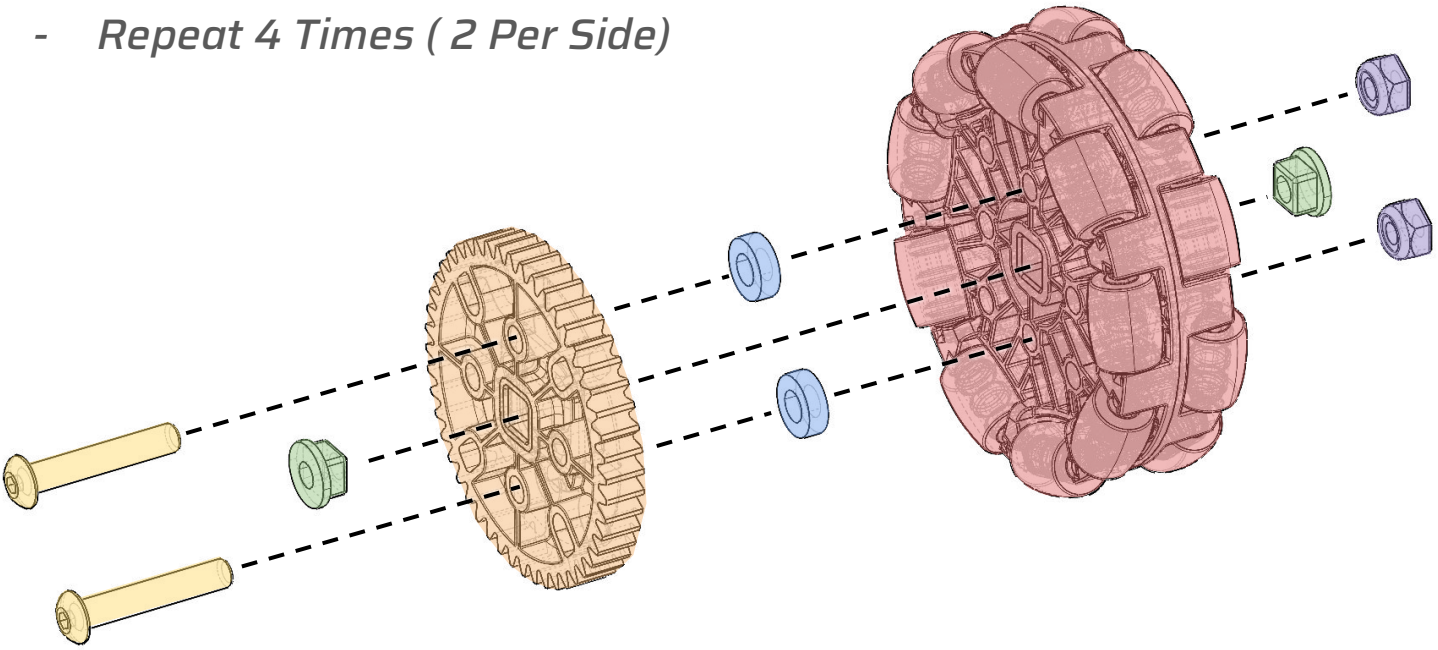
The first step to making a motor a hot swap motor is to unscrew the cap of the motor from the motor casing. Afterwards, you rubber band both parts together and make sure the cartridge is still inside of the motor. By rubber banding both parts together it is possible to remove the rubberband, allowing for the part of the motor prone to overheating to be removed. The cartridge and the motor casing should be removed and replaced with new ones.



Images taken from the Vex Robotics Website (some images are modified)

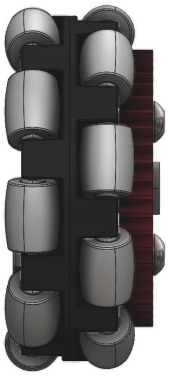
Step 6 - Omni Wheel and Gear Configuration - Part 3

- *Repeat 4 Times (2 Per Side)*

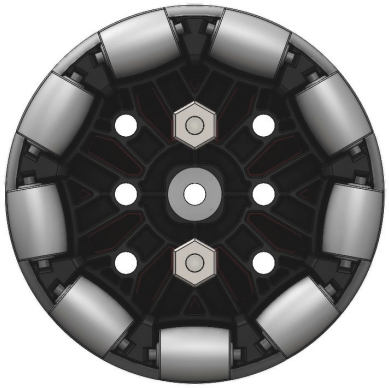


Front View

Side View



Back View



Part	Quantity (Total)	Color Code
2.75 Inch Omni Wheel	1	**Red**
48 Tooth Gear (Half Cut)	1	**Orange**
1 Inch Screw	2	**Yellow**
Plastic Insert	2	**Green**
0.125 Inch Spacer	2	**Blue**
Nylock	2	**Purple**

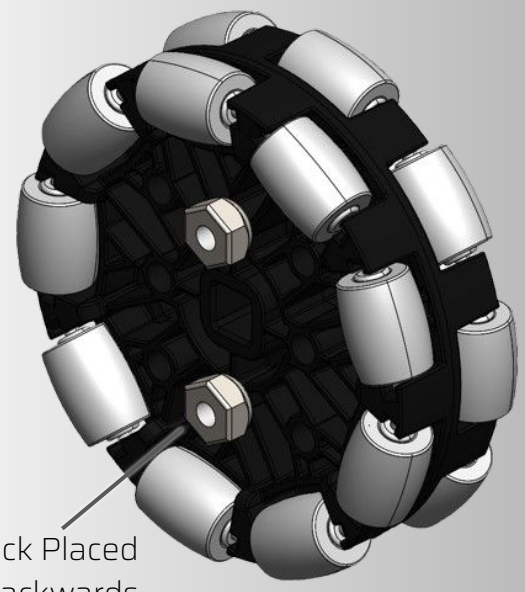
Nylock Placement

One way to ensure a screw doesn't fall off when screwing the wheel and gear together is by having the nylon portion of the nylock face towards the gear*. Since the nylon portion is closer to the end of the screw the locking portion prevents the screw from unscrewing.

**It might be difficult to screw in but it's possible*

Do	Don't
- Have the nylon portion closer to the end of the screw	- Have the nylon portion farther away from the end of the gear

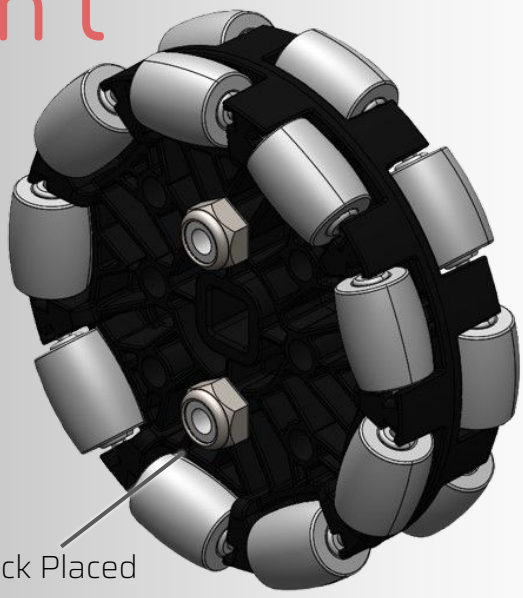
Do



Nylock Placed on Backwards

Since the nylock is placed backwards on the wheel it helps keep the nylock on because the locking portion is contacting the screw first.

Don't

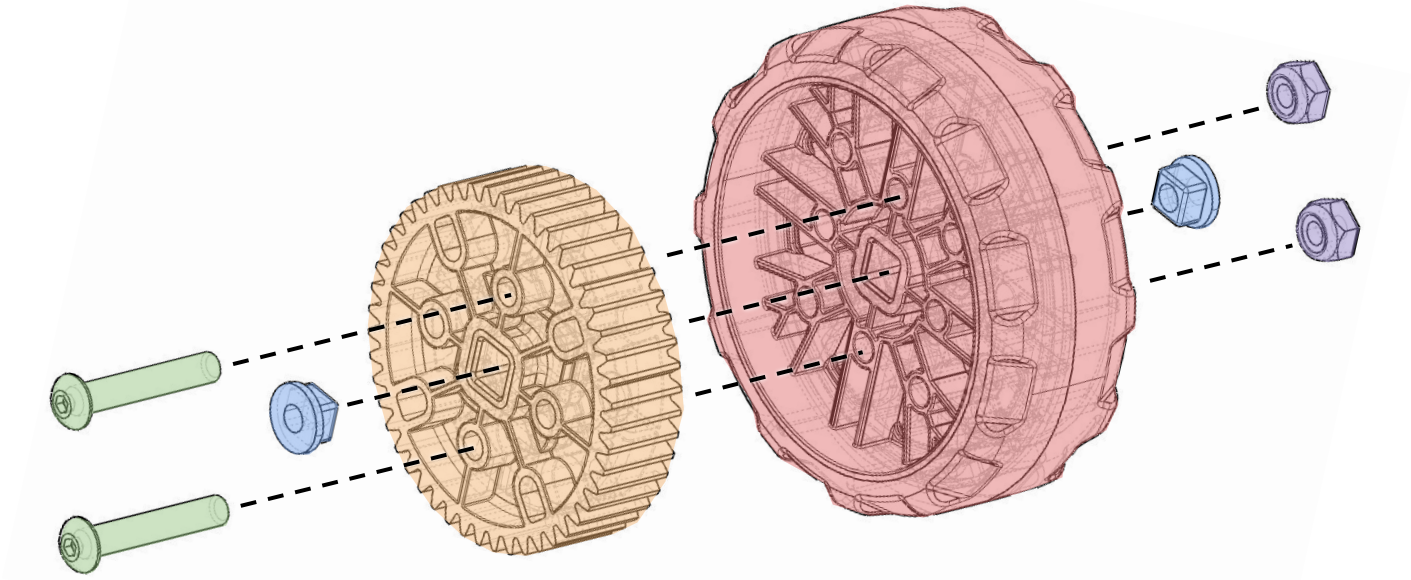


Nylock Placed on Normally

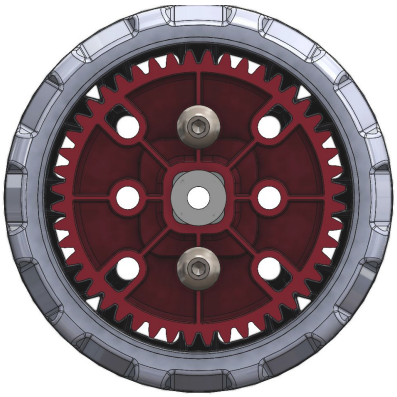
With this model the nylock is screwed on normally but the screw does not extend all the way through the nylock. This will make the nylock eventually screw off, affecting the structural integrity.

Step 7 - Traction Wheel and Gear Configuration - Part 4

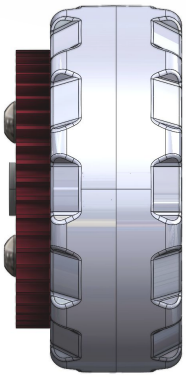
- *Repeat 4 Times (2 Per Side)*



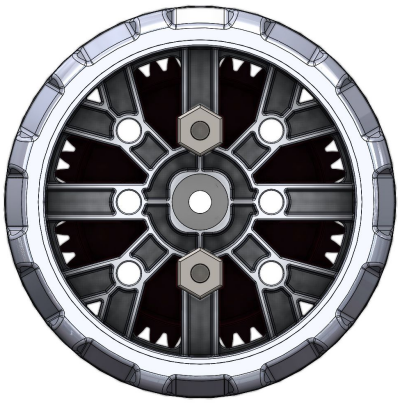
Front View



Side View



Back View



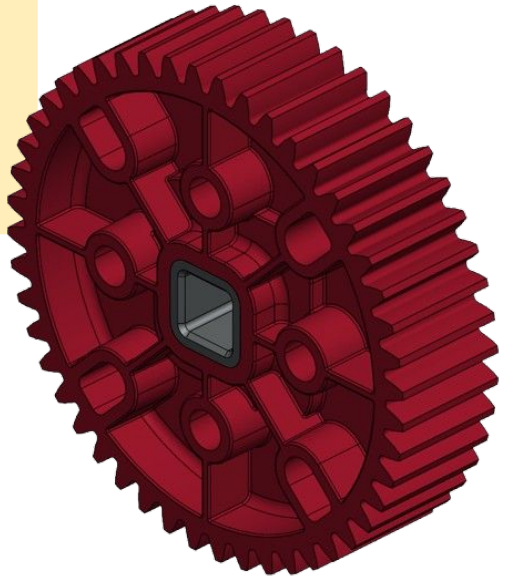
Part	Quantity (Total)	Color Code
2.75 Inch Traction Wheel	1	**Red**
48 Tooth Gear	1	**Orange**
1 Inch Screw	2	**Green**
Plastic Insert	2	**Blue**
Nylock	2	**Purple**

Cut vs. Non-Cut Gear

A cut gear is used for omni wheels to prevent the gear from needing to be excessively spaced out from the omni wheel. The gear will otherwise contact the roller if the spacing that is currently being used is applied to a full gear. With the traction wheels it is not an issue to have a full gear, meaning it is unnecessary to cut a gear in half.

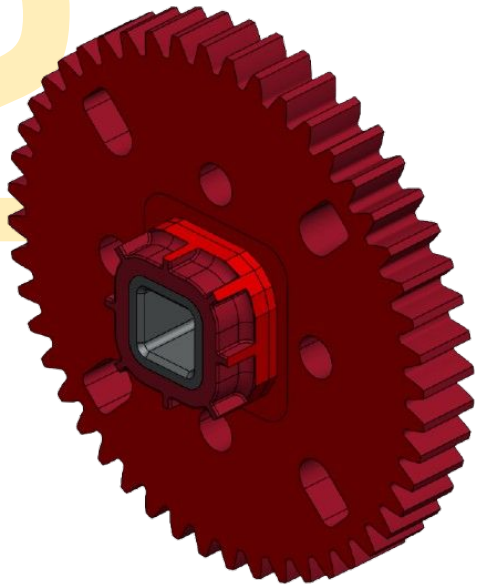
Do	Don't
- You can use a lathe to cut the gear in half - You can also use a bandsaw to cut the gear	- Make sure you do not cut the metal inside of a 48 tooth gear because it can make the metal shatter

1



The purpose of cutting the gear is only for the omni wheels, it is very unnecessary to cut gears for a traction wheel because the gear fits perfectly inside of the wheel.

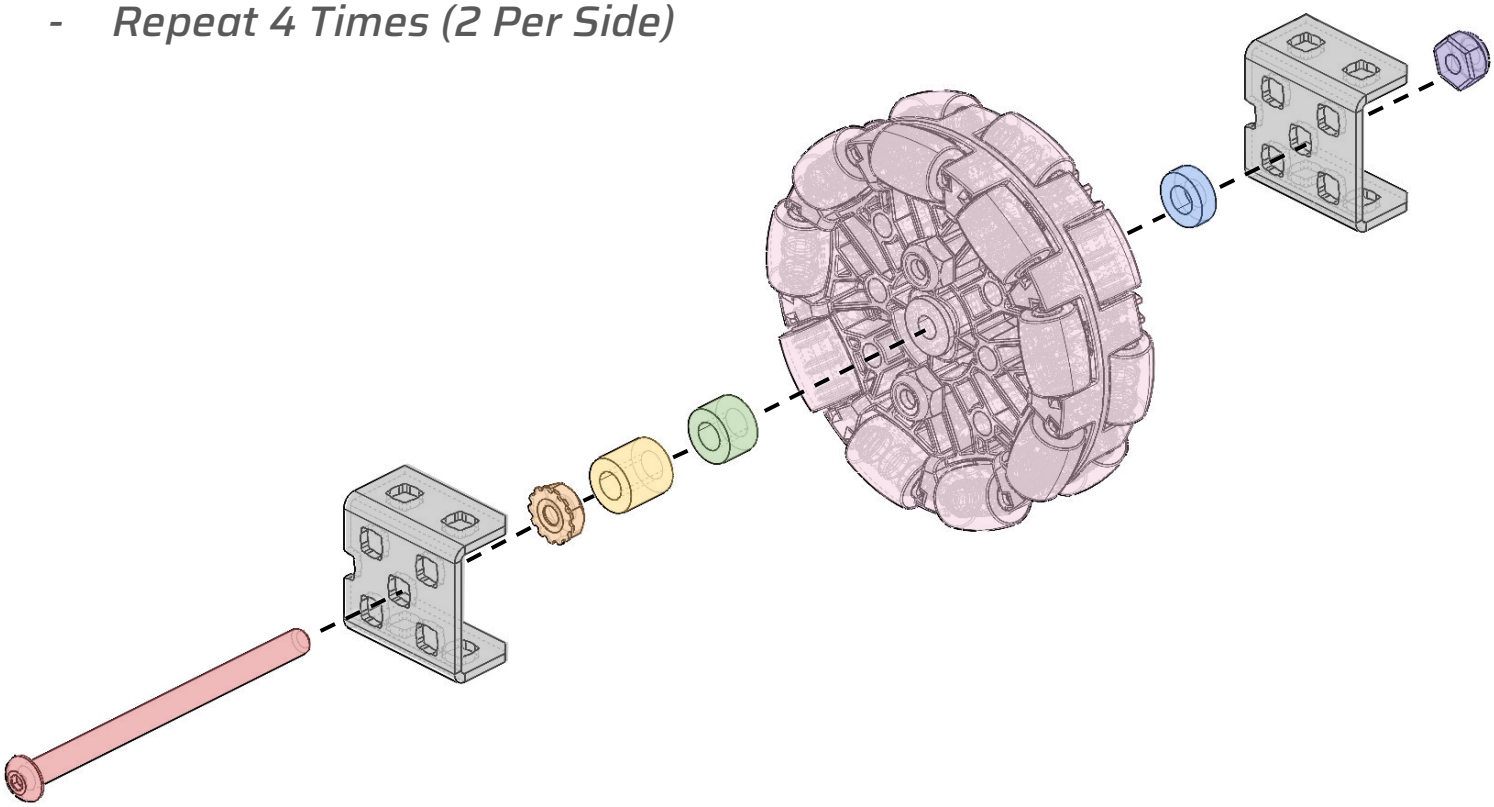
2



When cutting the gear it is important to be mindful of the metal piece inside of the gear because it will shatter when it is cut. Make sure when cutting the gear the gear comes out straight.

Step 8 - Omni Wheel Spacing - Representation - Part 5

- *Repeat 4 Times (2 Per Side)*

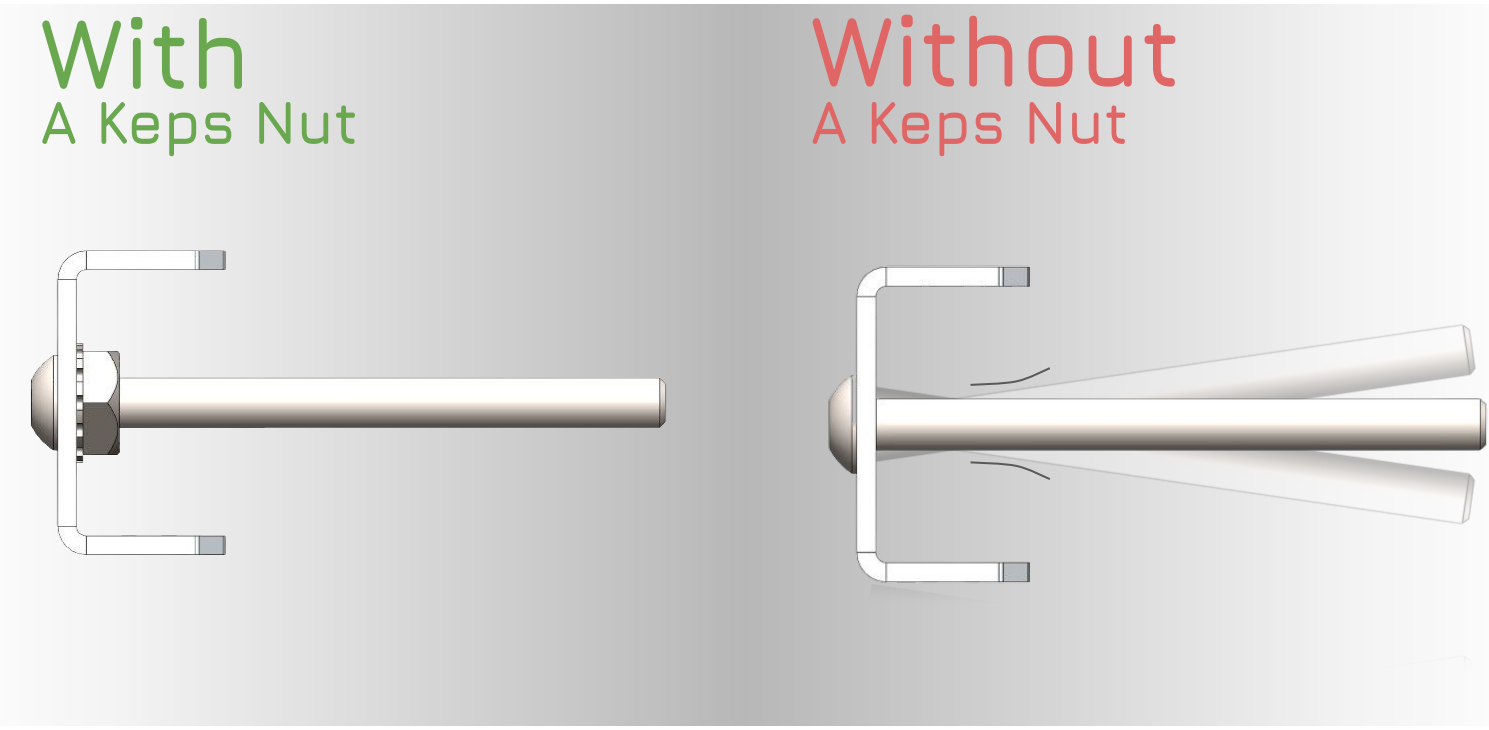


Part	Quantity (Total)	Color Code
2.5 Inch Screw	1	Red
Keps Nut	1	Orange
0.375 Inch Spacer	1	Yellow
0.250 Inch Spacer	1	Green
0.125 Inch Washer	1	Blue
Nylock	1	Purple
Part 3	1	Pink
C-Channel (Representation Only)	2	Gray

Reason for a Keps Nut in a Screw Joint

A common error when making a screw joint is forgetting the keps nut, the keps nut is important because it adds stability to screw by keeping the screw straight. This helps decrease the friction as well as keeping the screw from falling out of the chassis.

Screw joints are used in many instances but in this instance screw joints are being used with the wheels to decrease the friction of the chassis. This also makes the chassis run smoother.

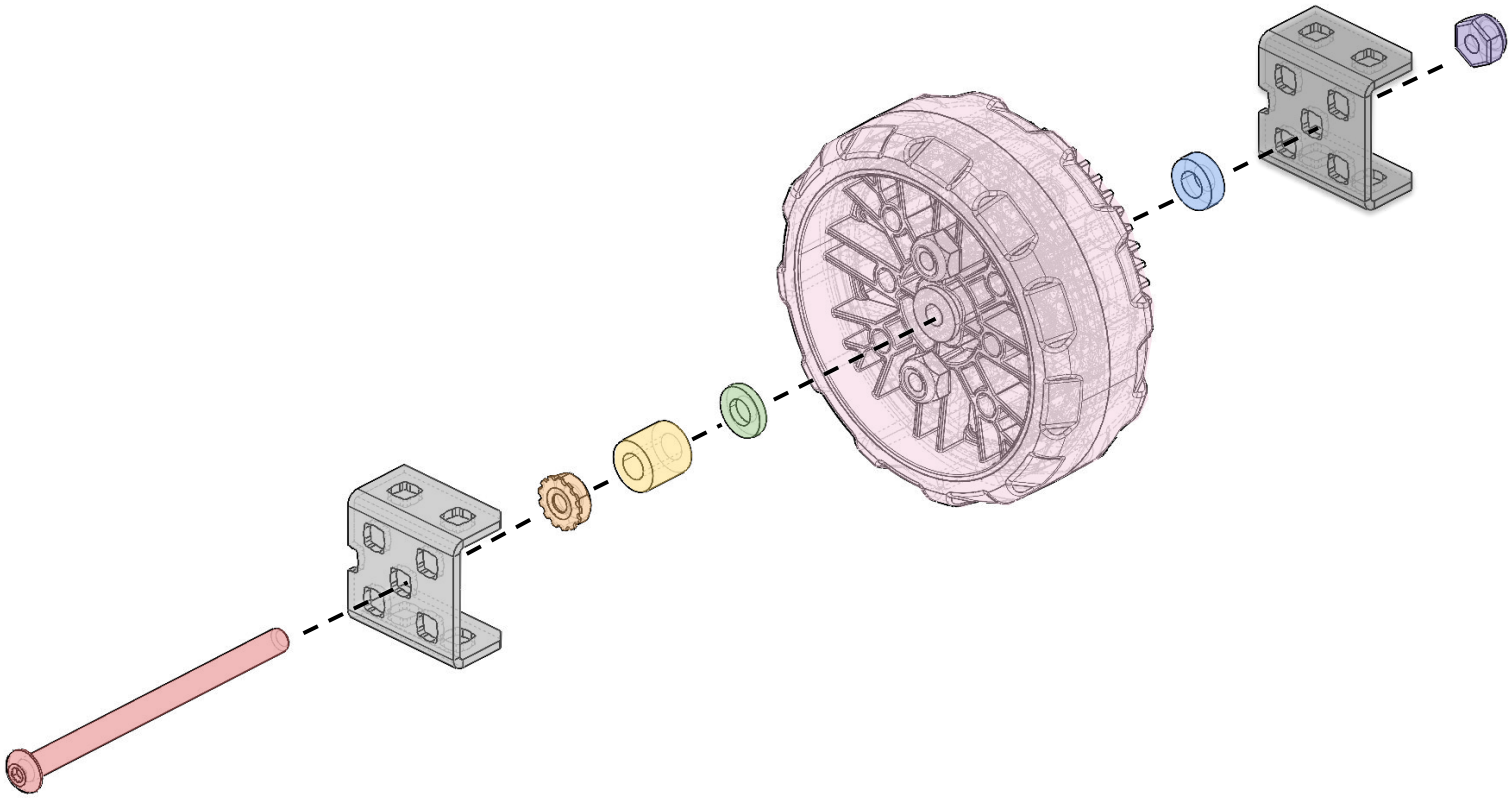


By having a keps nut on a screw joint it keeps the screw in place and straight. This keeps the integrity of the screw joint. The keps nut can sometimes become loose so it is important to occasionally tighten the keps nuts to prevent the screw from falling out.

Without a keps nut the screw joint will wobble more, increasing the friction as well as cause other issues. There is a higher chance of the screw unscrewing, and the wheels will not spin as smoothly on the screw. The reason why the wheel will not spin as smoothly is because the screw will also move, causing friction.

Step 9 - Traction Wheel Spacing - Representation - Part 6

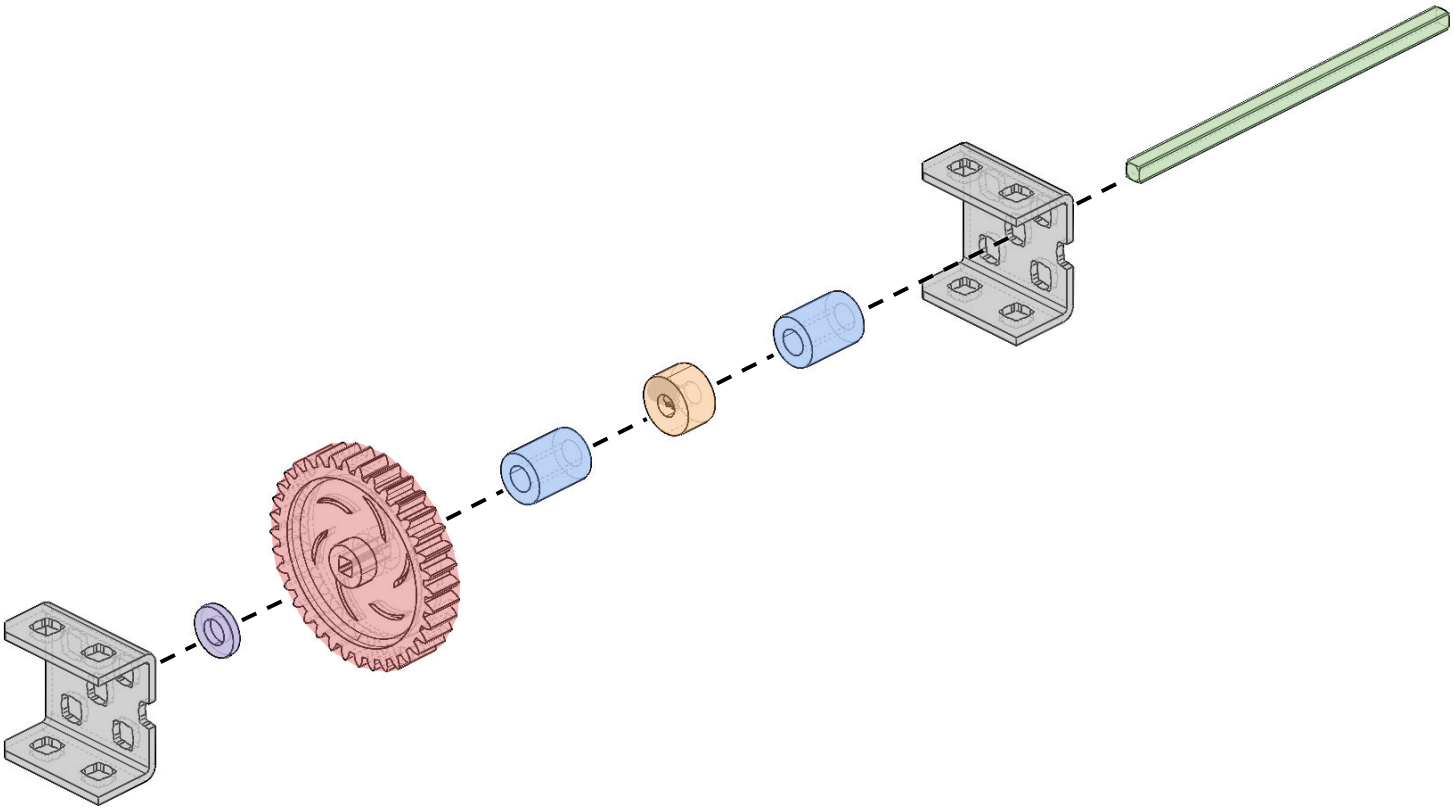
- *Repeat 4 Times (2 Per Side)*



Part	Quantity (Total)	Color Code
2.5 Inch Screw	1	Red
Keps Nut	1	Orange
0.500 Inch Spacer	1	Yellow
1/16 Inch Washer	1	Green
0.125 Inch Spacer	1	Blue
Nylock	1	Purple
Part 4	1	Pink
C-Channel (Representation Only)	2	Gray

Step 10 - Gear Spacing - Representation - Part 7

- *Repeat 8 Times (4 Per Side)*



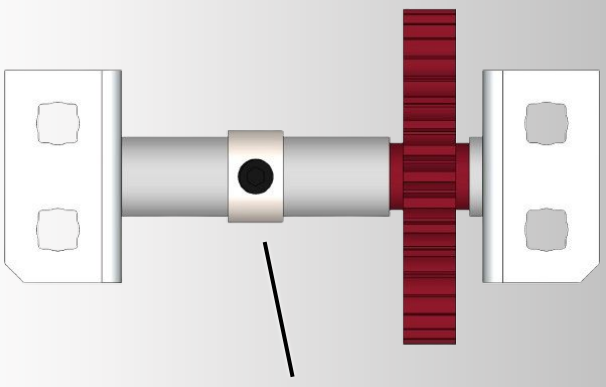
Part	Quantity (Total)	Color Code
36 Tooth Gear	1	Red
Shaft Collar	1	Orange
3 Inch Axle	1	Green
0.500 Inch Spacer	1	Blue
1/16 Inch Washer	1	Purple
C-Channel (Representation Only)	2	Gray

Shaft Collar Placement

When building an error easily made is the placement of the shaft collar, it can affect the amount of friction the chassis has. Having a single shaft collar between the chassis frame is better then having multiple shaft collars because it decreases the friction.

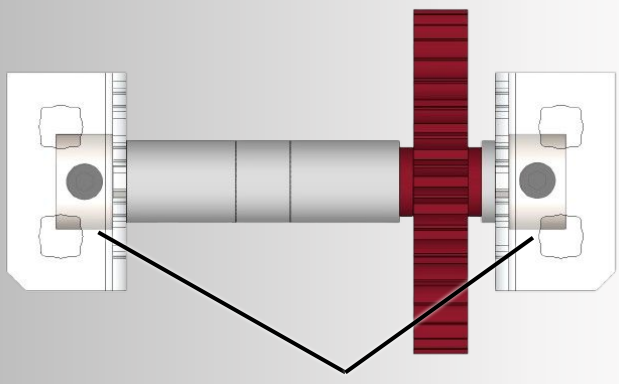
Do	Don't
- Completely space the inside of the chassis with one shaft collar - Use a single shaft collar for each axle - Have the shaft collar between the chassis frame	- Do not use more then one shaft collar for chassis spacing - Do not have metal against metal - Do not have the shaft collar between a c-channel and the motor

Do



A single shaft collar is used for the shaft

Don't



The shaft collars are placed on the outer ends of the shaft

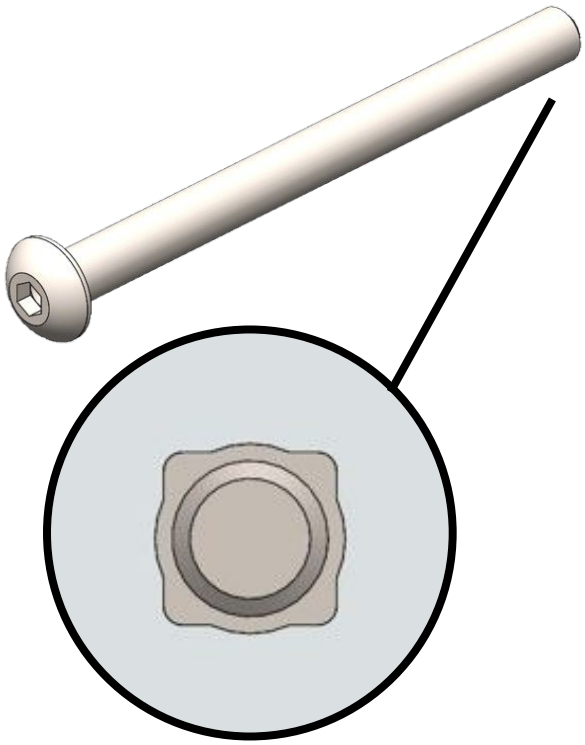
It is better to have a single shaft collar and space the axle. This decreases the amount of heavy parts that are used because shaft collars are heavier than multiple spacer.

Do not use multiple shaft collars on a single c-channel especially on the outside of the c-channel or between the c-channel and a motor. This is because it is unnecessary and decreases the clearance.

Difference Between a Screw Joint and Axle

There is one main difference between a screw joint and an axle; a screw joint has a screw which is a circle rotating in a circle while an axle is a square rotating in a circle. Due to the difference in the shape of both of these parts the friction level varies greatly. When a circle rotates inside of a circle is it much smoother than a square inside of a circle; this decreases the overall friction of the chassis making it run smoother.

Screw Joint

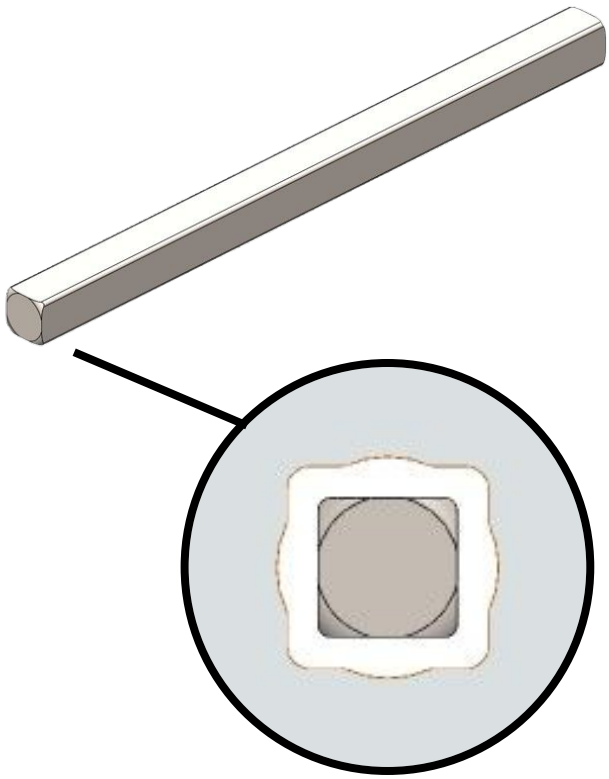


This image shows what a screw looks like inside of a hole in the c-channel (circle inside of a square)

Screw joints are smoother and have less friction (if done properly) compared to axles. This makes a chassis more performing when screw joints are used instead of axles for the wheels.

Vs

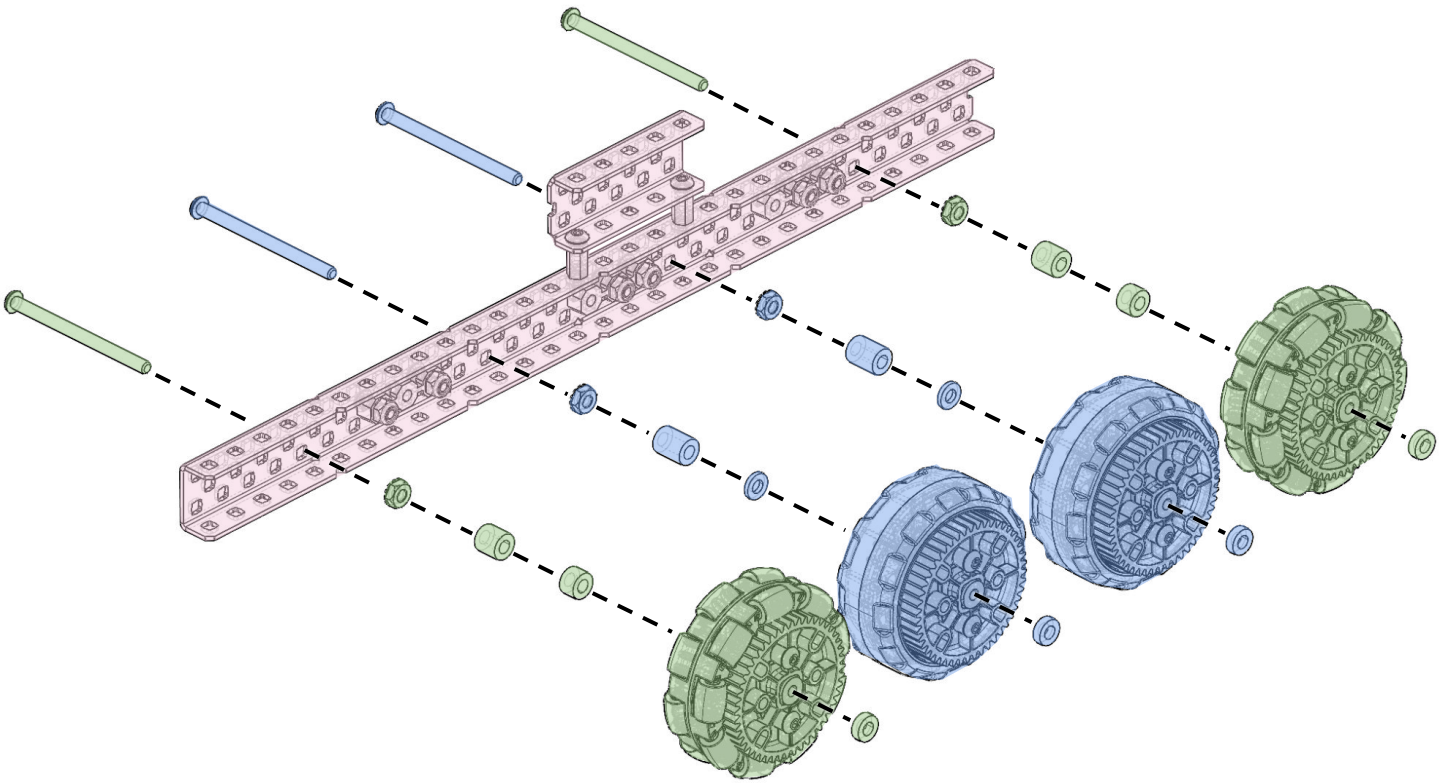
Axle

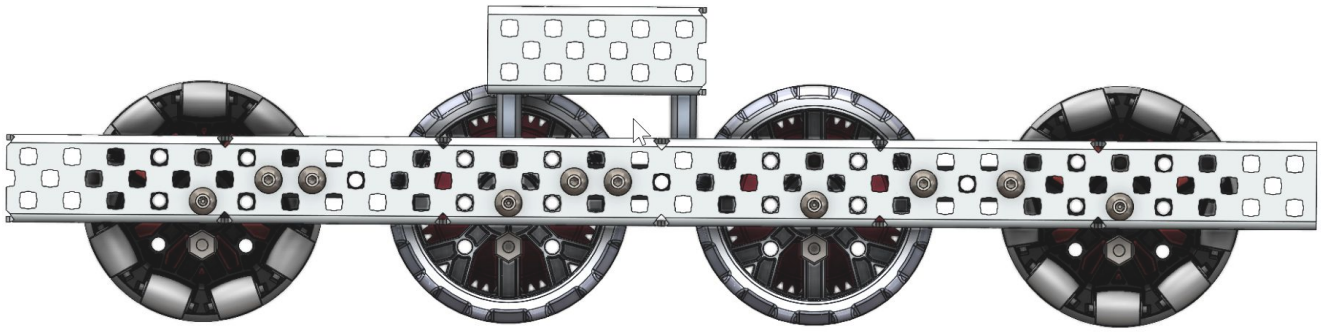


This image shows what an axle looks like inside of a hole in the c-channel (square inside of a square)

Axles cause much more friction then screw joints due to the shape of the part. Axles should only be used for the gears not the wheels because its unnecessary and causes more friction.

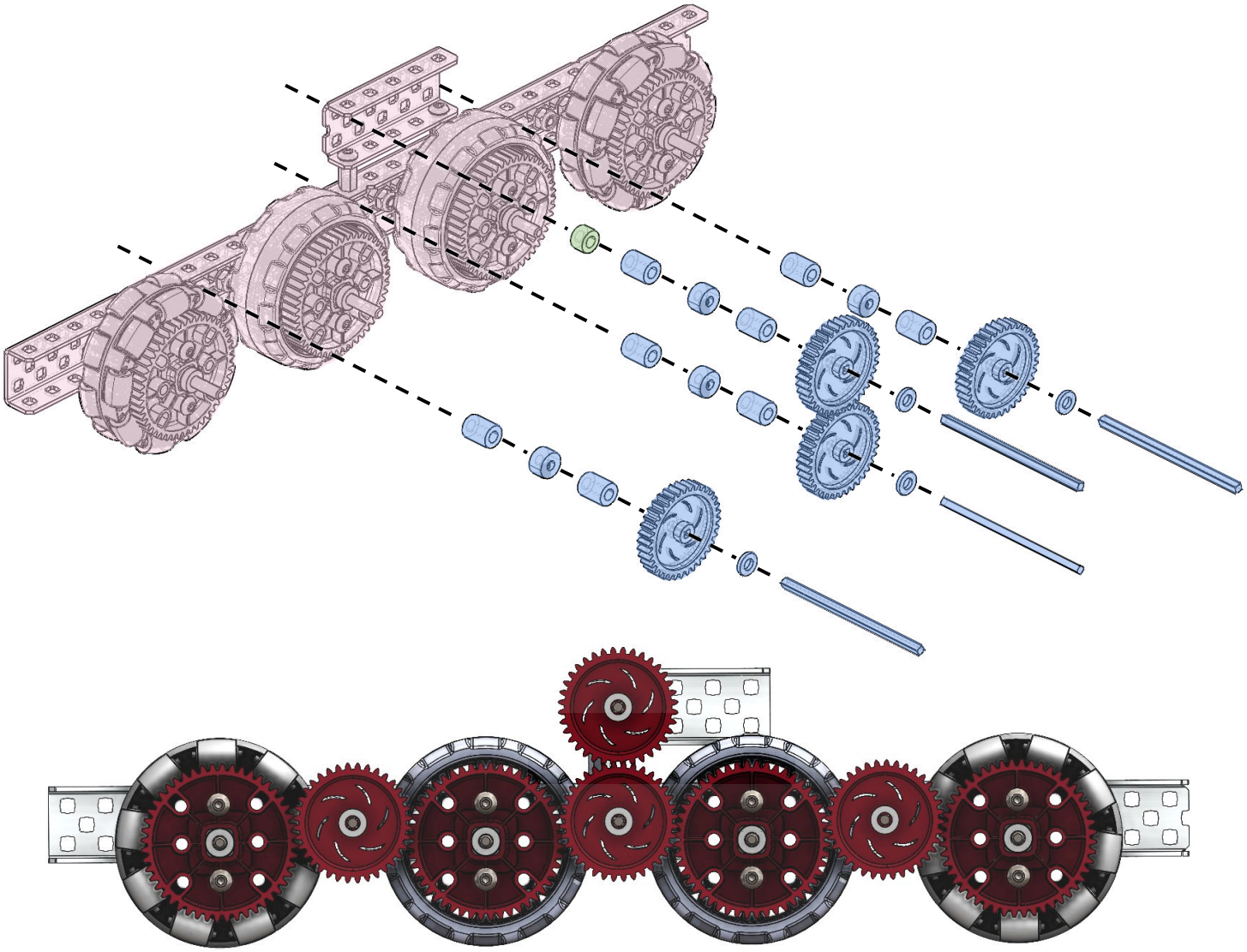
Step 11 - Assembling the Left Chassis Frame with the Wheels - Part 8





Part	Quantity (Total)	Color Code
Part 1	1	Pink
Part 3	2	Green
Part 4	2	Blue

Step 12 - Assembling the Left Half of the Chassis with Gears - Part 8

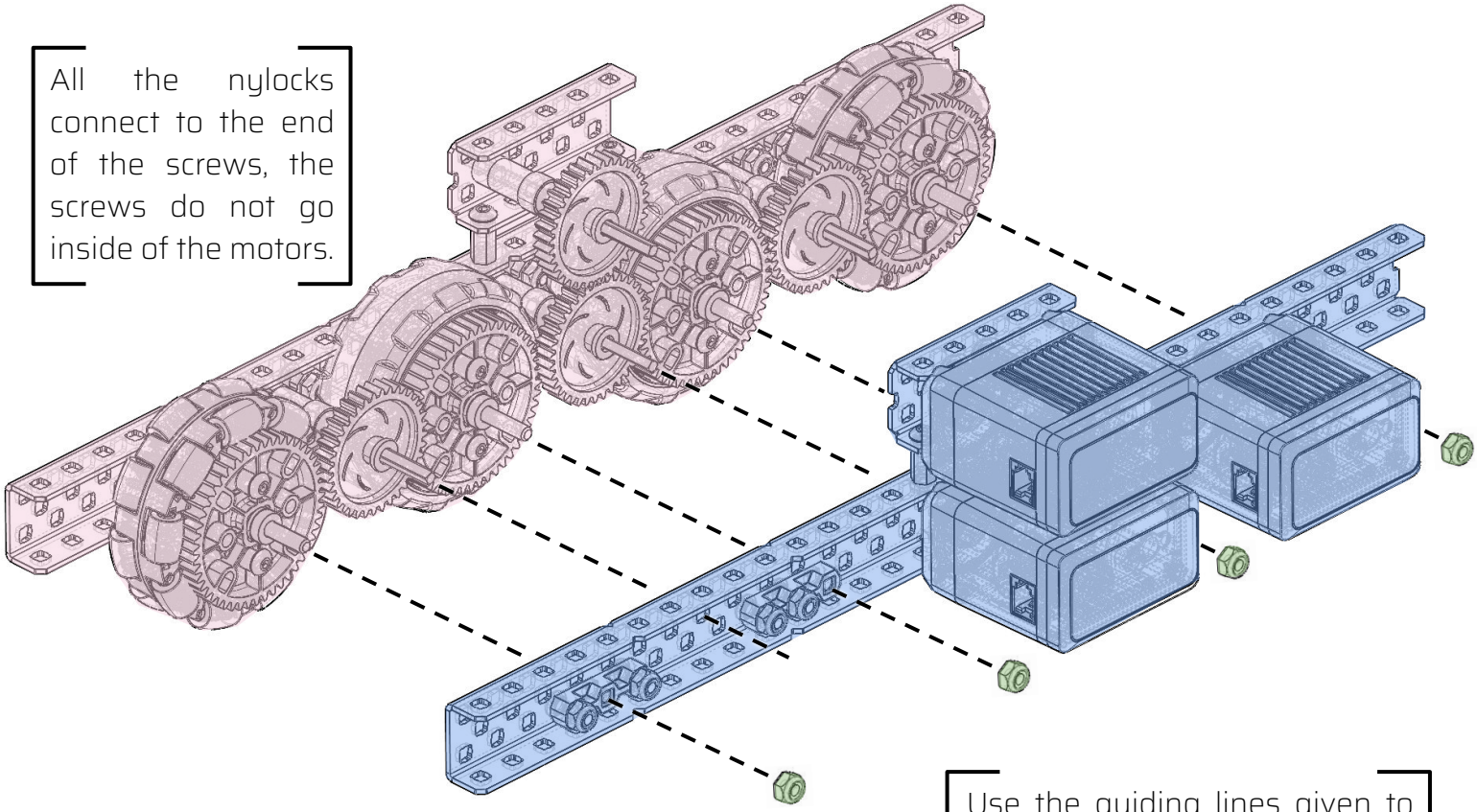


Part	Quantity (Total)	Color Code
0.250 Inch Spacer	1	Green
Part 7	4	Blue
Part from Previous Step	1	Pink

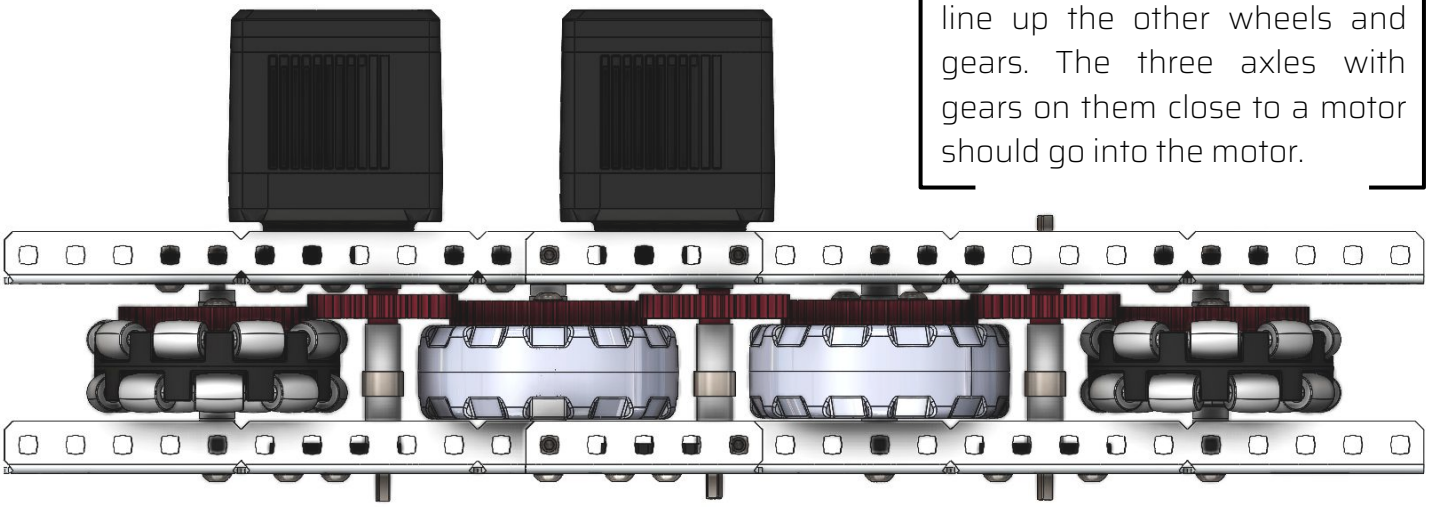
* There is an additional 0.250 inch spacer added to the gear spacing of the stacked motor to make up for the spacing the bearing flat gives to the other gears.
** All of the gear spacing lines up with a bearing flat, except for the gear spacing on the stacked motor.

Step 13 - Assembling the Left Half of the Chassis - Part 8

All the nylocks connect to the end of the screws, the screws do not go inside of the motors.

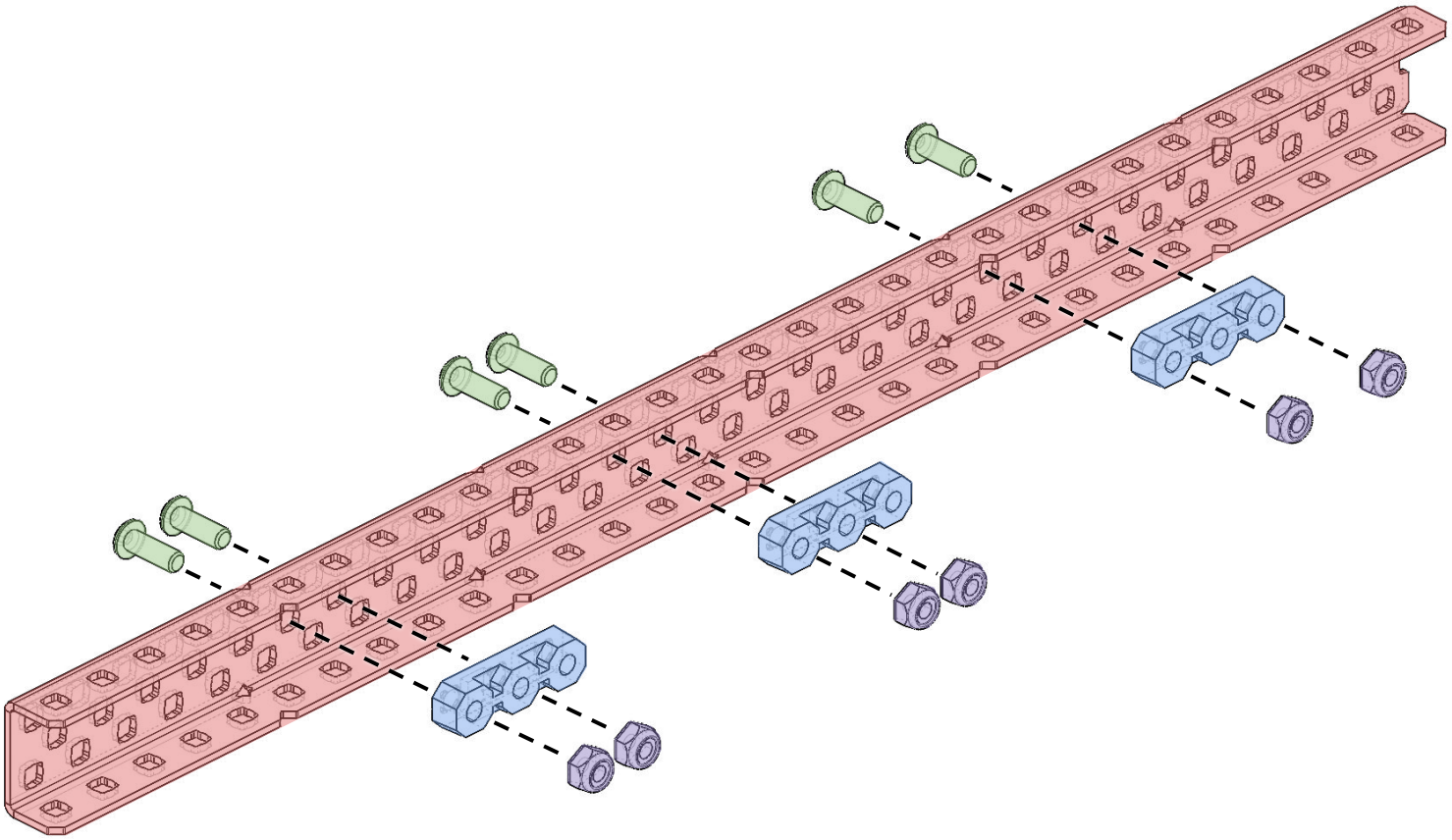


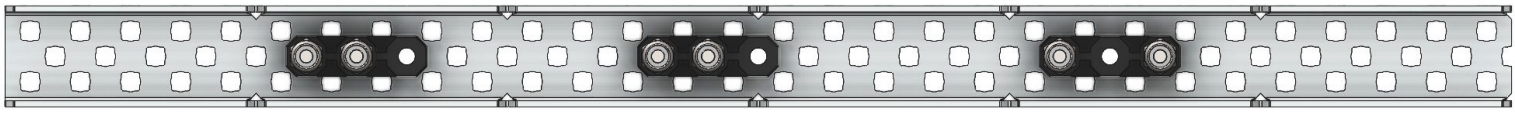
Use the guiding lines given to line up the other wheels and gears. The three axles with gears on them close to a motor should go into the motor.



Part	Quantity (Total)	Color Code
Nylock	4	Green
Part 2	1	Blue
Part from Previous Step	1	Pink

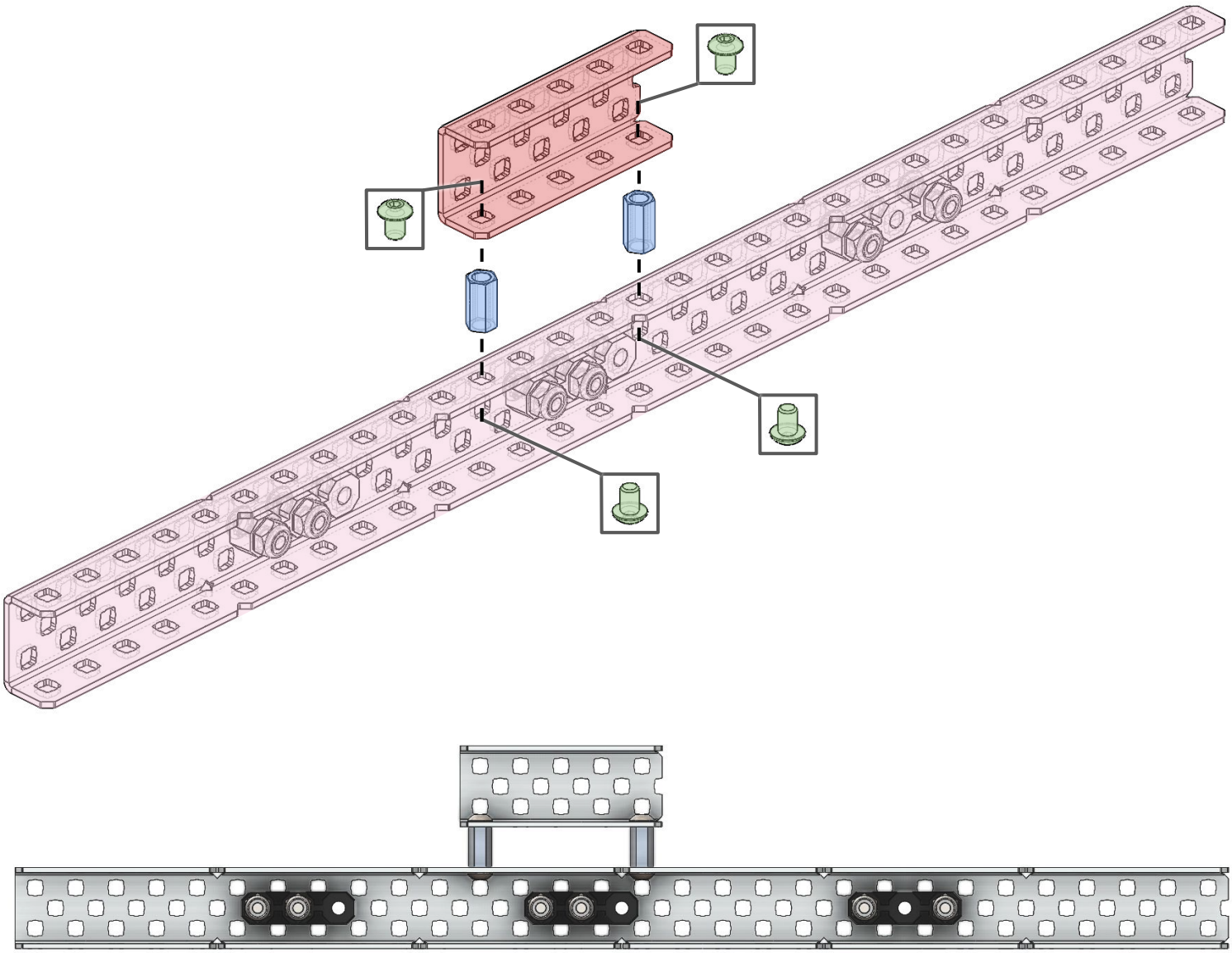
Step 14 - C-Channel Configuration - Outer Right Side - Part 9





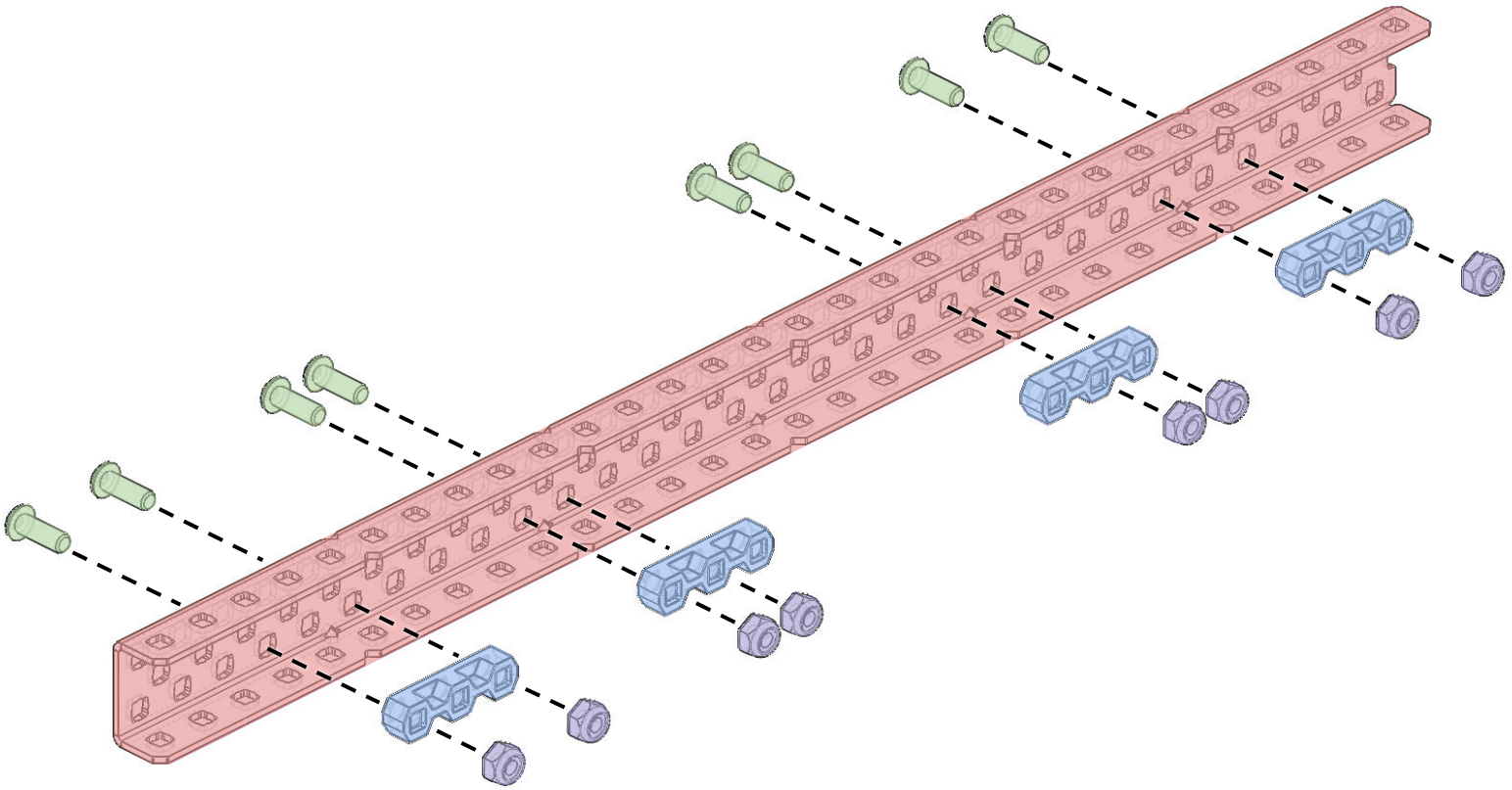
Part	Quantity (Total)	Color Code
1 x 2 x 1 x 30 Aluminum C-Channel	1	Red
0.5 Inch Screw	6	Green
Bearing Flat	3	Blue
Nylock	6	Purple

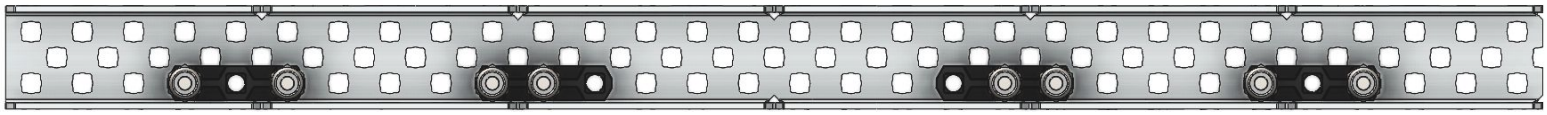
Step 15 - C-Channel Configuration - Outer Right Side - Part 9



Part	Quantity (Total)	Color Code
1 x 2 x 1 x 5 Aluminum C-Channel	1	Red
0.25 Inch Screw	4	Green
0.5 Inch Standoff	2	Blue
Part from Previous Step	1	Pink

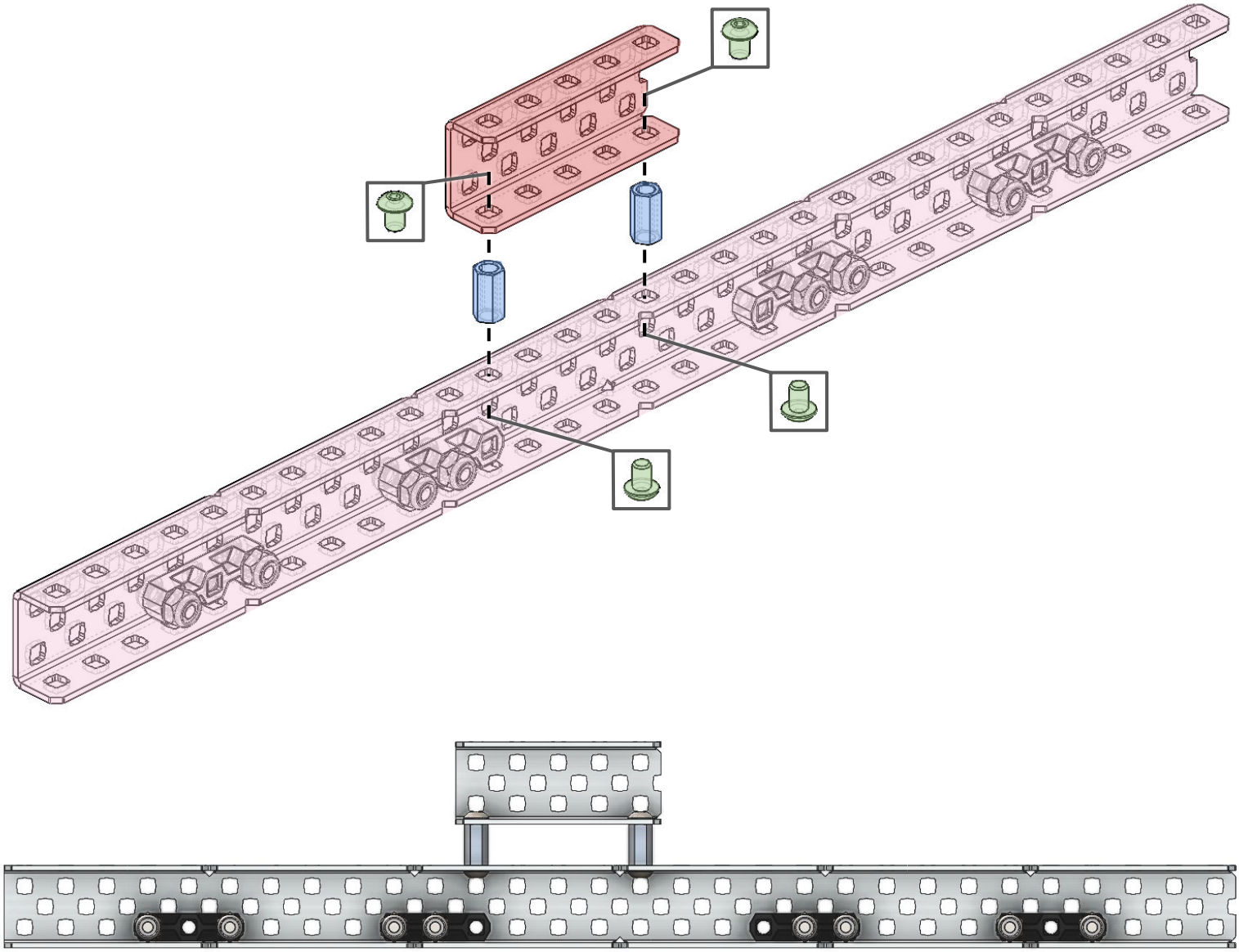
Step 16 - C-Channel Configuration - Inner Right Side - Part 10





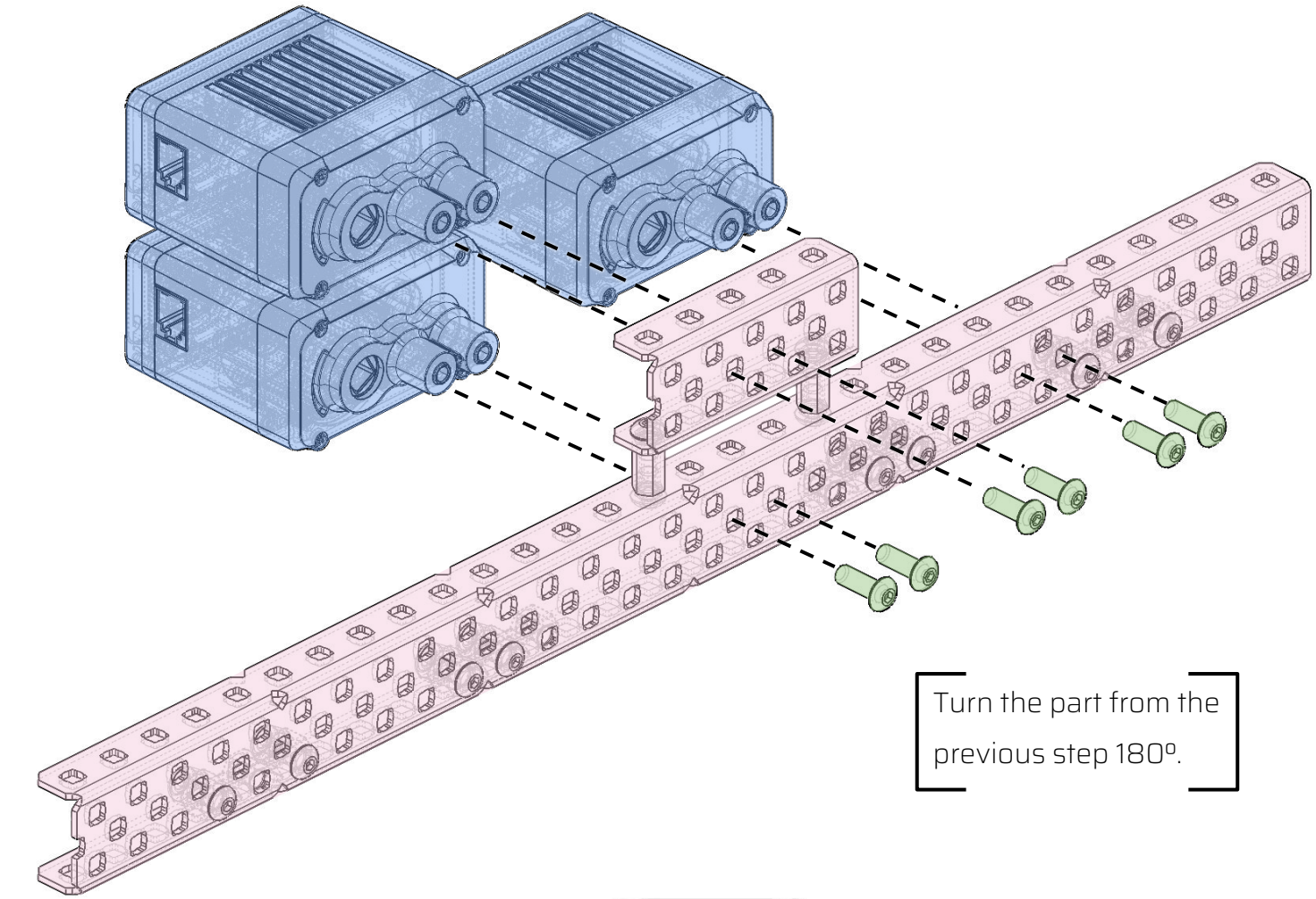
Part	Quantity (Total)	Color Code
1 x 2 x 1 x 30 Aluminum C-Channel	1	Red
0.5 Inch Screw	8	Green
Low Profile Bearing Flat	4	Blue
Nylock	8	Purple

Step 17 - C-Channel Configuration - Inner Right Side - Part 10

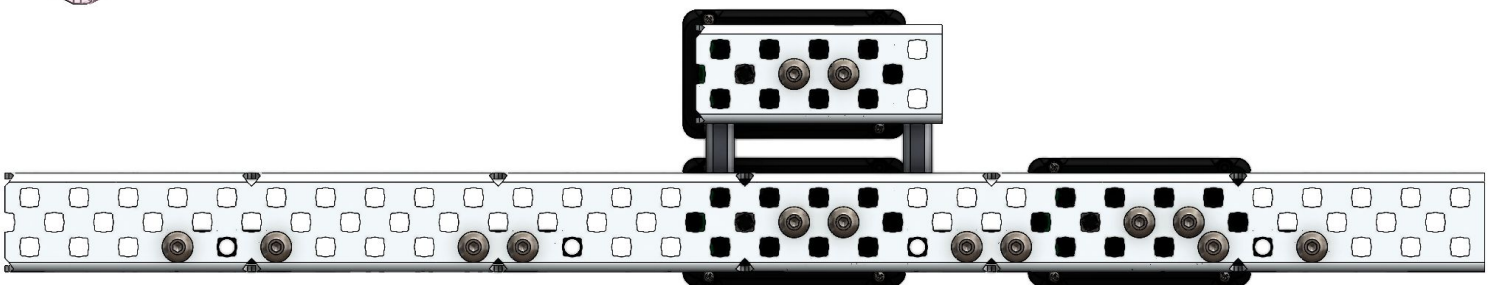


Part	Quantity (Total)	Color Code
1 x 2 x 1 x 5 Aluminum C-Channel	1	Red
0.25 Inch Screw	4	Green
0.5 Inch Standoff	2	Blue
Part from Previous Step	1	Pink

Step 18 - C-Channel Configuration - Right Side Motor Placement - Part 10

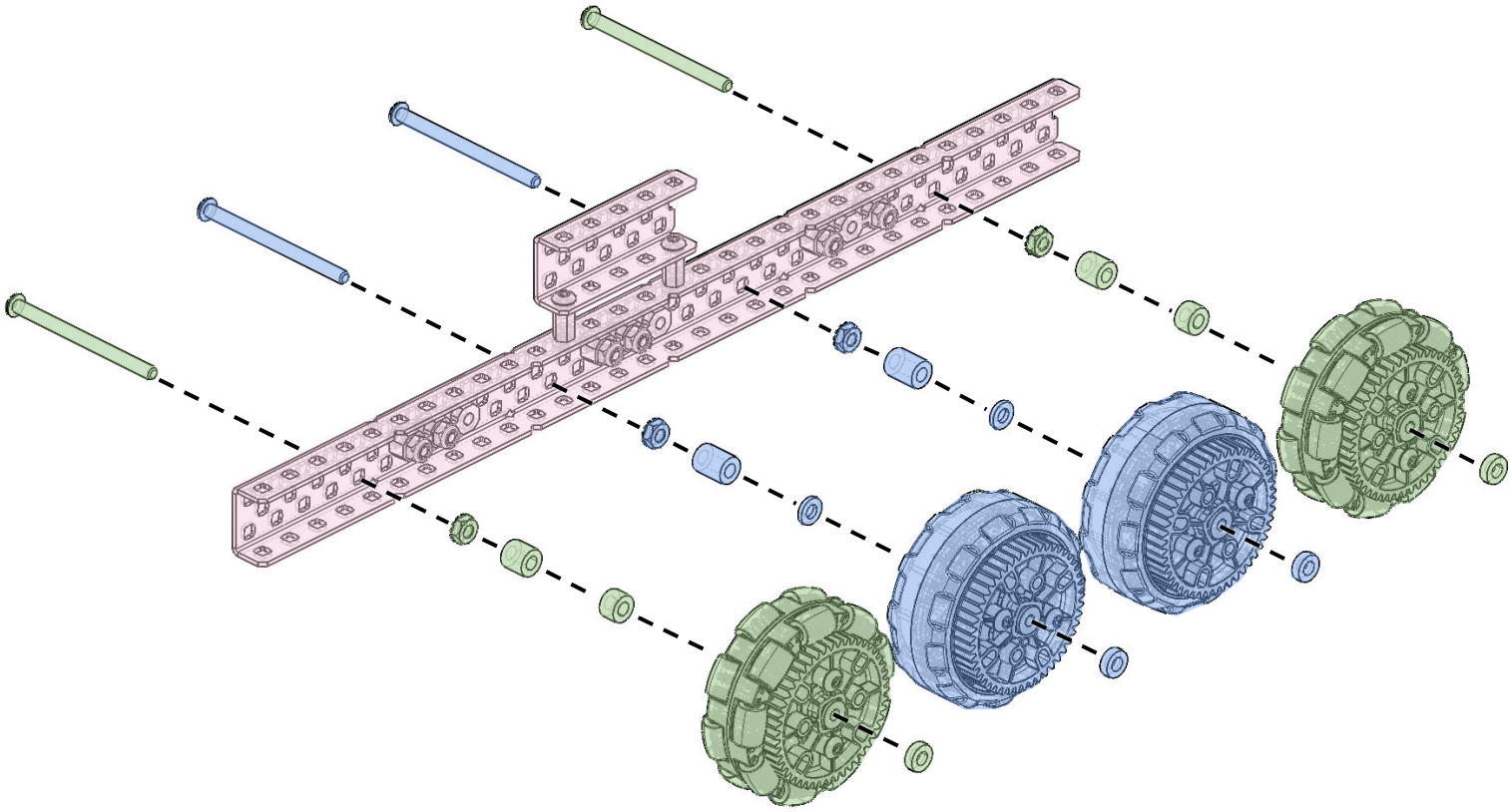


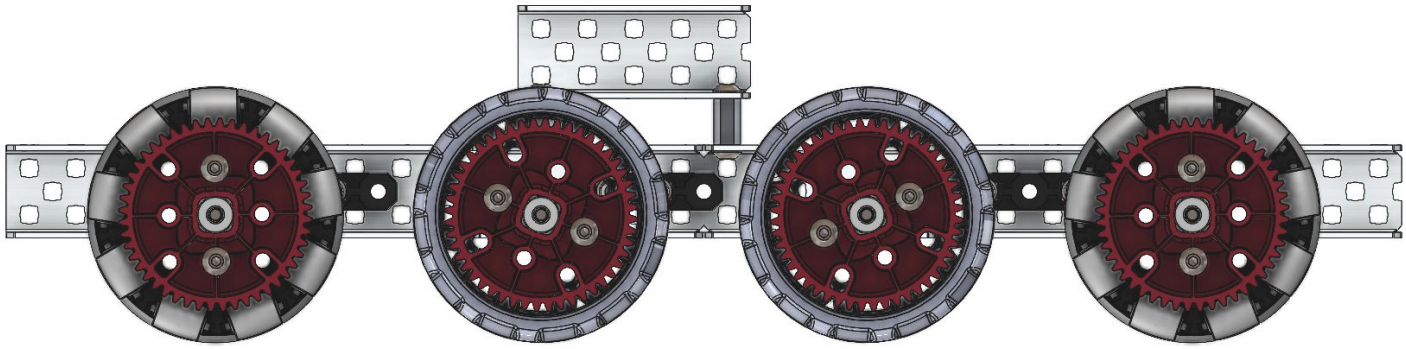
Turn the part from the previous step 180º.



Part	Quantity (Total)	Color Code
0.5 Inch Screw	6	Green
Blue Motor	3	Blue
Part from Previous Step	1	Pink

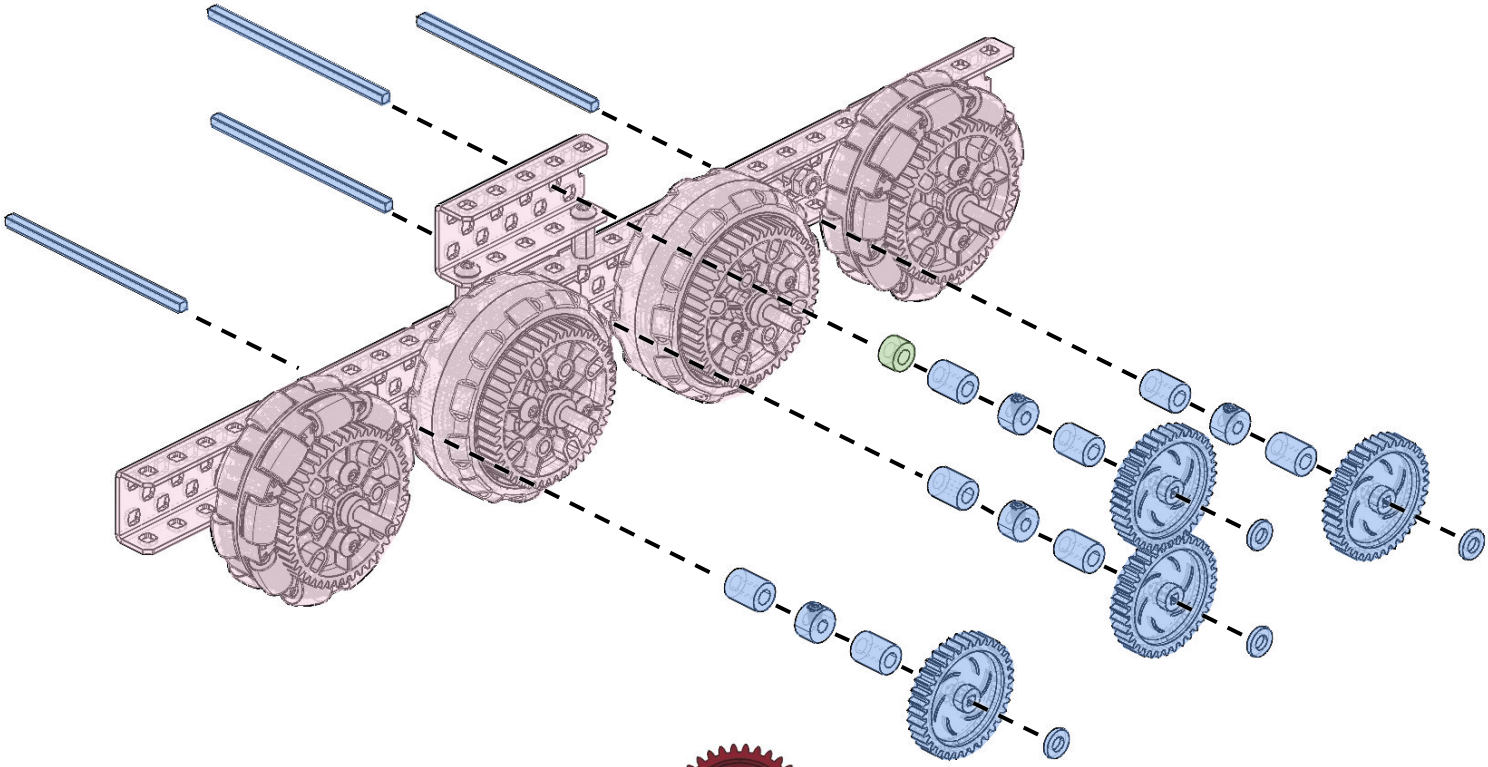
Step 19 - Assembling the Right Chassis Frame with the Wheels - Part 11





Part	Quantity (Total)	Color Code
Part 3	2	Green
Part 4	2	Blue
Part 9	1	Pink

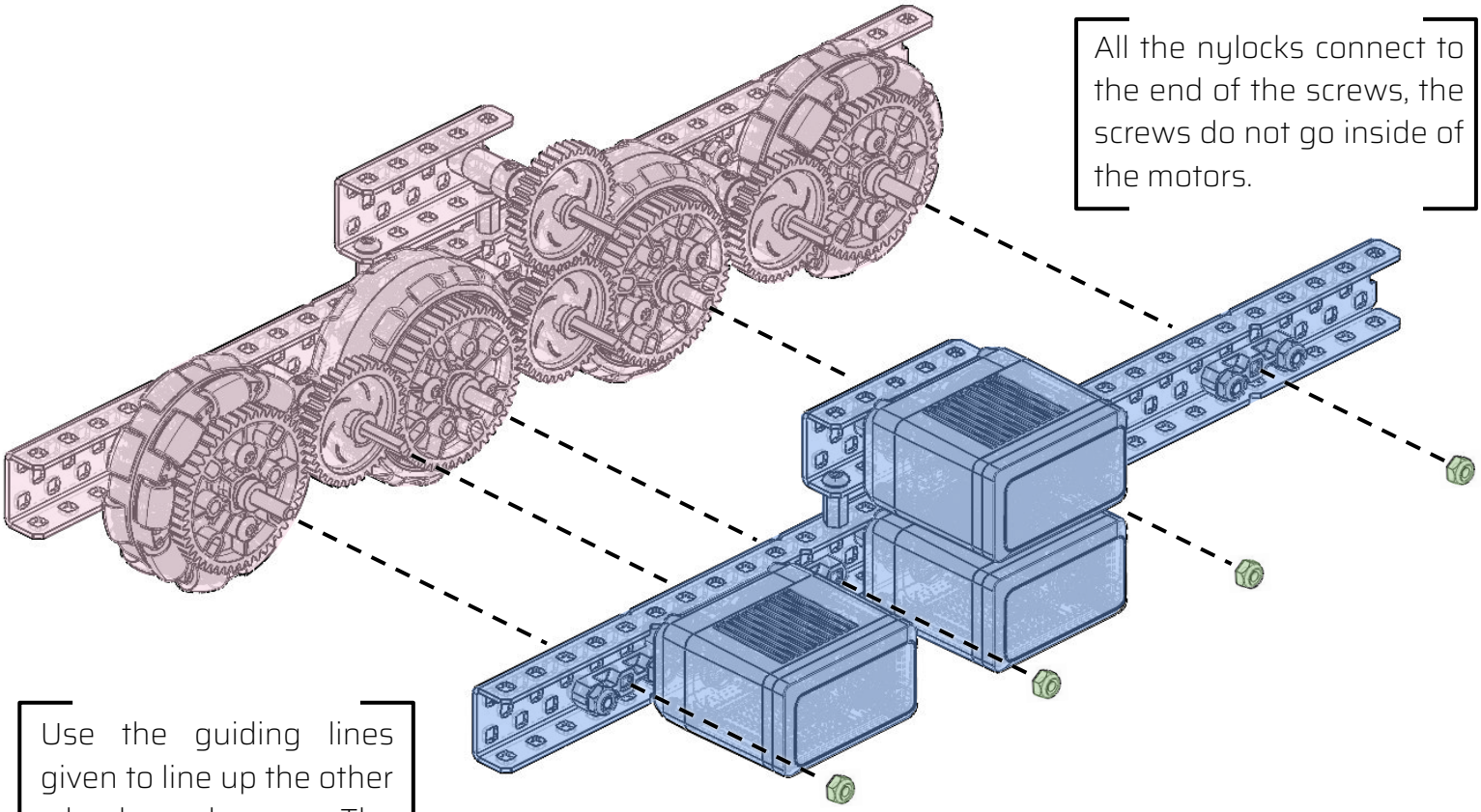
Step 20 - Assembling the Right Side of the Chassis with Gears - Part 11



Part	Quantity (Total)	Color Code
0.250 Inch Spacer	1	Green
Part 7	4	Blue
Part from Previous Step	1	Pink

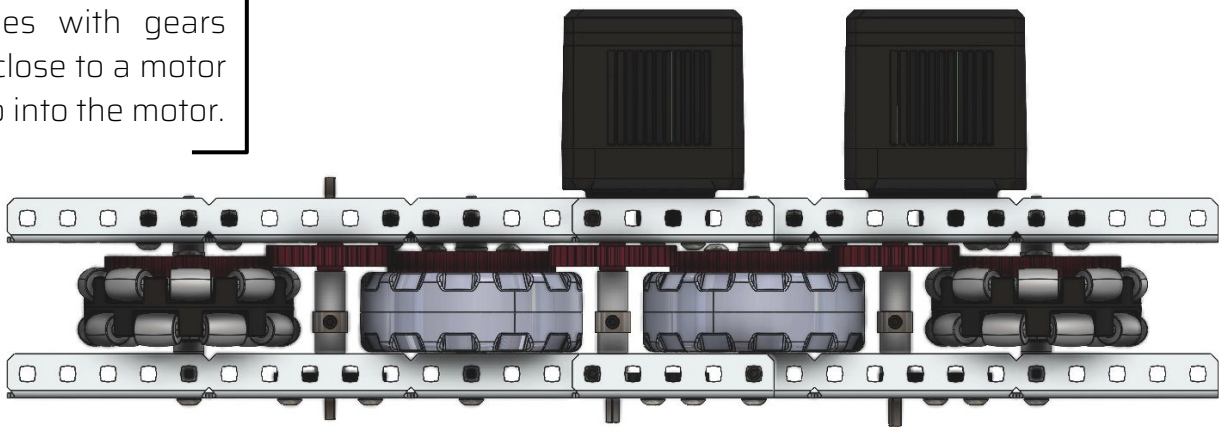
* There is an additional 0.250 inch spacer added to the gear spacing of the stacked motor to make up for the spacing the bearing flat gives to the other gears.
** All of the gear spacing lines up with a bearing flat, except for the gear spacing on the stacked motor.

Step 21 - Assembling the Right Portion of the Chassis - Part 11



All the nylocks connect to the end of the screws, the screws do not go inside of the motors.

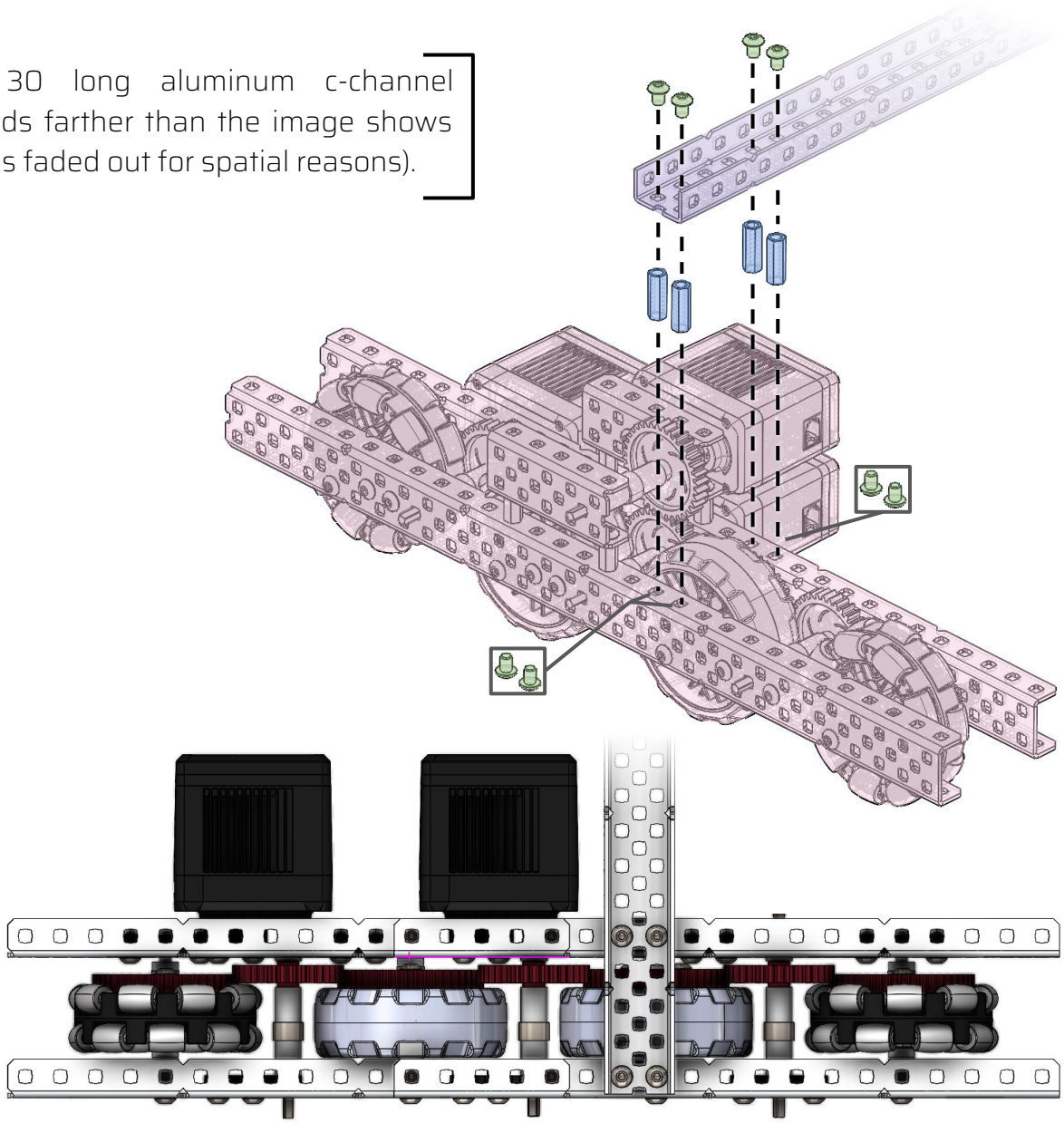
Use the guiding lines given to line up the other wheels and gears. The three axles with gears on them close to a motor should go into the motor.



Part	Quantity (Total)	Color Code
Nylock	4	Green
Part 10	1	Blue
Part from Previous Step	1	Pink

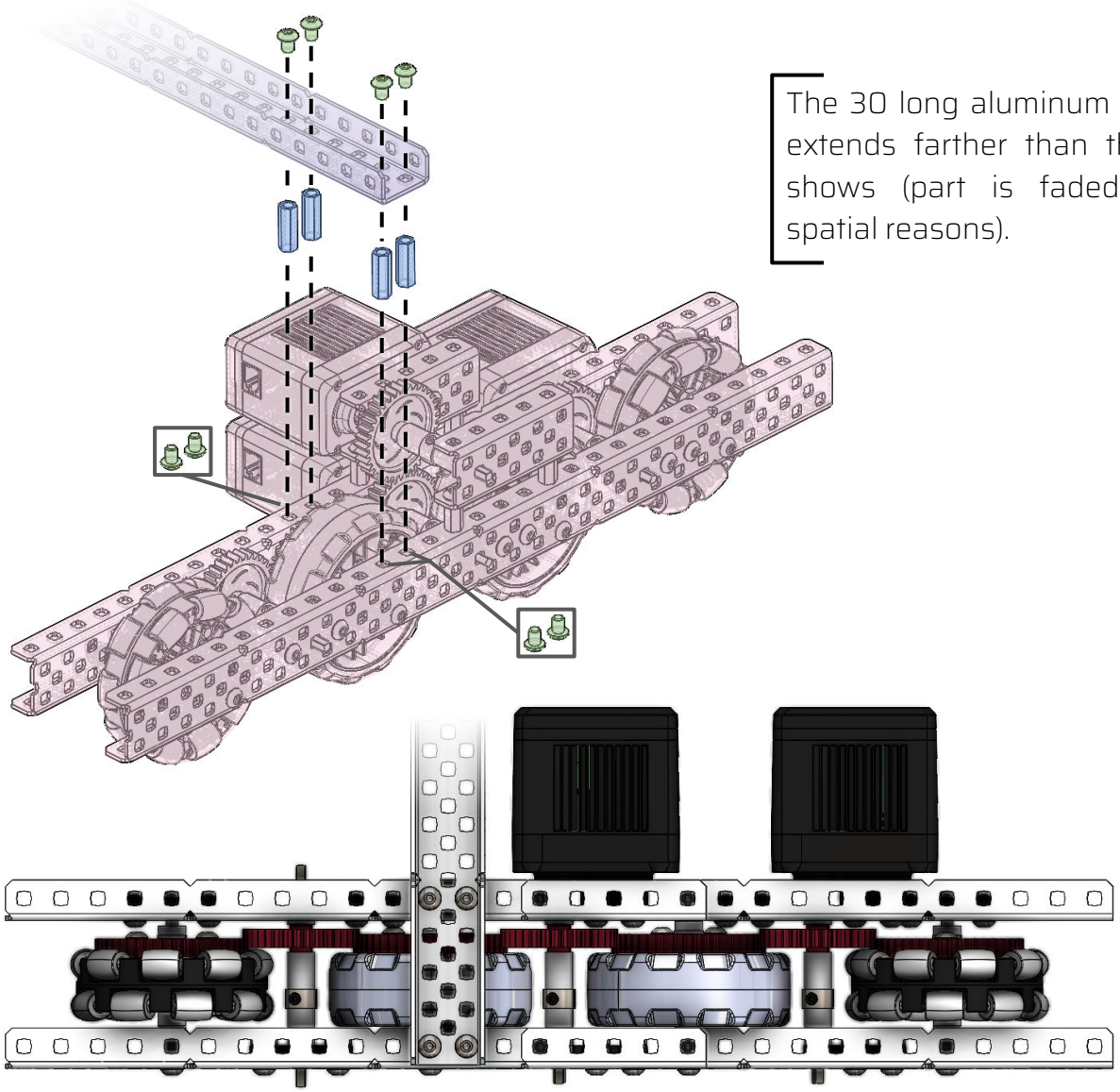
Step 22 - Bracing - Standoff Placement - Left Side - Final Assembly

The 30 long aluminum c-channel extends farther than the image shows (part is faded out for spatial reasons).



Part	Quantity (Total)	Color Code
0.25 Inch Screws	8	Green
0.75 Inch Standoffs	4	Blue
1 x 2 x 1 x 28 Aluminum C-Channel	1	Purple
Part 8	1	Pink

Step 23 - Bracing - Standoff Placement - Right Side - Final Assembly

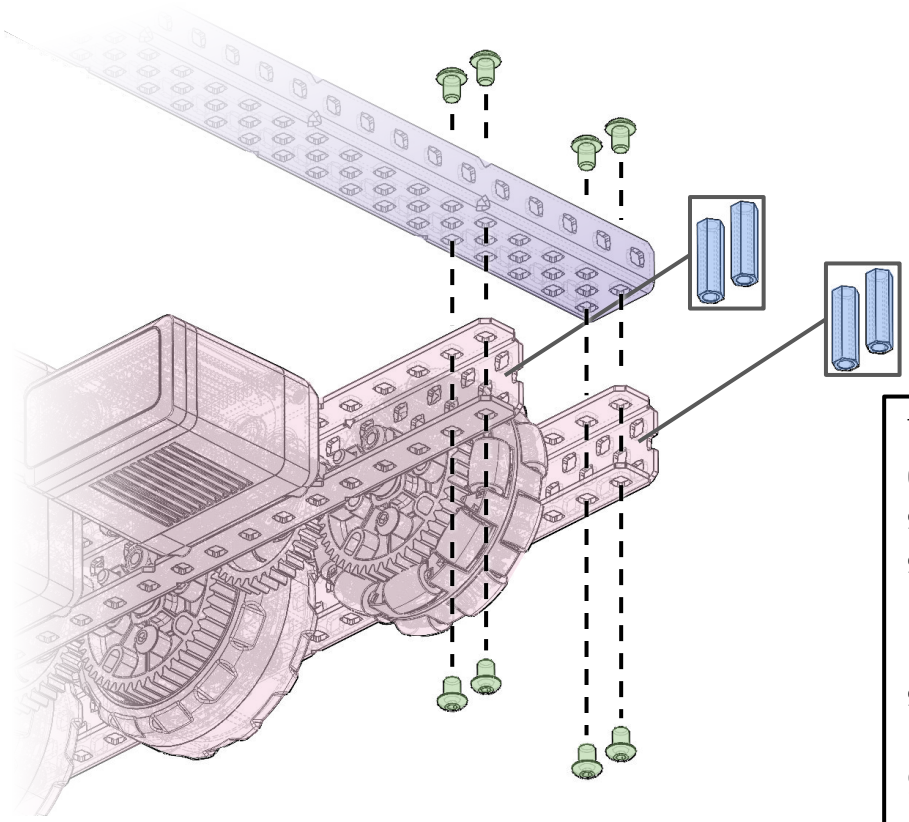


The 30 long aluminum c-channel extends farther than the image shows (part is faded out for spatial reasons).

Part	Quantity (Total)	Color Code
0.25 Inch Screws	8	Green
0.75 Inch Standoffs	4	Blue
1 x 2 x 1 x 28 Aluminum C-Channel*	1	Purple
Part from Previous Steps	1	Pink

* The Aluminum C-Channel being used in this step is the same one from the previous step which is already connected to the left half of the chassis

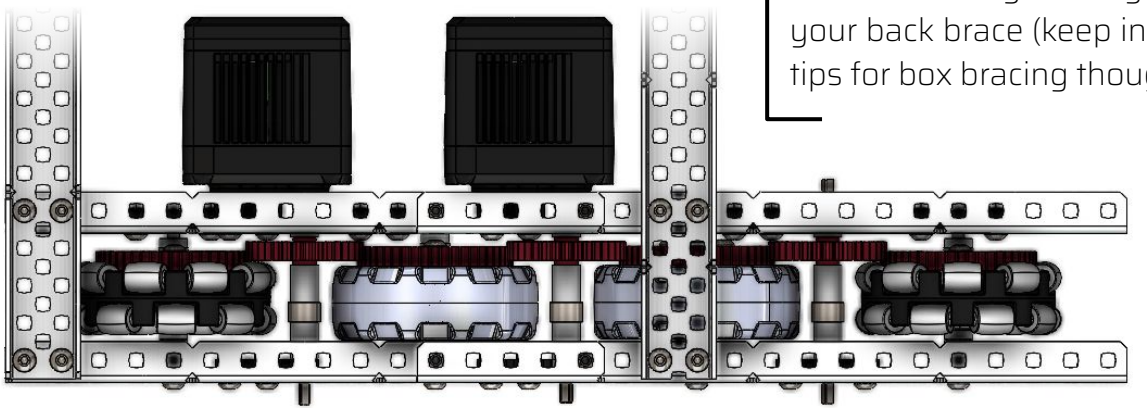
Step 24 - Bracing - Back Brace - Left Side - Final Assembly



The 30 long aluminum c-channel extends further than the image shows (part is faded out for spatial reasons).

Each standoff lines up with the screws.

Skip steps 24 and 25 if you would rather use a high strength axle as your back brace (keep in mind the tips for box bracing though).



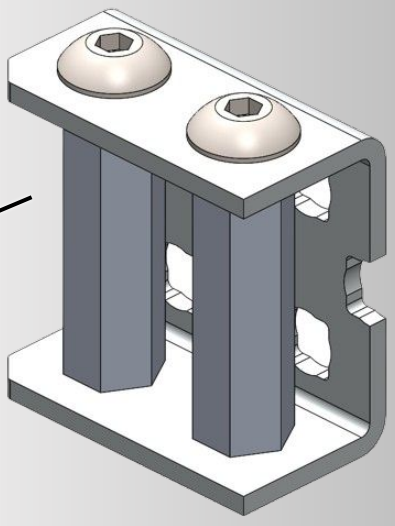
Part	Quantity (Total)	Color Code
0.25 Inch Screws	8	Green
0.875 Inch Standoffs	4	Blue
1 x 2 x 1 x 28 Aluminum C-Channel	1	Purple
Part from Previous Step	1	Pink

Box Bracing (With either standoffs or spacers)

The point of box bracing is to add greater stability and strength when connecting two pieces together. By box bracing, the bending of the brace is prevented. Either a 0.875 inch standoff can be used or a 0.875 inch spacer.

Do	Don't
- Use a standoff and use 2 small screws instead of a large one - Box brace wherever 2 parts are being connected and when more strength is needed	- Do not let your metal parts bend by forgetting to properly brace them with boxing standoffs

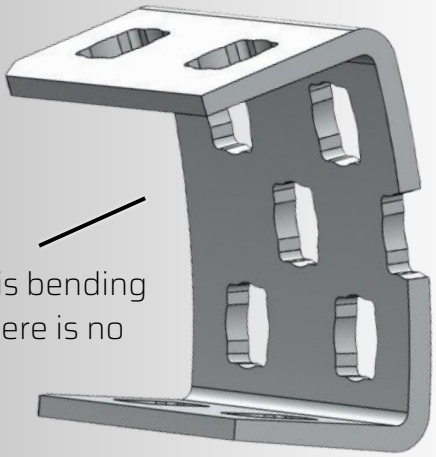
With Box Bracing



Proper bracing is being used so no bending is happening

By box bracing it prevents the metal from warping either from additional weight that may be added later on or from collisions. It is important to prevent warping because when the c-channel warps it will need to be replaced.

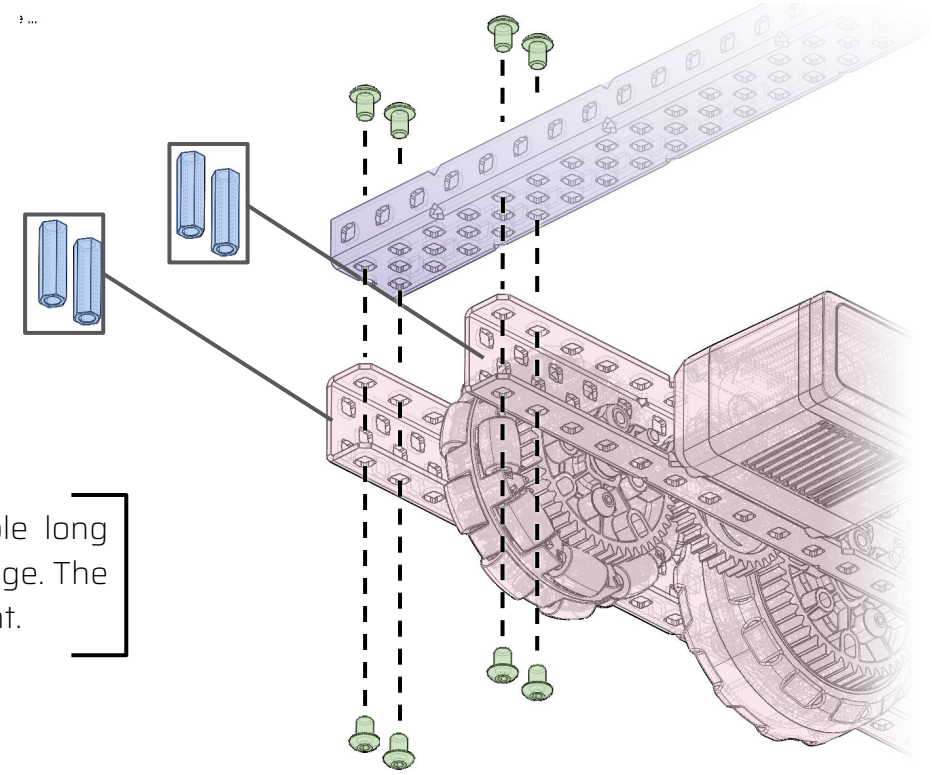
Without Box Bracing



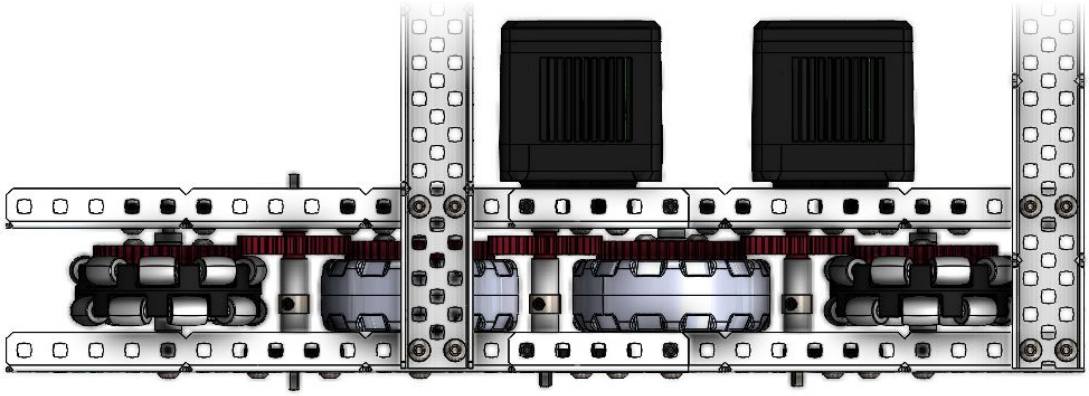
C-Channel is bending because there is no bracing

Without box bracing the risks of the metal bending increases because there is no structure inside preventing the metal from bending inwards.

Step 25 - Bracing - Back Brace - Right Side - Final Assembly



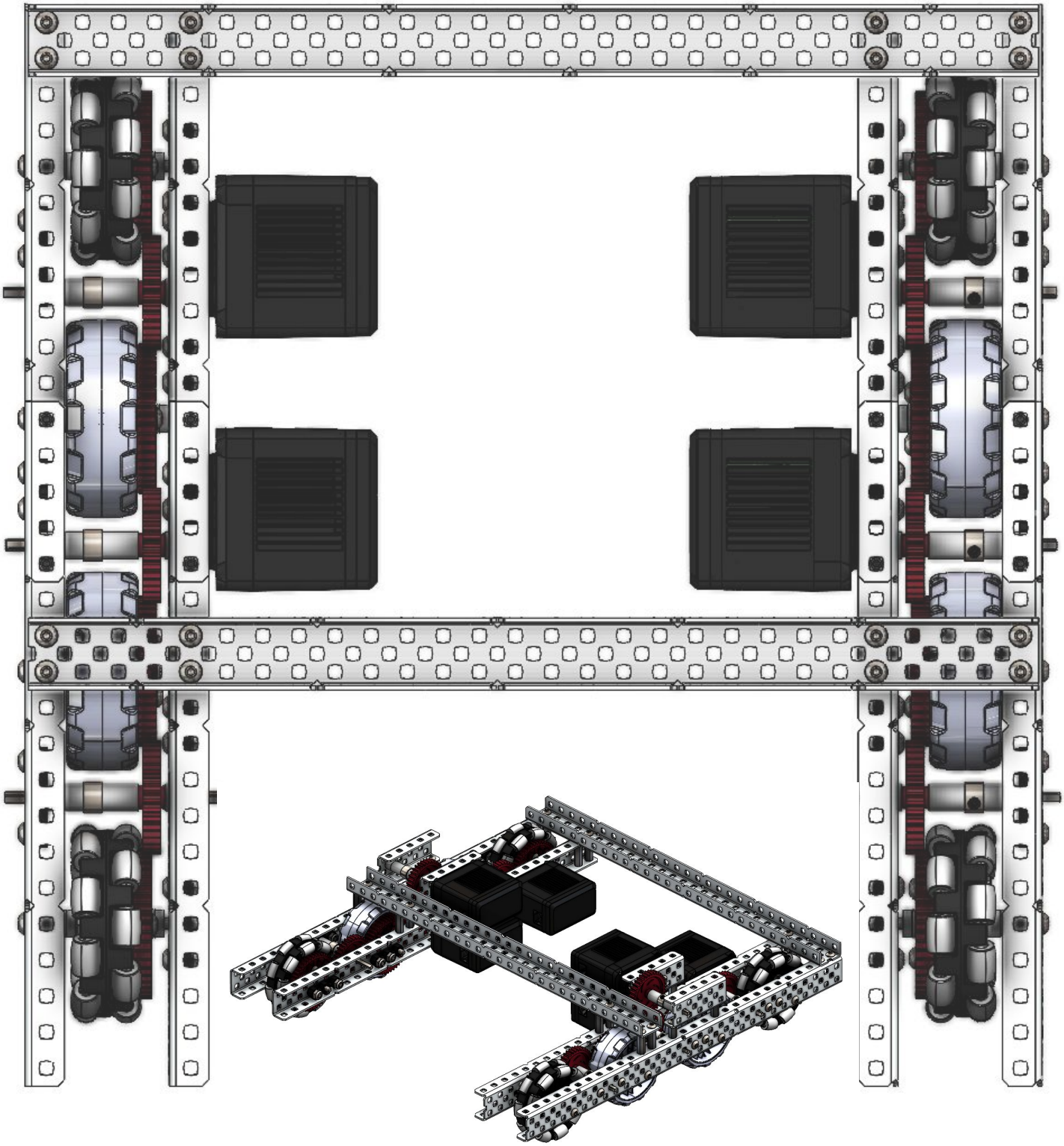
Only a portion of the 30 hole long c-channel is shown in this image. The rest extends further to the right.



Part	Quantity (Total)	Color Code
0.25 Inch Screws	8	Green
0.875 Inch Standoffs	4	Blue
1 x 2 x 1 x 28 Aluminum C-Channel*	1	Purple
Part from Previous Step	1	Pink

* The Aluminum C-Channel being used in this step is the same one from the previous step which is already connected to the left half of the chassis

Final Assembly - 8 Wheel, 6 Motor A-Chassis 9 (C-Channel Back Brace)



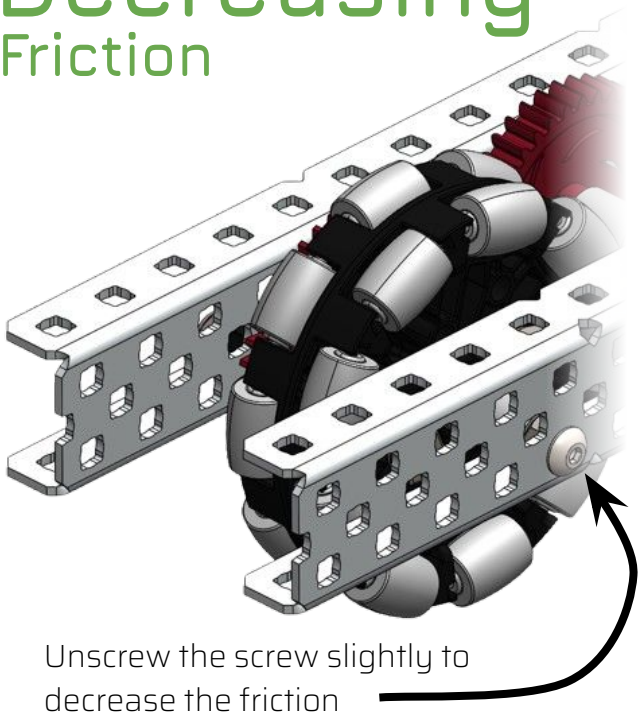
Top View

Friction

To reduce chassis friction, the screw joints can be loosened to create some wiggle room. Loosening the wheels and gears will allow for smoother movement and increased speed while motors are running.

Metal on metal contact is another situation to avoid in order to reduce friction*. For example, a metal washer should not be used as a spacer if it is contacting a moving part. Instead of using a metal washer, use plastic washers for spacing. When metal is contacting a moving metal part, the two pieces grind against each other, creating lots of friction.
*Only exception is a keps nut contacting a c-channel for a screw joint

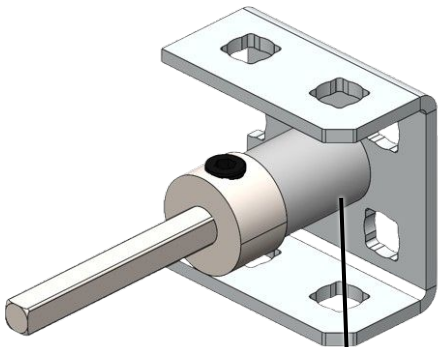
Decreasing Friction



Unscrew the screw slightly to decrease the friction

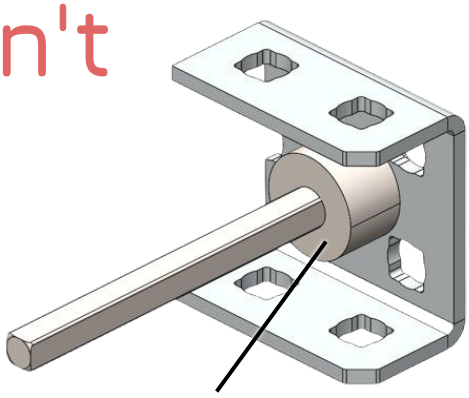
By unscrewing the screw, it allows the wheel and spacers to spin more freely, this decreases the overall friction of the drivetrain. Just make sure that the screws are not loosen too much because that could cause problems.

Do



Plastic is rubbing on the metal c-channel, which does not cause too much friction.

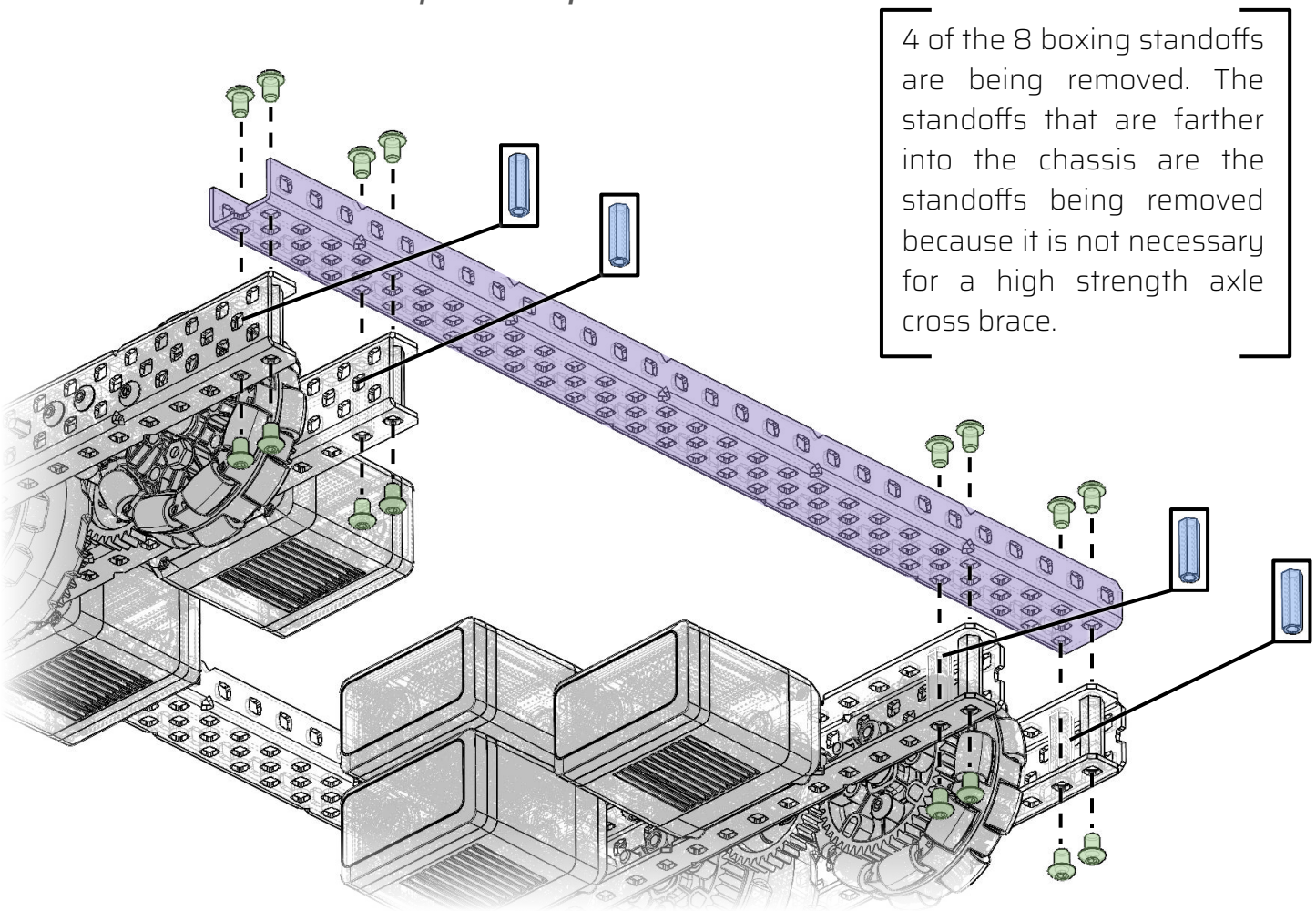
Don't



The metal shaft collar is rubbing on the metal c-channel which is causing more friction then if it were plastic rubbing on metal.

Step 26 - Back Brace - Removing C-Channel Brace - Optional

- *Removing back brace to add high strength axle if the back brace was added otherwise skip this step*



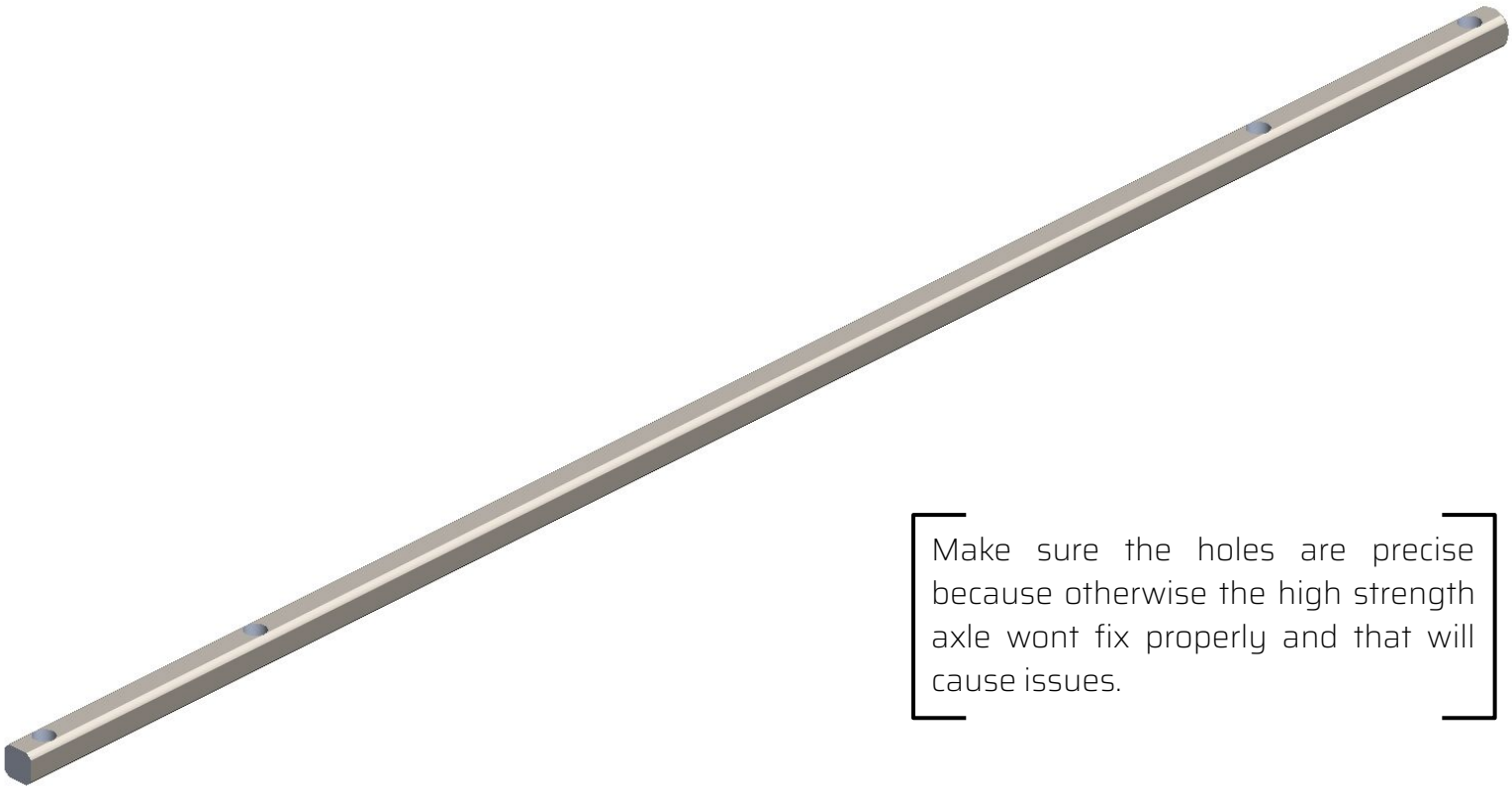
4 of the 8 boxing standoffs are being removed. The standoffs that are farther into the chassis are the standoffs being removed because it is not necessary for a high strength axle cross brace.

Parts Being Removed	Quantity (Total)	Color Code
0.25" Screw	8	Green
0.875 Inch Standoffs	4	Blue
28 Hole Long Aluminum C-Channel	1	Purple

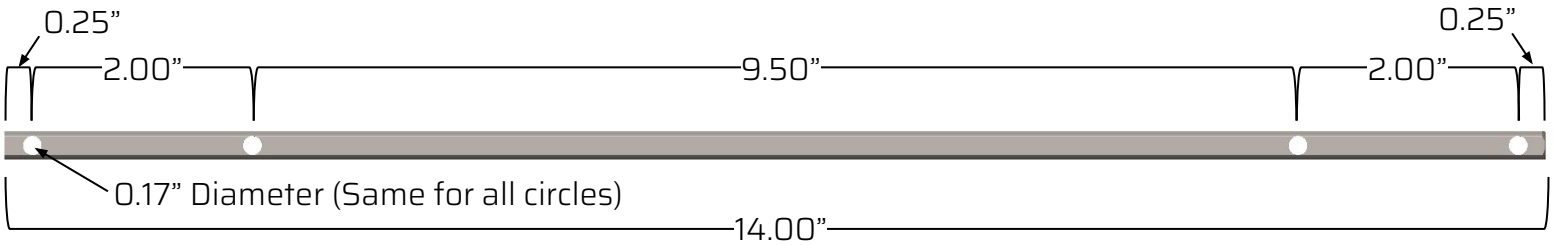
The back bracing is being removed to be replaced with a high strength axle. This is an optional adjustment that can be made. The use of having a high strength axle as the back brace makes it easier rotate an object or tilt it. A high strength axle as a back brace is weaker then a c-channel so unless there is a specific reason for this change it is not suggested.

Step 27 - Cross Brace - High Strength Axle - Part 12 - Optional

- *Cutting High Strength Axle*

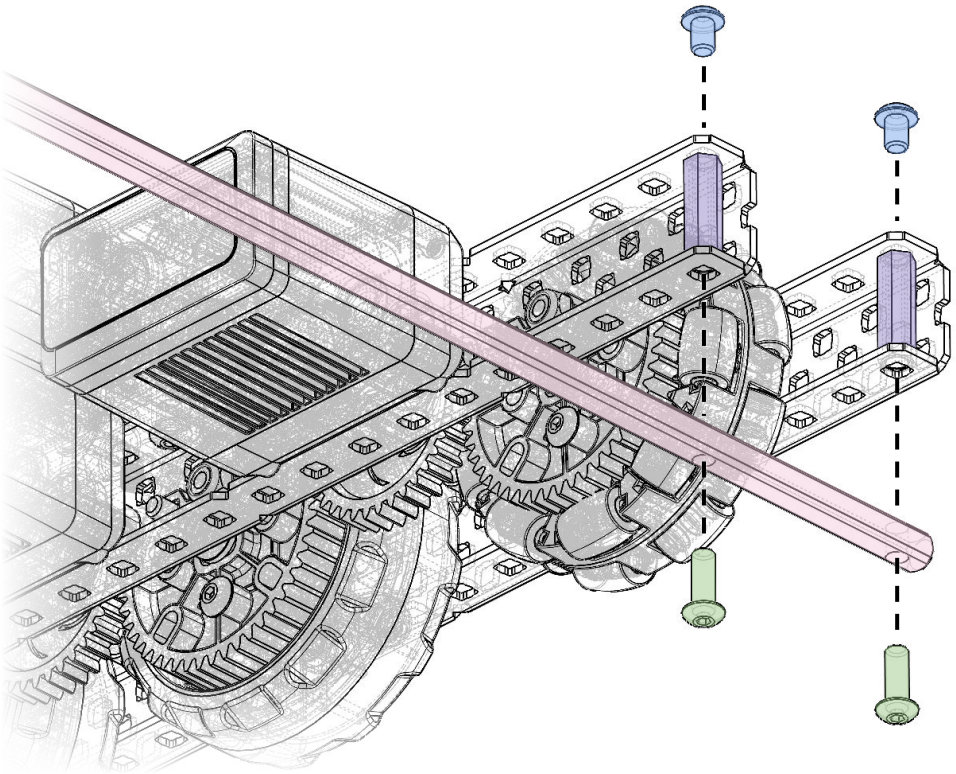


Make sure the holes are precise because otherwise the high strength axle wont fix properly and that will cause issues.

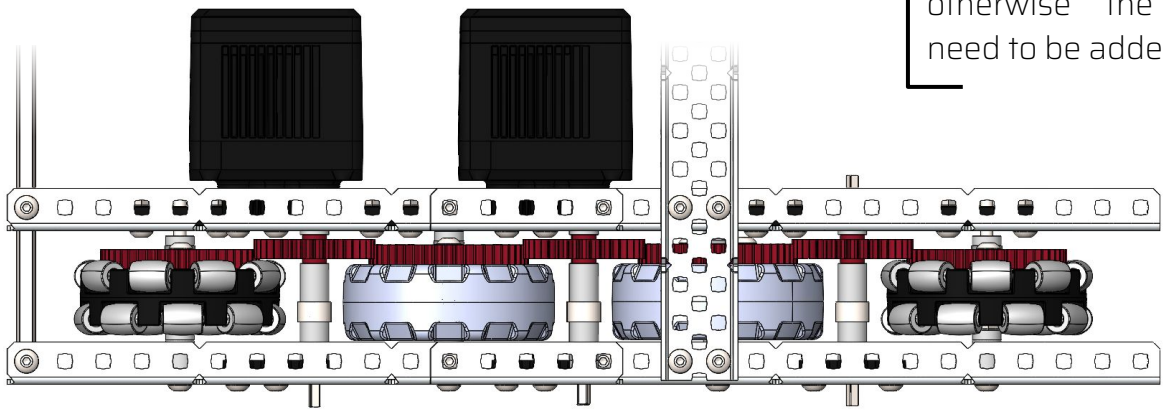


To cut the holes necessary for the high strength axle either a drill press or manual mill can be used. These tools need to be used precisely to make sure the hole is made in the correct spot. If a hole is made badly then it will affect the structural integrity of the high strength axle.

Step 28 - Cross Brace - High Strength Axle - Left Side - Optional

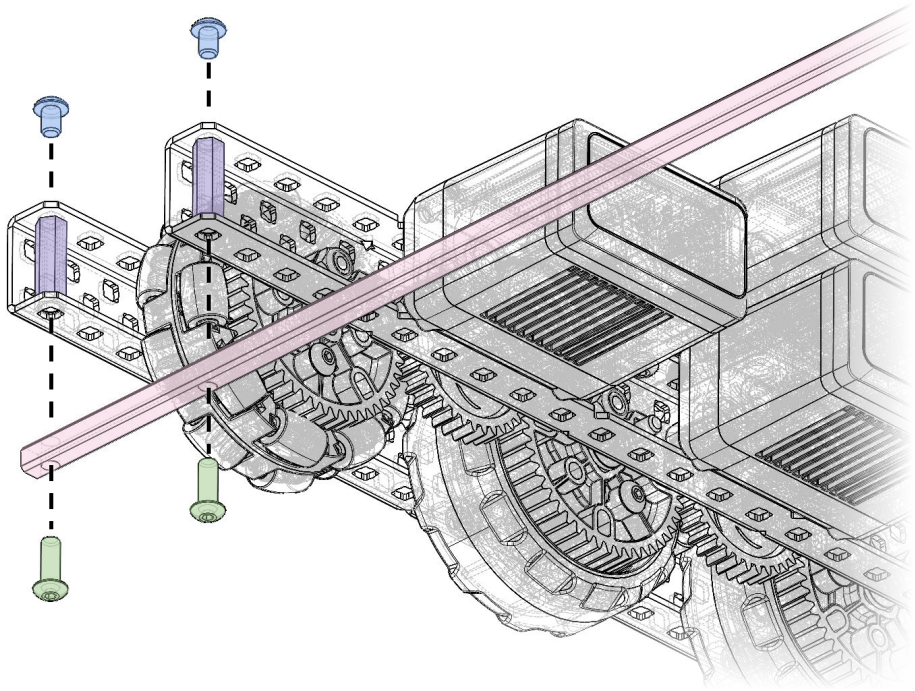


The standoffs should still be there from step 26 if back brace was added, otherwise the standoffs need to be added.

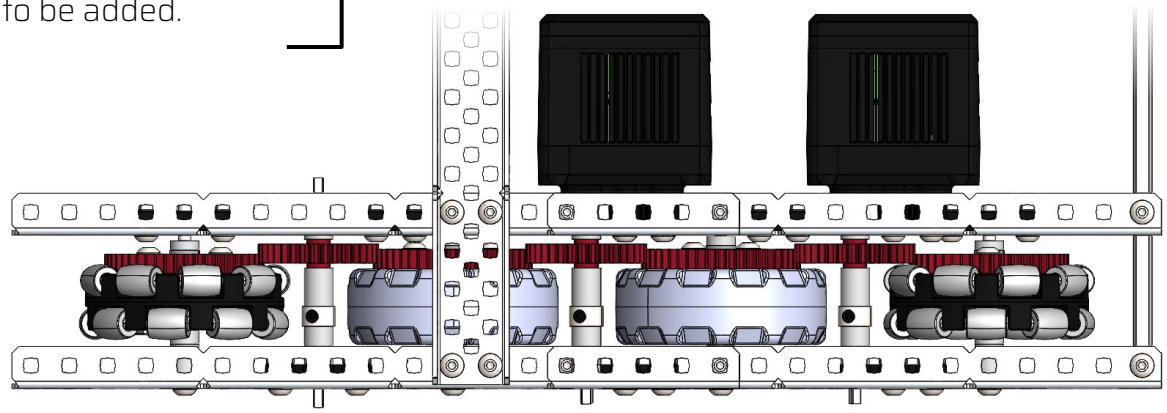


Part	Quantity (Total)	Color Code
0.5 Inch Screws	2	Green
0.25” Screws (reuse from step 26)	2	Blue
0.875” Standoffs	2	Purple
Part 12	1	Pink
Part from Step 23	1	Gray

Step 29 - Cross Brace - High Strength Axle - Right Side - Optional



The standoffs should still be there from step 26 if back brace was added, otherwise the standoffs need to be added.



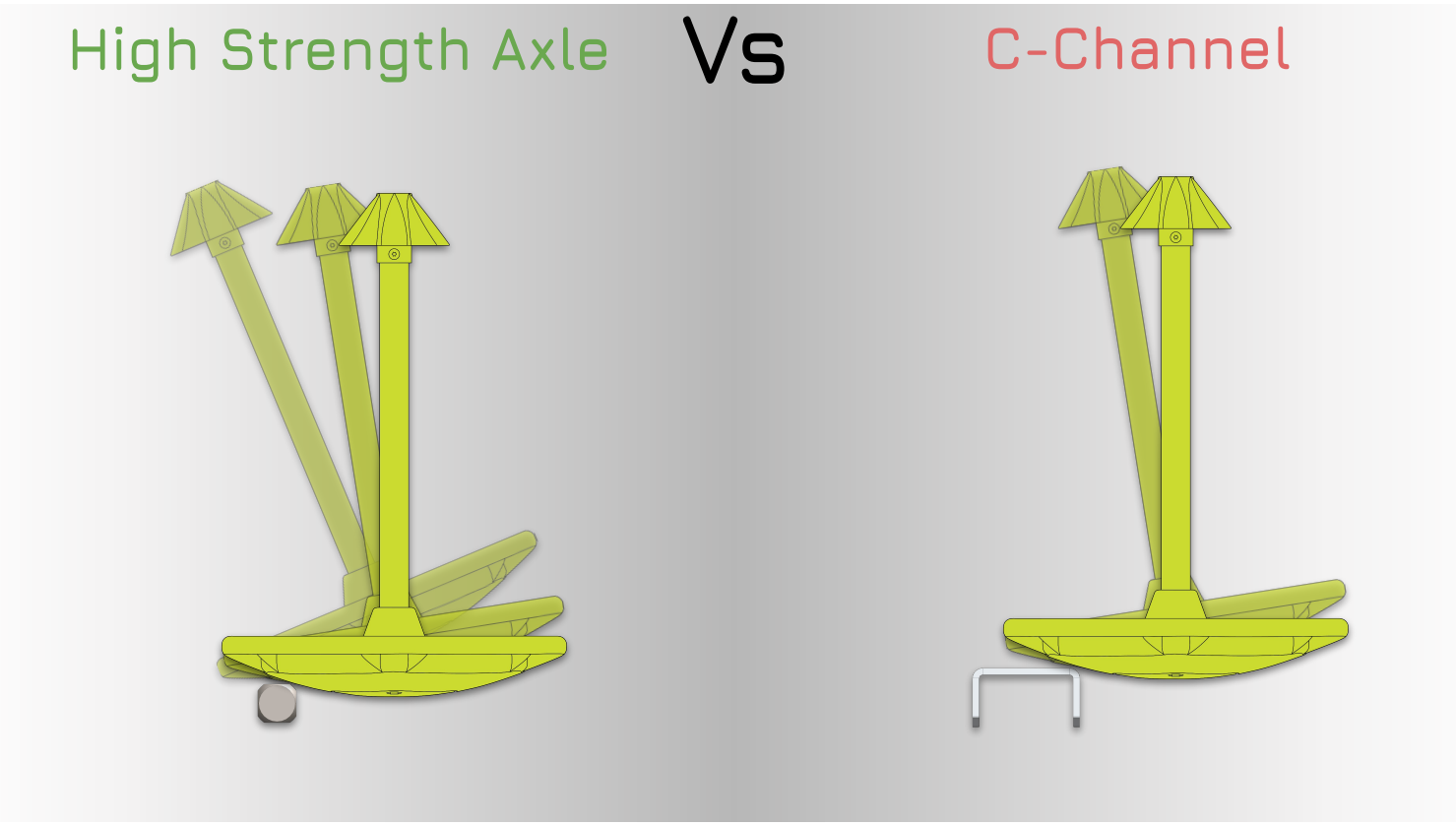
Part	Quantity (Total)	Color Code
0.5 Inch Screws	2	Green
0.25” Screws (reuse from step 26)	2	Blue
0.875” Standoffs	2	Purple
Part 12	1	Pink
Part from Step 23	1	Gray

Different Between Back Braces

There are 2 types of back bracing that are shown for this chassis, either a c-channel or a high strength axle.

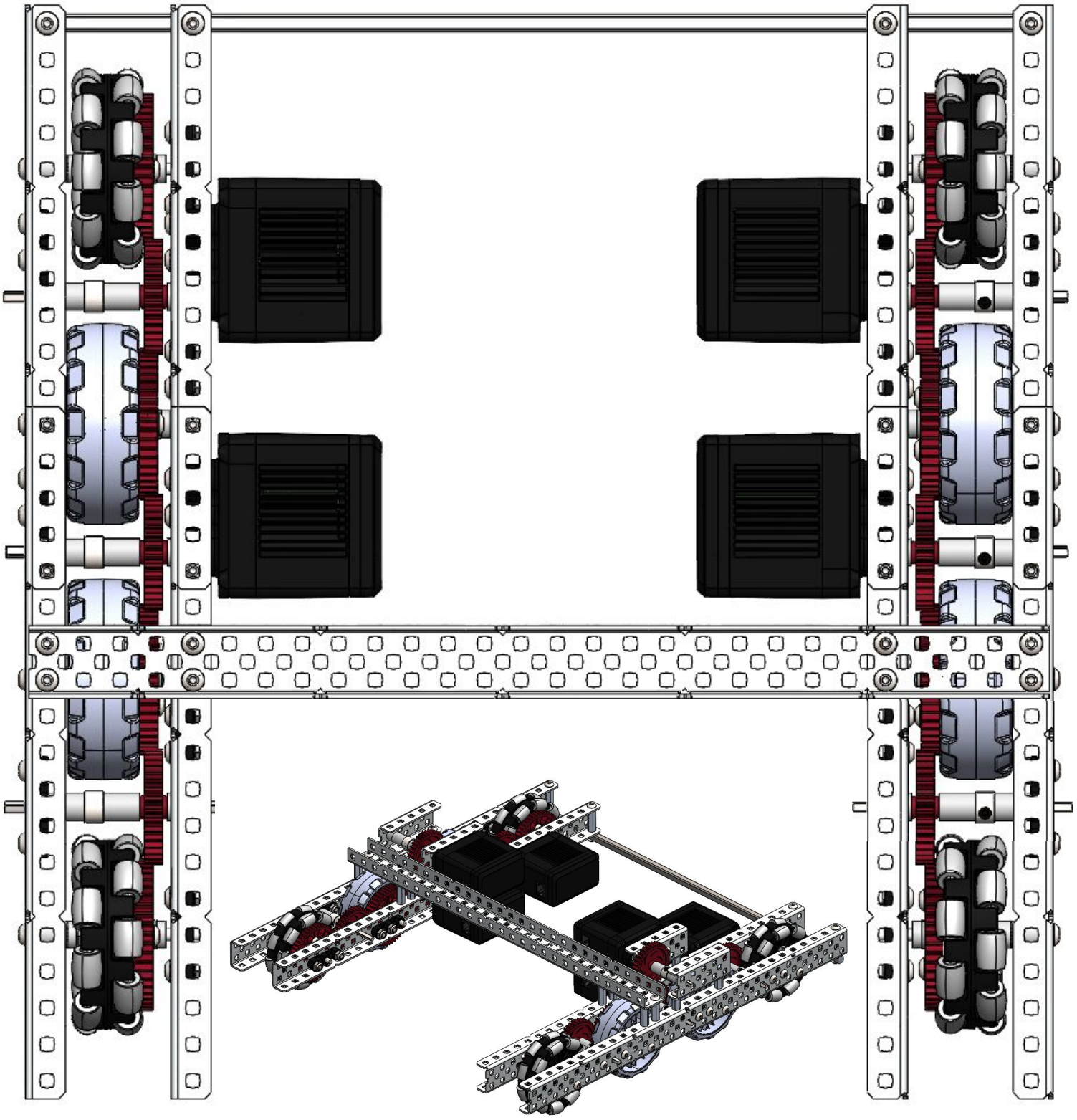
C-Channel - A c-channel is stronger and sturider compared to a high strength axle but it is harder to rotate an object on it (which is inconvenient when applied to this years game high stakes).

High Strength Axle - A high strength axle is useful when an object needs to be rotated on it but the axle has a higher chance of bending. This happens especially when unnecessary holes are drilled into the axle.



A high strength axle can be very useful for rotating an object on it. As seen in the image the mobile goal can rotate much more on the axle then the c-channel because there is nothing blocking it from rotating forwards. On a c-channel there is the flat part of the c-channel that can hinder the rotational movement of the mobile goal. This causes an axle to have more rotational potential. (the mobile goals from the game high stakes are being used as an example.)

Final Assembly - 8 Wheel, 6 Motor A-Chassis



Top View