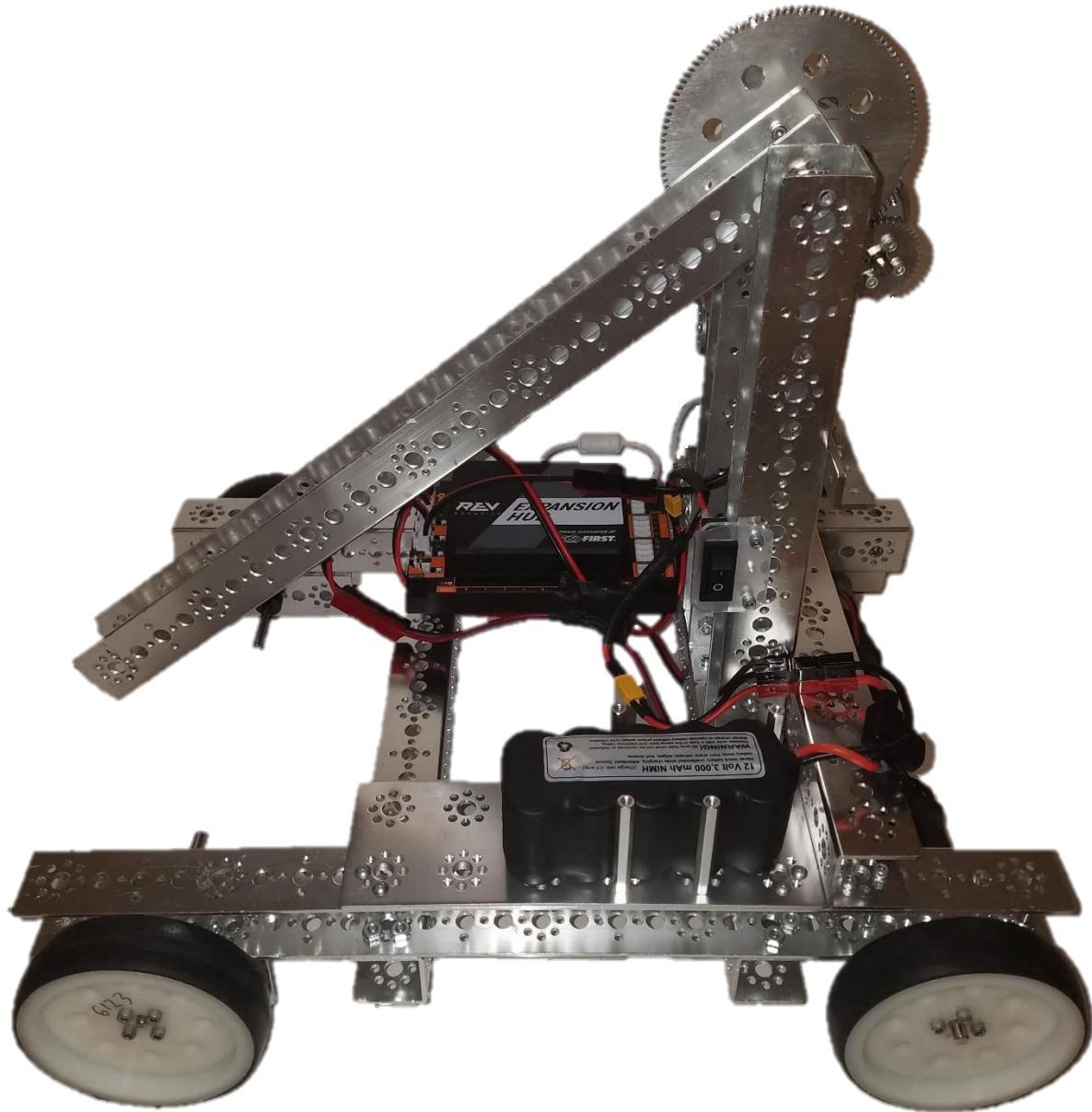


# **Pushbot 2.0**



**The Instruction Manual for People Getting Started  
Created By: FTC Team 6123**

## Part List

Short hand name	Part Name	Part Number	Number Needed
<b>Frame (Tetrix)</b>			
Button Head	Button Head Cap Screws	W39111	8
Nut	Kep Nut	W39094	73
Short Screw	6-32 x .3125 Socket Head Cap Screws	W39098	63
Regular Screw	6-32 x .5 Socket Head Cap Screws	W39097	24
Motor Hub	Motor Shaft Hub	W39079	3
Axle Hub	Axle Hub	W39172	3
Small Gear	40-tooth aluminum gear	W31901	1
Large Gear	120-tooth aluminum gear	W31901	1
Bushing	11mm Bronze Bushing	W39091	7
Axle	100mm Steel Axle	W39088	3
Long Bar	416mm Channel	W39069	3
Thin Spacer	.125 Axle Spacer	W39100	2
U Brackets	Inside C Connector	W39270	2
Three Hole Plate	Flat 96mm x 26mm	W39273	1
Two Hole Plate	Flat 64mm x 26mm	W39274	1
Standoffs	Stand-Off Posts (any size)	W39103/W39103/ W39107	4
Flat Plate	Flat Building Plate	W39073	1
Motor Mount	Motor Mount (has screws)	W39089	3
Square Bracket	Inside Corner Bracket	W39281	4
Medium Bar	288mm Channel	W39068	5
L Bar	144mm Angle	W39072	1
Small Bars	96mm Channel	W39066	2
Axle Collar	Axle Set Collar or Clamping Two-Piece Shaft Collars (McMASTER-CARR)	W39092 6436K6*	4
motors	DC Motor(Tetrix) or NeveRest Classic 60 (AndyMark)*	W39530 am-3103_ne*	3
Lock Nuts	M3 Nyloc Nuts (REV)	REV-41-1361	2
Hex Screws	M3x16mm Hex Cap	REV-41-1360	2
<b>2 Regular Wheels, 2 Omni wheels *recommended</b>			
Regular Wheels	4" Wheel	None	2
Omni Wheels	4" Omni Wheel	None	4
<b>4 Regular Wheels</b>			
Regular Wheels	4" Wheel	None	4
<b>Electronics (REV)</b>			
Expansion Hub	Expansion Hub	REV-31-1153	1
Motor Connector	Anderson to JST VH Cable, 12cm	REV-31-1381	3
Battery	12-Volt Rechargeable 3,000 mAh NiMH Battery(Tetrix)	W39057	1
Switch	Switch Cable and Bracket	REV-31-1387	1
Battery Connector	Tamiya to XT30 Adapter	REV-31-1382	1
Power Extension	XT30 Extension Cable	none	1
Phone Cord	Micro USB to Mini USB converter cord	None	1
Phone	FTC approved phone like ZTE speed	None	2
Controller	X-box controller FTC approved	None	1
<b>Tools</b>			
Red Allen Wrench	7/64in allen wrench (we color code ours to make things easier)	None	1
Blue Allen Wrench	3/32in allen wrench	None	1
Green Allen Wrench	5/64in allen wrench	None	1
Socket Wrench	Socket Wrench with a 7/32in socket or fastener	None	1
Pliers	Needle Nose Pliers although any will work	None	1

\*recommended

## Disclaimers

There are many ways to build a robot. This is just one way to build a sturdy base, and this base can be modified for many needs. You can attach a bucket to the front or even two servos and make a gripper, depending on the challenge. This manual features a robot with four normal wheels, but omni wheels are preferred. If you want to use omni wheels, follow the alternate instructions laid out in step 6. If you have any questions regarding the instructions, design, etc. please email the Mechanical Marauders at [ftc6123@gmail.com](mailto:ftc6123@gmail.com). I hope this proves to be a useful resource to teach you the basics!

## Extra Instructions:

### Counting Holes



### Using Screws

Screws should sandwich the metal or whatever you are trying to attach and what you are attaching it to. The head of the screw will be on one side and the nut will be on the other. The allen wrench or screw driver is a great tool to help turn the head of the screw and tighten it more than you could by hand.

### Hole Size

The screw holes are slightly larger than the actual screw. This means if the screw is not tight, no matter how many screws you have in a joint, it will always wiggle. So, when screwing in, put the nuts on all the screws and then tighten as much as possible to prevent unwanted movement.

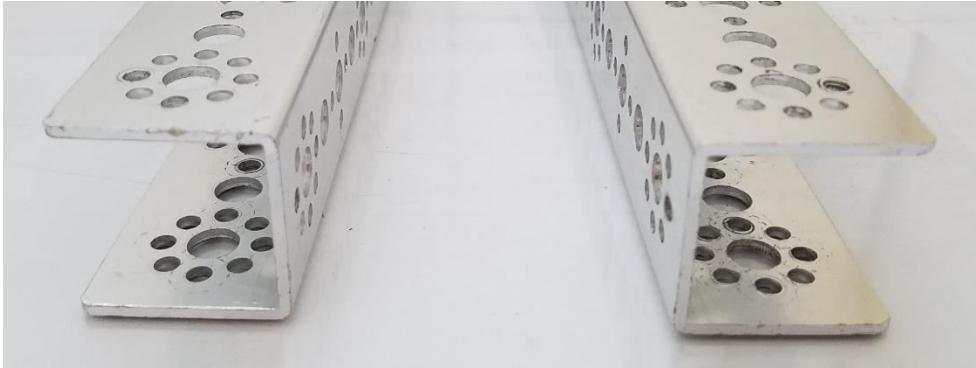
### Screw Length

I did my best to pick the correct length for the screws. However, a good rule of thumb is if you can feel the screw come out through a threaded section, it is long enough. This does not apply to stand offs though because they are threaded the entire way. If the screw barely makes it into the threaded section, you may need to choose a longer screw.

## **Step 1: Build the Base**

**Parts:** 2 Long bars, 3 medium bars, 18 short screws, 18 nuts

Lay the two long bars with the opening facing out.



Lay the first medium bar over the two long bars on the fourth hole with the opening facing you.



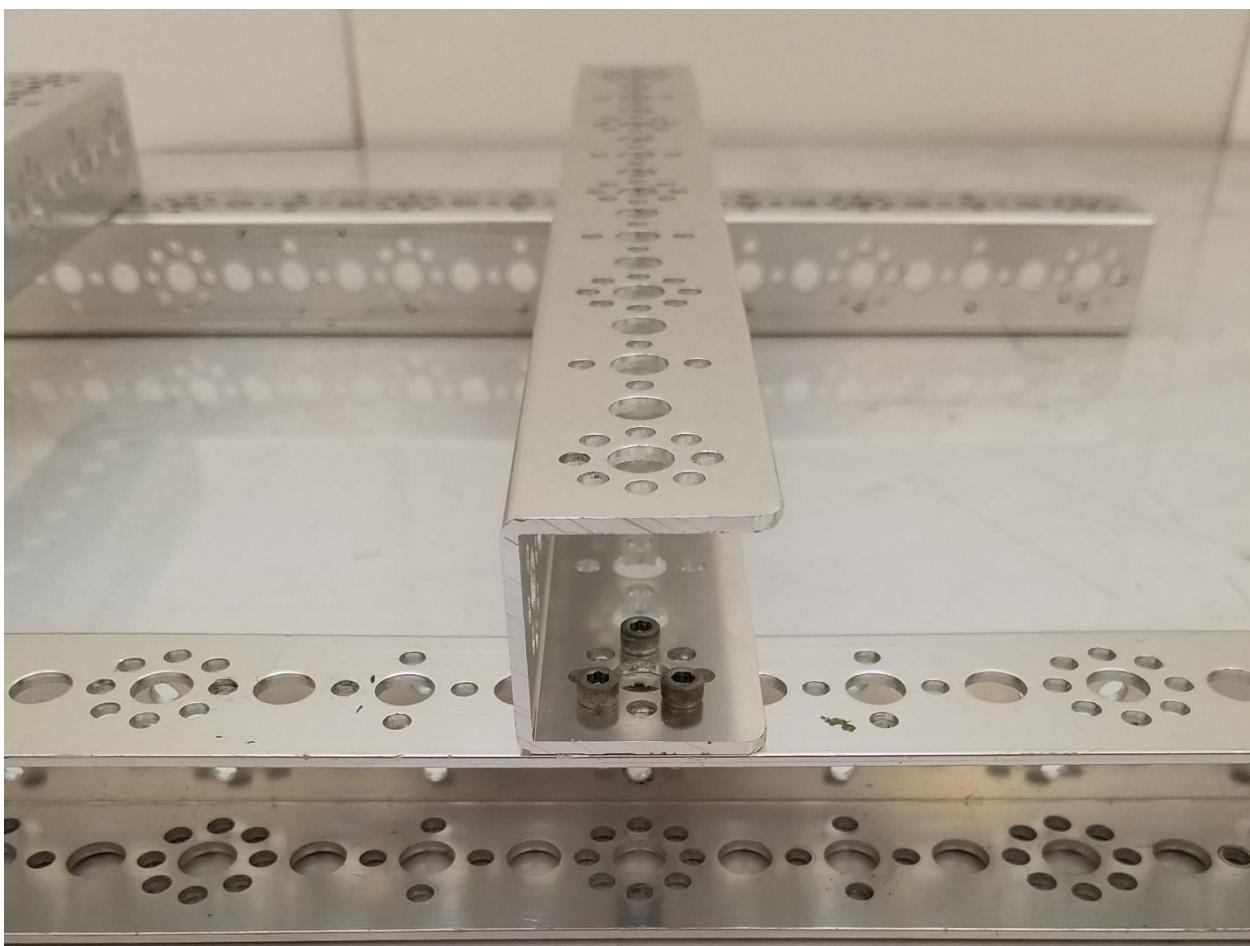
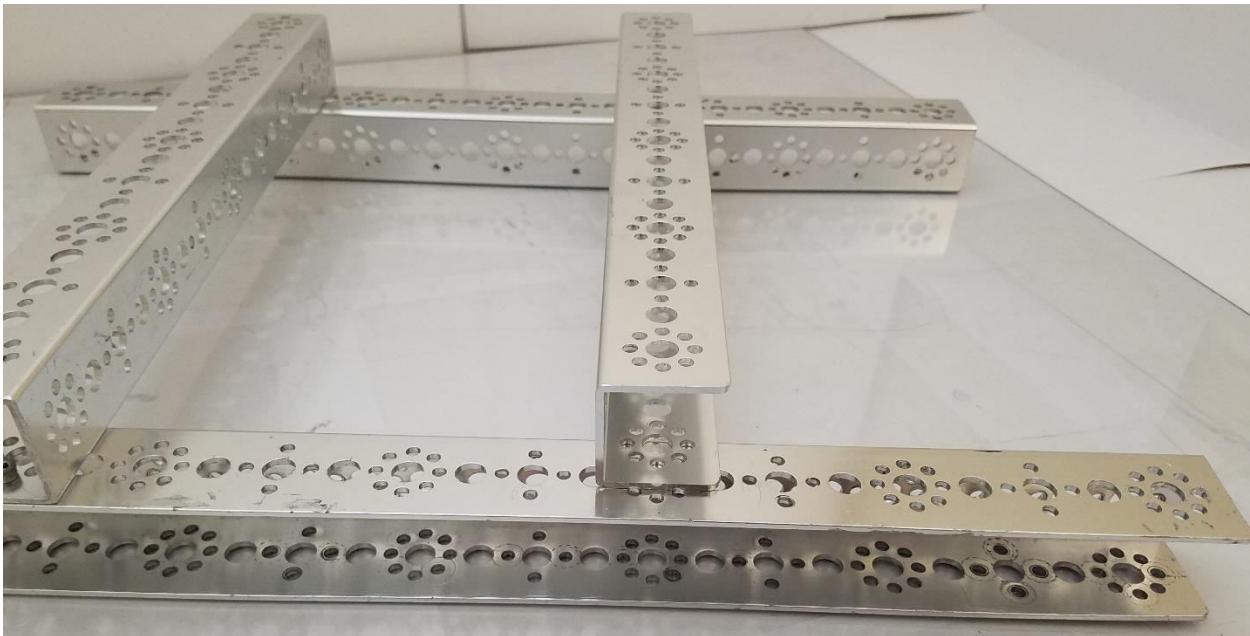
Use three short screws at each of the intersections. Next insert the red or 7/64 allen wrench through the top layer into the top of the screw. Then hold a nut with the washer (not threaded) facing the metal and turn the allen wrench clockwise to tighten. Repeat with all the screws.



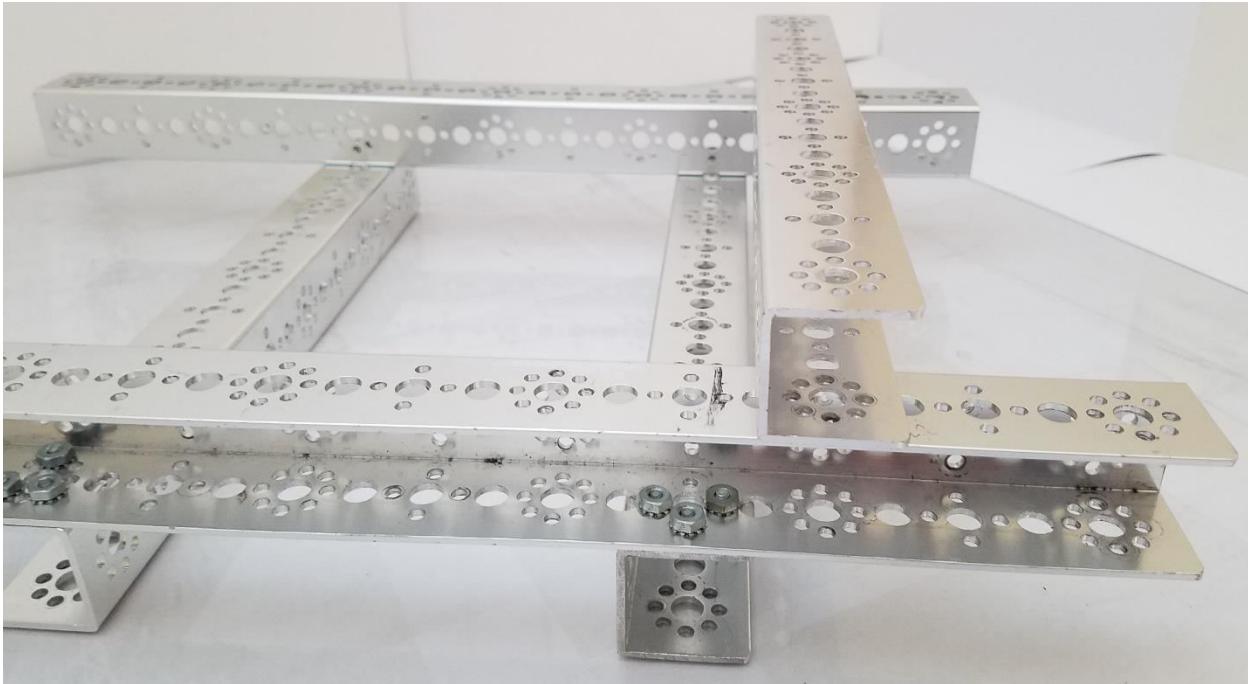
It should look like this



Next, add another medium bar like the first four holes from the other end and screw it in.



Flip the base over. Add the third bar two holes over from the edge. It should be one hole over from the first bar you added.



Screw in the last beam the same as the first with three screws in each intersection.



## **Step 2: Add Wheel Mount**

**Parts:** 2 short bars, 8 short screws, 2 motor mounts (including screws), 10 nuts, red allen wrench (7/64)

Flip the base over so that the two medium bars are on top.

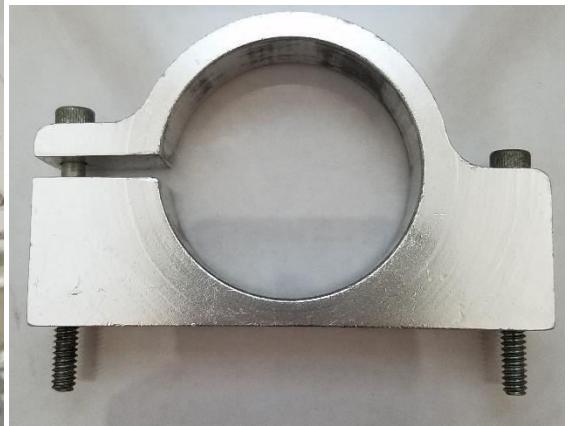
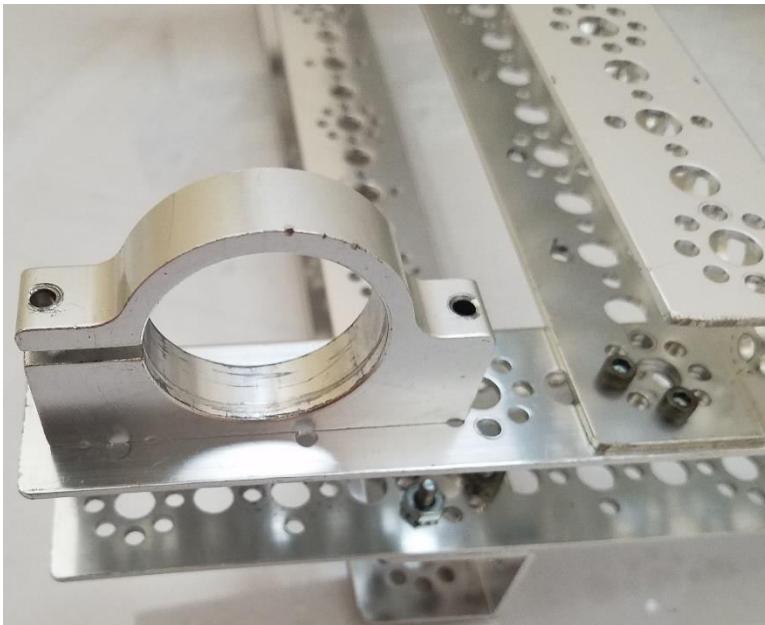
On the side with four holes (more space than the other) attached the small bars with four screws on each of the long bars.



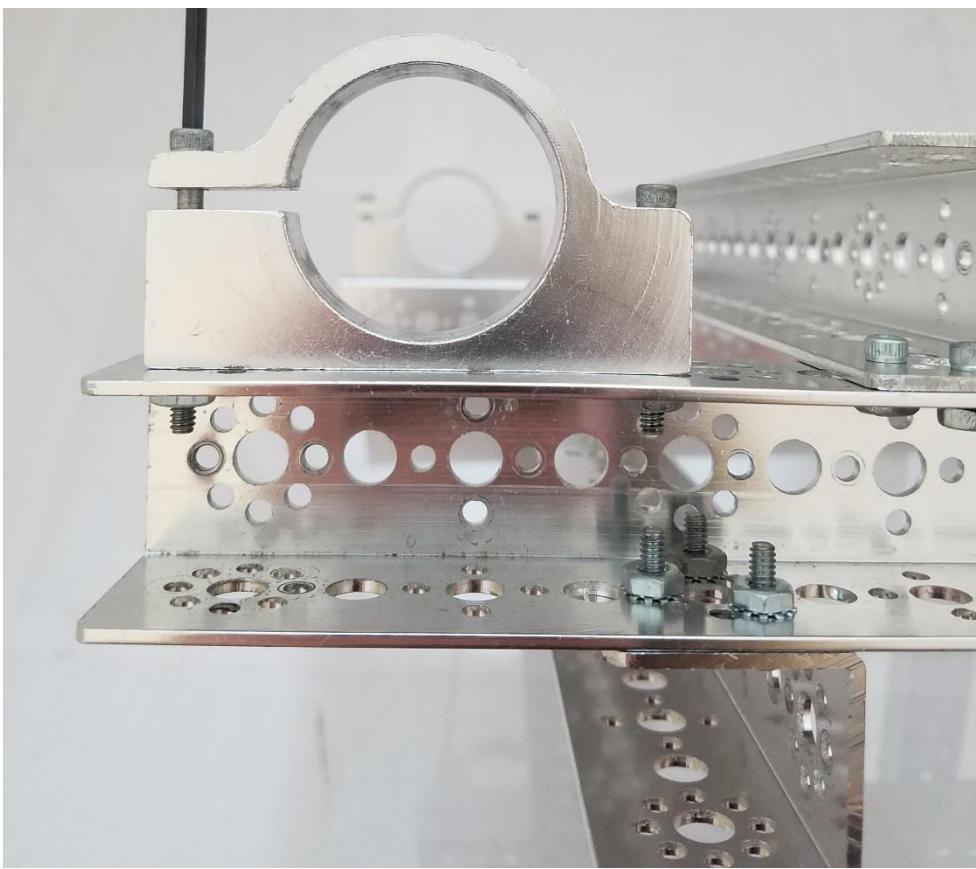
Here is a good way to organize the screws. Put nuts on and tighten.



Put the motor mount on the other side of the frame. When putting the screws in, the longer screw goes on the side with a gap and the shorter screw goes on the solid side so that the length protruding is equal.



Add nuts and screw it on.



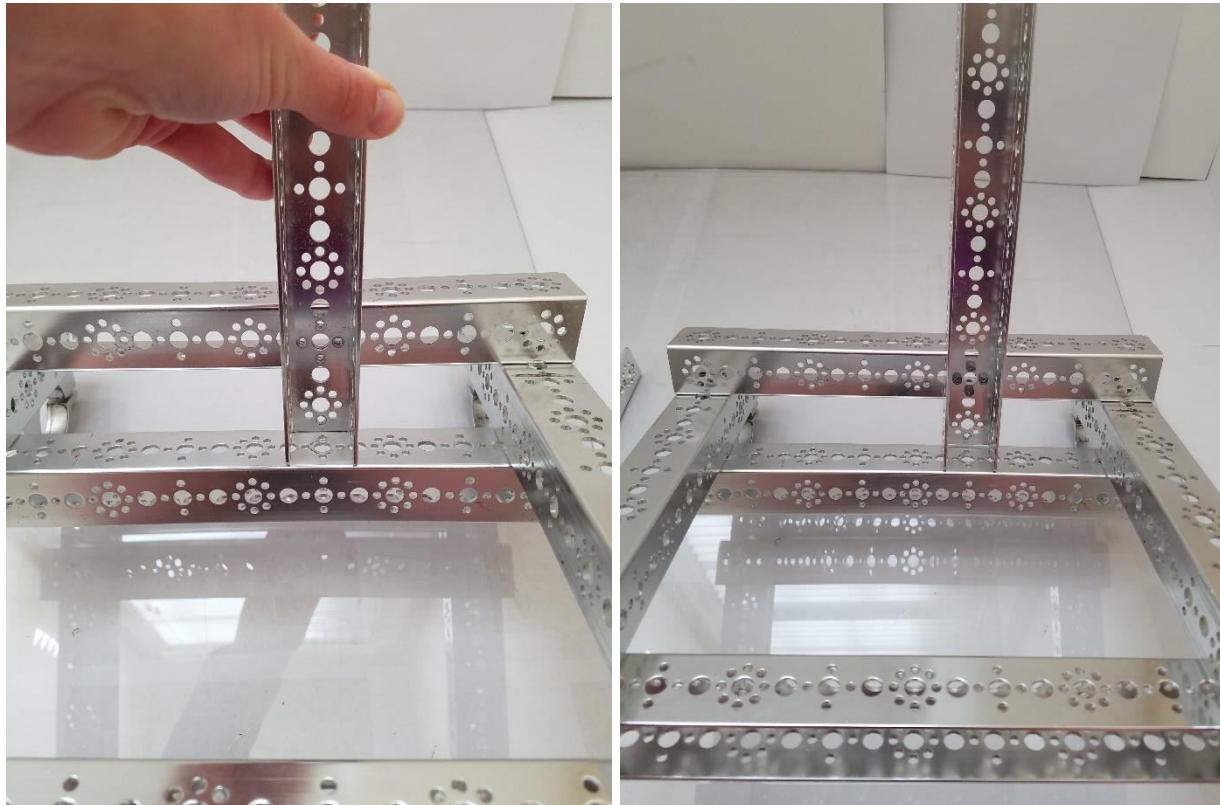
Here is what the robot should look like after the second step is completed.



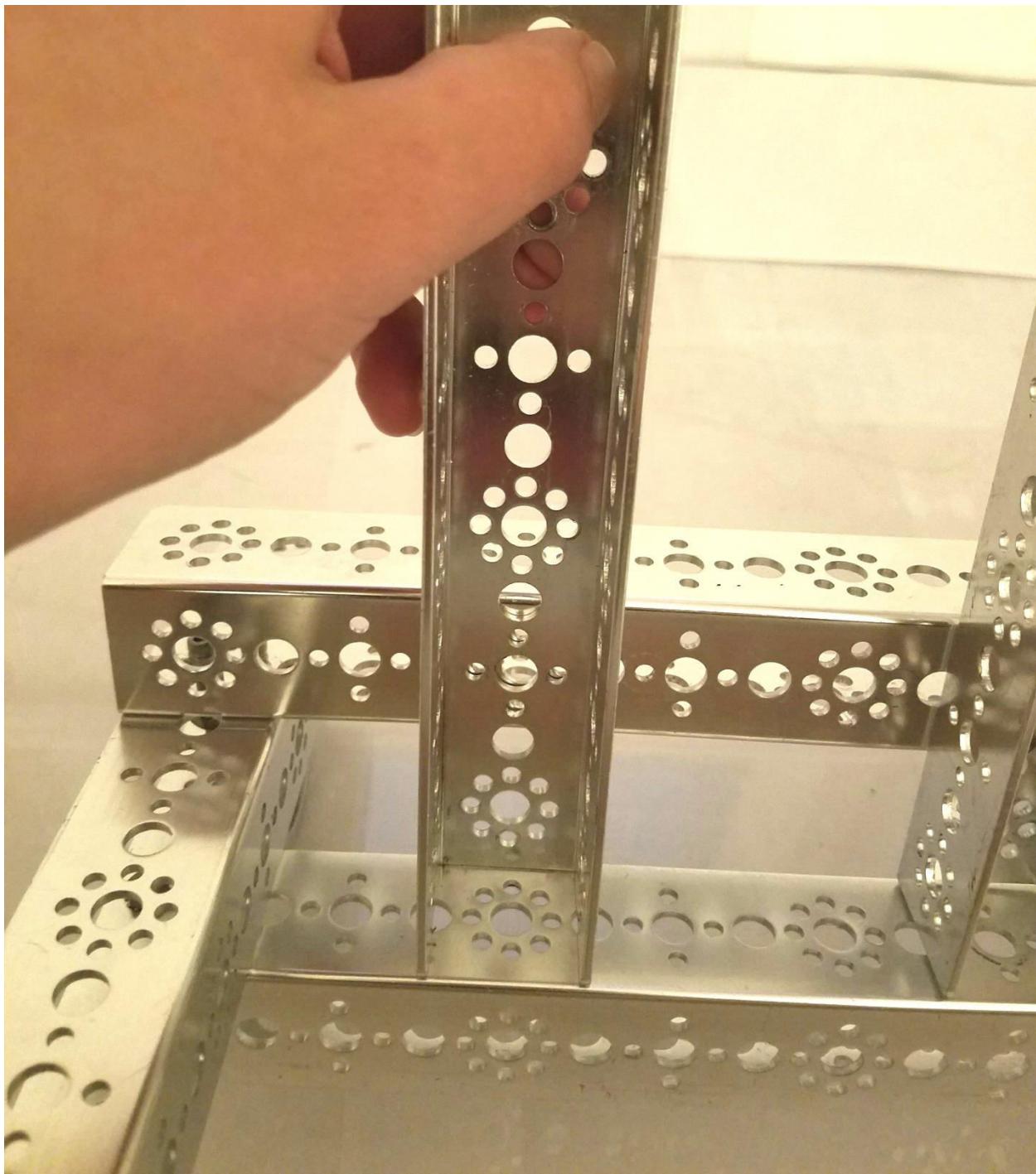
### **Step 3: Add the Central Tower**

**Parts:** 2 medium bars, 4 square brackets, 1 motor mount (with screws), 28 short screws, 1 L bar, 30 nuts

Flip over the frame so the motor bracket is down. On that side, put one medium bar two holes from the long bar. Use four screws and nuts to attach it to the medium bar behind it.



Place the next medium bar one hole from the edge.



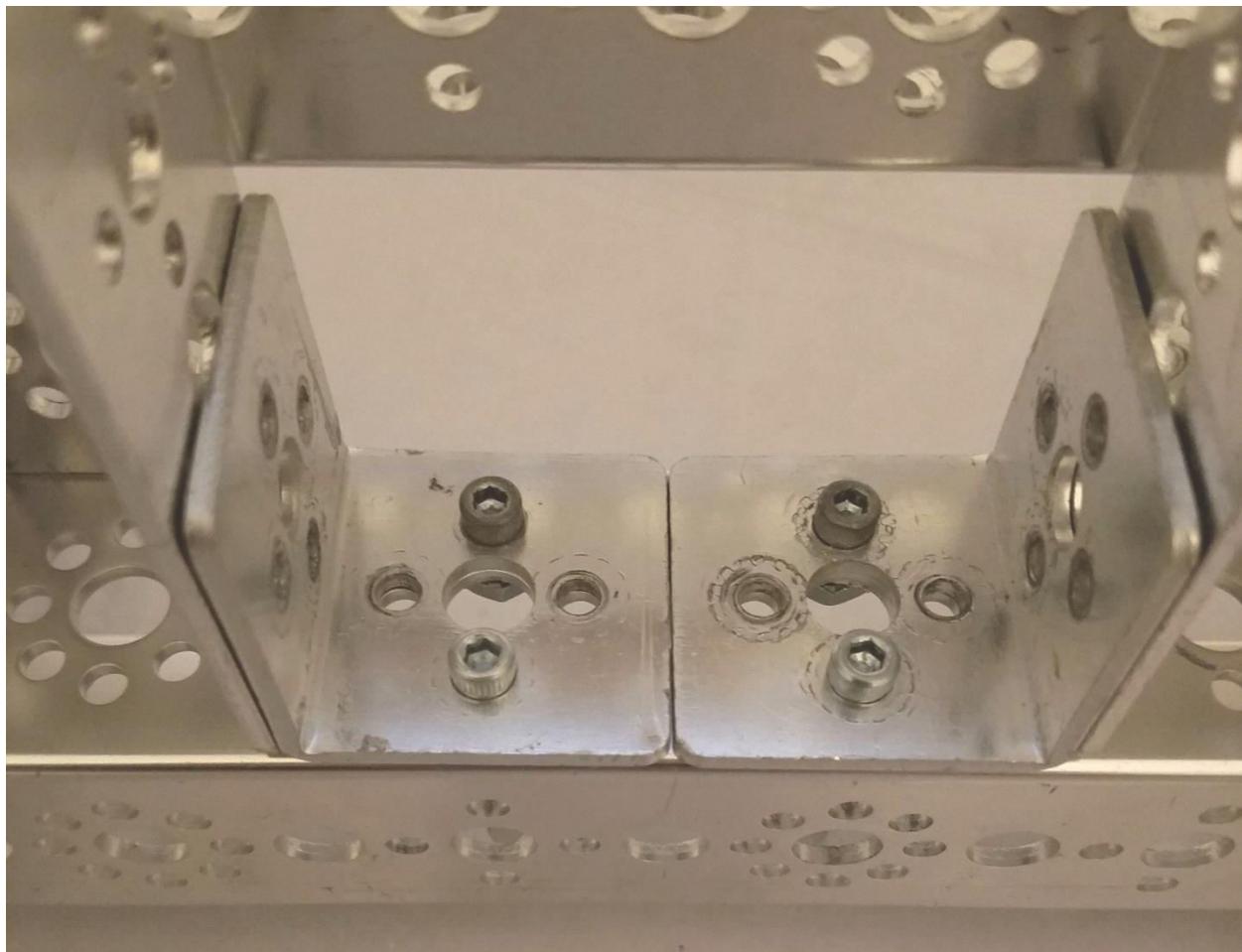
Screw it in the same as the other bar.



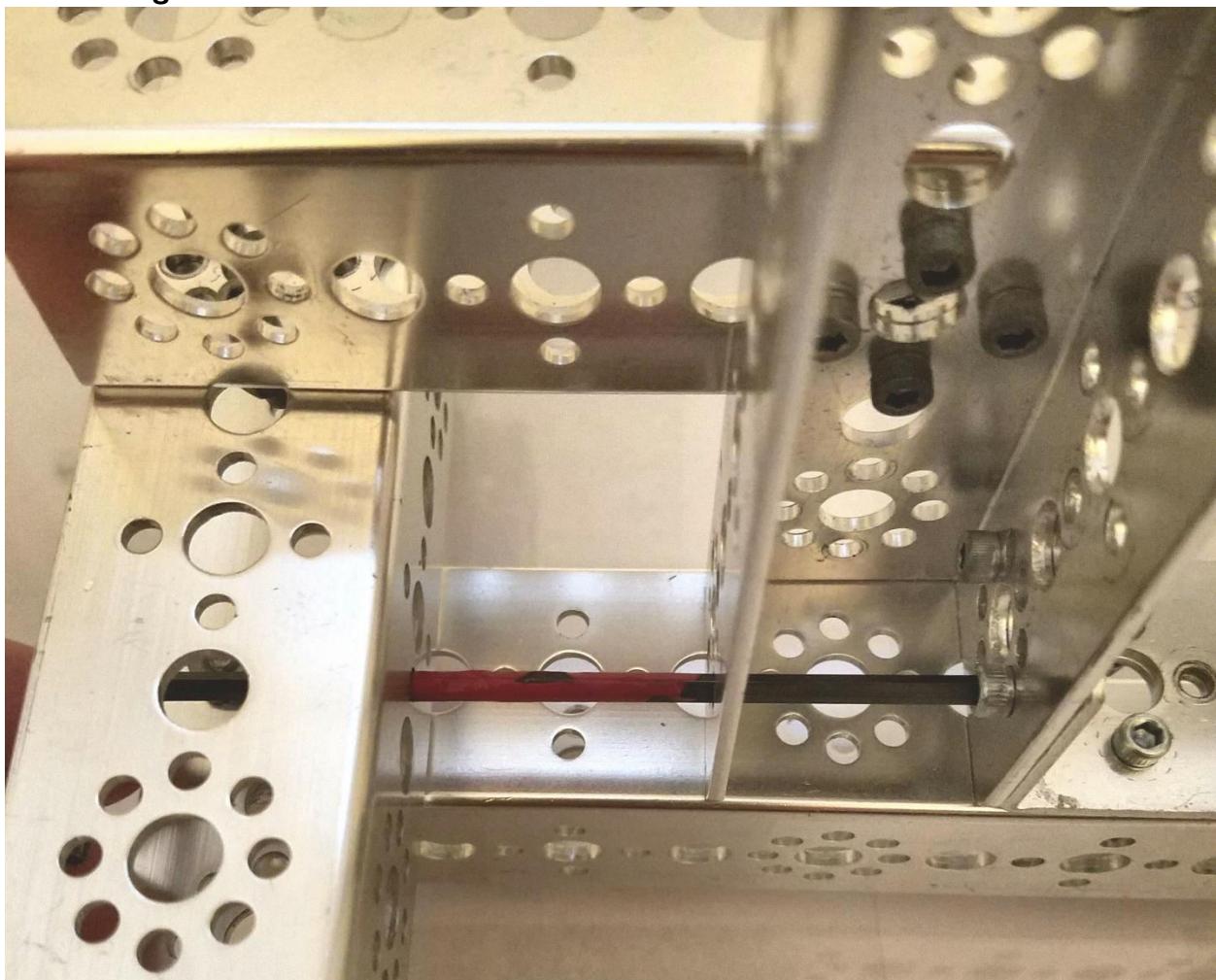
Put two square brackets between the two bars.



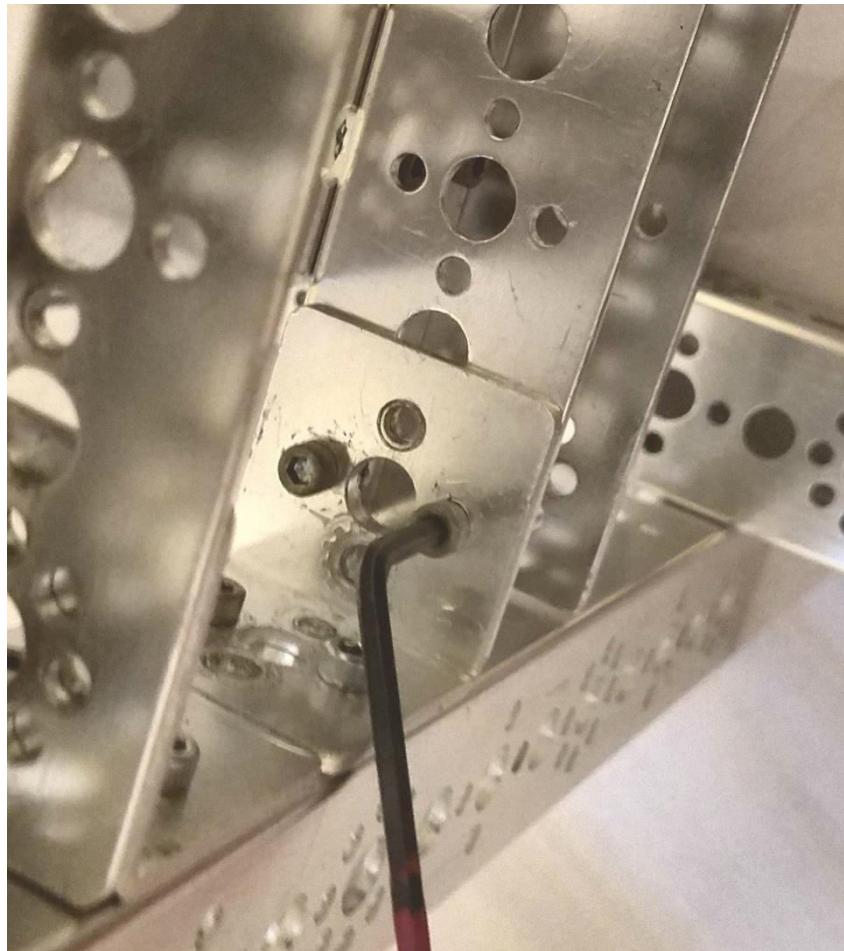
**Using two screws for each square brackets, screw the square brackets to the base of the robot.**



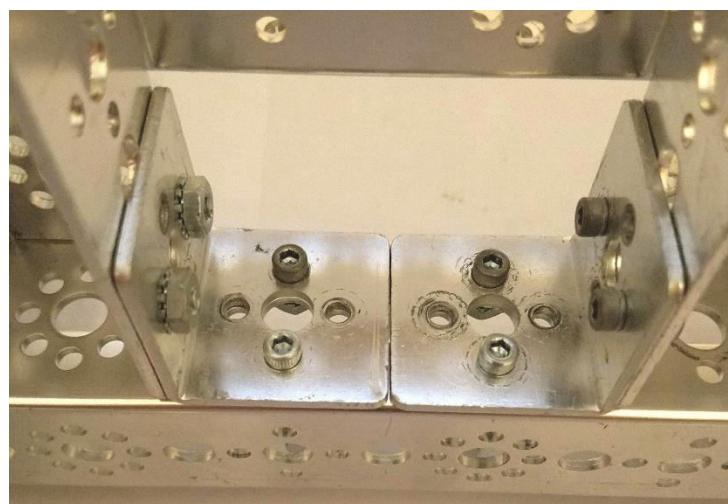
Next screw the left square bracket in upright medium bar with two screws (using nuts of course). You can run the red allen wrench through the bar on the side to make things easier.



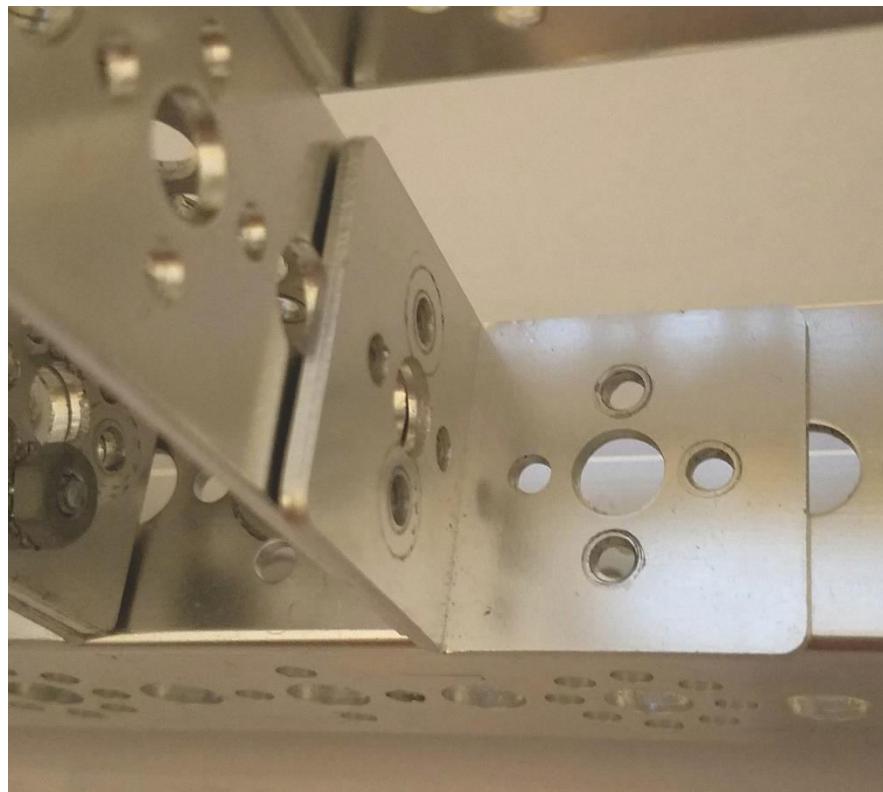
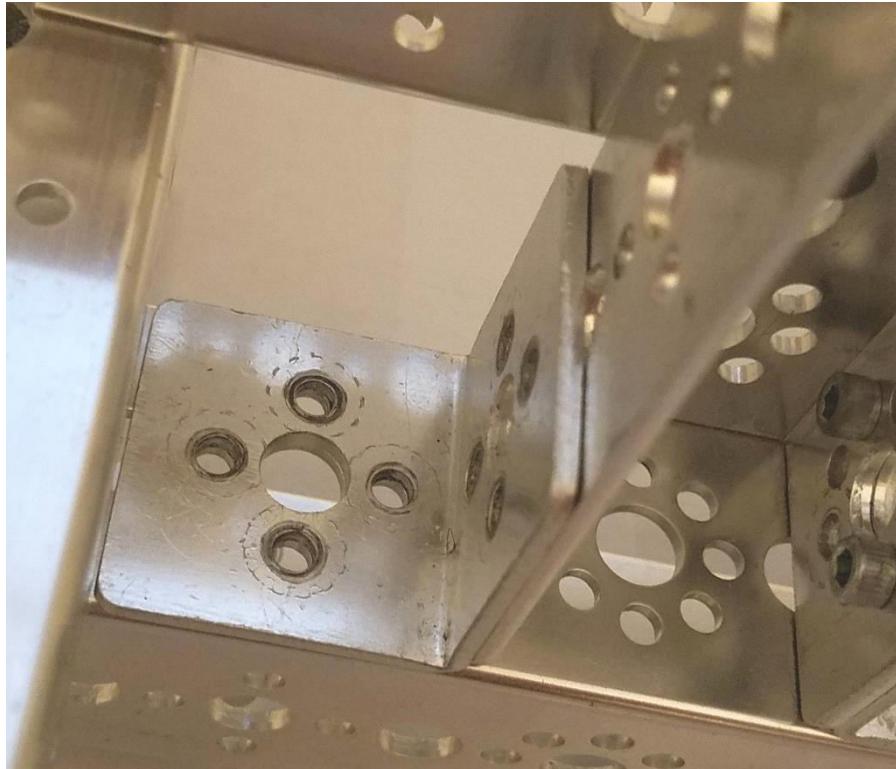
Screw the other square bracket into the upright medium bar. If your allen wrench is long enough, you can run it through like the left square bracket. Otherwise you can use the bent part of the allen wrench inserting the short side into the hole and rotating the long side like the picture.



It should look something like this.



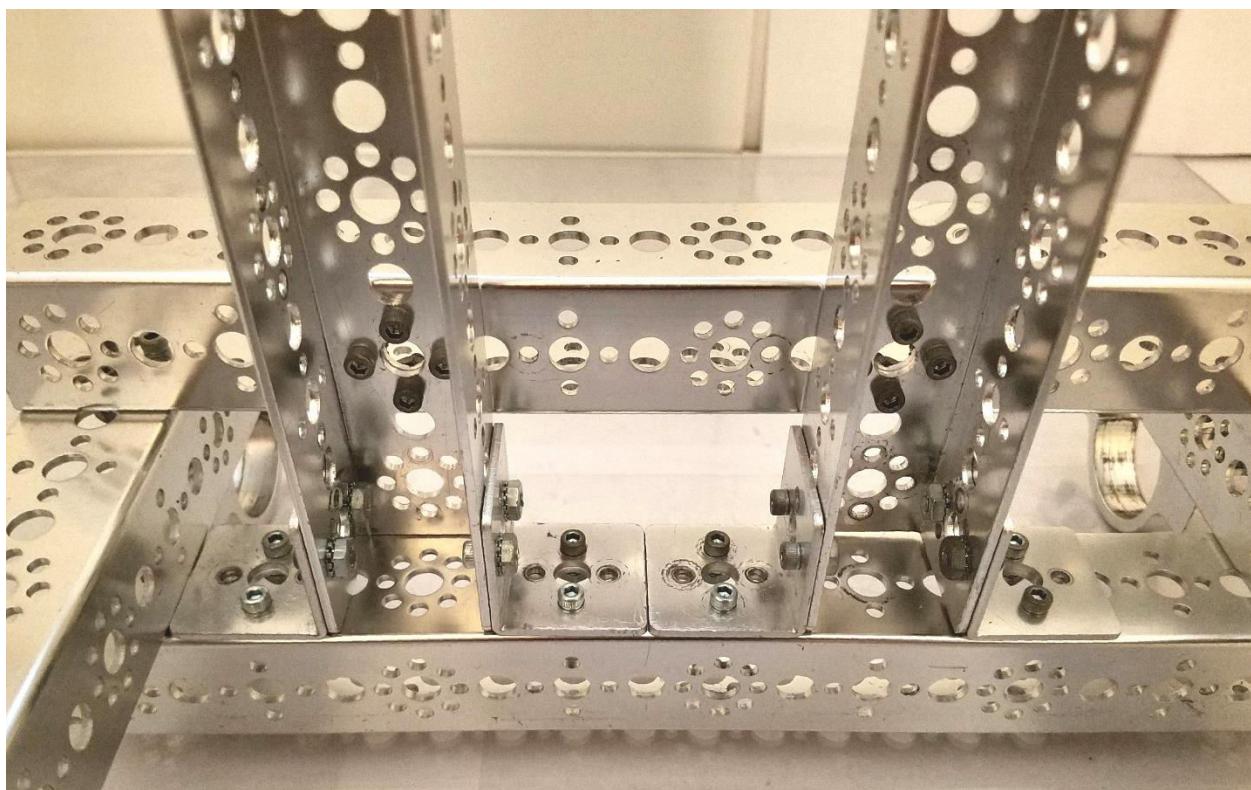
Place the other two square brackets on the other sides of the upright medium bars.



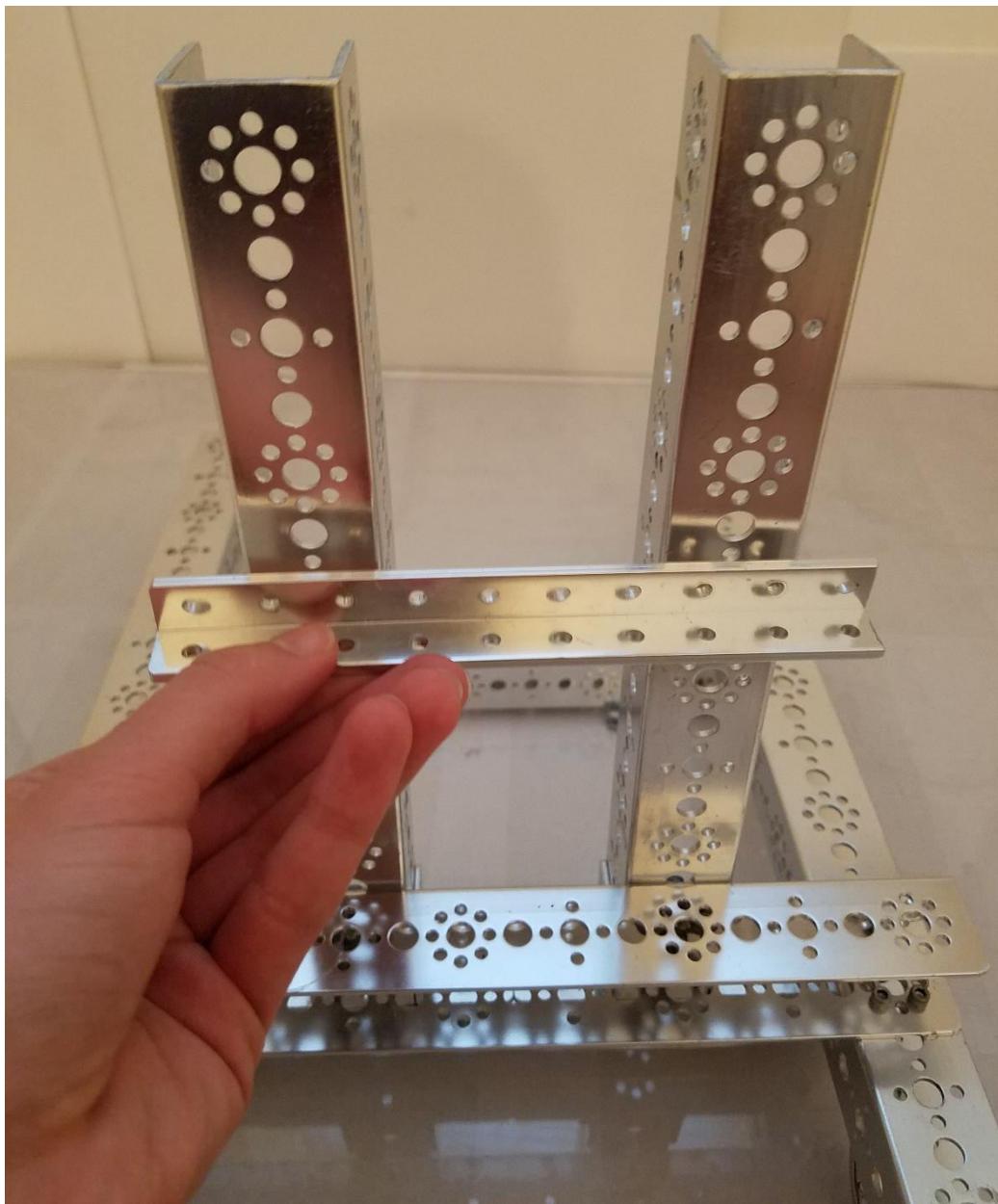
Screw in the brackets the same way you screwed in the ones in the center.

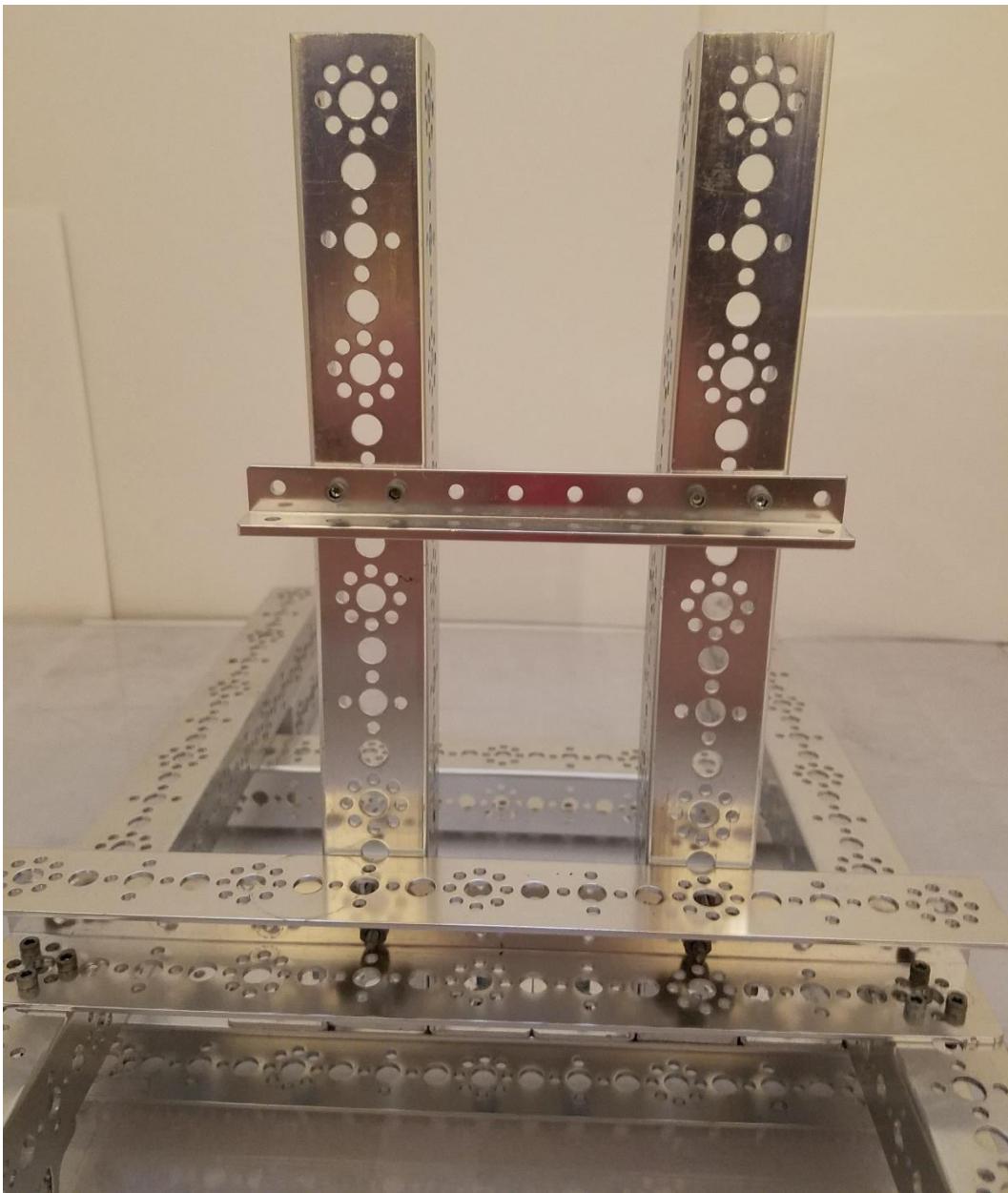


It should look something like this once you have completed all the steps so far.



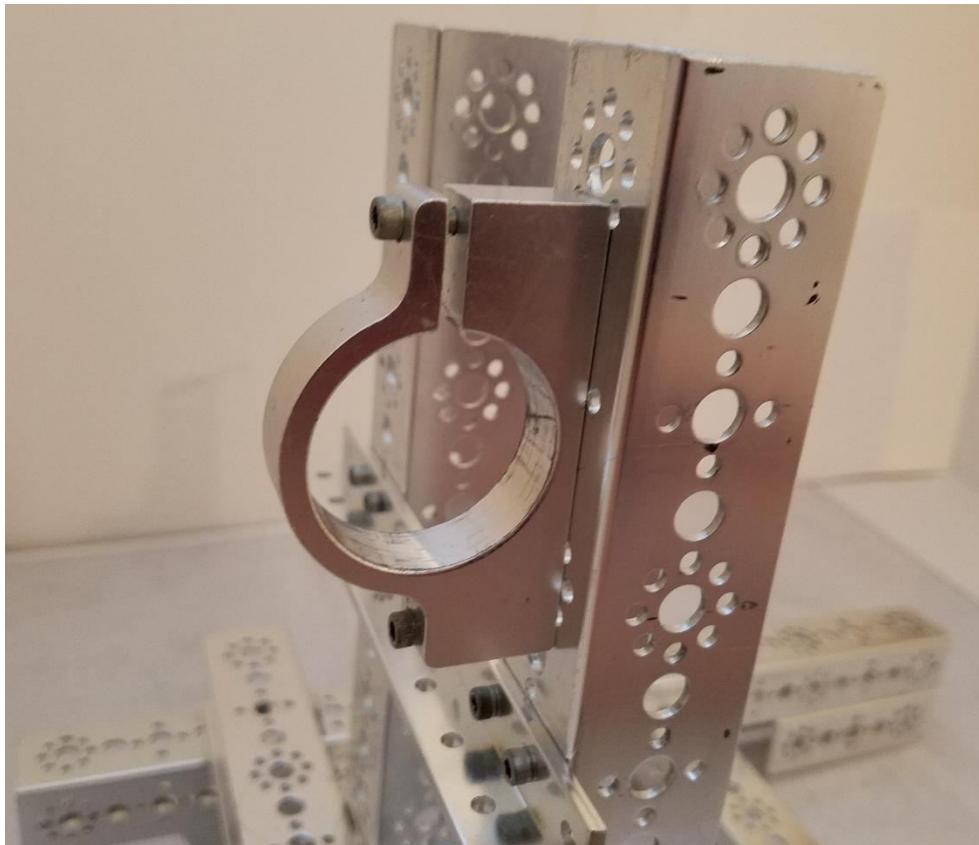
Attach the L bar between the two uprights. If the L bar is longer, don't worry just center it. Mount the L bar three holes down from the top and screw it in like the picture on the next page.



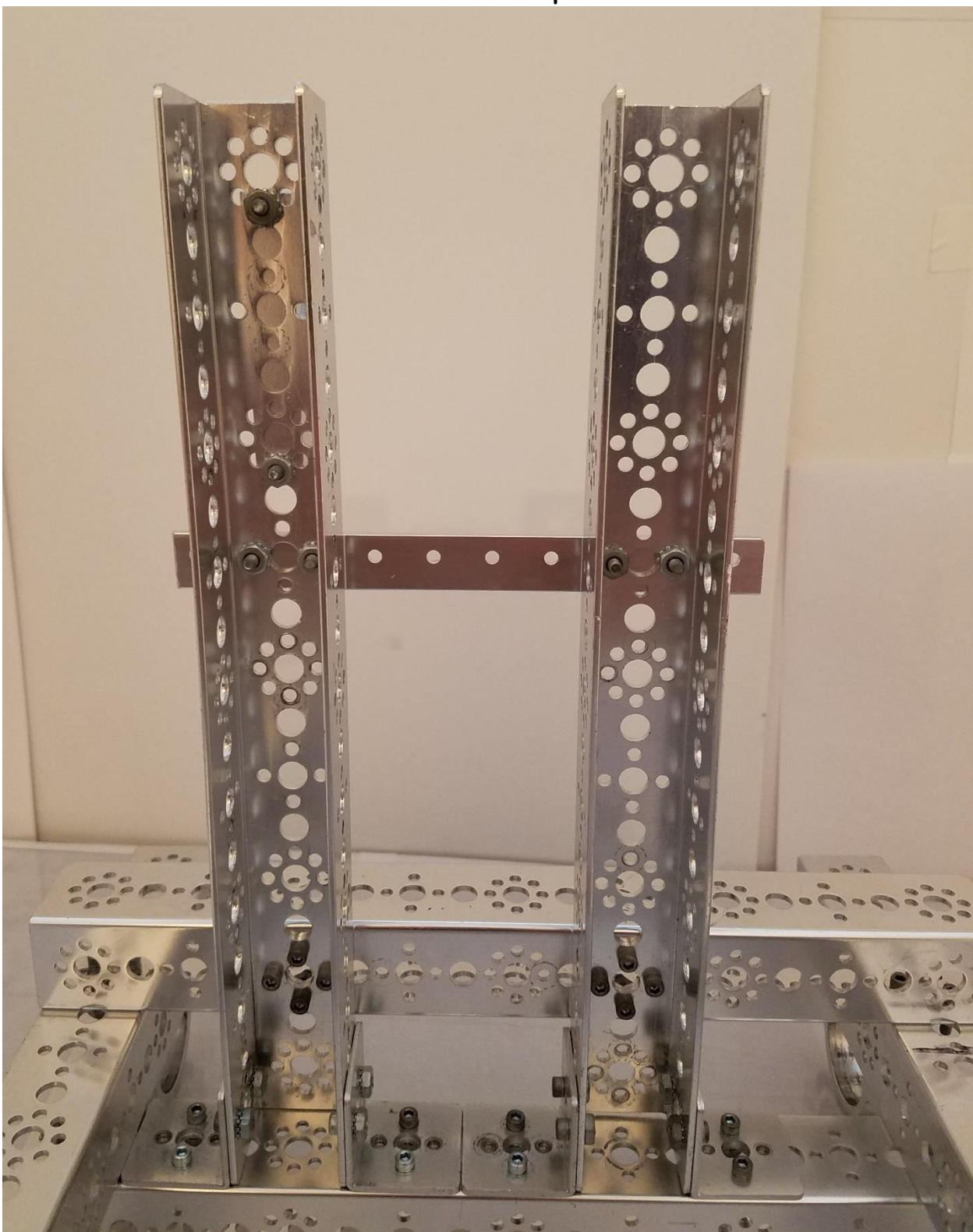


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Put the motor mount screws into the motor mount like you did last time with the motor mounts under the frame. Screw the motor mount onto the upright above the L bar like the picture provided. Do not tighten the longer screw all the way. That will come later.



This is how it should look at the end of this step.



## **Step 4: Assemble the Battery Holder**

**Parts:** 4 button heads, 4 short screws, 4 standoffs, 1 flat plate, red allen wrench (7/64), green allen wrench (5/64)

On the right side of the plate, use a short screw in the right most flower (a hole with eight screw holes around it) in the hole closest to you, to attach a standoff to the plate. (Not the next hole over, but the hole next to that do the same thing with another standoff and screw). It should look like this.



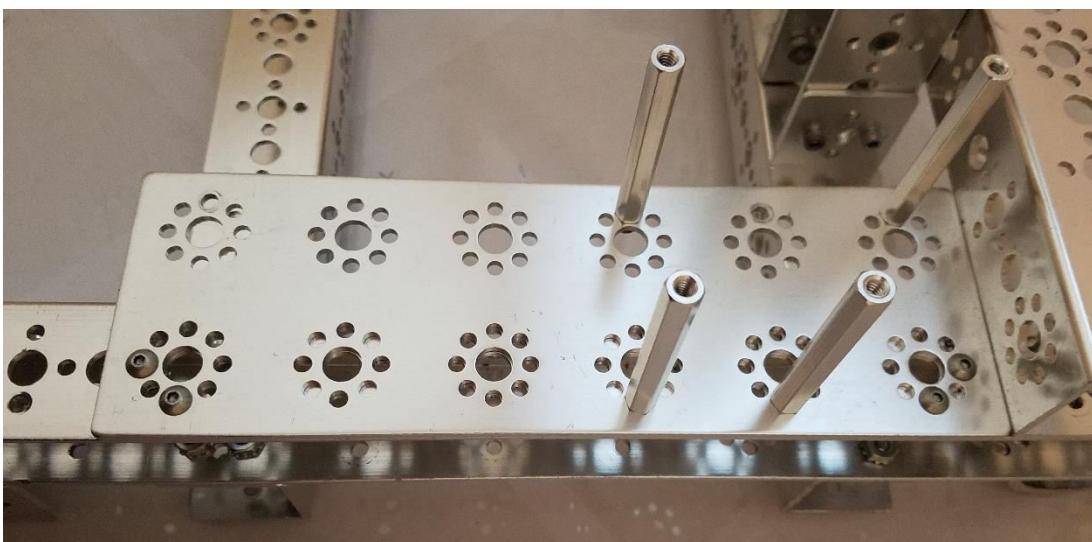
Next, we will put it on the robot.



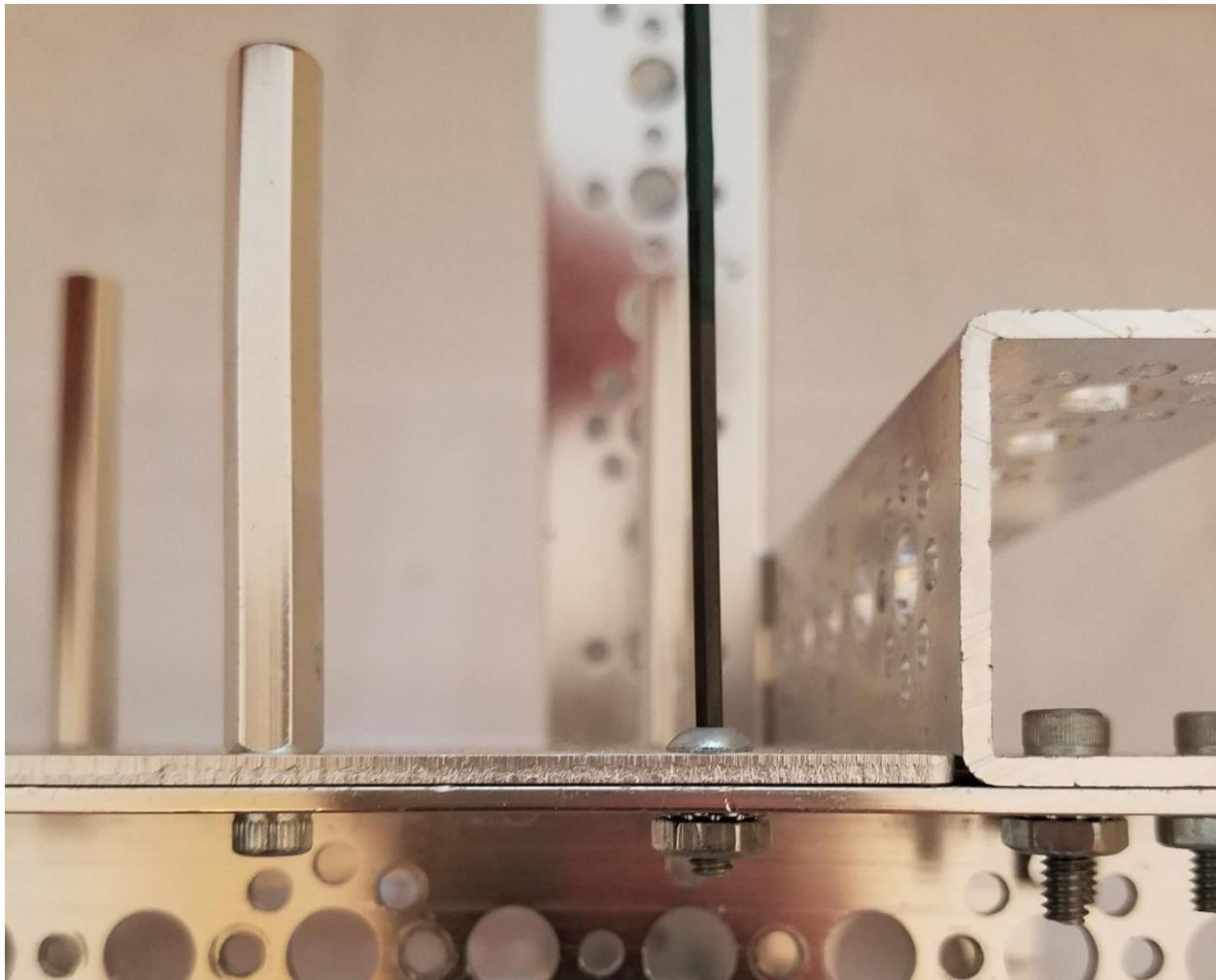
If the robot is facing you with the vertical bars in the back, place the plate on the right side with the existing standoffs closer to the center and the back. Next add the other two standoffs with the short screws running the red allen wrench through like the picture.



These should be mounted to look like the picture below. The first added standoff should be across from the standoff you added that is the closest forward. The second goes on the hole to the right of the standoff you just added on the screw hole furthest from the center of the plate like all of the other standoffs.



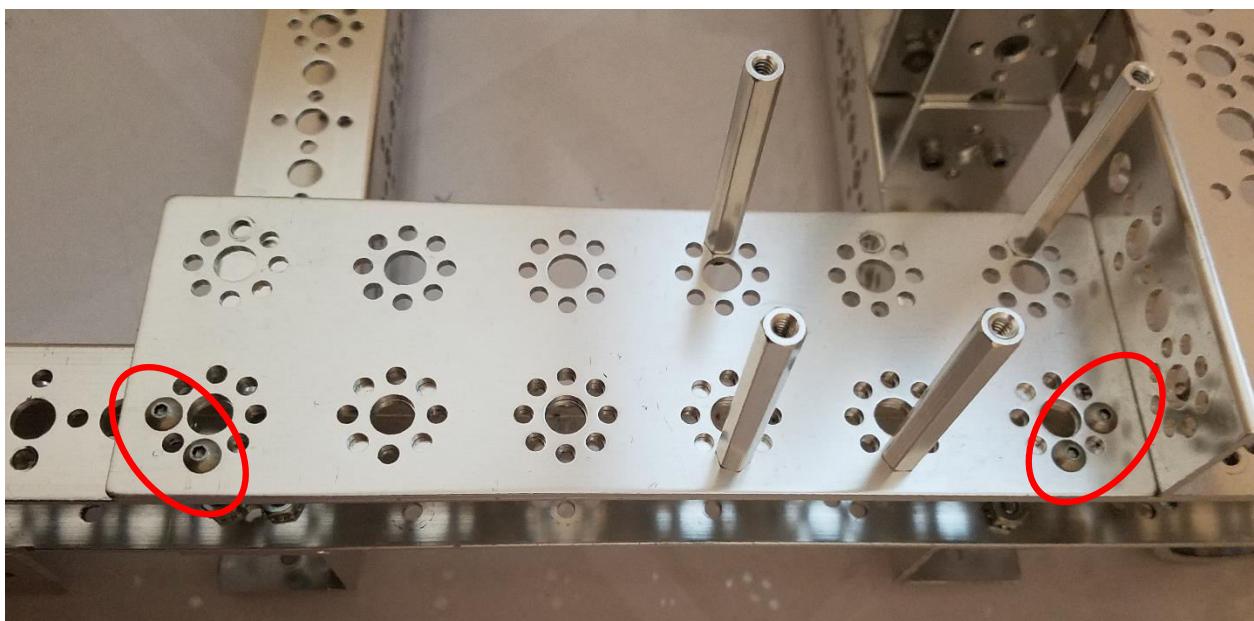
Next add two button heads diagonally in each corner with the green allen wrench with nuts securing them.



This is how the bottom should look.



When you are all done with this step, it should look like this picture.



This is where we will put the battery when we get to wiring the robot.

## **Step 5: Assemble the Phone Holder**

**Parts:** 1 three hole plate, 1 two hole plate, 2 u brackets, 9 nuts, 4 button heads, 5 short screws, red allen wrench (7/64), green allen wrench (5/64)

Use two button heads to mount one of the two hole plate to one side of the u bracket so the side is extended upward like the picture.



Next, use two button heads and screws to attach the u bracket to the frame of the robot like the picture below. This should be on the left side of the robot if the robot is facing you. The large holes should not line up so the u bracket extends past the bar of the base.

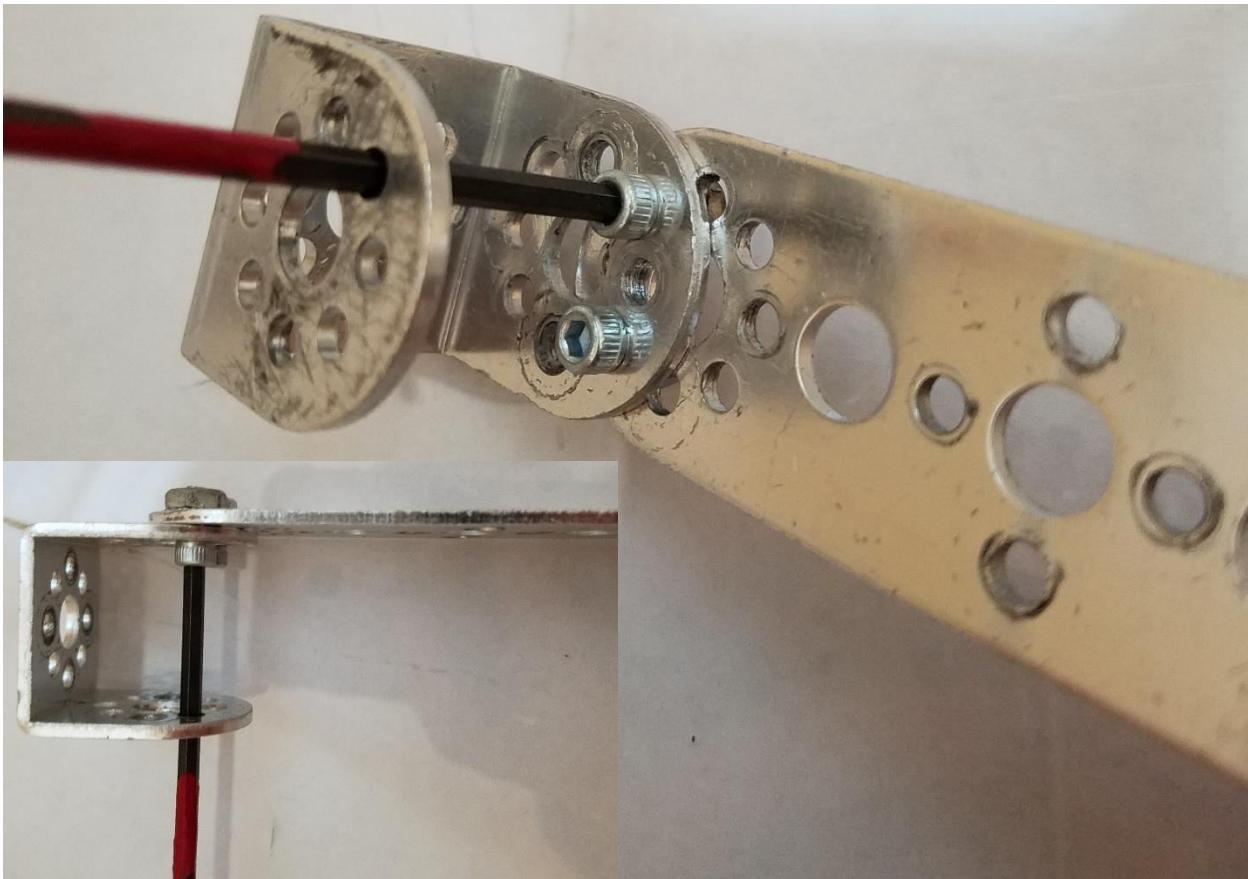


Here is a picture of the overlap=>

Screw into the red holes.



Attach the other u bracket to the three hole plate like the image with two short screws. They should be attached with the same overlap you attached the last u bracket to the base.



Now attach this three hole plate to the left upright bar (if the robot is facing you) one hole down from the L bar with three short screws like this.



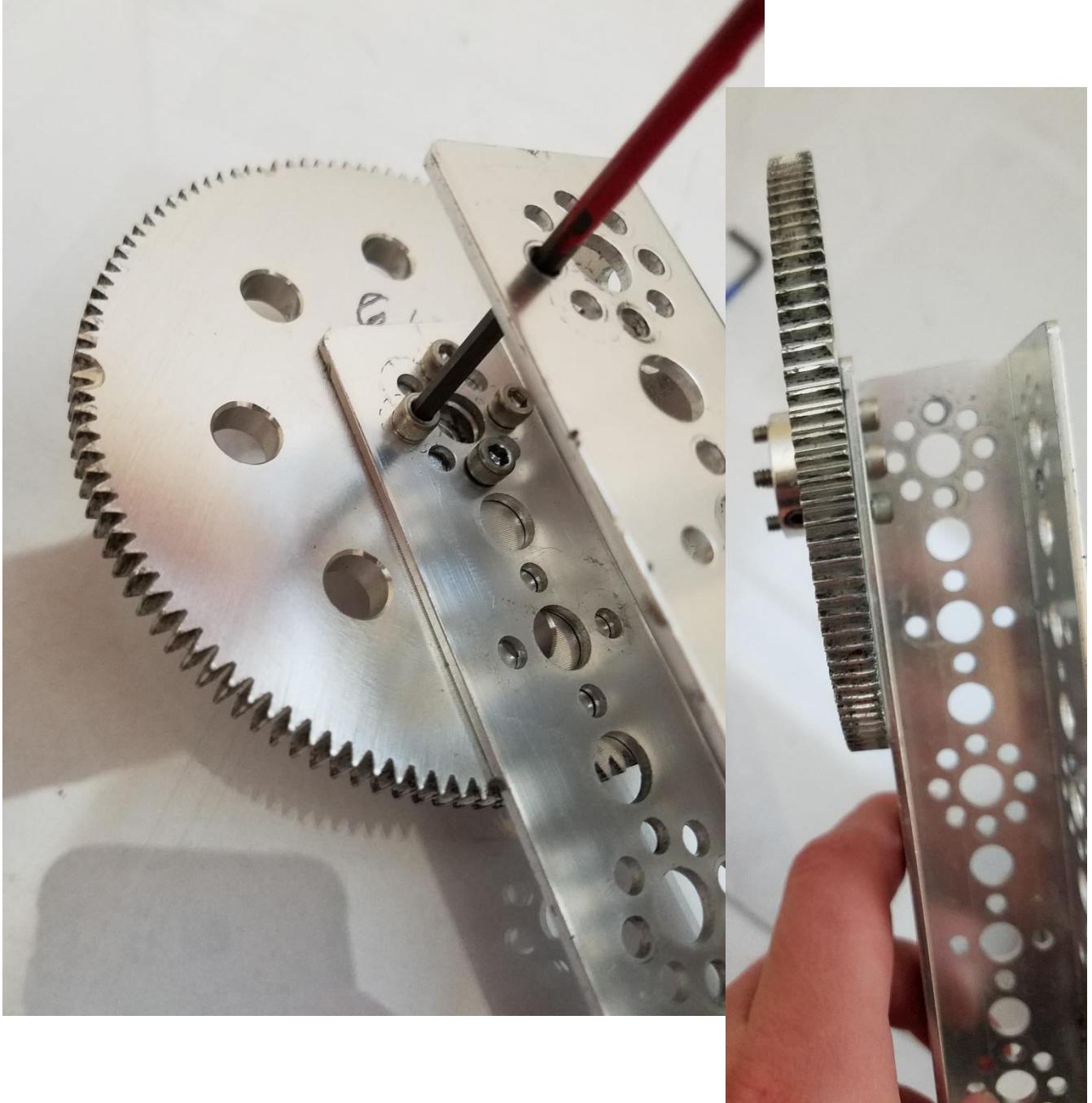
It should look like this once it is completed. This is where the robot controller phone will go.



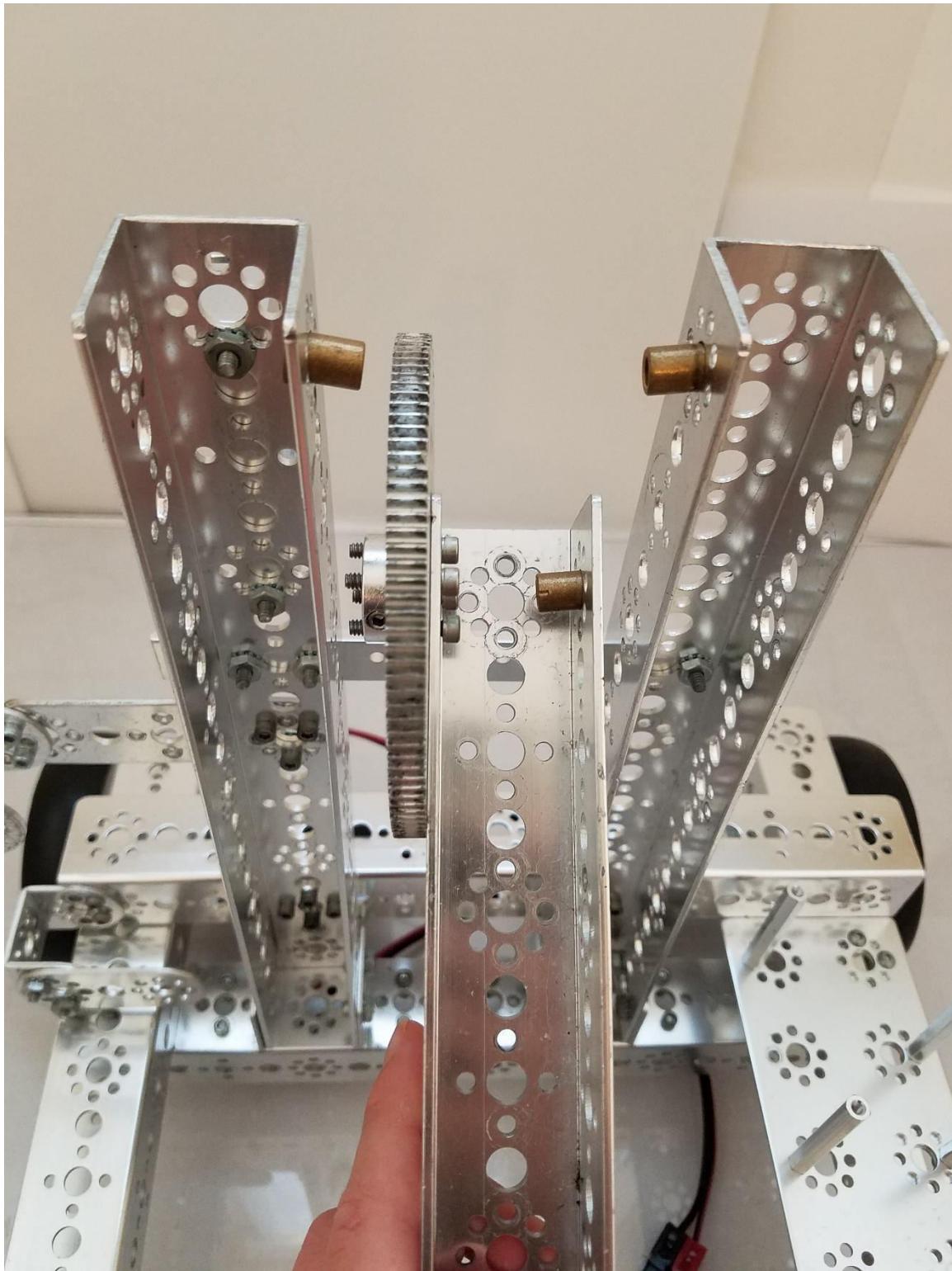
## Step 5: Put on the Arm

**Parts:** 8 regular screws, 1 large gear, 1 small gear, 3 bushings, 1 axle, 1 long bar, 1 axle hub, 1 motor hub, 1 motor, 2 axle collars, blue allen wrench (3/32), red allen wrench (7/64)

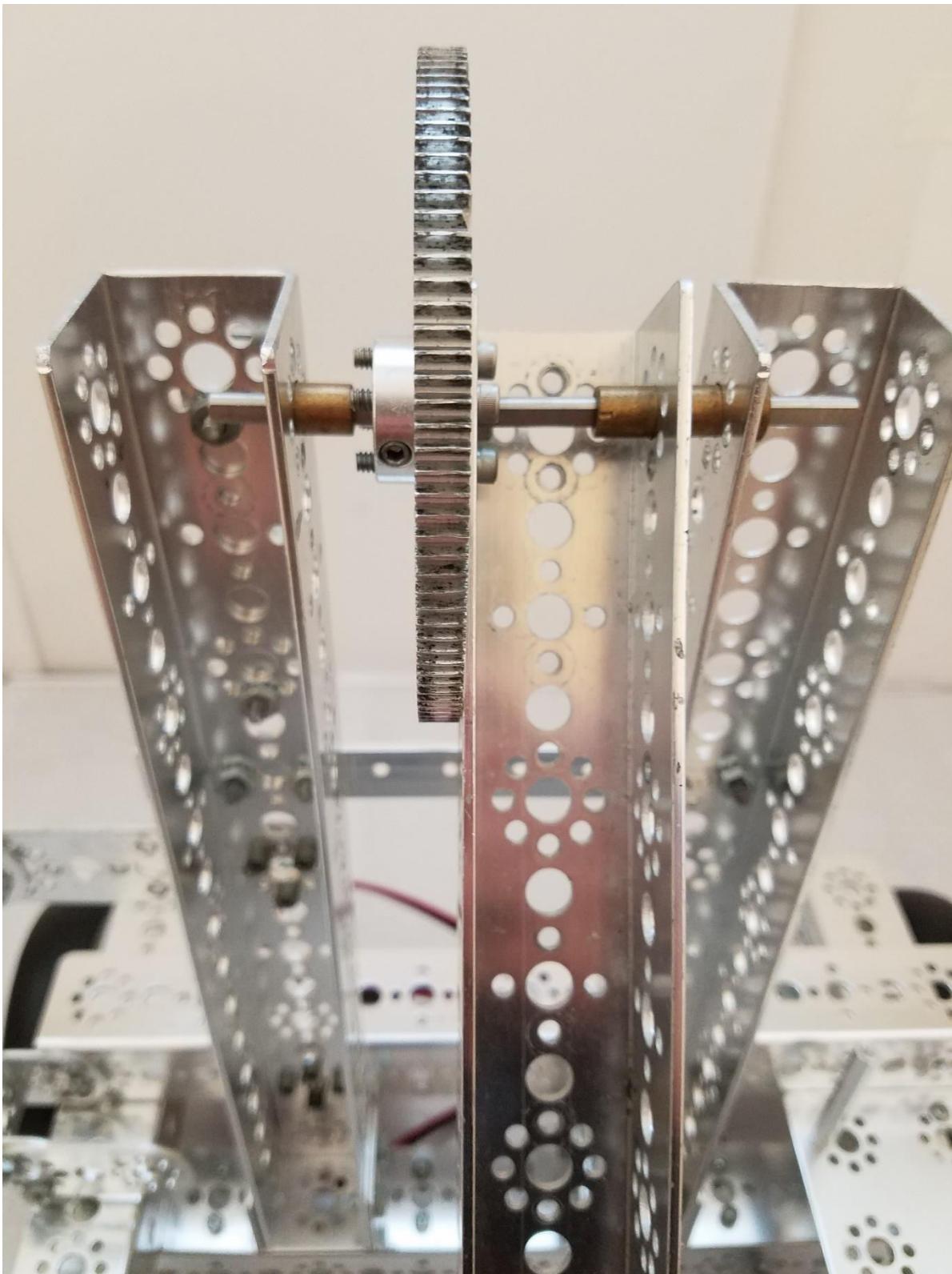
\*Use 4 regular screws and the long bar oriented with the open side facing up. Put the four screws in the top hole, then put the gear and instead of using nuts, use an axle hub to keep the screws in position.



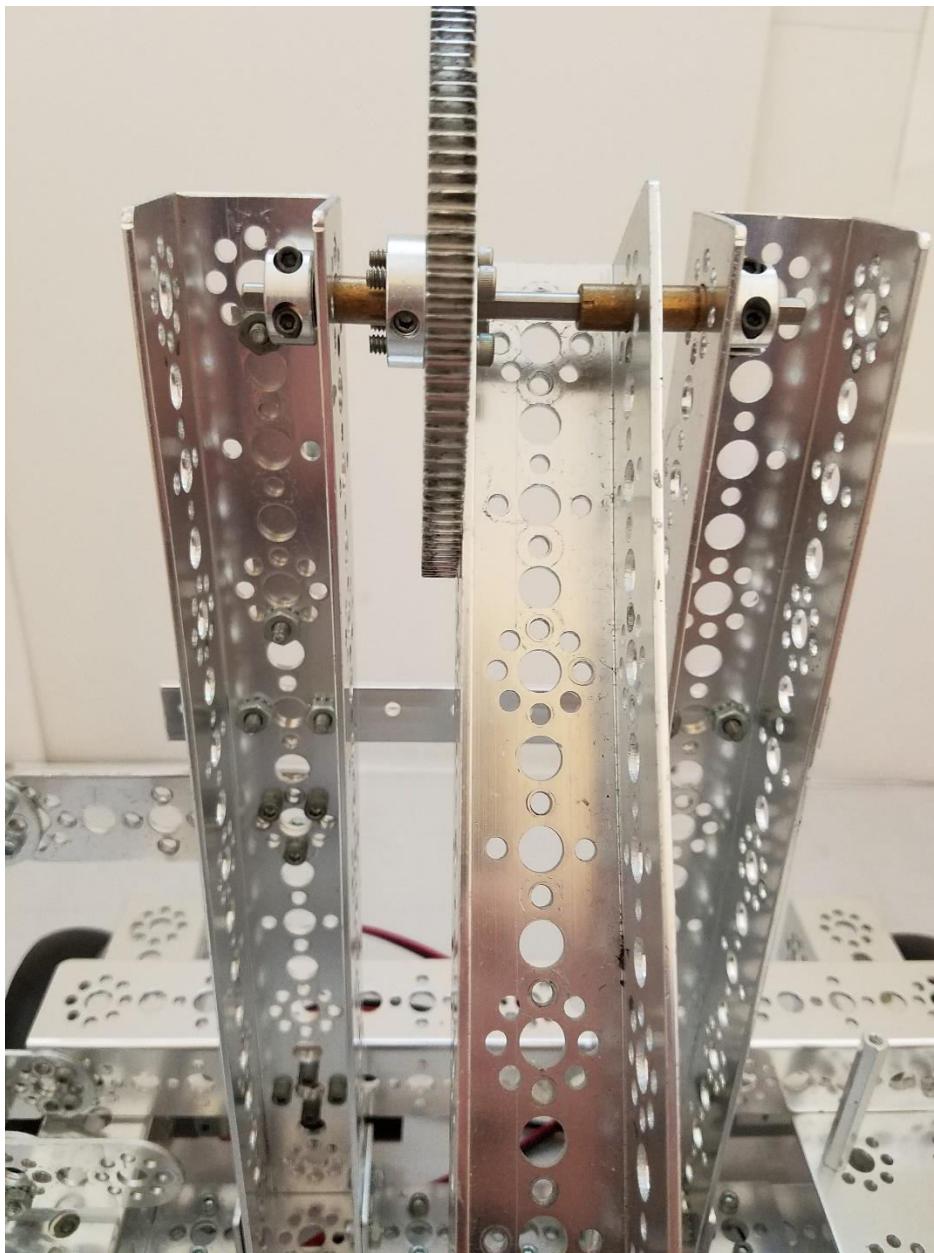
Next, put a bushing on each vertical bar on the top hole into the middle so the longer part is in the middle and the little ledge is in the middle of the bar. Add one more on the bar with the gear across from the gear. It should look like the picture below.



Then, put an axle through all the bars where the bushings are positioned. It should go completely through all the bushing leaving a little space on each side.



To complete the mounting of the arm, add two axle collars, one on each side and tighten. Remember if they have a set screw to align the set screw with the flat side of the axle. Center the arm and tighten the set screw of the axle hub with a blue allen wrench (3/32) making sure the set screw is on the flat side of the axle. It should look something like this and neither the arm, nor the axle should be able to slide.



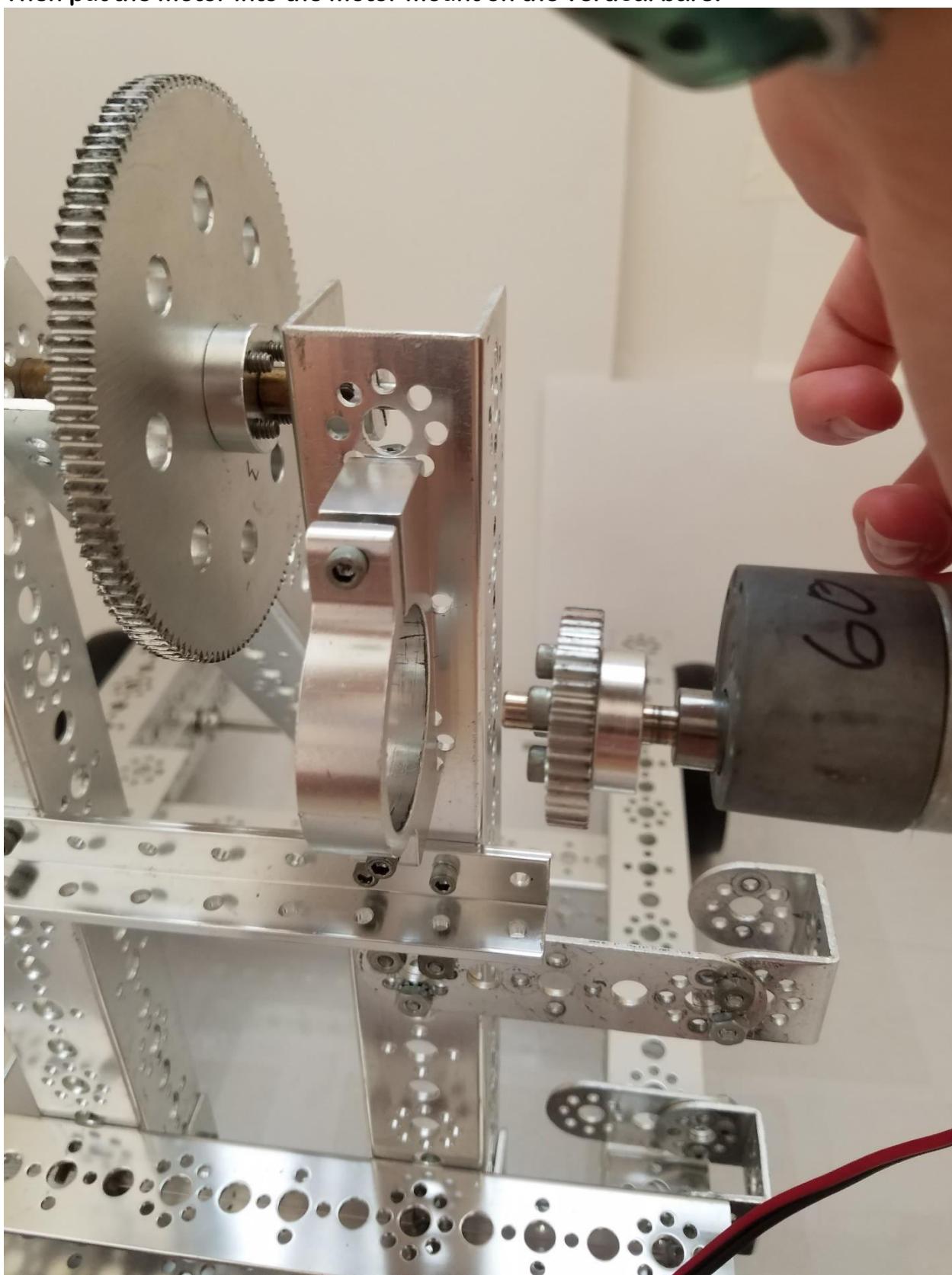
Use four regular screws and attach the small gear to a motor hub. The part of the motor hub that sticks out should go into the gear, so the outside is flush (apart from the screws). Then put this onto the motor as shown.

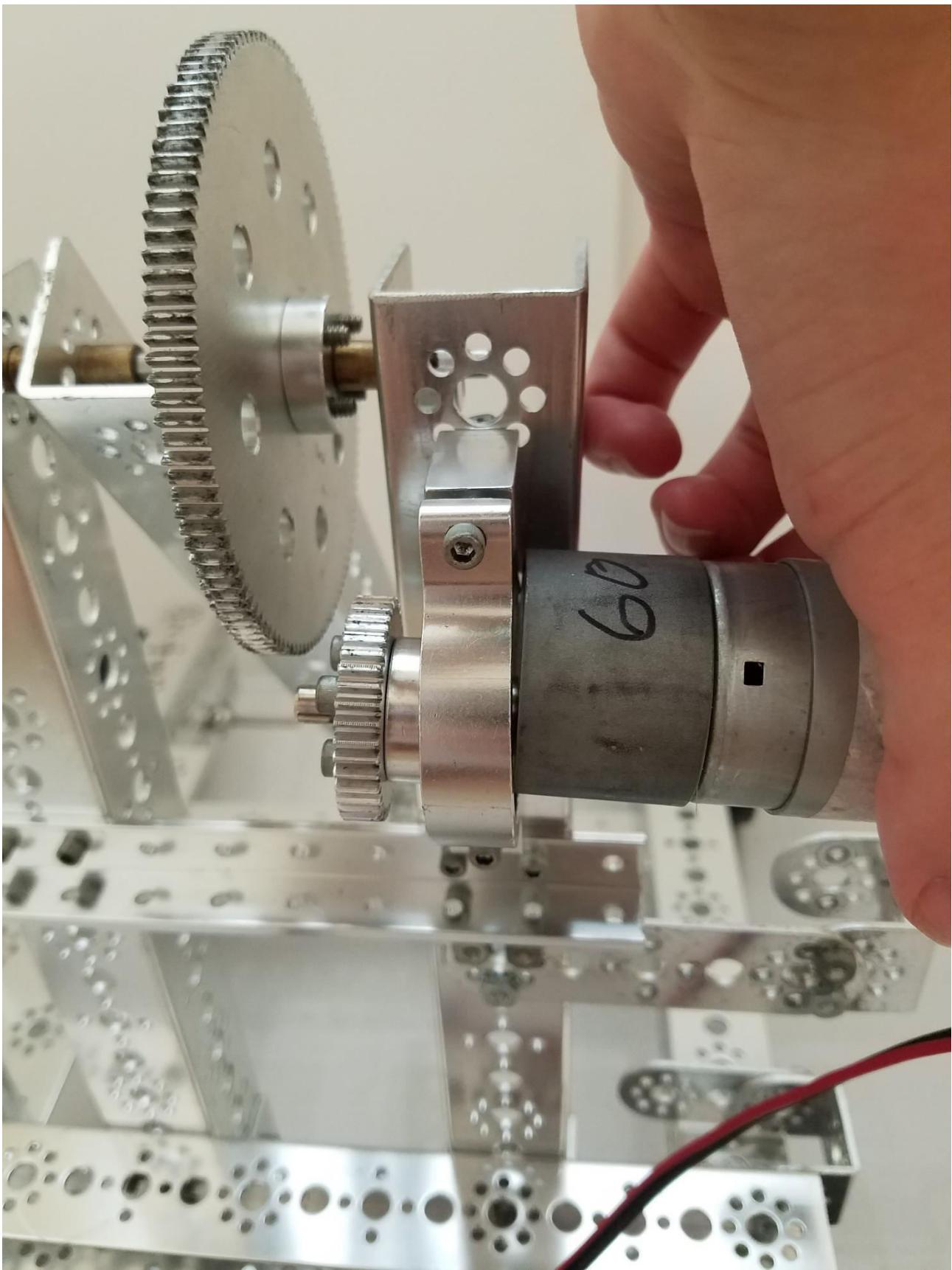


Next, find the set screw or little screw in the motor hub. Align the set screw and the flat side of the motor shaft. Use the blue allen wrench (3/32) to tighten the set screw. If the set screw is not on the flat side, it will never get as tight and will make it easy for the hub to come off the motor, so put it on the flat side.



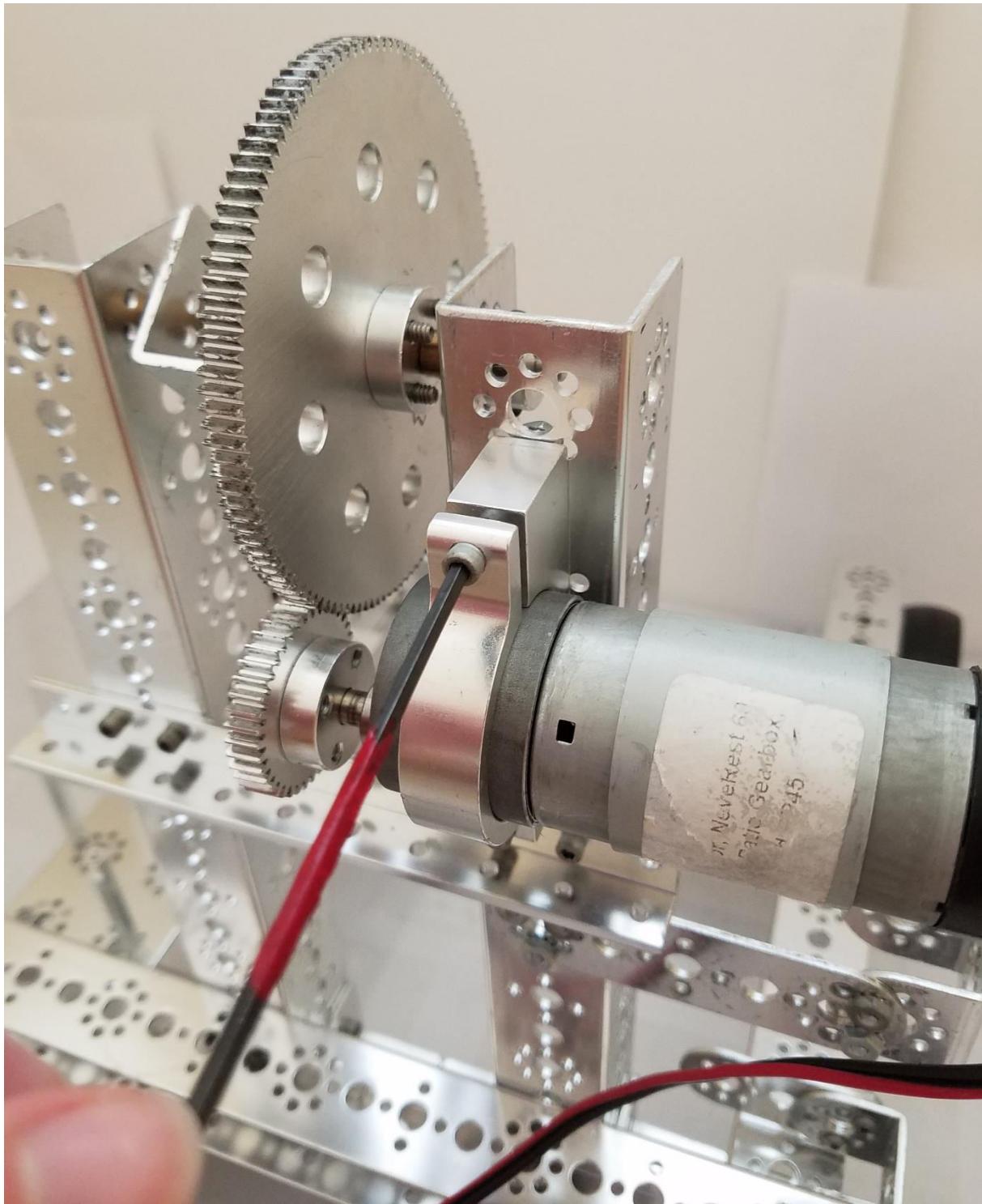
Then put the motor into the motor mount on the vertical bars.





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Rotate the motor until the gears mesh together. Use a red allen wrench (7/64) to tighten the long screw on the motor mount. It should be tight enough that the motor cannot be moved. If you had trouble getting the motor in, loosening the screw in the picture should help. The Tetrix motor will be harder to insert because the motor has a greater diameter, but it does fit.



## **Step 6: Put on the Wheels**

**Parts:** 16 regular screws, 2 motor hubs, 2 axle hubs, 2 regular wheels, 2 motors, 2 axles, 2 spaces, 2 axle collars, 4 bushings, red allen wrench (7/64), blue allen wrench(3/32)

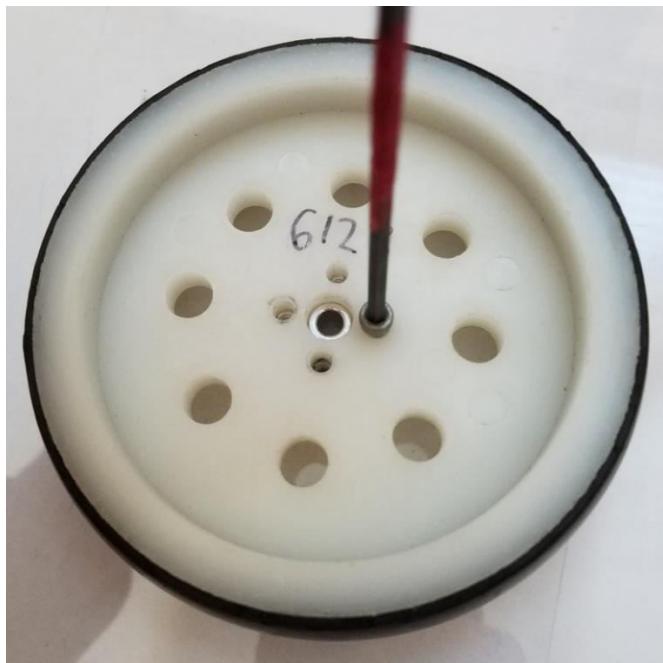
AND

2 regular wheels

OR

4 omni wheels

To assemble a regular wheel, use four regular screws, a motor hub and a regular wheel. Use the screws to attach the motor hub to the wheel. The motor hub is threaded so you will not use nuts. Repeat this with two wheels.



If you want omni wheels (recommended), you will sandwich the axle hub between two omni wheels. Have two screws attach the hub to one wheel and the other two attach the hub to the other wheel. The black wheels should be alternated like in the second picture. Two screws will go through one wheel and two will go through the other.

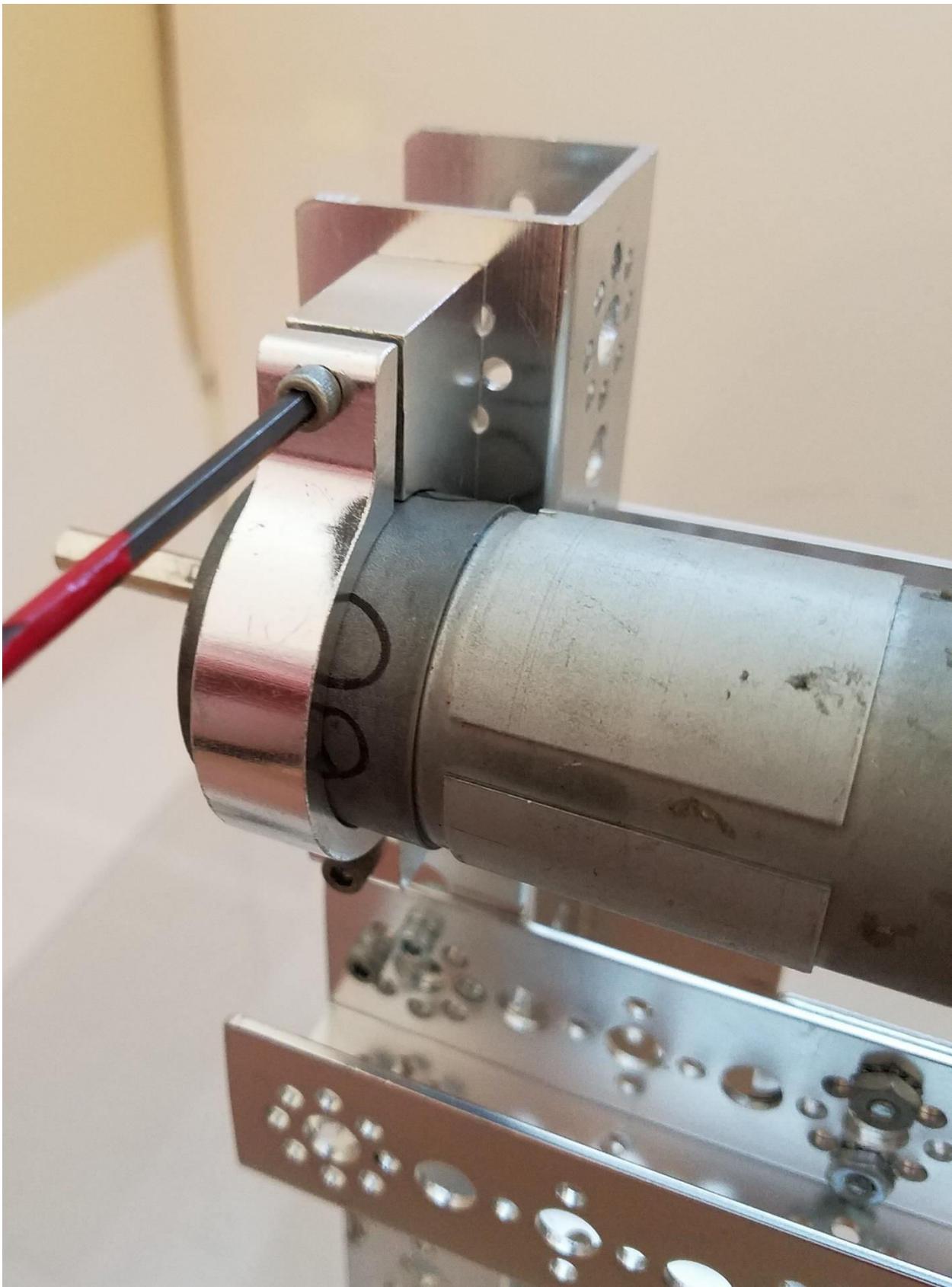


Otherwise, assemble the regular wheels like before but with axle hubs instead of motor hubs.

Either way, once you are done, you should have four wheels. Two with motor hubs, and two with axle hubs.

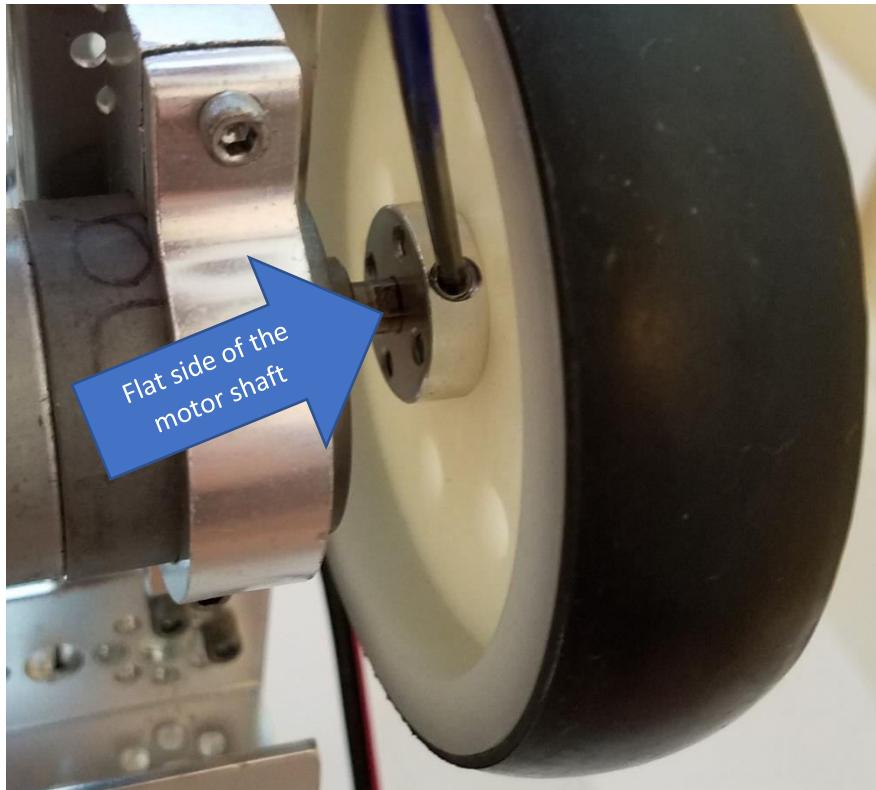
Next put the motors into the motor mounts under the robot. The motor shaft is not centered in the motor. As a result, the both the motors must be oriented in the same way. For this robot, rotate the motor so the motor shaft is as far up as it can go. If the motor is a clock, the shaft should be at 12 if the arm is up. Then tighten the longer motor mount screw. The motor should only be extended about a cm past the motor mount.



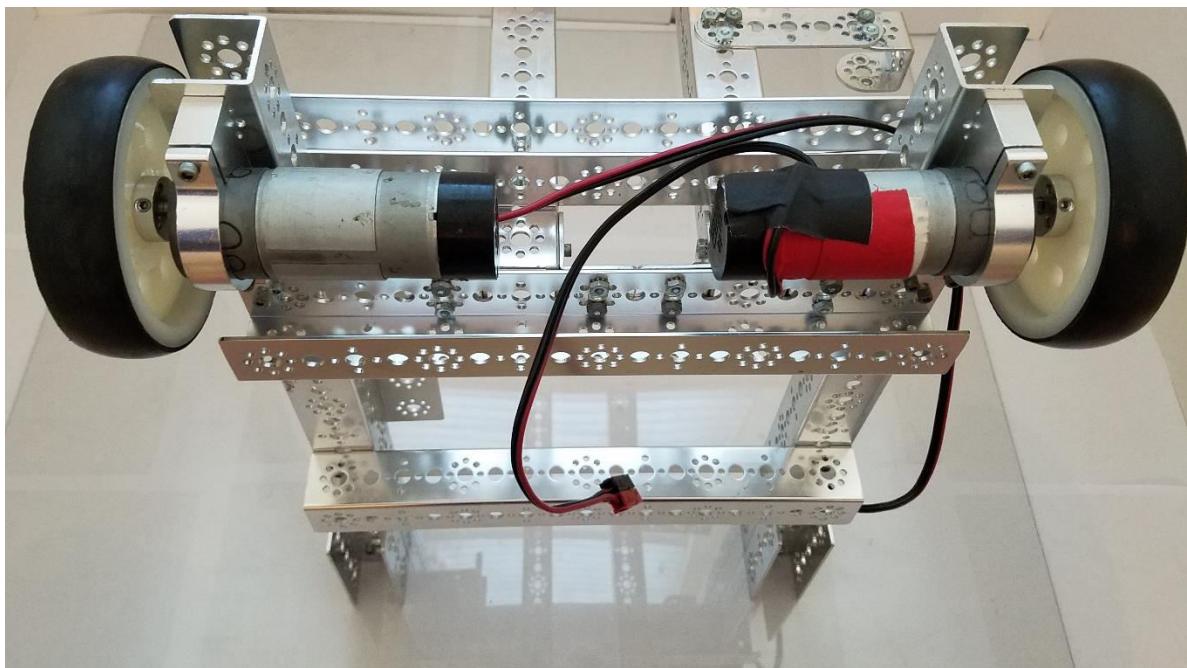


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Attach the wheels with the motor hub to the motor by putting it on the motor and tightening the set screw on the flat side of the motor shaft. Leave enough space to keep the wheel from scraping against the frame.



This is how it should look. Note the arm has not been added, there is more than one order to complete the steps.



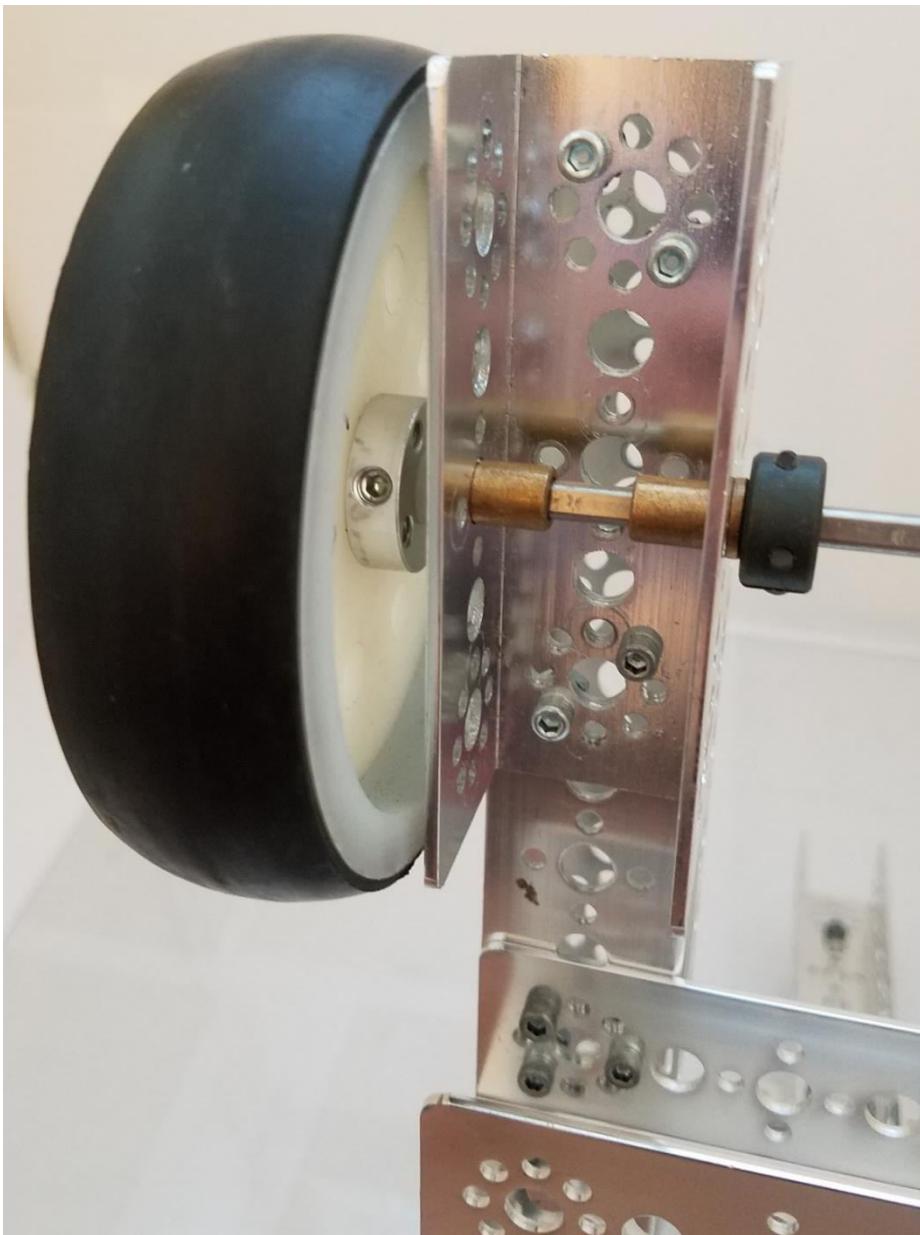
Next, we will mount the other two wheels. The regular wheels are pictured, but the mounting is the same with regular wheels and omni wheels. First attach the wheel to the end of the axle with the set screw on the flat side and without the axle extending outside the wheel. You want the axle flush with the screws or the plastic part of the wheel on the other side, so it does not catch on anything. Once the wheel is on, add a spacer and then a bushing. Repeat this process with the other wheel.



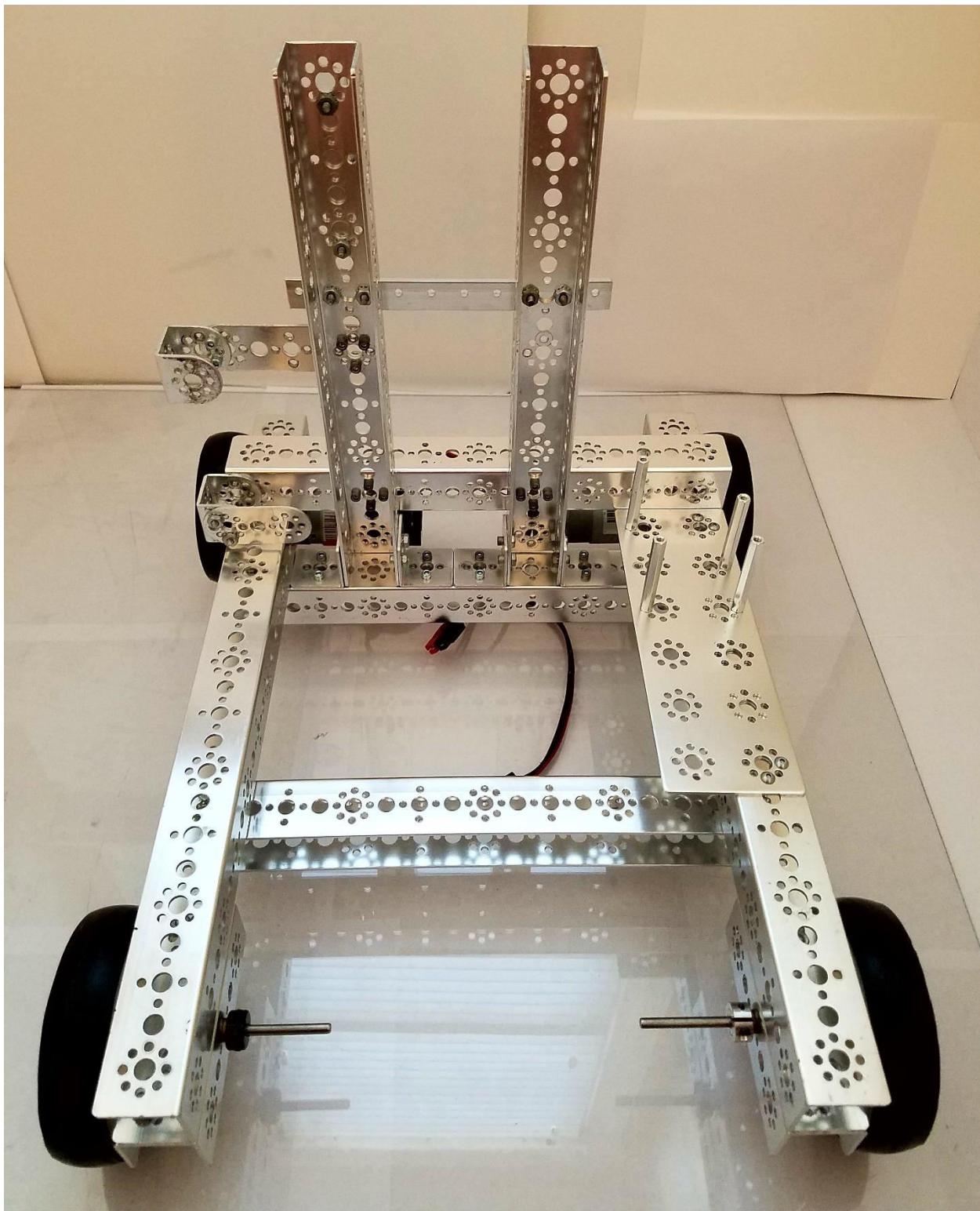
Insert the axle with wheel, bushing, and spacer into the middle hole of the small bars attached to the bottom of the robot. Put another bushing on the bar on the other side. It should look like this.



Finally, add an axle collar onto each axle to keep the wheel on. If the axle collar has a set screw, make sure it is tightened on the flat side.



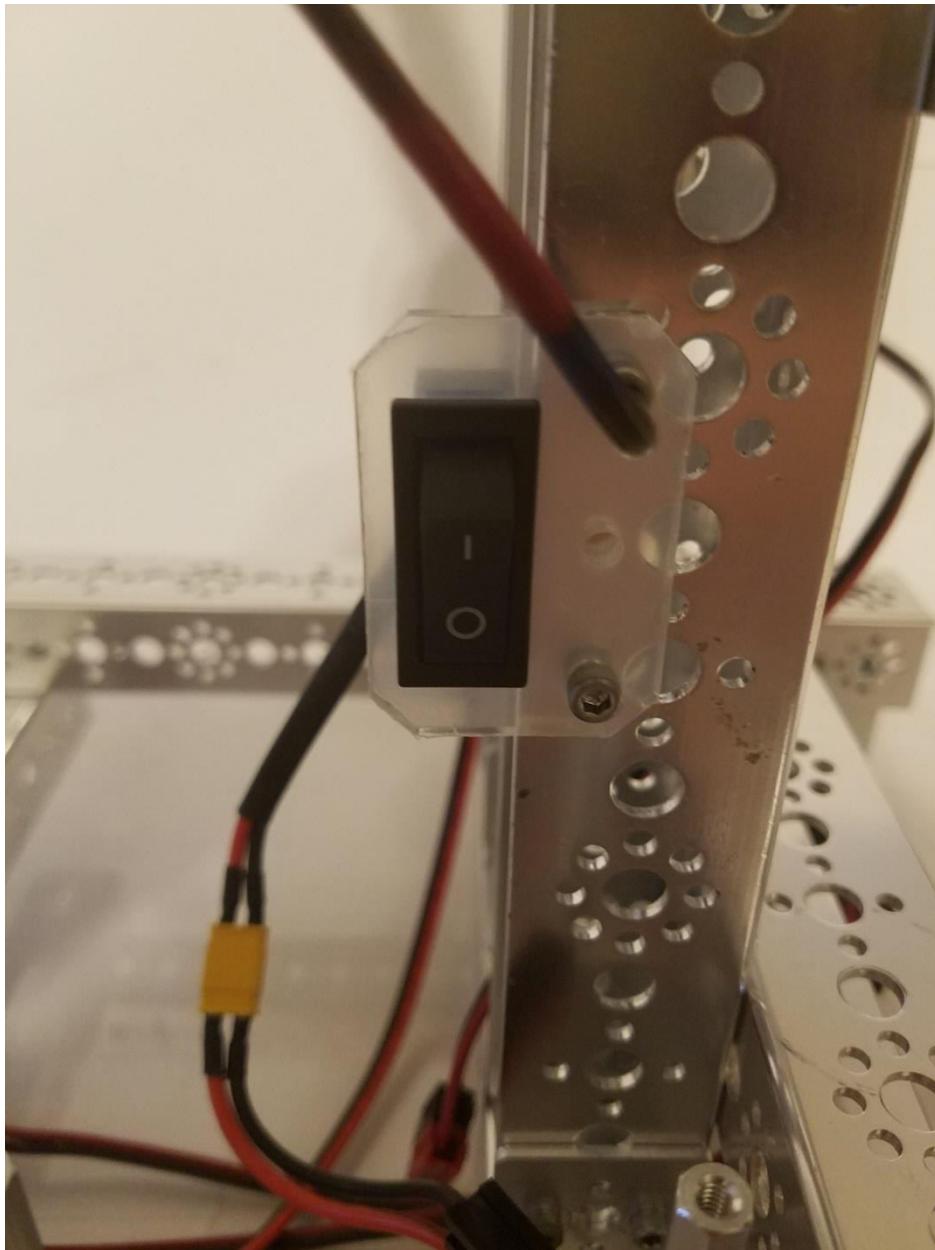
This is how the robot should look if the arm was not mounted yet. Again, the order of steps can be changed if you want. Anyway, this is how the wheels should be mounted.



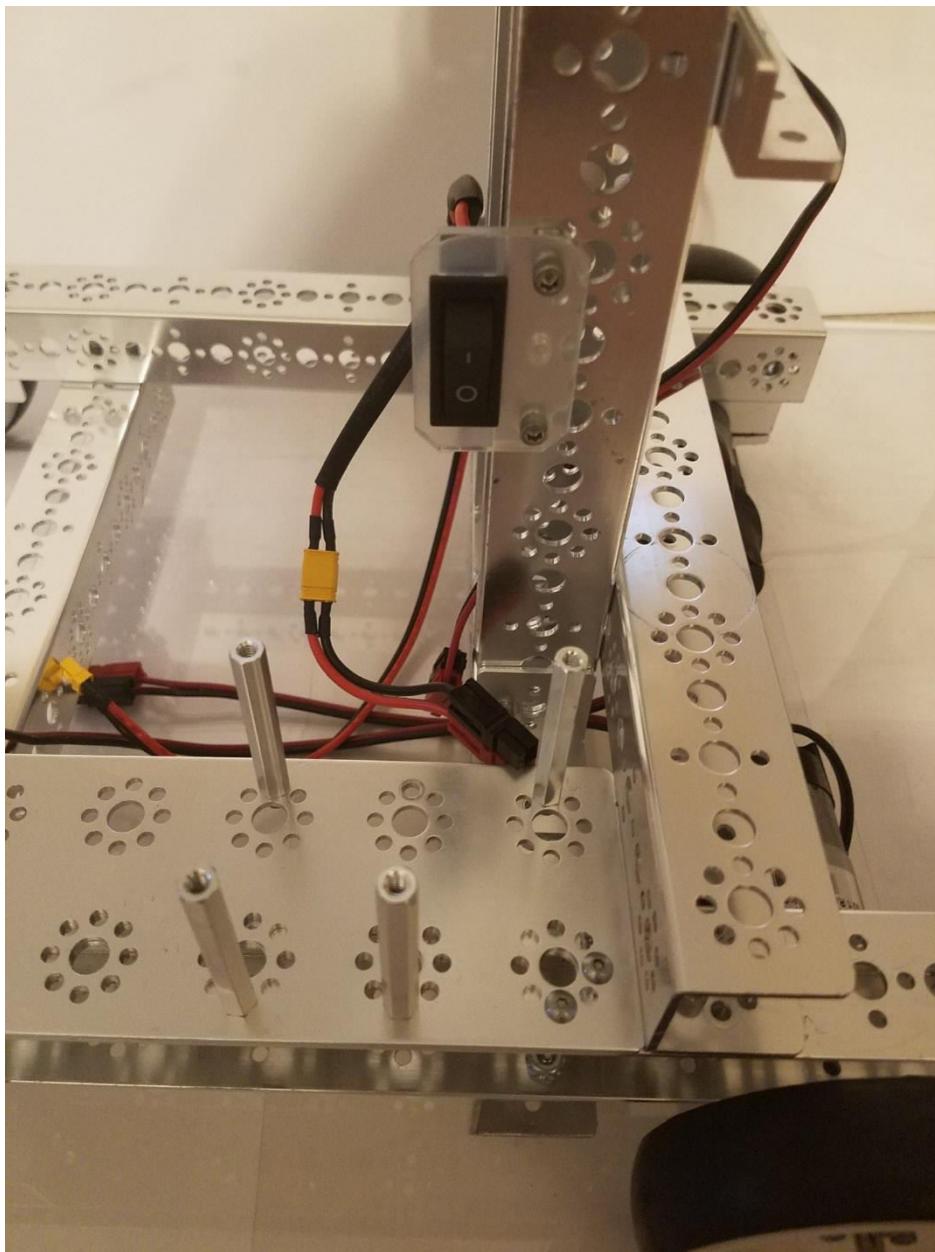
## **Step 7: Mount the Electronics**

**Parts:** 2 regular screws, 2 nuts, 1 switch, 1 battery, 1 expansion hub with 3 motor connectors plugged in, 2 hex screws, 2 lock nuts, 1 phone, 1 phone cord, 1 switch, 1 battery connector, 1 power extension, red allen wrench (7/64), 1 pair of pliers, and 1 socket wrench

One the vertical bar closest to the battery holder, attach the switch about three holes up from the bottom using a red allen wrench (7/64), two regular screws and nuts.



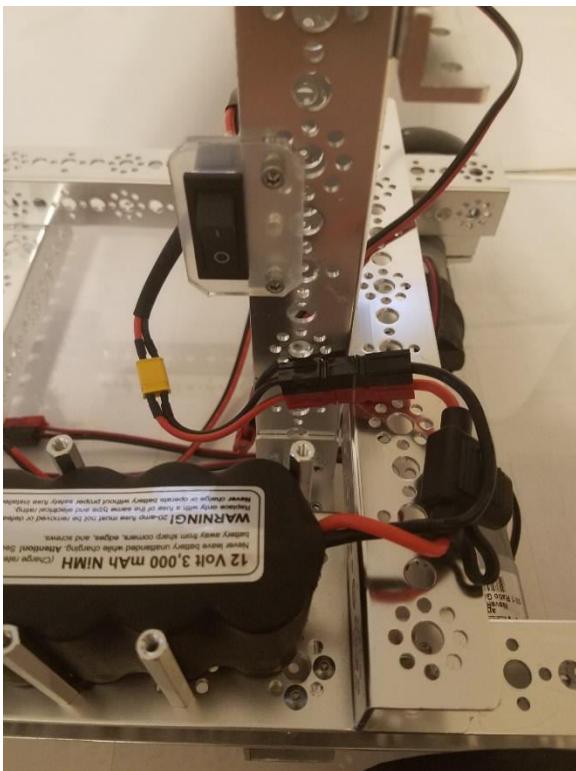
**Plug the battery connector on one end of the switch and the power extension on the other.**



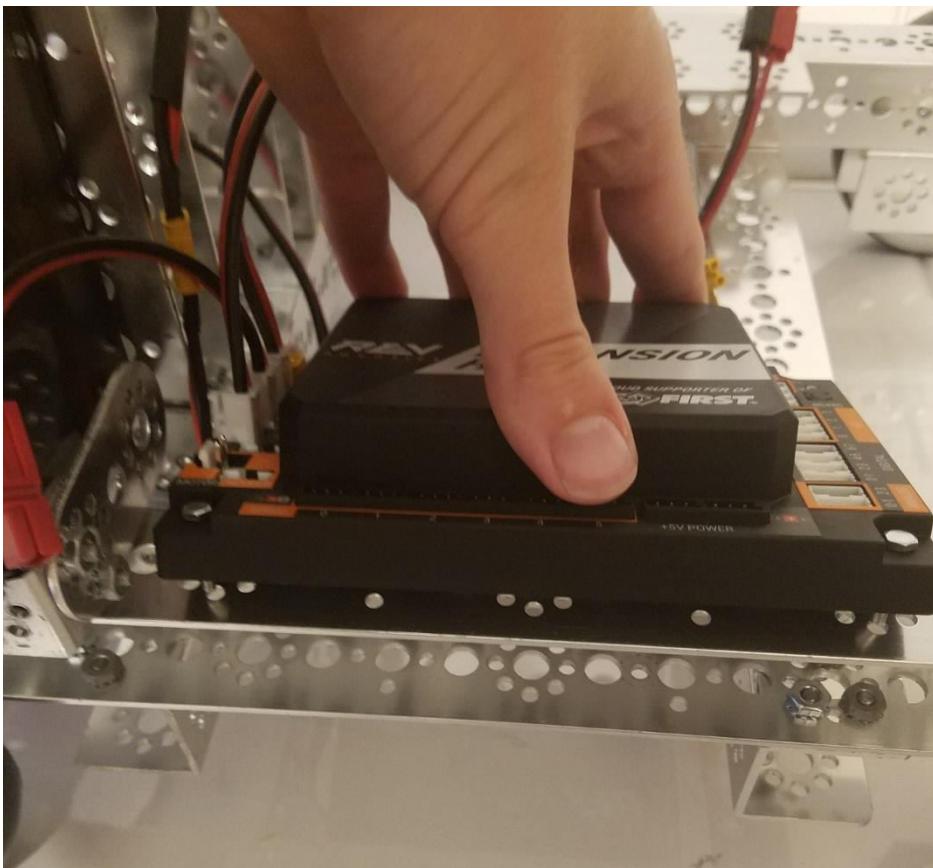
Next put the battery in the battery holder so the wires that supply power are pointing to the back of the robot.



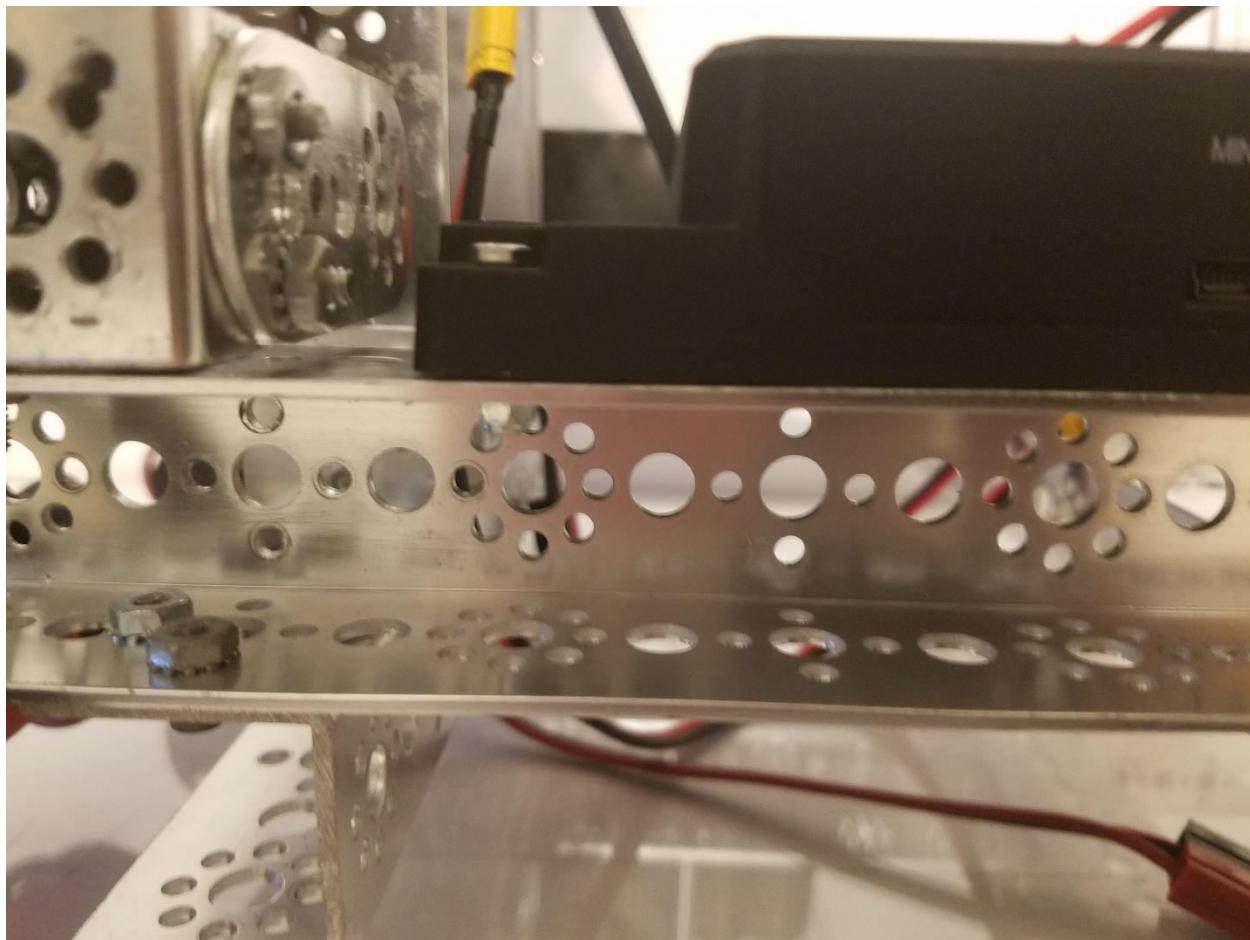
Plug in the battery.



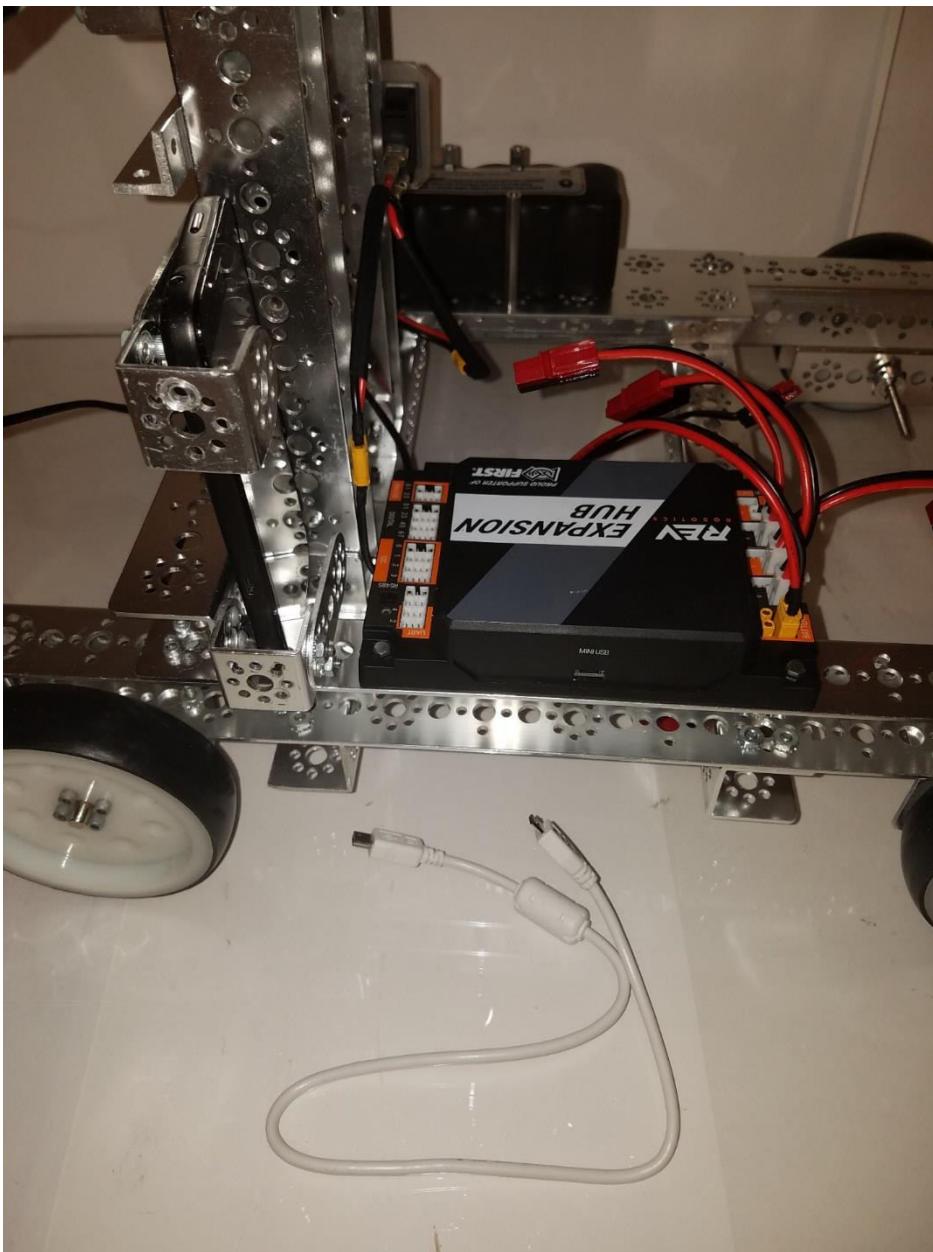
Rotate the robot 180 degrees to the other side. The expansion hub with motor connector wires already plugged in, will be attached on this side with the hex screws and lock nuts because the holes of the expansion hub are slightly smaller than the regular screw holes. The hub will be mounted so the longer side is on the main long bar of the frame. The right side will be on the hole directly over the forward cross bar like in the picture. The other screw will be on the fourth hole to the left like in the picture.



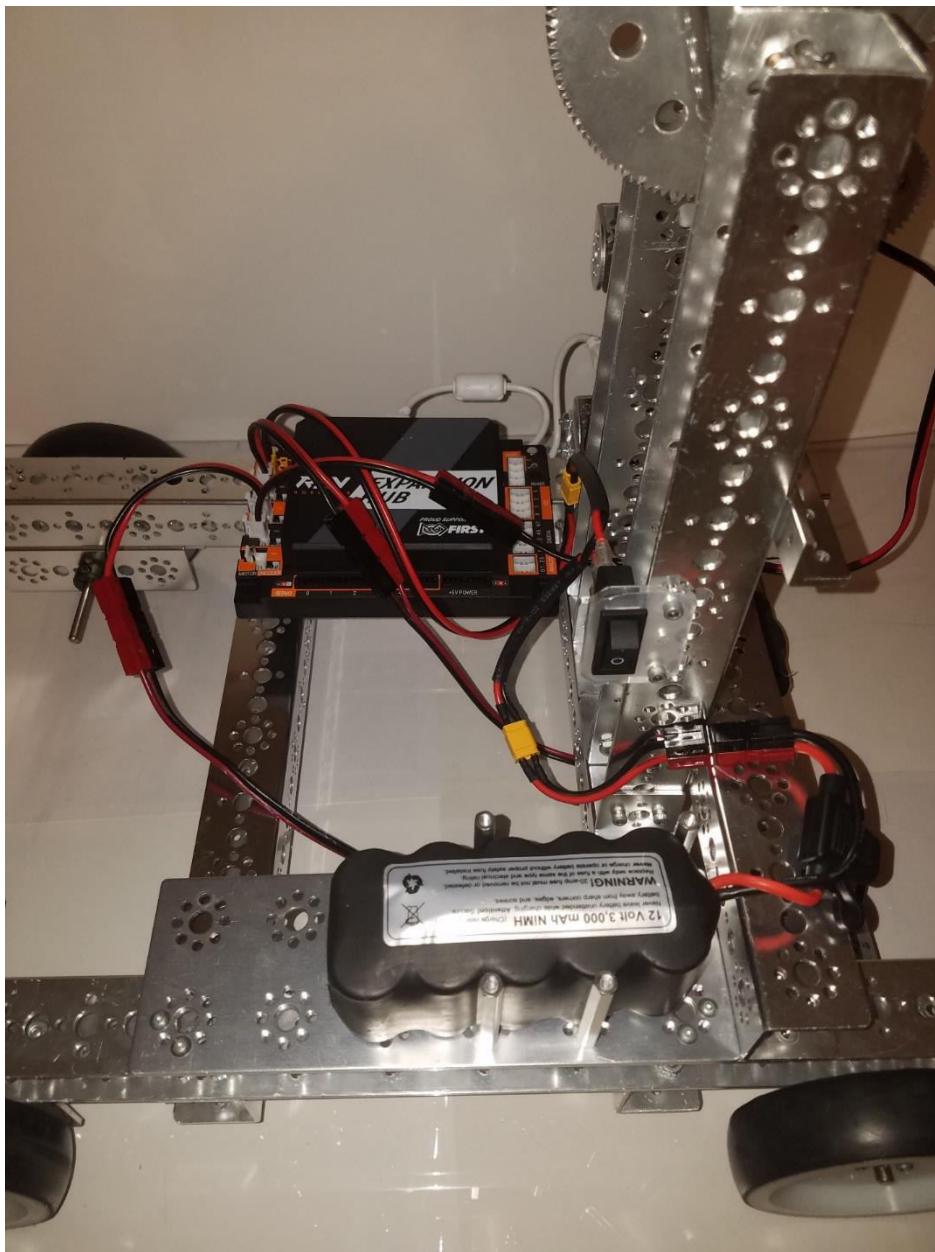
Using the pliers to hold the nut in place with the plastic piece facing toward the ground, twist the hex screw with the socket wrench until the screw is tight. Do this with both screws.



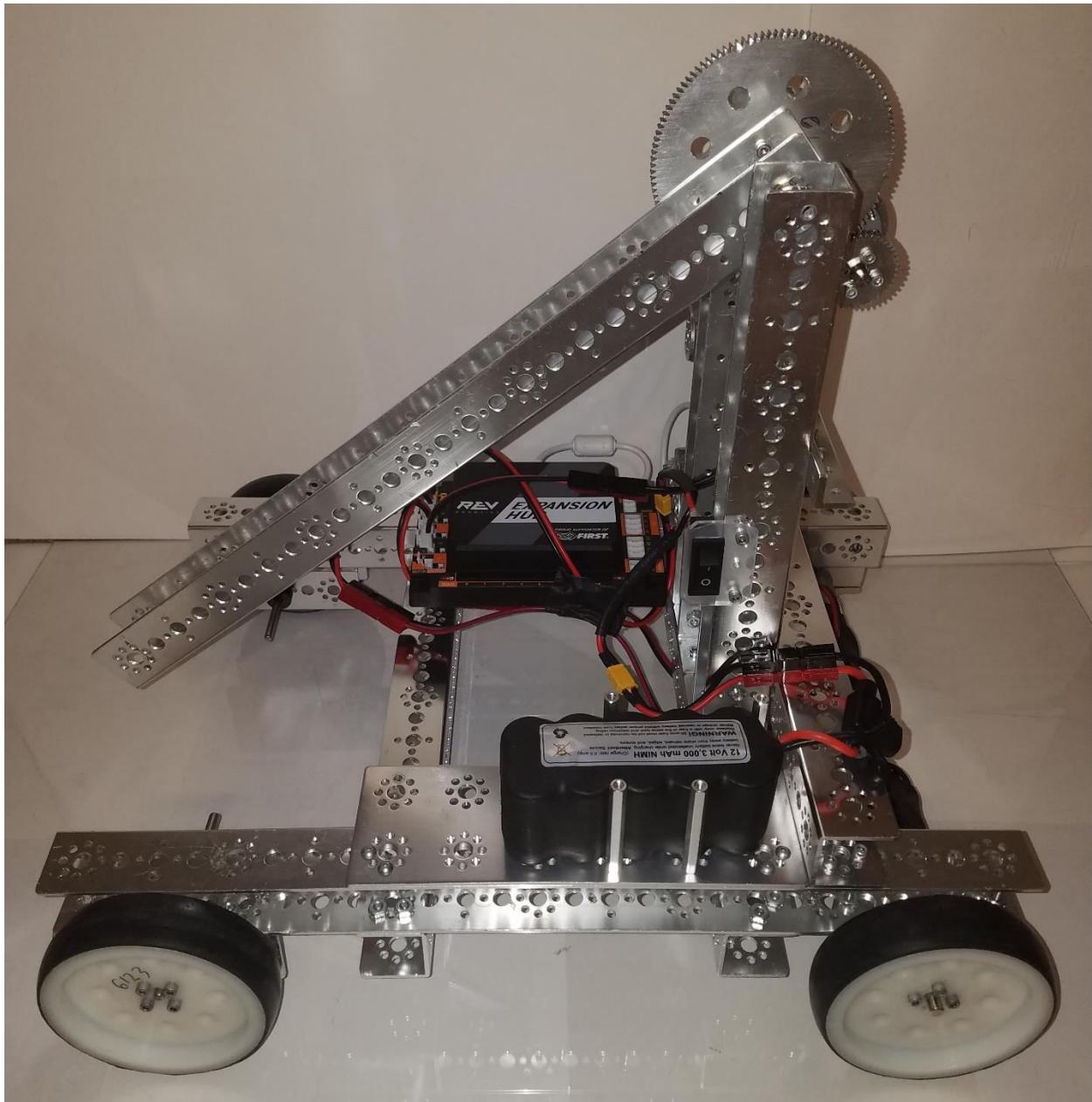
Insert the phone into the phone holder and get the phone cord (mini USB to micro USB)

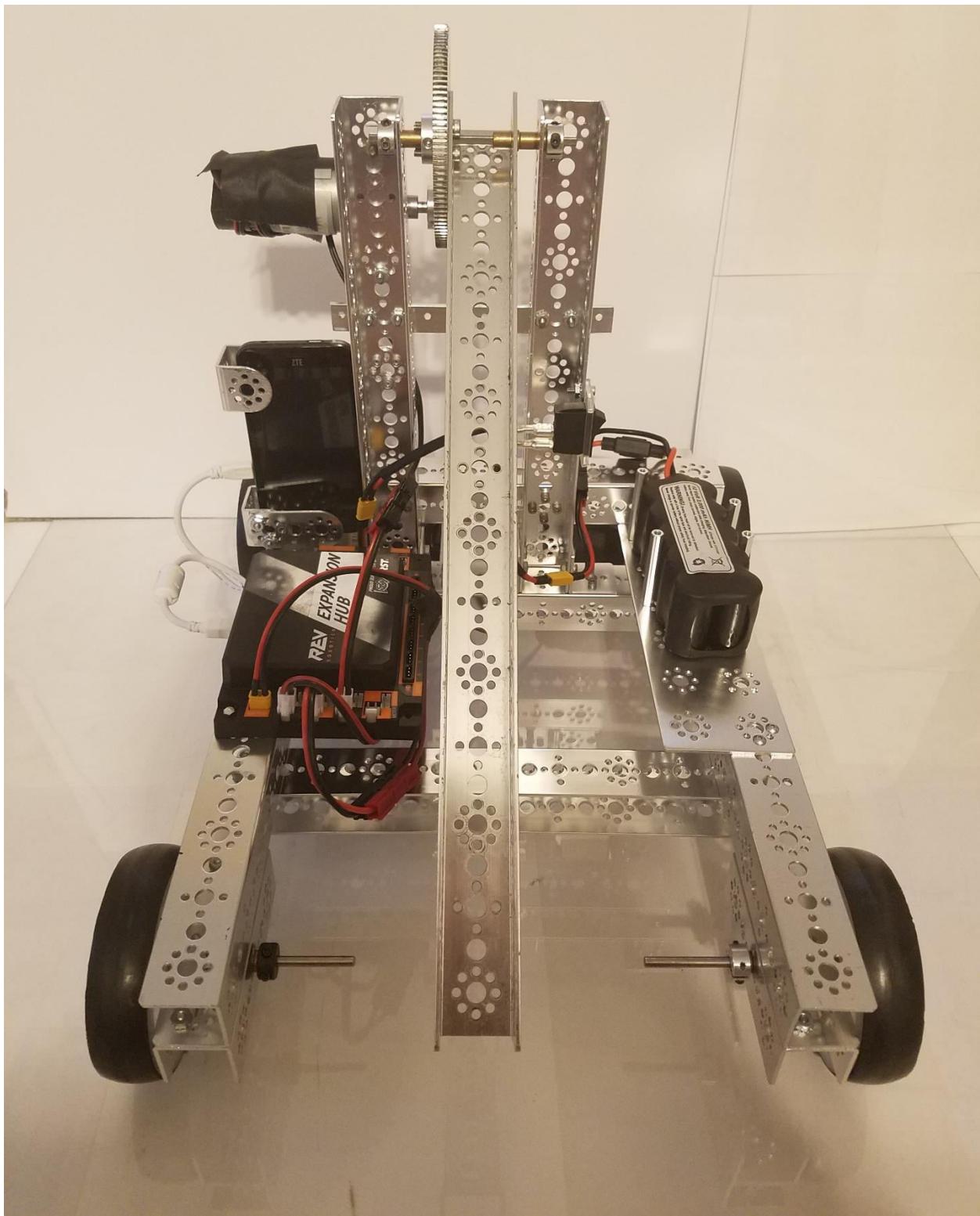


Plug in the phone to the expansion hub. Then plug each motor into the expansion hub. Finally, to finish wiring, plug the power extension from the switch into the expansion hub.



Congrats! You finished the robot. Before serious testing or if you want to pass inspection, tape or zip tie all the wires down to prevent them from becoming unplugged. If the motor wires are long (which in this case, they are) wrap the wire around the motor a few times and then tape it in place. Next, we will go over how to create a working program and setting up the robot configuration.





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## **Step 8: Program & Configure**

**Parts:** 1 laptop with android studio, 1 phone, 1 USB to micro USB

Save the pushbot program into your team code folder. Programming the robot is pretty easy. The most common keys you use are Ctrl, C, and V. You will have to comment out all the code relating to servos because there are no servos on the robot. First look for the lines where the servo is initialized. They should look something like this: **Servo name = null;**

To comment out, put two forward slashes in front of it. The text should change color: **//Servo name = null;**

Then comment out any text that now has a red underline. If you want to comment out a block of code you can put /\* in front and \*/ at the end.

Now, scroll to the top and comment out the line that says @Disabled. Commenting this out, will allow it to show up on the phone.

Plug in the robot controller phone (the one that was mounted on the robot) and press the green arrow to download the program onto the phone.

Turn on the robot and plug the phone back in. Go to settings and click on configure robot. This should open up a screen that has two expansion hubs. Click on the second one because the first is just a name. In the motor category add the three motors type either Tetrix or neveRest 60s. Then name them the name that they have given in the program. The motors you enter in the configuration should match with the ports each are plugged into. If you do use servos, you will have to do the same thing. For now, save the configuration and activate it.

Next, open the driver station on the other phone and plug the controller in. Connect the two phones and press start a on the controller. Once the controller and the phones are all connected, choose the program and initialize it. You should now have control of the robot with the controller.

I hope this detailed guide has been helpful. Good luck in all your robotic endeavors!