



PRESENTED BY **Qualcomm**

FIRST® RISE™ powered by Star Wars: Force for Change

2019-2020 *FIRST®* Tech Challenge

Basic 'Bot Guide for REV

Part 1



Sponsor Thank You

Thank you to our generous sponsors for your continued support of the *FIRST*® Tech Challenge!

***FIRST*® Tech Challenge
Season Presenting Sponsor**

Qualcomm

***FIRST*® Tech Challenge
Official Program Sponsor**



Collins Aerospace

***FIRST*® Tech Challenge
Official 3D Augmented Reality/
Virtual Reality Sponsor**



Revision History		
Revision	Date	Description
1	5/30/2019	First Revision
1.2	7/02/2019	Initial release

Contents

Contents	3
Introduction.....	5
What is FIRST® Tech Challenge?	5
FIRST Core Values	5
Gracious Professionalism®	5
Introduction to the Guide	6
Introduction	6
Parts	6
Tips and Tricks.....	6
Construction	7
Drive Assemblies and Frame	7
Step 1: Build Drive Brackets	7
Step 2: Build Motor Assemblies	8
Step 3: Build the Right and Left Rail	9
Step 4: Add Drive Wheels.....	10
Back Support Beam	11
Step 1: Add Screws to Corner Brackets.....	11
Step 2: Add Corner Brackets to Beam	12
Step 3: Add Floating Screws to Beam	13
Step 4: Add Back Support Beam	14
Front Support Beam.....	15
Step 1: Add Screws to Corner Brackets.....	15
Step 2: Add Corner Brackets to Beam	16
Step 3: Add Floating Screws to Beam	17
Step 4: Add Front Support Beam.....	18
Step 5: Add Switch Bracket	19
Caster Wheels	20
Step 1: Build Caster Brackets	20
Step 2: Add Caster Brackets to Chassis	21
Step 2: Add the Omni Wheels.....	22
Motor and Sensor Controller	25
Step 1: Add the Support Plate	25

Step 2: Add the Rev Robotics Expansion Hub.....	26
Step 3: Add the Expansion Hub to Phone Cable	27
Step 4: Add the Left Drive Motor Power Cable	28
Step 5: Add the Right Drive Motor Power Cable	29
Robot Controller.....	30
Step 1: Add the Phone Support Plate	30
Step 2: Add the Robot Controller Cell Phone to the Holder.....	31
Step 3: Connect the Robot Controller to the Expansion Hub (Part 1).....	32
Step 4: Connect the Robot Controller to the Expansion Hub (Part 2).....	33
Power Switch	34
Step 1: Add the Switch	34
Step 2: Connect the Switch to the Motor and Sensor Controller	35
Battery	36
Step 1: Add the Battery	36
Step 2: Connect the Battery to the Switch	37
Final Steps	38
Special Thanks and Best Wishes	38
Appendix A – Resources	39
Game Forum Q&A	39
<i>FIRST</i> Tech Challenge Game Manuals.....	39
<i>FIRST</i> Headquarters Pre-Event Support.....	39
<i>FIRST</i> Websites.....	39
<i>FIRST</i> Tech Challenge Social Media	39
Feedback.....	39

Introduction

What is FIRST® Tech Challenge?

FIRST® Tech Challenge is a student-centered program that focuses on giving students a unique and stimulating experience. Each year, teams engage in a new game where they design, build, test, and program autonomous and driver operated robots that must perform a series of tasks. To learn more about FIRST® Tech Challenge and other FIRST® Programs, visit www.firstinspires.org.

FIRST Core Values

We express the FIRST® philosophies of *Gracious Professionalism®* and *Coopertition®* through our Core Values:

- **Discovery:** *We explore new skills and ideas.*
- **Innovation:** *We use creativity and persistence to solve problems.*
- **Impact:** *We apply what we learn to improve our world.*
- **Inclusion:** *We respect each other and embrace our differences.*
- **Teamwork:** *We are stronger when we work together.*
- **Fun:** *We enjoy and celebrate what we do!*

Gracious Professionalism®

FIRST® uses this term to describe our programs' intent.

Gracious Professionalism® is a way of doing things that encourages high-quality work, emphasizes the value of others, and respects individuals and the community.

Watch Dr. Woodie Flowers explain *Gracious Professionalism* in this [short video](#).

Introduction to the Guide

Introduction

The Basic 'Bot Guide is designed to be a resource for teams looking for step-by-step instructional for building the basic chassis and structure needed in a *FIRST* Tech Challenge competition. There are multiple versions of this guide, previously called the "Push Bot Guide", this version the **Basic 'Bot Guide for REV** has been created to use the new and differing parts in the 2019-2020 season's REV kit of parts.

Parts

- Rev FTC Competition Set
- Electronics Modules and Sensors Set
- Control & Communication Set 1 or 2
- (Optional) Only the tools included in the FTC Competition Set will be needed to build the chassis. The screws and nuts are a standard size and having more tools may allow more students to participate at the same time.
- (Optional) A ruler is not needed to build this robot, but it is necessary to make sure that the robot is competition ready.

Tips and Tricks

- Secure the screws/nuts just enough, so parts do not slide/move relative to each other. Overtightening the screws will damage the aluminum extrusions.
- Make sure that set screws are installed in every axle hub, motor hub, and axle collar.
- Refer to the legend provided in the Kit of Parts, if any parts are unfamiliar.
- Make sure that all assemblies are square. It is hard to drive a crooked robot straight!
- The drive wheels are powered by two DC motors, which are relatively heavy. The drive wheels are on the back of the robot, because that is where the most weight is. This weight is needed to help the wheels grip the surface better.
- Omni wheels are on the front of the robot, which allows the robot to turn more easily. The omni wheels can slide sideways with very little friction due to the rollers.

Unless otherwise noted, the top image in each step shows the necessary parts; the lower image shows the completed assembly.

Construction

Drive Assemblies and Frame

Step 1: Build Drive Brackets

Parts Needed:

REV-41-1303 – Bracket, Motion (4)

REV-41-1361 – Nut, Locking, M3 (8)

REV-41-1359 – Screw, Hex Cap, M3, 8mm (8)

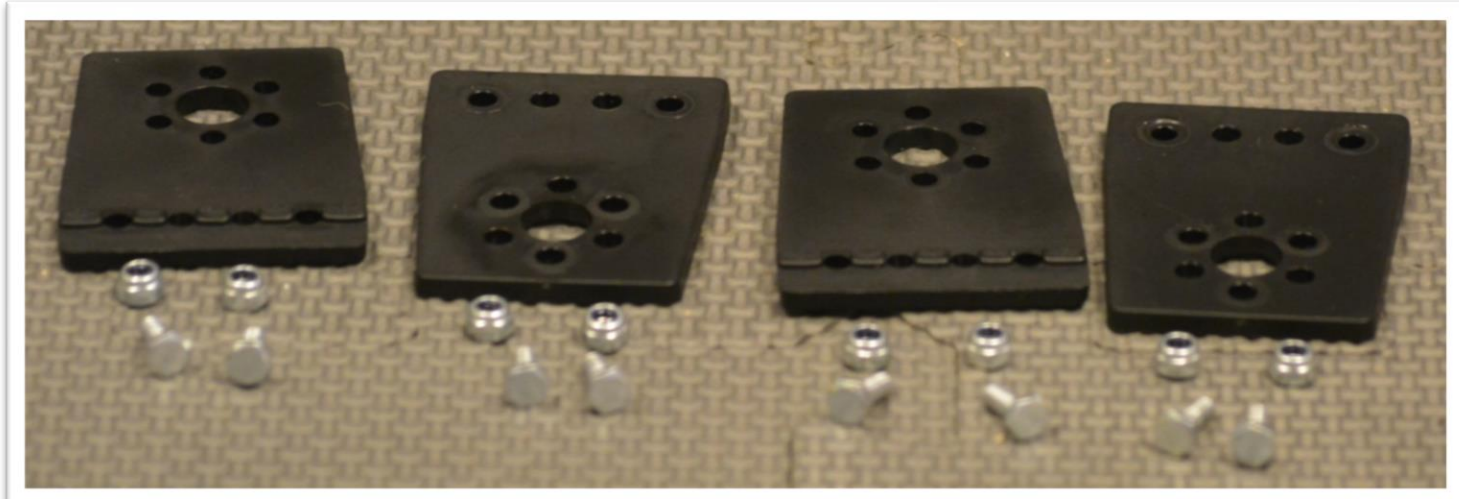


Figure 1- Unassembled view

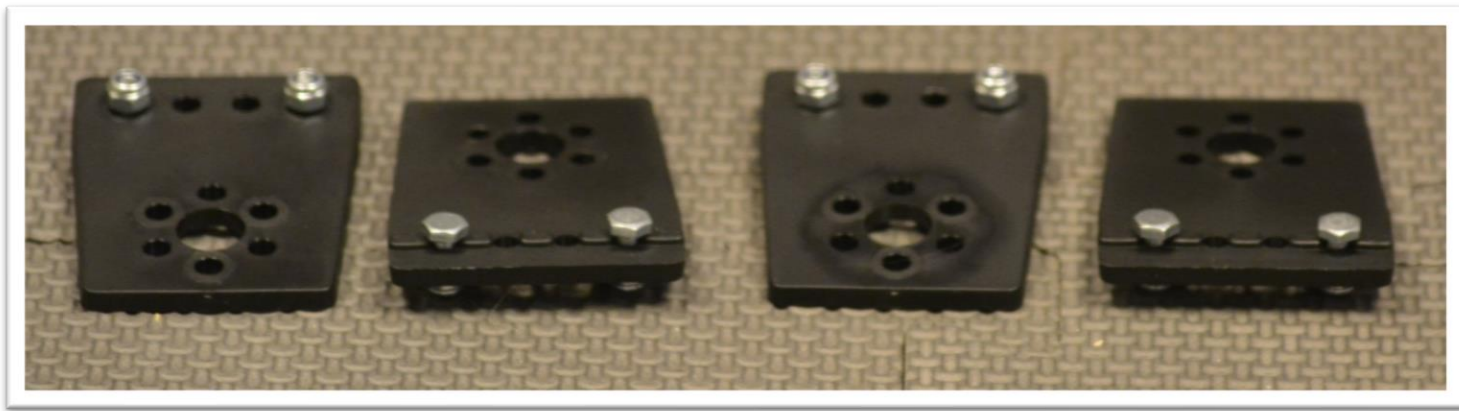


Figure 2- Assembled view

Helpful Hint:

- Do not overtighten the screws. Screw heads will need to slide along the center of an extrusion in a later step.

Step 2: Build Motor Assemblies

Parts Needed:

REV-41-1300 – Core Hex Motor w/cables (2)

REV-41-1359 – Screw, Hex Cap, M3, 8mm (3 per motor; 6 in total)

Drive Bracket Assemblies – (1 per motor; 2 in total)

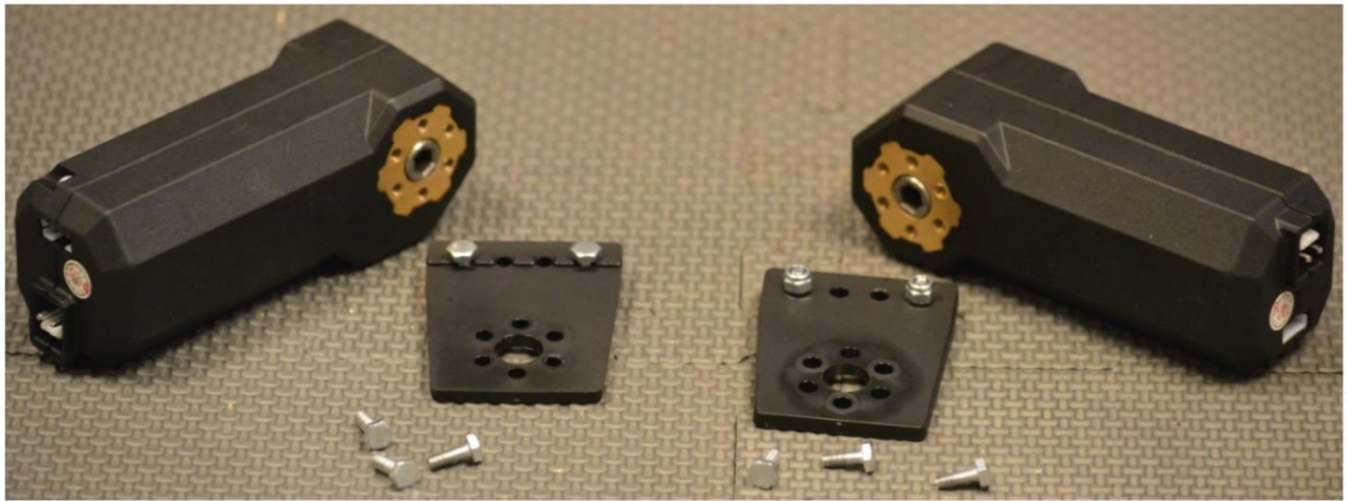


Figure 3- Unassembled view

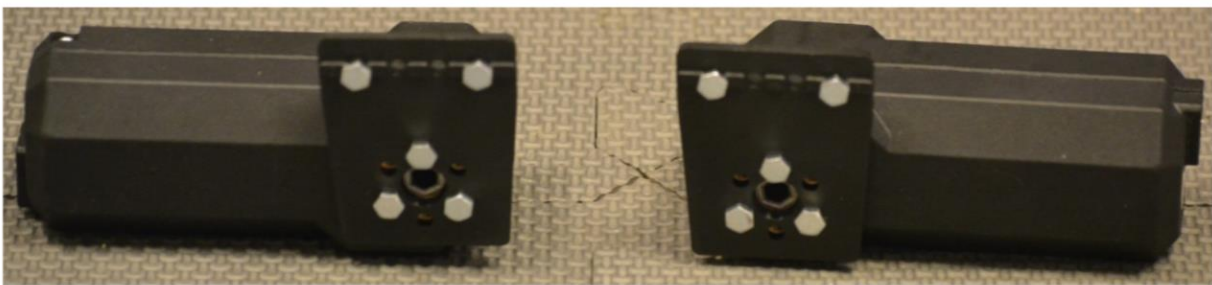


Figure 4- Assembled view

Helpful Hints:

- Make sure that the brackets are facing the correct direction; the alignment ribs should be on the side away from the motor.
- Motor directions are reversed – the power plug of the motor pictured on the left is on the bottom; the plug of the motor on the right is on the top.
- Do not yet plug cables into the motors
- Use only two of the assemblies from step 1.

Step 3: Build the Right and Left Rail

Parts Needed:

REV-41-1432 – Extrusion, 420mm, 90-90 degree (1 per side; 2 in total)
 REV-41-1324 – Spacer, 3mm (3 per side; 6 in total)
 REV-41-1327 – Shaft Collar (1 per side; 2 in total)
 REV-41-1326 – Bearing, Through Bore, Short (1 per side; 2 in total)
 REV-41-1347 – Shaft, 5mm Hex, 75mm (1 per side; 2 in total)
 Motor Assemblies- (1 per side; 2 in total – from step 2)
 Drive Bracket assemblies-(1 per side; 2 in total –the two remaining from step 1)

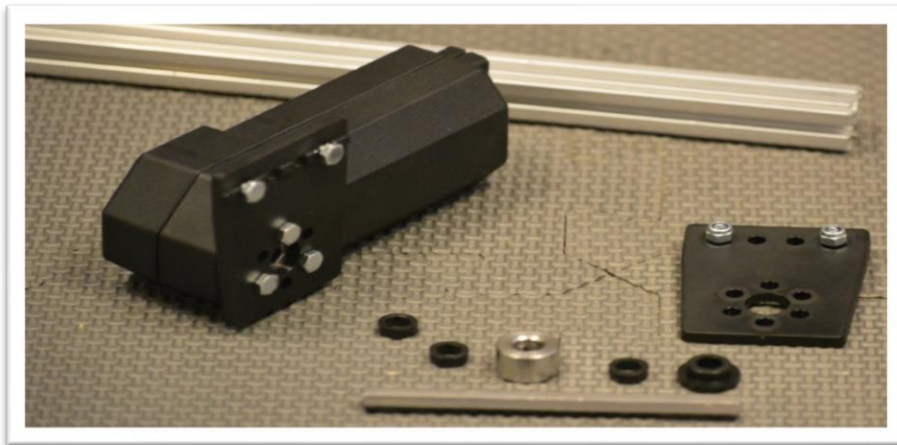


Figure 5 Unassembled view

(The image above shows only the right rail. Duplicate the number of parts for the left rail.)



Figure 6- Assembled view

Helpful Hints:

- Slide the head of the screws down the center of the extrusions. The brackets should be flush with the end of the extrusions.
- Order from the outside in: bracket, bearing, spacer, collar, two spacers, bracket with attached motor

Step 4: Add Drive Wheels

Parts Needed:

REV-41-1354 – Wheel, Traction 90mm (1 per side; 2 in total)
REV-41-1327 – Shaft Collar (1 per side; 2 in total)
REV-41-1324 – Spacer, 3mm (1 per side; 2 in total)
Rail Assemblies (1 per side; 2 in total) **from step 3*

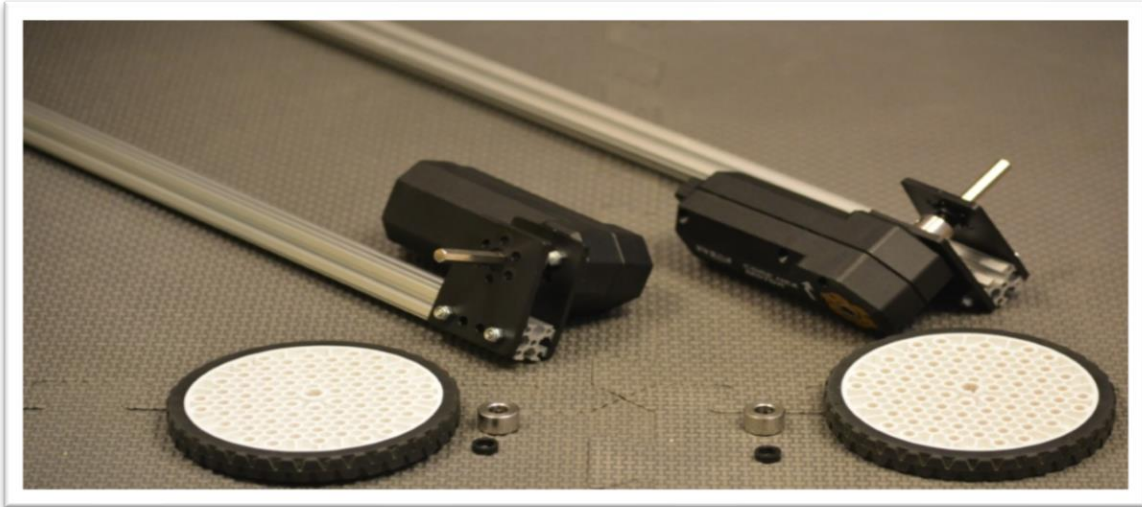


Figure 7- Unassembled view

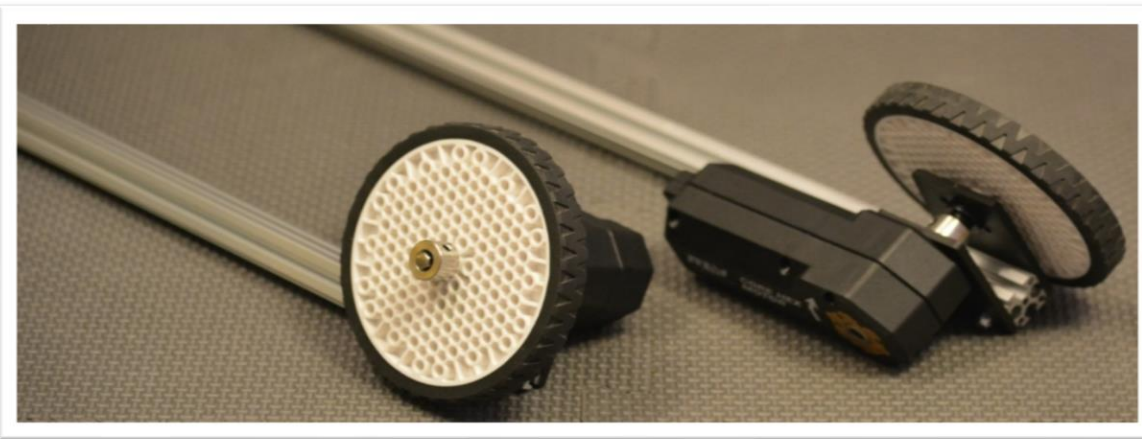


Figure 8- Assembled view

Helpful Hints:

- *Order from the outside in: collar, wheel, spacer, rail assembly.*
- *Make sure that the wheels do not rub the nuts. If they do, then revisit previous steps to make sure the construction is accurate.*
- *Adjust axle length, so it is flush with the collar*

Back Support Beam

Step 1: Add Screws to Corner Brackets

Parts Needed:

REV-41-1320 – Bracket, Inside Corner (2)
REV-41-1359 – Screw, Hex Cap, M3, 8mm (8)
REV-41-1361 – Nut, Locking, M3 (8)

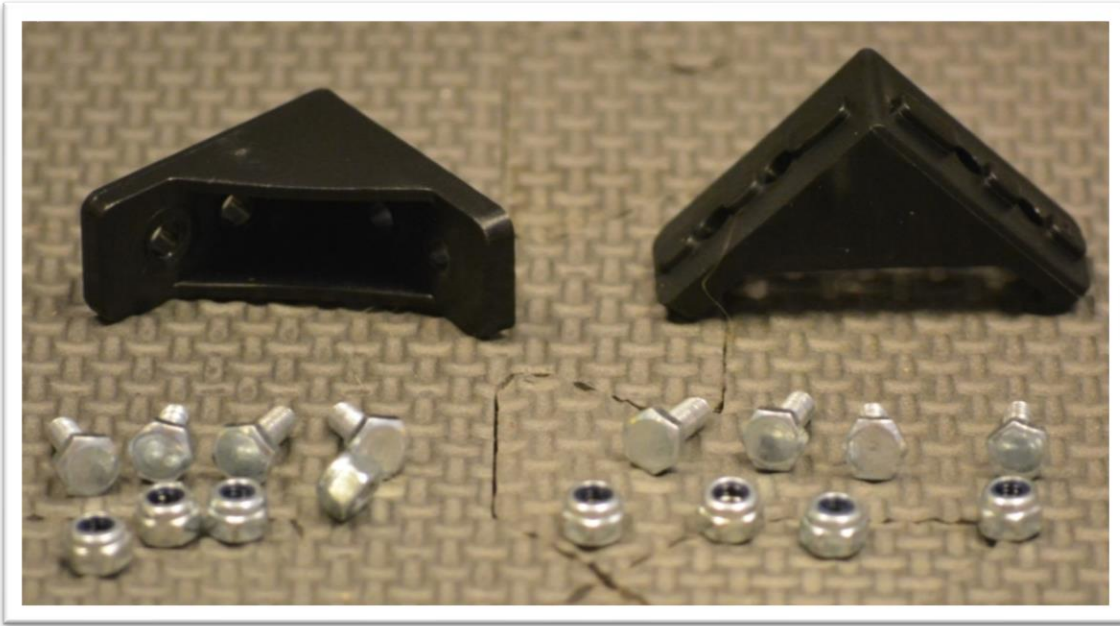


Figure 9- Unassembled View



Figure 10- Assembled view

Helpful Hint:

- Screw the nuts onto the screws just until it's difficult to turn them; do not overtighten! The screw heads will need to slide along the center of an extrusion in a later step

Step 2: Add Corner Brackets to Beam

Parts Needed:

REV-41-1431 – Extrusion, 225mm, 90-90

Degree (1)

Corner Bracket Assemblies (2 - from step 1)



Figure 11- Unassembled View

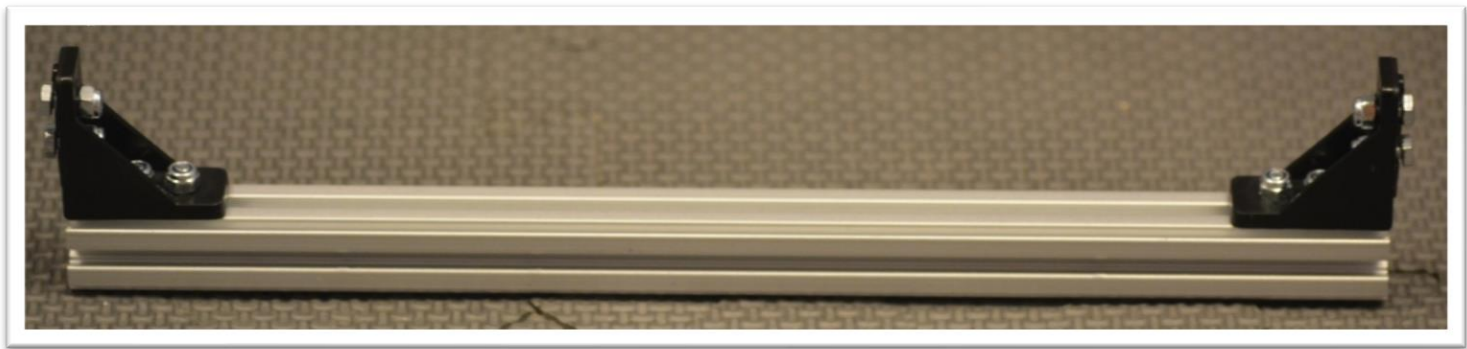


Figure 12- Assembled view

Helpful Hint:

- Slide the head of the screws down the center of the extrusion.

Step 3: Add Floating Screws to Beam

Parts Needed:

REV-41-1359 – Screw, Hex Cap, M3, 8mm (2)
Back Support Assembly (1 - from step 2)



Figure 13- Unassembled View



Figure 14- Assembled view

Helpful Hint:

- The two 8mm screws are loaded onto what will become the top face of the beam.

Step 4: Add Back Support Beam

Parts Needed:

Chassis (from Drive Assemblies and Frame, step 4)
Back Support Beam Assembly (from the

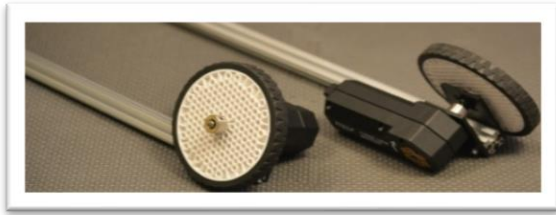


Figure 15- Unassembled view 1



Figure 16- Unassembled view 2

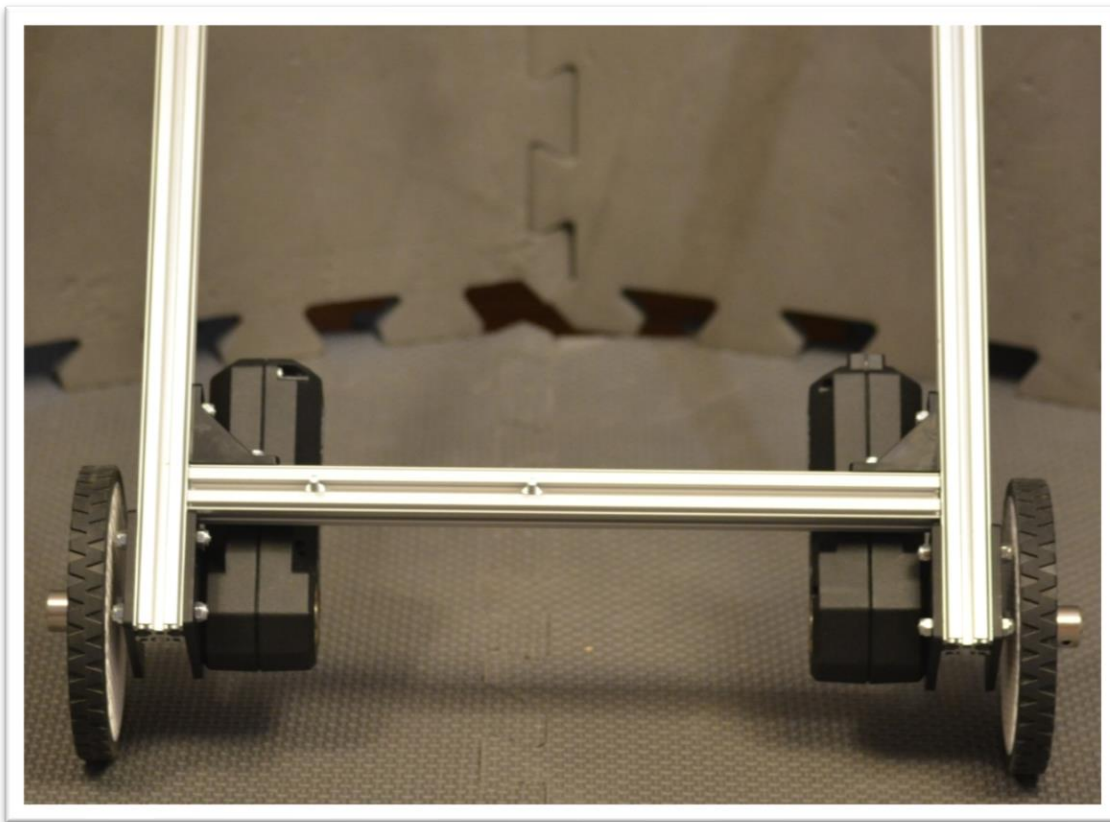


Figure 17- Assembled view

Helpful Hint:

- *The beam should touch the drive wheel brackets.*

Front Support Beam

Step 1: Add Screws to Corner Brackets

Parts Needed:

- REV-41-1320 – Bracket, Inside Corner (2)
- REV-41-1359 – Screw, Hex Cap, M3, 8mm (8)
- REV-41-1361 – Nut, Locking, M3 (8)

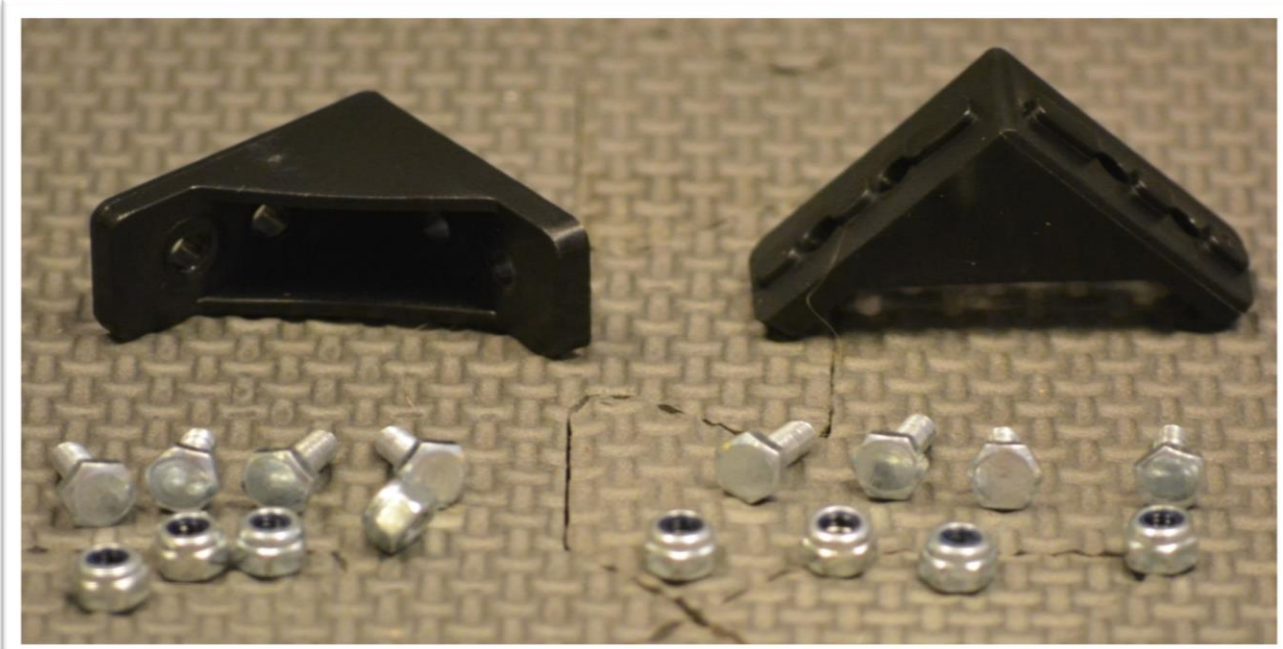


Figure 18- Unassembled view



Figure 19- Assembled view

Helpful Hints:

- Screw the nuts onto the screws just until it's difficult to turn them; just so that the nuts don't fall off.
- The screw heads will need to slide along the center of an extrusion in a later step.

Step 2: Add Corner Brackets to Beam

Parts Needed:

Front Beam Assembly (1 - from step 2)
REV-41-1431 – Extrusion, 225mm, 90-90 Degree (1)
Corner Bracket Assemblies (2 - from step 1)

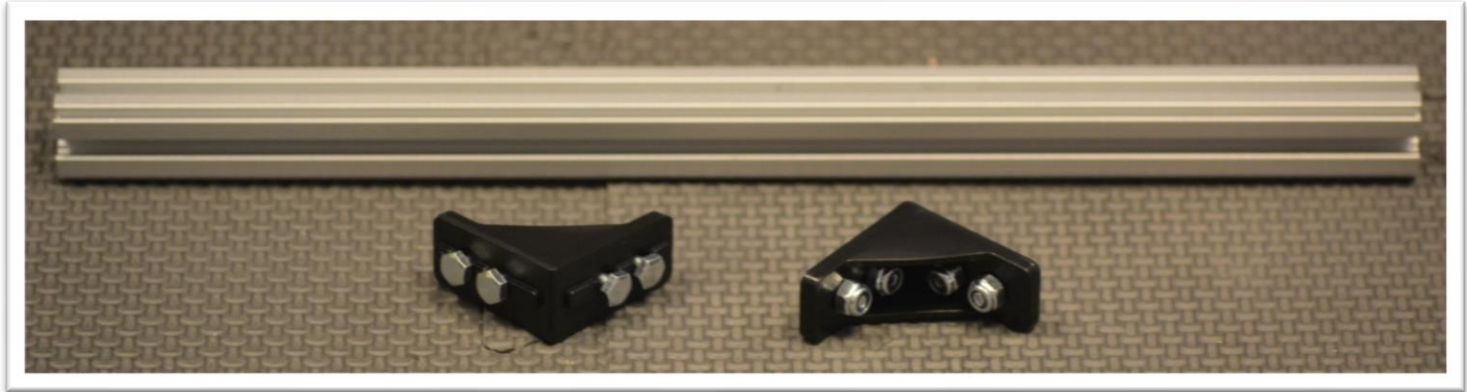


Figure 20- Unassembled view



Figure 21- Assembled view

Step 3: Add Floating Screws to Beam

Parts Needed:

REV-41-1359 – Screw, Hex Cap, M3, 8mm (3)
REV-41-1360 – Screw, Hex Cap, M3, 16mm (2)
Front Beam Assembly (1 - from step 2)

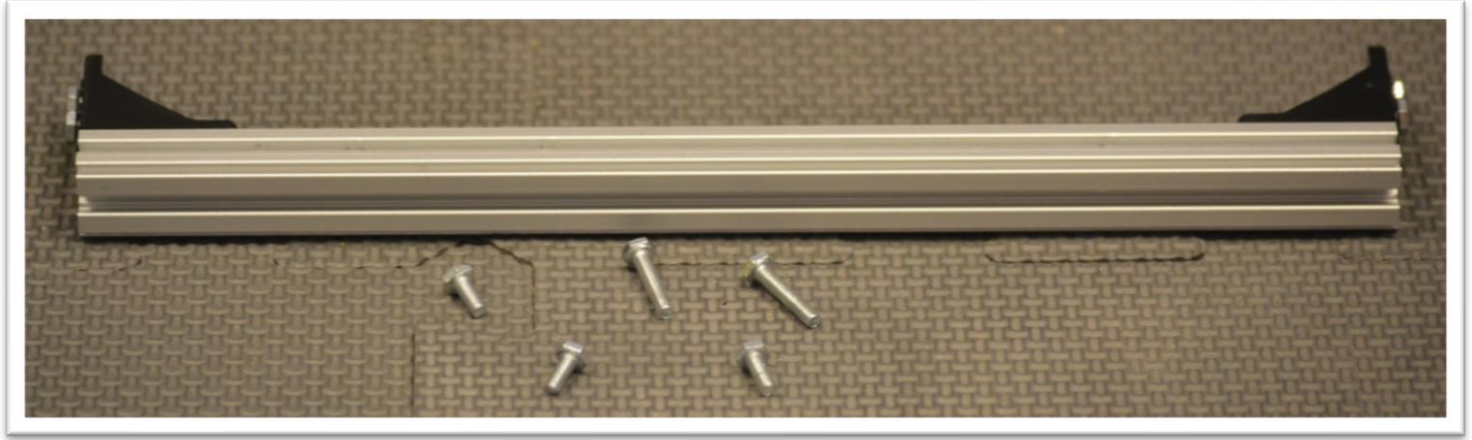


Figure 22- Unassembled view

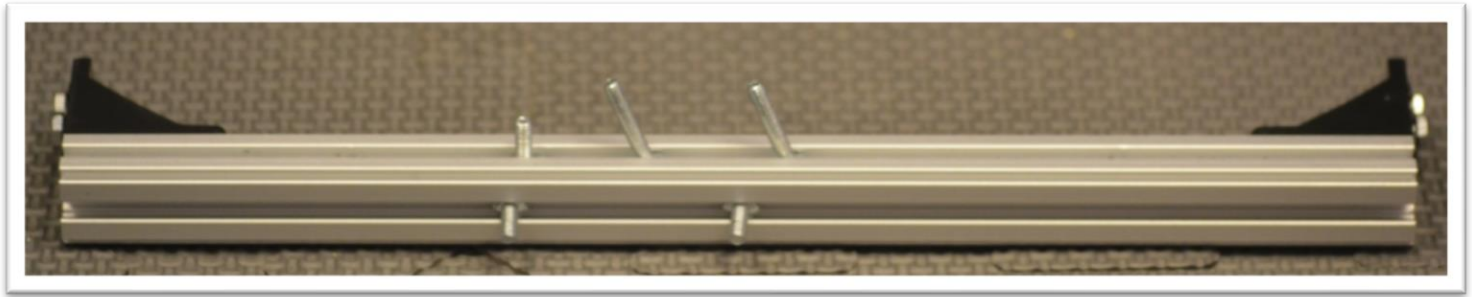


Figure 23- Assembled view

Helpful Hints:

- Two of the 8mm screws are loaded onto what will become the front face of the beam.
- One of the 8mm and two of the 16mm screws are loaded onto what will become the top face of the beam.

Step 4: Add Front Support Beam

Parts Needed:

Chassis (from Back Support Beam, step 4)
Front Support beam assembly (1 - from step 3)

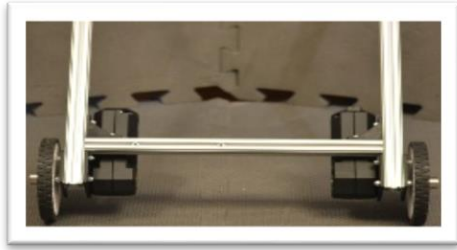


Figure 24- Unassembled view 1

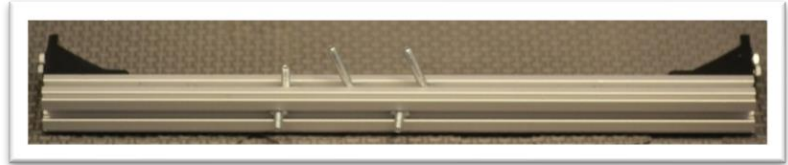


Figure 25- Unassembled view 2

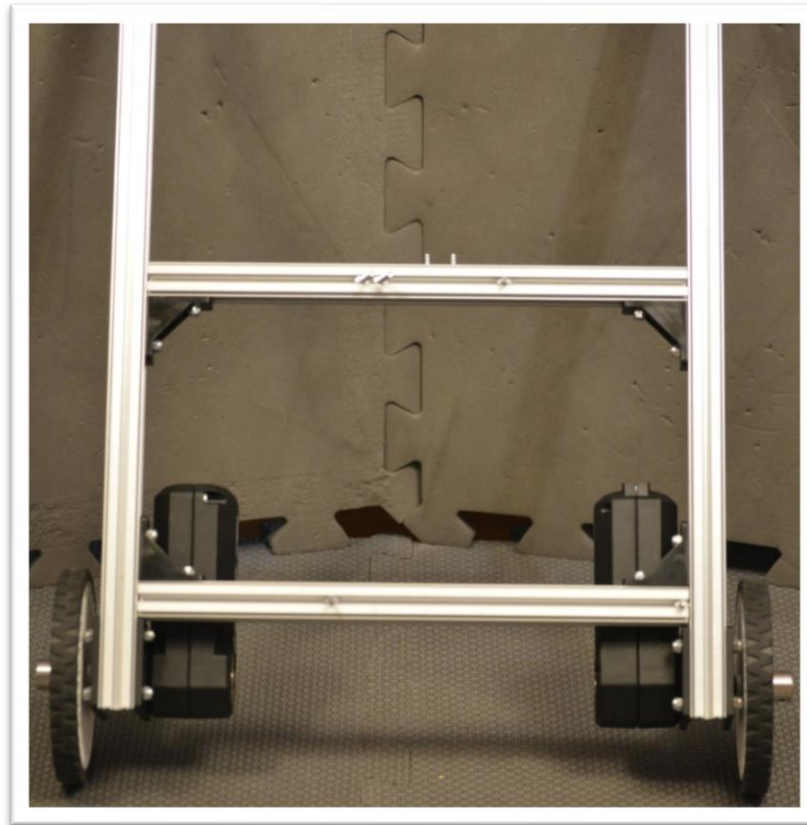


Figure 26- Assembled view

Helpful Hint:

- There should be 121mm between the back support beam and the front support beam (there will be 136mm center to center).
 - If a ruler is not available, the position may need to be adjusted in a later step.

Step 5: Add Switch Bracket**Parts Needed:**

REV-41-1361 – Nut, Locking, M3 (2)
Chassis
Switch Plate (part of REV-31-1387)

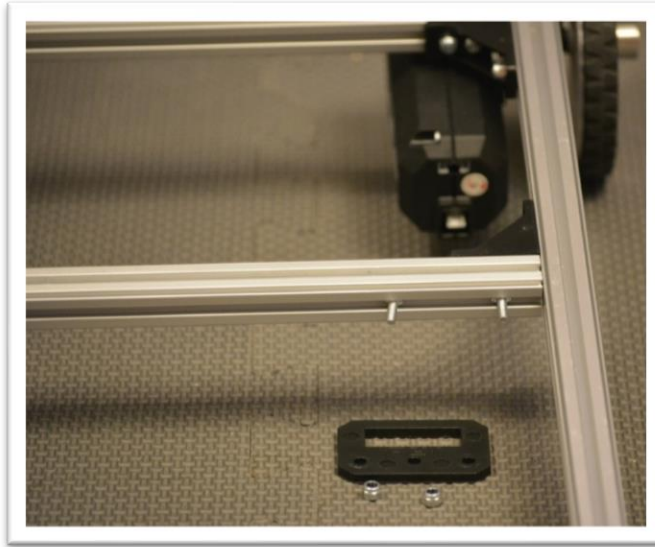


Figure 27- Unassembled view

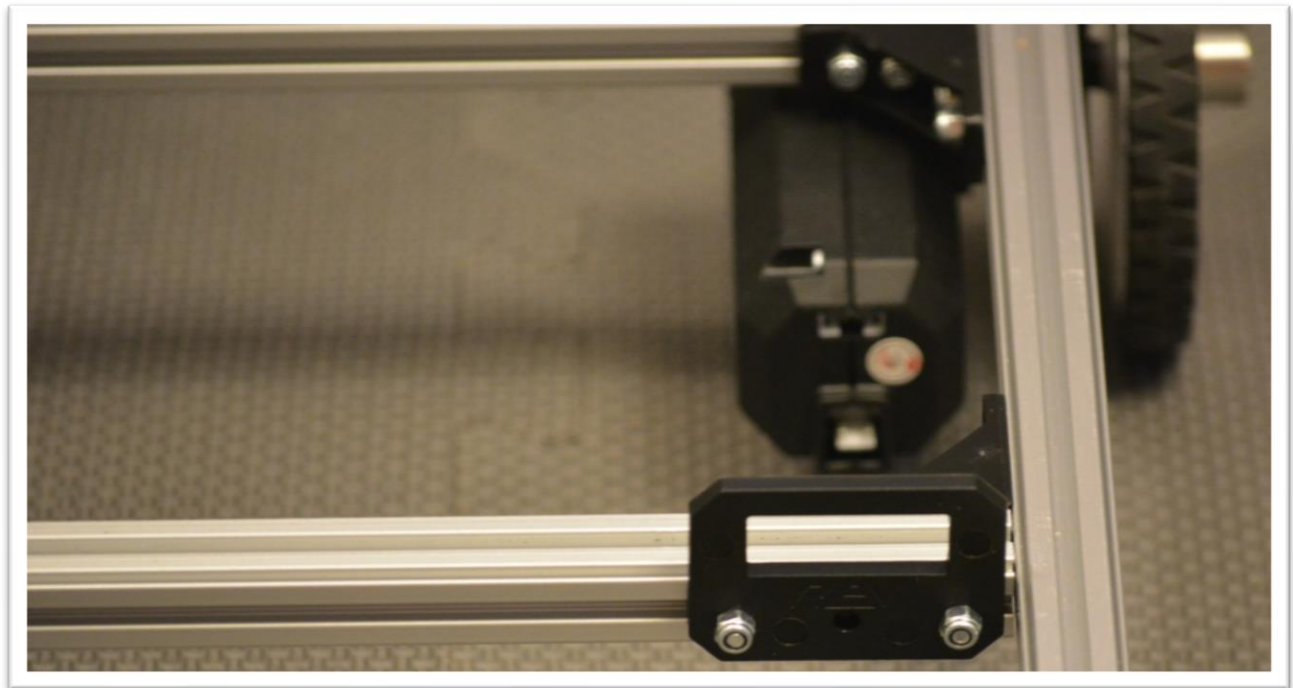


Figure 28- Assembled view

Caster Wheels

Step 1: Build Caster Brackets

Parts Needed:

REV-41-1303 – Bracket, Motion (2 per side, 4 total)
REV-41-1361 – Nut, Locking, M3 (2 per bracket, 4 per side, 8 total)
REV-41-1359 – Screw, Hex Cap, M3, 8mm (2 per bracket, 4 per side, 8 total)

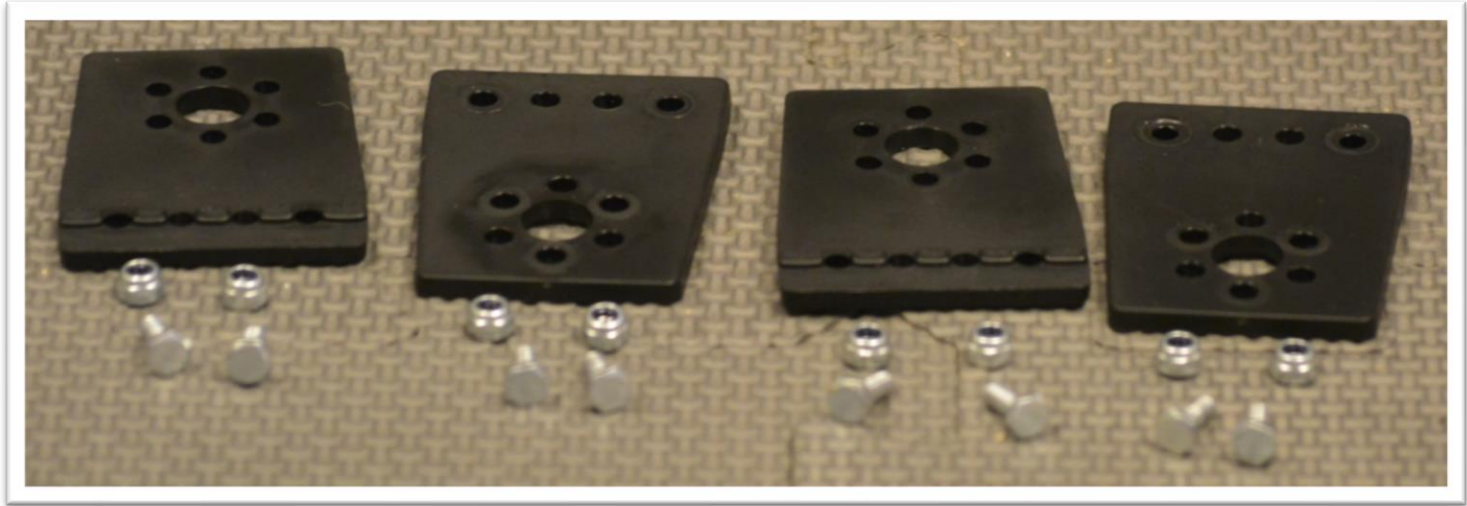


Figure 29- Unassembled view

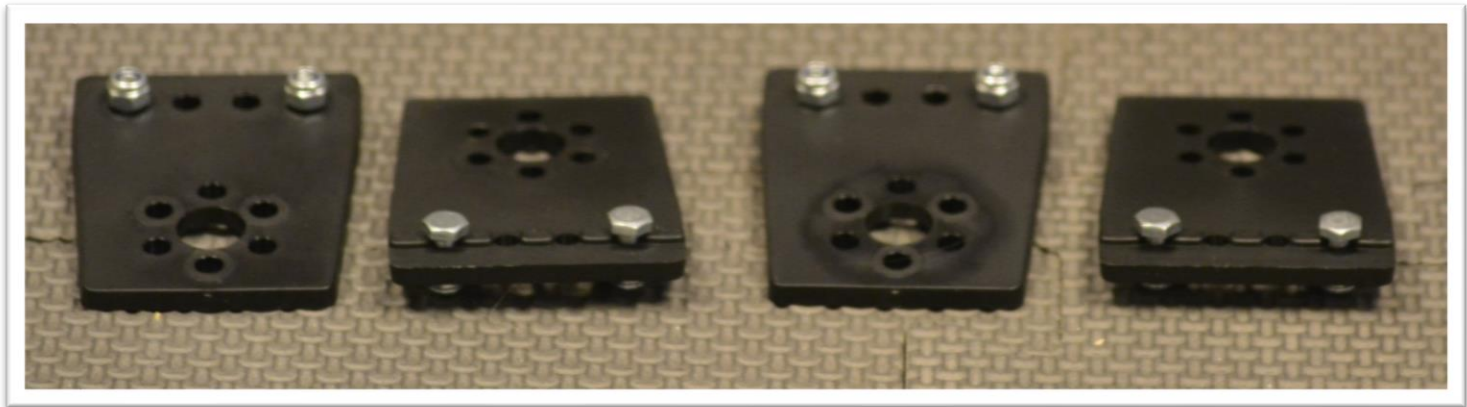


Figure 30- Assembled view

Helpful Hint:

- Screw the nuts onto the screws just until it's difficult to turn them; do not overtighten because the screw heads will need to slide along the center of an extrusion in a later step.

Step 2: Add Caster Brackets to Chassis

Parts Needed:

Caster Bracket Assemblies (4 from the previous step)

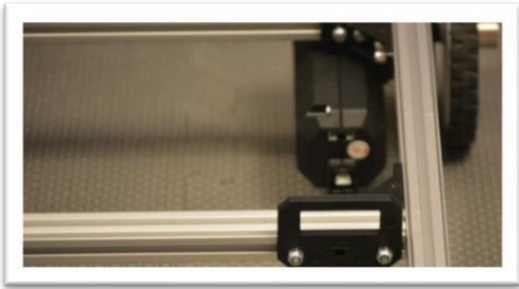


Figure 31- Unassembled view 1

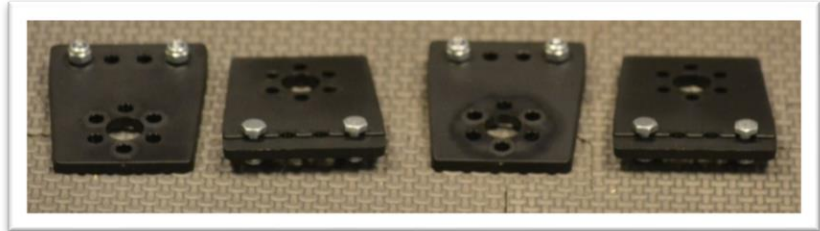


Figure 32- Unassembled view 2

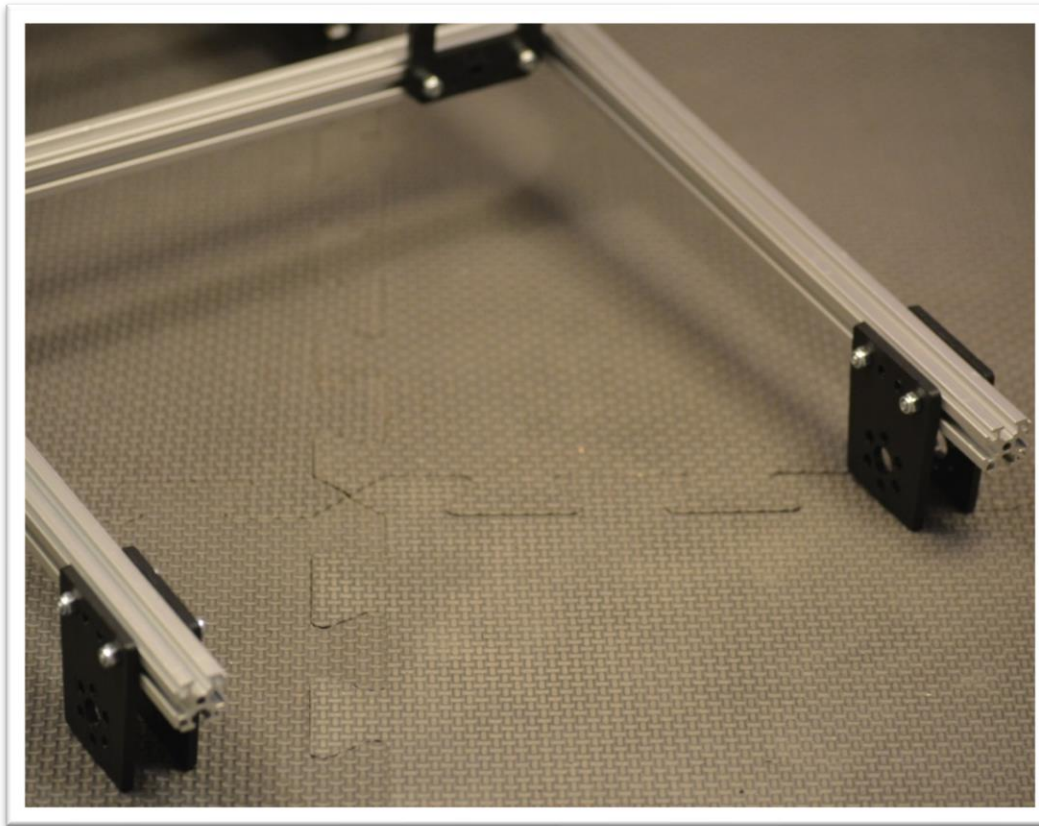


Figure 33- Assembled view

Helpful Hints:

- Brackets must be installed 2 cm from the end of the extrusion, if used for competition, to fit within the sizing cube.
- Ensure that the pair of brackets on the same extrusion are the same distance from the end of the extrusion or the wheels will not rotate properly.

Step 2: Add the Omni Wheels

Parts Needed:

REV-41-1327 – Shaft Collar (2 per side – 4 total)
REV-41-1326 – Bearing, Through Bore, Short (2 per side – 4 total)
REV-41-1323 – Spacer, 15mm (1 per side – 2 total)
REV-41-1324 – Spacer, 3mm (1 per side – 2 total)
REV-41-1347 – Shaft, 5mm Hex, 75mm (1 per side – 2 total)
REV-41-1190 – Wheel, Omni 90mm (1 per side – 2 total)

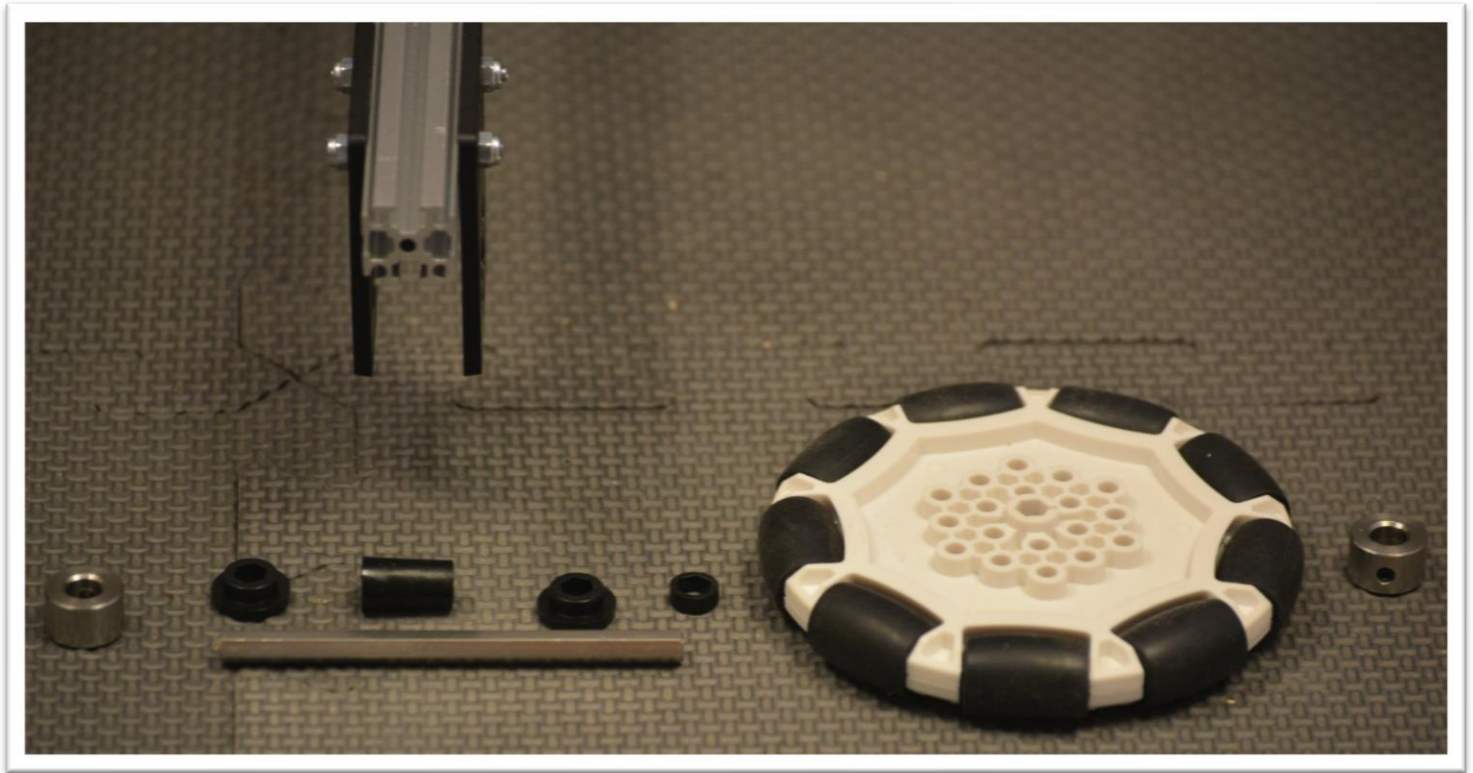


Figure 34- Unassembled view of left wheel (Make a mirror image for the right side)

[Continued on the next page, so detail can be seen more easily.]

[Continued from pervious page]

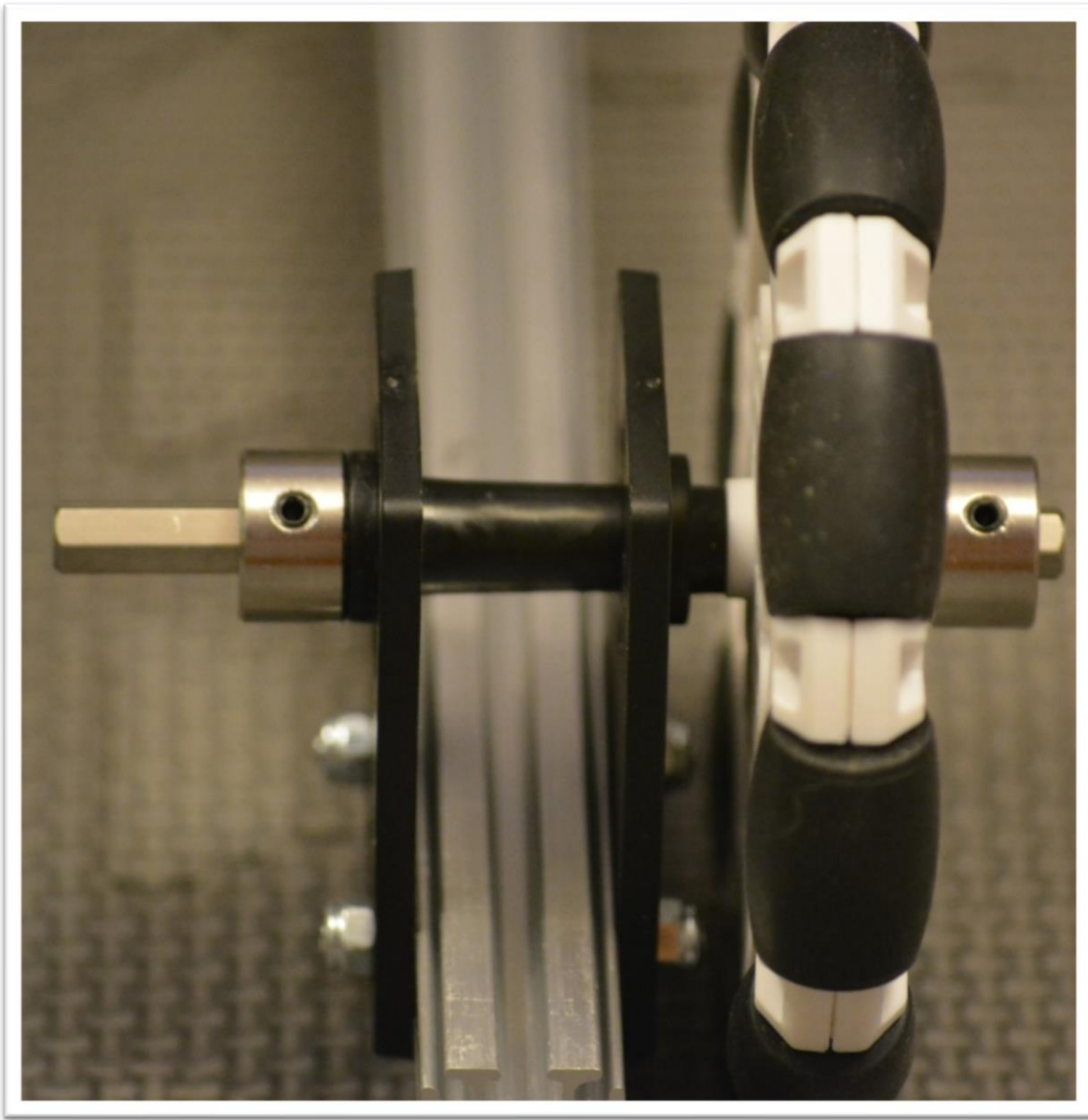


Figure 35 Above shows only the right wheel.

(Make a mirror image for left wheel)

Helpful Hints:

- Order from the outside in: collar, omni wheel, 3mm spacer, bearing, bracket, 15mm spacer, bracket, bearing, collar.
- Adjust axle length, so it is flush with the collar

[Continued on the next page, so detail can be seen more easily.]

[Continued from pervious page]

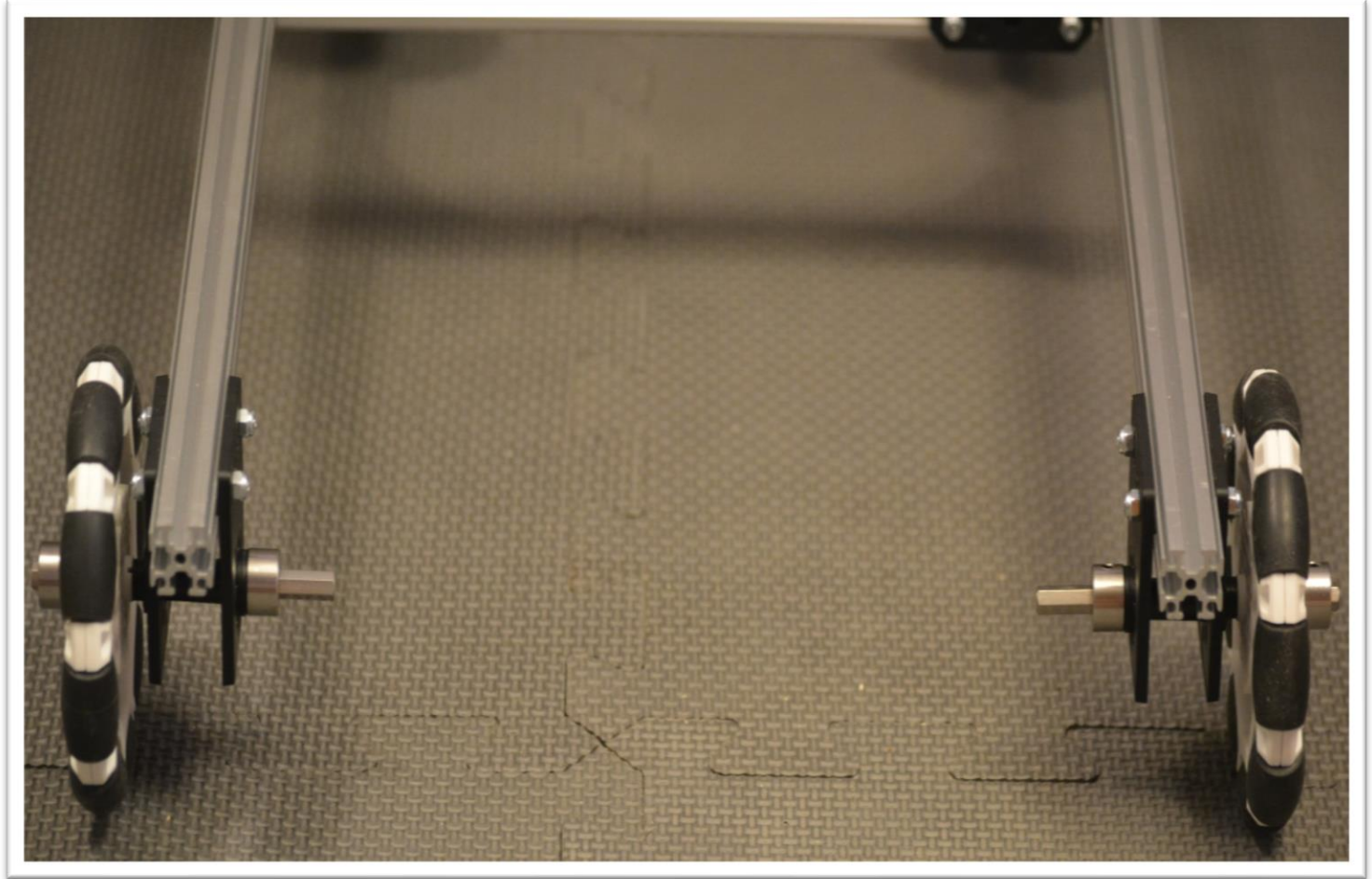


Figure 36- Assembled view

Motor and Sensor Controller

Step 1: Add the Support Plate

Parts Needed:

REV-41-1166 – Battery Holder Plate (1)
REV-41-1361 – Nut, Locking, M3 (2)

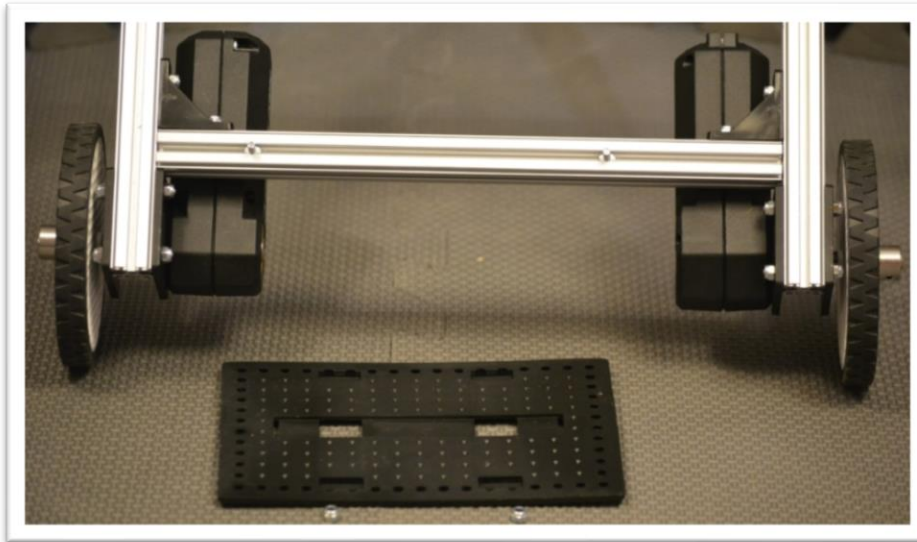


Figure 37- Unassembled view

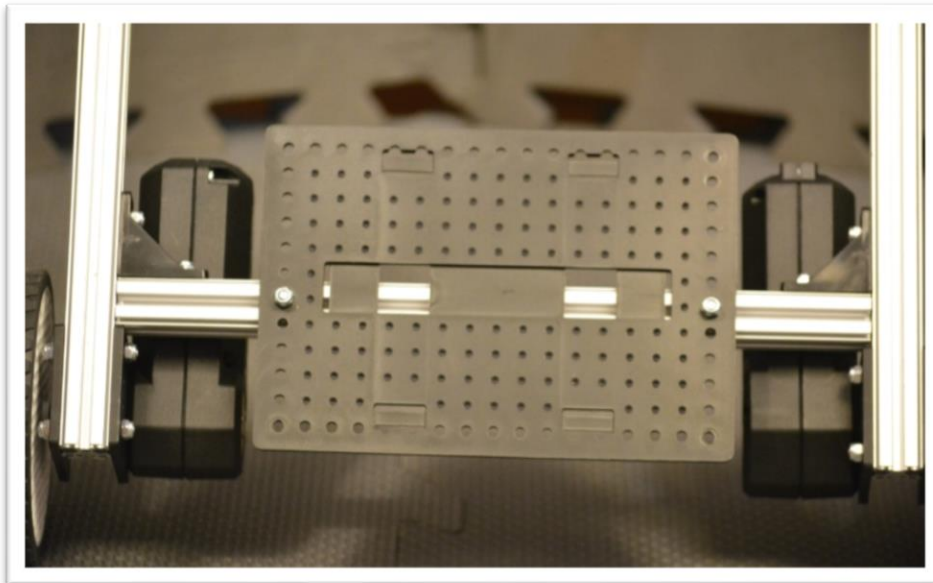


Figure 38- Assembled view

Helpful Hint:

- Center the plate on the extrusion.

Step 2: Add the Rev Robotics Expansion Hub

Parts Needed:

REV-31-1153 – Expansion Hub (1)
REV-41-1360 – Screw, Hex Cap, M3, 16mm (2)
(two other screws are already in the extrusion)

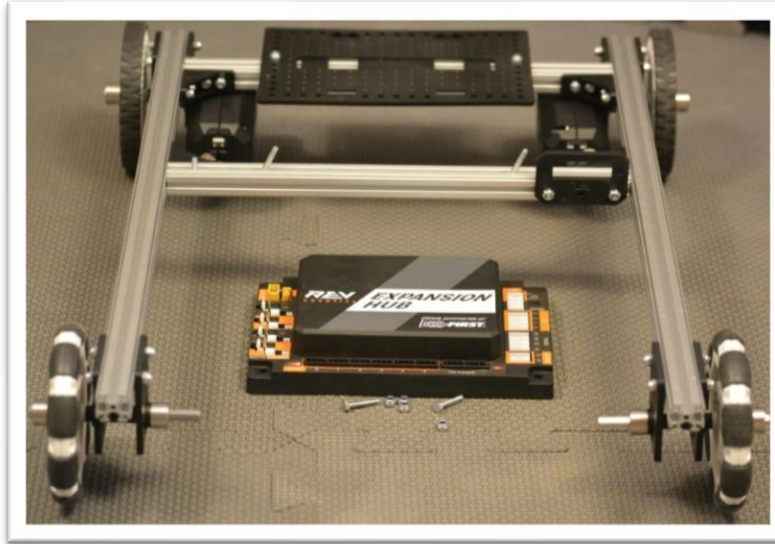


Figure 39- Unassembled view

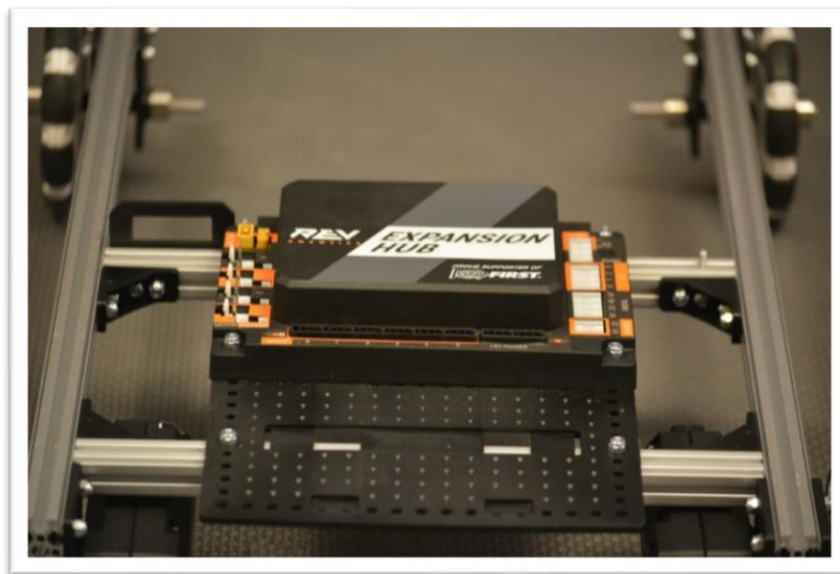


Figure 40- Assembled view

Helpful Hint:

- Reposition the front support beam, if necessary, to accomplish the proper spacing – the two floating screws on the front beam need to be at the corners of the expansion hub

Step 3: Add the Expansion Hub to Phone Cable

Parts Needed:
5446 - Monoprice USB Cable (1)

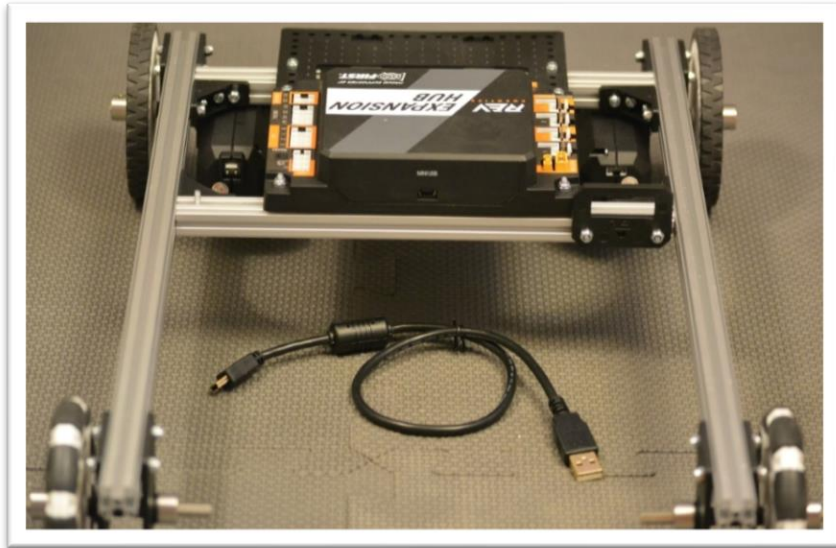


Figure 41- Unassembled view

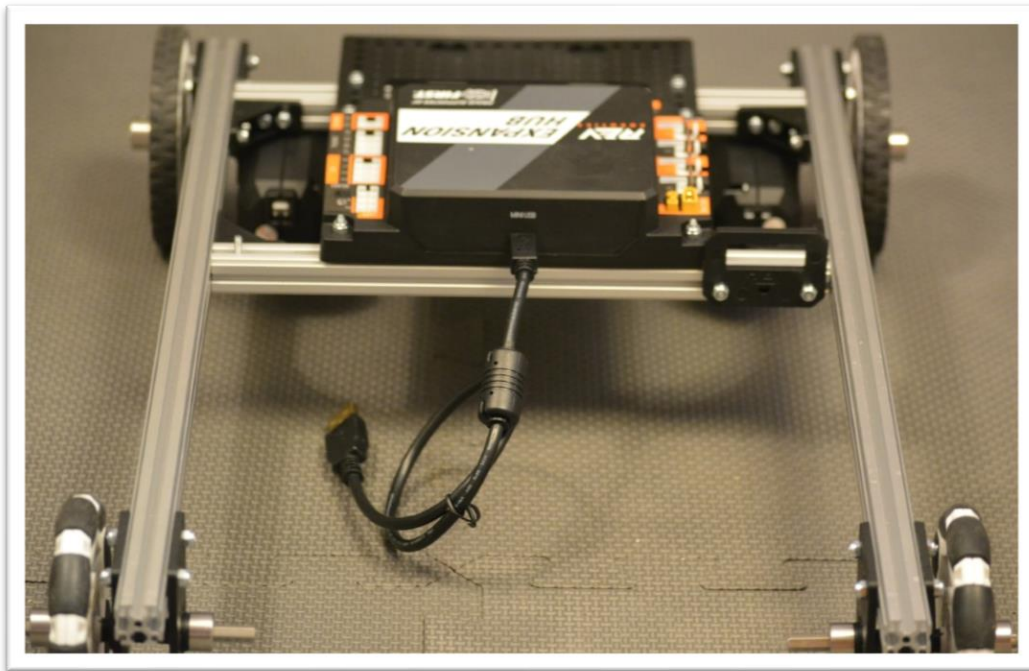


Figure 42- Assembled view

Helpful Hint:

- Plug the Mini USB plug into the Expansion Hub

Step 4: Add the Left Drive Motor Power Cable

Parts Needed:

Motor Power Cable (1 – comes with the core hex motor – REV-41-1300)

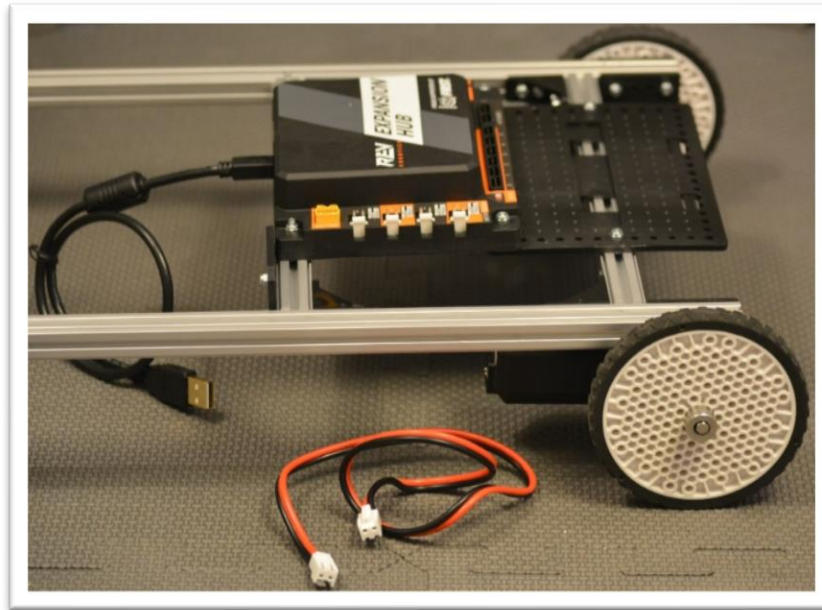


Figure 43- Unassembled view

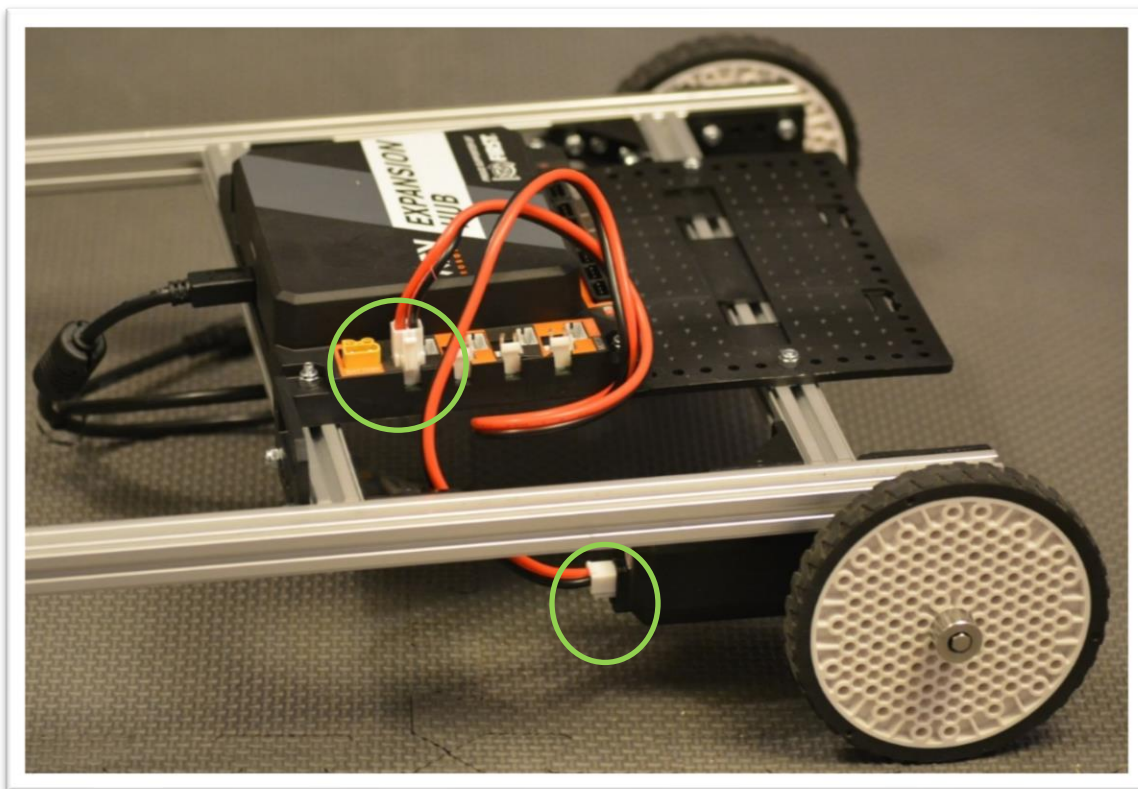


Figure 44- Assembled view

Step 5: Add the Right Drive Motor Power Cable

Parts Needed:

Motor Power Cable (1 – comes with the core hex motor – REV-41-1300)

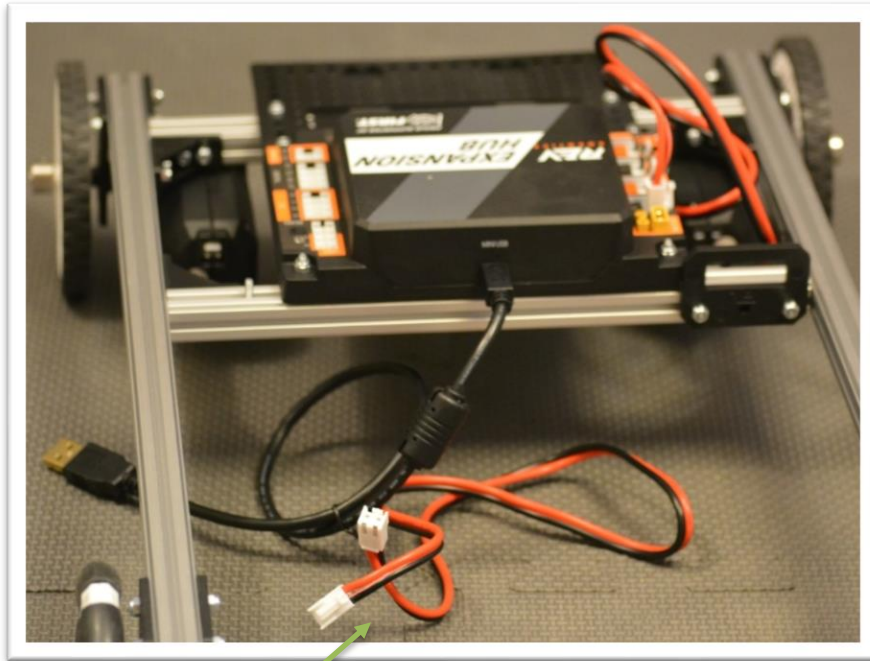


Figure 45- Unassembled view

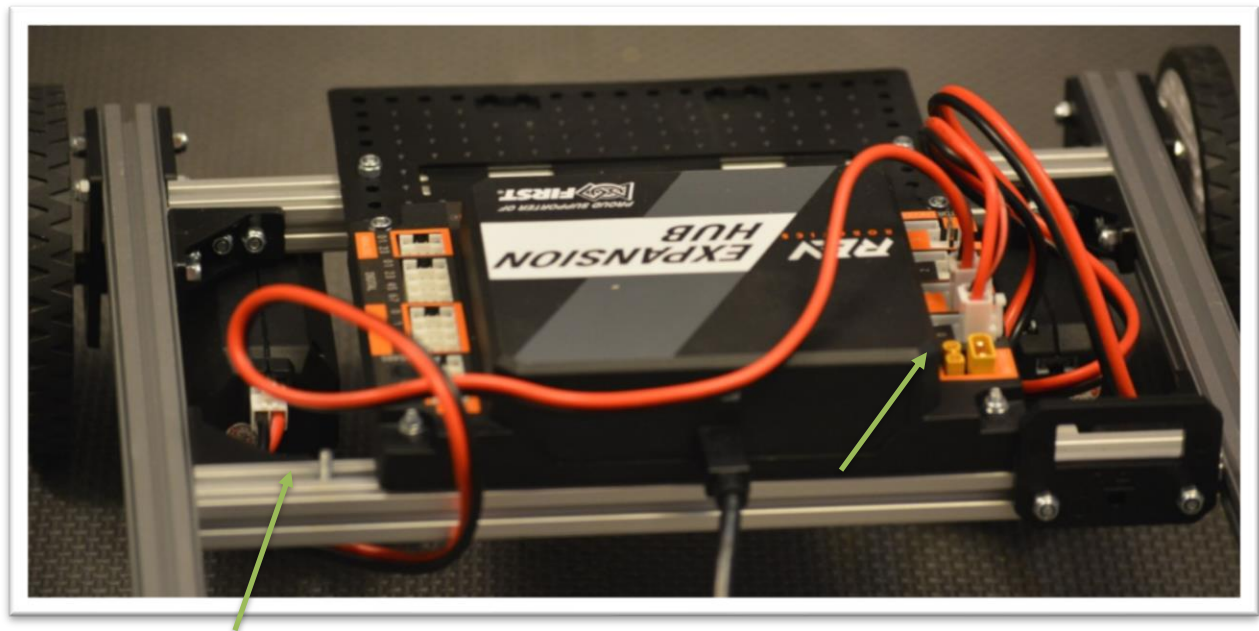


Figure 46- Assembled view

Robot Controller

Step 1: Add the Phone Support Plate

Parts Needed:

- REV-41-1166 – Battery Holder Plate (1)
- REV-41-1359 – Screw, Hex Cap, M3, 8mm (2) (a third screw is already in the extrusion from an earlier step)
- REV-41-1361 – Nut, Locking, M3 (3)

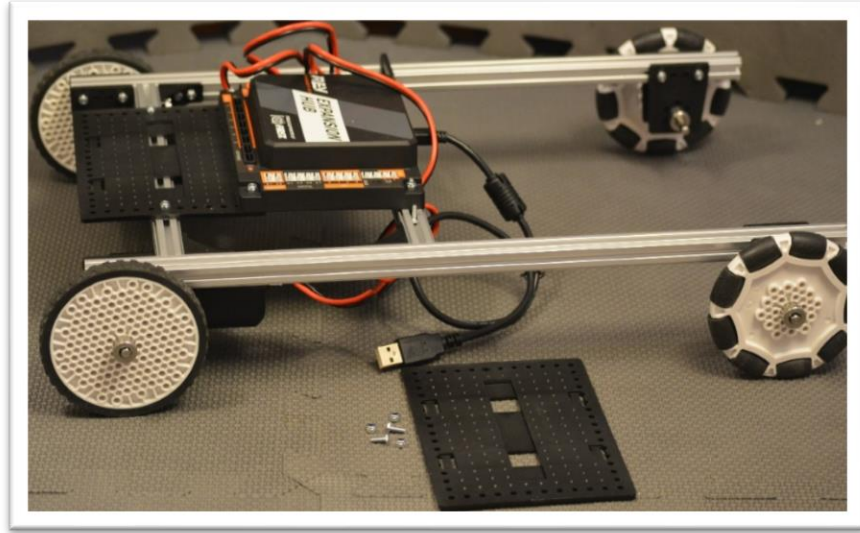


Figure 47- Unassembled view

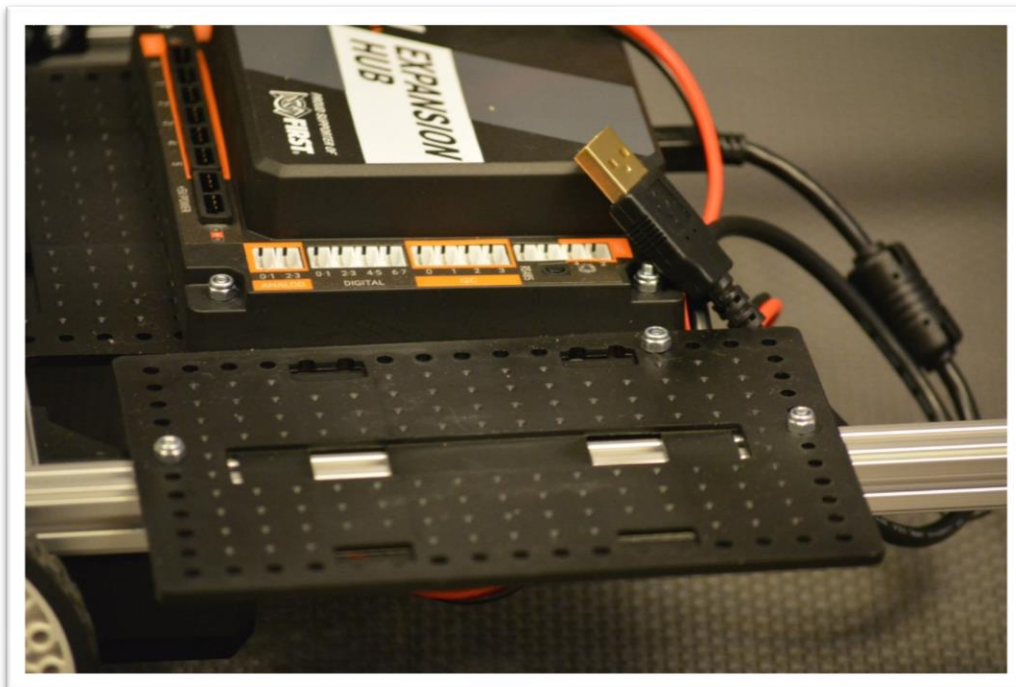
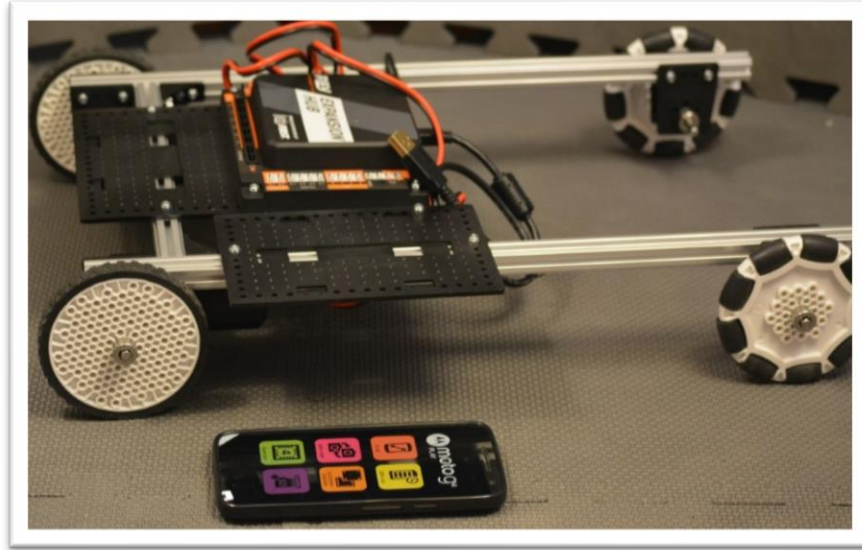
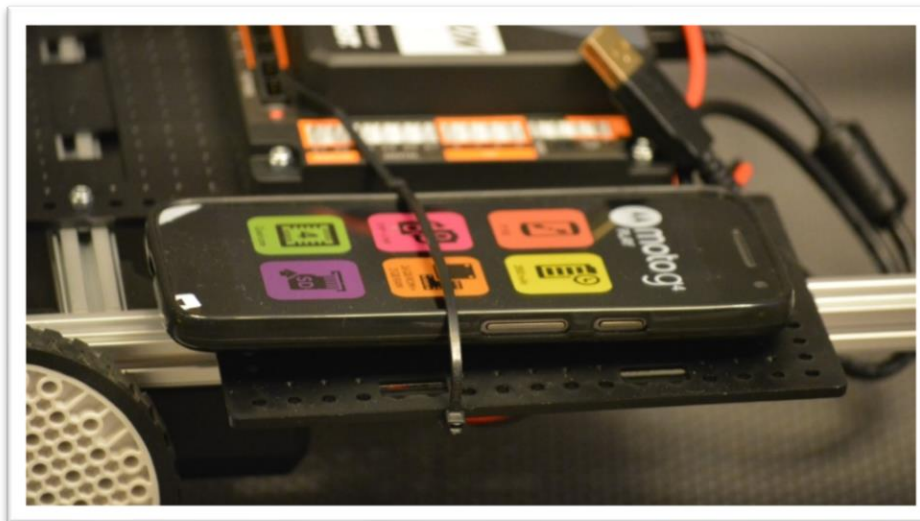


Figure 48- Assembled view

Step 2: Add the Robot Controller Cell Phone to the Holder**Parts Needed:**

REV-41-1161 - Zip Tie, 160mm (2)

Cell phone configured as the robot controller

*Figure 49- Assembled view**Figure 50- Assembled view***Helpful Hint:**

- It is recommended that an approved material such as non-skid be layered between the phone and the plate to prevent damage to the phone.
 - The foam that comes in the phone's packaging works well for this.

Step 3: Connect the Robot Controller to the Expansion Hub (Part 1)

Parts Needed:
USB On the Go (OTG)
Adapter Cable (1)

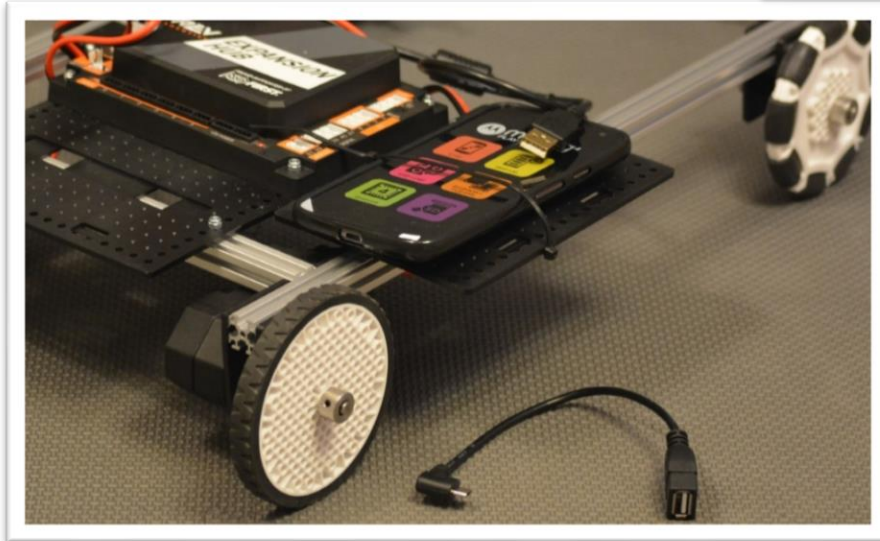


Figure 51- Unassembled view



Figure 52- Assembled view

Helpful Hint:

- Plug the Micro USB plug into the bottom of the cell phone.

Step 4: Connect the Robot Controller to the Expansion Hub (Part 2)



Figure 53- Unassembled view

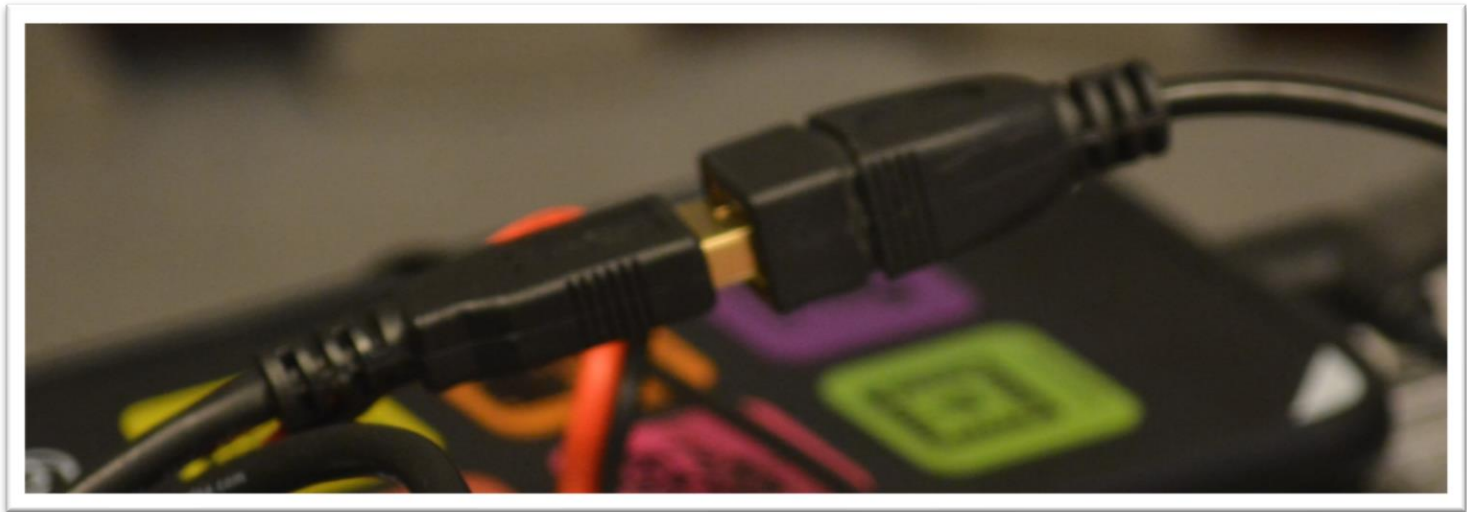


Figure 54- Assembled view

Helpful Hint:

- Plug the USB-A socket (from the phone) into the USB-A plug (to the Expansion Hub).

Power Switch

Step 1: Add the Switch

Parts Needed:
REV-31-1387 Switch (1)

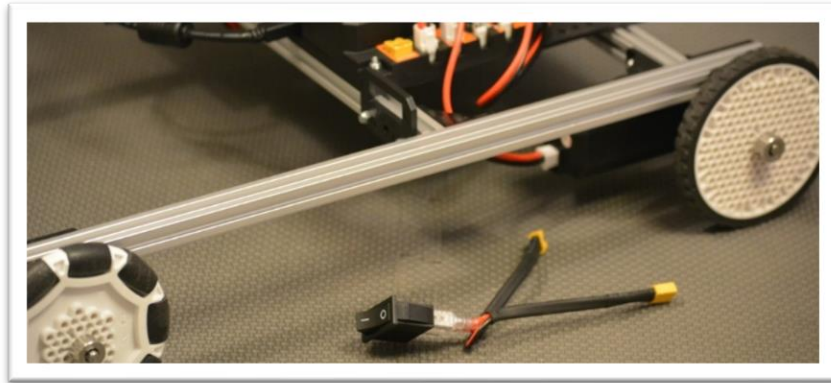


Figure 55- Unassembled view

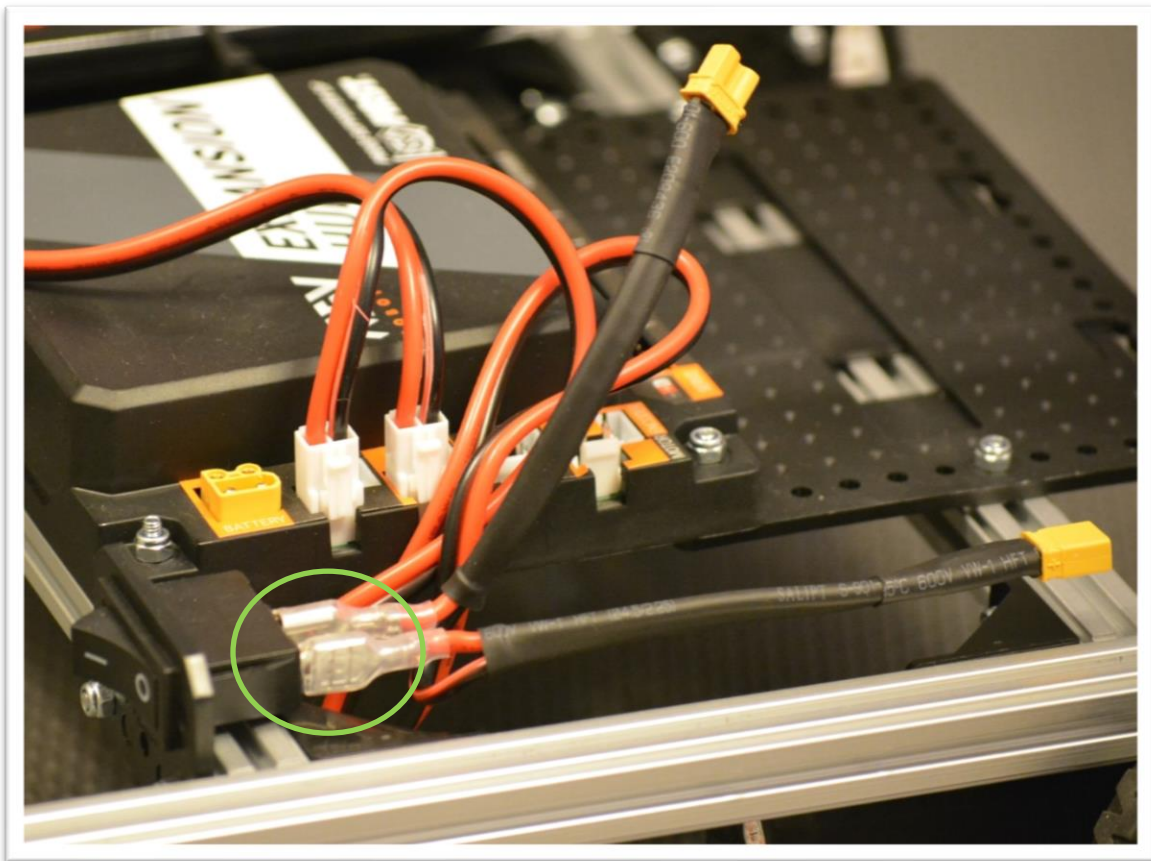


Figure 56- Assembled view

Step 2: Connect the Switch to the Motor and Sensor Controller

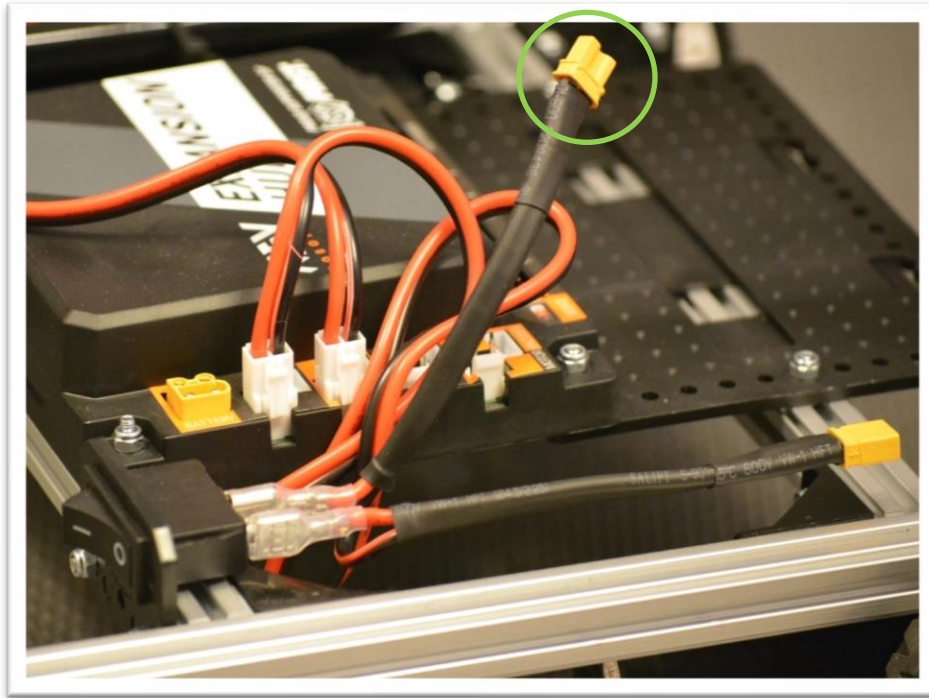


Figure 57- Unassembled view

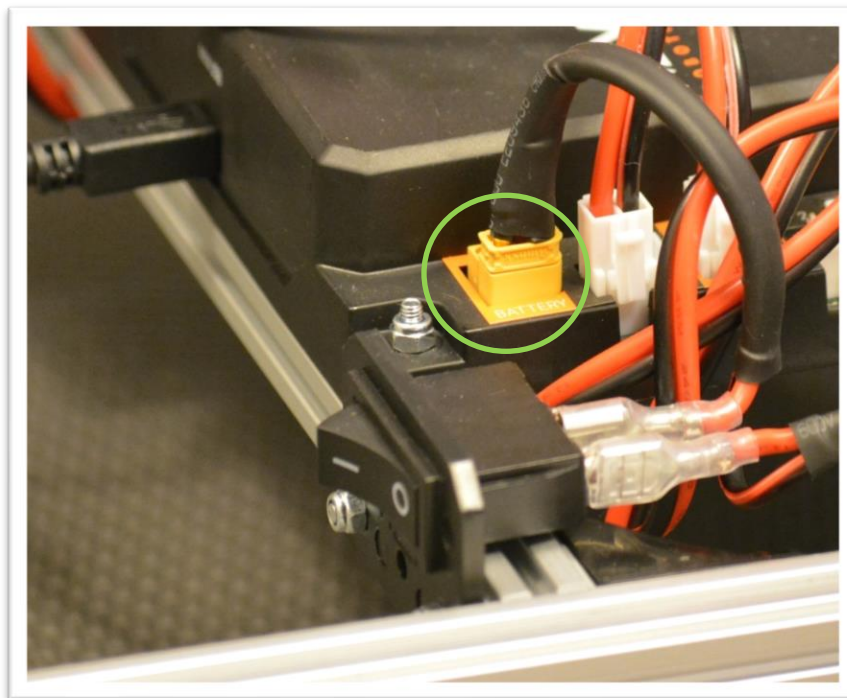


Figure 58- Assembled view

Battery

Step 1: Add the Battery

Parts Needed:

REV-31-1302 – Slim Battery, 3000mAh (1)
REV-41-1161 – Zip Tie, 160mm (2)

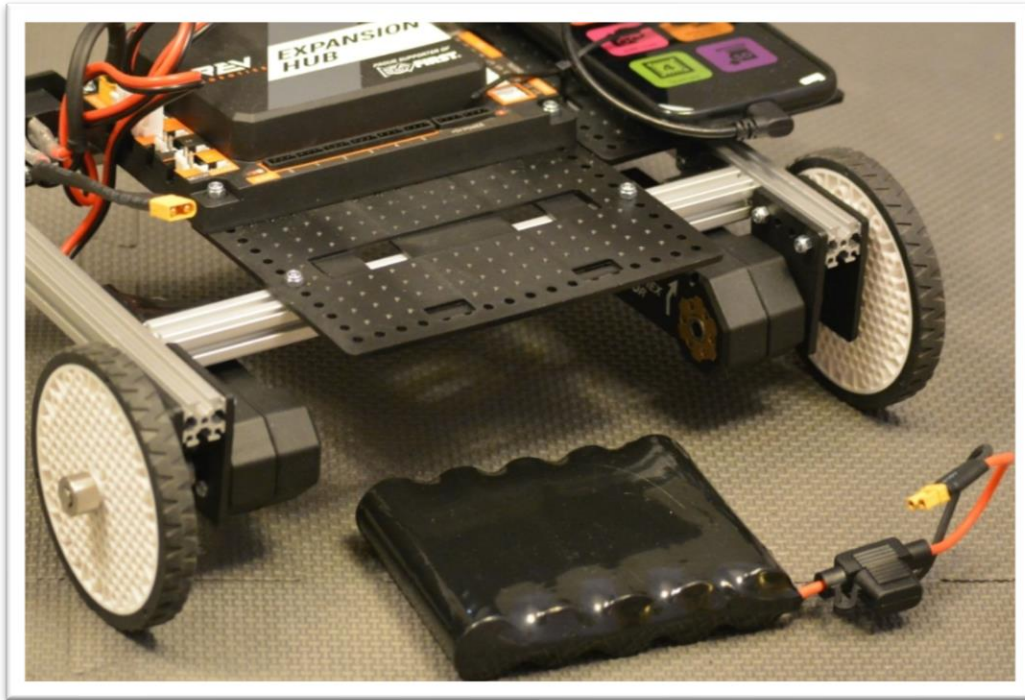


Figure 59- Unassembled view



Figure 60- Assembled view

Helpful Hint:

- Care should be taken to make sure the mounting points for the battery DO NOT puncture or break the insulation of the battery or battery leads!

Step 2: Connect the Battery to the Switch

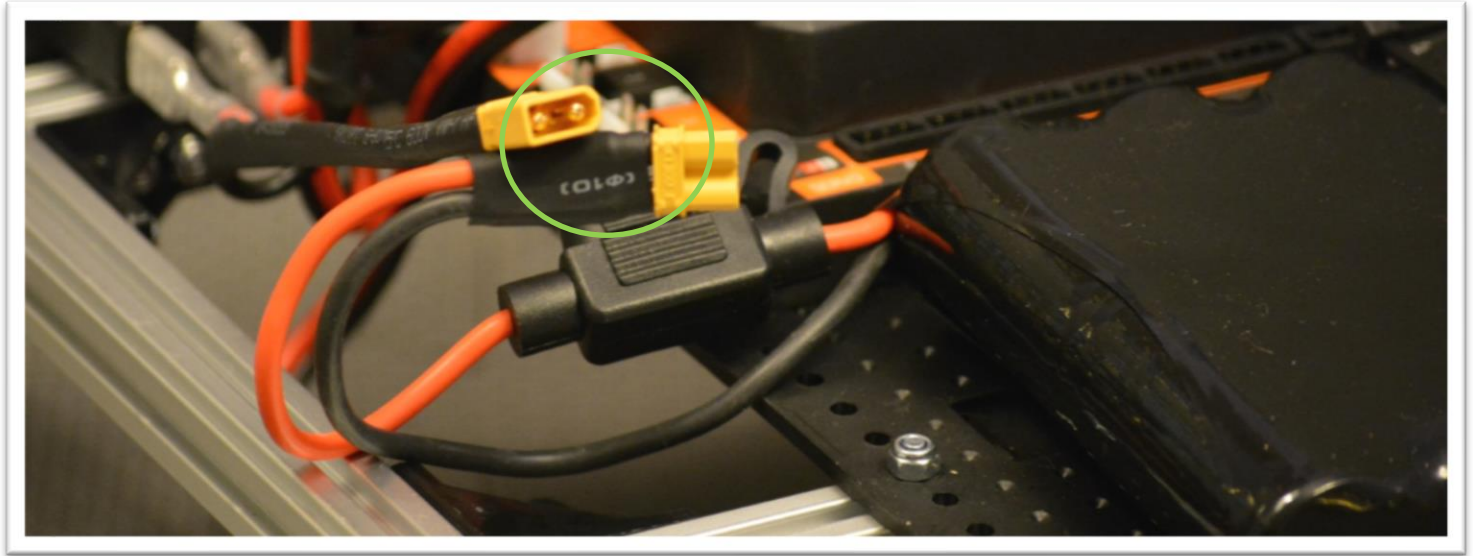


Figure 61-Unassembled view

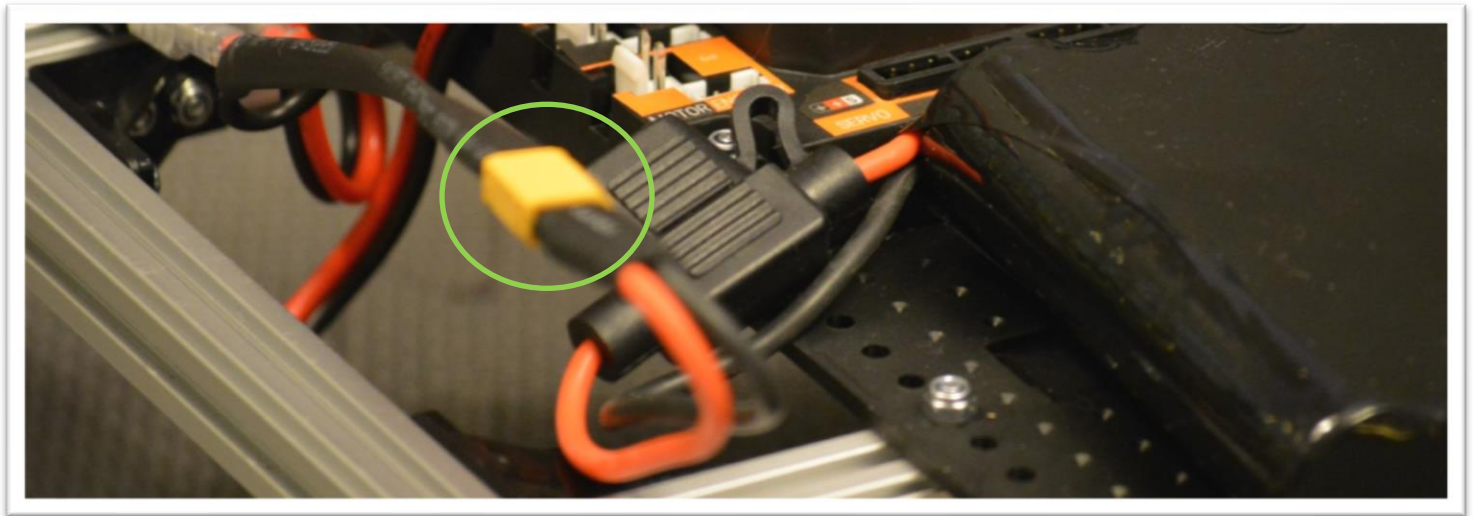


Figure 62- Assembled view

Helpful Hint:

- Connect the two yellow plugs
- Care should be taken to make sure the mounting points for the battery DO NOT puncture or break the insulation of the battery or battery leads!

Final Steps

The frame has been built, however programming will be needed to make the robot functional. Testing should be done to determine whether anything needs to be changed or optimized for the season's game rules. It will also show whether more cables need to be secured or re-routed. Numbers and other stickers will be needed to make the robot competition ready.

Check the game rules for all the applicable stickers- [The Game Manual Part 1](#) includes a robot inspection checklist. FIRST strongly recommends that you go through the robot inspection checklist before a competition to be sure that you are prepared on the day of competition and don't have any disallowed parts on the robot.

[Visit the FIRST website for programming instructions.](#)

Special Thanks and Best Wishes

FIRST® Tech Challenge would like to sincerely thank the creators of this document **Dave and Lydean Spangler**. The Spangler's have worked tirelessly over many years and seasons to create, update and improve this document to give teams a "how to" guide for building the robot chassis of the robot to build upon and improve. We are forever grateful for their help and support in this endeavor.

Please direct any questions or comments about this guide to: firsttechchallenge@firstinspires.org and put "Questions about the Robot Chassis Build Guide for REV" in the subject line and we will redirect the emails to the appropriate responders.

Appendix A – Resources

Game Forum Q&A

<http://ftcforum.usfirst.org/forum.php>

Anyone may view questions and answers within the *FIRST*® Tech Challenge Game Q&A forum without a password. To submit a new question, you must have a unique Q&A System User Name and Password for your team.

FIRST Tech Challenge Game Manuals

Part 1 and 2 - <https://www.firstinspires.org/resource-library/ftc/game-and-season-info>

FIRST Headquarters Pre-Event Support

Phone: 603-666-3906

Mon – Fri

8:30am – 5:00pm

Email: Firsttechchallenge@firstinspires.org

FIRST Websites

FIRST homepage – www.firstinspires.org

[FIRST Tech Challenge Page](#) – For everything *FIRST* Tech Challenge.

[FIRST Tech Challenge Event Schedule](#) – Find *FIRST* Tech Challenge events in your area.

FIRST Tech Challenge Social Media

[FIRST Tech Challenge Twitter Feed](#) - If you are on Twitter, follow the *FIRST* Tech Challenge Twitter feed for news updates.

[FIRST Tech Challenge Facebook page](#) - If you are on Facebook, follow the *FIRST* Tech Challenge page for news updates.

[FIRST Tech Challenge YouTube Channel](#) – Contains training videos, Game animations, news clips, and more.

[FIRST Tech Challenge Blog](#) – Weekly articles for the *FIRST* Tech Challenge community, including Outstanding Volunteer Recognition!

[FIRST Tech Challenge Team Email Blasts](#) – contain the most recent *FIRST* Tech Challenge news for Teams.

Feedback

We strive to create support materials that are the best they can be. If you have feedback about this manual, please email firsttechchallenge@firstinspires.org. Thank you!