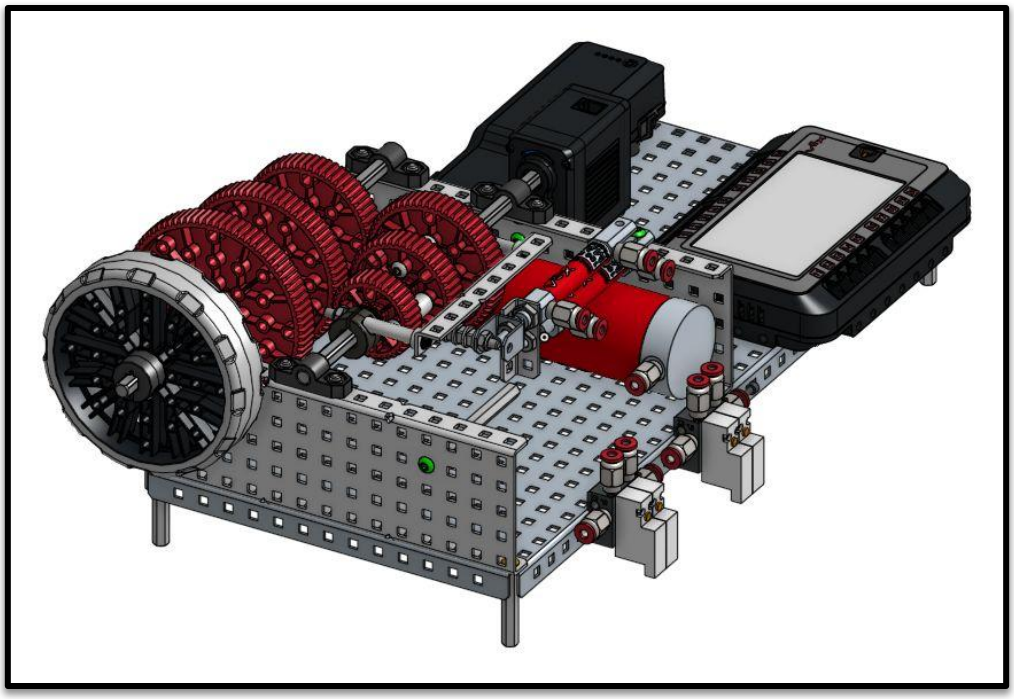
V5RC 24-25 Build Instructions: A Guide To Vex Transmissions



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By Team: 603B, I Don't Know

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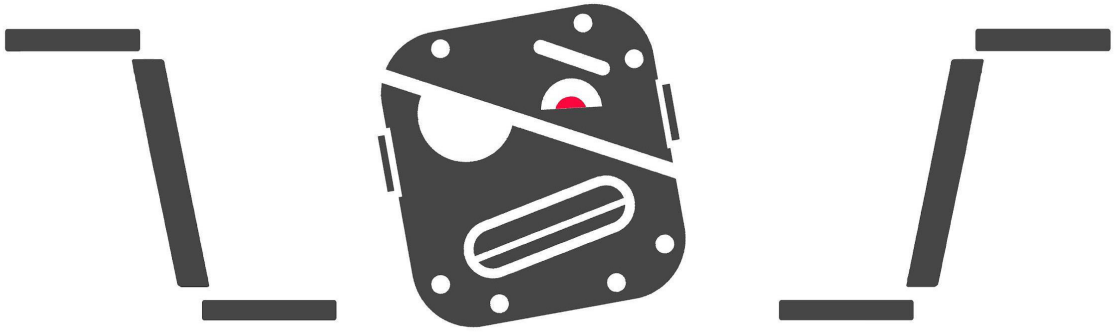

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Introduction

My name is Odin Provost, and this is my 6th year doing V5RC. Over the years, I have learned many things, including how to make and use different types of transmissions. There are two new robotics students on my team, and there are several other newcomers in the 603 robotics program this year. Because I'm graduating this year, I want to share my knowledge, which is why I chose to do this online challenge.

Note: I designed all of these with rule G3 in mind.

What's a Transmission?

What Is It?

A transmission is a type of mechanism that shifts gears to create different gear ratios. This alters the output rotations per minute (RPM) of a device, and is commonly used in robotics for a higher speed/strength output.

Where Can They Be Found?

Transmissions in the real world are most commonly used in cars. They allow the engine to output different amounts of speed without overworking itself. This allows the car to either drive faster using higher speed ratios, or drive slower using higher strength ratios.

Strength Vs. Speed

In robotics, drivetrain RPM is key in determining how fast a robot can go. Slower robots have more strength, due to the drivetrain RPM being slower than the motor RPM, which can aid in defense. However, they can get outsped by faster robots. By utilizing a transmission in your robot's drivetrain, you can achieve both speed and strength at any point in a match.

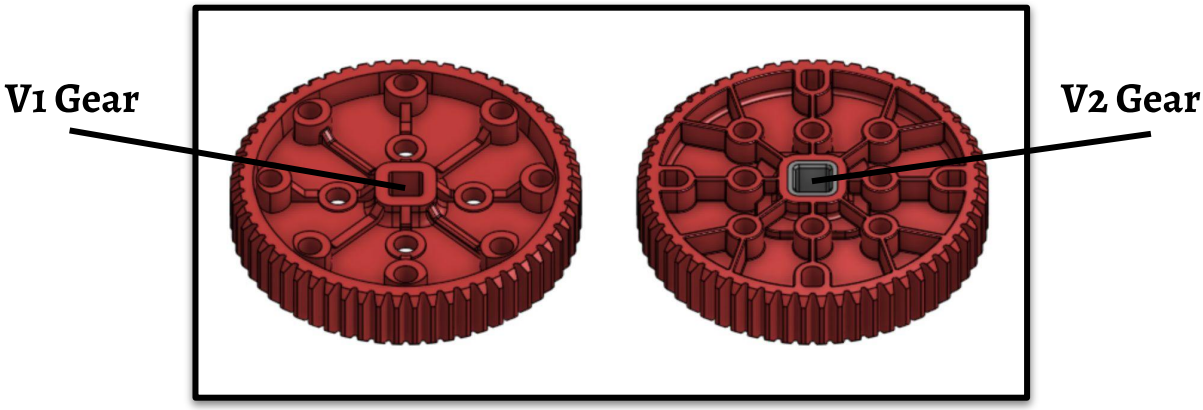
Different Types

There are several different types of transmissions, but I will go over three different types, all of which use pneumatics to move the transmission gears. Standard transmissions use two gear ratios, one for speed and the other for strength. A power take-off diverts power from one output to another. A triple transmission uses three different gear ratios for multiple outputs.

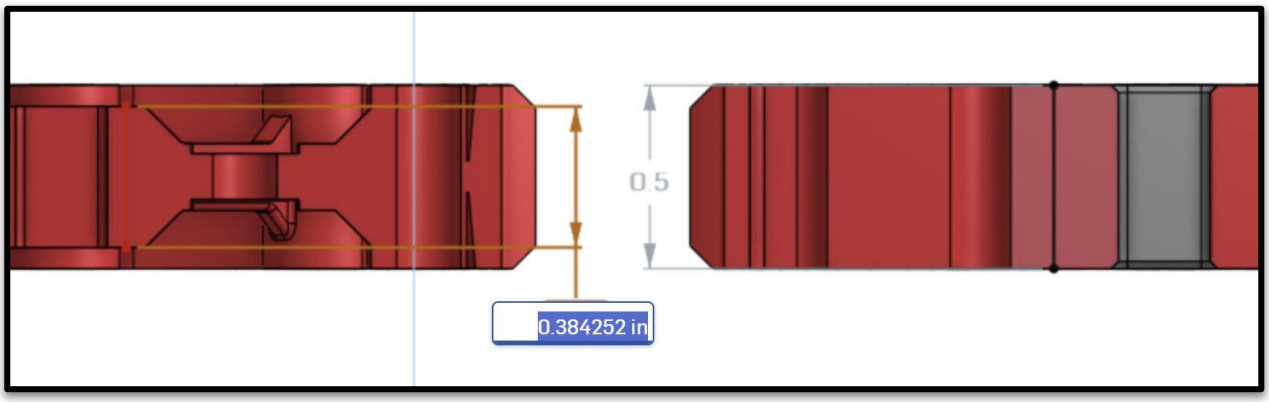
Transmission Gears

Gear Types

There are three main types of gears; low strength, high strength, and high strength V2. Low strength gears are usually too thin for transmissions, so we won't be using them. Here's an example of the two types of high strength gears:



The differences between these two types are: More screw holes on the V2 gears, reinforced metal middle on the V2 gears, and the thickness of the middles of both types.
Here's a comparison of the middle thickness of the two:

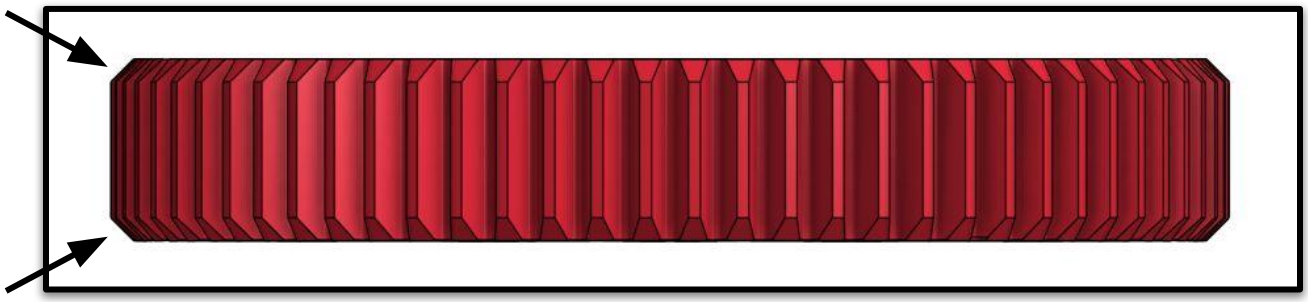


The V1 gears are 0.384252 inches thick in the middle, while the V2 gears are 0.5 inches thick. This leaves a difference of 0.057874 inches on either side of the V1 gears. This difference can throw off the spacing of your transmissions, which is something to look out for.

Transmission Gears

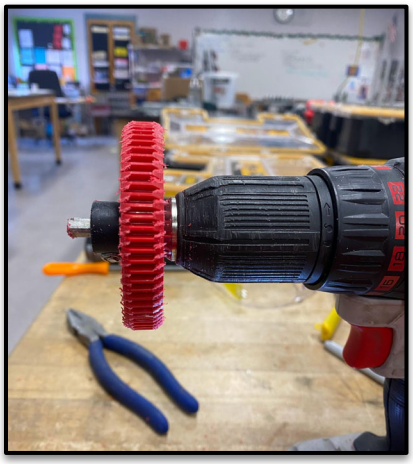
How To Make

Transmission gears are slightly different from normal gears, as the edges of them are beveled like this:



This beveling allows the gears to smoothly slide into each other and helps prevent the gears from catching on each other.

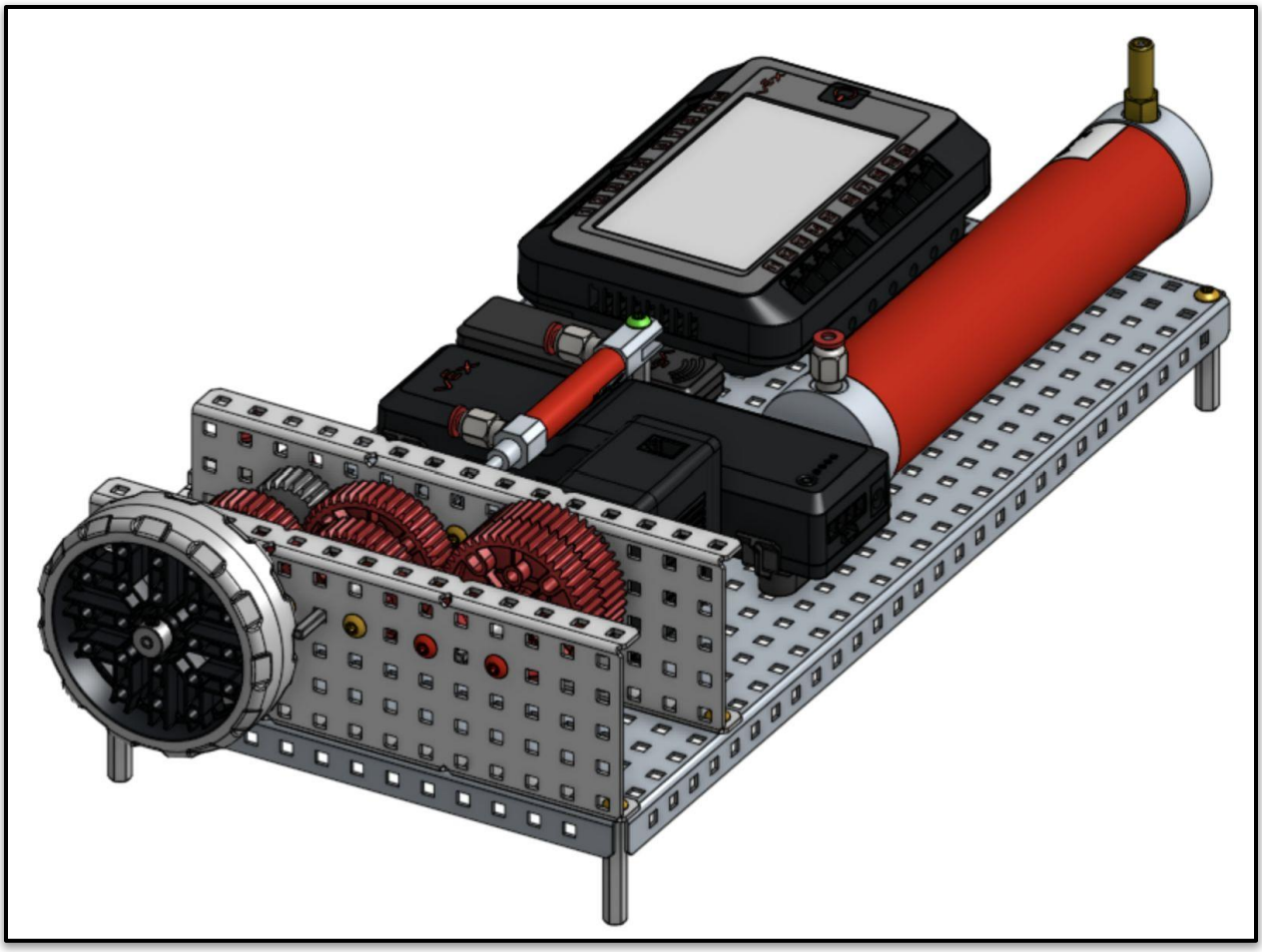
The easiest way to bevel gears is to attach them to a drill using a high strength axle and clamping collar like this ->



<- Then turn on the drill and file the gear like this

Be careful not to bevel the gear too much, as it then would have a higher chance of slipping when being used. Also be careful of the plastic shavings, as it can be dangerous to breathe it in. Always make sure to wear a mask to avoid breathing in the shavings.

Transmission



Description

A simple transmission just moves two transmission gears to change the output ratio. The transmission piece gets driven by gears equal to its size. This keeps it at a 1:1 gear ratio, so the ratio only gets changed by the transmission piece changing gears.

This will change the output ratio which can change the speed and strength of the output. This is an example of a transmission my team used earlier in the season to change our drivetrain RPM.

Transmission

Parts List

Here are the parts you will need to build a Transmission:

Structure:

- 1x: 15 x 30 Base Plate (276-1341)
- 2x: 1 x 5 x 1 x 15 Aluminum C-Channel (276-2298)
- 5x: 1.5" Long #8-32 Standoff (276-2013)

Gears:

- 2x: 36T High Strength Gear V2 (276-7747)
- 3x: 48T High Strength Gear V2 (276-7573)
- 1x: 24T High Strength Gear V2 (276-7572)

Spacers:

- 1x: 0.03125" L x 0.375" OD (1/32”) Spacer
- 4x: 0.0625" L x 0.375" OD (1/16”) Spacer
- 2x: 1/8" x 3/8" OD x #8 Nylon Spacer (276-6340)
- 2x: 1/4" x 3/8" OD x #8 Nylon Spacer (276-6340)
- 1x: 3/8" x 3/8" OD x #8 Nylon Spacer (276-6340)
- 2x: 1/2" x 3/8" OD x #8 Nylon Spacer (276-6340)
- 1x: 0.75" L x 0.25" OD Spacer

Screws & Nuts:

- 3x: #8-32 x 1/4" Star Drive Screw (33-31)
- 19x: #8-32 x 3/8" Star Drive Screw (33-32)
- 6x: #8-32 x 1/2" Star Drive Screw (33-33)
- 3x: #8-32 x 5/8" Star Drive Screw (33-34)
- 2x: #8-32 x 1-1/4" Star Drive Screw (33-38)
- 2x: #8-32 Hex Nut (275-1028)
- 18x: #8-32 Thin Nylock Nut (32-02)

Transmission

Parts List

Pneumatics & Electronics:

- 1x: 25mm Stroke Pneumatic Cylinder (276-8642)
- 7x: Straight Pneumatic Fitting (276-8636-001)
- 1x: Cylinder Mount (from the legacy pneumatics)
- 1x: Pneumatic Reservoir (276-8749)
- 1x: Double Acting Solenoid (276-8650-020)
- 1x: V5 Smart Motor (18:1) (276-4840)
- 1x: V5 Robot Brain (276-4810)
- 1x: V5 Robot Battery (276-4811)
- 1x: Valve stem
- 1x: V5 Robot Radio (276-4831)

High/Low Strength:

- 5x: High Strength Shaft Adapter, LS Square Bore (276-8235)
- 2x: High Strength Shaft Adapter, #8 Round Bore (276-8034)
- 3x: Flat Bearing (276-1209)
- 2x: Plastic Lock Plates (No longer sold)
- 6x: Shaft Collar (276-2010)
- 2x: 3.5" Standard Shaft (276-1149)
- 1x: 4.5" Standard Shaft (276-1149)

Miscellaneous:

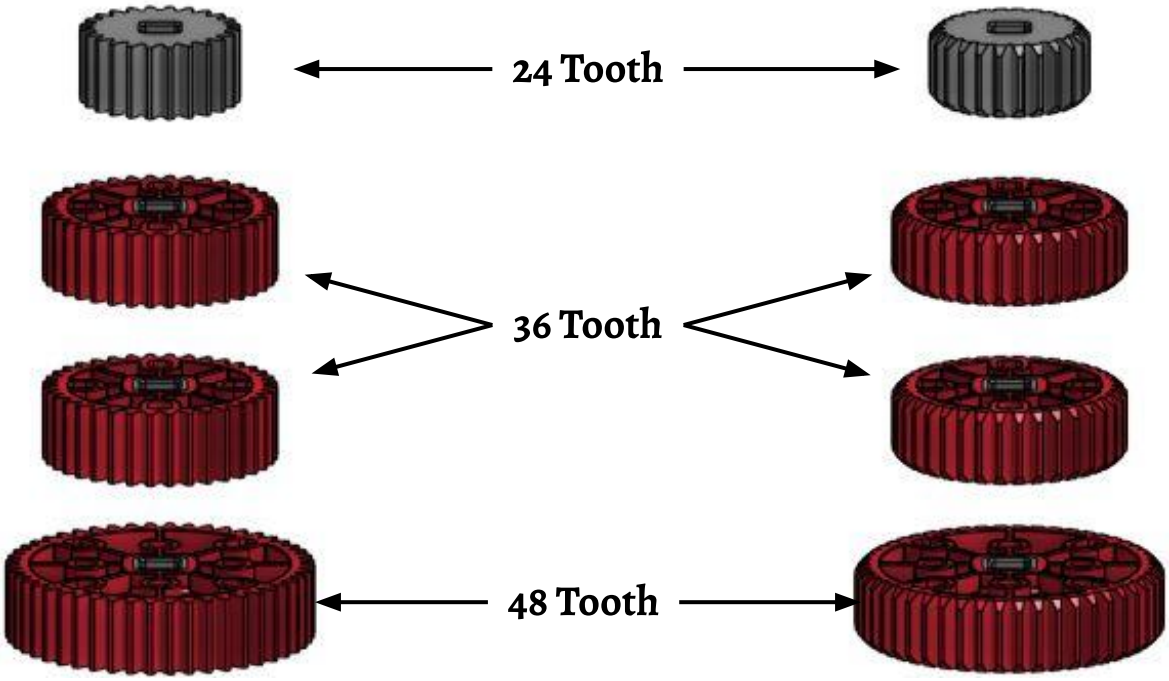
- 1x: 3.25" Anti-Static Wheel (260mm Travel) (276-7771)
- 2x: V5 Battery Clip (276-6020)
- 1x: 4mm Fitting Plug (276-8757-001)
- Pneumatic tubing, custom lengths
- Motor wire, custom length
- 1x: 180 mm Power Cable
- 1x: V5 Double Acting Solenoid Driver Cable

Transmission

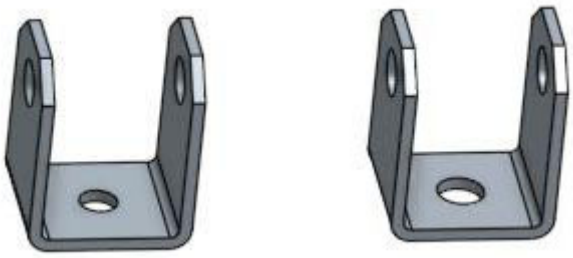
Preparing Parts

Some of the parts will need to be prepared first before building. The two 36 Tooth V2 gears, one 48 Tooth V2 gear, and the 24 Tooth V2 gear all need to be turned into transmission gears, refer to page 6 for a guide.

They should go from this: To this:



The bottom hole on the normal cylinder mounts (Left) are not wide enough for the 25mm Stroke Pneumatic Cylinder Rods, which have the same dimensions as a screw's threading. The hole will need to be drilled out carefully with an 11/64 drill bit (Right).



Transmission

Assembly

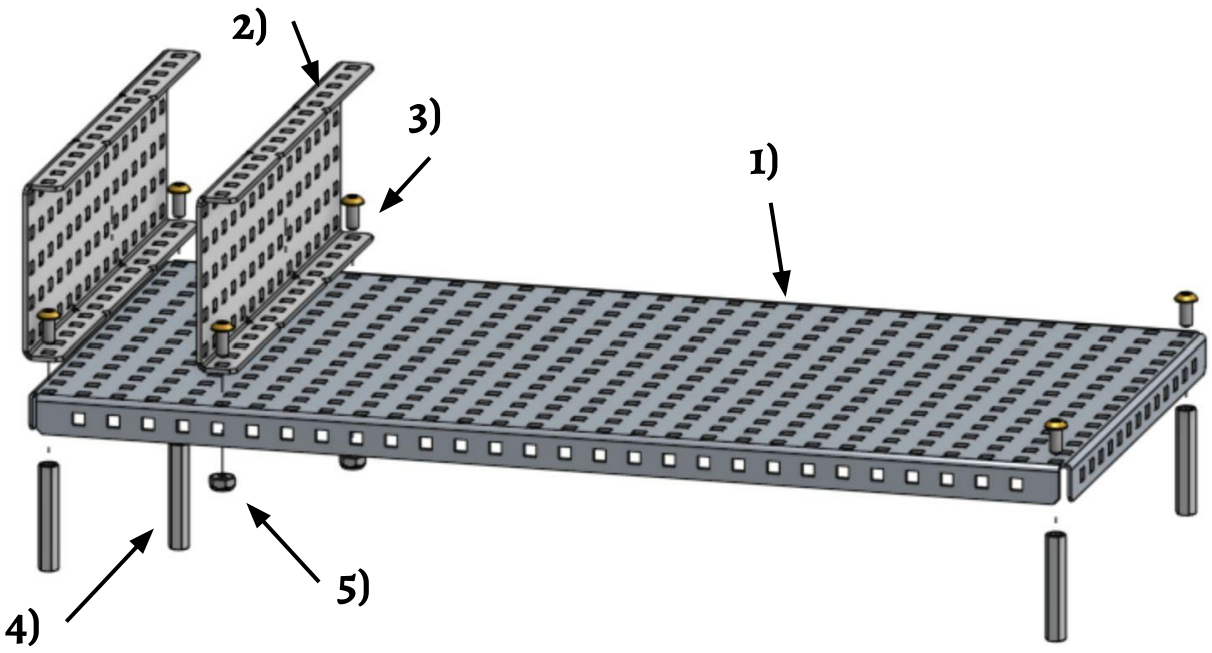
Now it is time to start assembling the Transmission.

Step 1: ***Build the platform***

Gather:

1) 1x: 15 x 30 Base Plate
2) 2x: 1 x 5 x 1 x 15 Aluminum C-Channels
3) 6x: #8-32 x 3/8" Star Drive Screws
4) 4x: 1.5" Long #8-32 Standoff
5) 2x: #8-32 Thin Nylock Nut

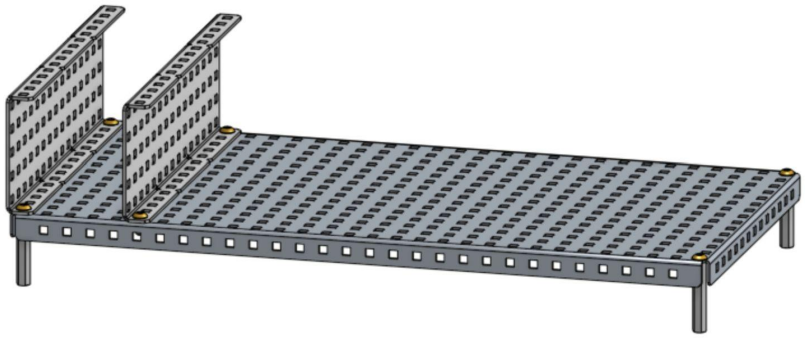
Assemble as shown:



Transmission

Assembly

It should look like this:

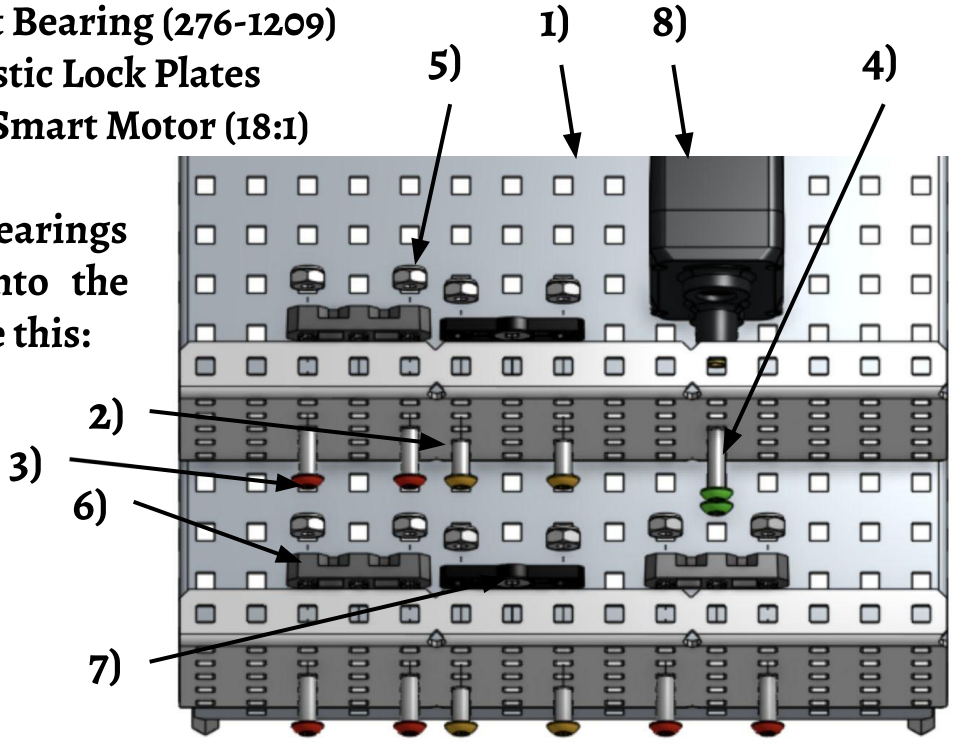


Step 2: *Install the bearings & motor*

Gather:

1) 1x: Platform
2) 4x: #8-32 x 3/8" Star Drive Screws
3) 6x: #8-32 x 1/2" Star Drive Screw
4) 3x: #8-32 x 5/8" Star Drive Screw
5) 10x: #8-32 Thin Nylock Nut
6) 3x: Flat Bearing (276-1209)
7) 2x: Plastic Lock Plates
8) 1x: V5 Smart Motor (18:1)

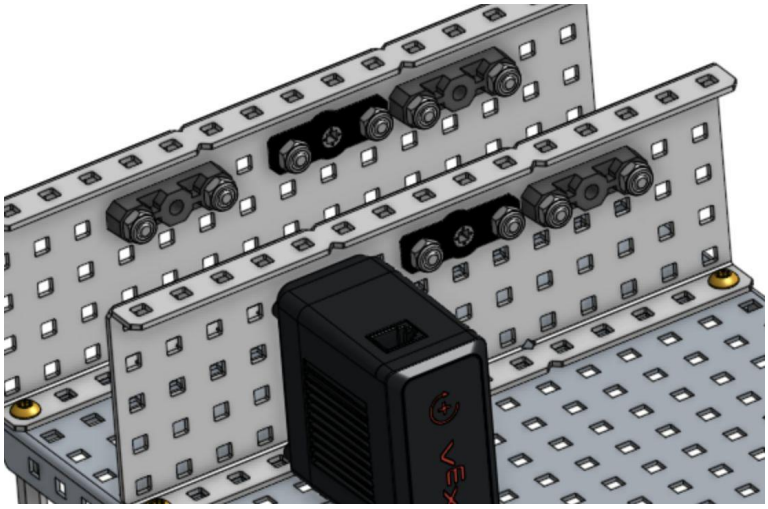
Screw the bearings and motor onto the c-channels like this:



Transmission

Assembly

It should look like this:

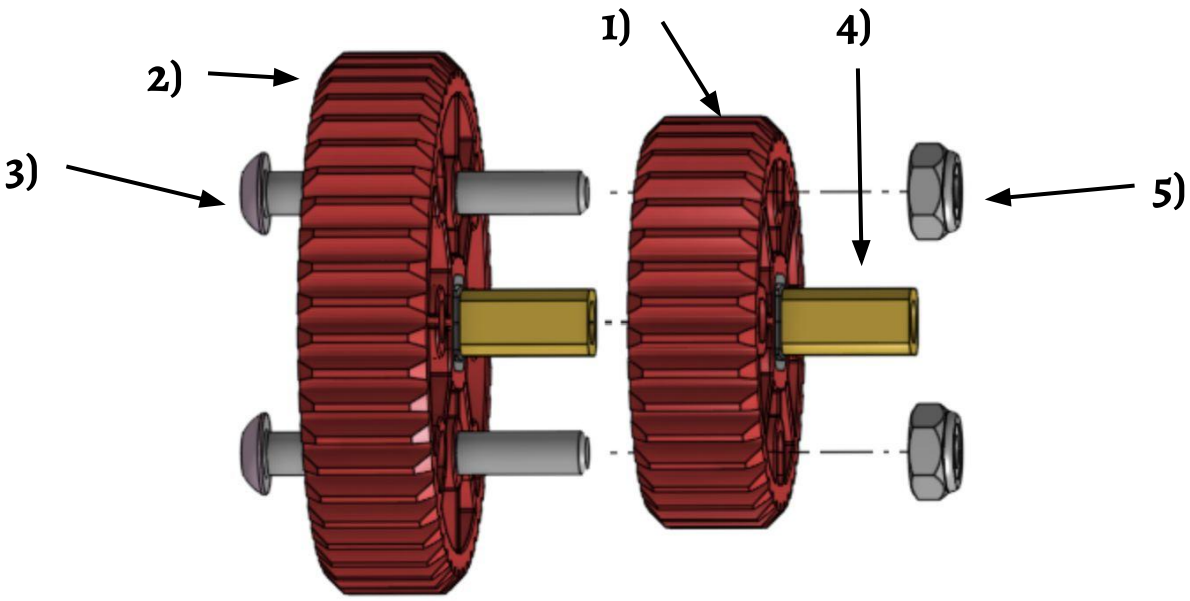


Step 3: *Assemble transmission gears*

Gather:

1) 1x: Transmission 36T High Strength Gear
2) 1x: Transmission 48T High Strength Gear
3) 2x: #8-32 x 1-1/4" Star Drive Screw
4) 2x: High Strength Shaft Adapter, #8 Round Bore, 1/2 Long
5) 2x: #8-32 Thin Nylock Nut

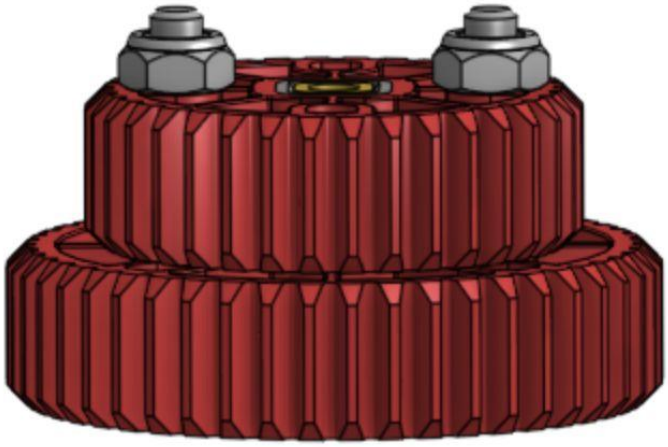
Screw the gears together and put in the inserts like this:



Transmission

Assembly

It should look like this:

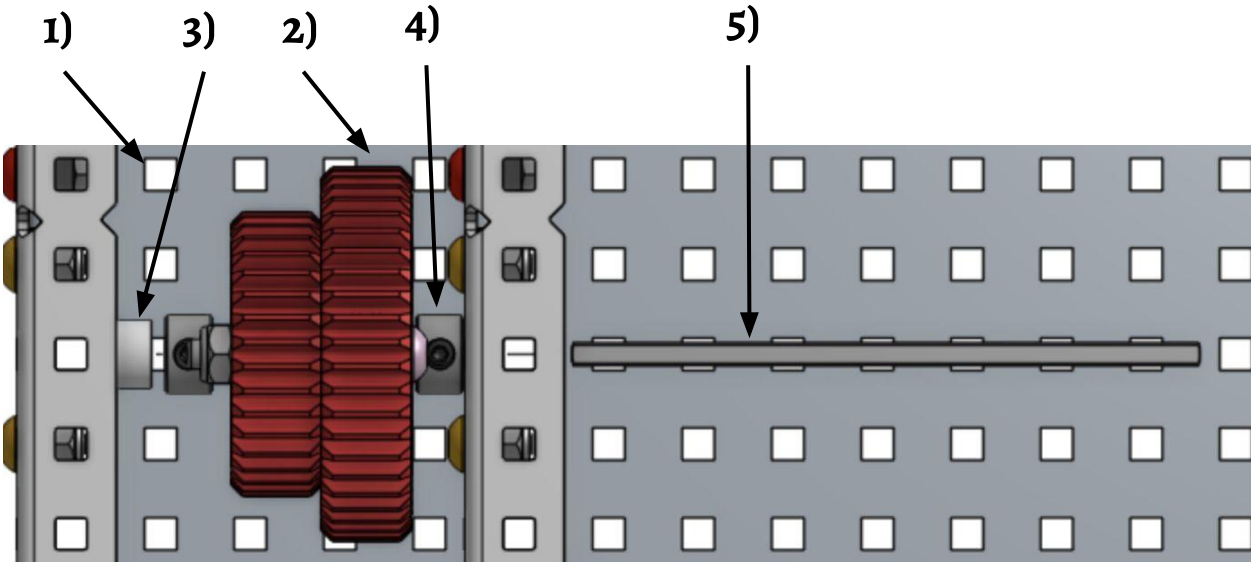


Step 4: *Install the transmission gears*

Gather:

1) 1x: Platform
2) 1x: Transmission Gears
3) 1x: 1/4" x 3/8" OD x #8 Nylon Spacer
4) 2x: Shaft Collar
5) 1x: 3.5" Standard Shaft

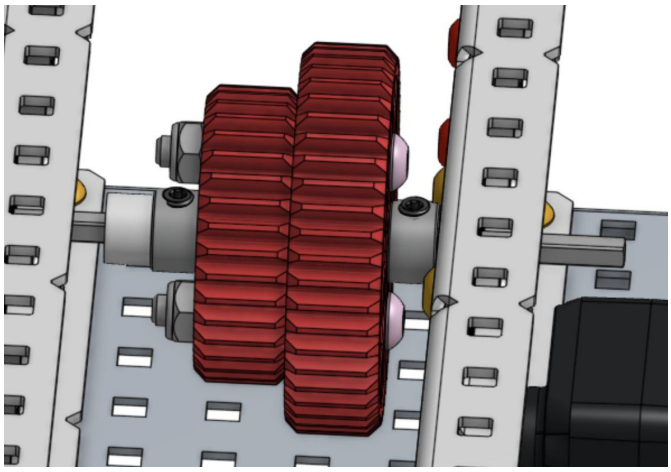
Slide the shaft through the parts as shown, then tighten the shaft collars:



Transmission

Assembly

It should look like this:

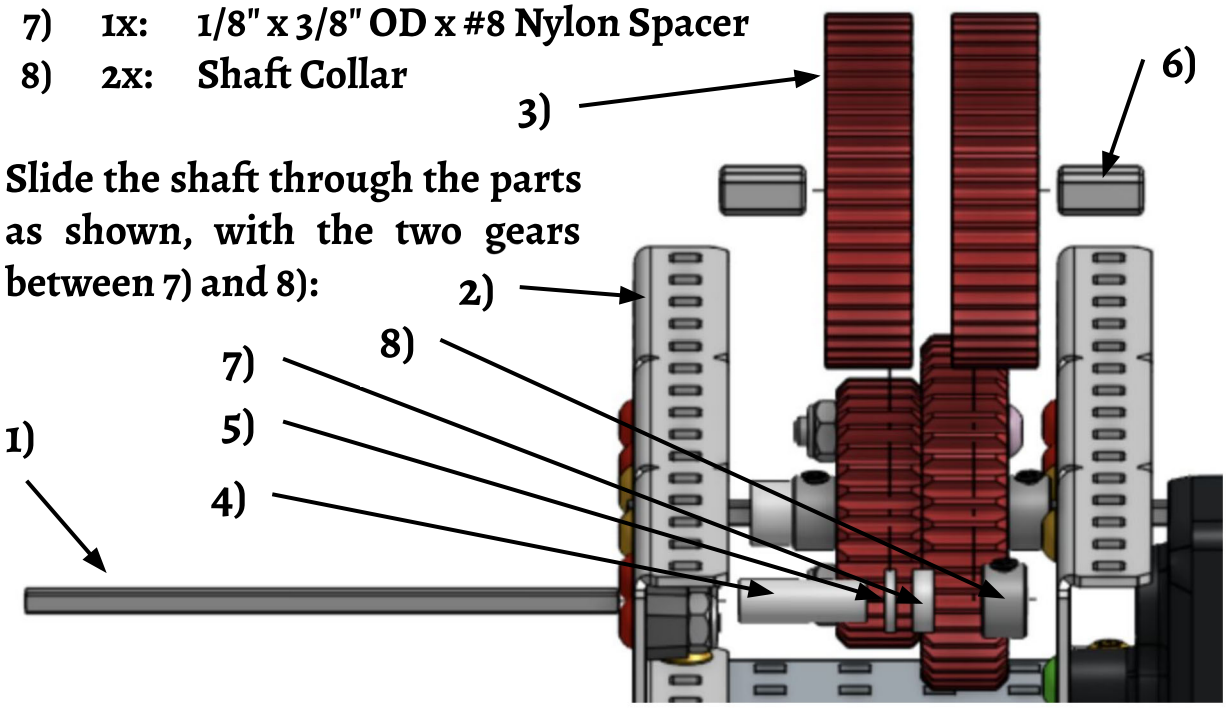


Step 5: *Install the motor gears*

Gather:

1) 1x: 3.5" Standard Shaft
2) 1x: Platform
3) 2x: 48T High Strength Gear V2
4) 1x: 0.75" L x 0.25" OD Spacer
5) 1x: 0.0625" L x 0.375" OD (1/16")
6) 2x: High Strength Shaft Adapter, LS Square Bore, 1/2" Long
7) 1x: 1/8" x 3/8" OD x #8 Nylon Spacer
8) 2x: Shaft Collar

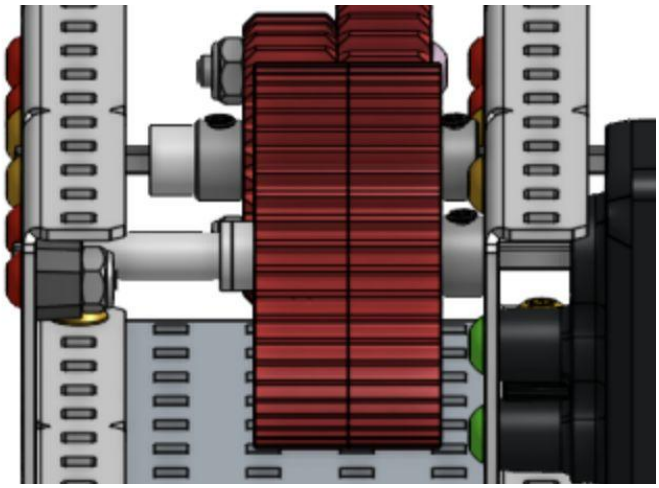
Slide the shaft through the parts as shown, with the two gears between 7) and 8):



Transmission

Assembly

It should look like this, with the shaft all the way in the motor, and the shaft collar fully tightened:

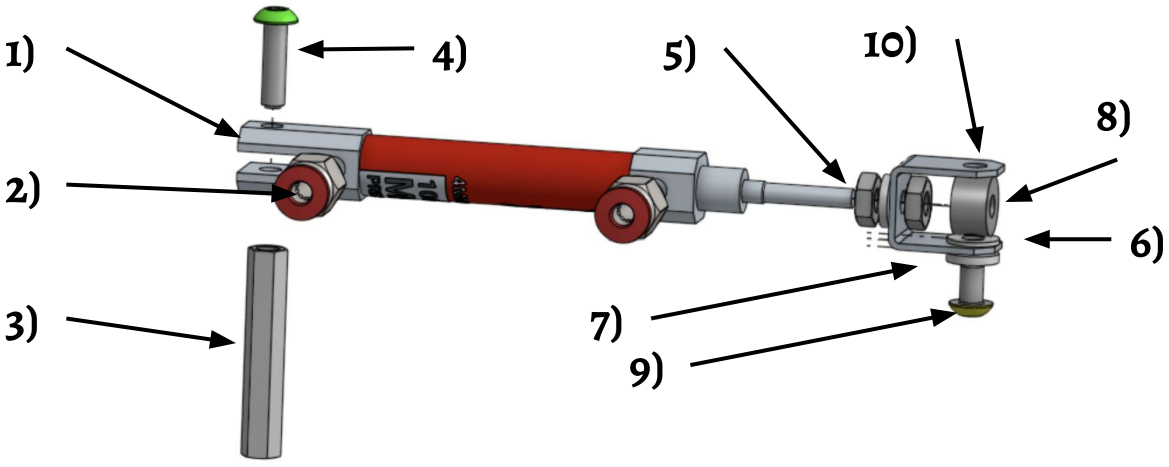


Step 6: *Assemble shifter*

Gather:

1) 1x: 25mm Stroke Pneumatic Cylinder
2) 2x: Straight Pneumatic Fitting
3) 1x: 1.5" Long #8-32 Standoff
4) 1x: #8-32 x 5/8" Star Drive Screw
5) 2x: #8-32 Hex Nut
6) 1x: 0.03125" L x 0.375" OD (1/32”) Spacer
7) 2x: 0.0625" L x 0.375" OD (1/16”) Spacer
8) 1x: Shaft Collar (without the screw inside)
9) 1x: #8-32 x 1/4" Star Drive Screw
10) 1x: Cylinder Mount

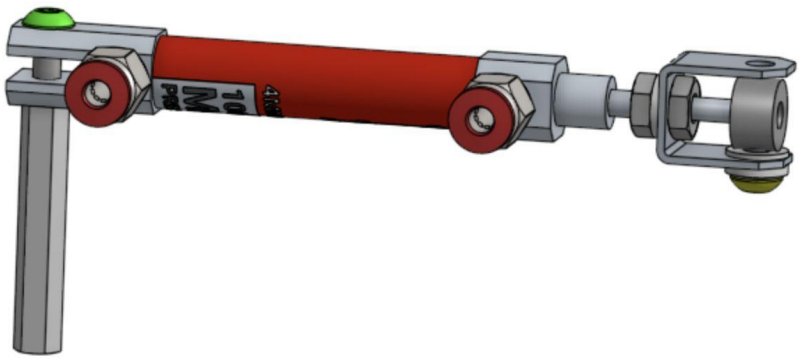
Assemble as shown, but don’t screw the shaft collar all the way in:



Transmission

Assembly

It should look like this:

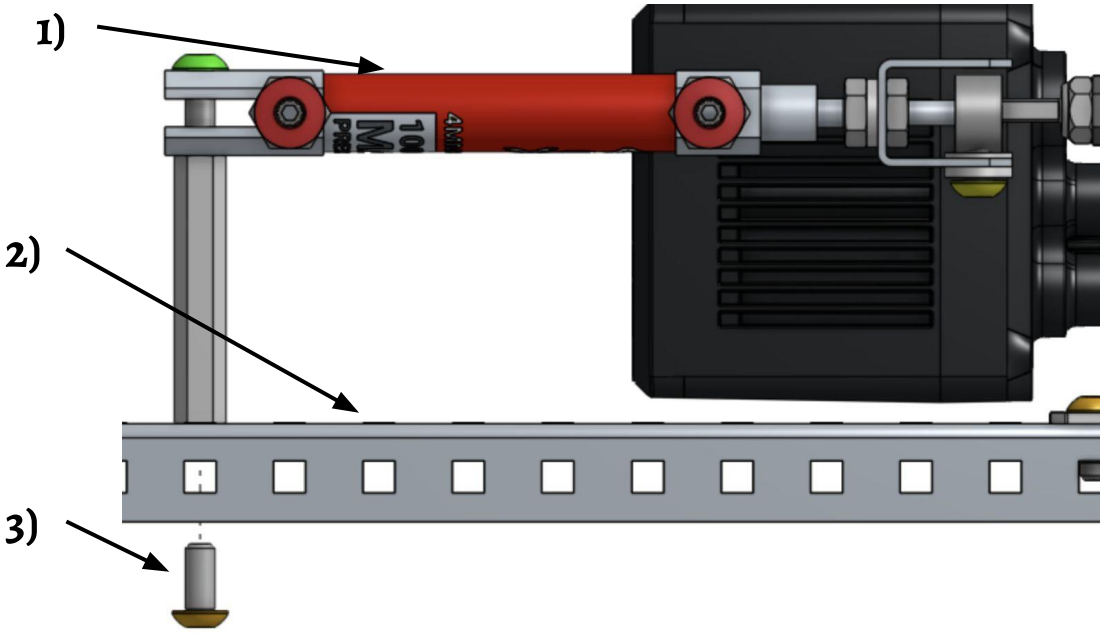


Step 7: ***Install shifter***

Gather:

1) 1x: Shifter
2) 1x: Platform
3) 1x: #8-32 x 3/8" Star Drive Screw

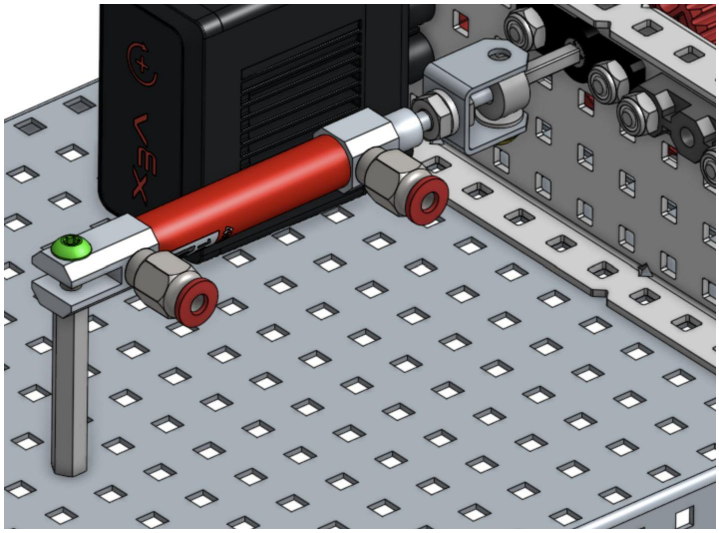
Install the shifter aligned with the transmission gears' shaft:



Transmission

Assembly

It should look like this, with the shaft collar screwed into the shaft:

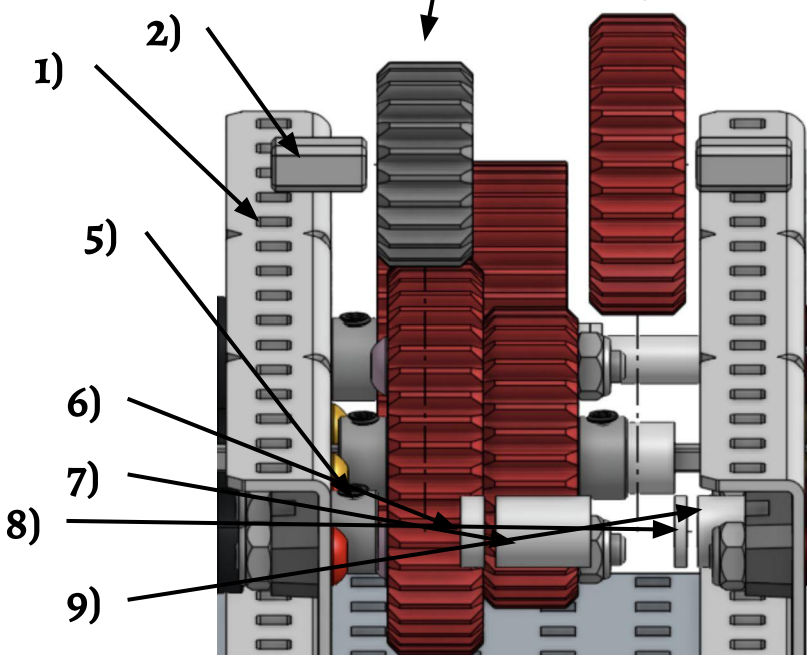


Step 8: *Install ratio*

Gather:

1) 1x: Platform
2) 2x: High Strength Shaft Adapter, LS Square Bore, 1/2" Long
3) 1x: Transmission 24T High Strength Gear
4) 1x: Transmission 36T High Strength Gear
5) 1x: Shaft Collar
6) 1x: 1/8" x 3/8" OD x #8 Nylon Spacer
7) 1x: 1/2" x 3/8" OD x #8 Nylon Spacer
8) 1x: 0.0625" L x 0.375" OD (1/16") Spacer
9) 1x: 1/4" x 3/8" OD x #8 Nylon Spacer

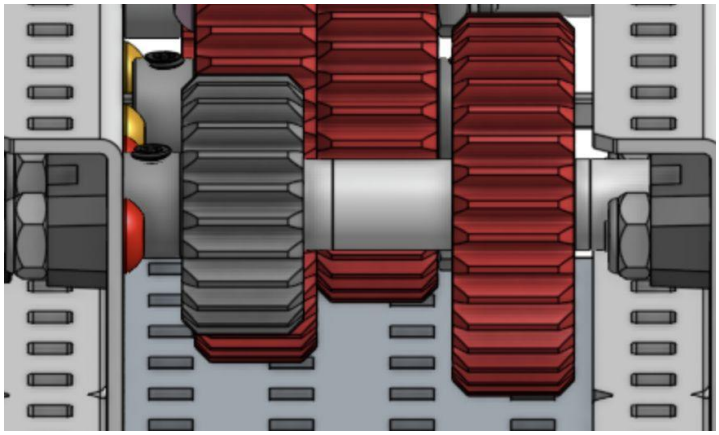
Install the ratio like so :



Transmission

Assembly

It should look like this, with the shaft holding it in place:

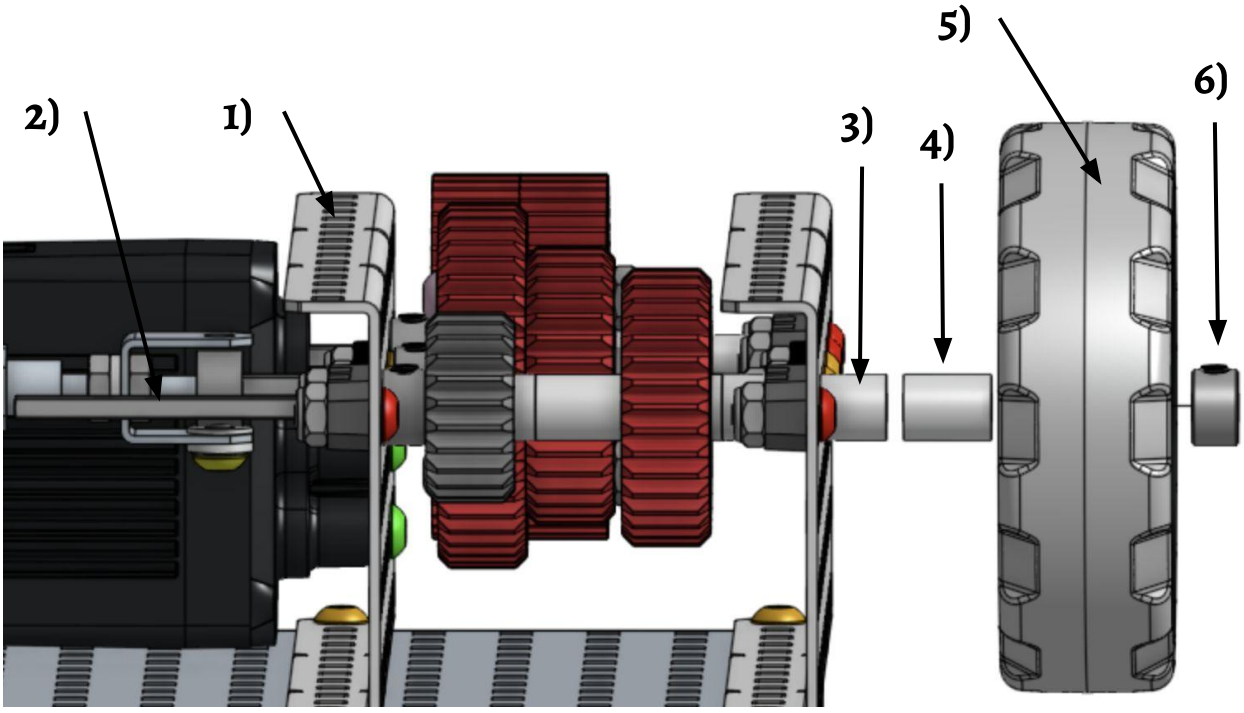


Step 9: *Install ratio*

Gather:

1) 1x: Platform
2) 1x: 4.5" Standard Shaft
3) 1x: 3/8" x 3/8" OD x #8 Nylon Spacer
4) 1x: 1/2" x 3/8" OD x #8 Nylon Spacer
5) 1x: 3.25" Anti-Static Wheel (260mm Travel)
6) 1x: Shaft Collar
7) 1x: High Strength Shaft Adapter, LS Square Bore, 1/2" Long

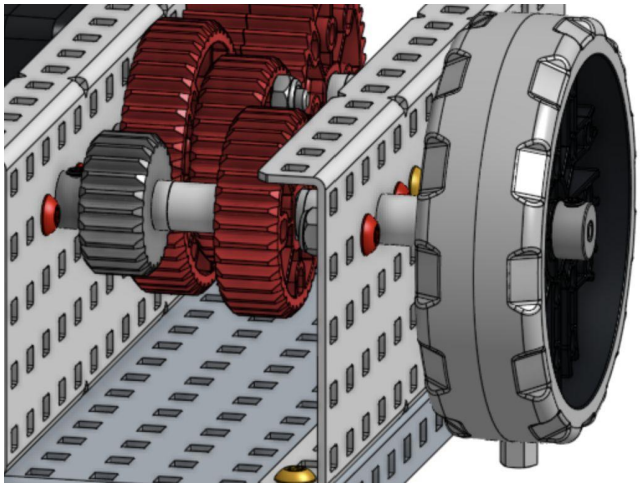
Put 7) inside 5), and install the ratio like so:



Transmission

Assembly

It should look like this, with the shaft collar holding the wheel in:

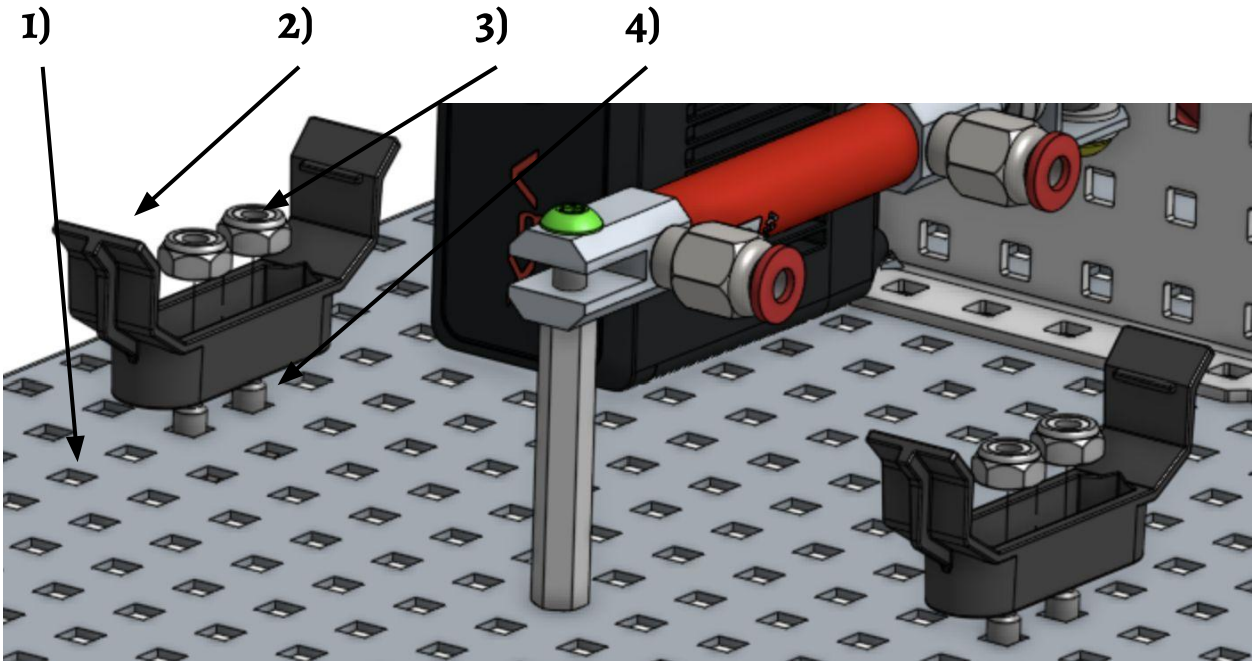


Step 10: *Install clips*

Gather:

1) 1x: Platform
2) 2x: V5 Battery Clip
3) 4x: #8-32 Thin Nylock Nut
4) 4x: #8-32 x 3/8" Star Drive Screw

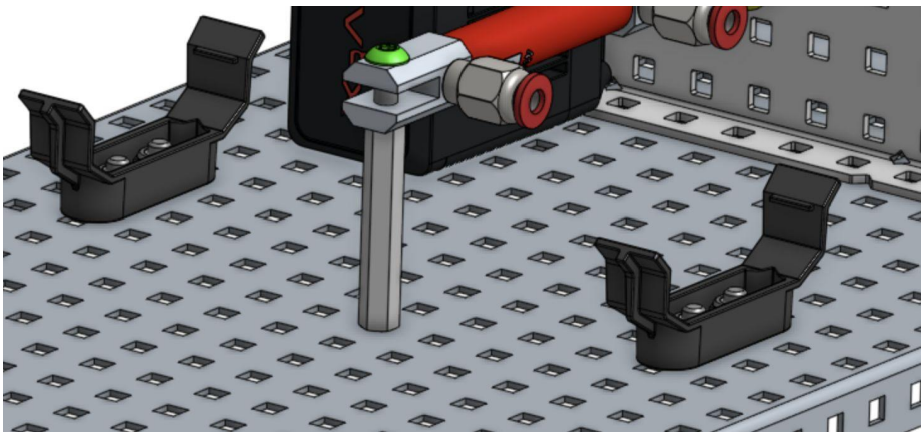
Install the battery clips like this:



Transmission

Assembly

It should look like this:

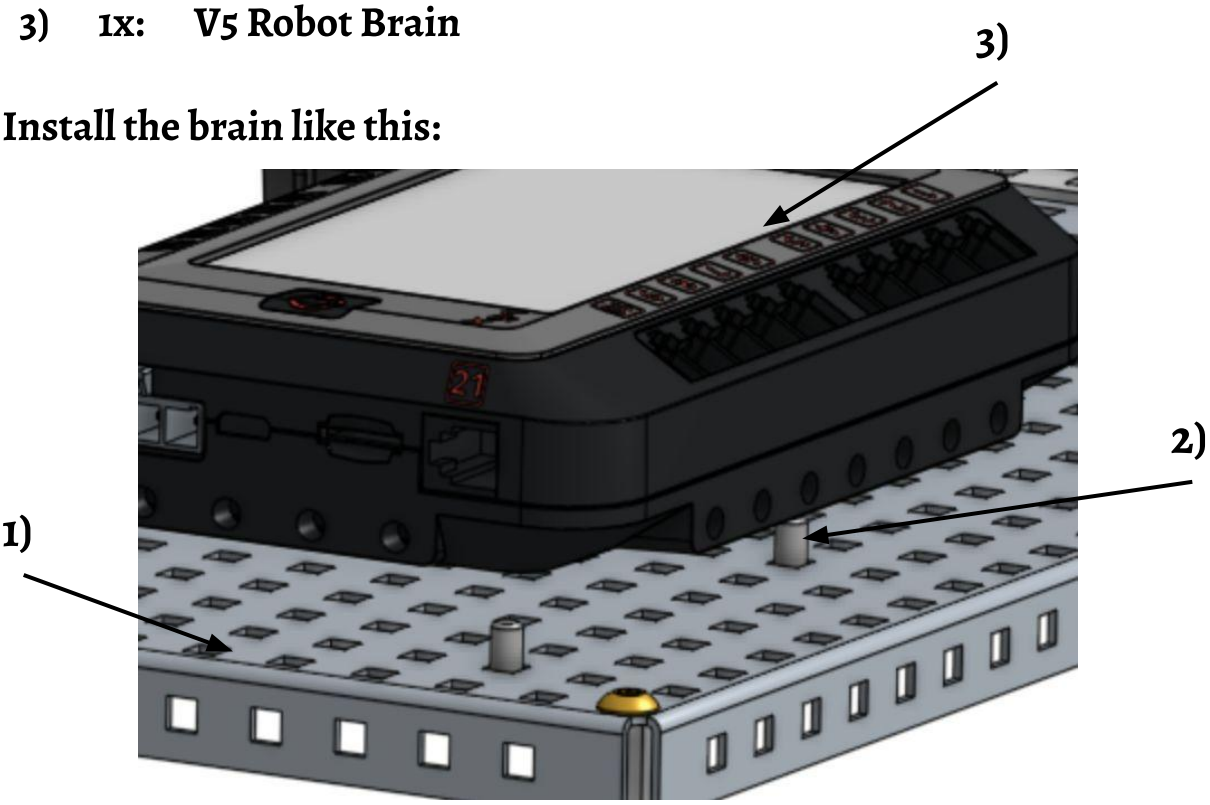


Step 11: ***Install brain***

Gather:

1) 1x: Platform
2) 2x: #8-32 x 1/4" Star Drive Screw
3) 1x: V5 Robot Brain

Install the brain like this:



Transmission

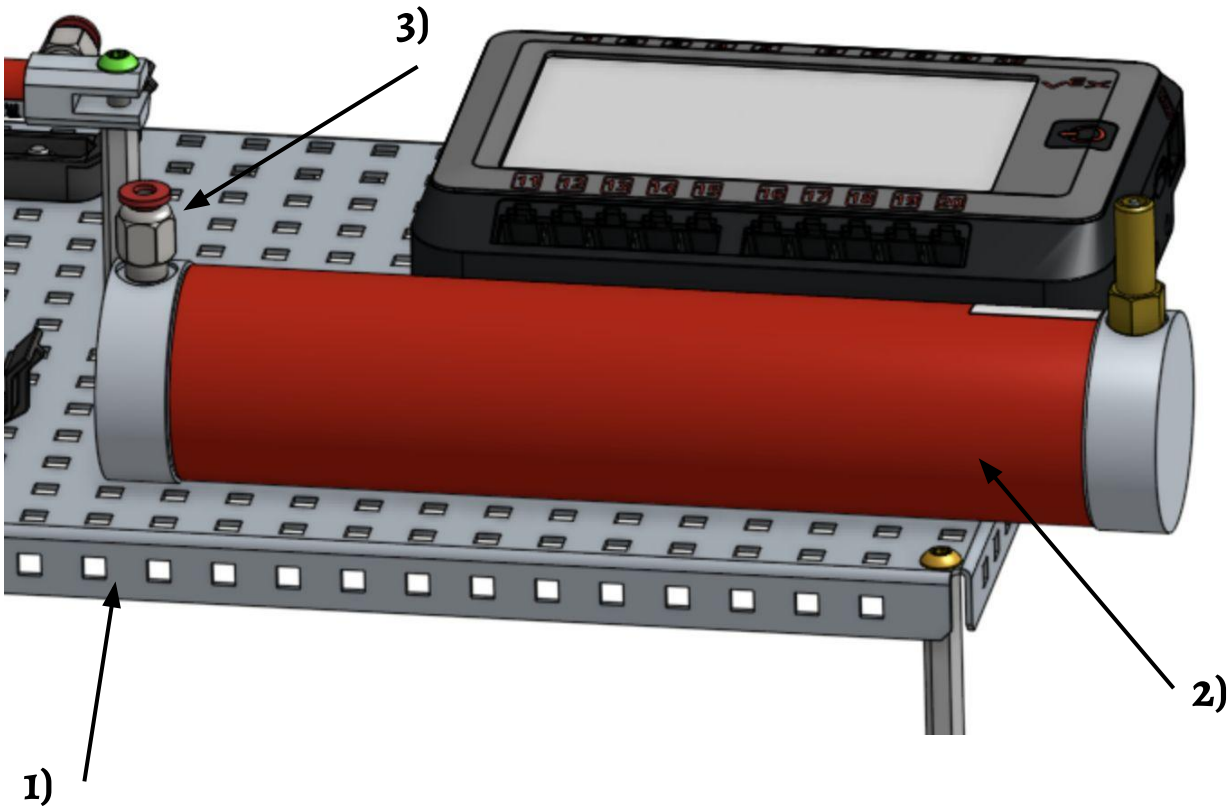
Assembly

Step 12: ***Put on the tank***

Gather:

1) 1x: Platform
2) 1x: Pneumatic Reservoir
3) 1x: Straight Pneumatic Fitting

Put on the air tank like so:



Transmission

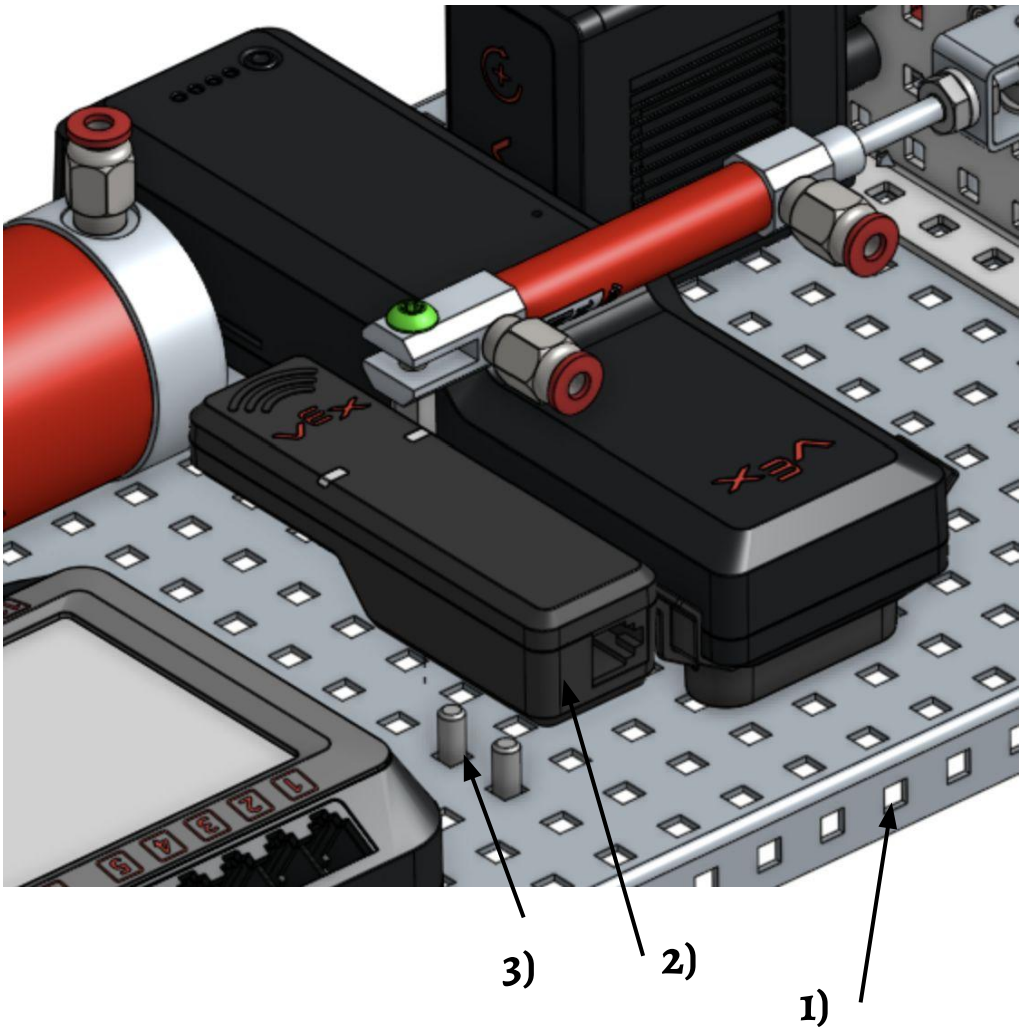
Assembly

Step 13: ***Install the radio***

Gather:

1) 1x: Platform
2) 1x: V5 Robot Radio
3) 2x: #8-32 x 3/8" Star Drive Screw

Put on the radio like so:



Transmission

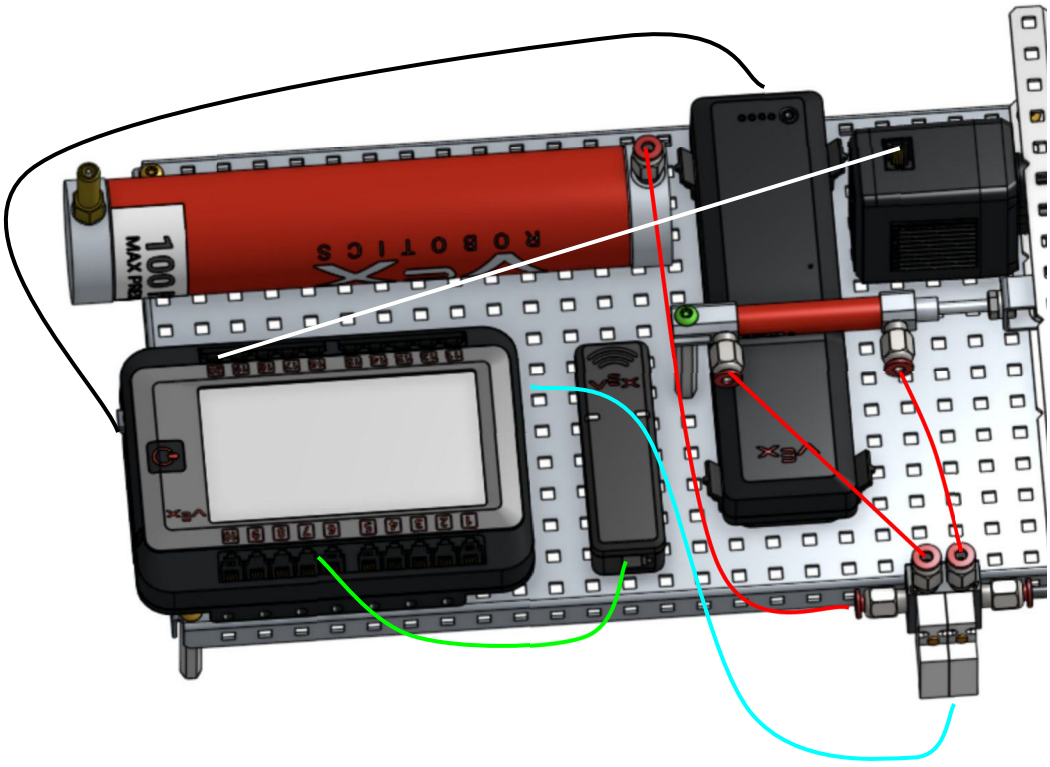
Assembly

Step 14: *Wire and tube everything (Solenoid in port H)*

Gather:

1) Pneumatic tubing, custom lengths (Red lines)
2) Motor wire, custom length (White/green lines)
3) 1x: 180 mm Power Cable (Black line)
4) 1x: Double Acting Solenoid
5) 2x: #8-32 x 3/8" Star Drive Screw
6) 1x: 4mm Fitting Plug
7) 1x: V5 Double Acting Solenoid Driver Cable (Blue line)

Wire and tube according to the lines. The solenoid can go on the side like so, and gets screwed in with the two ⅜” screws:

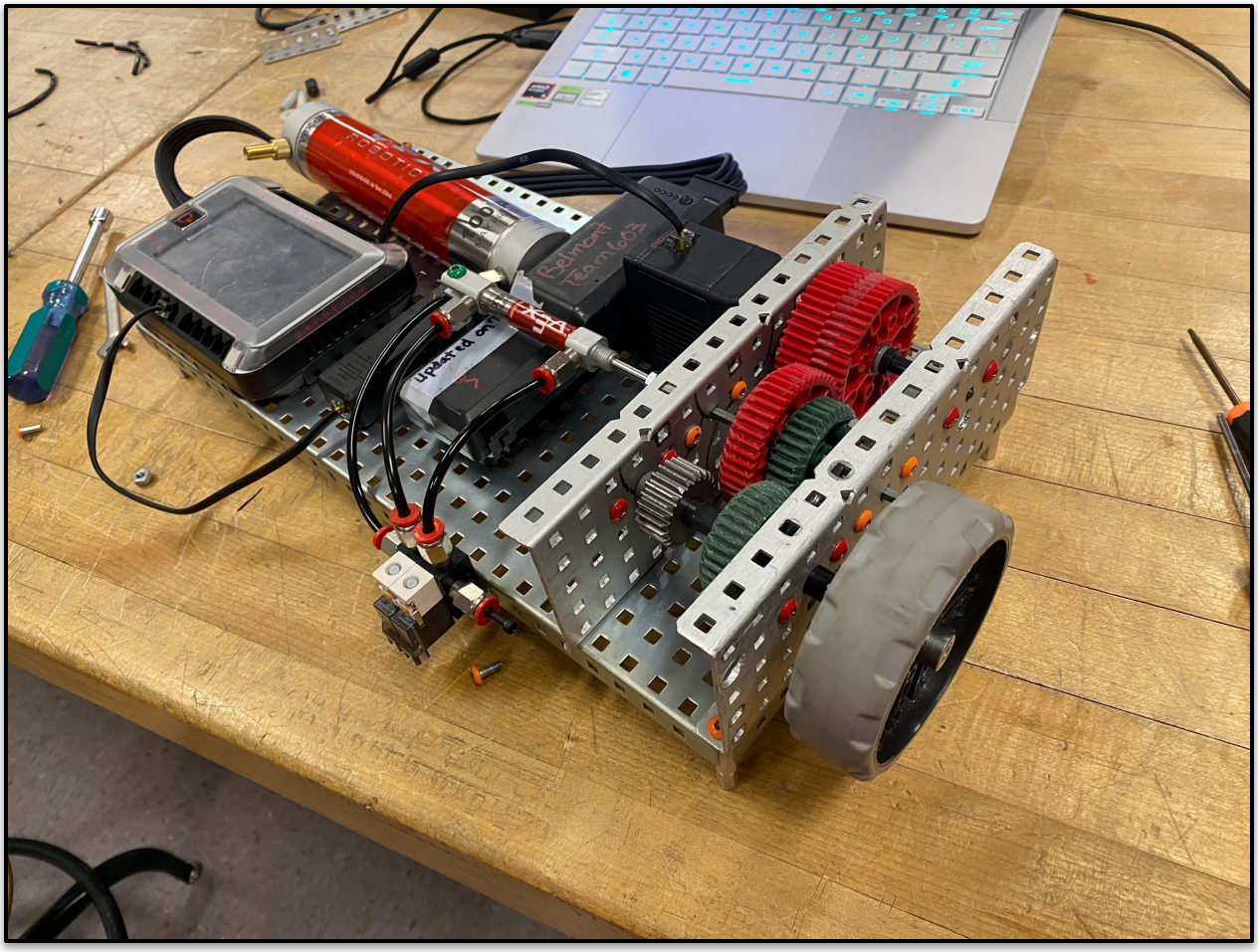


Note: The plug goes in the open fitting on the solenoid. This prevents the air from releasing out the side.

Transmission

Complete

This is what the transmission should look like once it is built:



It is now fully built, but it is not ready to use quite yet. Refer to page 73 for instructions on how to code it to work.

Transmission

How To Use

Download the code onto the brain, and link a controller to the radio. Ensure the pneumatic reservoir is filled completely. Because this is a transmission, there are only two ratios:

Strength:

Press button A on the controller to change to the strength ratio of 36:36 (1:1). This makes a ratio of (200/1 * 1/1) = *200 output RPM*.

Speed:

Default ratio, press button B on the controller to change to the speed ratio of 48:24 (2:1). This makes a ratio of (200/1 * 2/1) = *400 output RPM*.

Control:

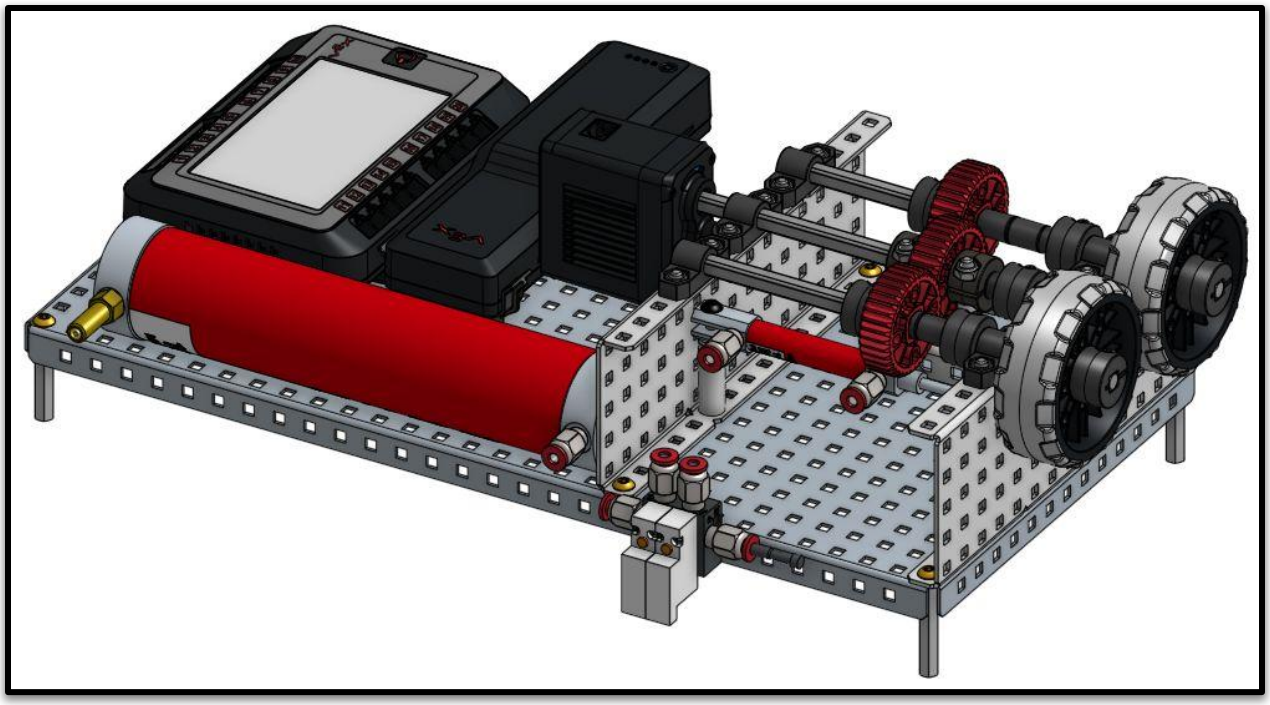
Moving the right joystick forward, the wheel will spin at the joystick position(percent) * the output ratio. For example, a 1:1 ratio and joystick all the way up will make the wheel spin at 200 RPM.

Specific tips:

- It may be helpful to screw together the motor gears, as this would reduce slop and make the transmission smoother.

- I am using a few of the old V1 gears (the green ones), and I am using 1/16" washers to accommodate for the spacing difference.

Power Take-Off



Description

A power take-off, or PTO for short, can be very helpful in a robot design. It allows motors to take off power from a mechanism. It is commonly used to divert power from one section to another, which can save on motor wattage. If two sections of your robot don't need to work at the same time, a PTO can be used to efficiently use your motors so you're not wasting them.

A PTO is probably the simplest type of transmission to build, as it doesn't need too many parts.

Power Take-Off

Parts List

Here are the parts you will need to build a PTO:

Structure:

- 1x: 15 x 30 Base Plate (276-1341)
- 1x: 1 x 1 x 5 Aluminum Angle (276-6484)
- 2x: 1 x 5 x 1 x 15 Aluminum C-Channel (276-2298)
- 4x: 1.5" Long #8-32 Standoff (276-2013)

Gears:

- 3x: 36T High Strength Gear (276-7747)

Spacers:

- 1x: 0.03125" L x 0.375" OD (1/32”) Spacer
- 1x: 0.0625" L x 0.375" OD (1/16”) Spacer
- 2x: 1/8" x 3/8" OD x #8 Nylon Spacer (276-6340)
- 2x: 0.75" L x 0.25" OD Spacer
- 1x: 1" L x 0.375" OD Spacer

Screws & Nuts:

- 2x: #8-32 x 1/4" Star Drive Screw (33-31)
- 24x: #8-32 x 3/8" Star Drive Screw (33-32)
- 10x: #8-32 x 1/2" Star Drive Screw (33-33)
- 2x: #8-32 x 5/8" Star Drive Screw (33-34)
- 2x: #8-32 x 1-1/2" Star Drive Screw (33-39)
- 1x: #8-32 x 2" Star Drive Screw (33-41)
- 2x: #8-32 Hex Nut (275-1028)
- 31x: #8-32 Thin Nylock Nut (32-02)

Power Take-Off

Parts List

Pneumatics & Electronics:

- 1x: 25mm Stroke Pneumatic Cylinder (276-8642)
- 7x: Straight Pneumatic Fitting (276-8636-001)
- 1x: Cylinder Mount (from the legacy pneumatics)
- 1x: Pneumatic Reservoir (276-8749)
- 1x: Double Acting Solenoid (276-8650-020)
- 1x: V5 Smart Motor (6:1) (276-4840)
- 1x: V5 Robot Brain (276-4810)
- 1x: V5 Robot Battery (276-4811)
- 1x: Valve stem
- 1x: V5 Robot Radio

High Strength:

- 3x: 1/8" High Strength Shaft Spacer (276-3441)
- 2x: 1/4" High Strength Shaft Spacer (276-3441)
- 3x: 1/2" High Strength Shaft Spacer (276-3441)
- 1x: 6.25" High Strength Shaft (276-7465)
- 2x: 7" High Strength Shaft (276-7465)
- 11x: High Strength Clamping Shaft Collar (276-6101)
- 6x: High Strength Pillow Block Bearing (276-8383)

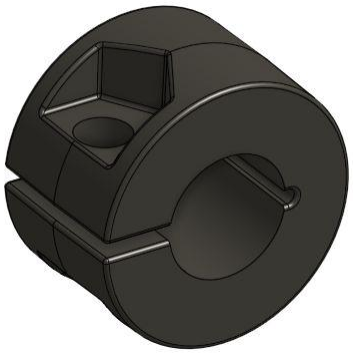
Miscellaneous:

- 2x: 2.75" Anti-Static Wheel (220mm Travel) (276-8098)
- 2x: V5 Battery Clip (276-6020)
- 1x: 4mm Fitting Plug (276-8757-001)
- Pneumatic tubing, custom lengths
- Motor wire, custom length
- 1x: 180 mm Power Cable
- 1x: V5 Double Acting Solenoid Driver Cable

Power Take-Off

Preparing Parts

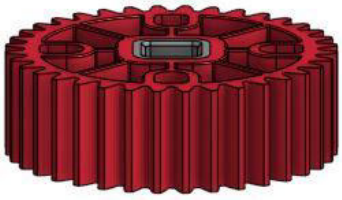
Some of the parts will need to be prepared first before building. Two shaft collars need to be drilled out with a ⅜ drill bit, and be sure to be safe when drilling. They should look like this:



Afterwards, put a ½" screw and nylock nut in the other 9 collars, tightening only a little bit.

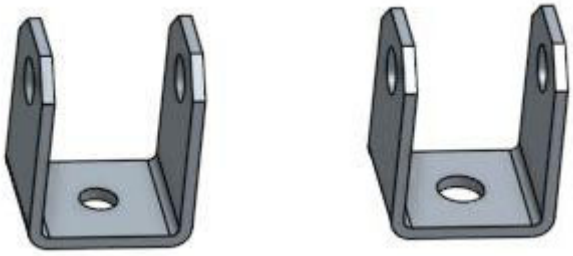
The 36 Tooth V2 gears need to be turned into transmission gears, refer to page 6 for a guide.

They should go from this:



To this:

The bottom hole on the normal cylinder mounts (Left) are not wide enough for the 25mm Stroke Pneumatic Cylinder Rods, which have the same dimensions as a screw's threading. The hole will need to be drilled out carefully with an 11/64 drill bit (Right).



Power Take-Off

Assembly

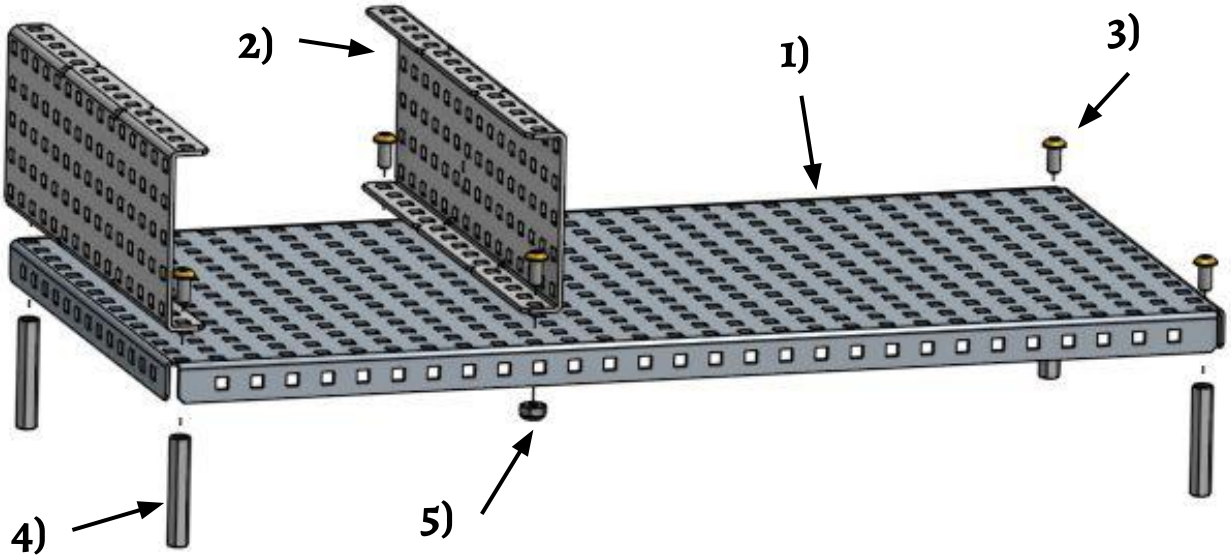
Now it is time to start assembling the PTO.

Step 1: ***Build the platform***

Gather:

1) 1x: 15 x 30 Base Plate
2) 2x: 1 x 5 x 1 x 15 Aluminum C-Channels
3) 6x: #8-32 x 3/8" Star Drive Screws
4) 4x: 1.5" Long #8-32 Standoff
5) 2x: #8-32 Thin Nylock Nut

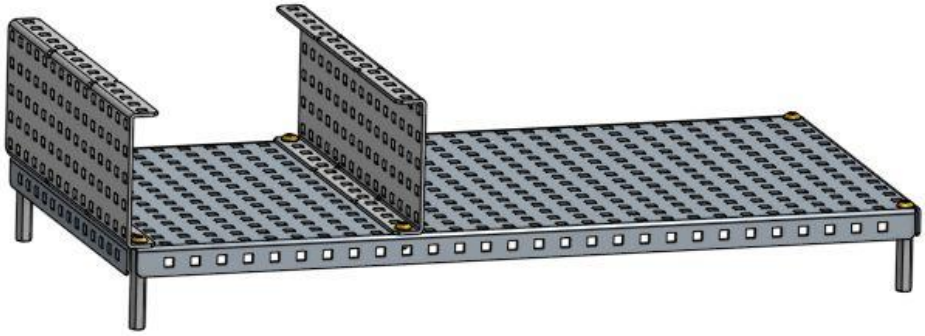
Assemble as shown:



Power Take-Off

Assembly

It should look like this:

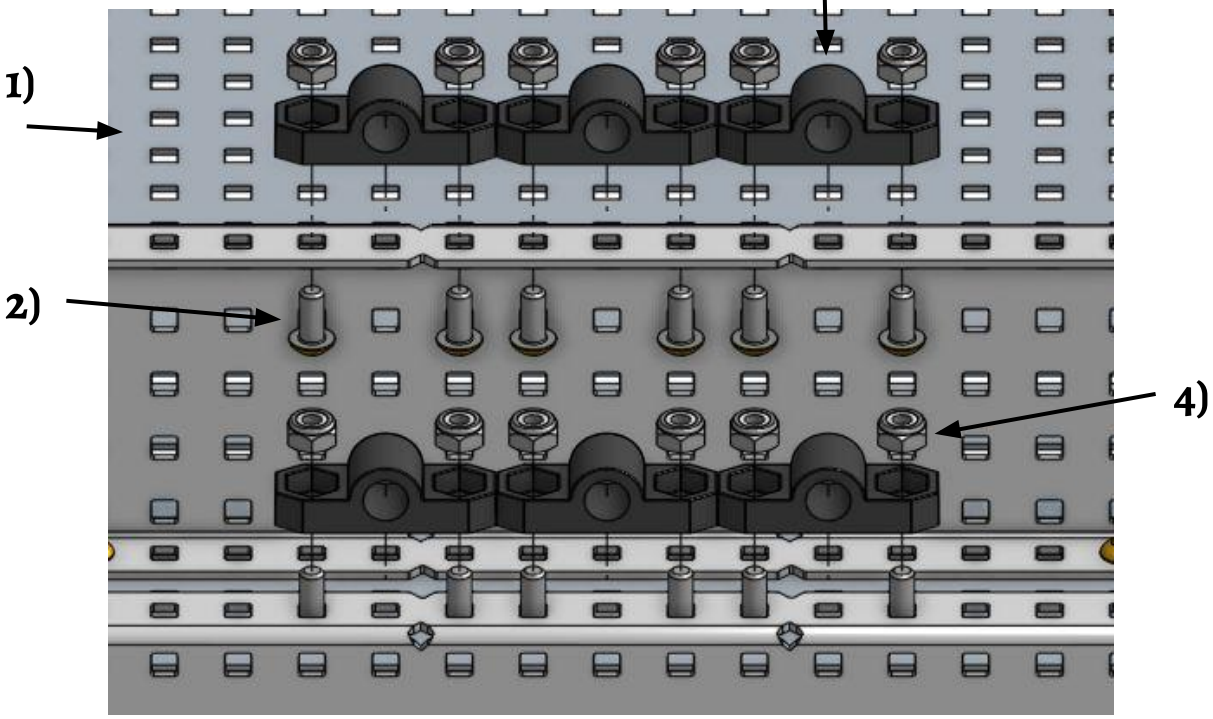


Step 2: ***Install the bearings***

Gather:

1) 1x: Platform
2) 12x: #8-32 x 3/8" Star Drive Screws
3) 6x: High Strength Pillow Block Bearing
4) 12x: #8-32 Thin Nylock Nut

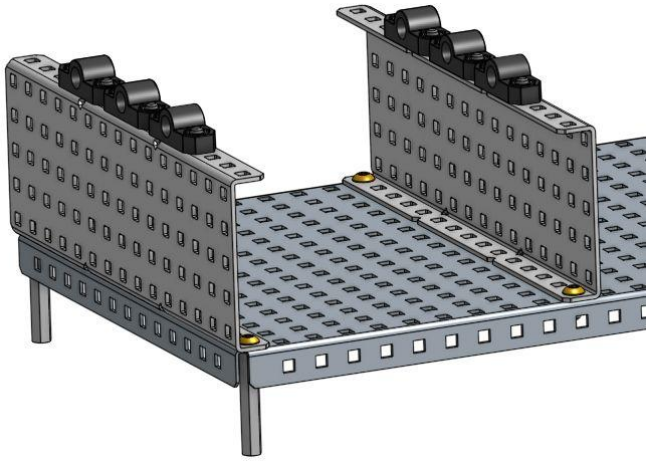
Screw the bearings onto the c-channels like shown:



Power Take-Off

Assembly

It should look like this:

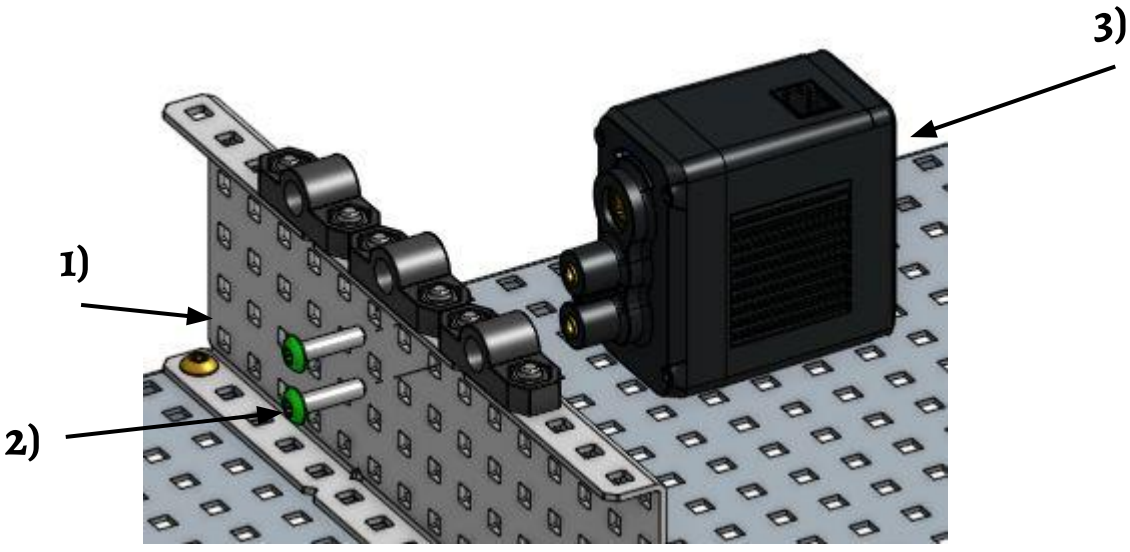


Step 3: ***Install electronics: Motor***

Gather:

1) 1x: Platform
2) 2x: #8-32 x 5/8" Star Drive Screws
3) 1x: V5 Smart Motor (6:1)

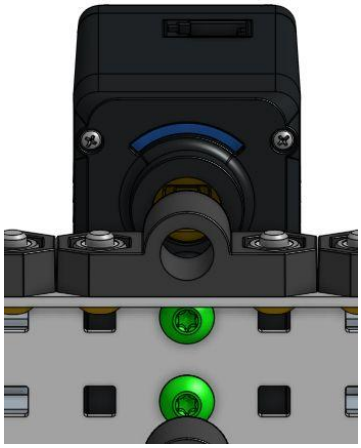
Install the motor under the middle bearing like this:



Power Take-Off

Assembly

With the motor on, it should look like this:



Step 4: ***Install electronics: Brain***

Gather:

1) 1x: Platform
2) 2x: #8-32 x 1/4" Star Drive Screws
3) 1x: V5 Robot Brain

Install the brain in the back like this:

Power Take-Off

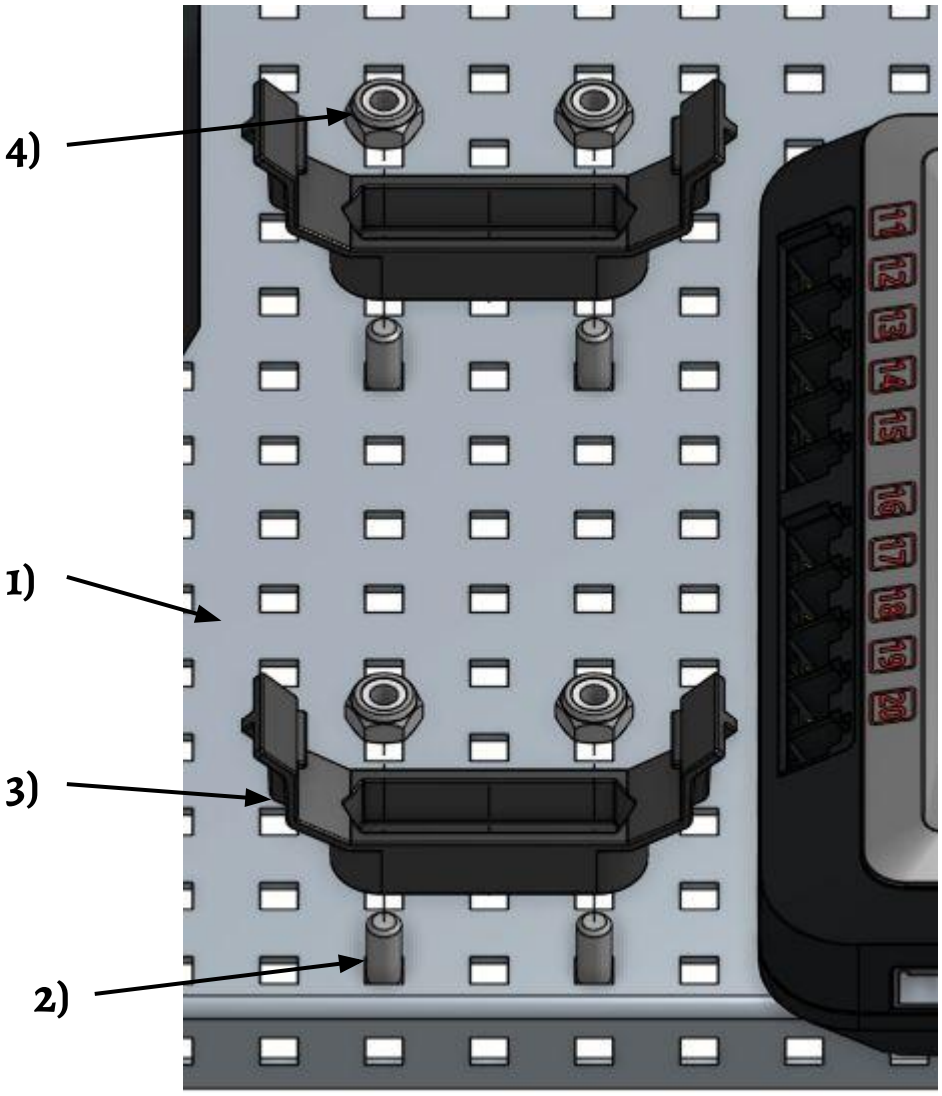
Assembly

Step 5: *Install electronics: Battery*

Gather:

1) 1x: Platform
2) 4x: #8-32 x 3/8" Star Drive Screws
3) 2x: V5 Battery Clip
4) 4x: #8-32 Thin Nylock Nut

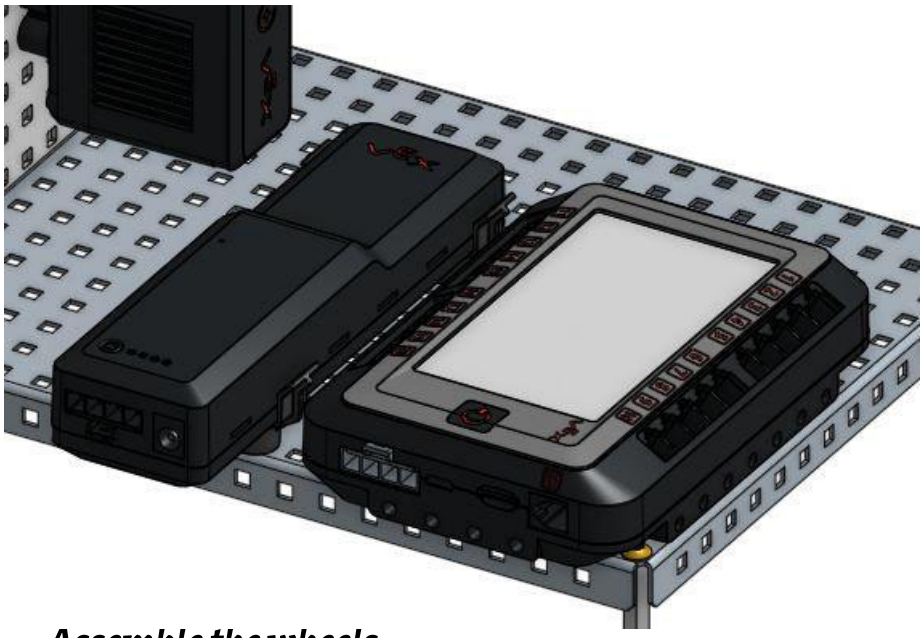
Install the battery clips next to the brain like this:



Power Take-Off

Assembly

Then put the V5 Robot Battery on like this:

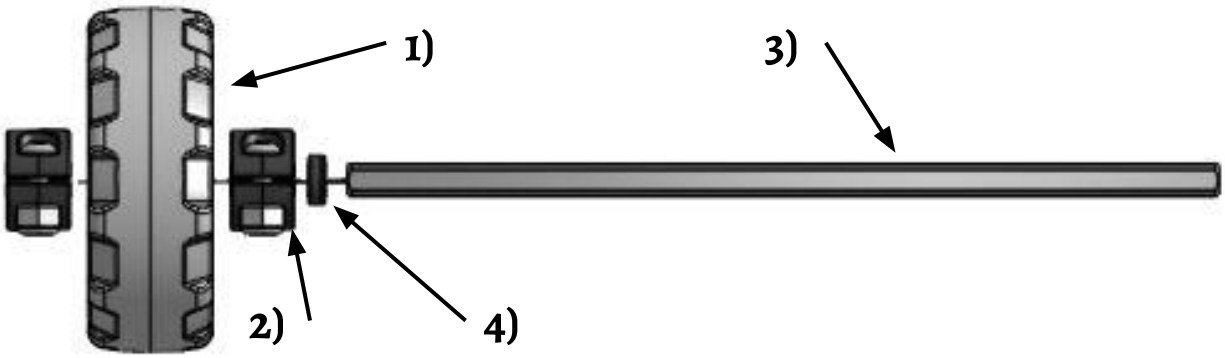


Step 6: ***Assemble the wheels***

Gather:

1) 2x: 2.75" Anti-Static Wheel (220mm Travel)
2) 4x: Prepared High Strength Clamping Shaft Collar
3) 2x: 7" High Strength Shaft
4) 2x: 1/8" High Strength Shaft Spacer

Slide the 7" High Strength Shaft through the parts in this order, and make two of these:



Power Take-Off

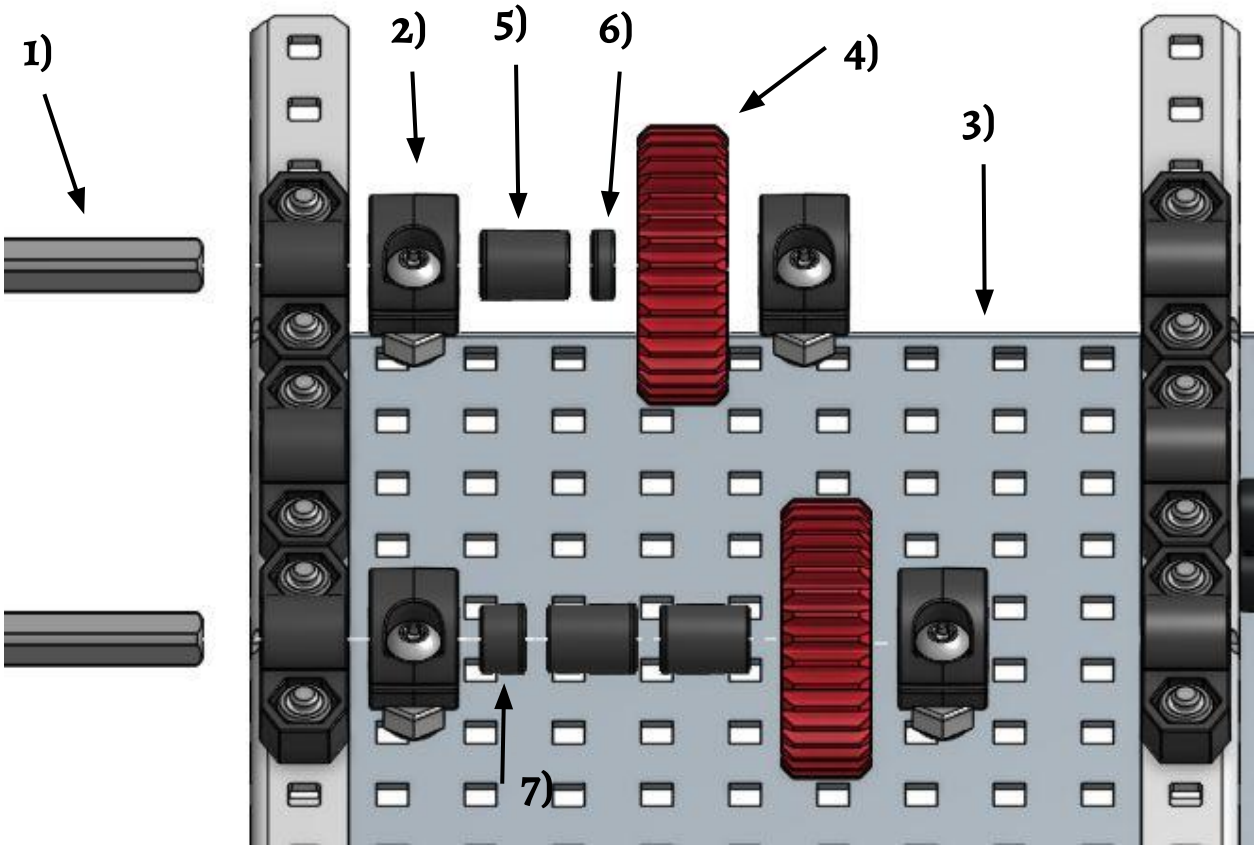
Assembly

Step 7: *Install the wheels*

Gather:

1) 2x: The two wheel assemblies
2) 4x: Prepared High Strength Clamping Shaft Collar
3) 1x: Platform
4) 2x: Transmission 36T High Strength Gear
5) 3x: 1/2" High Strength Shaft Spacer
6) 1x: 1/8" High Strength Shaft Spacer
7) 1x: 1/4" High Strength Shaft Spacer

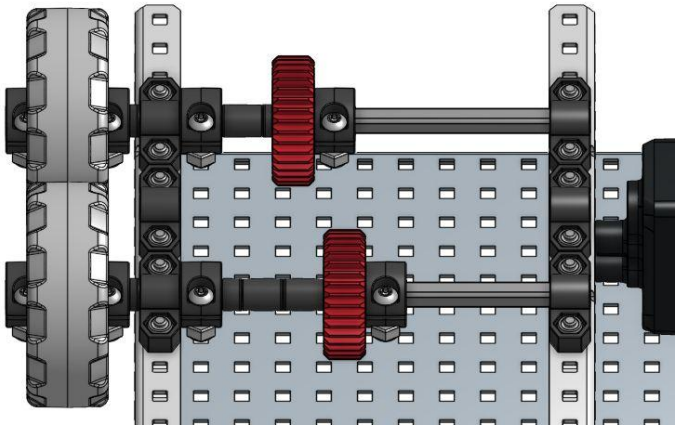
Take the wheel assemblies you just made and slide the through the bearings and parts as shown:



Power Take-Off

Assembly

With the wheels on now, it should look like this:

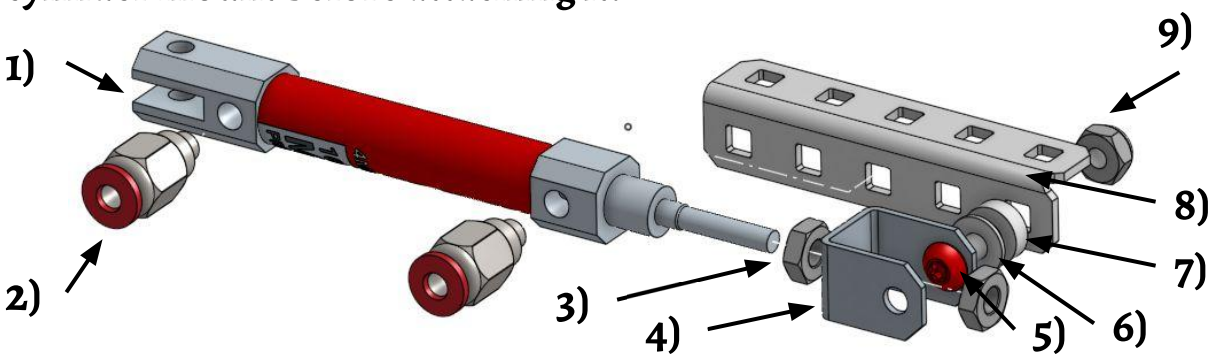


Step 8: ***Assemble the shifter***

Gather:

1) 1x: 25mm Stroke Pneumatic Cylinder
2) 2x: Straight Pneumatic Fitting
3) 2x: #8-32 Hex Nut
4) 1x: Prepared Cylinder Mount
5) 1x: #8-32 x 1/2" Star Drive Screw
6) 1x: 0.03125" L x 0.375" OD (1/32") Spacer
7) 1x: 1/8" x 3/8" OD x #8 Nylon Spacer
8) 1x: 1 x 1 x 5 Aluminum Angle
9) 1x: #8-32 Thin Nylock Nut

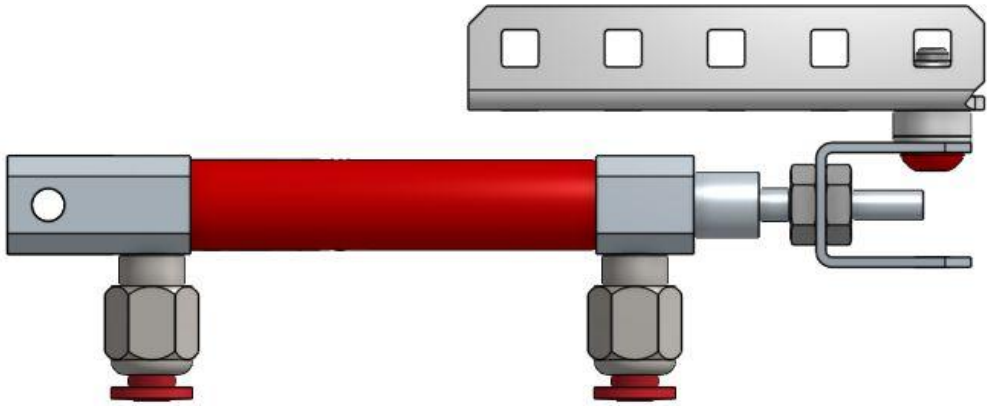
Assemble the parts as shown, putting the ½" screw through the cylinder mount before attaching it:



Power Take-Off

Assembly

The shifter should look like this:

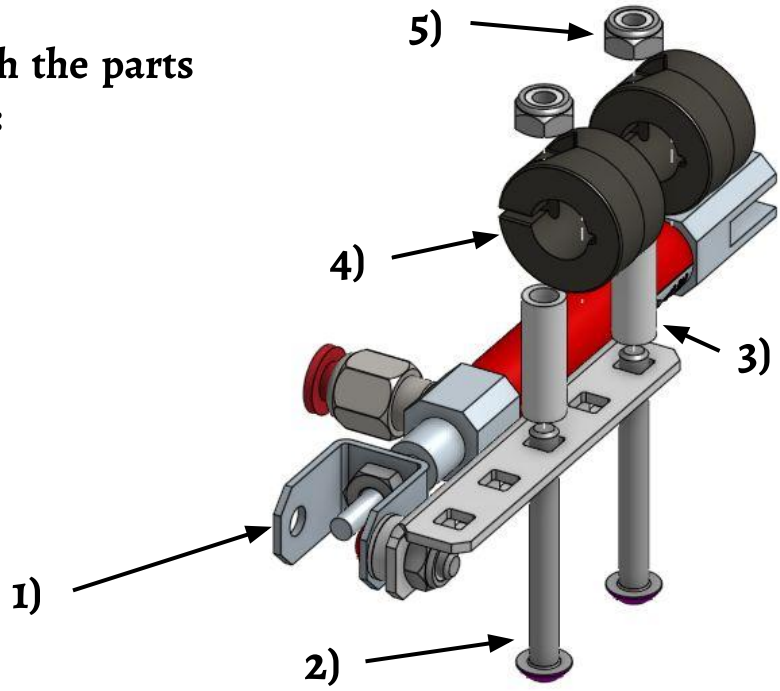


Step 9: ***Attach collars to shifter***

Gather:

1) 1x: Shifter
2) 2x: #8-32 x 1-1/2" Star Drive Screw
3) 2x: 0.75" L x 0.25" OD Spacer
4) 2x: Drilled High Strength Clamping Shaft Collar
5) 2x: #8-32 Thin Nylock Nut

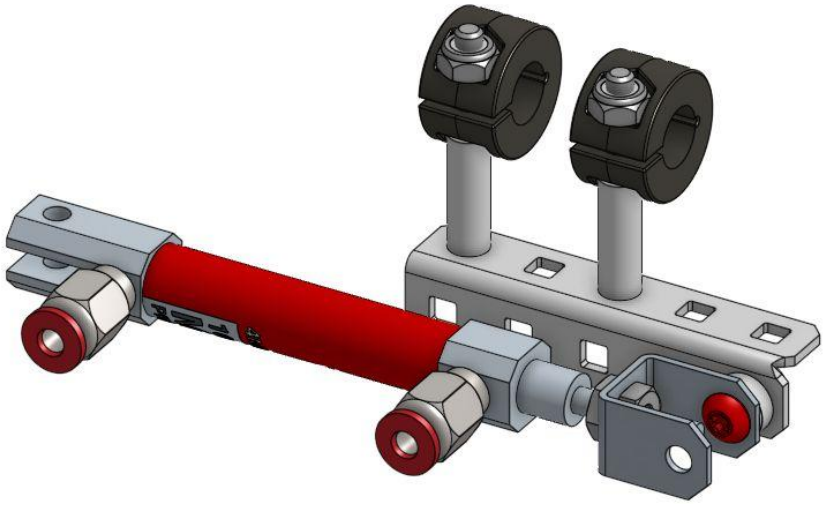
Slide the screws through the parts like so and tighten them:



Power Take-Off

Assembly

The shifter should now look like this:

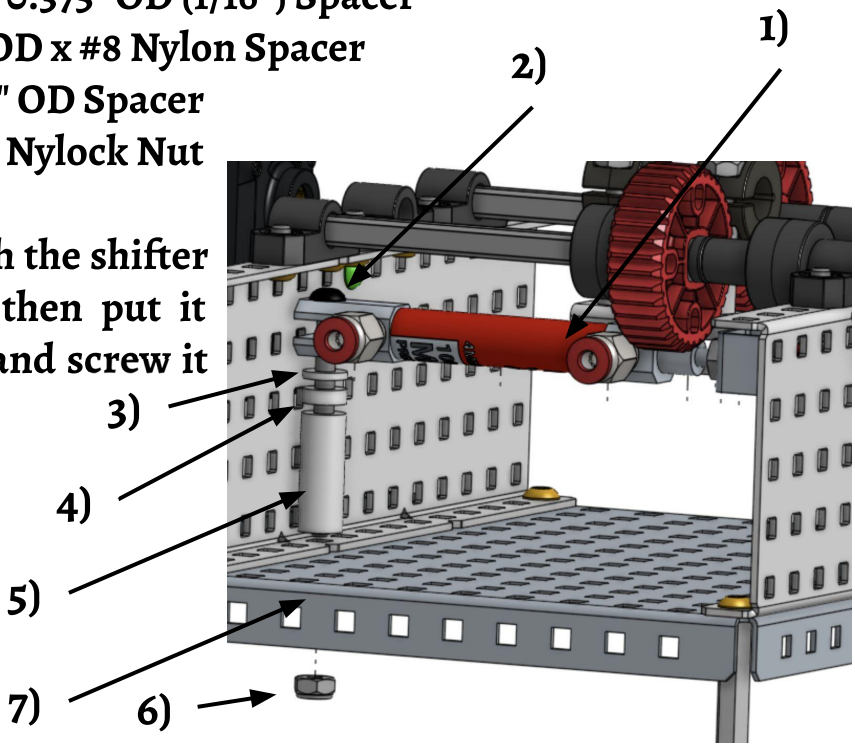


Step 10: *Install the shifter*

Gather:

1) 1x: Shifter
2) 1x: #8-32 x 2" Star Drive Screw
3) 1x: 0.0625" L x 0.375" OD (1/16") Spacer
4) 1x: 1/8" x 3/8" OD x #8 Nylon Spacer
5) 1x: 1" L x 0.375" OD Spacer
6) 1x: #8-32 Thin Nylock Nut
7) 1x: Platform

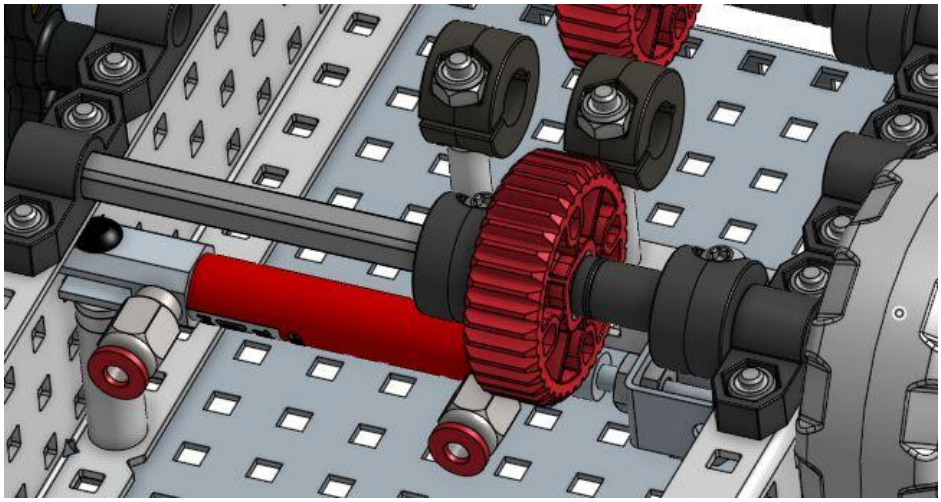
Put the screw through the shifter pneumatic cylinder, then put it through the spacers and screw it into the platform:



Power Take-Off

Assembly

With the shifter installed, it should look like this:

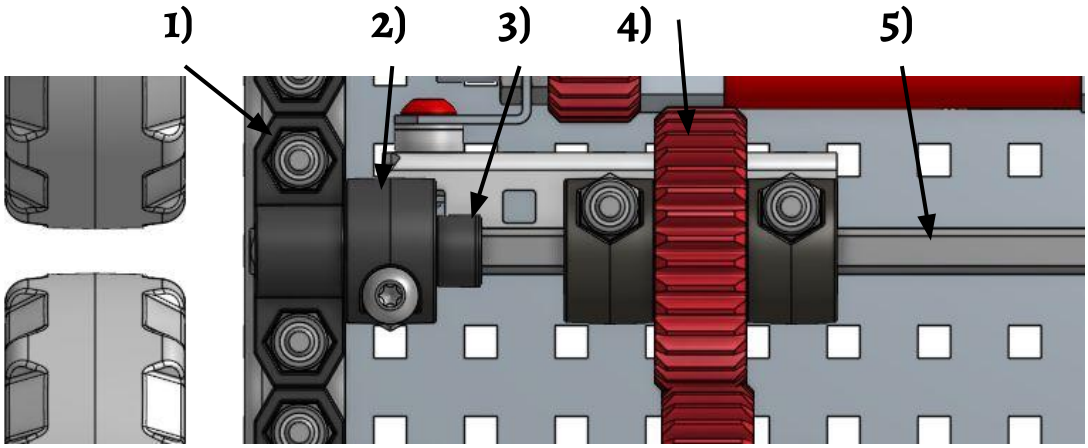


Step 11: ***Finish the shifter***

Gather:

1) 1x: Platform
2) 1x: Prepared High Strength Clamping Shaft Collar
3) 1x: 1/4" High Strength Shaft Spacer
4) 1x: Transmission 36T High Strength Gear
5) 1x: 6.25" High Strength Shaft

To finish the shifter, slide the 6.25" High Strength Shaft through the bearing and parts into the motor. It will be a tight fit between the wheels, so I recommend going in at a slight angle:



Power Take-Off

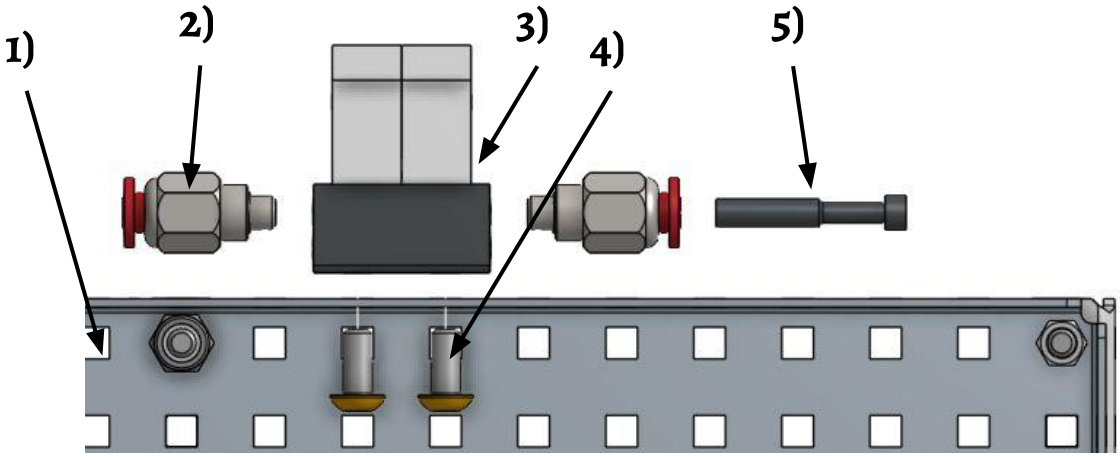
Assembly

Step 12: ***Install the solenoid***

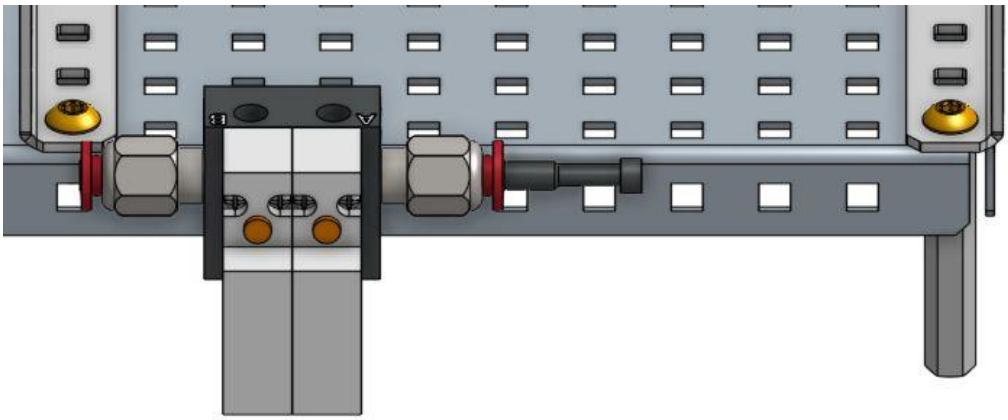
Gather:

1) 1x: Platform
2) 2x: Straight Pneumatic Fitting
3) 1x: Double Acting Solenoid
4) 2x: #8-32 x 3/8" Star Drive Screw
5) 1x: 4mm Fitting Plug

Install the solenoid as shown:



It should look like this:



Power Take-Off

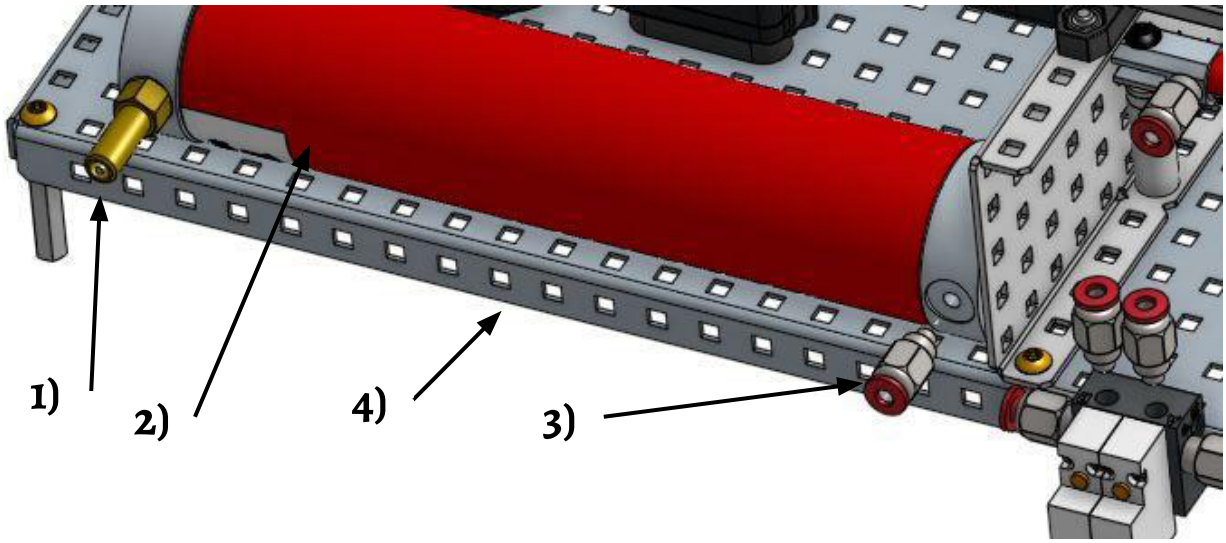
Assembly

Step 13: ***Finish installing the pneumatics***

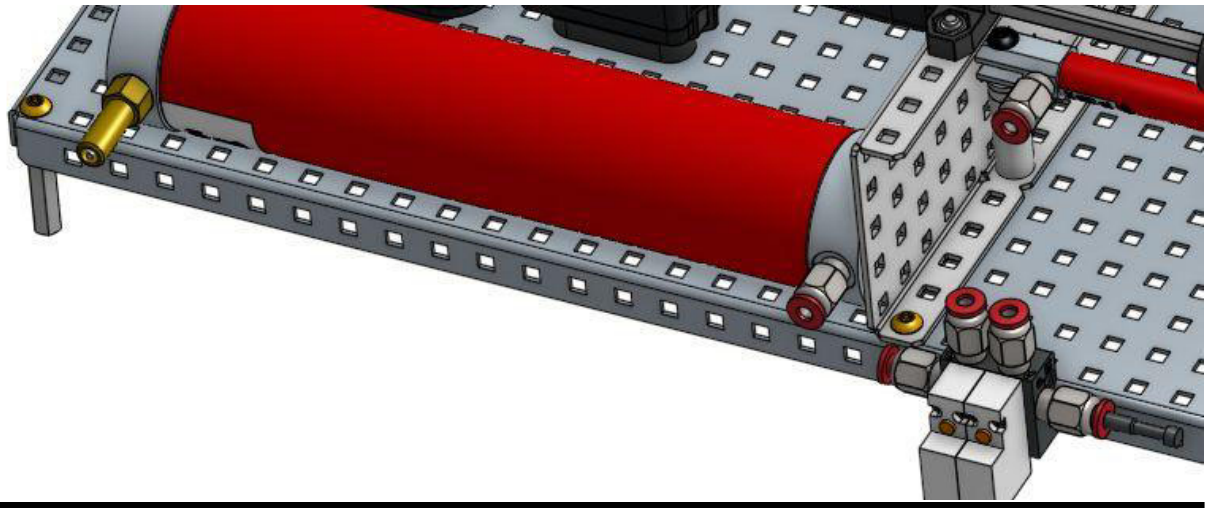
Gather:

1) 1x: Valve Stem
2) 1x: Pneumatic Reservoir
3) 3x: Straight Pneumatic Fitting
4) 1x: Platform

Install the rest as shown:



It should look like this:



Power Take-Off

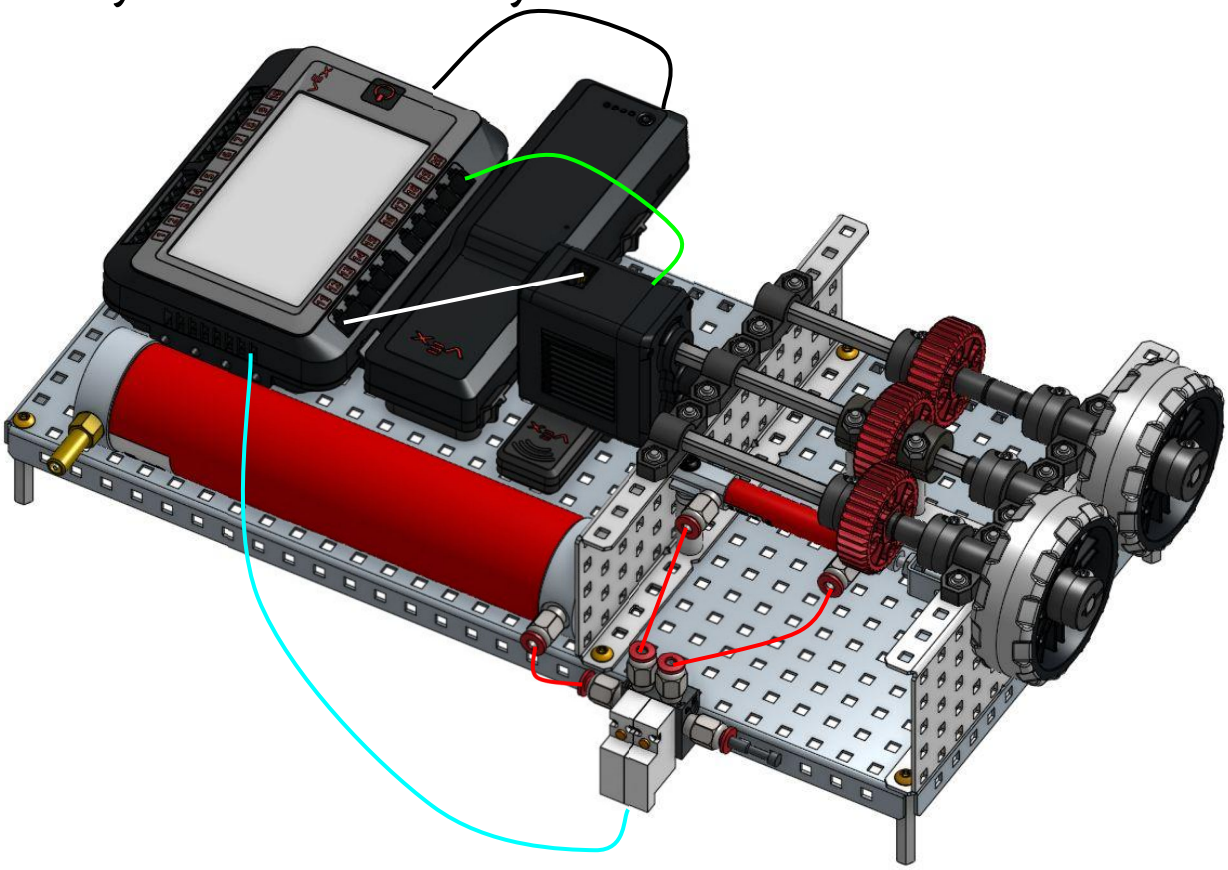
Assembly

Step 14: ***Wire and tube everything, and add radio***

Gather:

1) **Pneumatic tubing, custom lengths (Red lines)**
2) **Motor wire, custom length (White/green lines)**
3) **1x: 180 mm Power Cable (Black line)**
4) **1x: V5 Robot Radio**
5) **1x: V5 Double Acting Solenoid Driver Cable (Blue line)**

Wire and tube according to the lines. The radio can rest next to the battery and does not need any screws:

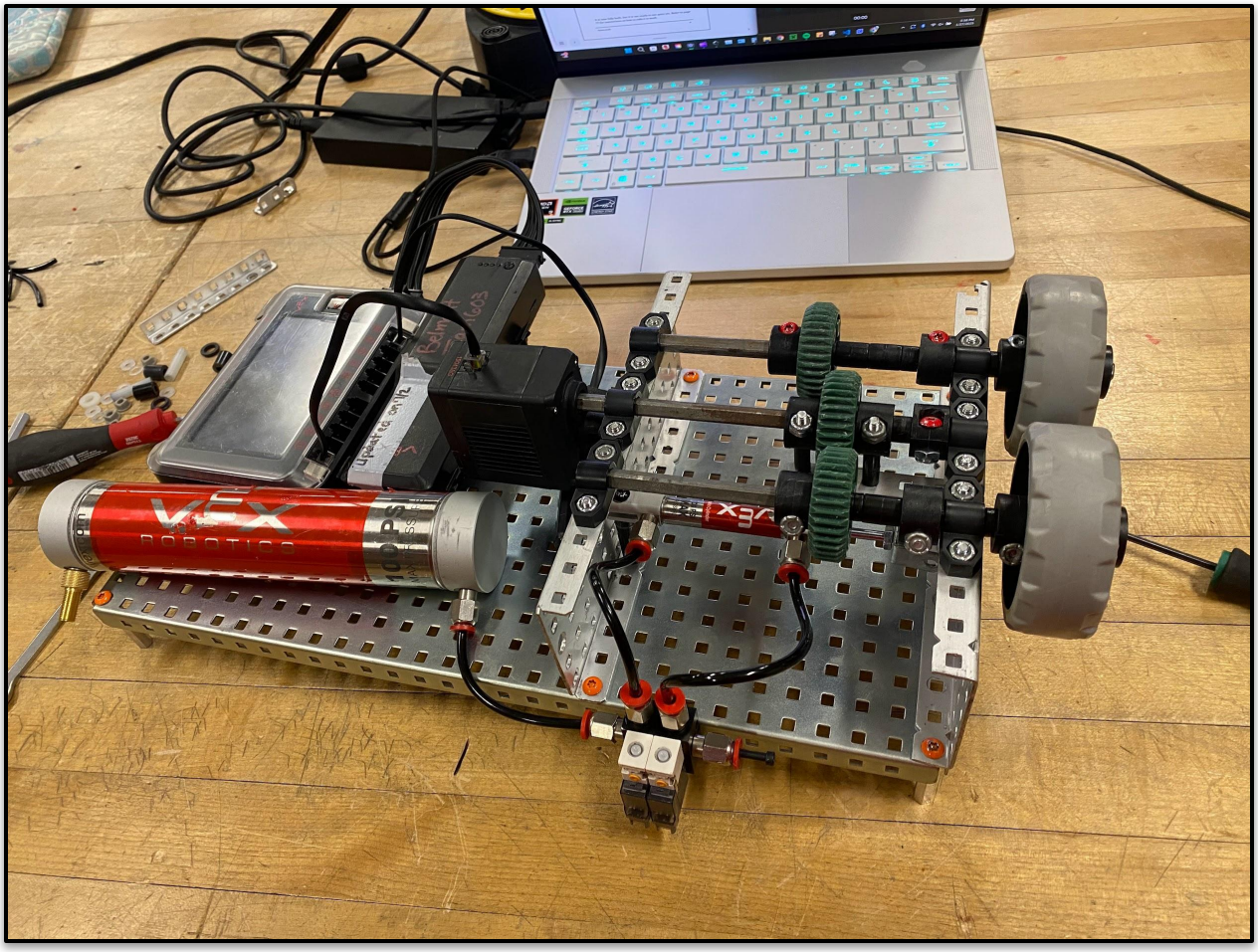


Note: The green line represents the wire for the radio, which is partly hidden underneath the motor.

Power Take-Off

Complete

This is what the PTO should look like once it is built:



It is now fully built, but it is not ready to use quite yet. Refer to page 73 for instructions on how to code it to work.

Power Take-Off

How To Use

Download the code onto the brain, and link a controller to the radio. Ensure the pneumatic reservoir is filled completely. This is a PTO, so there are only two states:

Left:

Due to the tubing, the default state is the left wheel. You can press button X to return to this state.

Right:

Press button B on the controller to change to the right wheel state. This disables the left wheel by taking power off of it, and transfers the power to the right wheel.

Control:

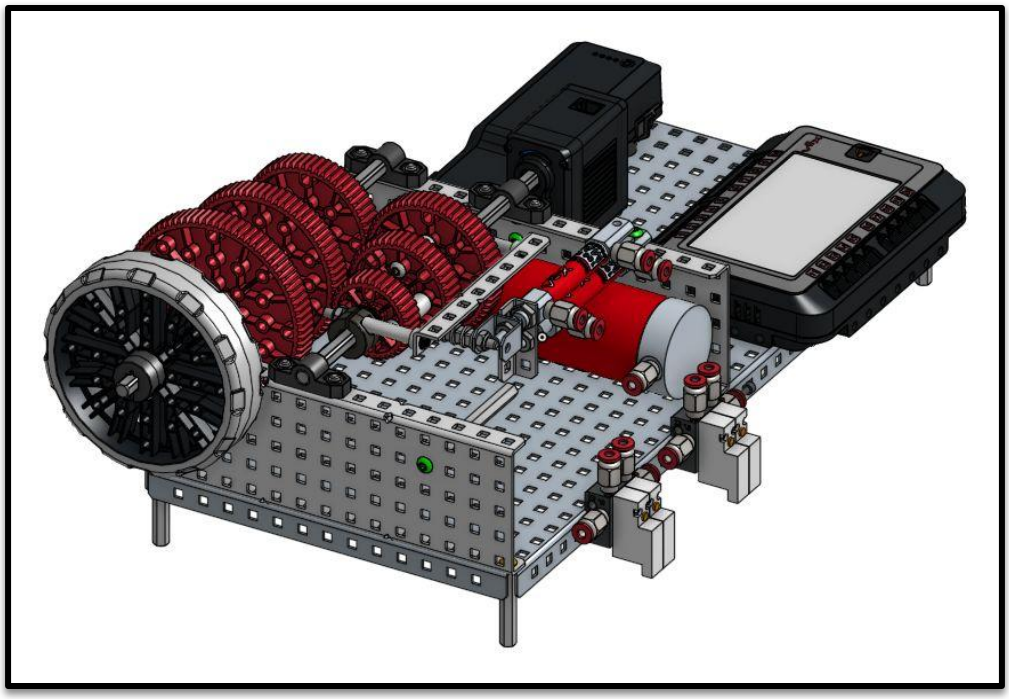
Moving the right joystick forward, the wheel will spin right. You can also press button R1 to make the motor spin at a constant rate of 100%. Press button R2 to stop the wheel. While the wheel is spinning, try changing the transmission state. If the gears are filed down correctly, it should shift smoothly.

Specific tips:

- Because the motor axle spins through the drilled collars, ensure that they are drilled out enough so there's less friction.

- I am using the old V1 gears (the green ones), and I am using 1/16" high strength spacers on both sides to accommodate for the spacing difference.

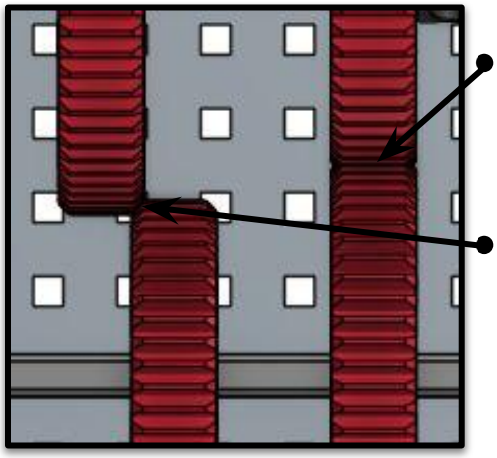
Triple Transmission



Description

A triple transmission uses two pneumatic pistons/air cylinders to shift three gears across an axle to form different gear ratios. All the gears need to be spaced out exactly to avoid any catching.

Catching is where two gears unintentionally contact each other while their axles are rotating. Here's an example:



These two gears are aligned correctly, and spin with a 1:1 ratio.

These gears are catching, and normally spin at a 2:3 ratio.

Because these ratios don't match, the gears that are catching will clip each other and will get damaged.

Triple Transmission

Parts List

Here are the parts you will need to build a triple transmission:

Structure:

- 1x: 15 x 30 Base Plate (276-1341)
- 1x: 1 x 1 x 8 Aluminum Angle (276-6484)
- 1x: 1 x 1 x 3 Aluminum Angle (276-6484)
- 2x: 1 x 5 x 1 x 15 Aluminum C-Channel (276-2298)
- 1x: 2.5" Long #8-32 Standoff (276-2013)
- 4x: 1.5" Long #8-32 Standoff (276-2013)

Gears:

- 1x: 36T High Strength Gear (276-7747)
- 1x: 48T High Strength Gear V2 (276-7573)
- 2x: 60T High Strength Gear V2 (276-7748)
- 1x: 72T High Strength Gear V2 (276-7573)
- 1x: 84T High Strength Gear V2 (276-7749)

Spacers:

- 1x: 0.015625" L x 0.375" OD (1/64") Washer
- 4x: 0.03125" L x 0.375" OD (1/32”) Spacer
- 3x: 0.0625" L x 0.375" OD (1/16”) Spacer
- 2x: 0.125" L x 0.375" OD Spacer
- 1x: 3/8" x 1/2" OD x #8 Nylon Spacer (275-1066)
- 4x: 1/2" x 3/8" OD x #8 Nylon Spacer (276-6340)
- 2x: 1" L x 0.25" OD Spacer

Triple Transmission

Parts List

Screws & Nuts:

- 2x: #8-32 x 1/4" Star Drive Screw (33-31)
- 22x: #8-32 x 3/8" Star Drive Screw (33-32)
- 3x: #8-32 x 1/2" Star Drive Screw (33-33)
- 4x: #8-32 x 5/8" Star Drive Screw (33-34)
- 1x: #8-32 x 1-1/4" Star Drive Screw (33-38)
- 4x: #8-32 x 1-3/4" Star Drive Screw (33-40)
- 2x: #8-32 x 2" Star Drive Screw (33-41)
- 4x: #8-32 Hex Nut (275-1028)
- 25x: #8-32 Thin Nylock Nut (32-02)

Pneumatics & Electronics:

- 2x: 25mm Stroke Pneumatic Cylinder (276-8642)
- 13x: Straight Pneumatic Fitting (276-8636-001)
- 1x: Cylinder Mount (from the legacy pneumatics)
- 1x: Pneumatic Reservoir (276-8749)
- 2x: Double Acting Solenoid (276-8650-020)
- 1x: V5 Smart Motor (6:1) (276-4840)
- 1x: V5 Robot Brain (276-4810)
- 1x: V5 Robot Battery (276-4811)
- 1x: Valve stem
- 1x: V5 Robot Radio

Triple Transmission

Parts List

High Strength:

- 3x: 1/16" High Strength Shaft Spacer (276-3441)
- 2x: 1/8" High Strength Shaft Spacer (276-3441)
- 3x: 1/2" High Strength Shaft Spacer (276-3441)
- 1x: 8.22" High Strength Shaft (276-7465)
- 1x: 9.5" High Strength Shaft (276-7465)
- 5x: High Strength Clamping Shaft Collar (276-6101)
- 3x: High Strength Shaft Bushing, 1/8" Thick (276-7582)
- 4x: High Strength Shaft Bushing, 5/16" Thick (276-7582)
- 4x: High Strength Pillow Block Bearing (276-8383)
- 4x: High Strength Free Spinning Gear Insert (276-3881)

Miscellaneous:

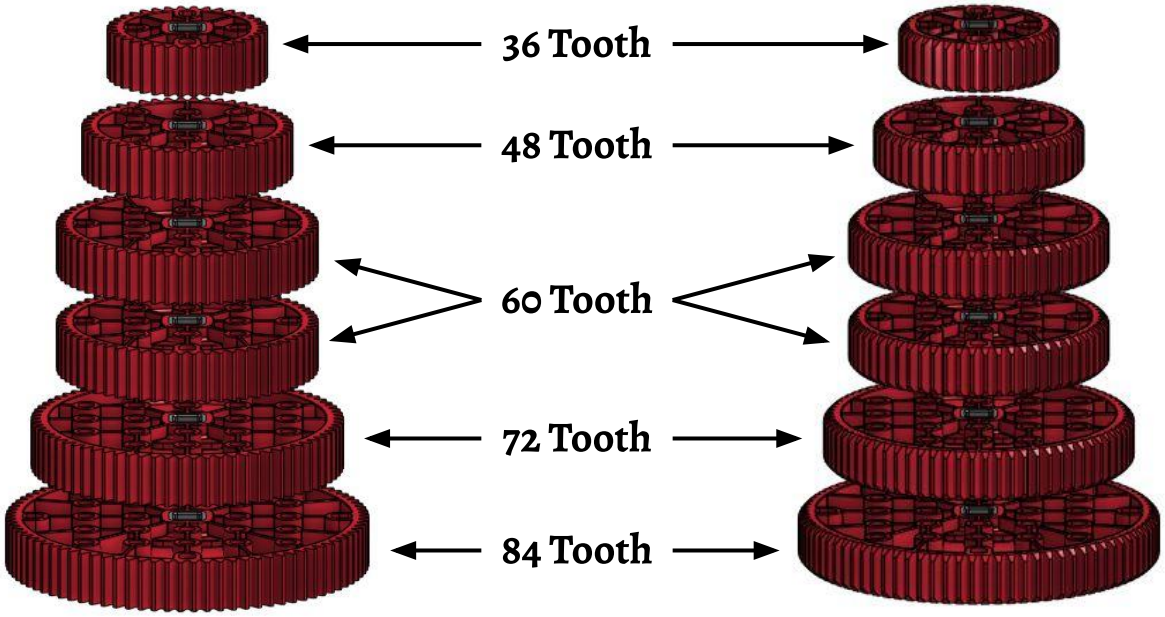
- 1x: 4" Anti-Static Wheel (320mm Travel) (276-8103)
- 2x: V5 Battery Clip (276-6020)
- 1x: 4mm Fitting Plug (276-8757-001)
- Pneumatic tubing, custom lengths
- Motor wire, custom length
- 1x: 180 mm Power Cable
- 2x: V5 Double Acting Solenoid Driver Cable

Triple Transmission

Preparing Parts

Some of the parts will need to be prepared first before building. Two shaft collars need to be drilled out with a ⅜ drill bit, and be sure to be safe when drilling. Put a ½" screw and nylock nut in the other 3 collars, tightening only a little bit. The 6 V2 gears need to be turned into transmission gears, refer to page 6 for a guide.

They should go from this: To this:

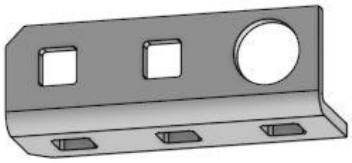


The bottom hole on the normal cylinder mounts (A1) are not wide enough for the 25mm Stroke Pneumatic Cylinder Rods, which have the same dimensions as a screw's threading. The hole will need to be drilled out carefully with an 11/64 drill bit (A2).

A1

A2

The 1 x 1 x 3 Aluminum Angle needs a 21/64" hole drilled out like this:



Triple Transmission

Assembly

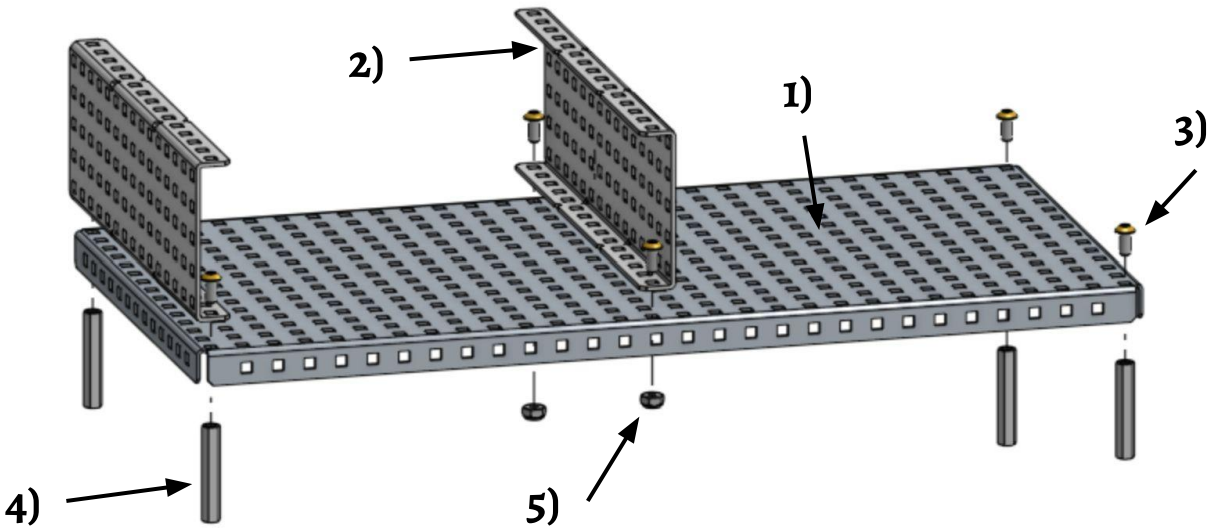
Now it is time to start assembling the triple transmission.

Step 1: ***Build the platform***

Gather:

1) 1x: 15 x 30 Base Plate
2) 2x: 1 x 5 x 1 x 15 Aluminum C-Channels
3) 6x: #8-32 x 3/8" Star Drive Screws
4) 4x: 1.5" Long #8-32 Standoff
5) 2x: #8-32 Thin Nylock Nut

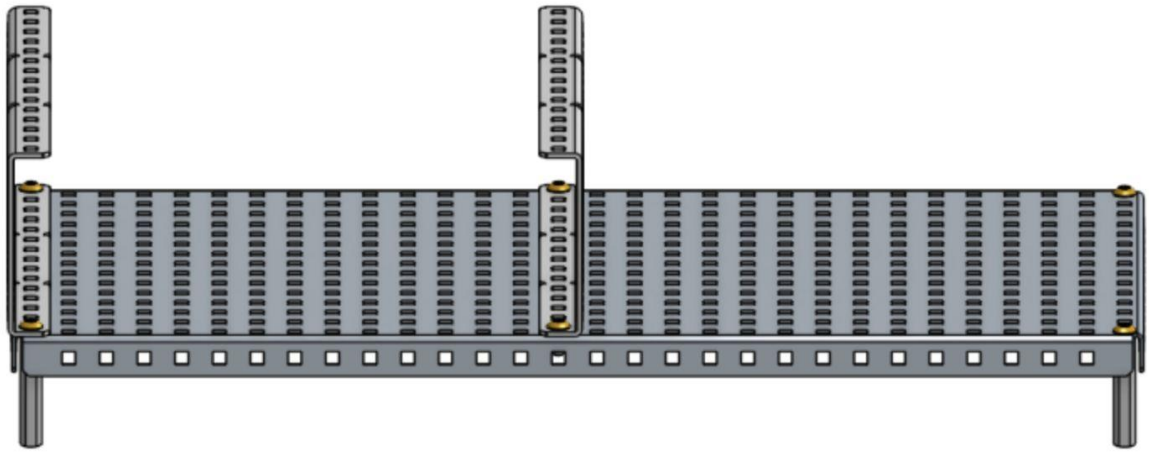
Assemble as shown, with the right c-channel 15 squares to the right:



Triple Transmission

Assembly

It should look like this:

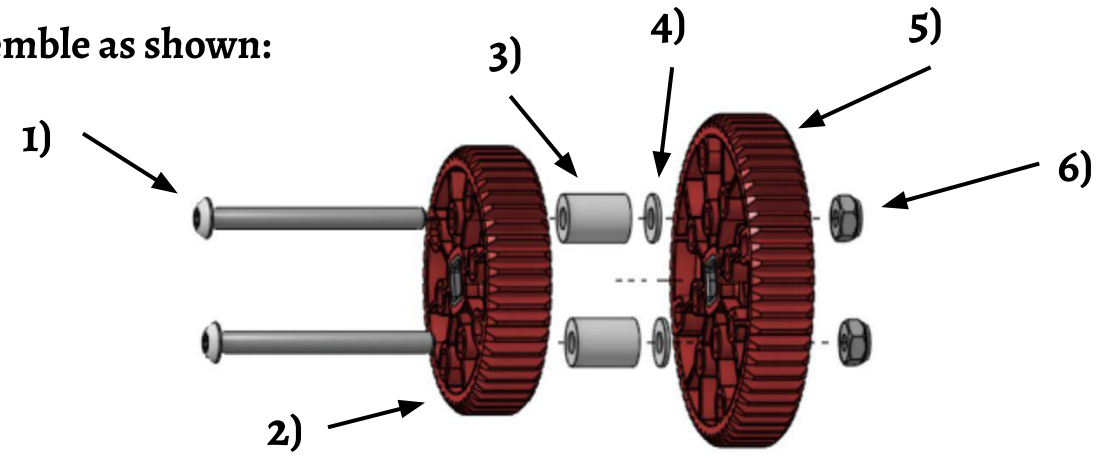


Step 2: ***Build shifting piece: Bottom***

Gather:

1) 2x: #8-32 x 1-3/4" Star Drive Screw
2) 1x: Transmission 48T High Strength Gear
3) 2x: 1/2" x 3/8" OD x #8 Nylon Spacer
4) 2x: 0.03125" L x 0.375" OD (1/32") Spacer
5) 1x: Transmission 60T High Strength Gear
6) 2x: #8-32 Thin Nylock Nut

Assemble as shown:



Triple Transmission

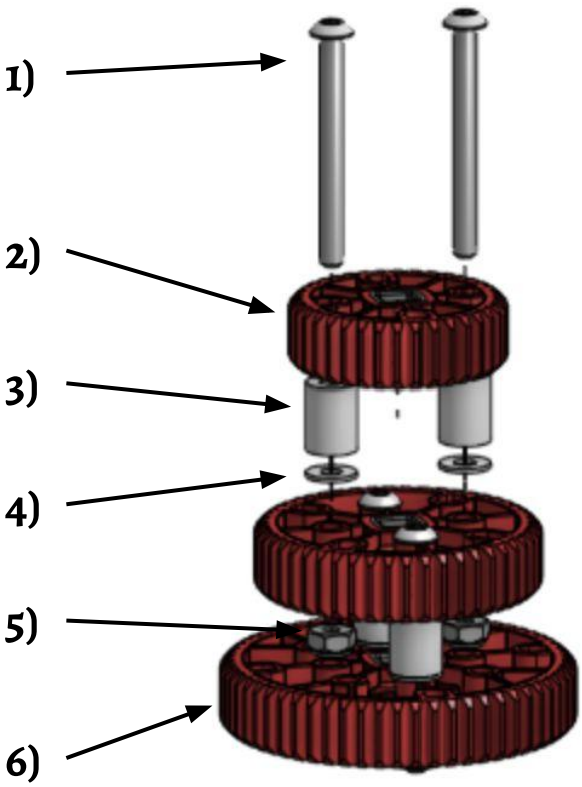
Assembly

Step 3: ***Build shifting piece: Top***

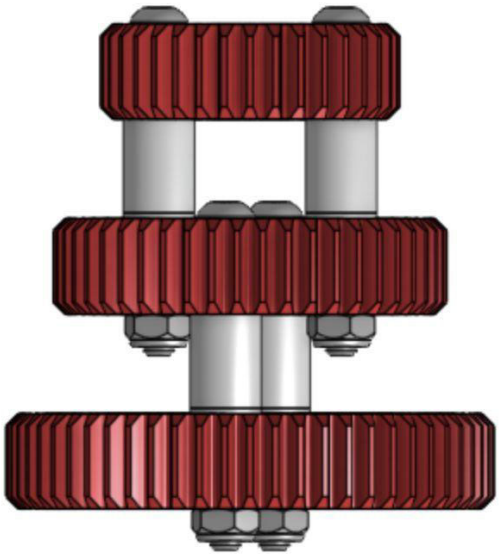
Gather:

1) 2x: #8-32 x 1-3/4" Star Drive Screw
2) 1x: Transmission 36T High Strength Gear
3) 2x: 1/2" x 3/8" OD x #8 Nylon Spacer
4) 2x: 0.03125" L x 0.375" OD (1/32") Spacer
5) 2x: #8-32 Thin Nylock Nut
6) 1x: Shifting piece: Bottom

Attach onto the bottom:



It should look like this:



Triple Transmission

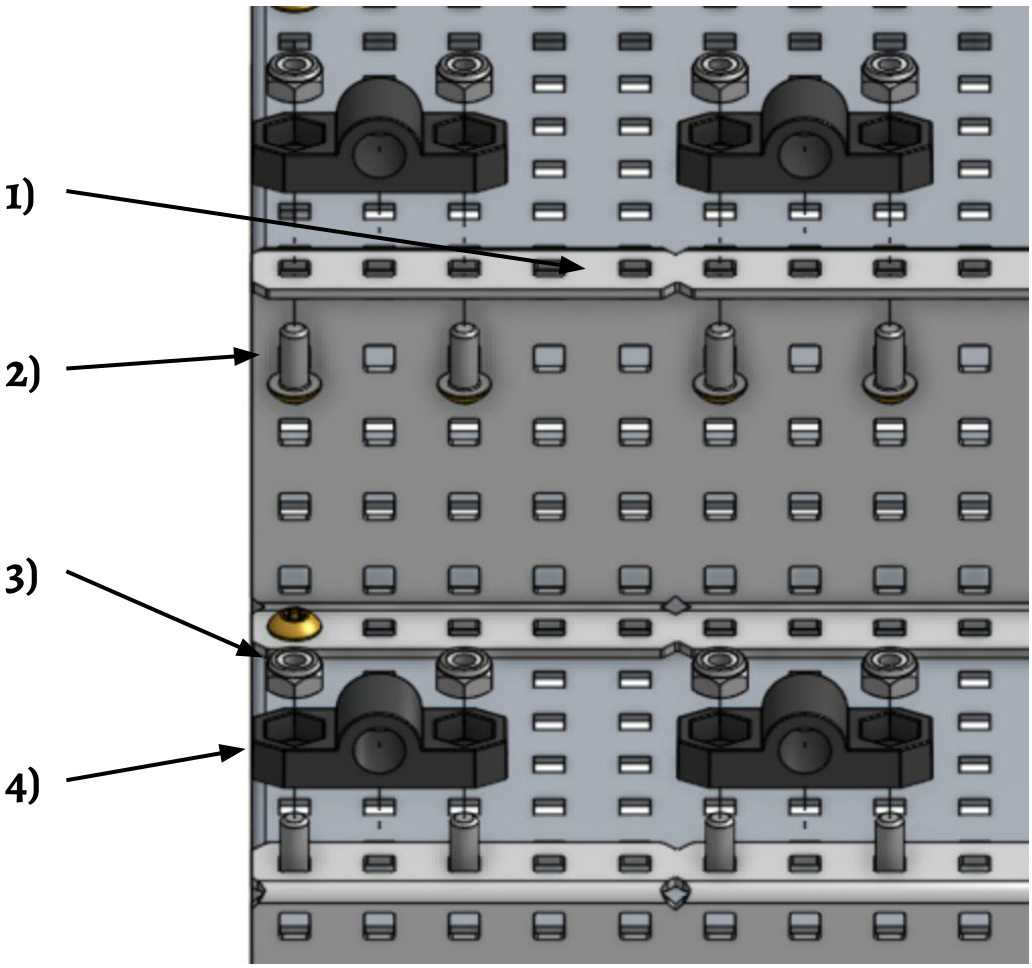
Assembly

Step 4: *Attach the bearings*

Gather:

1) 1x: Platform
2) 8x: #8-32 x 3/8" Star Drive Screw
3) 8x: #8-32 Thin Nylock Nut
4) 4x: High Strength Pillow Block Bearing

Screw the bearings on as shown:



Triple Transmission

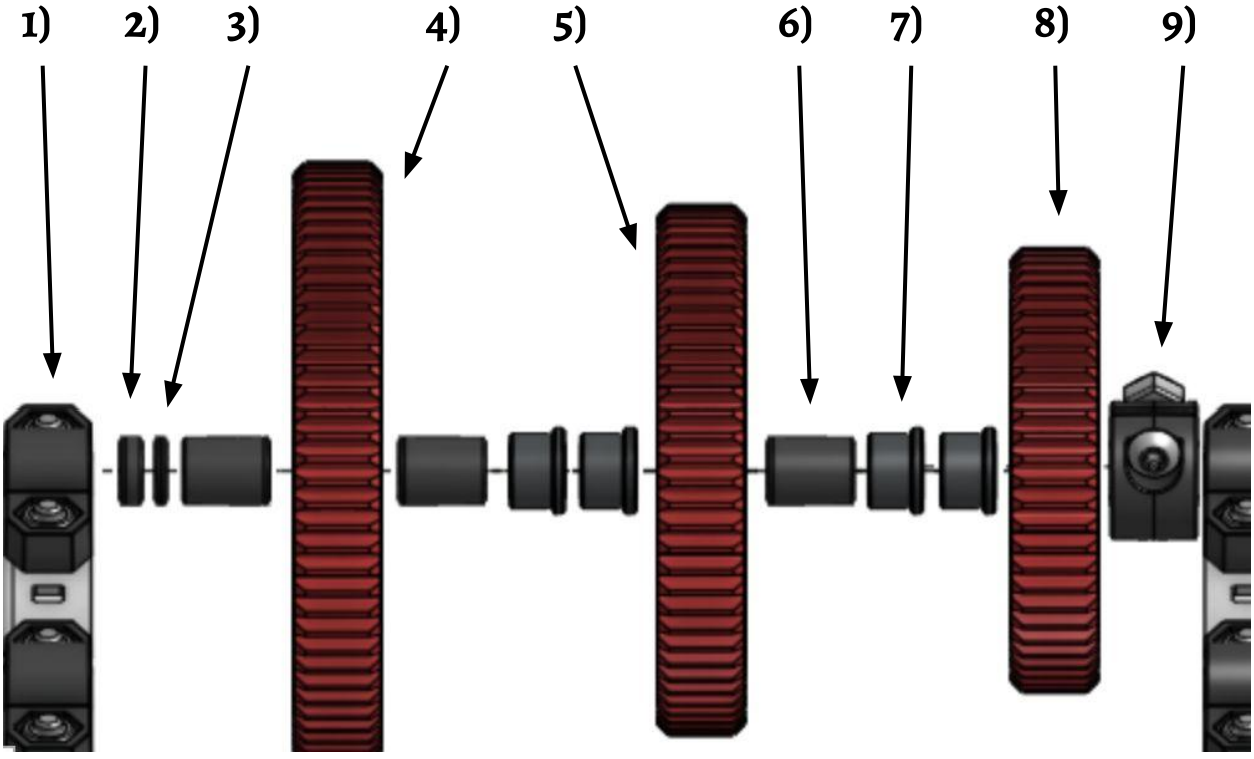
Assembly

Step 5: *Install driven piece*

Gather:

1) 1x: Platform
2) 1x: 1/8" High Strength Shaft Spacer
3) 1x: 1/16" High Strength Shaft Spacer
4) 1x: Transmission 84T High Strength Gear
5) 1x: Transmission 72T High Strength Gear
6) 3x: 1/2" High Strength Shaft Spacer
7) 4x: High Strength Shaft Bushing, 5/16" Thick
8) 1x: Transmission 60T High Strength Gear
9) 1x: Prepared High Strength Clamping Shaft Collar

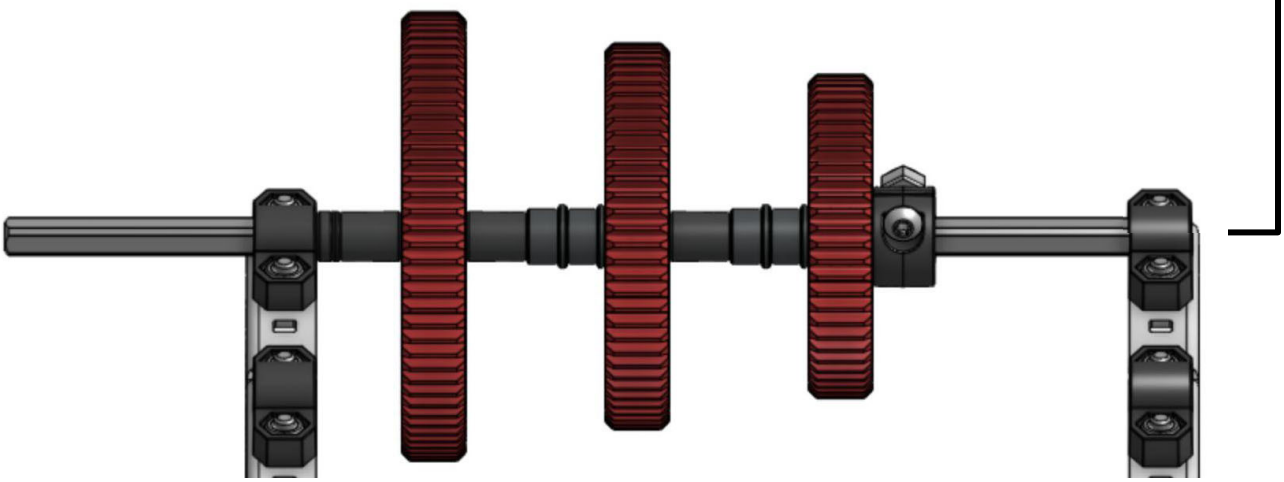
Line up the parts as shown, and slide the 9.5" High Strength Shaft in:



Triple Transmission

Assembly

With the 9.5" High Strength Shaft stopping at the end of the bearing, it should look like this:

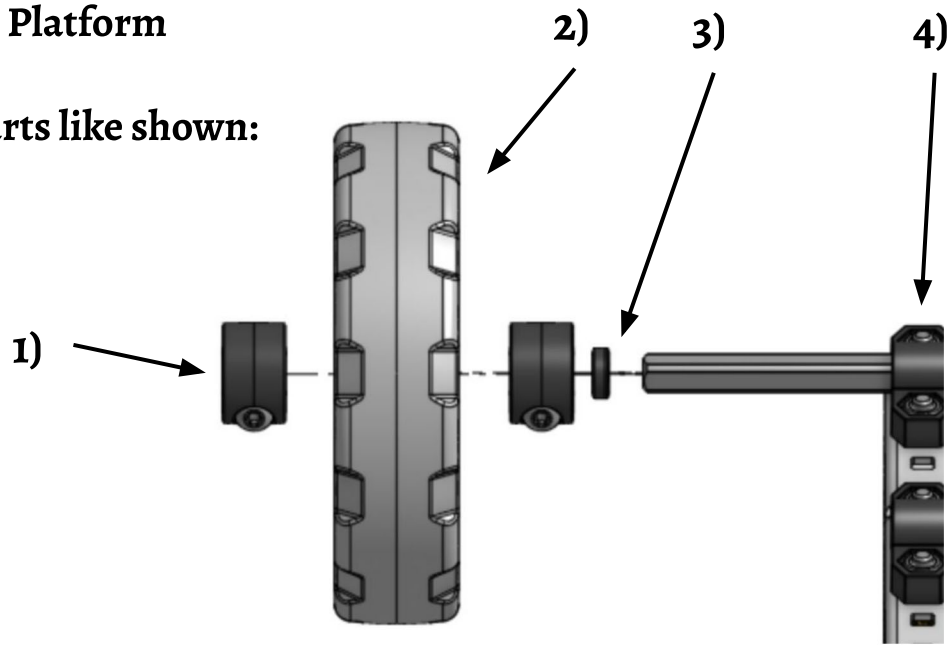


Step 6: ***Install wheel***

Gather:

1) 2x: Prepared High Strength Clamping Shaft Collar
2) 1x: 4" Anti-Static Wheel (320mm Travel)
3) 1x: 1/8" High Strength Shaft Spacer
4) 1x: Platform

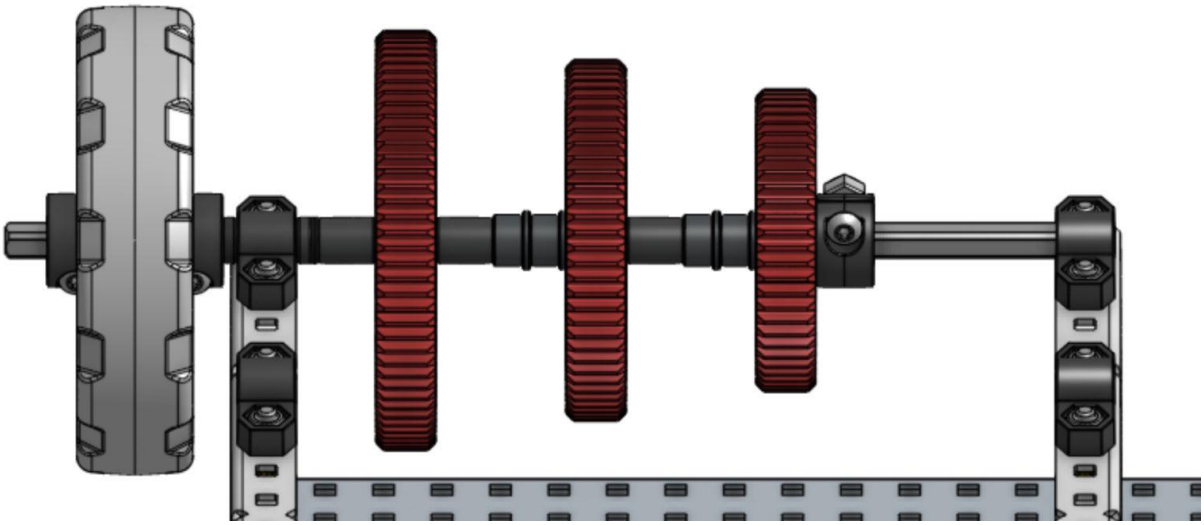
Add the parts like shown:



Triple Transmission

Assembly

The driven piece should now look like this:



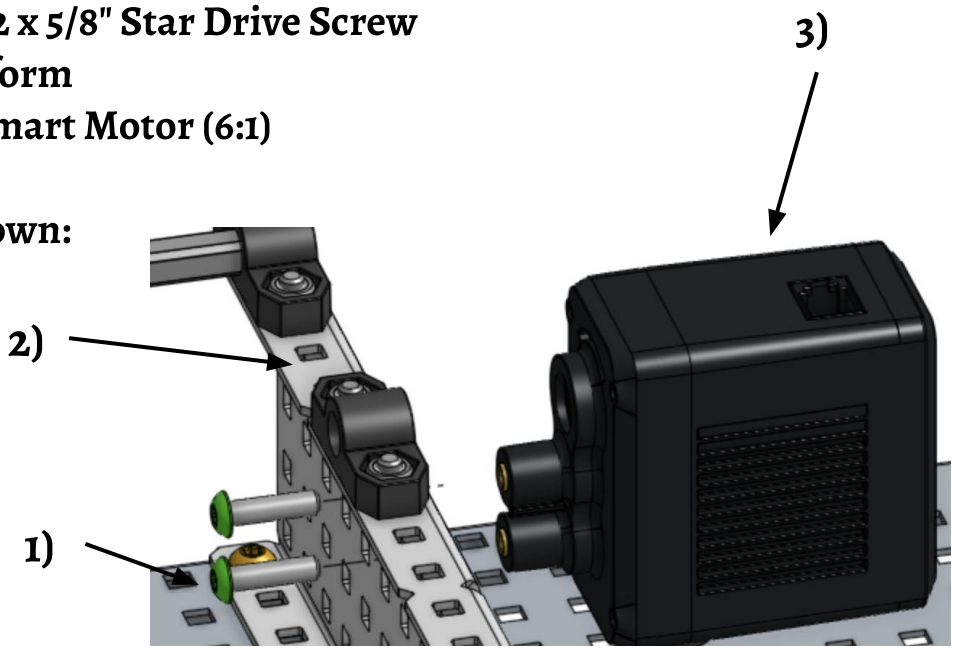
Note: Make sure to tighten the shaft collars all the way now.

Step 7: ***Installing electronics: Motor***

Gather:

1) 2x: #8-32 x 5/8" Star Drive Screw
2) 1x: Platform
3) 1x: V5 Smart Motor (6:1)

Assemble as shown:



Triple Transmission

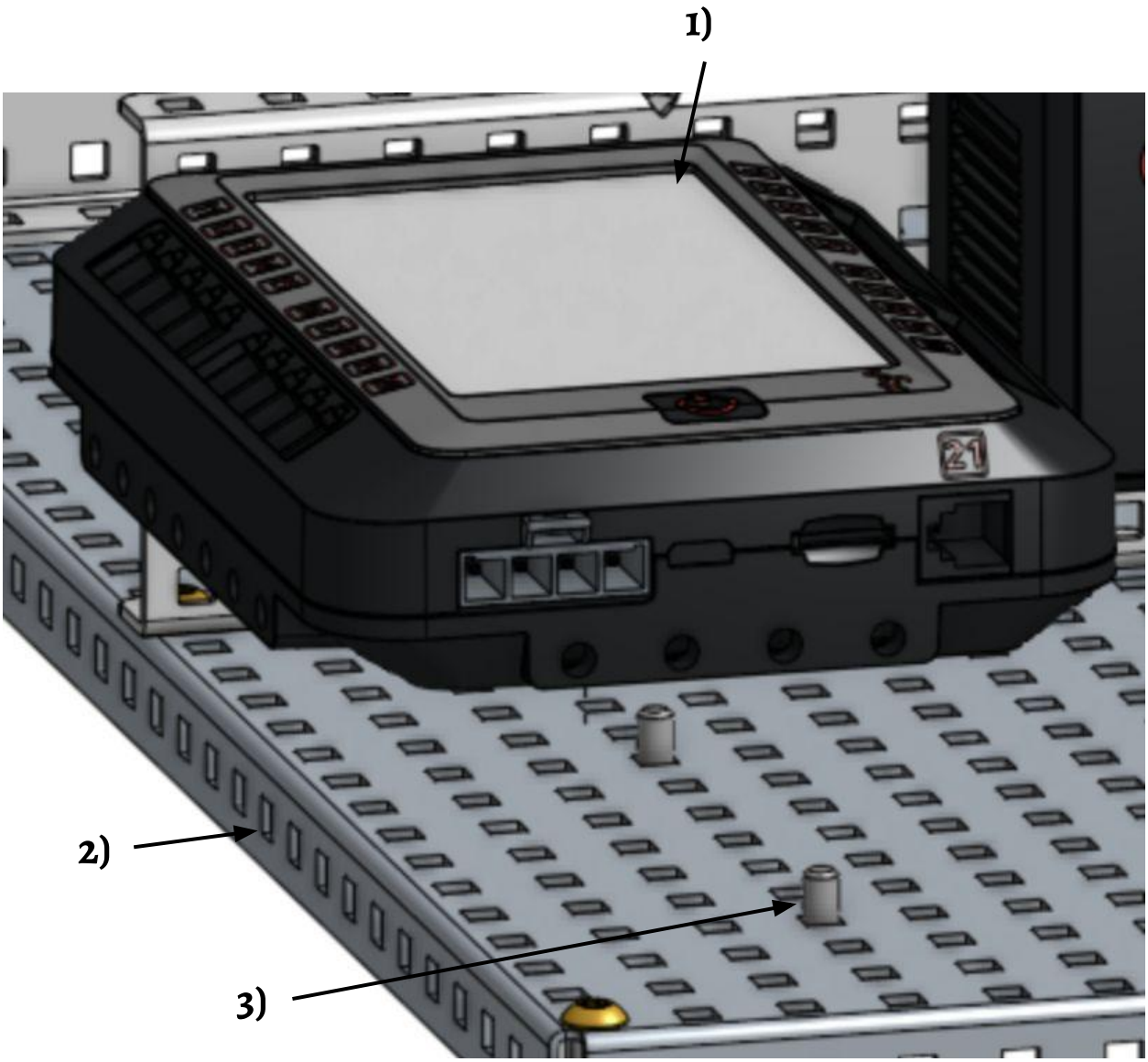
Assembly

Step 8: ***Installing electronics: Brain***

Gather:

1) 1x: V5 Robot Brain
2) 1x: Platform
3) 2x: #8-32 x 1/4" Star Drive Screw

Screw in the brain as shown:



Triple Transmission

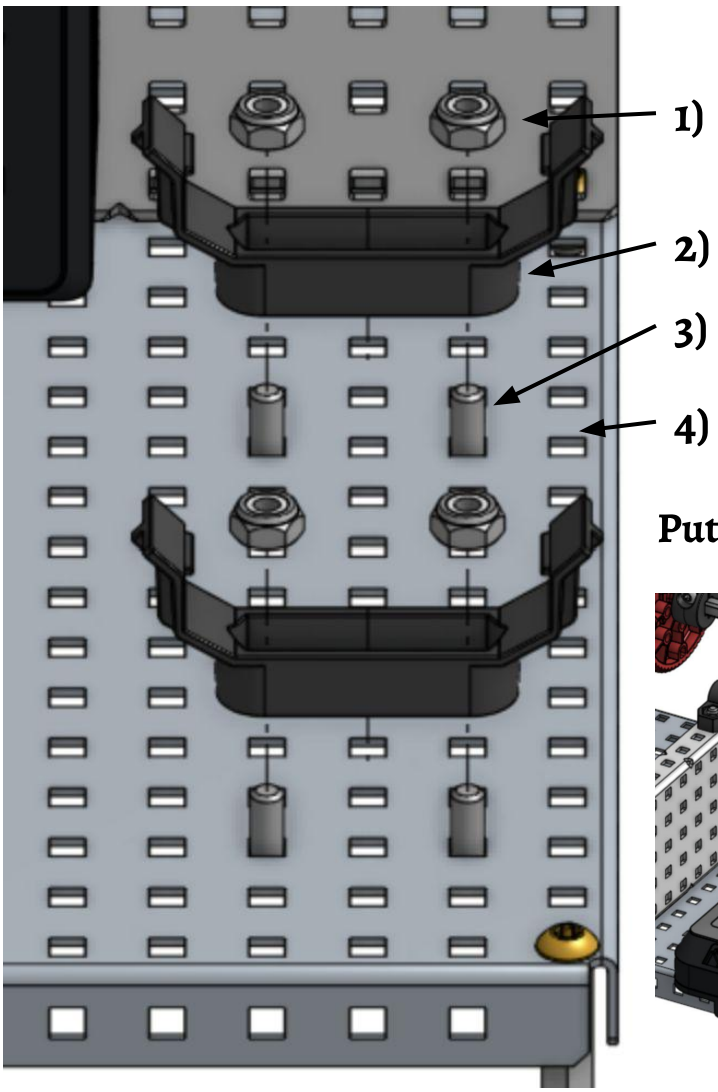
Assembly

Step 9: ***Installing electronics: Battery***

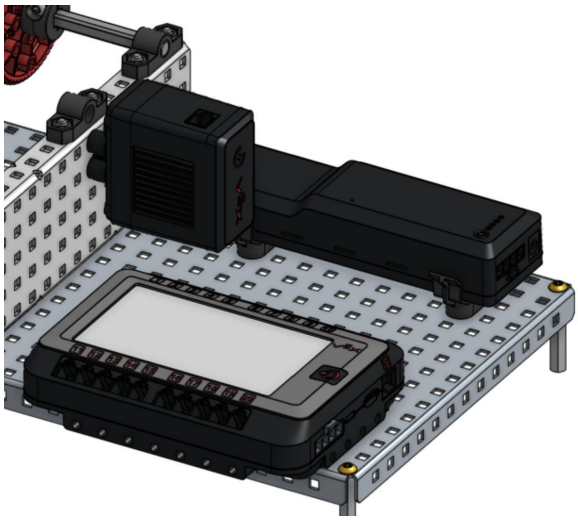
Gather:

1) 4x: #8-32 Thin Nylock Nut
2) 2x: V5 Battery Clip
3) 4x: #8-32 x 3/8" Star Drive Screw
4) 1x: Platform

Install as shown:



Put the battery on like this:



Triple Transmission

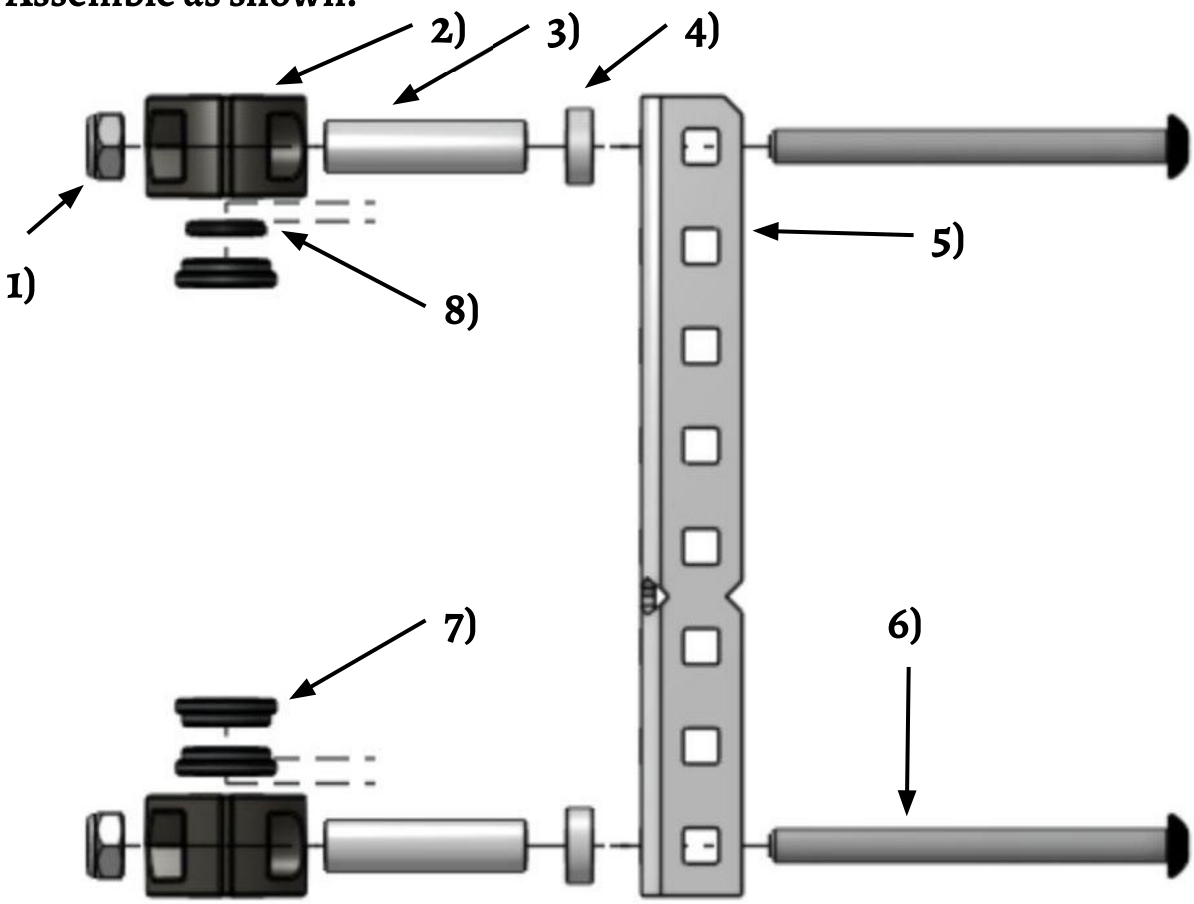
Assembly

Step 10: *Making the shifting housing*

Gather:

1) 2x: #8-32 Thin Nylock Nut
2) 2x: Prepared Drilled High Strength Clamping Shaft Collar
3) 2x: 1" L x 0.25" OD Spacer
4) 2x: 0.125" L x 0.375" OD Spacer
5) 1x: 1 x 1 x 8 Aluminum Angle
6) 2x: #8-32 x 2" Star Drive Screw
7) 3x: High Strength Shaft Bushing, 1/8" Thick
8) 1x: 1/16" High Strength Shaft Spacer

Assemble as shown:

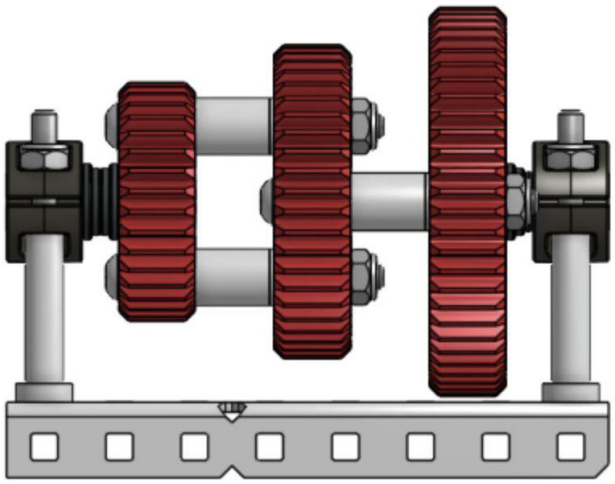


Triple Transmission

Assembly

The shifting piece and housing together should look like this:

Note: The pieces will not stay together without being on the shaft.

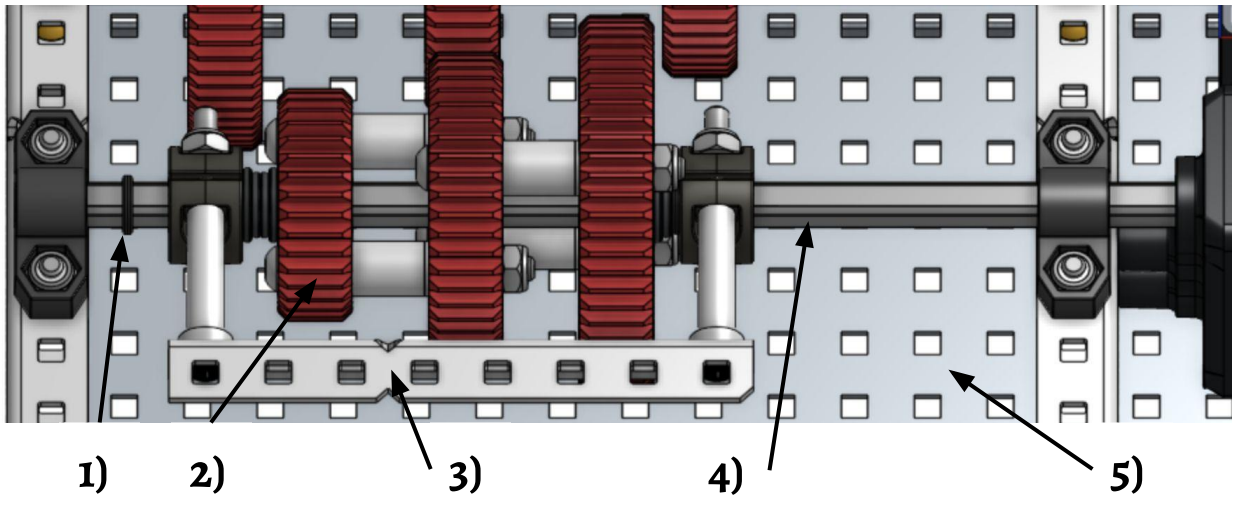


Step 11: ***Installing the shifting pieces***

Gather:

1) 1x: 1/16" High Strength Shaft Spacer
2) 1x: Shifting piece
3) 1x: Shifting housing
4) 1x: 8.22" High Strength Shaft
5) 1x: Platform

Slide the shaft in through the left, and assemble as shown:



Triple Transmission

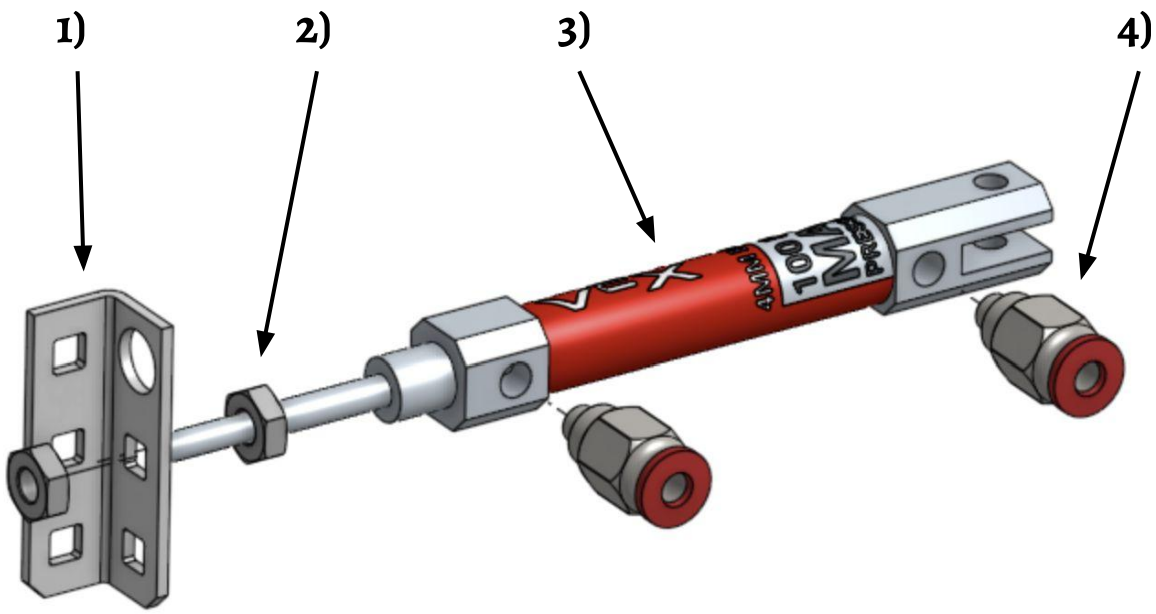
Assembly

Step 12: ***Assemble the shifter: Bottom***

Gather:

1) 1x: Prepared 1 x 1 x 3 Aluminum Angle
2) 2x: #8-32 Hex Nut
3) 1x: 25mm Stroke Pneumatic Cylinder
4) 2x: Straight Pneumatic Fitting

Assemble as shown:



Note: Use the newer V5 pneumatic kits, as the original V5 pneumatic kits had slightly different pneumatic cylinders; The threading on the piston rods had no physical limit for nuts, unlike the newer pneumatic cylinders.

Triple Transmission

Assembly

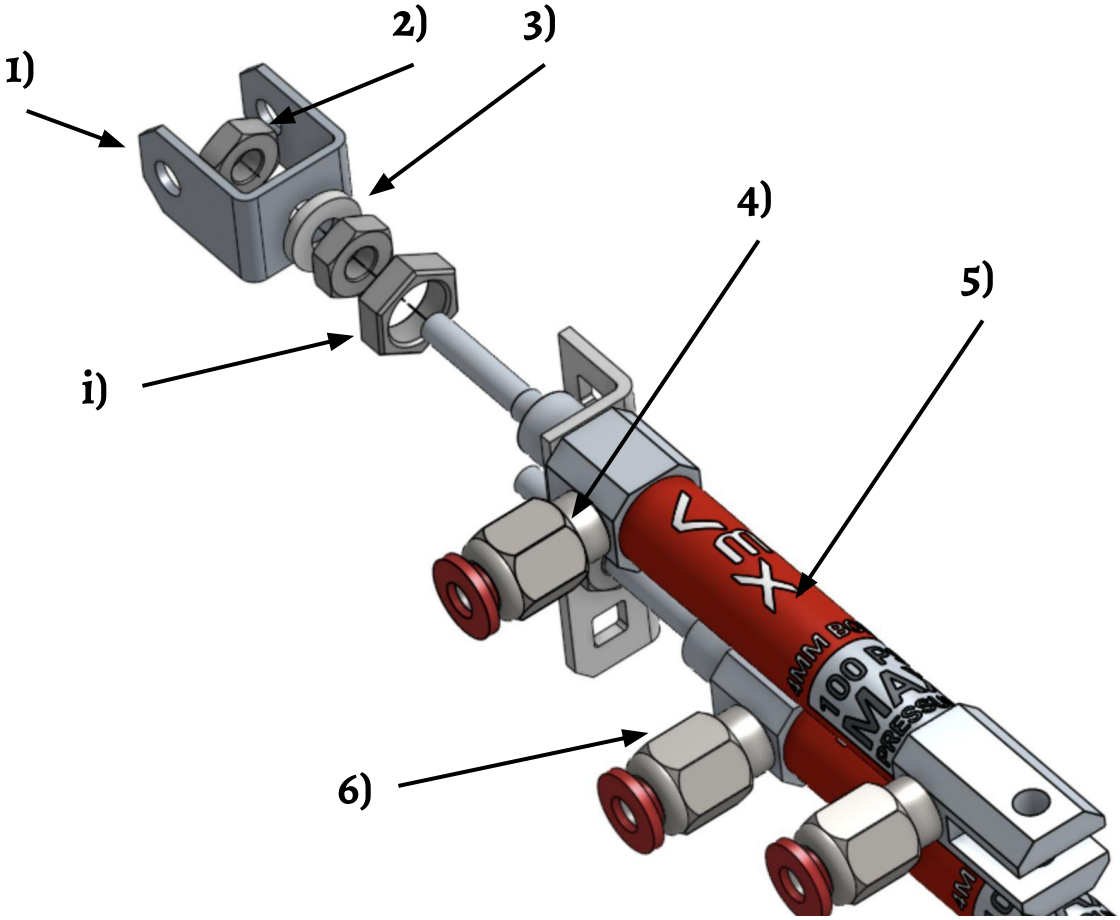
Step 13: ***Assemble the shifter: Top***

Gather:

1) 1x: Prepared Cylinder Mount
2) 2x: #8-32 Hex Nut
3) 1x: 0.0625" L x 0.375" OD (1/16") Spacer
4) 2x: Straight Pneumatic Fitting
5) 1x: 25mm Stroke Pneumatic Cylinder
6) 1x: Shifter: Bottom

i) This is a nut that comes with the pneumatic cylinder

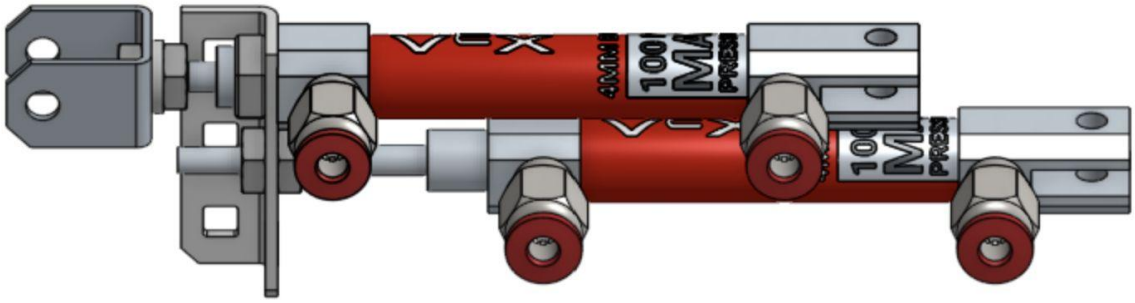
Assemble as shown:



Triple Transmission

Assembly

The assembled shifter should look like this:

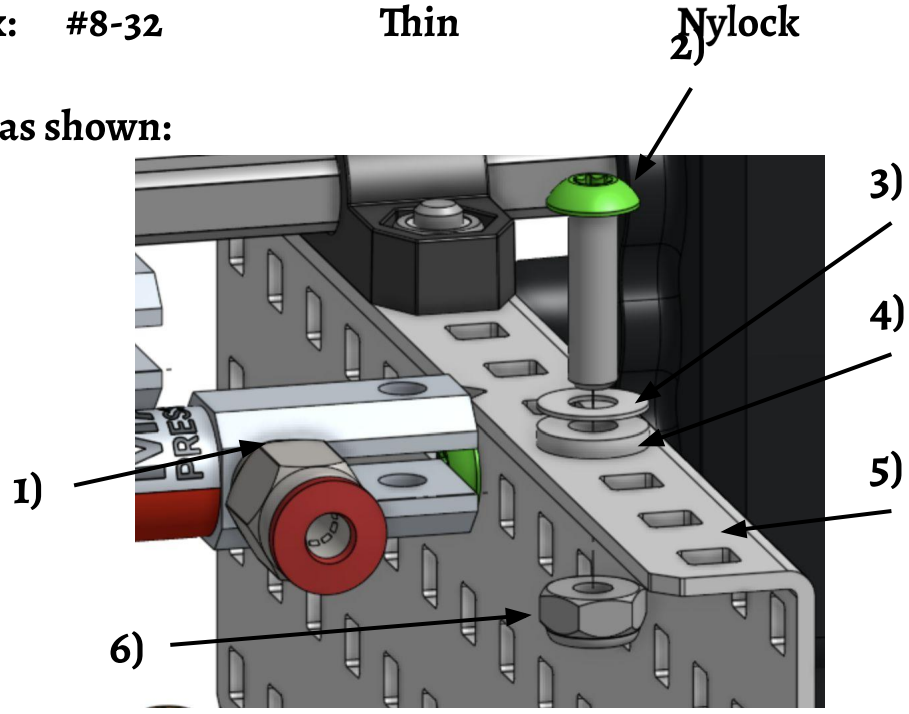


Step 14: ***Install the shifter***

Gather:

1) 1x: Shifter
2) 1x: #8-32 x 5/8" Star Drive Screw
3) 1x: 0.015625" L x 0.375" OD (1/64") Washer
4) 1x: 0.0625" L x 0.375" OD (1/16") Spacer
5) 1x: Platform
6) 1x: #8-32 Thin Nylock Nut

Attach as shown:



Triple Transmission

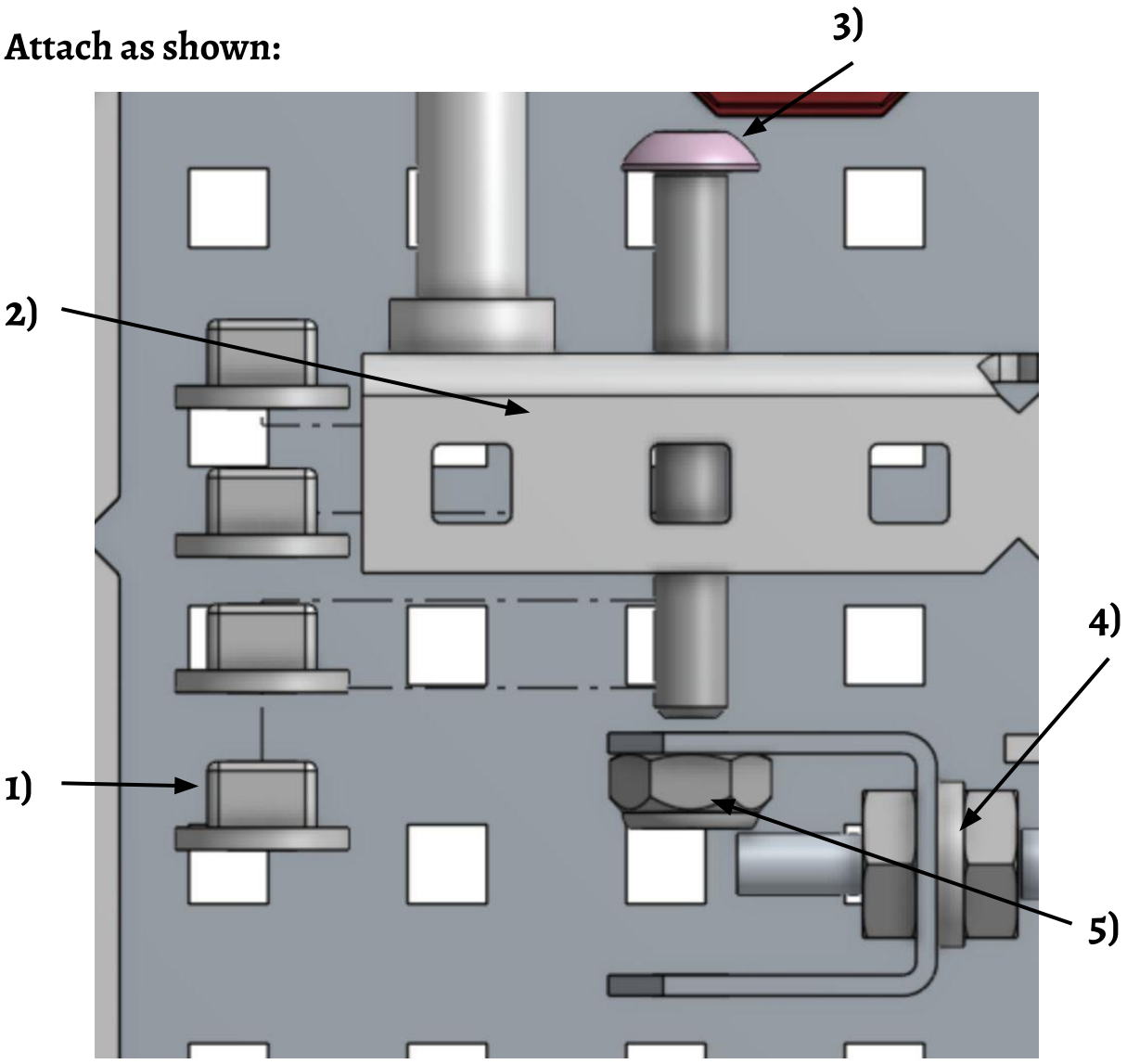
Assembly

Step 15: ***Connect the shifter to the shifting piece***

Gather:

1) 4x: High Strength Free Spinning Gear Insert
2) 1x: Shifting piece
3) 1x: #8-32 x 1-1/4" Star Drive Screw
4) 1x: Shifter
5) 1x: #8-32 Thin Nylock Nut

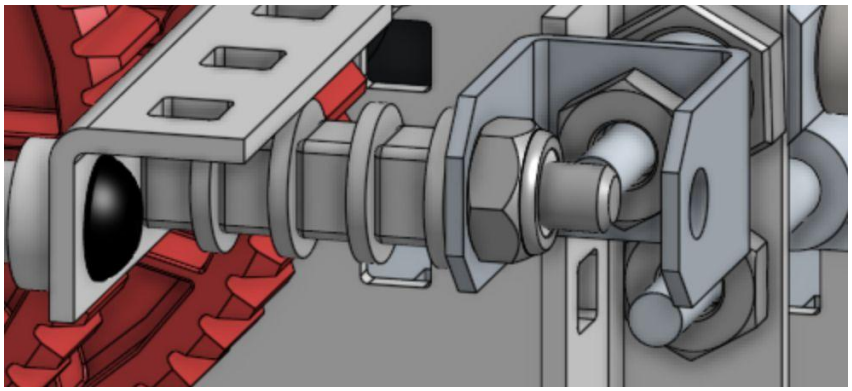
Attach as shown:



Triple Transmission

Assembly

It should look like this:

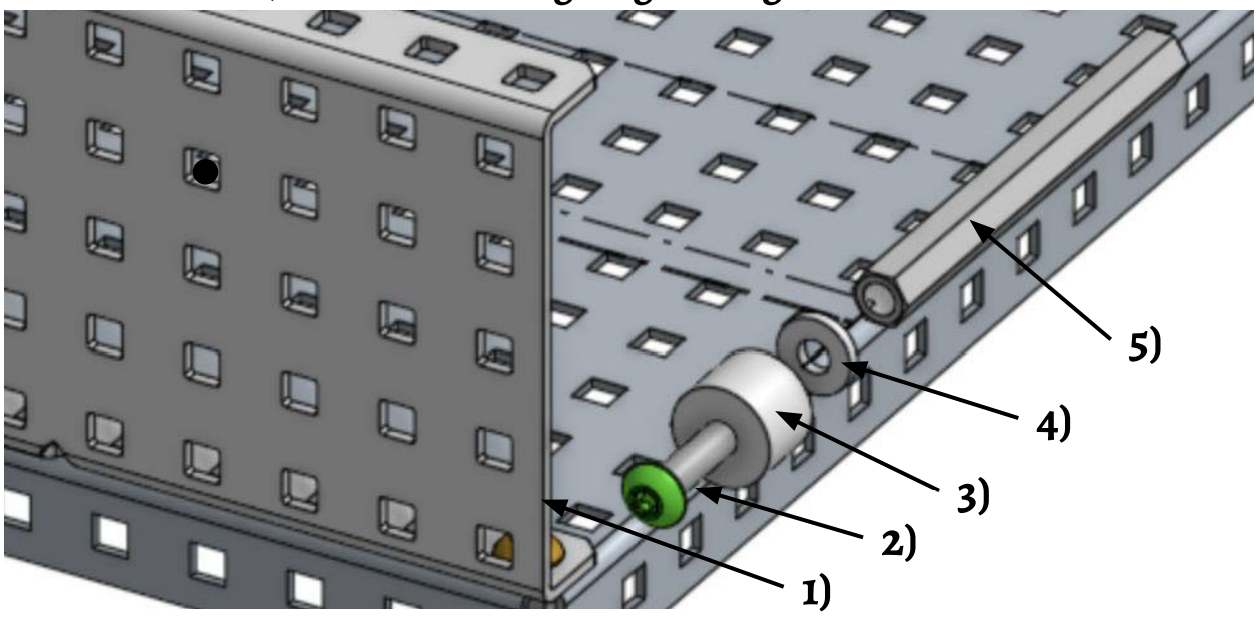


Step 16: ***Install limit***

Gather:

1) 1x: Platform
2) 1x: #8-32 x 5/8" Star Drive Screw
3) 1x: 3/8" x 1/2" OD x #8 Nylon Spacer
4) 1x: 0.0625" L x 0.375" OD (1/16") Spacer
5) 1x: 2.5" Long #8-32 Standoff

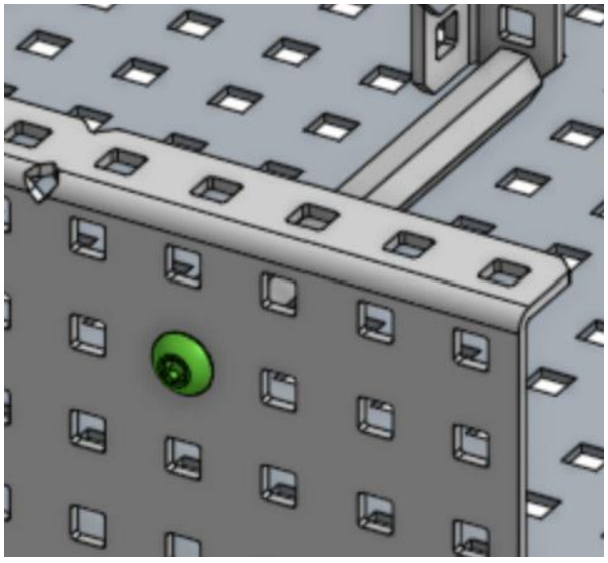
Screw in limit, with the screw going through the hole with the dot:



Triple Transmission

Assembly

The limit should look like this:

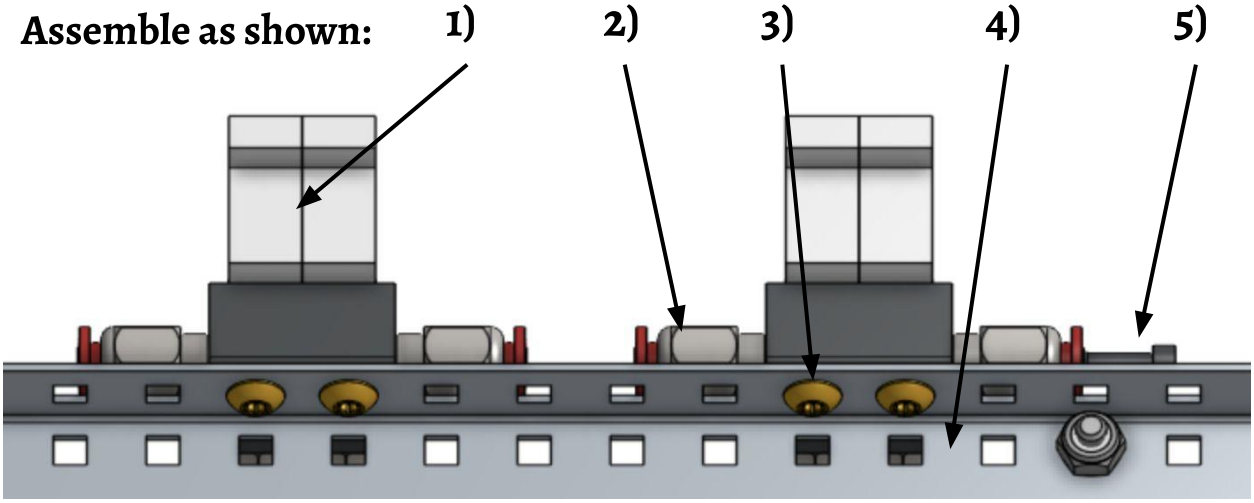


Step 17: ***Install solenoids***

Gather:

1) 2x: Double Acting Solenoid
2) 4x: Straight Pneumatic Fitting
3) 4x: #8-32 x 3/8" Star Drive Screw
4) 1x: Platform
5) 1x: 4mm Fitting Plug

Assemble as shown:



Triple Transmission

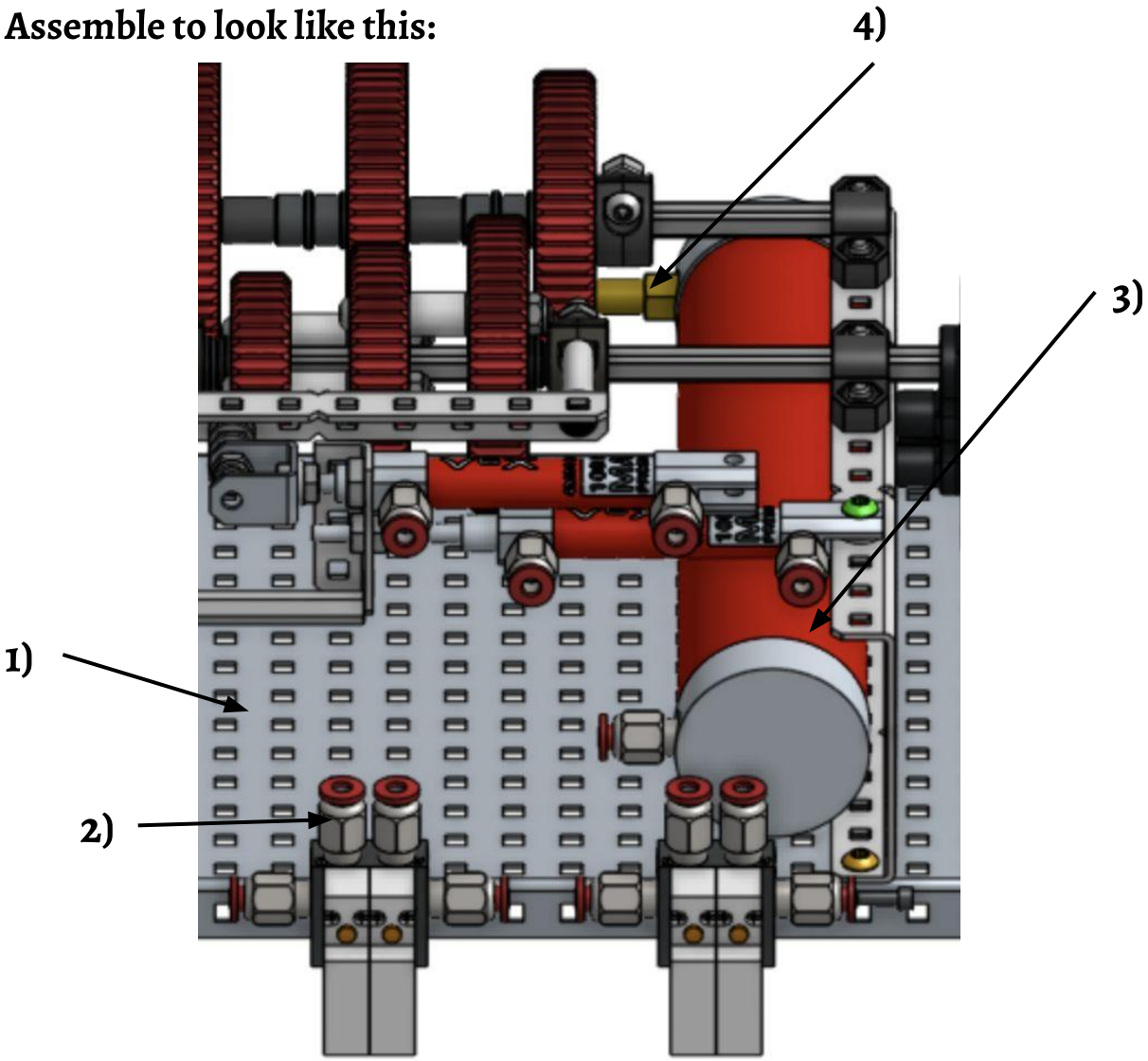
Assembly

Step 18: *Install the rest of the pneumatics*

Gather:

1) 1x: Platform
2) 5x: Straight Pneumatic Fitting
3) 1x: Pneumatic Reservoir
4) 1x: Valve stem

Assemble to look like this:



Triple Transmission

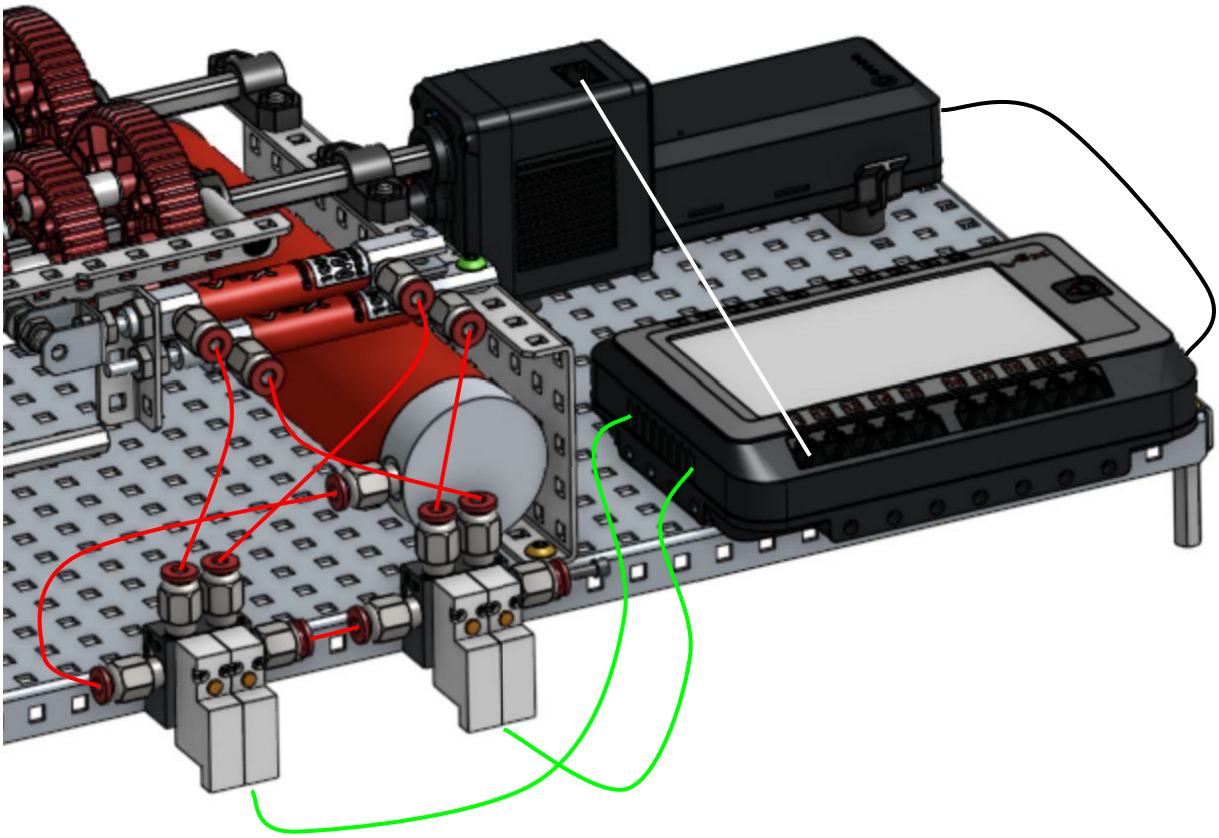
Assembly

Step 19: ***Wire and tube***

Gather:

1) **Pneumatic tubing, custom lengths (Red lines)**
2) **Motor wire, custom length (White line)**
3) **1x: 180 mm Power Cable (Black line)**
4) **2x: V5 Double Acting Solenoid Driver Cable (Green lines)**

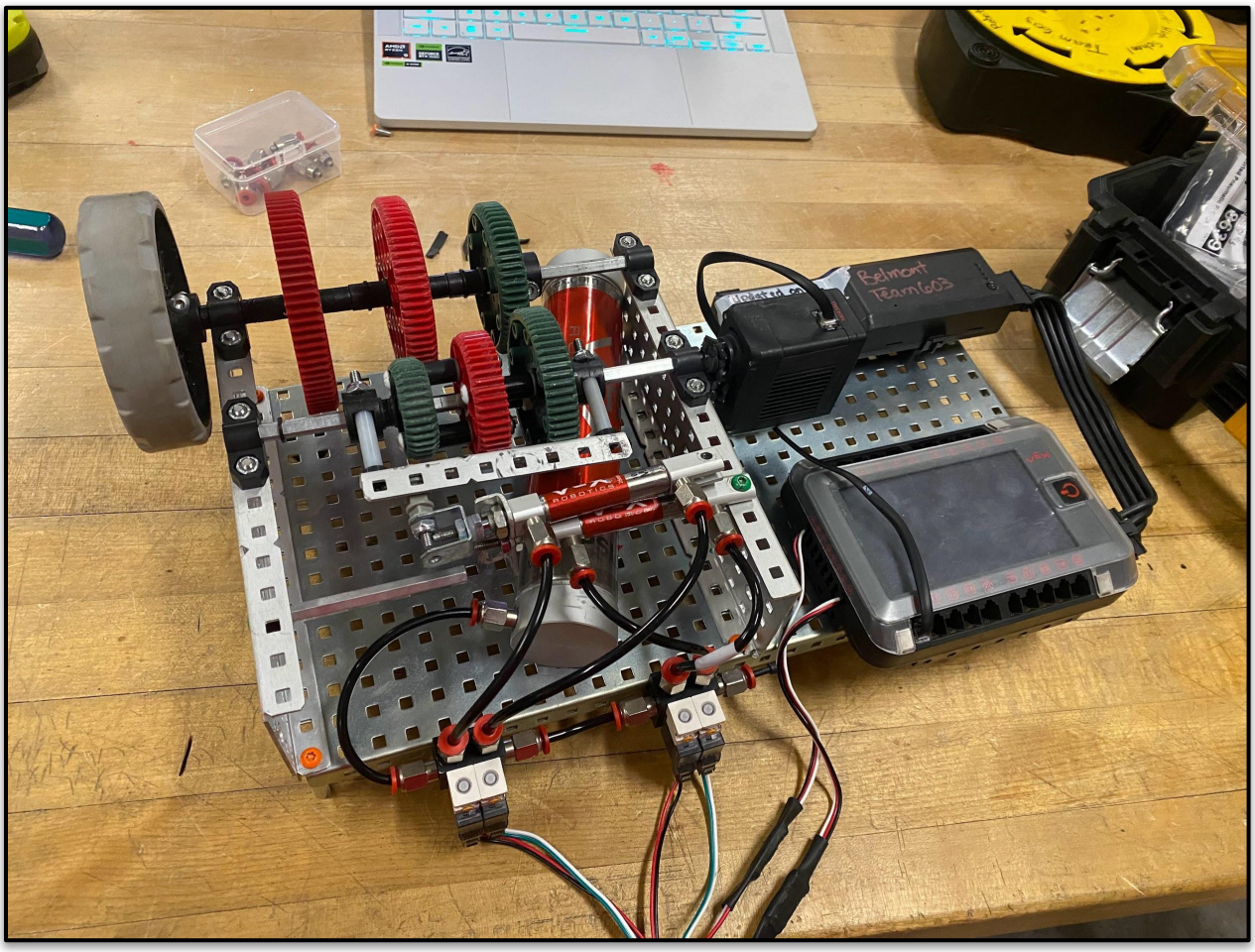
Now it is time to wire and tube it. Tube the pneumatic system like the red lines. Wire the motor like the white line. Wire the brain with the 180 mm Power Cable like the black line. Wire the solenoids like the green lines with the 2 V5 Double Acting Solenoid Driver Cables.



Triple Transmission

Complete

After plugging in the V5 Robot Radio into the brain, this is what the triple transmission should look like once it is built:



It is now fully built, but it is not ready to use quite yet. Refer to page 73 for instructions on how to code it to work.

Triple Transmission

How To Use

Download the code onto the brain, and link a controller to the radio. Ensure the pneumatic reservoir is filled completely. Because this is a triple transmission, there are three different gear ratios:

Default:

Due to the tubing, the default ratio is 48:72 (4:6). The motor has a blue 600 RPM cartridge, making a ratio of (600/1 * 4/6) = *400 output RPM*. Press button X on the controller to return to this state.

Strength:

Press button A on the controller to change to the strength ratio of 36:84 (3:7). This makes a ratio of (600/1 * 3/7) = *257.143 output RPM*.

Speed:

Press button B on the controller to change to the speed ratio of 60:60 (1:1). This makes a ratio of (600/1 * 1/1) = *600 output RPM*.

Control:

Moving the right joystick forward, the wheel will spin at the joystick position(percent) * the output ratio. For example, a 1:1 ratio and joystick all the way up will make the wheel spin at 600 RPM.

Specific tips:

- Like I mentioned in the introduction, be sure that the spacing is correct and good to avoid any catching. I am using a few of the old V1 gears (the green ones, plus the 84 tooth gear), and I am using 1/16" high strength spacers to accommodate for them.

- Also add something to prevent the motor axle from coming out, I forgot to add it.

Programming

```
// define your global instances of devices here
vex::brain      Brain;
controller Controller1;
motor Motor11 = motor(PORT11, false);
pneumatics Piston1 = pneumatics(Brain.ThreeWirePort.H);
pneumatics Piston2 = pneumatics(Brain.ThreeWirePort.A);

int main() {
  while(1) {
    // MOTOR CONTROLS
    Motor11.spin(forward, Controller1.Axis2.position(), pct);
    if (Controller1.ButtonR1.pressing()){
      Motor11.spin(forward, 100, pct);
    }
    else if (Controller1.ButtonR2.pressing()){
      Motor11.stop();
    }

    // PISTON CONTROLS
    if (Controller1.ButtonB.pressing()){
      Piston1.open();
      Piston2.close();
    }
    else if (Controller1.ButtonA.pressing()){
      Piston1.open();
      Piston2.open();
    }
    else if (Controller1.ButtonX.pressing()){
      Piston1.close();
      Piston2.close();
    }
  }
}
```

Note: You may have to alter the code a little bit. This is just an example of how to code it.