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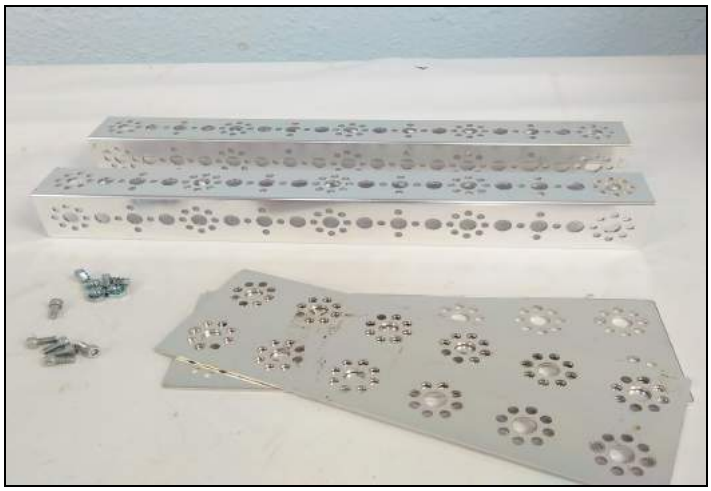
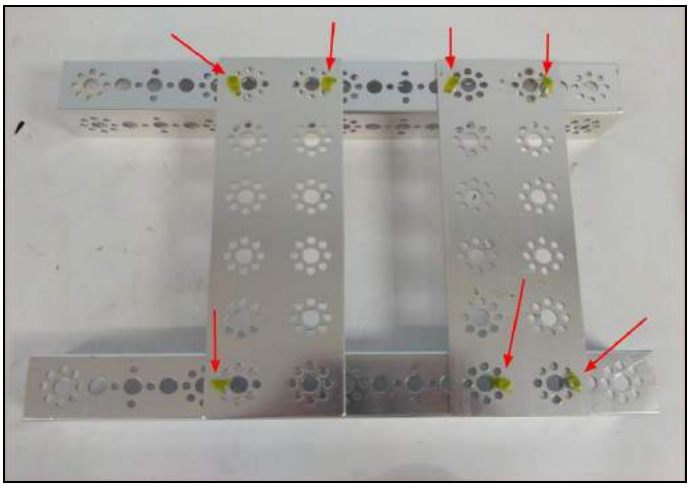
Part 1

Step 1: Chassis frame

Hardware: 288mm channels (x2), flat plates (x2), 5/16" socket head cap screws (**SHCS**) (x7), kep nuts (x7)

Instructions: Position the flat plates on top of the channels and screw in place. Make sure that the screws (marked in green) align with the plates and channels exactly as shown in the photo - this is where the REV hub will mount and we don't want any interference from the screw heads.

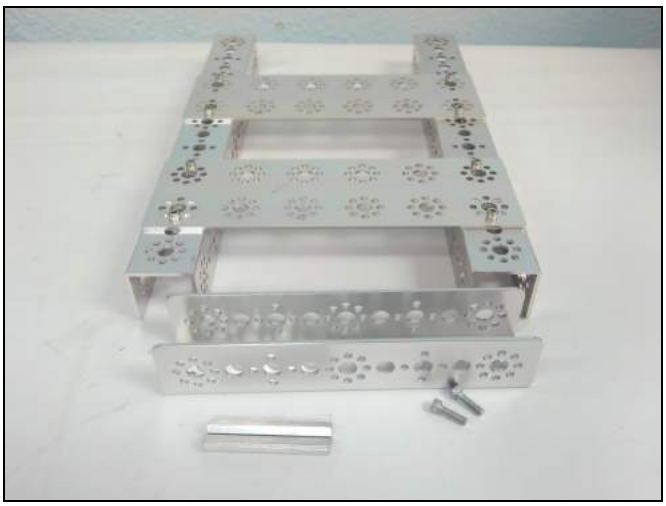


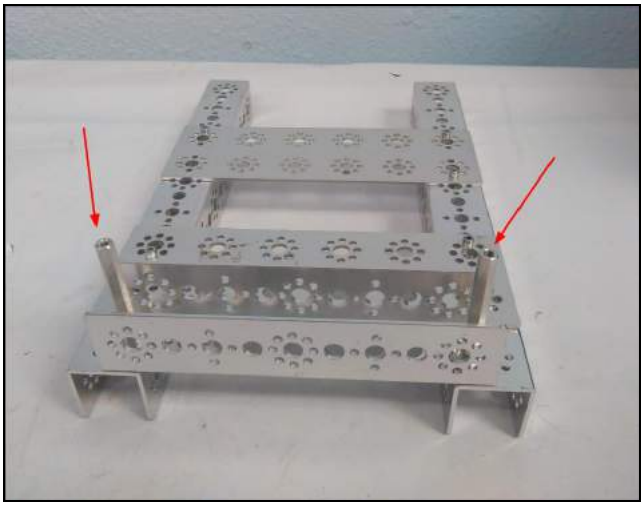


Step 2: Phone mount

Hardware: 160mm channel (x1), 1/2" SHCS (x2), 2" stand-off post (x2)

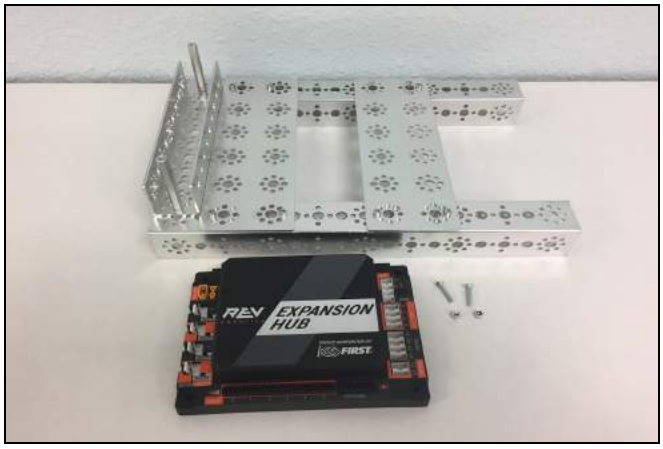
Instructions: Position the 160mm channel so that it touches both ends of the 288mm channels and the open side facing up. Screw the channel into place from the bottom, so that the posts stick up. This will hold the robot controller phone.

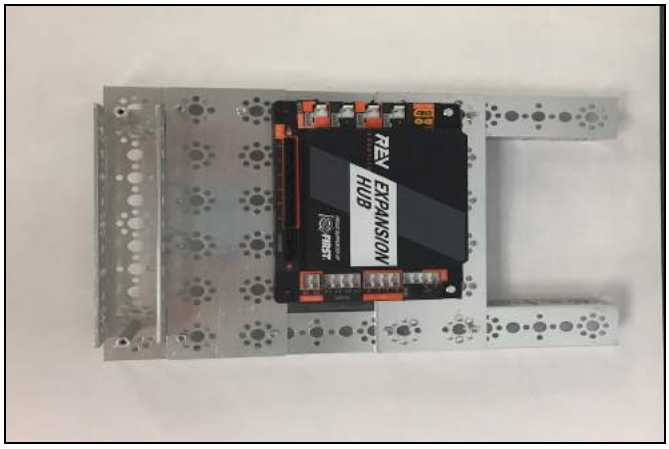




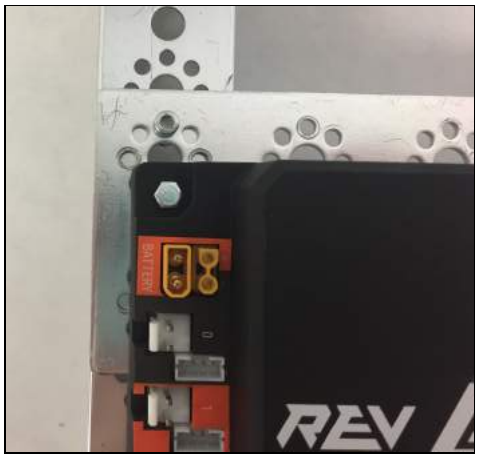
Step 3: REV Expansion Hub

Hardware: REV Expansion Hub, 16mm M3 screws (x2), M3 nyloc nuts (x2)
Instructions: Screw the REV Expansion Hub onto the robot plates. **Only 2** holes will be used. The REV hub will bridge the gap between both plates.

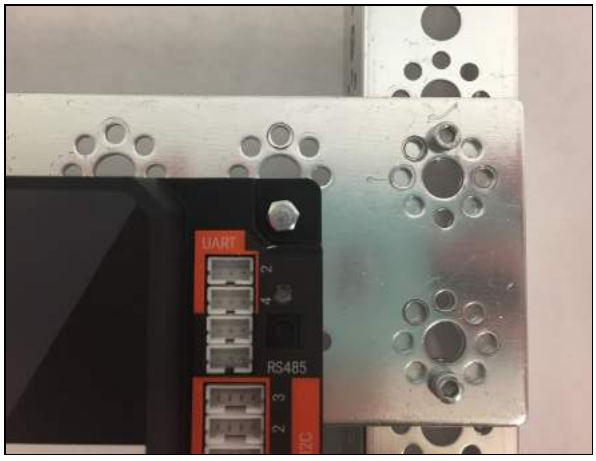




Note: You may find that the REV hub overlaps with screws already installed. If so, ***go back to*** Step 1 and check your screws to ensure they are in the right holes. ***Do not*** try to shift the hub around because it will create problems for the battery holder and cables later on.



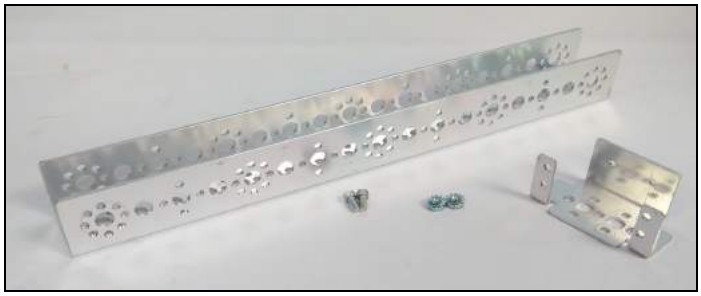
Top Left Screw

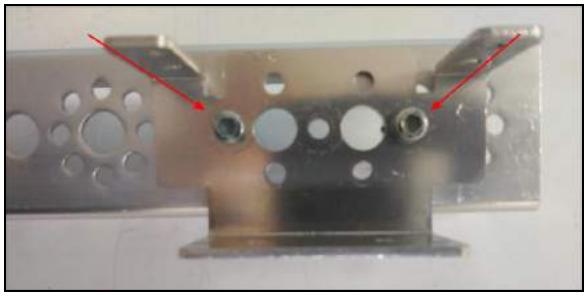


Top Right Screw

Step 4: Robot Arm

Hardware: 288mm channel, 5/16" SHCS (x2), kep nuts (x2), single servo bracket (x1)
Instructions: Add the servo bracket onto the channel at one end and screw in place. Follow screw holes indicated.



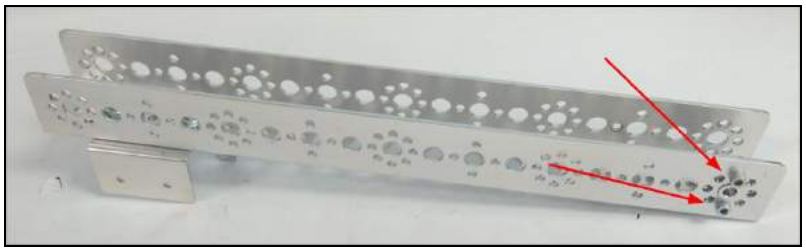


Step 5: Robot Arm (cont.)

Hardware: Arm assembly from step 4, axle hub (x1), 1/2" SHCS (x2)

Instructions: Screw the axle hub onto the channel. The flange (part that extrudes) should fit into the channel hole.

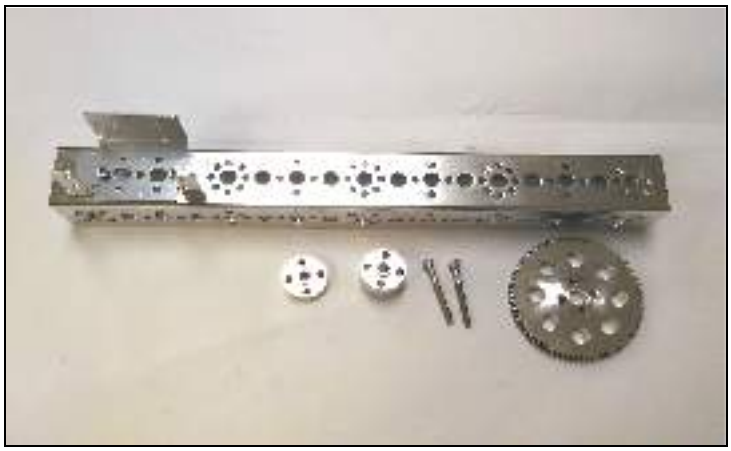
Note: Notice that there is a set screw on the side of the hub. We will use this later, so make sure that the set screw is in a position where it is accessible (i.e., away from the channel.)

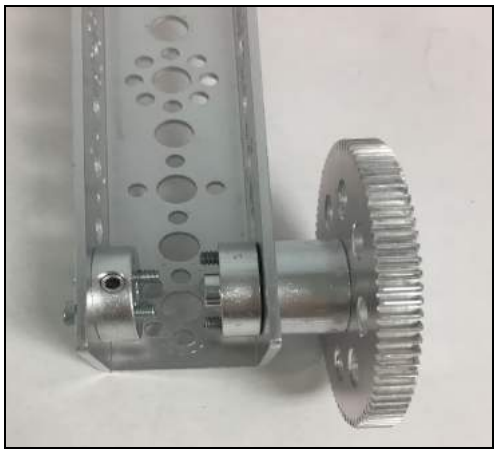


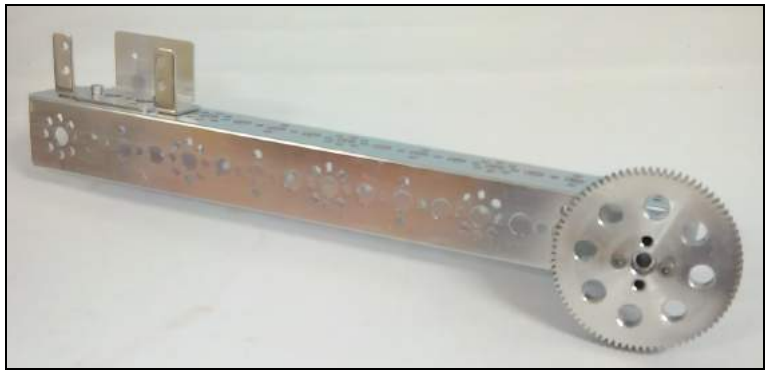
Step 6: Robot Arm (cont.)

Hardware: Arm assembly from step 5, 80-tooth gear (x1), axle hub (x1), hub gear spacer (x1), 1.25" SHCS (x2), 100mm axle (x2)

Instructions: Slide the screws onto the gear, then add the gear hub spacer, the arm channel as shown, and finally screw into an axle hub inside the channel. The holes of the axle hub are threaded and the screws will fit into that. Note that the flange on the axle hub must face away from the gear spacer because of the flange on the gear hub spacer. This is a complex step so take your time.



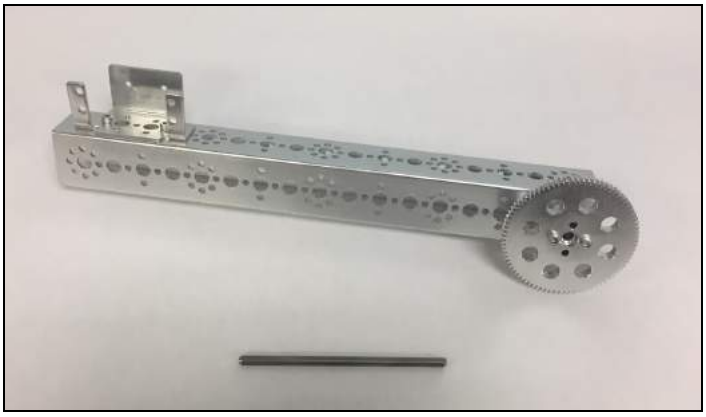
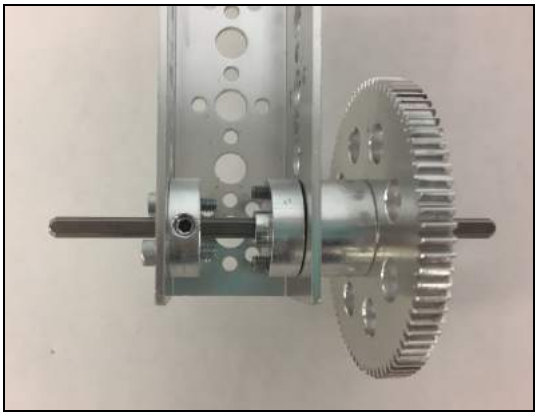




Step 7: Robot Arm (cont.)

Hardware: Arm assembly from Step 6, 100mm axle (x2)

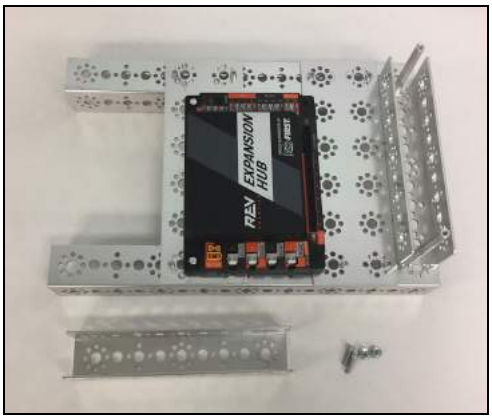
Instructions: Slide the axle into the gear assembly as shown. If some hubs are too tight to let the axle fit in, loosen the set screw. If there is still friction, loosen other screws and wiggle the axle in.

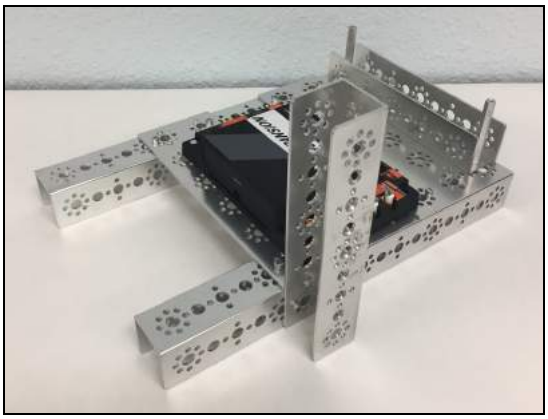
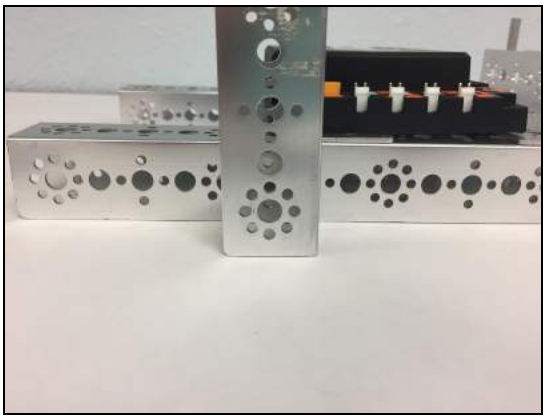



Step 8: First Arm Riser

Hardware: 160mm channel, kep nuts (x2) 1/2" SHCS (x2)

Instructions: Attach the channel to the robot, paying careful attention to the riser location.

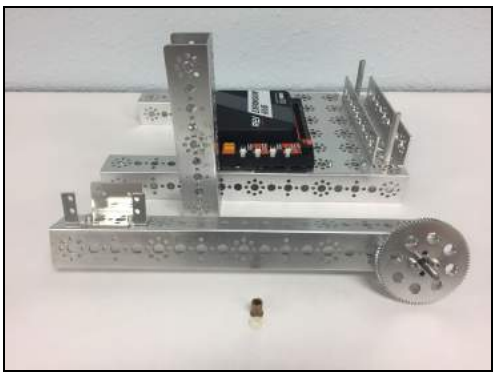


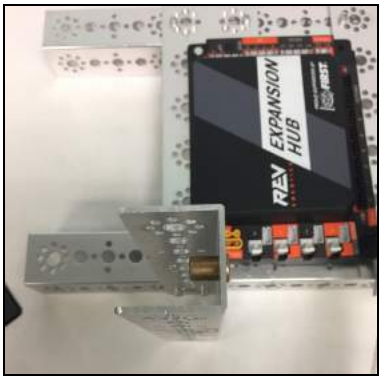



Step 9: Mount the arm

Hardware: Bronze bushing (x1), 1/8" nylon spacer (x1)

Instructions: Slide the spacer onto the axle. Make sure to slide it onto the correct side! Then insert the bronze bushing into the arm riser channel.

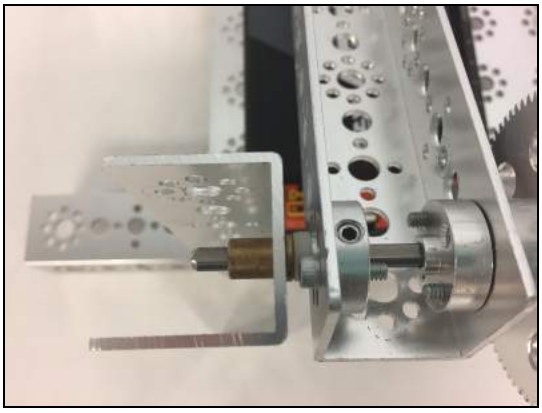




Step 10: Mounting the Axle

Hardware: Arm assembly

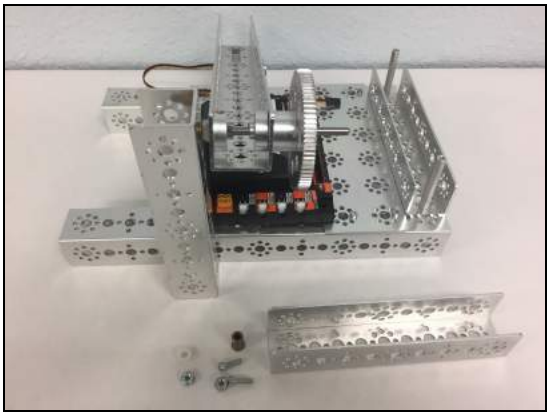
Instructions: Slide the arm assembly into place. The axle should go into the bronze bushing.

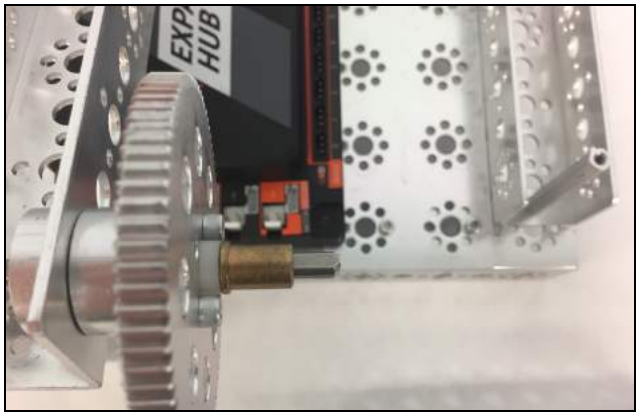


Step 11: Second Riser

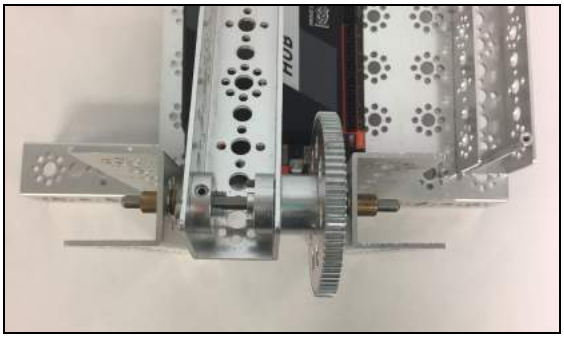
Hardware: Bronze bushing (x1), 1/8" nylon spacer (x1), kep nuts (x2), 1/2" SHCS (x2)

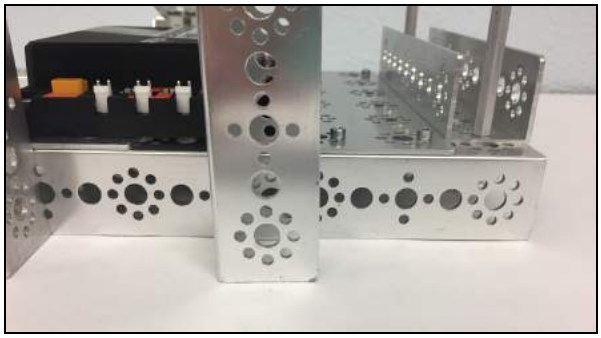
Instructions: Slide the spacer and bronze bushing onto the axle as shown - spacer first, then bushing.

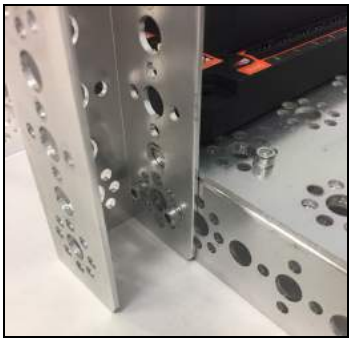




Now slide the channel onto the other end of the axle, over the bronze bushing. Screw it into place on the bottom of the robot. The channel should automatically align with the holes on the bottom channel. Nevertheless, ensure that the channel is straight and not crooked. The arm is now mounted!

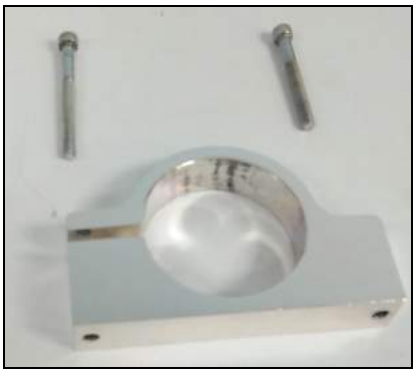


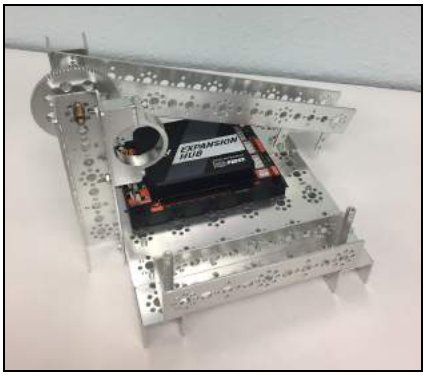
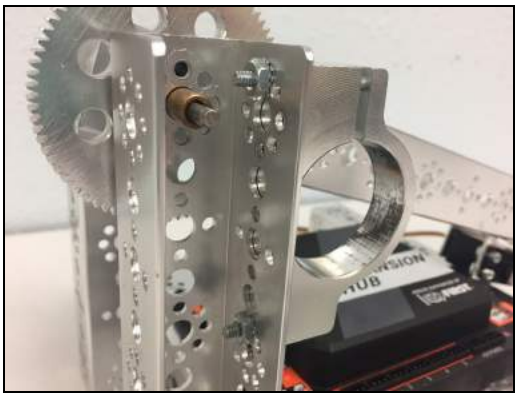
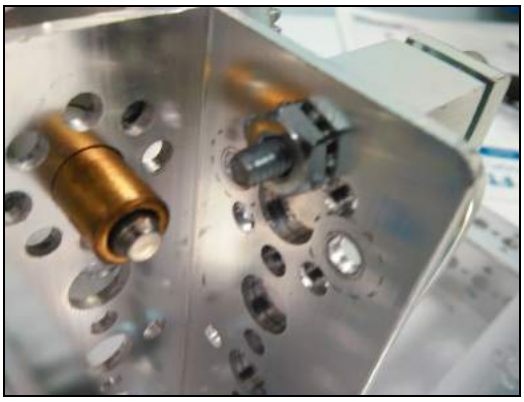




Step 12: Arm Motor Mount

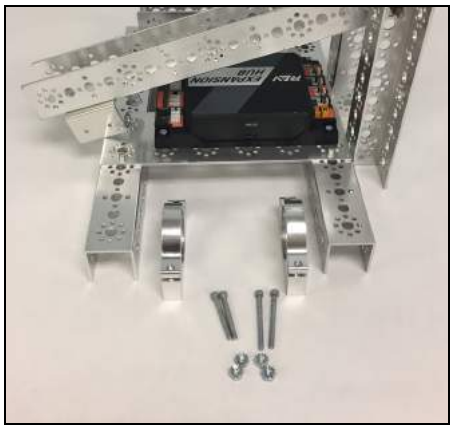
Hardware: Motor mount (x1), 1.25" SHCS (x1), motor mount screws 1.5" (x1), nuts (x2)
Instructions: Position the screws as shown on the motor mount. One of the screws will be longer than the other; this is fine, because one side of the motor mount is longer than the other. So place the longer screw in the longer (clamping) side; the screws should come out even in the end. Add the motor mount in the holes indicated, clamping side facing up.

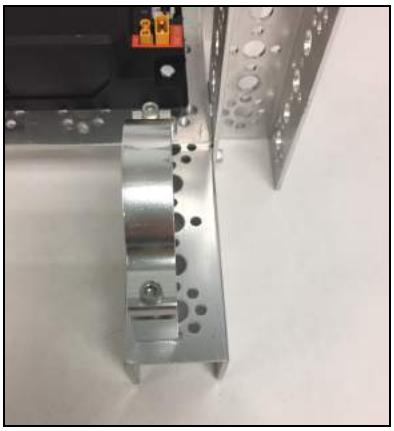


Step 13: Driving Motor Mounts

Hardware: Motor mount (x2), 1.25” SCHS (x2), 1.50” SCHS (x2), kep nuts (x4)
Instructions: Attach the motor mounts onto the base with the screws and nuts. The motor mounts should be offset by one screw hole towards the center of the chassis, not in the center of the channel. As in Step 8, the longer motor screw goes into the clamping side of the mount. We suggest placing the clamping side to the back of the robot.





Step 14: Motor Gear Assembly (x3)

Hardware: 40-tooth gear (x3), motor shaft hub (x3), 1/2" SHCS (x6)

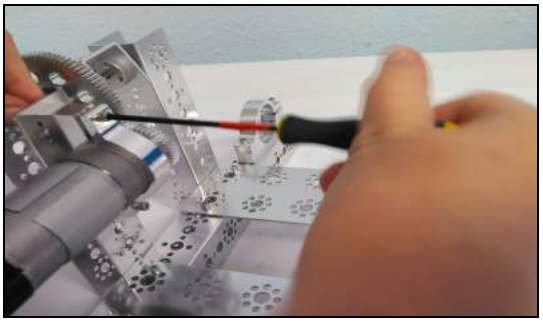
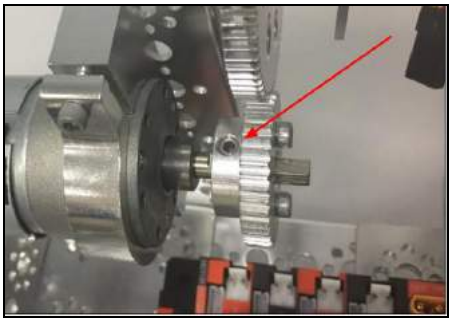
Instructions: Screw the hubs onto the gears, so that the flange fits into the gear.



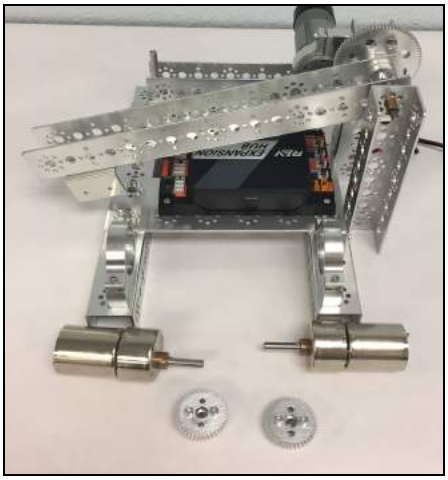
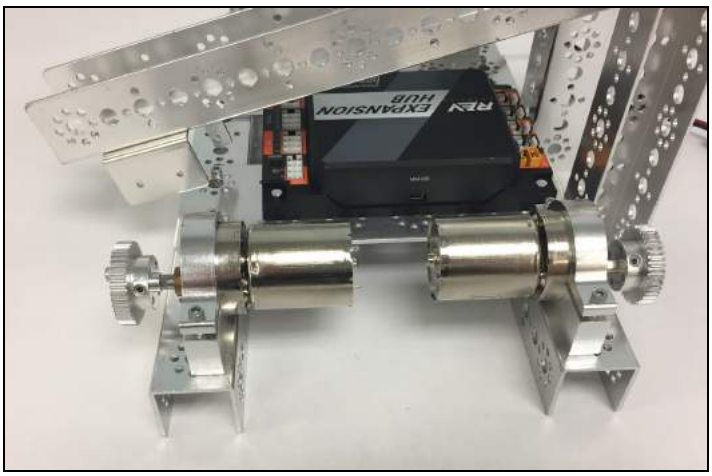
Step 15: Driving Motors

Hardware: DC motors (x2), NeveRest motor, gear assembly (x3) from step 10

Instructions: First insert the NeveRest motor into the arm motor mount. Notice how the motor shaft is not in the center of the motor. This allows the motor to be rotated in its mount to get the right spacing for gears and sprockets. Play around with the motor and gear positioning until the two gears mesh. Now add the gears onto the motor shafts so that the hub faces the inside of the gear. Then tighten the hub and the motor mount.

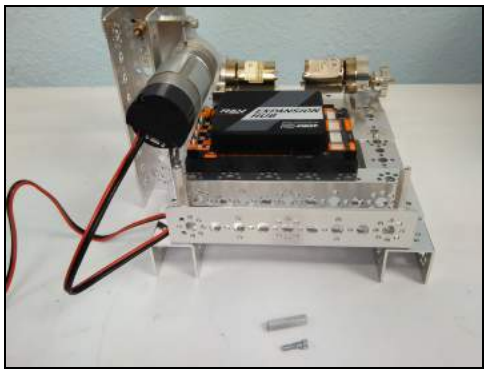
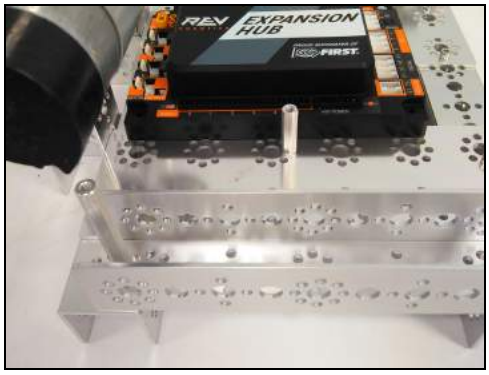




Do the same for the Tetrix motors. Add the gear assembly **AFTER** mounting the motor on the motor mount.

Step 16: Battery Holder

Hardware: 1/2" SCHS (x1), 1” stand-off post (this is smaller than the ones used for the phone mount)
Instructions: Screw the post in from the bottom so that it stands up. Ensure you have the right hole spacing. The battery will be placed between this post and the wall of the 144mm phone holder channel from step 2 (feel free to check that the battery will fit).

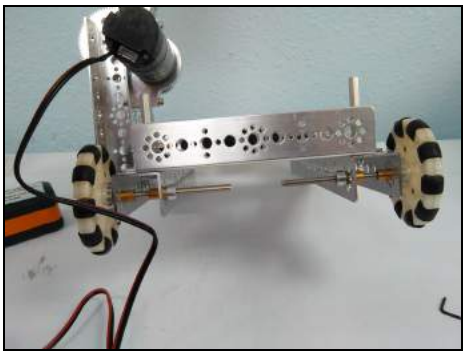
Step 17: Omni Wheels

Hardware: Omni wheels (x2), 100mm axle (x2), 1/2" SHCS (x4), axle hub (x2)
Instructions: Place the hub so that the flange fits into the omni wheel. Screw in place.Then add the axle; the axle should not extend past the screws on the wheel. Once on, tighten the axle hub set screw *onto the flat part of the axle*.



Step 18: Omni Wheels (cont.)

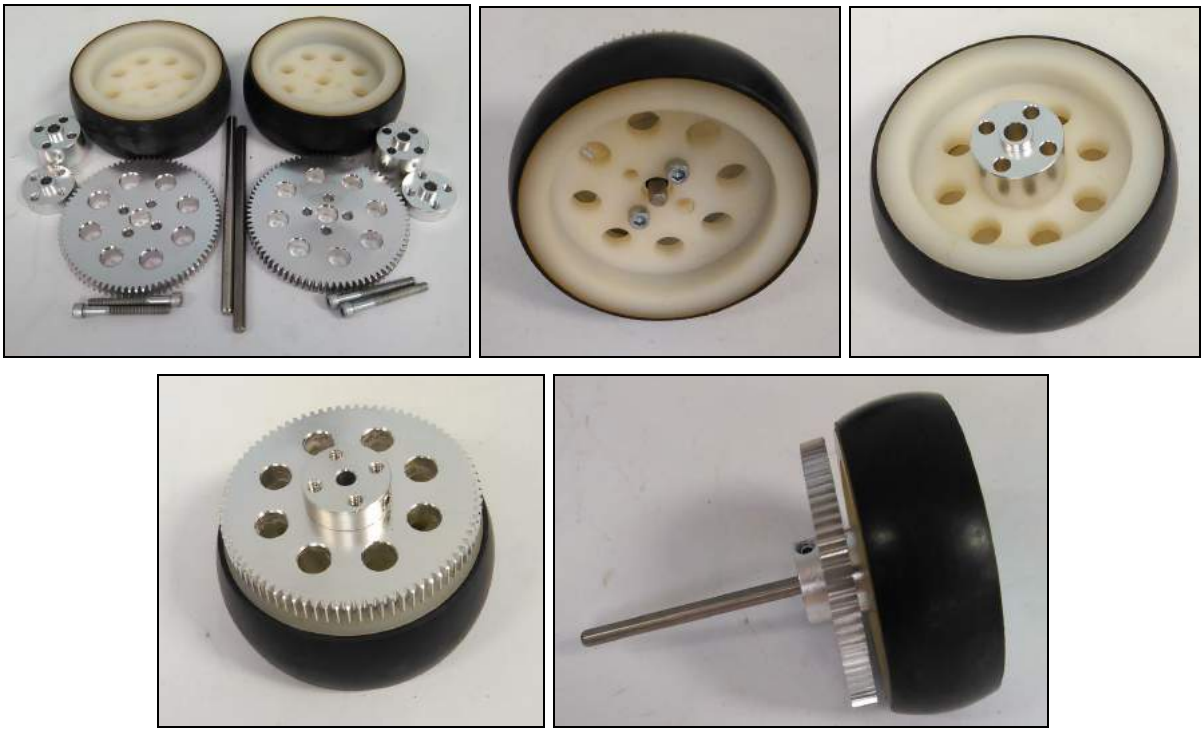
Hardware: Bronze bushings (x4), axle set collar (x2)
Instructions: Add the wheels as shown. Make sure the bronze bushings are facing the right direction. Tighten the collars.

Step 19: Driving Wheels

Hardware: Traction wheel (x2), 100mm axle (x2), hub gear spacer(x2), axle hub (x2), 80-tooth gear (x2), 1.25” motor mount SHCS (x4).

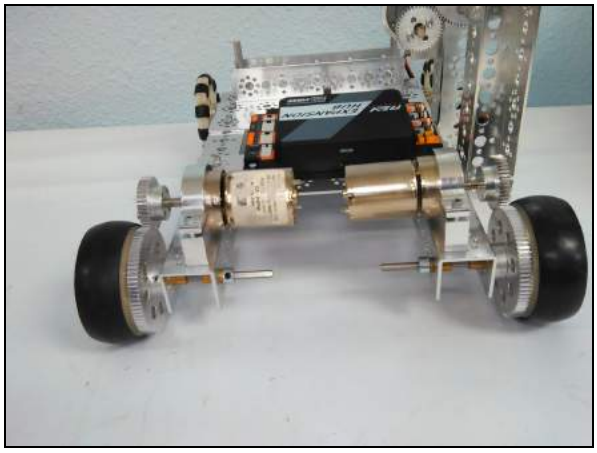
Instructions: Insert the two 1.25" SHCS into the wheel. Then add the gear spacer and gear. Attach the hub on top. Insert the axle into the assembly and tighten the hub set screw onto the flat part of the axle.



Step 20: Driving Wheels (cont.)

Hardware: Bronze bushings (x4), axle set collar (x2)

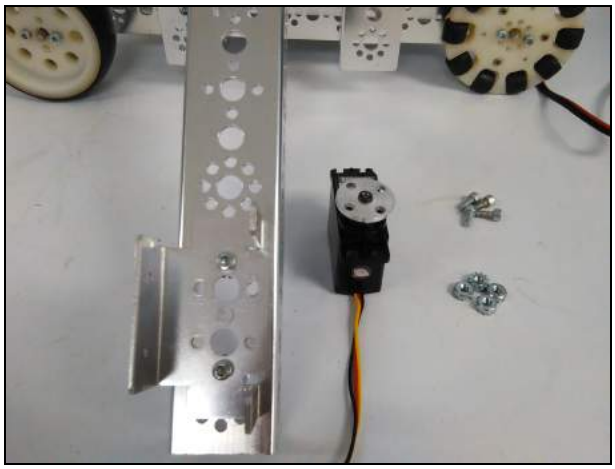
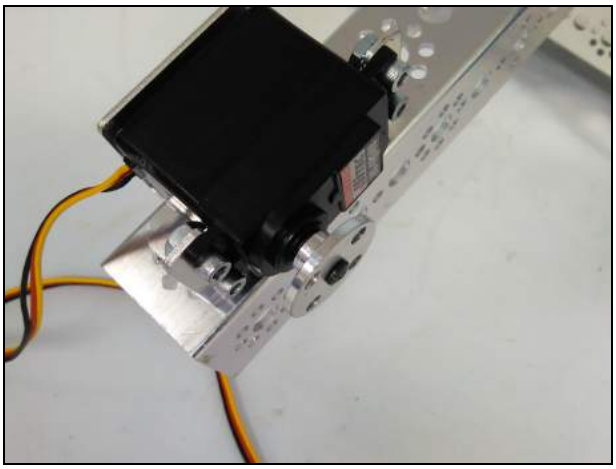
Instructions: Add the tires to the other side of the robot as shown. Make sure to tighten the hubs and collars. Rotate the motor within the mount until the gears mesh well. Gears mesh well when the align and sit together, so when you move the wheels, both gears turn together.

Step 21: Servo Attachment

Hardware: Servo (x1), 5/16 SCHS (x4), kep nuts (x4)

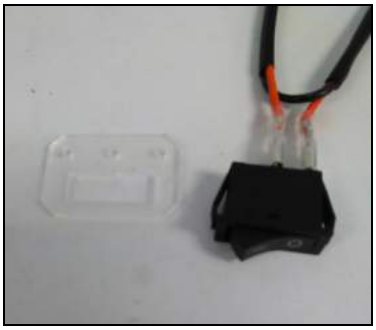
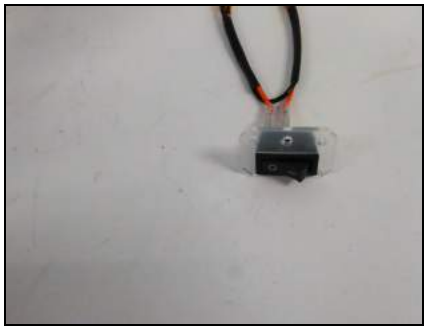
Instructions: Mount the servo onto the channel as shown. Place the servo so the mounting holes are on the outside of the bracket's holes.

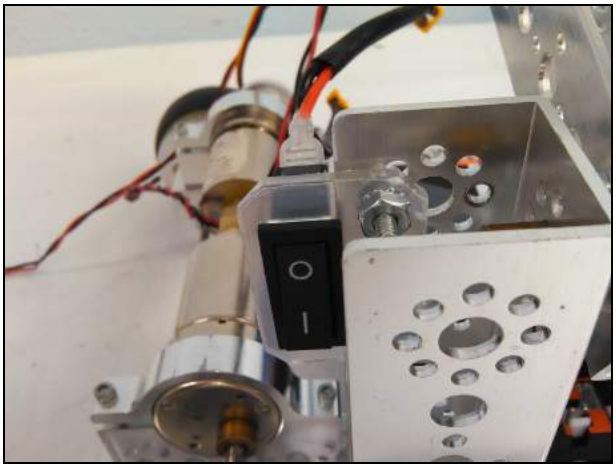
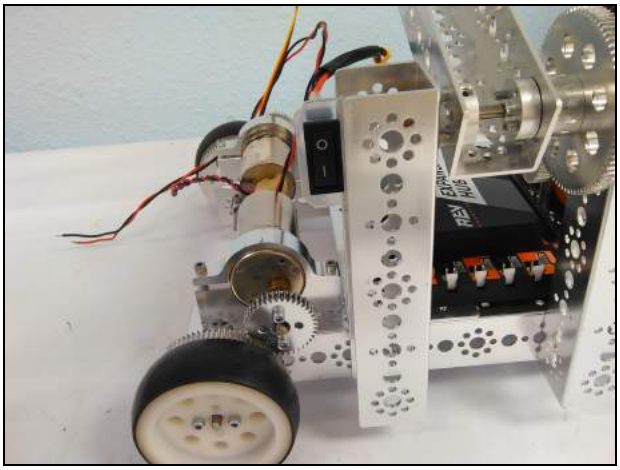



Step 22: Power Switch

Hardware: The power switch, power switch bracket, ½" SHCS (x2), nuts (x2)

Instructions: Insert the power switch into the bracket as shown. Then mount the switch and bracket onto the robot with the screws and nuts as shown.

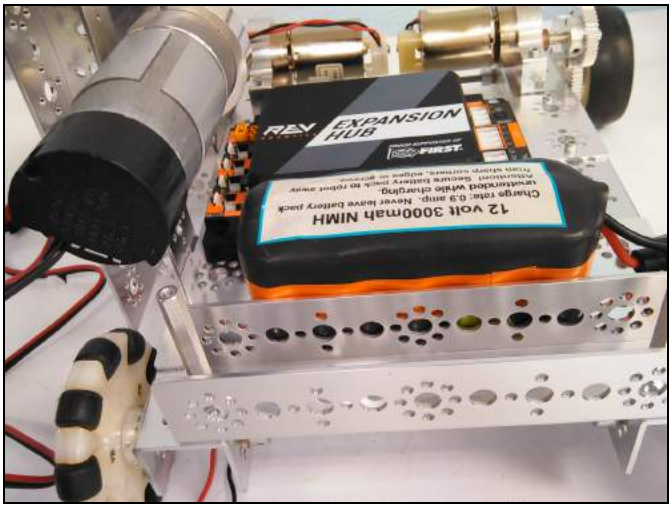



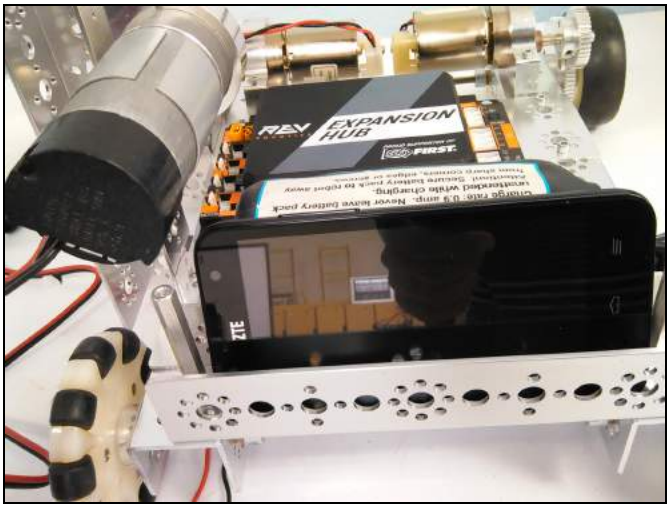



Step 23: Finishing Touches

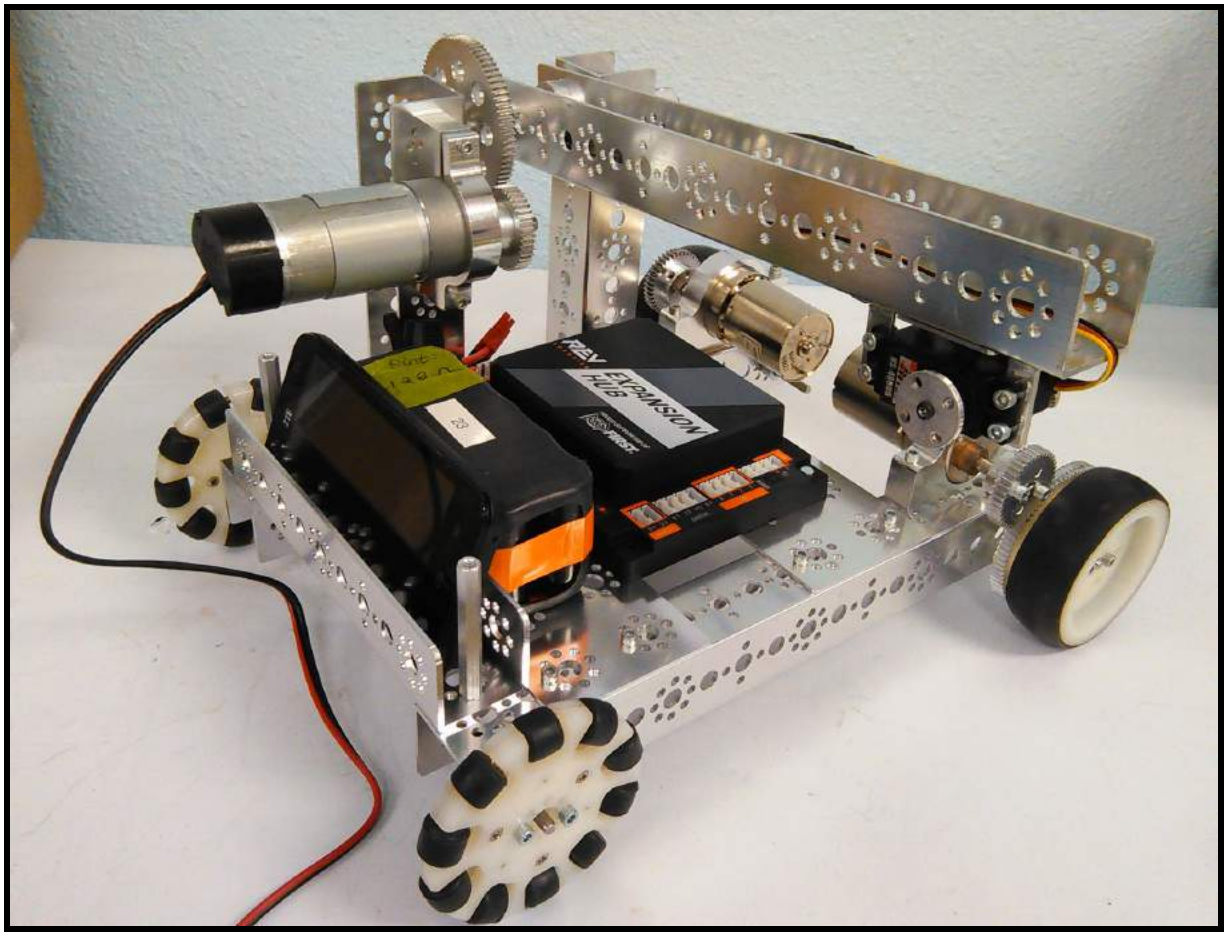
Hardware: Phone and battery pack

Instructions: Place the phone and battery in the robot in their respective places as shown.





Finished robot build:



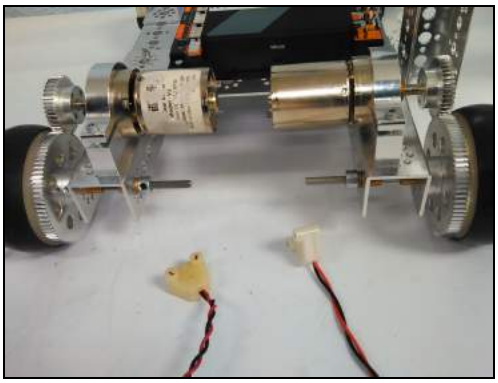
Congratulations! You have finished the robot build. Now to wire it! :)

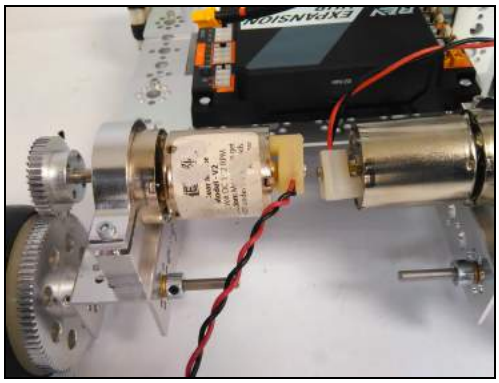
Part 2

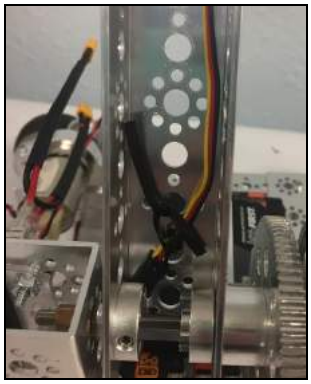
Step 24: Motor wiring

Hardware: Motor power cable (x2)

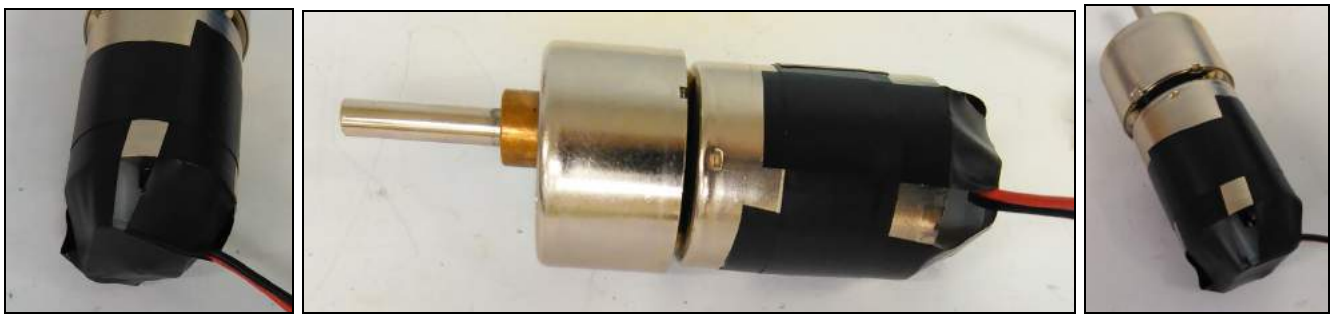
Instructions: Attach the motor power cable to the motors. Make sure all wires are tucked away. Zip tie or twist-tie the wires together.







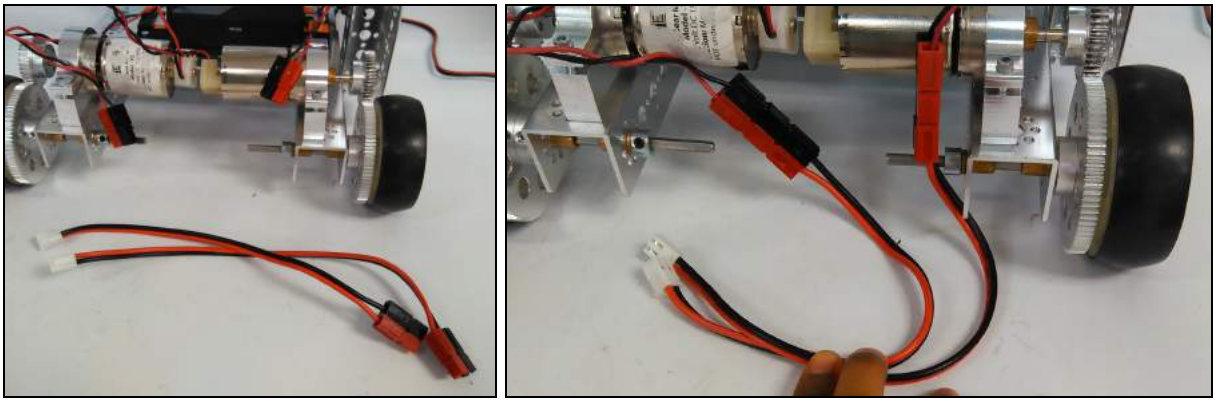
Note: On a competition robot the connectors for the motor cables should be secured to the motors, e.g., using electrical tape. This ensures that the connectors do not fall off during competition.



Step 25: Motor wiring (cont.)

Hardware: Anderson Powerpole to JST-VH adapter cables (x3)

Instructions: Take the adapter cables and attach them to the motor cables (wheels and arm).



Step 26: Motor wiring (cont.)

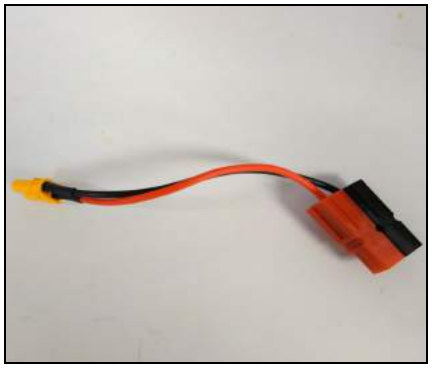
Take the white ends of the motor cables and plug them into the REV Expansion Hub.

Note: The omni wheels are the front of the robot. Plug the left driving motor (the side without the arm) in port 0 and the right driving motor (the side with the arm) in port 1.

Step 27: Battery wires

Hardware: Anderson Powerpole to XT30 cable (x1)

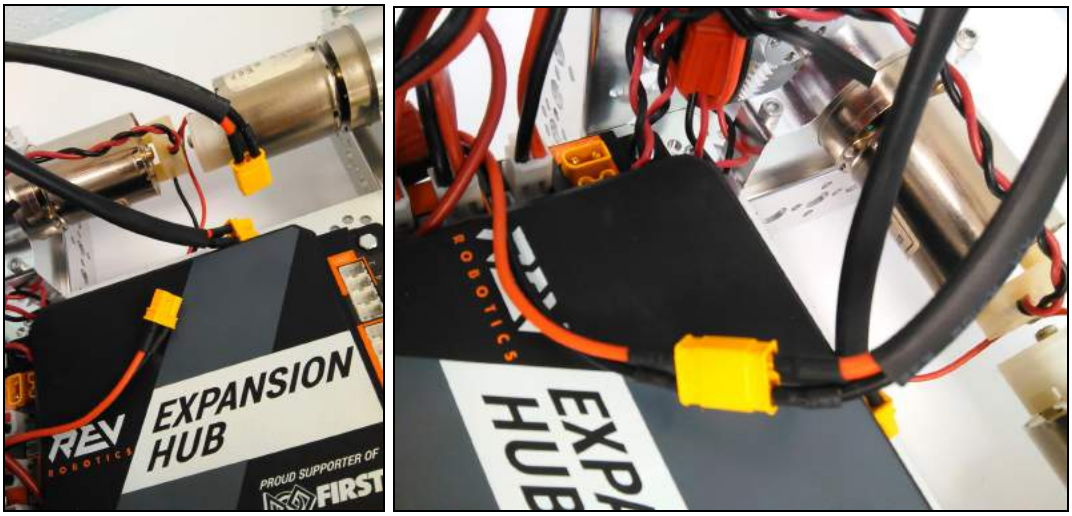
Instructions: Take the cable and attach it to the battery. (Battery has been removed from the robot for clarity.) The cable should extend from the left side of the battery, as shown in the picture.



Step 28: Battery wire attachment

Hardware: Battery assembly from **Step 23**

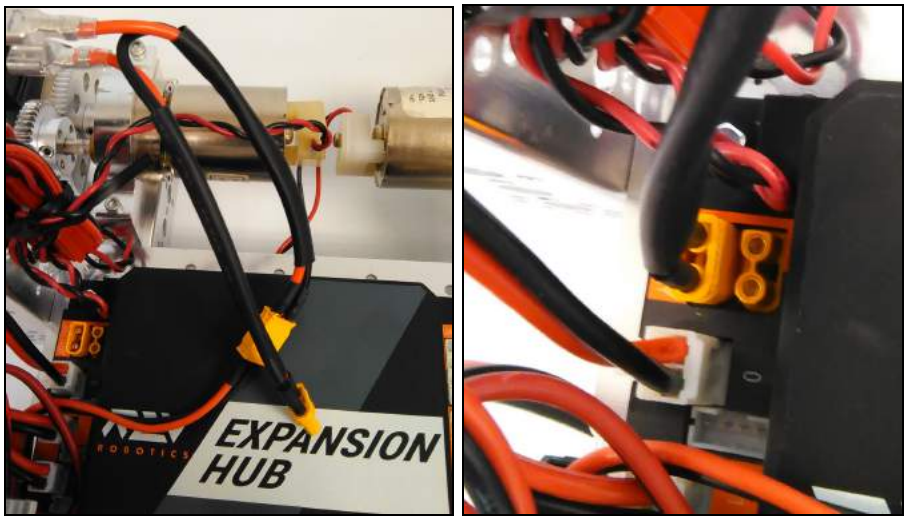
Instructions: Take the battery wire and attach it to the switch wire. (There are 2 switch wires; only one of them will fit.)



Step 29: Switch wires

Hardware: Switch Cables (x1)

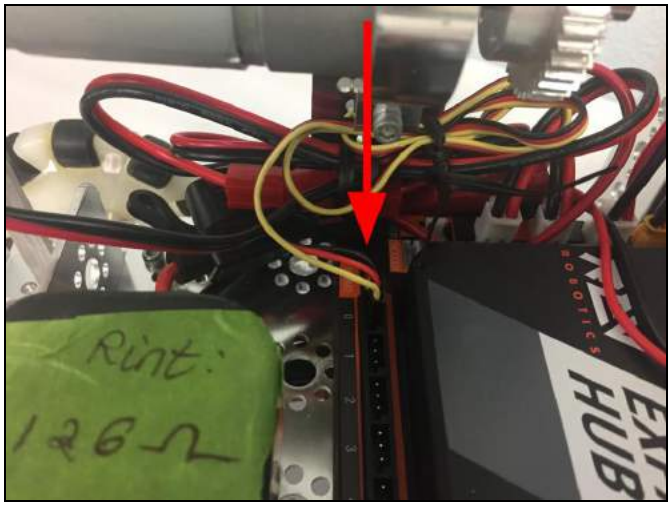
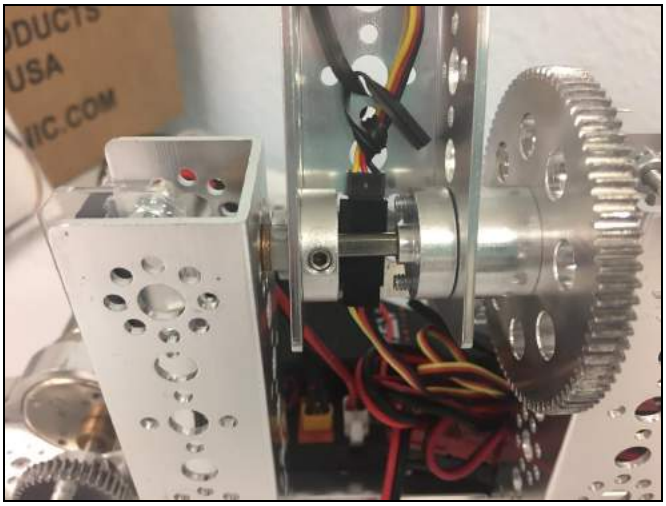
Instructions: Take the other switch wire (the one not connected to the battery) and plug it into the REV Expansion Hub. Again, there are two ports; only one will fit.



Step 30: Servo wiring

Hardware: Servo cable (x1)

Instructions: Attach a servo extension to the servo. Plug it into servo port 0 on the REV Expansion Hub.

Step 31: Phone wires

Hardware: OTG cable (x1), USB A to mini USB cable (x1)

Instructions: Attach the white USB A to mini USB cable to the hub and the black OTG cable. Follow that by attaching the black OTG cable to the robot controller phone.


Step 32: Phone wires (cont.)

Hardware: OTG cable (x1), Logitech controller

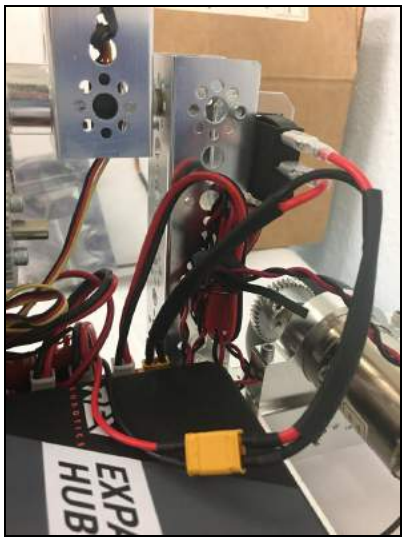
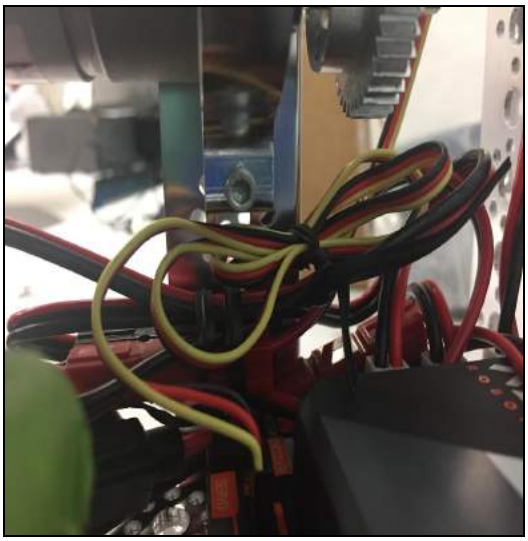
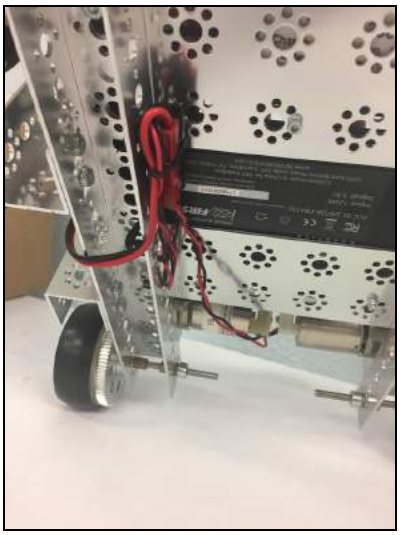
Instructions: Attach the black OTG cable to the phone and the controller by shown ports.



Step 33: Zipping 'em all up!

Hardware: Zip ties/wire ties

Instructions: Tie all loose wires into place. You can tie them up however you wish; feel free to use our robot as a guide. Just keep in mind that it is essential that there ben loose wires near gears/ other moving parts because of entanglement risks. The pictures you see below have the wires near the gears; however all the wires are tied down and do not move when the robot is moving.

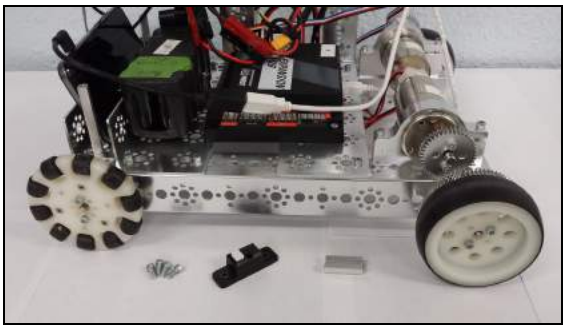
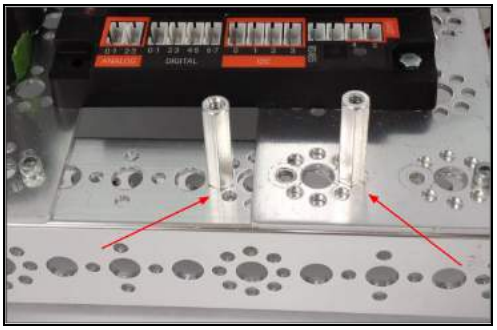




Part 3: Sensors

Step 34: Touch Sensor (the servo arm will trigger this)

Hardware: 5/16" SHCS (x4), 1" stand-off post (x2), REV touch sensor

Instructions: Screw the 1" stand-off posts in place using the screws. Insert the screws from bottom up. With the remaining 2 screws, attach the touch sensor in place. *Pay close attention to the orientation of the touch sensor - if you put it the other way, the arm will not hit it.*

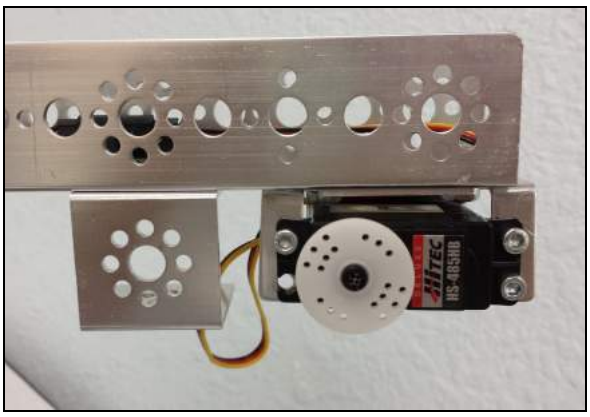
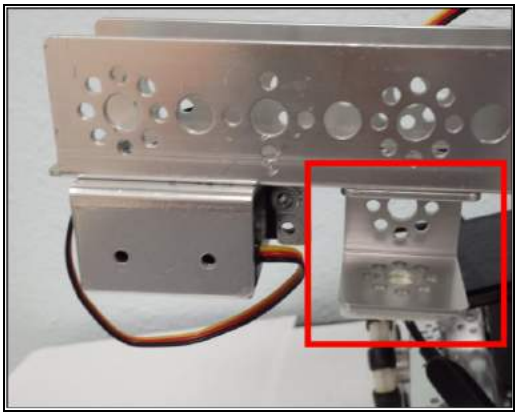




Step 35: Touch sensor trigger

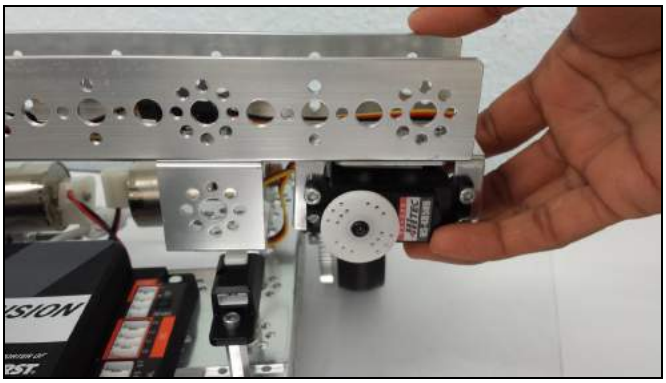
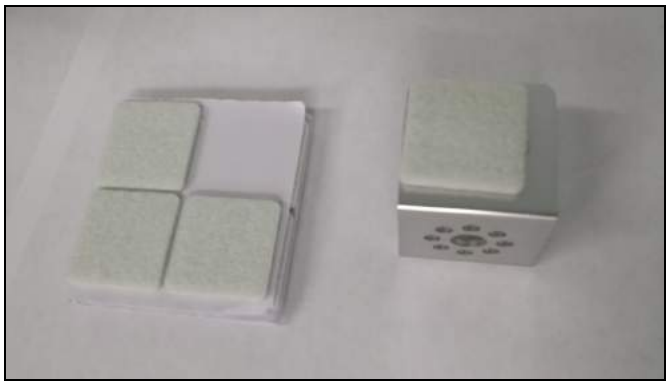
Hardware: 24mm channel

Instructions: Screw in the channel onto the servo arm mount as shown.

Front View **Bottom View** **Top View**

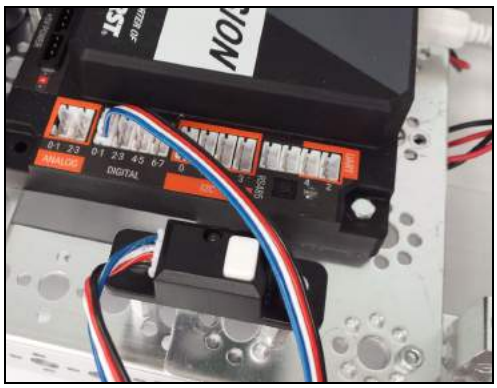

Then, test to see if the channel hits the touch sensor. You may have to play around with the channel a bit before it hits. Then, attach a square of furniture padding to **that particular part** of the channel. We attached ours to the top-left corner.

Step 36: Touch sensor wiring & testing

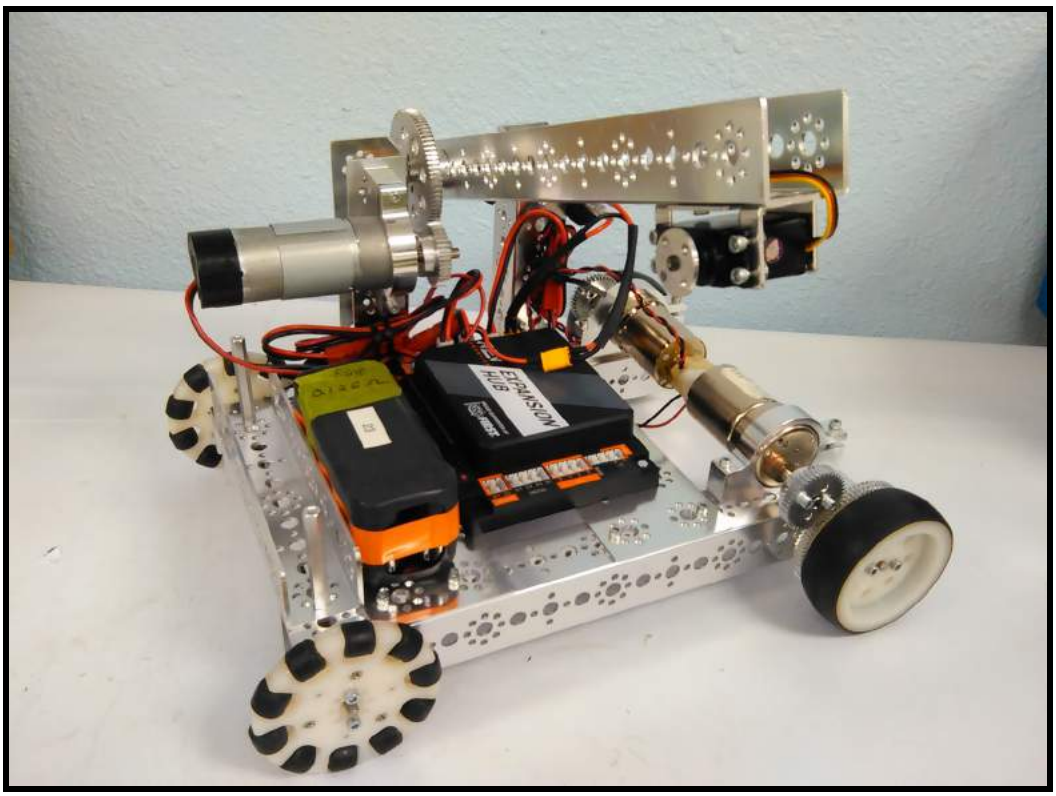
Hardware: 4-pin JST PH Cable (REV touch sensor wire)

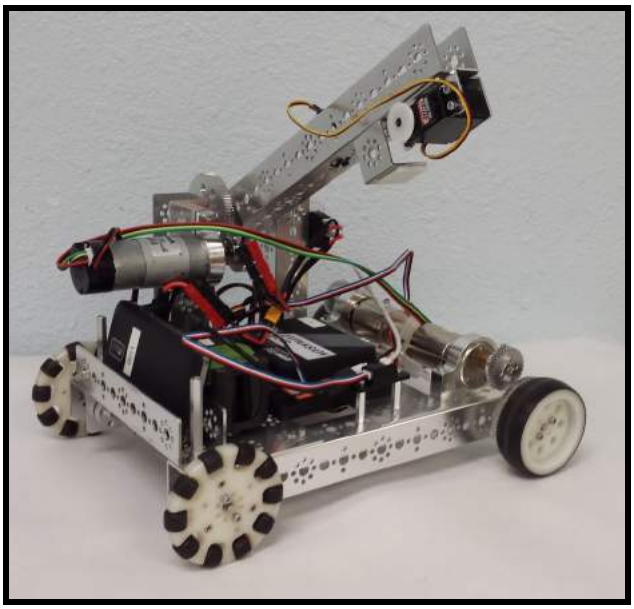
Instructions: Attach one end of the wire to the touch sensor. The other end plugs into the **0-1 Digital port** *(NOT Analog)*. Press the touch sensor to make sure it works - a blue light should shine if it does. Then test the arm to ensure that it hits the sensor.

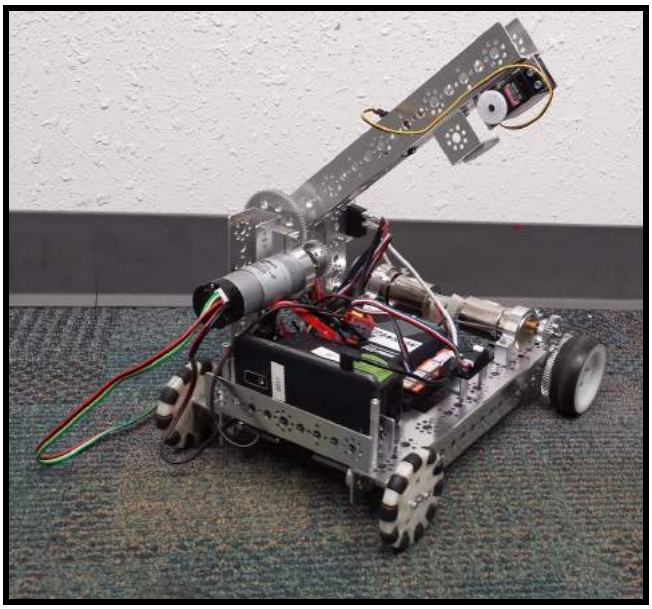



Step 37: Drive, Celebrate, and Enjoy!

Congratulations, you have now completed building the **Tomahawk!** This was a challenging build, so give yourself a pat on the back. Or get some ice cream. Or a big chocolate Hershey bar. (You can give it to me if you don't want it). Either way, sit back and have some fun driving your robot.







Tomahawk Design Notes

This robot was created to meet some very specific needs:

- Buildable in a relatively short period of time by first-time builders
- Uses only parts available in a single TETRIX Competition Kit (2016 and 2017 editions)
- Demonstrate important build skills and traps -- axles, gears, hubs, motor mounting, etc
    - Placement of power switch to avoid accidental triggering
- Be a useful platform for demonstrating programming topics
- Show how to circumvent design challenges -- mounting arm to chassis

Other notes:

- The design purposefully uses gears to drive the wheels and arms. One purpose is to gear down the motors to make the robots easier to control -- this is especially important for the arm.
- Another purpose is to make it easy to experiment/understand gear ratios -- e.g. on the driving wheels.
- The placement of the servo mount is intentional to protect the REV controller from being hit / damaged by the robot arm.
- Should add a note here about the importance of cable management and placement of components.