FIRST GLOBAL

Building Guide

REV ROBOTICS

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1 INTRODUCTION

1.1 HOW TO USE THIS GUIDE

This guide is intended to be an introduction to the REV Robotics Building System that is being used in FIRST Global. The goal of this document is to give an overview of the parts included in the system and some example building techniques which will make building your robot easier. The system itself was designed with flexibility in mind, where every bracket and part can be mounted in infinite locations along the REV Rails, making it easier to tune your design and speed up iterations.

There are already lots of examples in this document, but we're committed to continuing to add content to keep making it more accessible for people to build with REV.

Feel free to pick out specific sections of interest and read those, there is no need to consume this document in any sequential method.

1.2 REQUIRED TOOLS

The REV Robotics 15mm Building System for FIRST Global only requires a few basic tools. Please see Table 1 for recommendations.

Table 1: Recommended Tool List

Tool	Required	Use
5.5mm Nut Drive	Yes (Included)	M3 Hardware
5.5mm Combination Wrench	Yes (Included)	M3 Hardware
1.5mm Allen Wrench	Yes (Included)	M3 Shaft Collars
2mm Allen Wrench	Yes	Linear Motion Kit
Small Pliers	Optional	Working with Chain
Chain Breaker	Optional	Working with Chain
Hack Saw	Yes	Cutting Extrusion
Chop Saw	Optional	Cutting Extrusion
Band Saw	Optional	Cutting Extrusion
Diagonal/Flush Cutter	Optional	Trimming Brackets to Customize
File/Sandpaper	Optional	Trimming Brackets to Customize

2 ELECTRICAL COMPONENTS

2.1 ELECTRONICS

2.1.1 Introduction

Robots are made up of mechanical structures and the electrical components that move and control them. Electronics is a broad category which includes motors, sensors, and programmable controllers or hubs. The REV Robotics Building System has two kinds of Hubs: Control Hub and the Expansion Hub (Figure 1). The Control Hub has an integrated computer module running Android and is where the robot code runs, while the Expansion Hub only provides a break out of additional ports. Please note that every robot must have one Control Hub, but adding an Expansion Hub is optional.

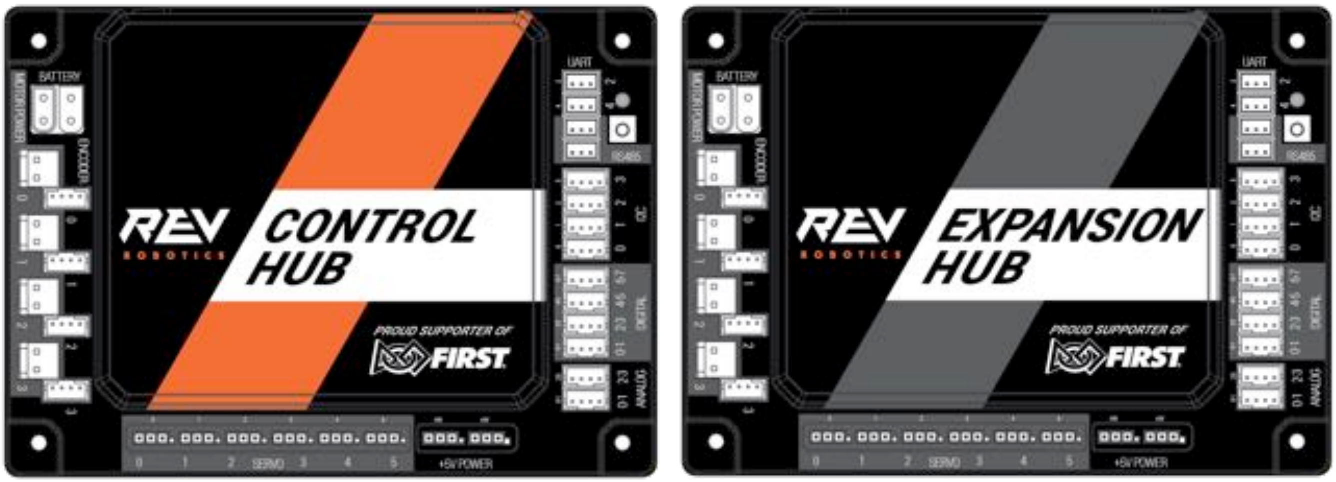


Figure 1: Control Hub and Expansion Hub

2.1.2 Hub Ports

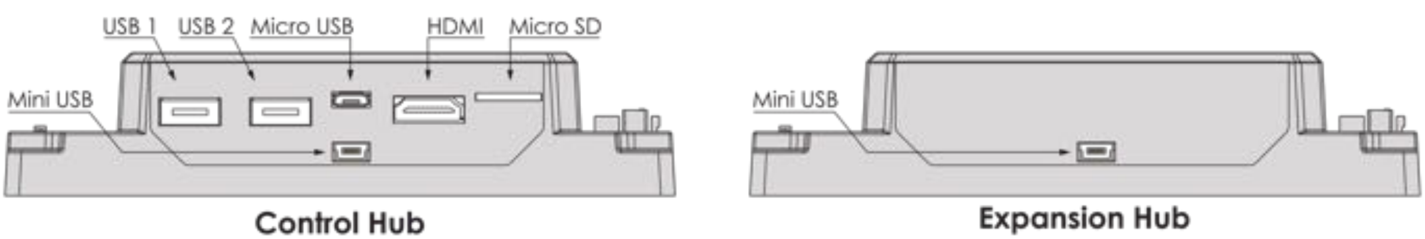
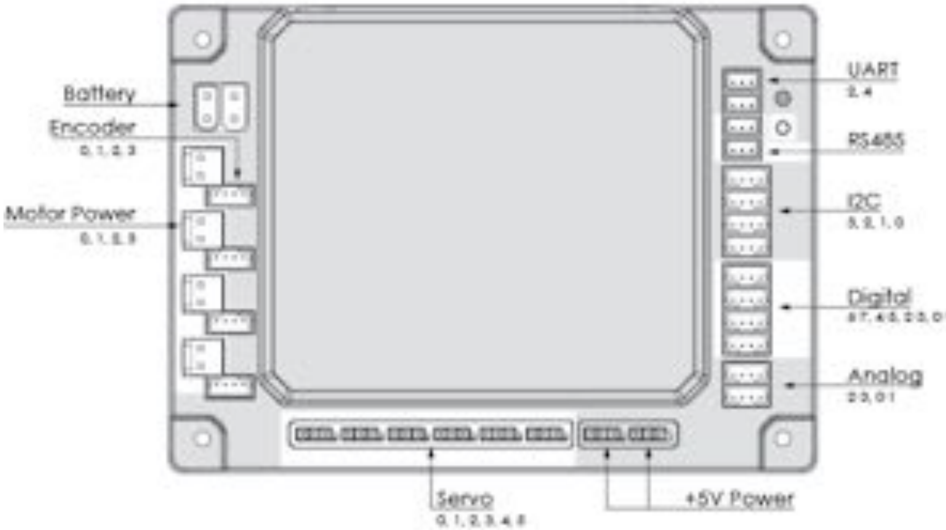


Figure 2: Control Hub and Expansion Hub Rear Ports

Mini USB	This connector is used for firmware updates
USB 1 and 2	Are used for connecting peripheral devices such as a keyboard and mouse. (**Control Hub Only)**
Micro USB	Used to download robot code from a computer. (**Control Hub Only)**
HDMI	Connect an external monitor. (**Control Hub Only)**
Micro SD	Accepts a standard MicroSD memory storage card which can be used for data logging. (**Control Hub Only)**



Battery	The battery connectors are a pair of male and female XT30 Connectors. Connect the REV Robotics 12V Slim Battery (REV-31-1302) to either connector. If your robot has both a Control Hub and an Expansion Hub you can use a battery extension cable to connect power between the two.
DC Motor Power	Connect motors to the hub's four built in speed controllers using these ports. The connector is a 2-pin JST VH connector.
DC Motor Encoder	Each motor has an encoder built-in. Connect the encoder cable to the same port that the motor is powered from. The connector is a 4-pin JST PH connector.
Servo Motor	Connect up to six Servo motors. The connector is a standard 0.1" Pitch male header. This connector is not keyed, so be sure to connect it in the correct orientation.
+5V Power	Auxiliary 5V power for robot accessories. The connector is a standard 0.1" Pitch male header. This connector is not keyed, so be sure to connect it in the correct orientation.
Analog	Analog input for 0-3.3V sensors. The connector is a 4-pin JST PH connector.
Digital	Digital input or output for 3.3V digital devices. The connector is a 4-pin JST PH connector.
I2C	There are four 3.3V compatible I2C buses. Multiple I2C devices can be connected to the same port, as long as they each have a different address. See the I2C sensor section for more details. The connector is a 4-pin JST PH connector.
RS485	This port is used to communicate between the Controller Hub and an Expansion Hub. The connector is a 3-pin JST PH connector.
UART	This port is output only and used for debugging. The connector is a 3-pin JST PH connector.
Status Indicator	LED indicator for robot mode and for debugging
Button	This button is used to pair the Controller Hub with the Robot Driver Station and can also be programed to have additional functions.

Most of the connectors on the Control Hub and Expansion Hub are keyed, meaning that the connector is shaped so that it is not possible to plug the cable in backwards. The Servo Motor ports and the 5V Power ports are not keyed and the pin out is shown in Figure 3Figure 3

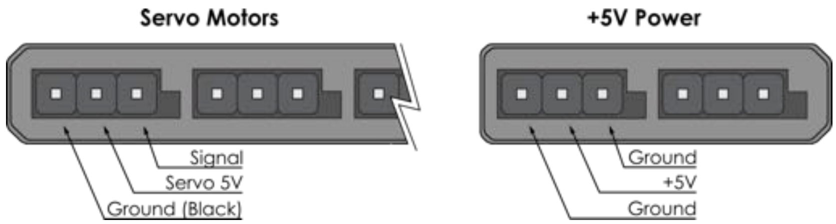


Figure 3: Servo and 5V Power Port Pinouts

2.2 SYSTEM WIRING DIAGRAM

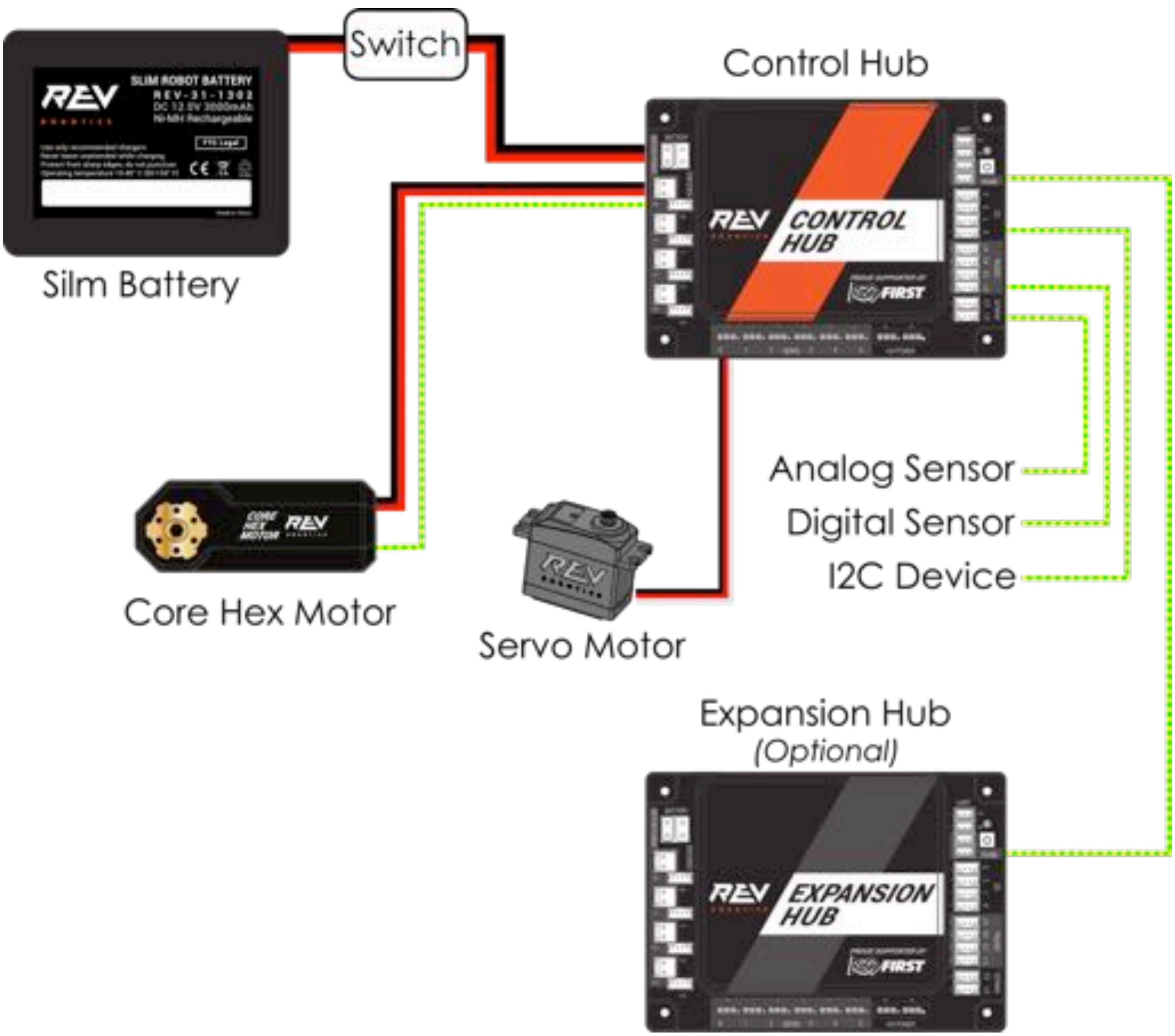


Figure 4: System Wiring Diagram

2.3 DC MOTORS

DC motors are used to power wheels and control moving robot parts, like arms. The Core Hex DC Motor (Figure 5) included in the FIRST Global Kit has a 5mm hex socket drive shaft surrounded by six m3 mounting holes on both sides called the Motion Interface Pattern. The back of the motor has a 2-pin connector for power and a 4-pin connector for an encoder cable. The normal rotation, the direction of spin when the motor is going “forward,” is marked with an arrow on the front of the motor.

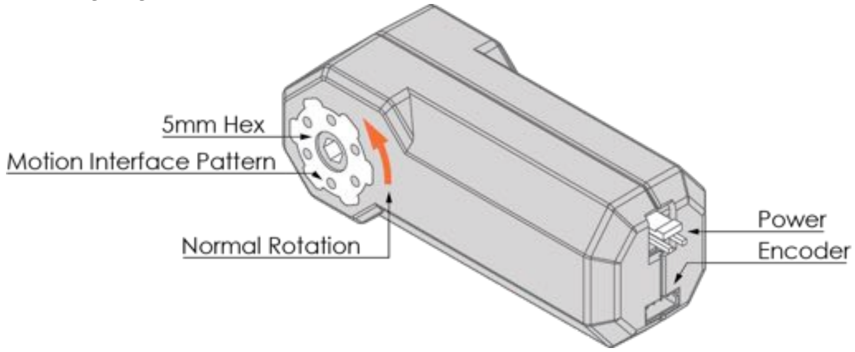


Figure 5: Core Hex DC Motor

Both sides of the Core Hex motor have a Motion Interface Pattern for bolting to any of our motion brackets (see Table 2). The Motion Interface Pattern consists of six evenly spaced bolt holes. The bolt hole pattern on both sides of the motor allow it to be mounted in multiple orientations (Figure 6).

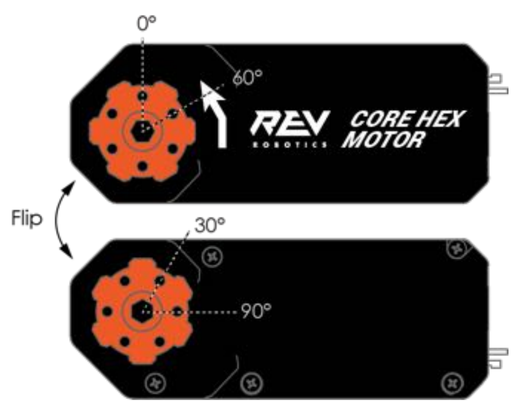


Figure 6: Core Hex Motor Front and Back Mounting Plates

The offset between the front and back mounting plates shown in Figure 6 enables the motor to be mounted at 12 different motor orientations, including vertical and horizontal when both sides of the motor are used. Figure 7 below shows a horizontally mounted motor which is flipped from the vertical motor with the front facing out. Note that when the motor is flipped, the direction that the shaft spins is also flipped.

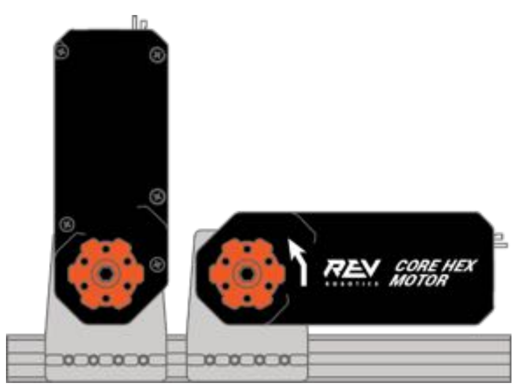


Figure 7: Core Hex Motor Mounting Options

The female hex shaft of the Core Hex Motor allows for any length 5mm hex shaft to be inserted through the body of the motor (Figure 8). The motor can drive wheels or gears on either side of the shaft, or a single shaft can be put through multiple motors to increase the power. If multiple motors are used on a single shaft, be sure that they are being controlled in the same direction to prevent damage.

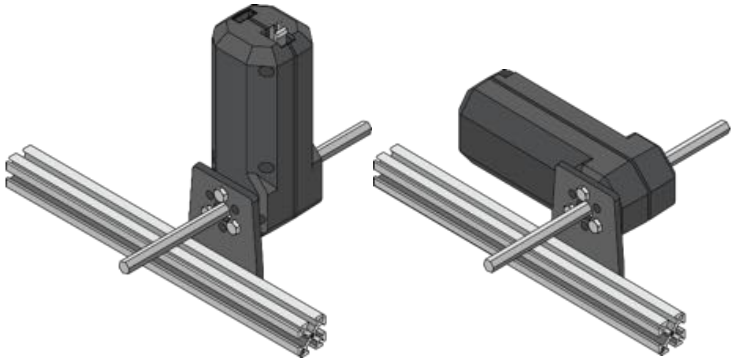


Figure 8: Hex Core Motor Mounted with 5mm Shaft Inserted

2.4 SERVO MOTORS

Servo motors are a specialized kind of motor which can be controlled to move to a specific angle instead of continuously rotating like a DC motor. Instead of a hex output shaft like the DC motor, servos have an output spline (Figure 9). A spline is a specific groove pattern cut into the shaft which allows the rotation of the servo motor to be transmitted to the attached Aluminum Servo Horn or Servo Adapter (see Table 6). Splines are like keys, so only matched types will fit together. The REV Robotics Servoa all use a 25T spline pattern.

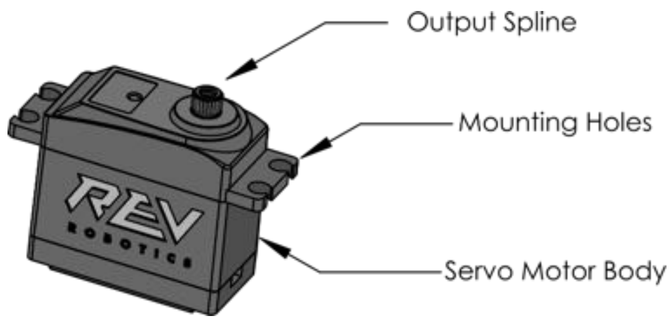


Figure 9: Servo Motor

Common servo motors take a programmed input signal range and map that to an angular range.   For example, for a servo with a 180° range, if the input range was from 0 to 1 then a signal input of 0 would cause the servo to turn to point -90°. For a signal input of 1, the servo would turn to +90° (Figure 10). Inputs between the minimum and maximum have corresponding angles evenly distributed between the minimum and maximum servo angle.

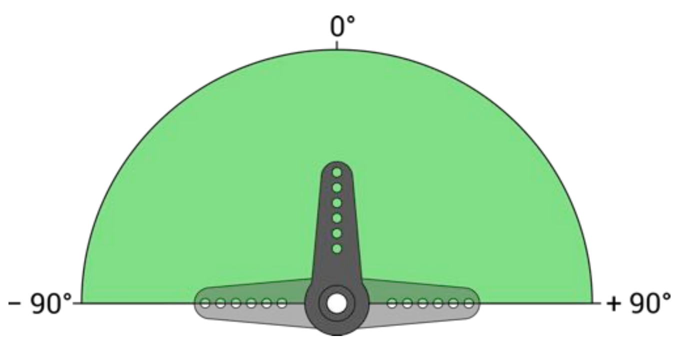


Figure 10: Servo Motor Angular Mode Output

2.5 SENSORS

2.5.1 Analog Sensors

Analog sensors provide measurement data within a continuous range by measuring the voltage output of a sensor. Analog sensors are good for measuring things like angle of rotation, brightness, and distance because the data they provide spans a continuous range which would correspond to angle, intensity, and range, respectively.

Sensor	Description
Potentiometer	Potentiometers have a limited measurement range of 0° to 180° and will be damaged if they are forced to rotate farther. The potentiometer has a 5mm hex socket and a Motion Interface Pattern. Connect this sensor to a shaft to measure the angle of rotation of the shaft. A typical example is using a potentiometer to measure the angle of a robot arm.

2.5.2 Digital Sensors

Digital sensors are very simple to use because they only provide one single piece of data, which is either a 0 or 1. A good example of a digital sensor is a limit switch. The switch is either pressed (1), or not pressed (0).

2.5.3 I2C Sensors

I2C is a common electronic communication standard that allows a master device, the Hubs, to communicate with multiple devices, slaves, attached to the same port. Each connector on a Hub is a separate I2C bus and many different sensors can be connected to each of the four I2C busses available on both the Control Hub and Expansion Hub. Every I2C slave device has an address, a number, which is normally fixed by the manufacturer. All of the devices on an individual I2C bus must have a unique address so that the master can communicate with one sensor at a time. If two devices have the same address, such as when using two of the same kind of sensor, they must be used on different I2C busses.

Sensor	Address	Description
9-Axis IMU	0x28	Each Control Hub and Expansion Hub has an 9-axis IMU (inertial measurement unit) built-in connected to I2C Port 0. An IMU uses built in accelerometers, gyros, and magnetometer to collect data about how it is being moved around and then combines all of those measurements to provide more accurate data about the speed, rotation and heading of the robot.
Color/Distance	TBD	This sensor can be used to detect specific primary colors or measure the distance to an object that is within 10cm.

2.5.4 Encoders

Encoders convert information about the rotation of the motor shaft into electrical signals that can be read by the Control Hub. Inside the Control Hub these electrical signals can be used to provide real world data to make better programming decisions. For example, a programmer can use this information to calculate how far the robot has gone or how fast a wheel is spinning. Every DC motor from REV Robotics comes with a quadrature encoder already installed. The encoder cable should be plugged into the same port from which the motor is powered.

The encoder is a relative encoder, which is also referred to as incremental encoder. It provides information about the motion of the shaft (e.g. forward at 5 RPM) and only provides data while the shaft is rotating. Stated another way, relative encoders return information on the incremental change of the motor output shaft. and only provide pulses as the motor turns; interpreting these pulses into useful information must be done externally in the Control or Expansion Hub. A relative encoder does not know what position it is in when it is turned on, but it is possible to create a calibration program that can be run at every start-up to obtain a reference point from which to calculate an angle.

The encoder uses four wires, 3.3V Power, Ground, Channel A and Channel B to communicate data back to the Hub (Figure 11). When the motor is rotating, the Hub can calculate the direction and speed of the motor.

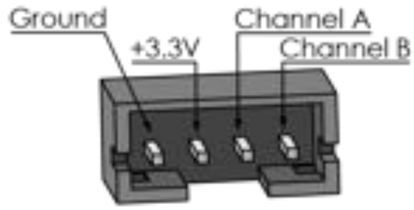


Figure 11: Encoder Connector Pinout

2.6 BATTERY

The Slim Robot Battery for FIRST Global is a 12V 3000mAh NimH battery with inline 20A mini ATX fuse for protection (Figure 12). The battery has a female XT30 Connector. This connector is polarized so that the battery cannot be plugged in incorrectly.

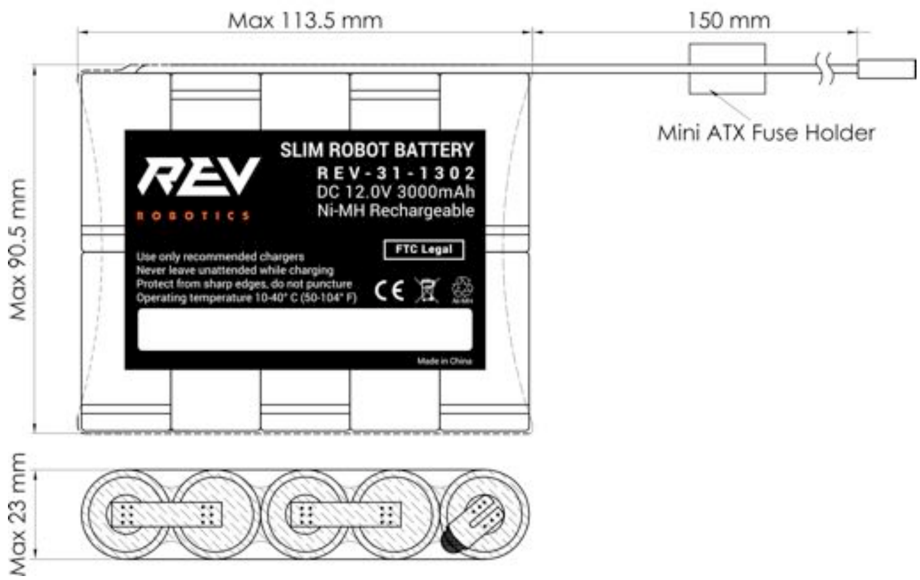


Figure 12: Slim Robot Battery

2.6.1 Battery Safety

Batteries store tremendous energy in a small size and it is important to take care of your batteries to keep them in good working order and to prevent dangerous conditions.

- Batteries should only be charged with approved chargers
- Never leave a charging battery unattended
- Do not leave a battery plugged into a robot when it is not in use and avoid other cases where a battery will be accidentally over discharged
- Batteries should be fully charged before they are put in storage for extended periods
- Properly dispose of any battery which has been damaged or which shows any signs of excessive heat or melting

3 MECHANICAL COMPONENTS

3.1 EXTRUSION

REV Rail Extrusion is 15mm x 15mm square profile clear anodized Aluminum. Slots accept standard M3 hex-head bolts or nuts, rather than expensive t-nuts. The five-hole pattern on the end of the extrusion can be M3 tapped (Figure 13). The slots in the extrusion allow attached brackets to be slid and retightened to an infinite number of locations. This makes things like mating gears and tensioning chain easy. Fine system adjustments can occur at any point in the system development which helps foster an iterative design process.

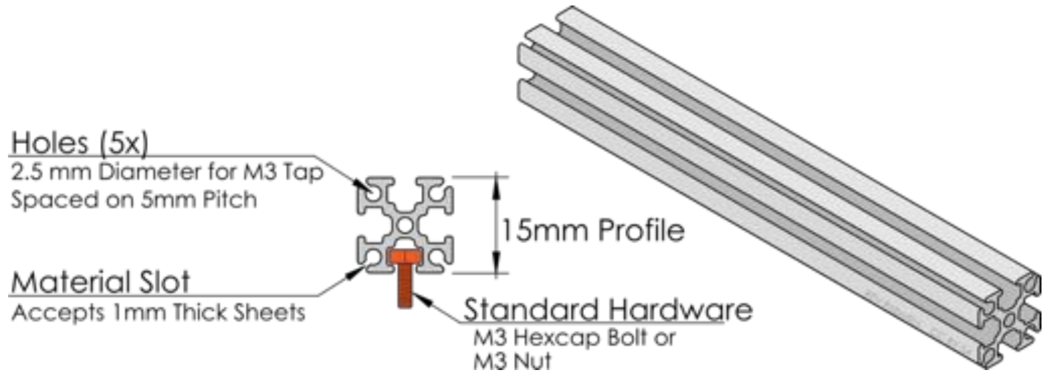


Figure 13: Extrusion and Cross-Section Details

3.2 BRACKETS

3.2.1 Bracket Features

Plastic brackets are nominally 3mm thick and made from molded nylon (PA66). Figure 14 lists key features of the Plastic Brackets for the REV Robotics Building System. Check individual product CAD models for exact dimensions for each bracket.

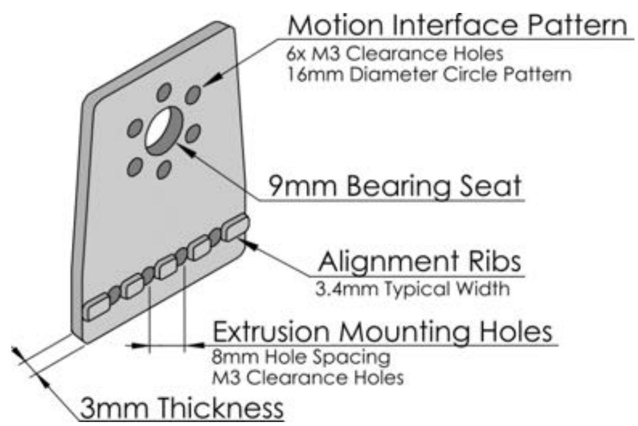


Figure 14: Motion Bracket Feature Details

Alignment Ribs: Protrusions on one side of the bracket seat into the extrusion channel and help align the bracket to the extrusion and add strength and rigidity to joints.
Extrusion Mounting Holes: M3 Mounting holes are on an 8mm pitch.
Bearing Seat: Brackets with a 9mm hole can be used to mate with any of the plastic bearings to support a shaft.
Motion Interface Mounting Pattern: Circular M3 hole pattern on a 16mm diameter is used to mount to REV Robotics shaft accessories such as motors and potentiometers.

3.2.2 All Bracket Types

Table 2 and Table 3 show all of the motion and construction brackets in the REV Robotics 15mm Plastic Building System.

Table 2: Motion Brackets

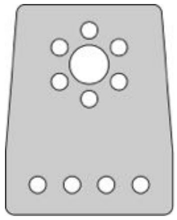
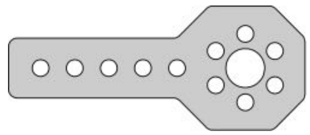
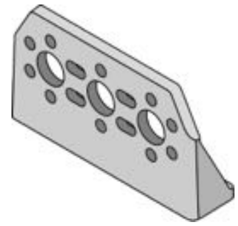
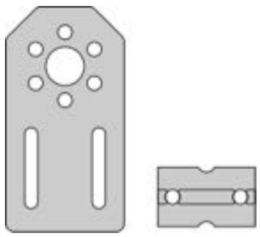
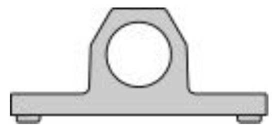
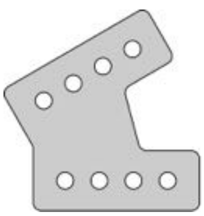
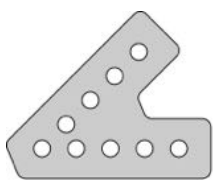
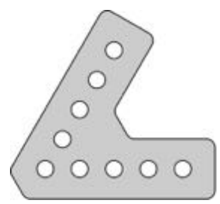
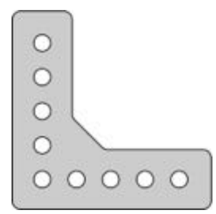
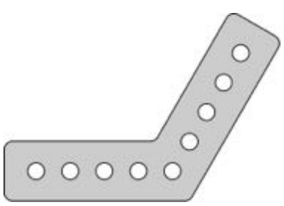
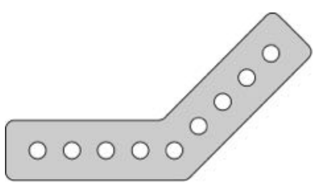
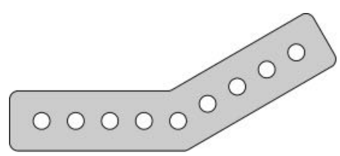
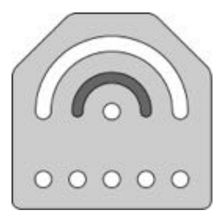
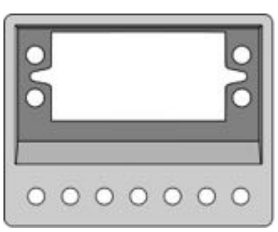
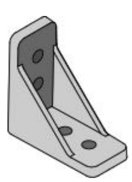
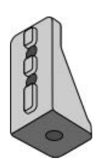
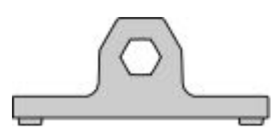
 Motion Bracket REV-41-1303	 Rod End Motion Bracket REV-41-1304	 Gearbox Motion Bracket REV-41-1315
 Indexable Motion Bracket REV-41-1313		 Bearing Pillow Block REV-41-1317

Table 3: Construction Brackets

 30° Bracket REV-41-1308	 45° Bracket REV-41-1307	 60° Bracket REV-41-1306	 90° Bracket REV-41-1305
 120° Bracket REV-41-1311	 135° Bracket REV-41-1310	 150° Bracket REV-41-1312	 Variable REV-41-1318
 Servo Bracket REV-41-1319	 Inside Corner Bracket REV-41-1320	 Lap Joint Bracket REV-41-1321	 Hex Pillow Block REV-41-1317

3.2.3 Pillow Blocks

The REV Robotics building system uses plastic nylon (PA66) molded pillow blocks (Figure 15). The bearing pillow block can be used with the long through-bore or end cap bearings to provide a low friction shaft support. The hex pillow block directly interfaces with a 5mm shaft which can be used to drive a light duty arm or as a dead (non-spinning) axle support.

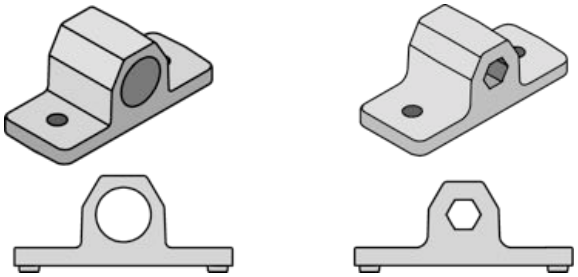


Figure 15: Pillow Blocks

3.2.4 Variable Angle Bracket

The variable angle bracket is a special kind of construction bracket which allows 2 pieces of extrusion to be mounted together at any angle from 0-180° (Figure 16). For additional strength, after the ideal angle has been set, miter the end of the extrusion which will be connected using the arced slot and drill a hole along the alignment mark arc so that it lines up with the extrusion channel and add another bolt to stop the angle from changing.

Figure 16: Adjustable Angle Bracket Example

3.2.5 Indexable Motion Bracket

The Indexable Motion Bracket is a specialized version of the Motion Bracket. This bracket is made up of two pieces: the smaller piece has alignment ribs and fits onto the extrusion, while the larger piece has a motion interface pattern and a bearing seat (Figure 17). On the inside face, where these brackets meet is a fine sawtooth pattern which mesh when they are bolted together to hold the shaft offset. To adjust the offset, loosen the bolts and adjust as needed, retighten with the teeth fully engaged to secure (Figure 18).

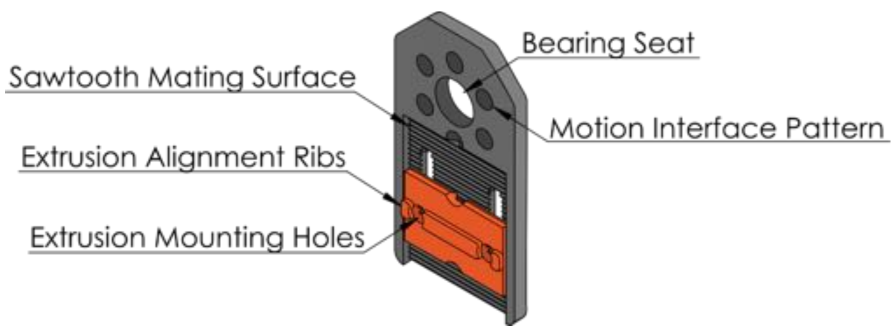


Figure 17: Indexable Motion Bracket

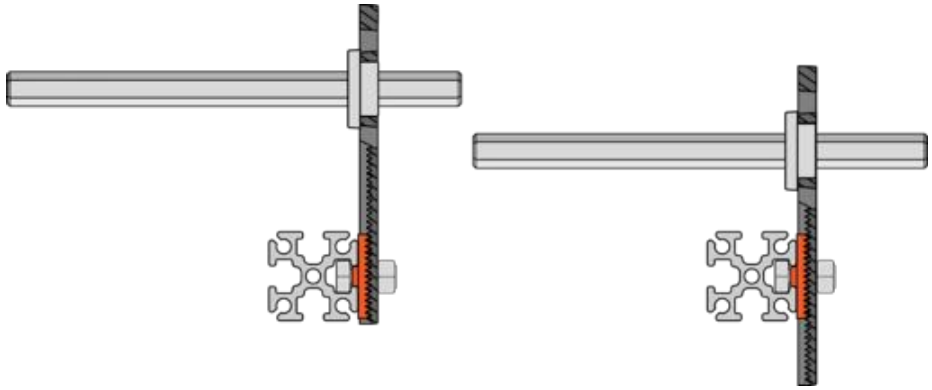


Figure 18: Shaft Offset Using an Indexable Bracket

3.3 JOINTS

3.3.1 Constructing Joints

In most cases joints should have at least two sides joined with brackets for strength and stability. Commonly this involves taking two of the same kind of bracket and sandwiching the pieces of extrusion (Figure 19), but this can also be two different kinds of brackets such as a 90 Degree Bracket and an Inside Corner Bracket installed on the same corner.

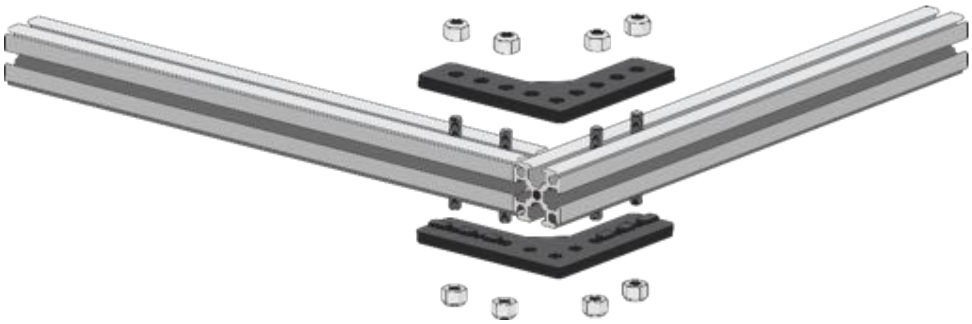


Figure 19: Install Brackets on Both Sides of the Joint

When using brackets to connect extrusion, the joint will be much stronger if the end of the extrusion is beveled (cut at an angle) so that the end will sit flush with the face of the adjoining extrusion (Figure 20).

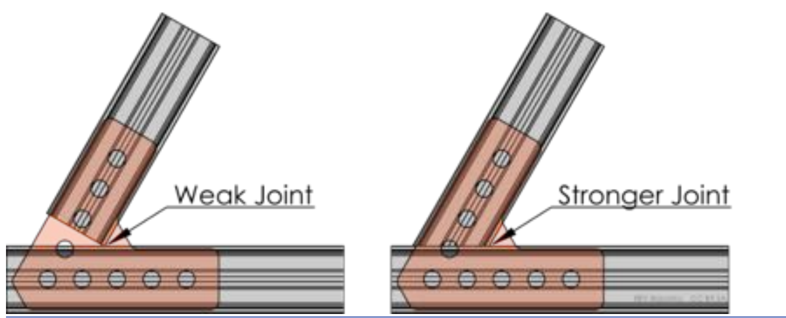


Figure 20: Extrusion with Beveled Joint

Different bracket angles can be combine to make structures (Figure 21). The joints in this example are all beveled to sit flush against the adjoining extrusion.

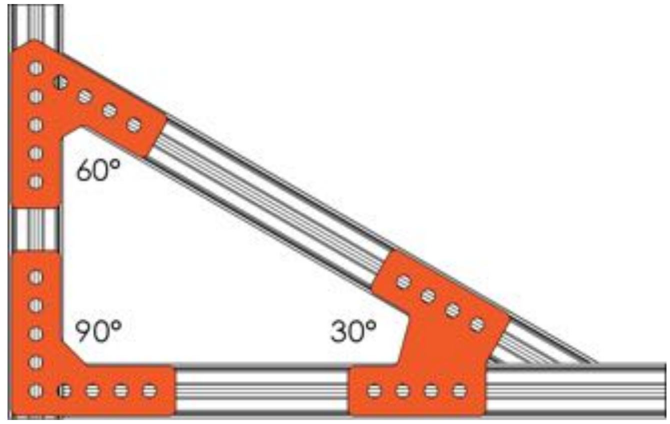


Figure 21: Combine Angled Brackets to Create Structures

3.3.2 Corner Bracket Joint Examples

There are three main ways to create extrusion joints that are at 90 degrees (Figure 22). The most common is the 90° bracket which mates to pieces of extrusion at 90° in the same plane. The second is an inside corner bracket is functionally equivalent to the 90° bracket. The third type is called a lap joint bracket which allowed to pieces of extrusion to "overlap."

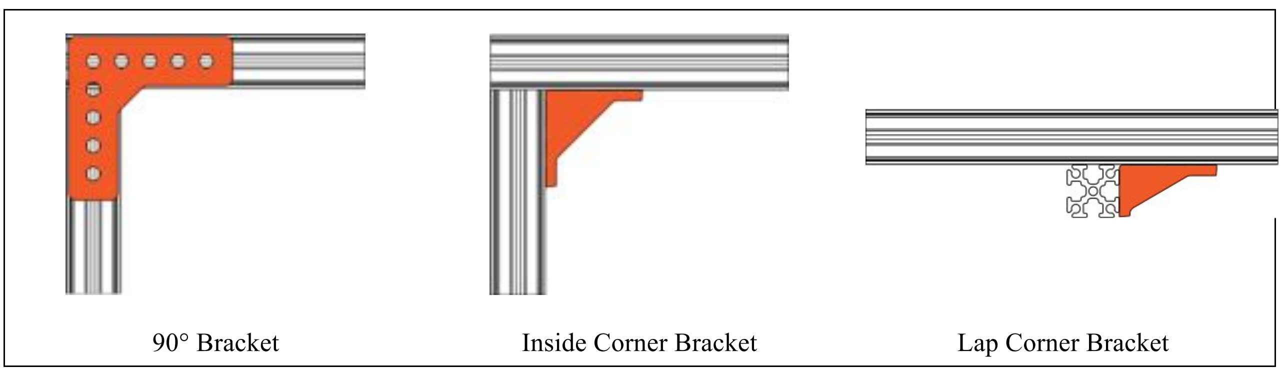


Figure 22: Corner Bracket Examples

3.4 BRACKET ASSEMBLY TECHNIQUES

There are several different ways to assemble brackets and extrusion; these are explained in detail in this section. There is no right or wrong way, but different techniques may be needed if the end of the extrusion has become blocked during the assembly process.

3.4.1 Bracket Assembly Method

Using pre-assembled brackets is the simplest way to install a bracket on extrusion. Brackets are preassembled with nuts and bolts before being slid into the extrusion slot and tightened (Figure 23).

1. Insert bolts into the desired bracket holes.
2. Put nuts onto the inserted bolts. Do not fully tighten these nuts, just a few turns will be enough. If using locknuts, finger tight is appropriate. There should be enough exposed thread on the bolt so that the bolt head can slide into the channel in the extrusion.
3. Slide the bolt heads into the extrusion slot. Note that the bolt heads will only fit if they are turned with flat sides parallel to the extrusion slot. Using a gentle shaking motion on the bracket while aligned with the slot can help align the bolt heads.
4. Slide the bracket to the desired location and tighten the nuts.

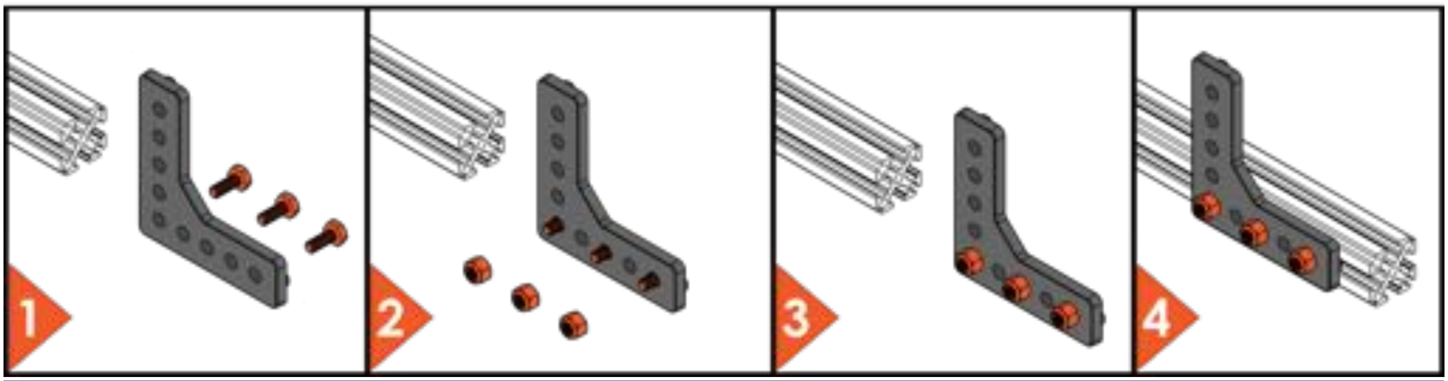


Figure 23: Preassembled Bracket Installation Method

3.4.2 Bolt-First Method

The bolt-first method may be necessary when certain constraints prevent the bracket from sliding into its final position. Bolts are slid into the extrusion slot and then aligned with the bracket and nuts (Figure 24).

1. Slide the required bolts into the extrusion channel.
2. Slide the bolts so that they are approximately spaced to fit into the bracket.
3. Place the bracket on the the protruding bolts.
4. Add nuts to the exposed bolts, slide the bracket into position and tighten.

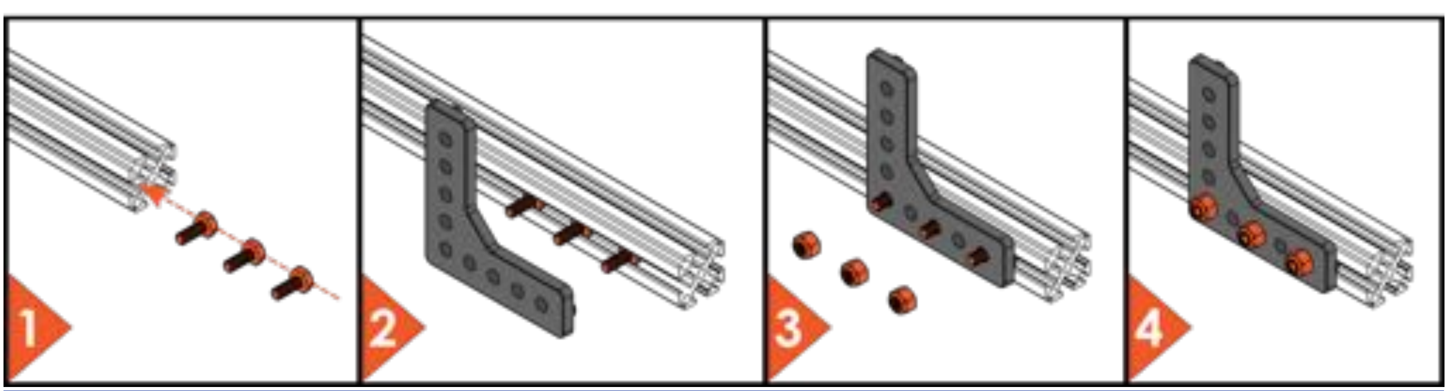


Figure 24: Bolt-first Assembly Method

3.4.3 Access-Hole Method

The access-hole method is necessary when the ends of the extrusion profile are blocked preventing bolts from entering the slots. Drill a 6.5mm (1/4”) hole centered on the slot in a convenient location away from the final bracket position (Figure 25).

1. Drill a 6.5mm (5/16”) hole centered on the extrusion slot away from the final bracket location. Drop the bolt heads into the hole and then slide them into the slot one by one.
2. Align the bolts so their spacing approximately matches with the bracket hole spacing.
3. Place the bracket on to the protruding bolts.
4. Start the nuts on all of the protruding bolts. Slide the bracket to the desired final location and tighten the nuts.

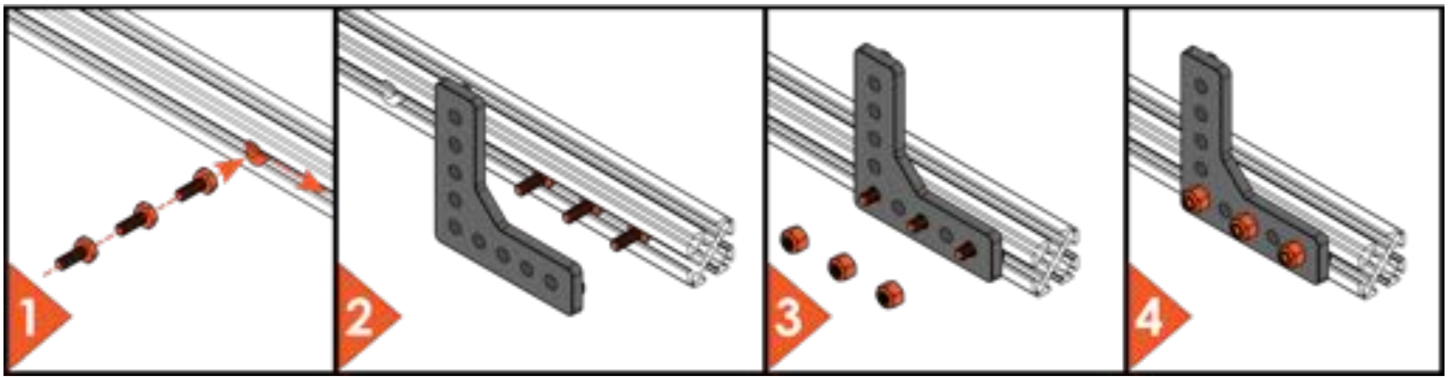


Figure 25: Access-hole Assembly Method

3.4.4 Drop-In Bolt Method

Drop-in bolts are specialty bolts with a modified head profile which allows them to be inserted into the extrusion channel without needing to drill an access hole (Figure 26).

1. Place drop in bolts in the extrusion slot.
2. Align the bolts so their spacing approximately matches with the bracket hole spacing.
3. Place the bracket on to the protruding bolts.
4. Start the nuts on all of the protruding bolts. Slide the bracket to the desired final location and tighten the nuts.

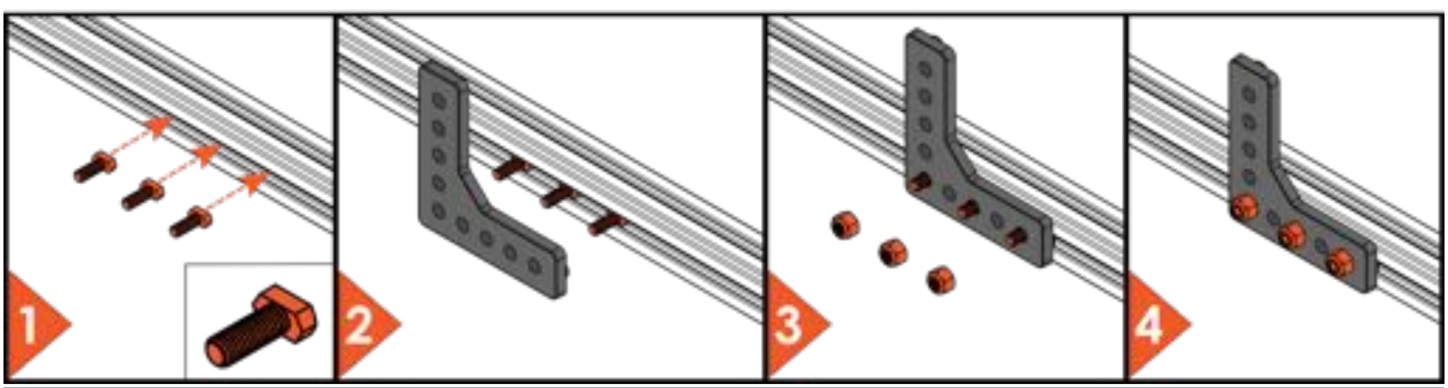


Figure 26: Drop-in Bolt Assembly Method

3.4.5 End-Tapped Extrusion Method

The end-tapped extrusion assembly method is good for quick simple structures to verify spacing of a design. This is not a primary building method and once the correct spacing has been established, a bracket should be added to reinforce the joint.

1. Thread the M3 bolt into the center hole on the end of the extrusion. Using a standard driver, the bolt should self-tap into the end of the extrusion. An actual M3 tapping tool can also be used if desired.

2. Tighten the bolt until it feels securely threaded into the hole. Leave enough thread exposed that the head can be slid into the channel of another piece of extrusion.
3. Slide the extrusion with the bolt in it to the desired location and then turn the extrusion to tighten the bolt.
4. This joint is sufficient for quick, light duty testing, but brackets should be added when the design is finalized.

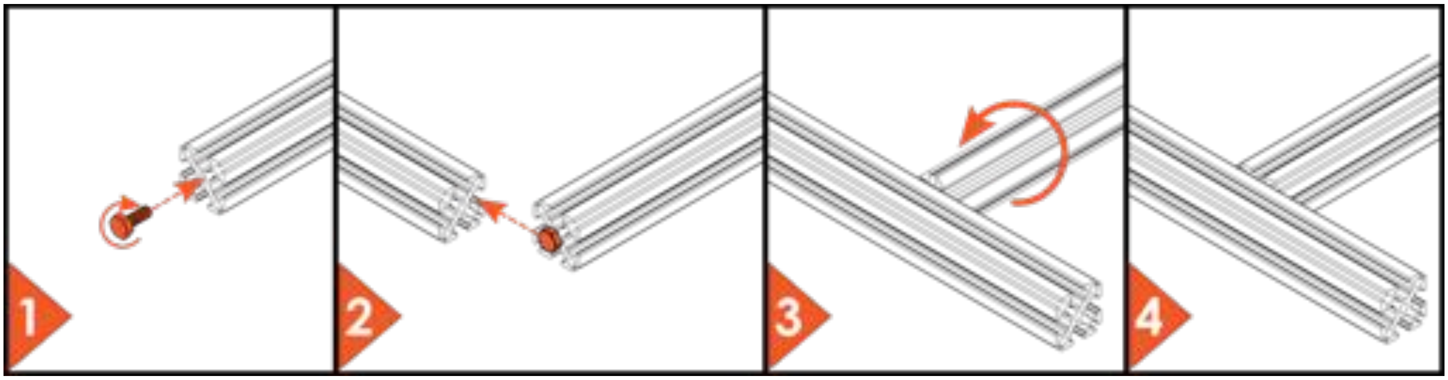


Figure 27: Extrusion to Extrusion Quick Joint

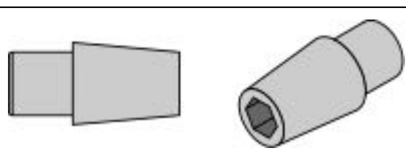
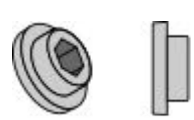
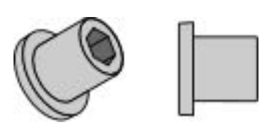
3.5 BEARINGS

The REV Robotics Building System uses plastic acetal (Delrin/POM) molded bearings. These bearings have a maximum 9mm outer diameter (OD) which fit inside the 9mm inner diameter (ID) hole in the all the motion brackets (Figure 28).

Figure 28: Plastic Bearing in a Motion Bracket

These Delrin bearings provide stable, low friction axle support in our nylon brackets. The two materials were carefully chosen because they have a very low coefficient of friction and are also incompatible materials, meaning that they will not stick together under extreme heat. REV Robotics Bearings come in three varieties (Table 4).

Table 4: Bearings

		
End Cap Bearing REV-41-1322	Short Through-bore Bearing REV-41-1326	Long Through-Bore Bearing REV-41-1329

End cap bearings are closed on one end, so when these bearings are placed on both ends of a shaft and fit into motion brackets the shaft is free to rotate but is fully constrained laterally (sideways).

Short Through-bore Bearings are low profile pass through bearings intended to seat directly into any of the motion brackets. These low profile bearings have a 3mm contact surface which makes them flush with one side of the motion plate. Shaft collars are recommended to laterally constrain the shaft.

Long Through-bore Bearings are full depth bearings which can be used with any of the motion brackets or the bearing pillow block. Unlike the end cap bearing, because a shaft can pass though this bearing it can be used with the bearing pillow block to have a pivot between to fixed shaft ends. Shaft collars are recommended to laterally constrain the shaft.

There are number of different bearing, shaft collar, and motion bracket combinations that are recommended. See Figure 29 for a visual representation of some of the recommended combinations.

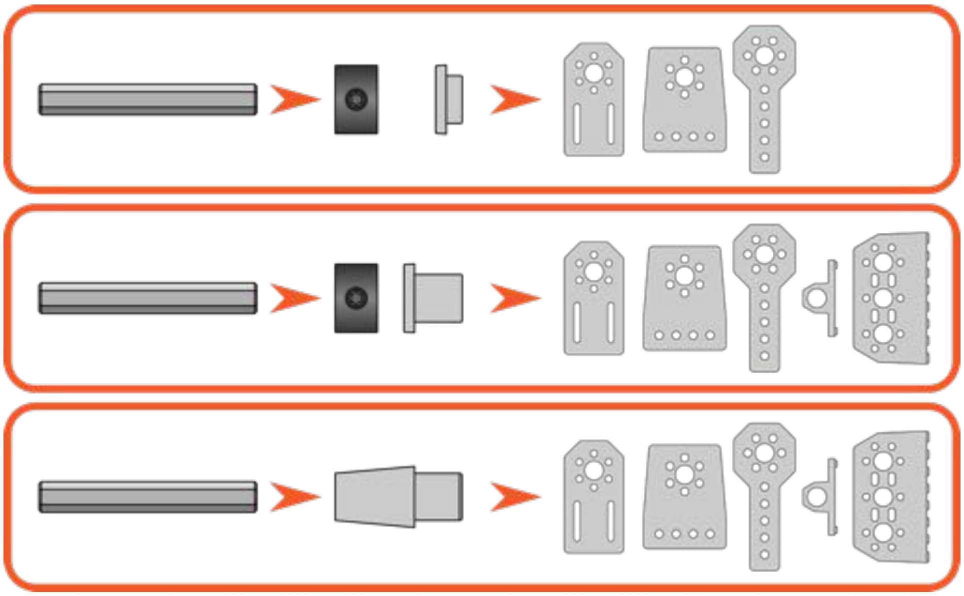


Figure 29: Bearing Assembly Combination Recommendations

Figure 30 - Figure 33 shows several possible combinations for bearings, motion brackets, and pillow blocks. In these figures the brackets are all depicted as facing "up" but brackets can also point "down" just as well.

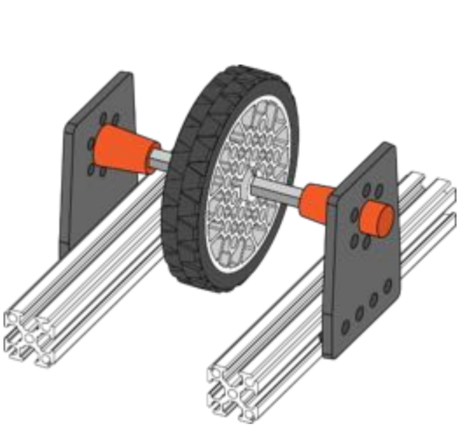


Figure 30: Motion Brackets and End Cap Bearings

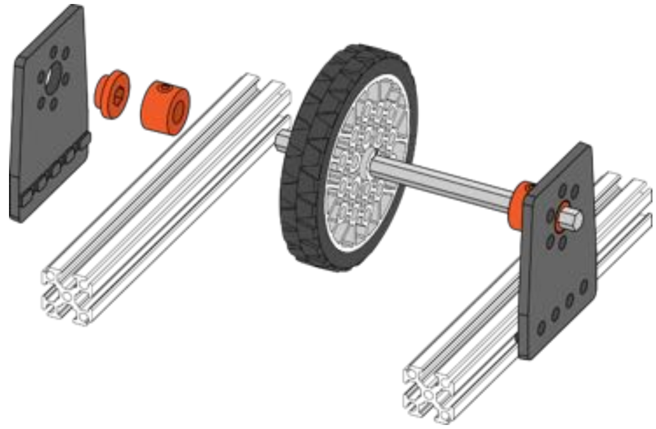


Figure 31: Motion Bracket and Short Through bore Bearings

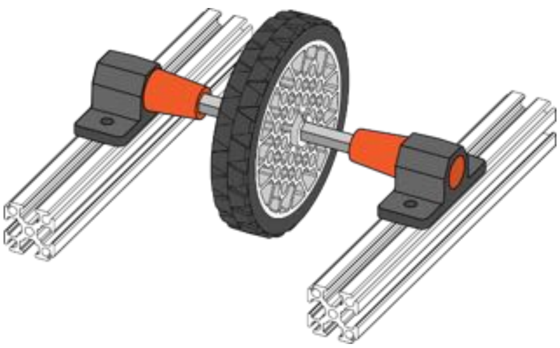


Figure 32: Pillow Blocks and End Cap Bearings

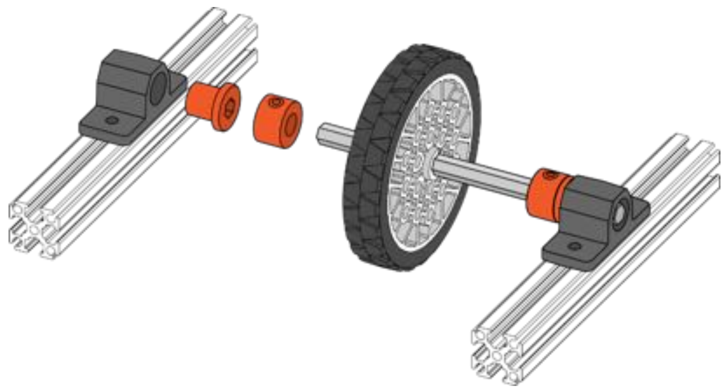


Figure 33: Pillow Blocks and Long Through bore Bearings

3.6 LINEAR MOTION

3.6.1 Kit Components

The REV Robotics Linear Motion kit is intended to be used with the REV Rail to help make creating linear motion on your robot easy. The Linear Motion kit contains all the necessary hardware (Figure 34) to build a 2-stage lift. A 5.5mm Nut driver and 2mm Allen key are needed for assembly.

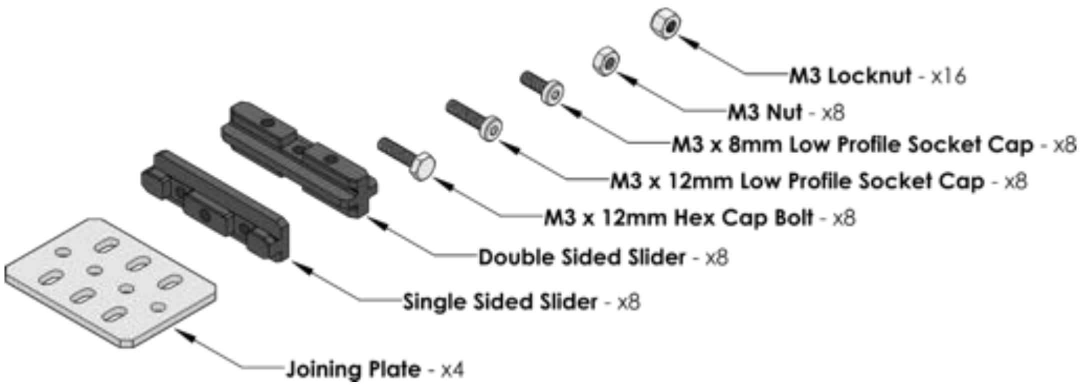


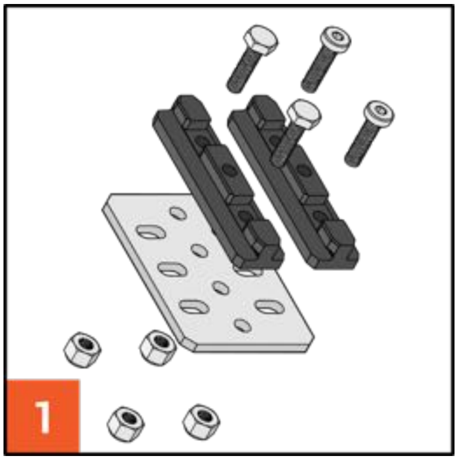
Figure 34: Linear Motion Kit Contents (REV-41-1098)

To drive the linear motion system, you will need:

- Small Pulley Bearings (REV-41-1368)
- M3 x 16mm or longer hex cap bolts (REV-41-1360)
- M3 Nyloc Nuts (REV-41-1361)
- Non-Stretching String

3.6.2 Assembly Instructions

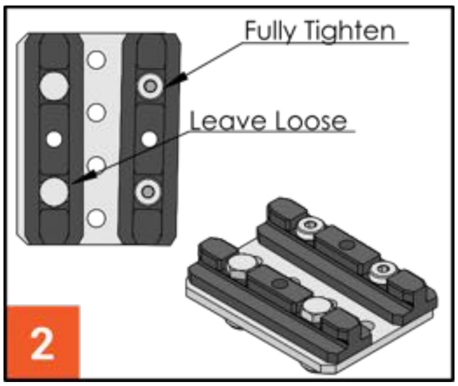
These instructions explain how to build one half of a single stage lift. Each REV Robotics 15mm Linear Motion Kit contains enough hardware to create a 2-stage lift.



Step 1

Required Components:

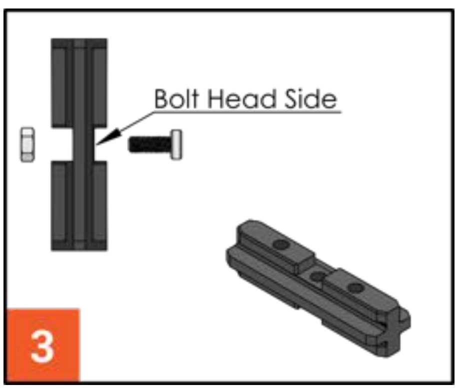
- Joining Plate – x2
- Single Sided Slider – x2
- M3 x 12mm Hex Cap Bolts – x2
- M3 x 12mm Low Profile Socket Cap Bolts –x2
- M3 Nylon Locknuts –x4



Step 2

On the single-sided slider side with the low profile socket cap bolts, fully tighten the single-sided slider onto the joining plate so that the edge of the slider and the plate are roughly parallel.

On the single-sided slider with the hex cap bolts, just start the nuts enough so they will not fall off, but leave the bolts loose.

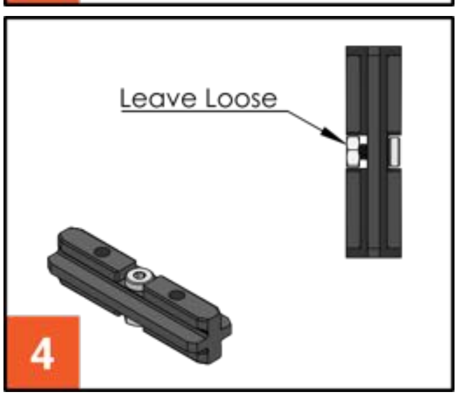


Step 3

Required Components:

- Double Sided Slider – x1
- M3 x 8mm Low Profile Socket Cap Bolts –x1
- M3 Nut –x1

Be sure that you insert the bolt from the correct side because the double-side slider is not completely symmetric. The bolt should be on the side with the shallower cutout as shown.

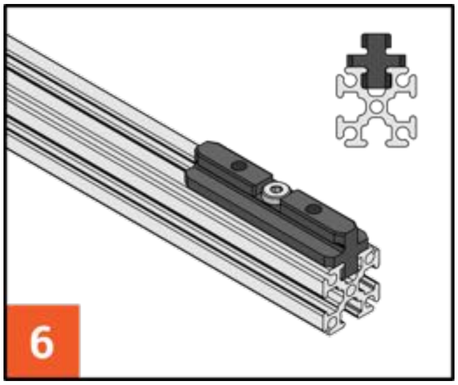


Step 4

When assembling the double-sided slider, only tighten the nut so that it is flush with the bottom of the slider when the bolt head is all the way down. There should be clearance between the top of the nut and the slider as shown.

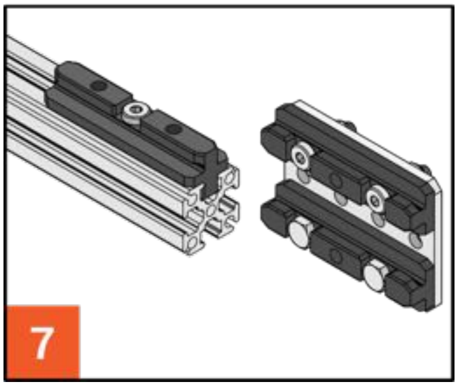
Step 5

Insert the double-sided slider into the extrusion channel. You may have to slightly loosen or tighten the nut so that it will align with the channel.



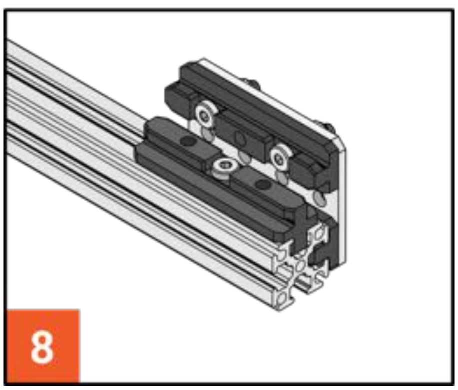
Step 6

Once the slider is fully inserted into the channel, tighten the bolt until snug.



Step 7

Take the single-sided assembly from Step 2 and slide the hex cap bolt slider into the extrusion channel on the side adjacent to the double-sided slider.



Step 8

Once the slider assembly from Step 2 is fully inserted into the channel, tighten just enough so that the single-sided slider assembly does not freely slide in the channel, but is still loose enough that you can move the slider with some minimal force.

The above steps 1-8 will result in the basic building assembly for a linear motion elevator using the REV Robotics 15mm Linear Motion Kit and Extrusion (Figure 35). Repeat the steps 1-8 above for as many stages as needed, a minimum of two assemblies are needed.

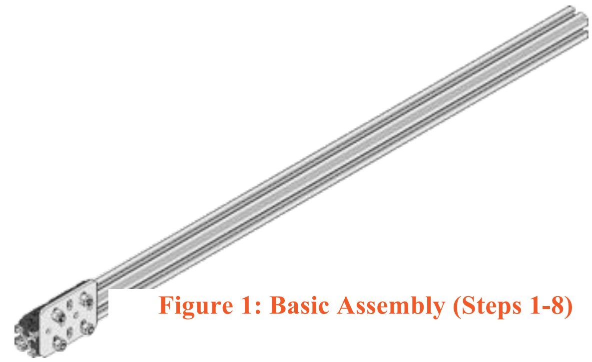
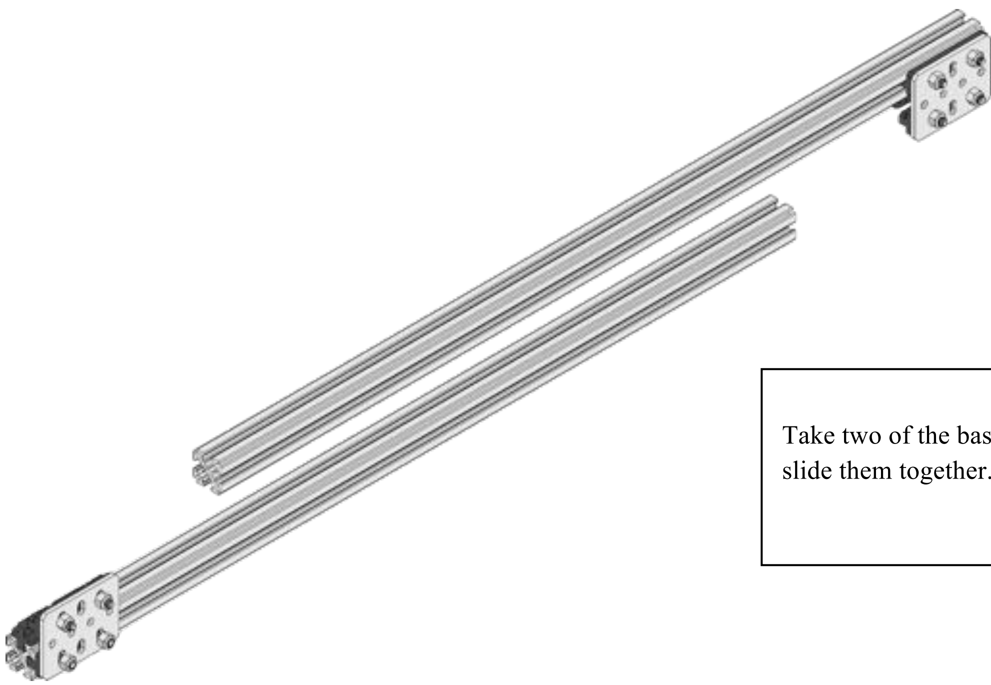
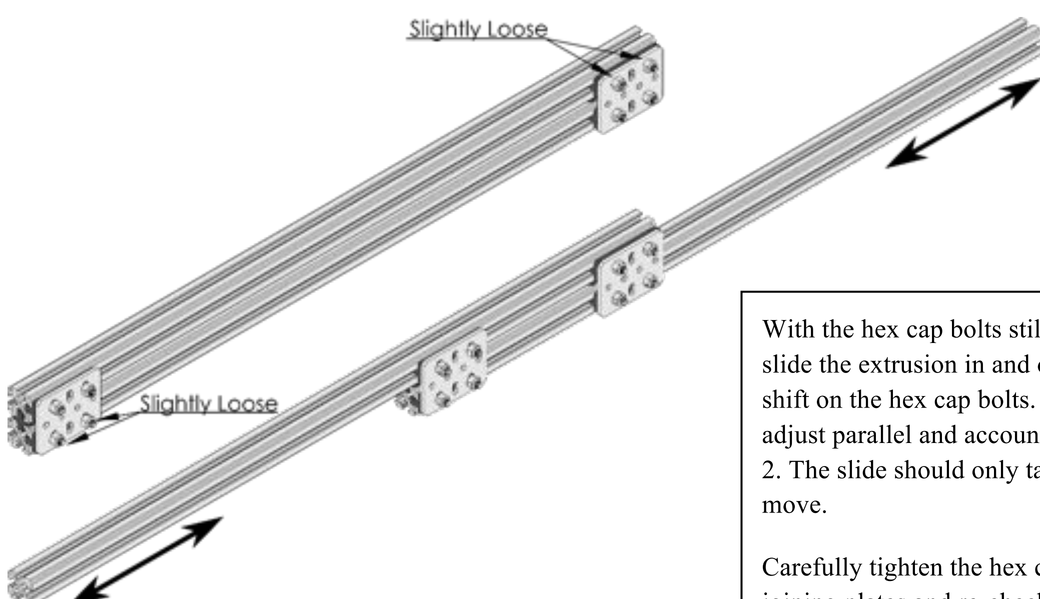


Figure 1: Basic Assembly (Steps 1-8)



Take two of the basic assemblies created in Steps 1-8 and slide them together.



With the hex cap bolts still slightly loose from step 8, gently slide the extrusion in and out allowing the joining plates to shift on the hex cap bolts. This allows for the sliders to self-adjust parallel and accounts for any misalignment from step 2. The slide should only take a very minimum effort to move.

Carefully tighten the hex cap bolts without shifting the joining plates and re-check the slide for any binding. Repeat as necessary.

3.7 HARDWARE

3.7.1 Nuts and Bolts

The REV Robotics 15mm Extrusion Building System is intended to be used with all M3 hardware (Figure 36). M3 hex cap bolts, nylon-insert lock nuts ("Nyloc"), and plain nuts are all readily available online and at many hardware stores. Always use high quality hardware because low quality hardware is made from softer materials which will become damaged while tightening.

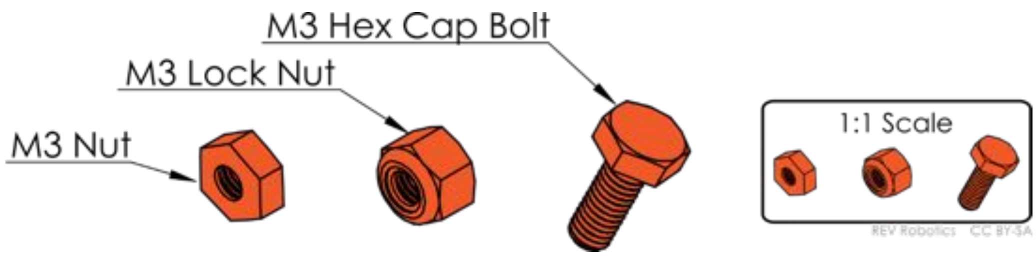


Figure 36: M3 Hardware

M3 hex cap bolts inserted into the extrusion and M3 nylon-insert nuts on the outside is the recommended "stud up" building orientation. The stud-up method doesn't require precise bolt lengths and is compatible with locking nuts. Regular M3 Nuts will fit in the extrusion channel, but nylon-insert nuts will not. If attaching plastic brackets to the extrusion in the "stud down" orientation, be sure to use an appropriate length bolt with plain nuts in the channel.

3.7.2 Drop-in Bolts

Drop-in bolts have a modified head profile which allow the head to drop into the extrusion channel and then be tightened in place (Figure 37). This is a big advantage when modifying an existing design because new brackets can be added to any extrusion location– unlike standard hex cap bolts which must have access to an open end of extrusion so the heads can be slid into the channel from the edge. These assembly techniques are discussed in more detail in the ASSEMBLY TECHNIQUES section.

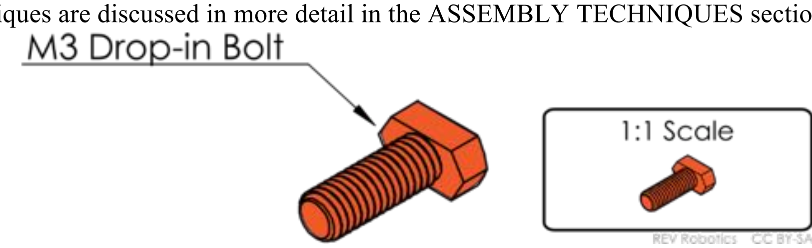


Figure 37: M3 Drop-in Bolt

3.7.3 5mm Hex Shaft

The REV Robotics building system is constructed around a 5mm hex shaft. Using a hex shaft to transmit torque in the system removes the need for set screws, which can loosen over time and can damage shafts. Hex Shafts are precision ground 5mm stainless steel and fits snuggly in all hex drive motion components (Figure 38).

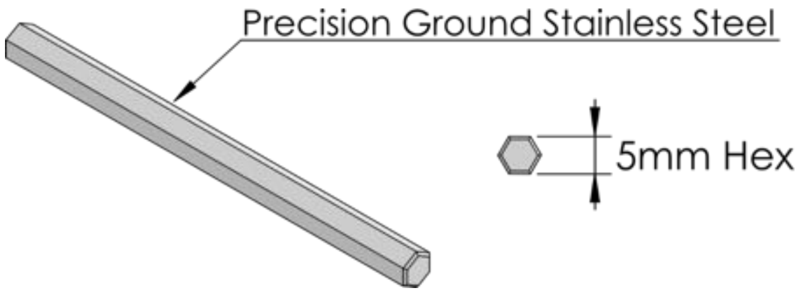


Figure 38: Stainless Steel 5mm Hex

REV Robotics Hex Shafts come in three lengths, 75mm (REV-41-1347), 135mm (REV-41-1347) and 400mm (REV-41-1362). For high load applications, it is recommended to either stack multiple gears or sprockets in parallel, or use the metal hex hub adaptor (REV-41-1362) to increase strength.

3.7.4 Shaft Collars and Spacers

Shaft collars are used to prevent lateral (sideways/sliding) movement of a shaft, or a part on the shaft. A shaft collar is a hollow cylinder with one more set screws which tighten towards its center and an inner dimension (ID) that is just slightly larger than the shaft it is being used on (Figure 39). Since shaft collars are used to prevent lateral shaft movement they are often used in place of shaft spacers.

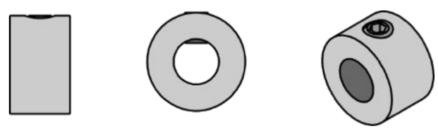


Figure 39: 6mm Shaft Collar

To use the shaft collar, slide it onto the hex shaft and rotate it until a flat side is facing the setscrew (Figure 40). Adjust the collar to the desired location and use a 1.5mm Allen wrench to tighten the included set screw snuggly against the shaft. A small amount of a thread locker product, like Loctite Blue, can be used if desired.

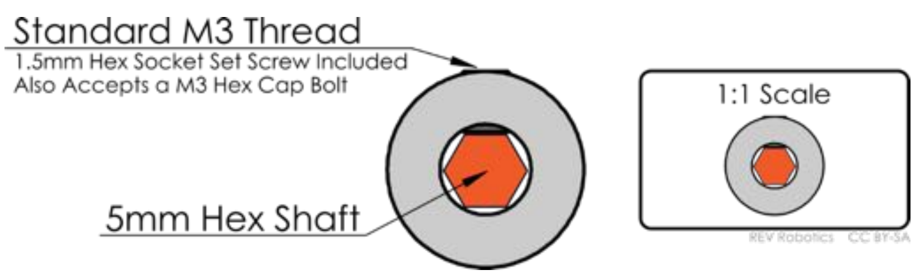


Figure 40: Shaft Collar Tightened on a Hex Shaft

The REV Robotics shaft collar has a 6mm inside diameter and is customized with a M3 thread so a standard hex cap bolt can be used instead of the supplied set screw (Figure 41).

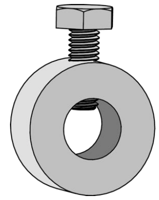
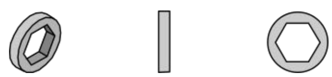
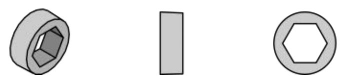
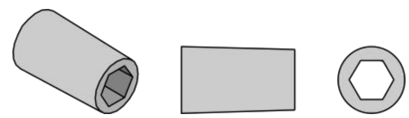


Figure 41: Shaft Collar with Standard M3 Hex Cap Fastener

Spacers for the 15mm building system have a 5mm hex center, are made of Delrin, and come in 3 lengths (Table 5). Spacers are used between parts on a shaft to take up the extra space and prevent the parts from sliding on the shaft. If more than a few spacers are needed, it is typically better to use a shaft collar.

Table 5: Spacers

		
1.5mm Spacers REV-41-1325	3mm Spacers REV-41-1324	15mm Spacers REV-41-1323

Spacers and shaft collars are used for the same purpose: to constrain components on a shaft. This keeps shafts from falling out and also keeps motion components, such as gears and sprockets, aligned. For larger sections of exposed shaft, shaft collars are preferred because installing multiple spacers is less efficient and is more difficult to manage during robot building and maintenance. For shorter shaft lengths, spacers are generally more efficient (Figure 42).

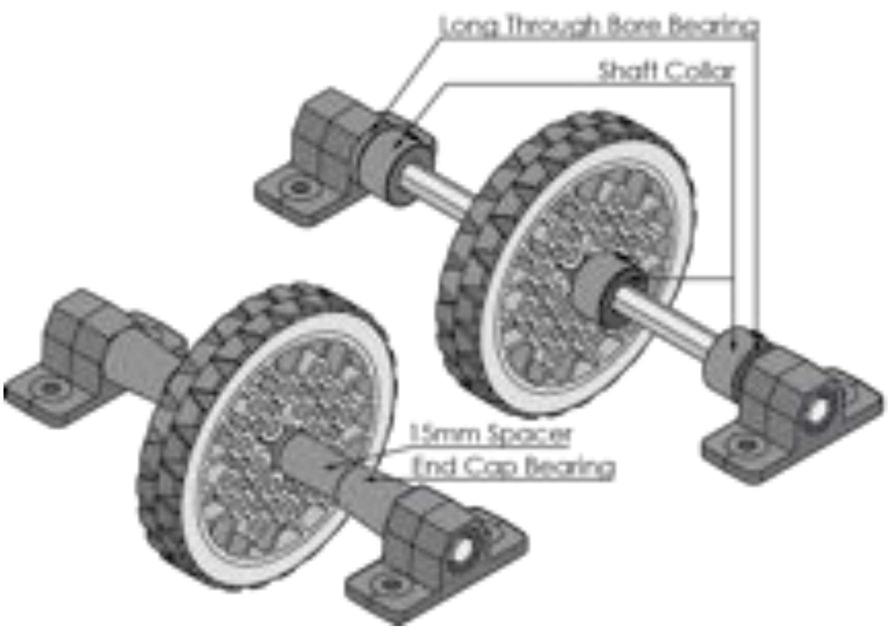
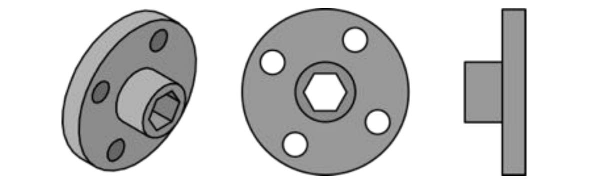


Figure 42: Shaft Collar and Spacer Side by Side

3.8 ADAPTERS

3.8.1 Hex Hub Adapter

The aluminum hex hub adapter should be added in any high torque application. The Hex hub adapter has mounting 4 mounting holes and are compatible with any of the REV robotics hex driven motion products.



Hex Hub Adaptor
REV-41-1146

When the hex hub adaptor is used with another motion component, such as the 60 tooth gear in Figure 43, the raised part of the hub should face away from the gear. There will be a small gap between the back of the hub and the body of the gear because of the built-in spacer on the gear. Insert a shaft into both parts and then using M3x20mm and nylocs, evenly tighten the hub against the gear to ensure good alignment.

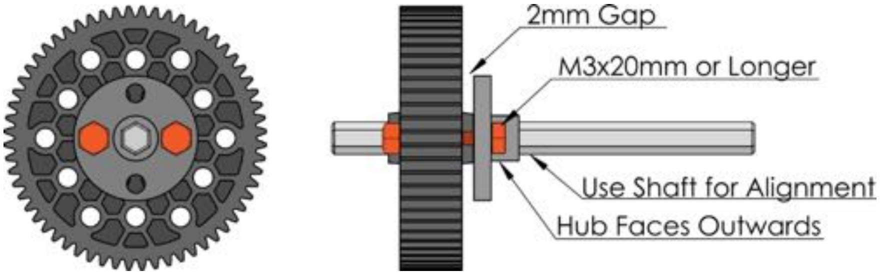
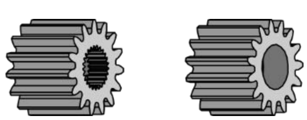
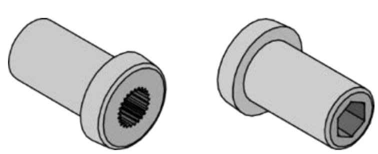
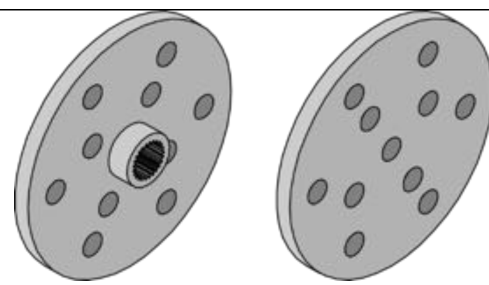


Figure 43: Hex Hub Adapter Mounted on a REV Gear for Added Strength

3.8.2 Servo Adapters

Servo Adapters fit 25T spline servos like the REV Robotics Smart Robot Servo (REV-41-1097). In addition to the variety pack of generic servo horns which come with the Smart Robot Servo, there are three other custom servo adapters which make using servos with the REV Robotics building system very easy (Table 6).

Table 6: Servo Adapters

		
Servo Gear Adaptor REV-41-1364	Servo Shaft Adaptor REV-41-1328	Aluminum Servo Horn REV-41-1363

Servo Gear Adaptors convert a 25T servo into 15 tooth Delrin gear which is compatible with the other REV Robotics Gears.

Servo Shaft Adaptors convert a 25T spline servo output shaft into a female 5mm hex socket. This adapter can be used to use a servo to drive a 5mm hex shaft directly.

Aluminum Servo Horns have a tapped hole pattern that can be directly mounted to any of the REV Robotics gears, wheels, or sprockets with a 6-hole pattern.

3.9 MOTION COMPONENTS

All REV Robotics Motion Components, including wheels, sprockets, gears, and pulleys, all have a uniform thickness of 15mm (Figure 44). The purpose of this is to improve the iterative design experience. Changing from gears to a solution with chain and sprocket, or switching to directly driving a wheel, will not require any frame or spacer changes.

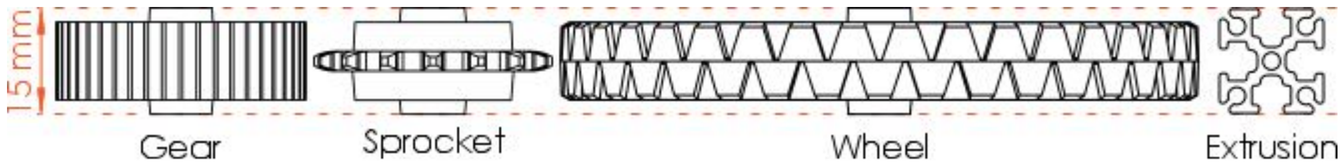


Figure 44: All Motion Parts Share Common 15mm Part Thickness

All Motion components have a M3 bolt hole mounting pattern that is on an 8mm pitch as shown in Figure 45. This makes it easy to directly mount to brackets and extrusion.

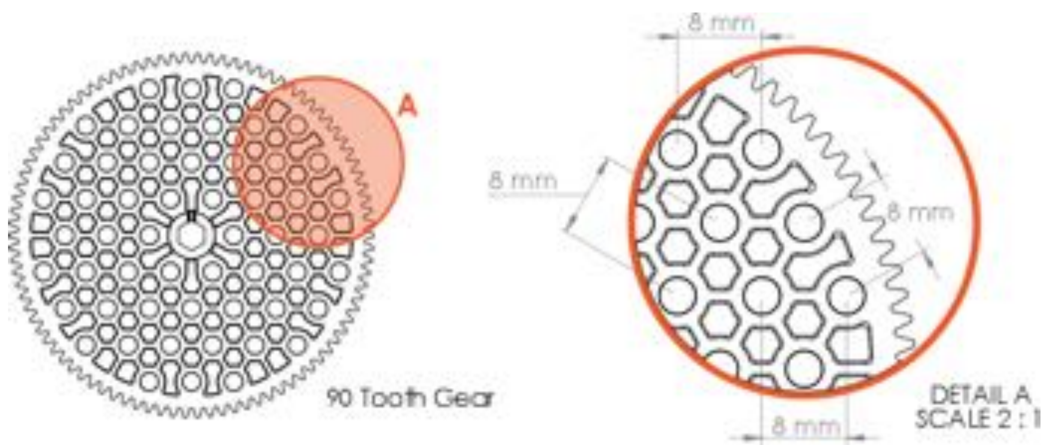


Figure 45: Motion Component Bolt Pattern Detail

Sometimes, it may be desirable to stack together multiple of the same gear or sprocket on a shaft.   As a best practice, all components should have the alignment notch (Figure 46) oriented the same direction on the shaft. The alignment notch can be found on the raised hub on either side of the gear or sprocket.

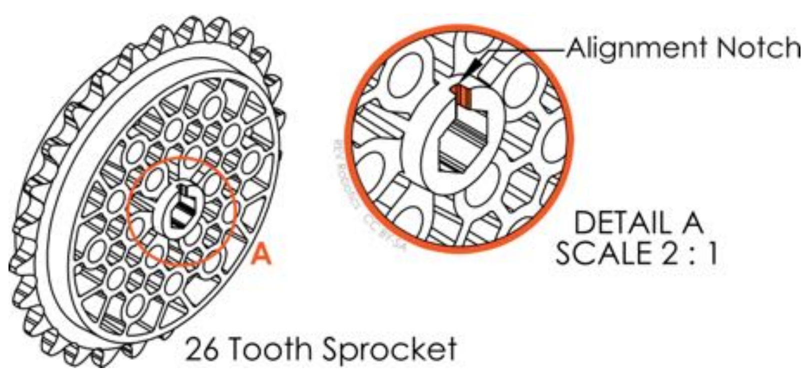


Figure 46: Shaft Alignment Notch Detail

In many cases the number of teeth on the gear or sprocket is not divisible by six, the number of sides on the hex shaft, and therefore the relative rotation between two of the same part will result in the teeth being out of alignment with each other. As Figure 47 shows, if the first sprocket was put on a shaft with the alignment notch facing upwards (noted by ①), there would be a valley at the top of the sprocket. If the second sprocket was added to the shaft, but rotated clockwise by 60 degrees (by the turn of one flat side), there would be most of a sprocket tooth at the top of that sprocket (noted by ②). It's possible to build a working system without aligning stacked parts, but it's not recommended.

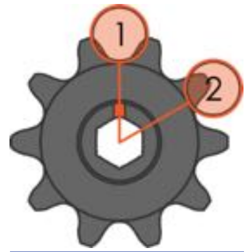


Figure 47: Shaft Alignment Example

3.10 WHEELS

The REV Robotics Building System has three different traction wheel sizes (Table 7) and two different Omni Wheel sizes (Table 8). Traction wheels are co-molded with a polyurethane tread for increased traction.

3.10.1 Omni Wheels

Omni wheels are a special kind of wheel that has smaller rollers round the circumference of the wheel. These rollers can passively roll perpendicularly to the direction the wheel is driven (Figure 48). This wheel makes it easier for a robot to turn and can also be used in conjunction with some advanced drivetrains to create more maneuverable robots.

Figure 48: Omni Wheel Rollers

A single omni wheel is the same thickness, 15mm, as all other motion components. In some applications, it might be desirable to stack two omni wheels, with one rotated by 60° from the other, as shown in Figure 49. By setting your wheels in this configuration you ensure that a roller is always in contact with the ground. This results in smoother operation and a more consistent ability to roll perpendicular to the normal rotation of the wheel.

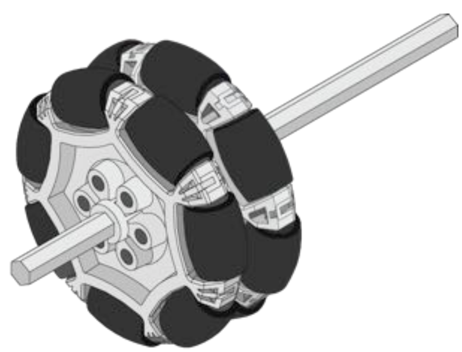


Figure 49: Double Stacked Omni Wheels

3.10.2 All Wheels

Table 7: Traction Wheels

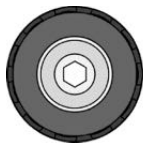
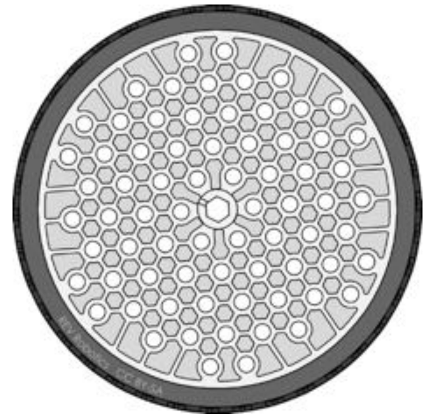
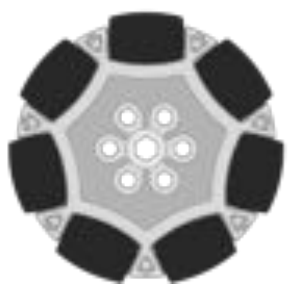
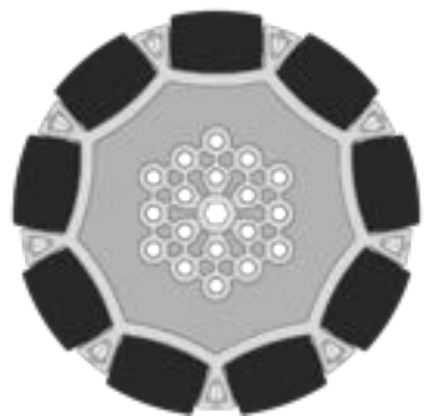
		
30mm Traction Wheel REV-41-1353	60mm Traction Wheel REV-41-1350	90mm Traction Wheel REV-41-1354

Table 8: Omni Wheels

	
60mm Omni Wheel REV-41-1353	90mm Omni Wheel REV-41-1354

3.11 SPROCKETS AND CHAIN

REV Robotics sprockets are a #25 pitch and are made from molded acetal (Delrin/POM). Sprockets are designed to fit a 5mm hex shaft, which eliminates the need for special hubs and setscrews. The REV Robotics building system is designed around slotted extrusion which allows components attached to the extrusion to slide to any desired location for tension adjustment. There are six different sprocket sizes available with a maximum reduction of 5.4 (Table 9).

Sprockets are used with chain to transmit torque from one axle to another. By selecting sprockets larger or smaller relative to the input sprocket, we can either increase the output speed or increase the output torque as shown in Figure 50. However, the total power in the system is not effected.

When a larger sprocket drives a smaller one, for one rotation of the larger sprocket the smaller sprocket must complete more revolutions so the output will be faster than the input. If we reverse the situation and a smaller sprocket drives a larger output sprocket, then for one rotation of the input the output will complete less than one revolution resulting in a speed decrease from the input. The ratio of the sizes of the two sprockets is proportional to the speed and torque changes between them.

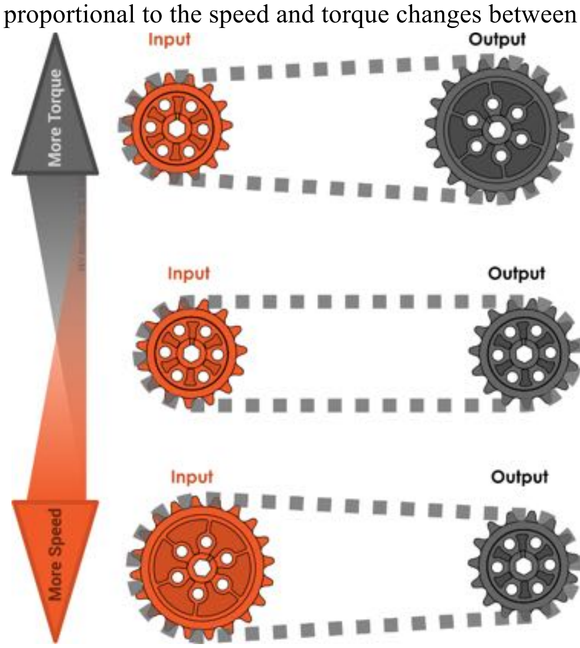


Figure 50: Using Gears to Increase Speed or Torque

From Figure 50 we know that the ratio in size from the input (driving) sprocket to the output (driven) sprocket determines if the output is faster (less torque) or has more torque (slower). To calculate exactly how the sprocket size ratio effects the relationship from input to output we can use the ratio of the number of teeth between the two sprockets.

Sprocket and chain is a very efficient way to transmit torque over long distances. Modest reductions can be accomplished using sprockets and chain, but gears typically provide a more space efficient solution for higher ratio reductions.

3.11.1 Chain Tension

In order for sprockets to work effectively, it is important that the center-to-center distance is correctly adjusted. The sprocket and chain in Figure 51 may work under very light load, but they will certainly not work and will skip under any significant loading. The sprockets in this example are too close together so chain is loose enough that it can skip on the sprocket teeth. The sprockets in Figure 52 are correctly spaced which will provide smooth, reliable operation.

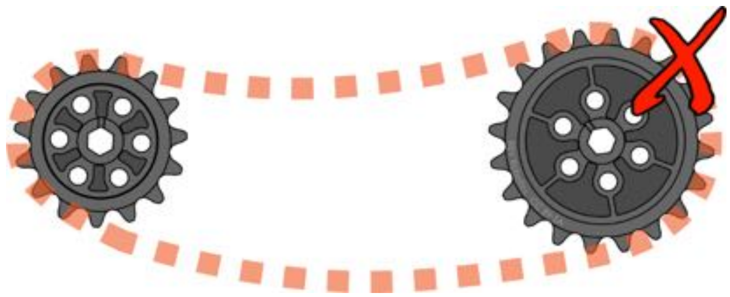


Figure 51: Incorrectly Spaced Sprockets (Chain too Loose)

Figure 52: Correctly Spaced Sprockets (Chain Correctly Tensioned)

To correctly space REV Robotics sprockets, use the following procedure:

1. Securely fix the axle of either the input or output sprocket. In the case of a gear train with multiple idlers or a compound reduction, consider which axle makes the most sense to fix such as the very first input gear or the very last gear.
2. Starting with the fixed axle, then identify all the driving and driven sprockets for any sprockets on that axle. One by one loosen these axles, slide them until the chain is tensioned and then retighten the axle mounts.
3. Continue the procedure from Step 2 for each fixed axle until all the chains are tight and all the axles have been retightened.

3.11.2 Anatomy of Chain

Roller chain is used to connect two sprockets together and transfer torque. Roller chain is made up of a series of inner and outer links connected together to form a flexible strand (Figure 53).

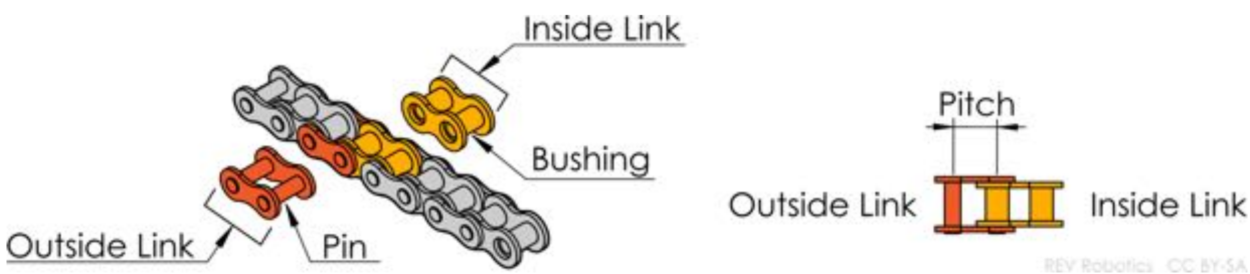


Figure 53: Basic Chain Nomenclature

Outside Links consist of two outside plates which are connected by two ***pins*** that are pressed into each plate. The ***pins*** in the outside link go through the inside of the hollow ***bushings*** when the inner and outer links are assembled. The ***pins*** can freely spin on the inside of the ***bushings***.

Inside Link consist of two inside plates that are connected by two hollow ***bushings*** which are pressed into each plate. The teeth of the sprocket contact the surface of the ***bushings*** when the chain is wrapped around a sprocket.

Pitch is the distance between the centers of two adjacent ***pins***. The REV Robotics building system uses #25 chain.

3.11.3 Custom Length Chain

In almost all applications, chain links are connected to form a loop. While chain can sometimes be purchased in specific length loops, it is more common to receive chain in bulk lengths and make custom loop lengths to fit the application. It is recommended to use a specialized tool, called a chain breaker, to cut chain into desired lengths in order to prevent accidental damage.

Chain breakers do not actually "break" or cut the chain, instead they are used to press out the pins holding a link together. After the pins have been removed the chain can be separated leaving inner links on both ends of the break. Refer to individual tool instructions for more specific and detailed chain break procedures.

3.11.4 Master Links

Roller chain is typically connected into a continuous loop. This can be done using a special tool to press the pins in and out of the desired outer link, or if the chain is already the correct length, an accessory called a master link, or quick-release link, (Figure 54) can be used to connect two ends of the chain.

Figure 54: Master Link (Enlarged)

Master links allow for easy chain assembly/disassembly without any special chain tools. Master links can typically be reused many times, but will eventually become bent after repeated uses and should then be discarded. Master links replace an outside link in a section of chain, but before examining the master link connecting two sections of chain, Figure 55 depicts the basic operation for assembling a master link.

1. Place the loose outer plate onto the two pins pressed into the other outer plate.
2. Ensure the outer plate is inserted onto the pins far enough that the grooves on the pins are fully exposed past the outer plate.
3. Align the widest gap near the middle of the clip with one of the pins.
4. The gap in the clip should allow the clip to slip over the pin and sit flush against the outer plate and aligned with the groove in the pins.
5. Use pliers or another tool to slide the clip towards the other pin until the clip is securely engaged with the grooves on both pins.

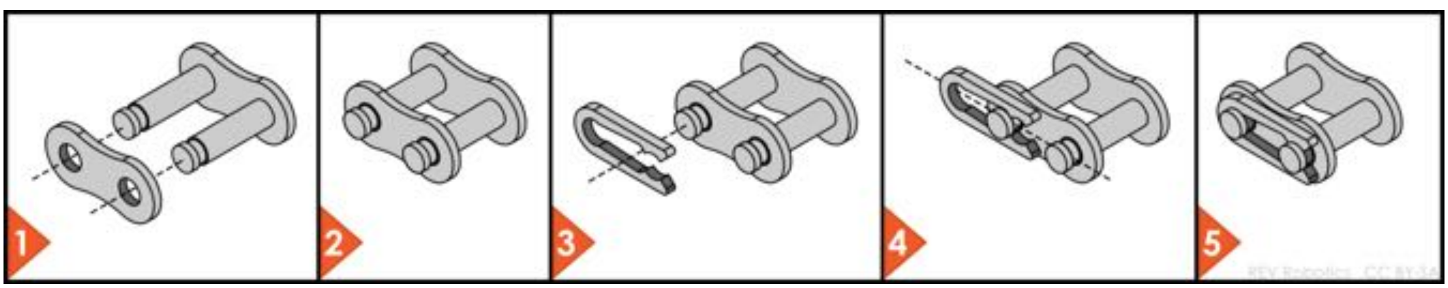


Figure 55: Master Link Detailed Assembly for Reference

Installing the clip as shown in Steps 4 and Step 5 of Figure 55 can be sometimes difficult.

There are a number of approaches that may work for these steps, but a common method is to use a pair of needle nose pliers to grip between the back of the clip and the nearest pin to slide the clip (Figure 56).

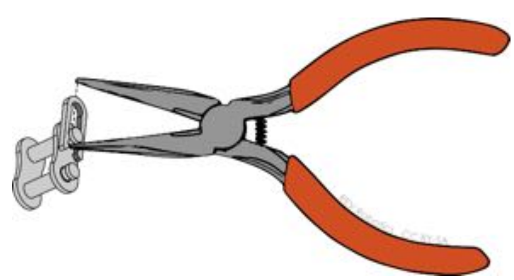


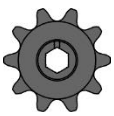
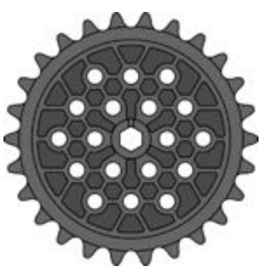
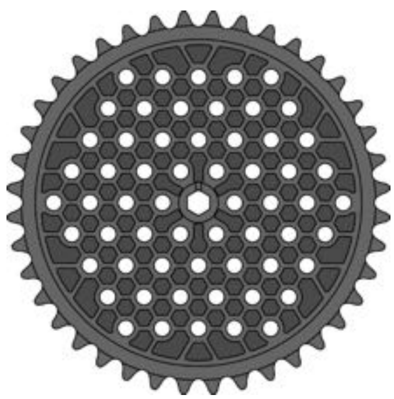
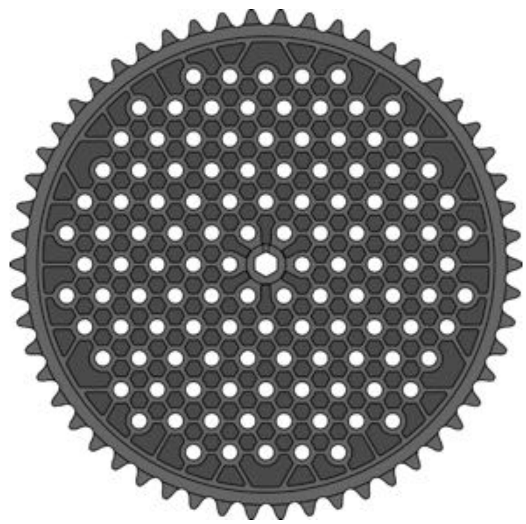
Figure 56: Installing the Maser Link Clip with Pliers

Master links are used to connect two ends of a section of chain to create a loop of chain. In order to use a master link, the chain ends should both terminate with inside links (Figure 57). Slide the two pins from the master link into the rollers of the two terminating inside links. Follow the procedure from Figure 55 to complete the link installation.

Figure 57: Master Link Assembly on Chain

3.11.5 All Sprockets

Table 9: #25 Sprockets

		
10 Tooth Sprocket REV-41-1338	15 Tooth Sprocket REV-41-1339	20 Tooth Sprocket REV-41-1340
		
26 Tooth Sprocket REV-41-1342	40 Tooth Sprocket REV-41-1343	54 Tooth Sprocket REV-41-1341

3.12 GEARS

Gears are rotating parts that have teeth and are meshed with other gears to transmit torque. Gears can be used to change the speed, torque (turning force), or direction of a motor’s original output. For gears to be compatible with each other, the meshing teeth must have the same shape (size and pitch).

REV Robotics Gears have a 0.75 module, 20° pressure angle and are made from molded acetal (Delrin/POM). The webbed designed with a wide face width and small tooth profile increases the gear strength without adding significant weight. REV Robotics Gears are designed to fit a 5mm hex shaft which eliminates the need for special hubs and setscrews. This system has seven different gear sizes with a maximum reduction of 8.3 (Table 10).

Meshing two or more gears together is known as a gear train. By selecting the gears in the gear train as larger or smaller relative to the input gear we can either increase the output speed, or increase the output torque as shown in Figure 58, but the total power is not affected.

When a larger gear drives a smaller one, for one rotation of the larger gear the small gear must complete more revolutions - so the output will be faster than the input. If the situation is reversed, and a smaller gear drives a larger output gear, then for one rotation of the input the output will complete less than one revolution – so the output will be slower than the input. The ratio of the sizes of the two gears is proportional to the speed and torque changes between them.

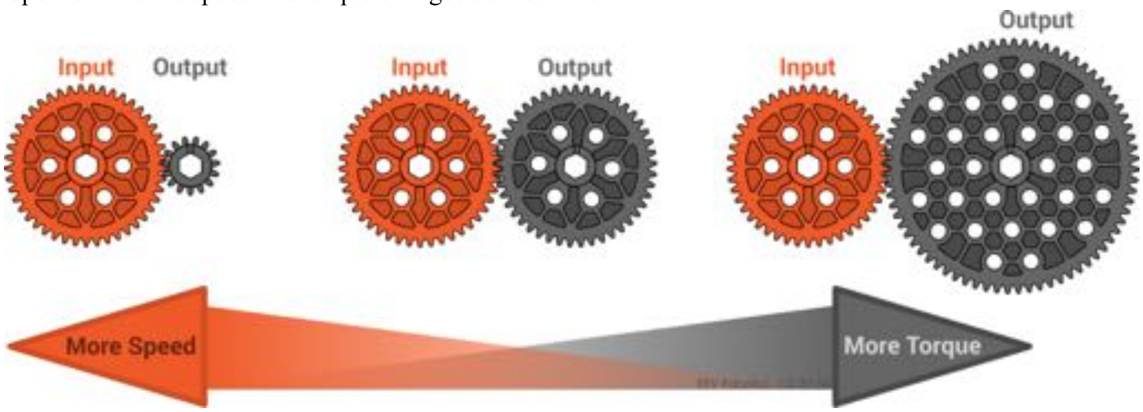


Figure 58: Using Gears to Increase Speed or Torque

3.12.1 Correct Gear Spacing

In order for gears to work effectively, and not become damaged, it's important that the center-to-center distance is correctly adjusted. The gears in *DETAIL A* of Figure 59 may work under very light load, but they will certainly not work and will skip under any significant loading. The gears in that example are too far apart and so the teeth of each gear barely contact each other. The gears in *DETAIL B* of Figure 59 are correctly spaced and will provide smooth and reliable operation.

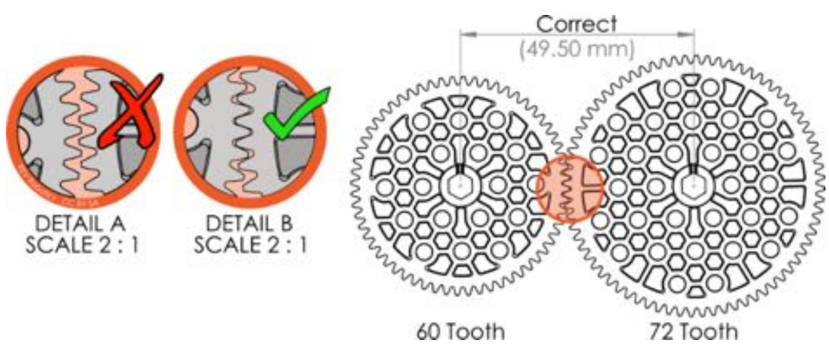


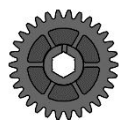
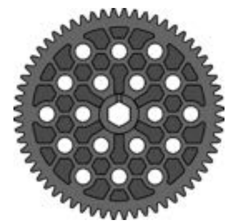
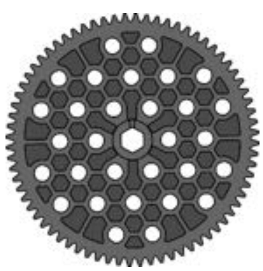
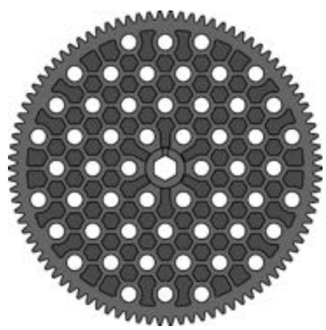
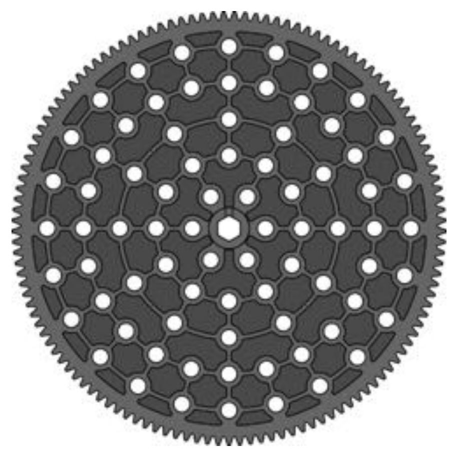
Figure 59: Gear Spacing Example

To correctly space REV Robotics Gears, use the following procedure:

1. Securely fix the axle of either the input or output gear. In the case of a gear train with multiple idlers or a compound reduction, consider which axle makes the most sense to fix, such as the very first input gear or the very last gear.
2. Starting with the fixed axle, identify all the driving and driven gears for any gears on that axle. One by one, loosen these axles and slide them until the teeth of both gears are fully engaged and parallel. Retighten the axle mounts.
3. Continue the procedure from Step 2 for each fixed axle until all the gears are tightly meshed and all the axles have been retightened.

3.12.2 All Gears

Table 10: Spur Gears

 15 Tooth Gear REV-41-1331	 30 Tooth Gear REV-41-1332	 45 Tooth Gear REV-41-1334	 60 Tooth Gear REV-41-1335
 72 Tooth Gear REV-41-1336	 90 Tooth Gear REV-41-1337	 125 Tooth Gear REV-41-1333	

3.13 PULLEYS AND ROUND BELT

Pulleys can be used to transmit torque the same way that gears and chain can, but they are also used to move objects. Pulleys are connected by belts in a manner that is very similar to the way that chain connects sprockets (Figure 60).

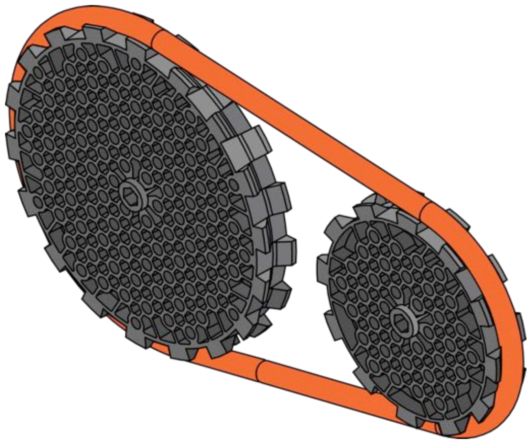
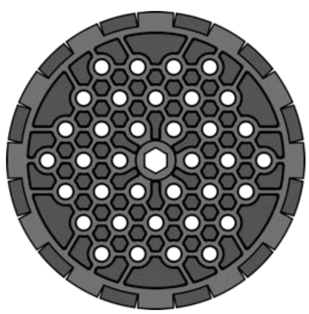
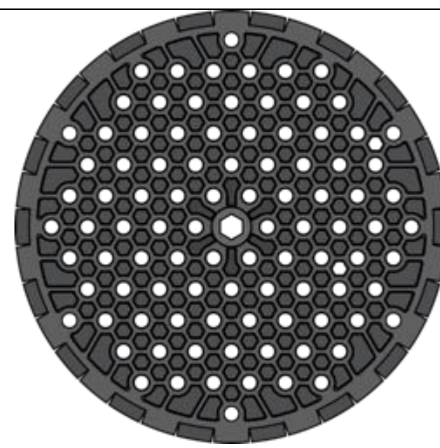
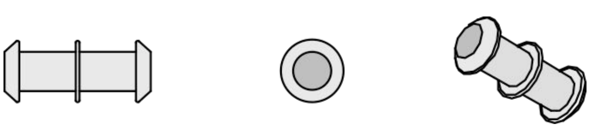
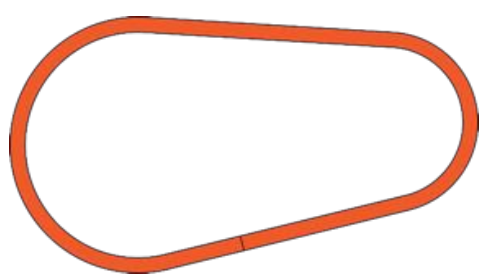


Figure 60: Pulleys with Round Belting

Belts are cut to length and then the belt ends are connected using a small metal part called a barb. The barb is forced into the two ends of the belt to form a loop. Belt systems are more prone to slipping than sprockets and chain or gears; therefore, belts should be tight in order to effectively transmit torque and prevent slip. It is important to keep this characteristic in mind when building systems that require high torque.

3.13.1 All Pulleys and Pulley Parts

Table 11: Pulley Components

 30mm Pulley REV-41-1344	 60mm Pulley REV-41-1345	 99mm Pulley REV-41-1346
 Pulley Belt Barb REV-41-1165		 Round Pulley Cord REV-41-1164

4 BASIC BUILDING GUIDE

4.1 DRIVE TRAIN GUIDE

4.1.1 DROP CENTER 6-WHEEL DRIVE

When designing a 6-wheel drive robot, it is typically desirable to drop the center wheel by a small amount in order to improve the turning ability of the robot. There are two straight forward ways to do this using the REV Building System.

In Figure 61, the center wheel is dropped by about 3mm using the Indexable Motion Bracket with motion brackets on the outside wheels. The Indexable motion bracket is easily adjustable in 1mm increments, so the ideal center drop for a robot design can be determined quickly through testing.

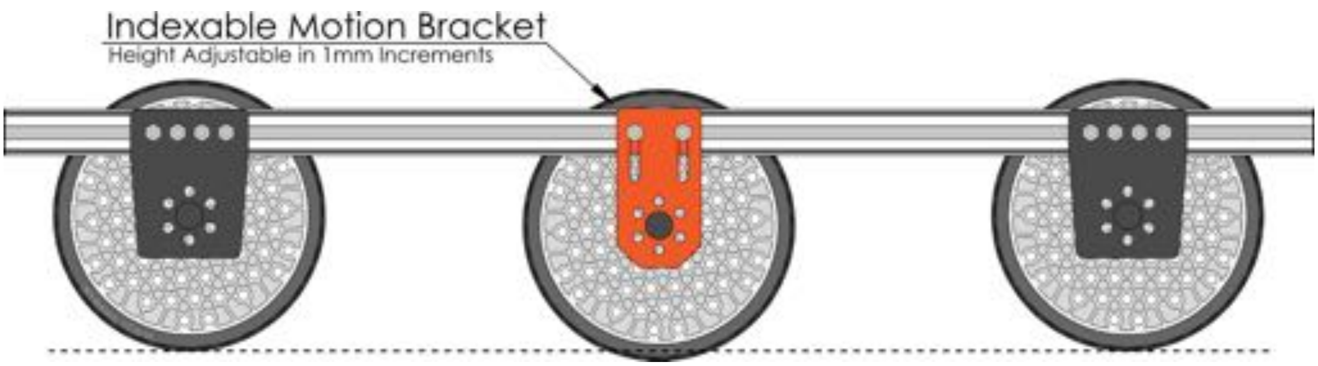


Figure 61: Drop Center Wheel Using an Indexable Bracket

Figure 62 shows an alternate way to create a dropped center wheel using all pillow blocks. The center pillow block has had the alignment ribs (small bumps on the bottom) sanded down, and then washers or a custom fit piece of plastic sheet inserted underneath. The bolts hold the pillow block and the washers to the extrusion. The thickness or number of washers can be changed to adjust the amount of center drop.

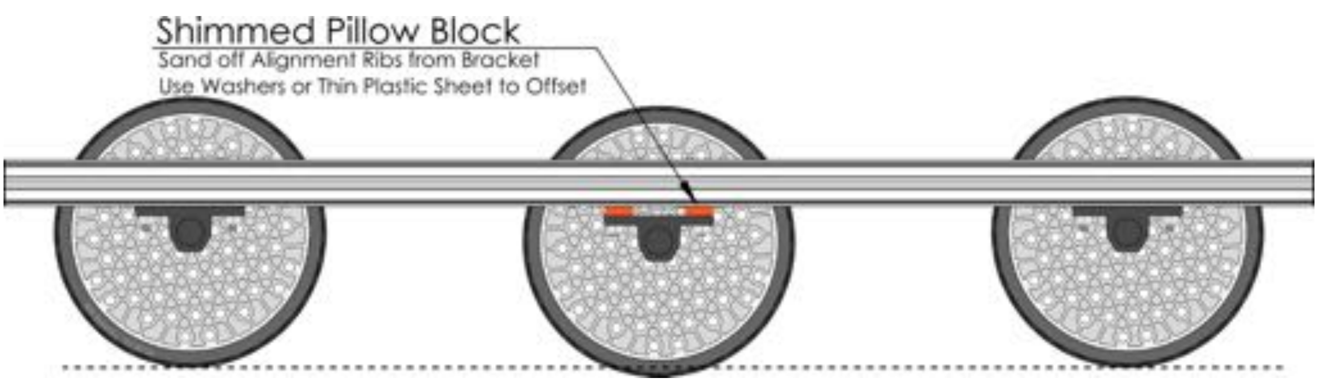


Figure 62: Drop Center Using a Shimmed Pillow Block

4.1.2 Geared Drive Train

Idler gears are a good way to transmit power across distances in your robot. An idler gear is any intermediate gear which does not drive an output shaft. Idler gears are used to transmit torque over longer distances than would be practical by using just a single pair of gears.

A common example of this is an all gear drivetrain (Figure 63). In this example, the gears on the end are linked to the drive wheels with one of the center gears being driven by a motor (not shown). The orange arrows indicate the relative rotation of each of the gears showing that the two wheels are mechanically linked and will always rotate in the same direction. Because idler gears reverse the direction of rotation, it is important to pay attention to the number of gears in the drivetrain. In Figure 64, because there is an even number of gears in the drivetrain the wheels will always spin in opposite directions, which would get that robot nowhere fast.

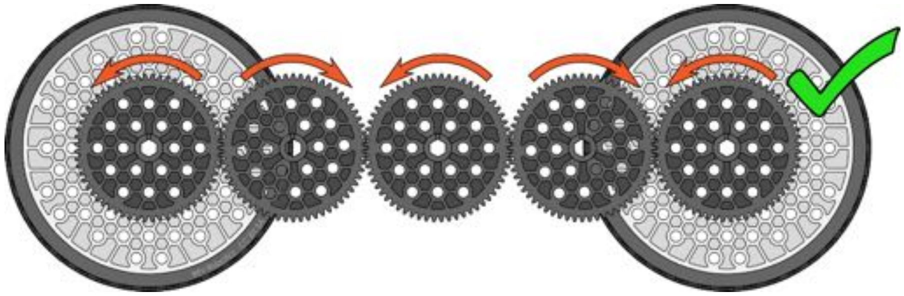


Figure 63: Correct All Gear Drivetrain

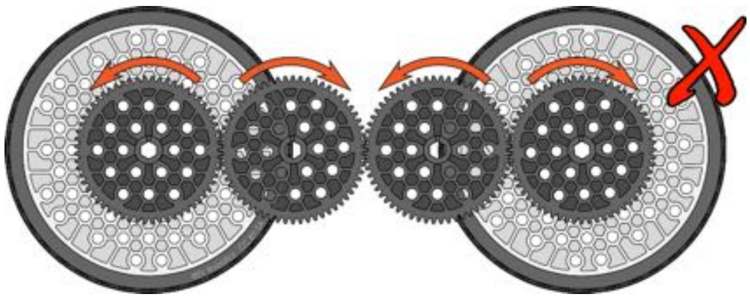


Figure 64: Incorrect All Gear Drivetrain

4.1.3 Sprocket and Chain Drive Train

Sprocket and chain is an efficient way to transmit torque long distances in a robot. A common example of this is a sprocket and chain drivetrain (Figure 65). In this example the sprockets on the ends are linked to the drive wheels and the center sprocket is driven by a motor (not shown). Because the driving and driven sprockets are all inside the chain, they all have the same rotation direction. The smaller sprockets on the outside of the chain loop are used to increase the amount of chain wrap on the driving sprocket.

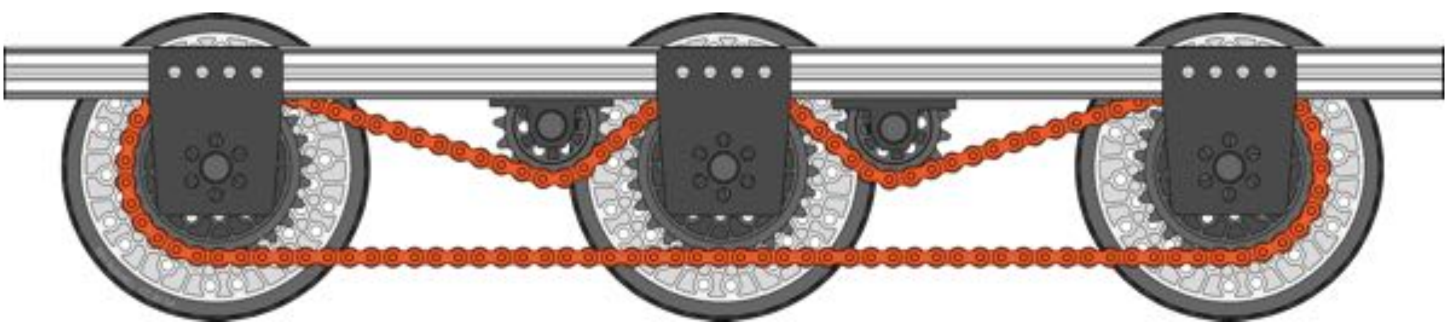


Figure 65: Example Sprocket and Chain Drive Train

All sprockets on the same side of a chain have the same rotation. In Figure 66, the driving and driven sprocket are inside the chain and are rotating counter clockwise while the idler sprocket is outside of the chain loop and is rotating clockwise.

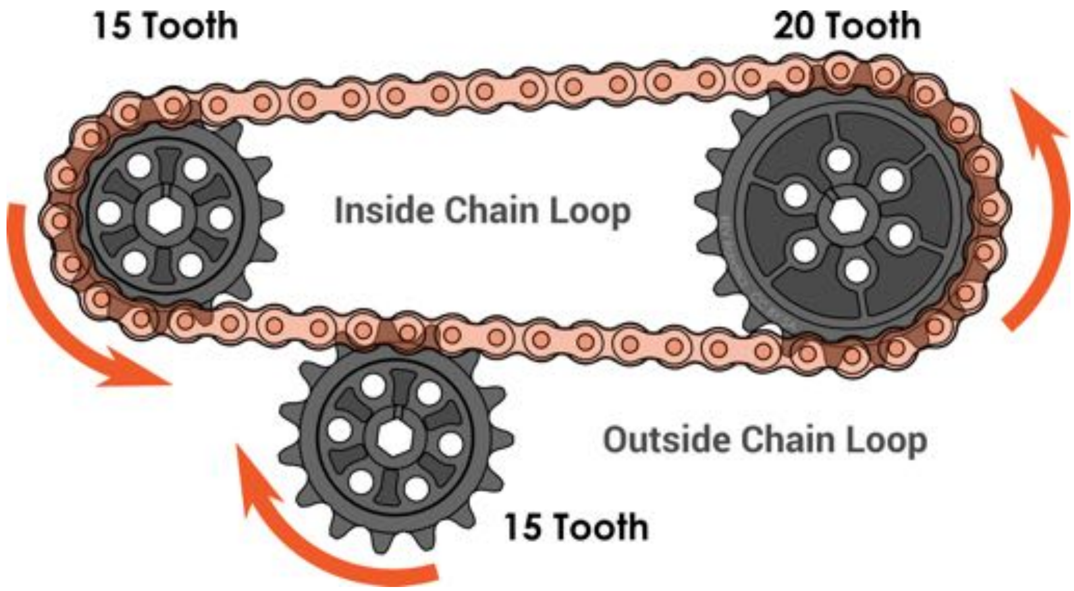


Figure 66: Single Stage Reduction (15:20) with Idler

Idlers can be used to tension chain or increase the amount of chain wrap around a sprocket. From Figure 67, all power transmission sprockets should have chain wrapped approximately 180° around the circumference of the sprocket. This amount of wrap is necessary so that there are sufficient teeth engaged with the chain to transmit the torque. Too little wrap (<120°) and the chain will skip under heavy load, while excessive wrap (>200°) can decrease system efficiency. In Figure 67 the sprocket outside of the chain is noted with a warning because it has a chain wrap of <90°. If this sprocket is an idler, then it is unpowered and minimal chain wrap is acceptable, however if this sprocket will be driving a shaft then this amount of wrap would be insufficient.

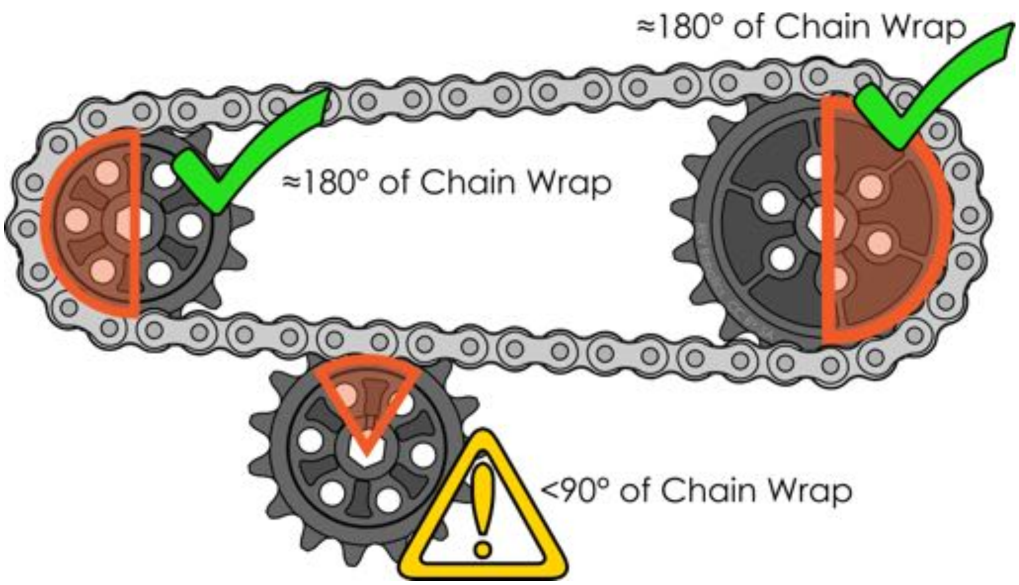


Figure 67: Chain Wrap Illustration

4.2 ARM GUIDE

4.2.1 Simple Arms

Two methods to create a simple are shown in the figures below. Figure 68 uses a Hex Pillow Block bolted to a piece of extrusion and the hex shaft can be rotated (not shown) to turn the light duty arm. In Figure 69 gears are bolted to the extrusion for a heavier duty arm. In this example, another shaft with gears can be places parallel to the arm pivot to drive the larger gears.

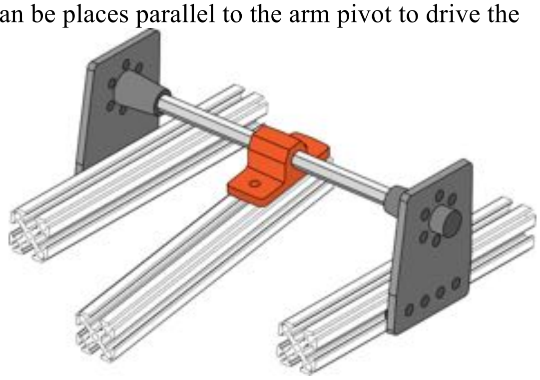


Figure 68: Simple Low Torque Arm Example

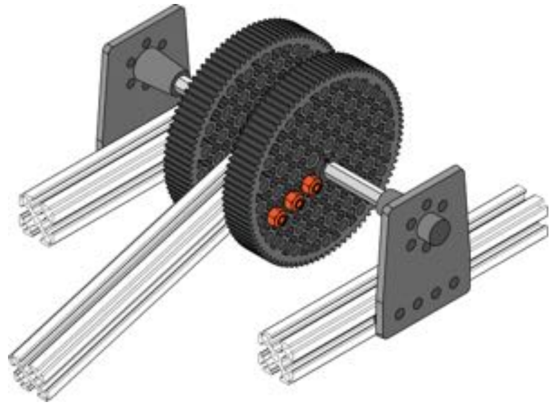


Figure 69: Simple Gear Driven Arm Example

4.3 MINI ROBOT EXAMPLE

The mini robot (Minibot) is a simple and easy to build robot that can be put together in under an hour. The purpose of this model is to learn the basic building skills (Figure 70) required to build larger more complex robots. The Minibot is also a good platform to start learning to write basic code and learn to use sensors before your larger robot is finished. A Complete getting started instructions for the Minibot are available separately.

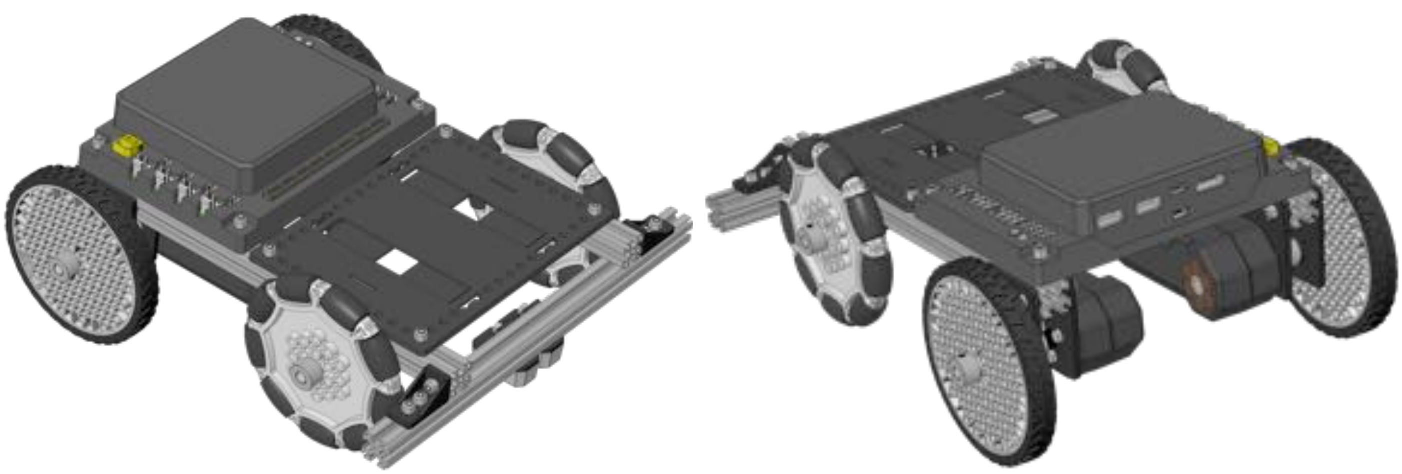


Figure 70: Mini Robot

ALL COMPONENTS (1:1 Scale)

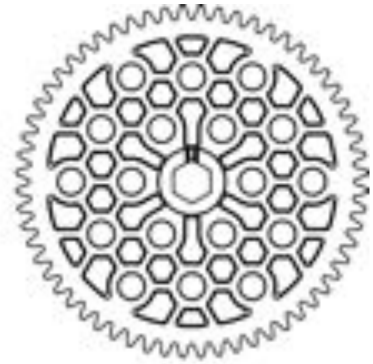
This section has 1:1 scale drawings for the REV Robotics 15mm Extrusion Building system components. Use this list as a reference for part numbers, or print the pages out at full scale and use them to help identify unknown parts.

GEARS (1:1 Scale)

REV-41-1331
15 Tooth Gear

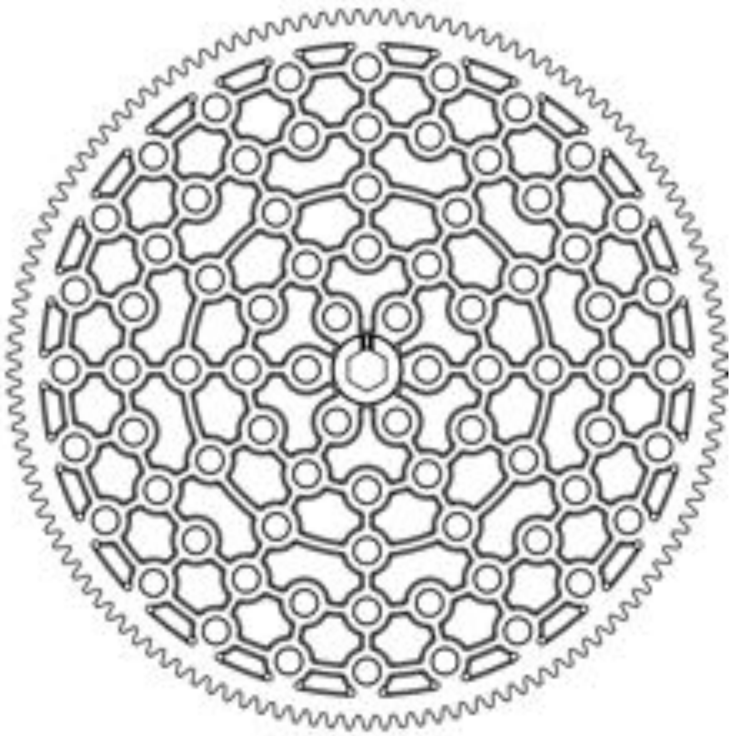
REV-41-1332
30 Tooth Gear

REV-41-1334
45 Tooth Gear



REV-41-1335
60 Tooth Gear

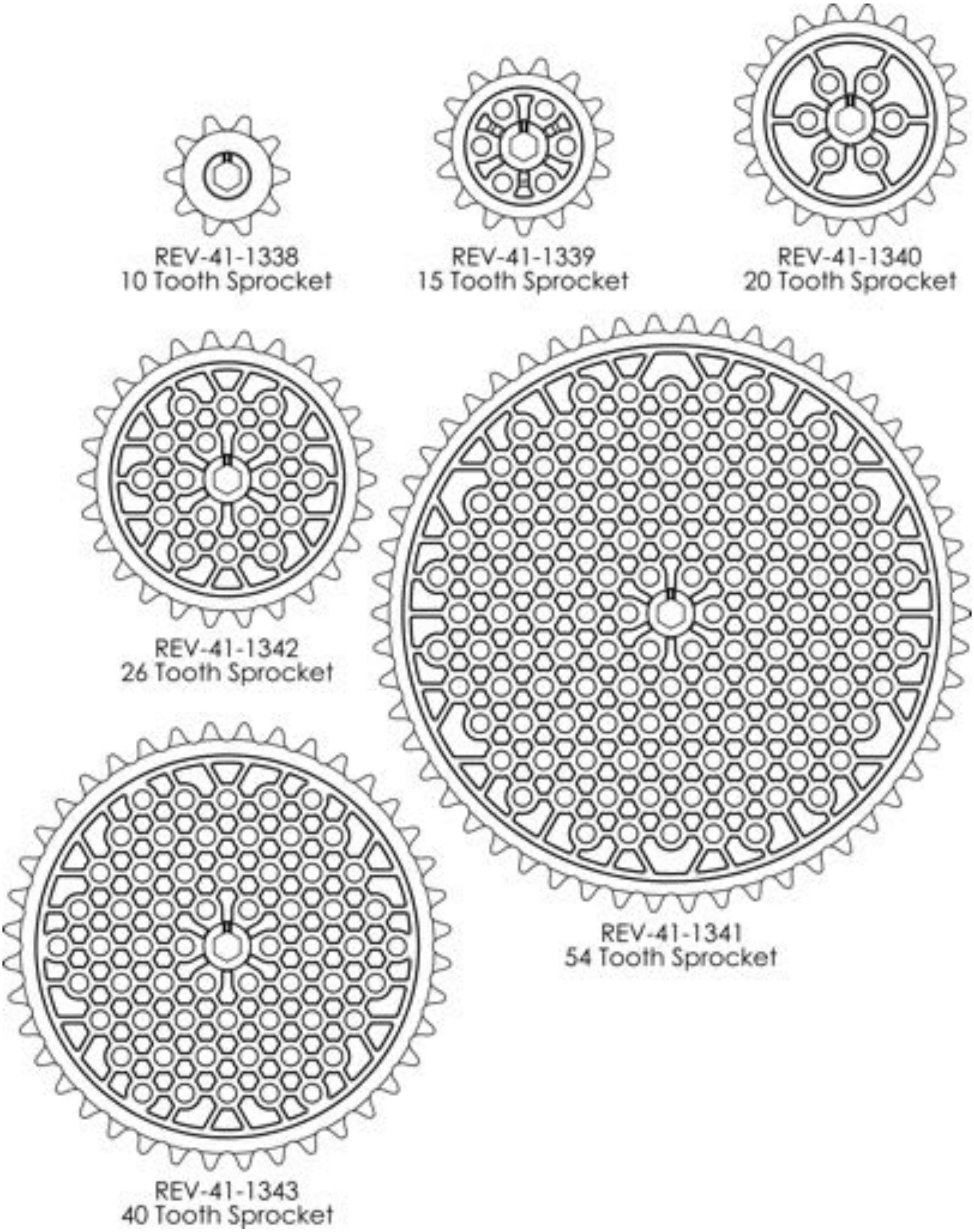
REV-41-1336
72 Tooth Gear



REV-41-1333
125 Tooth Gear

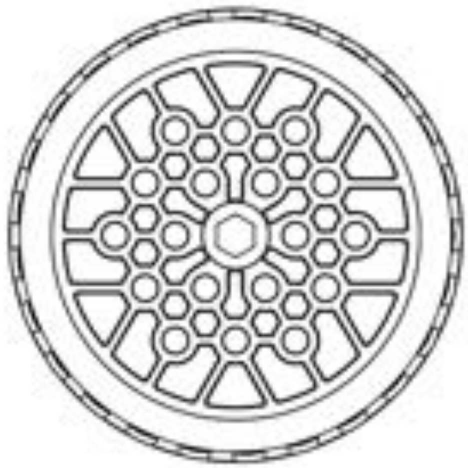
REV-41-1337
90 Tooth Gear

SPROCKETS (1:1 Scale)

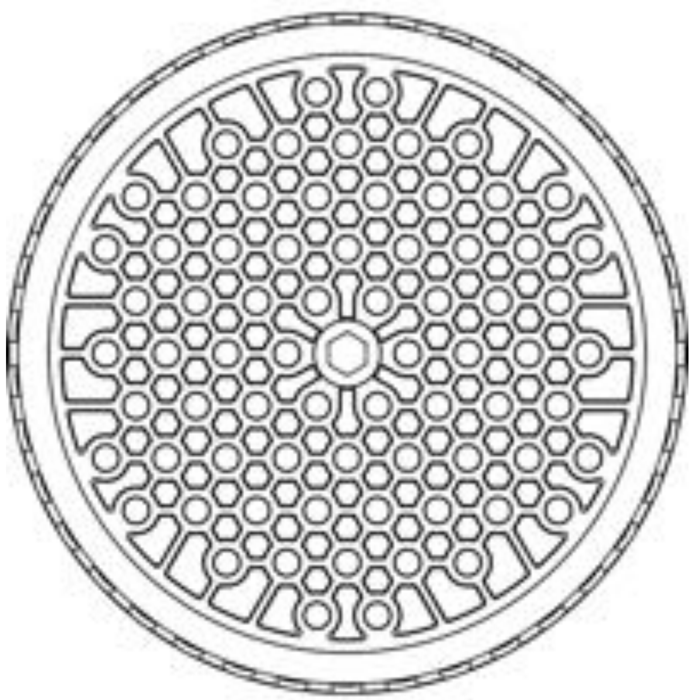


TRACTION WHEELS (1:1 Scale)

REV-41-1353
30mm Traction Wheel

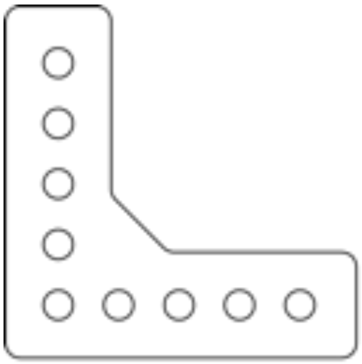


REV-41-1350
60mm Traction Wheel

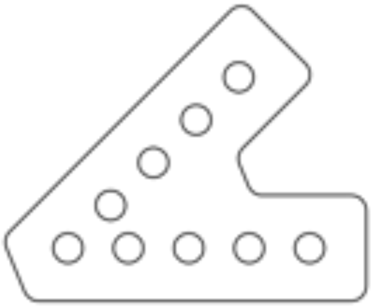


REV-41-1354
90mm Traction Wheel

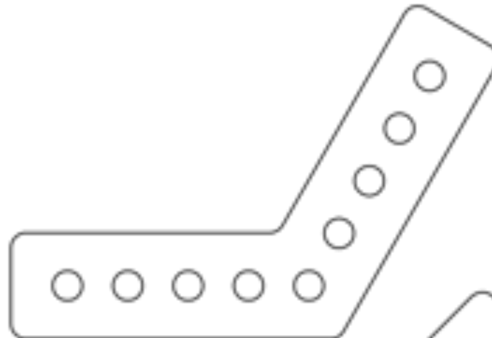
BRACKETS (1:1 Scale)



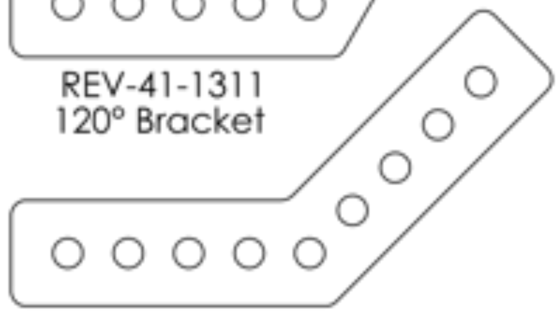
REV-41-1305
90° Bracket



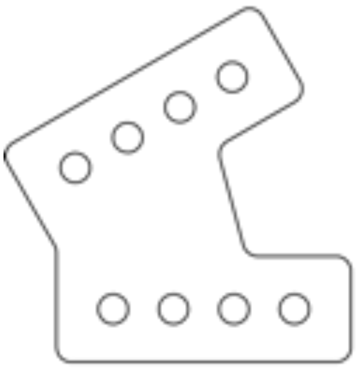
REV-41-1307
45° Bracket



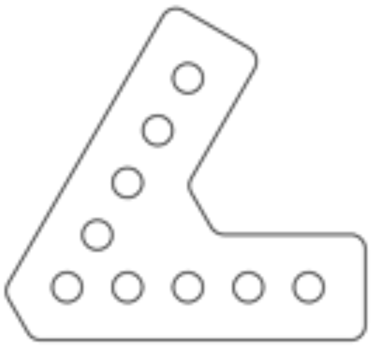
REV-41-1311
120° Bracket



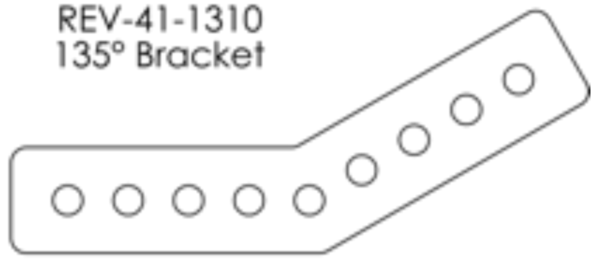
REV-41-1310
135° Bracket



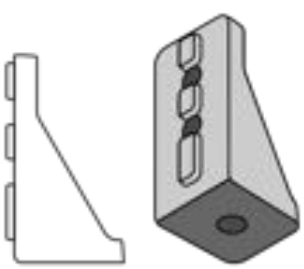
REV-41-1308
30° Bracket



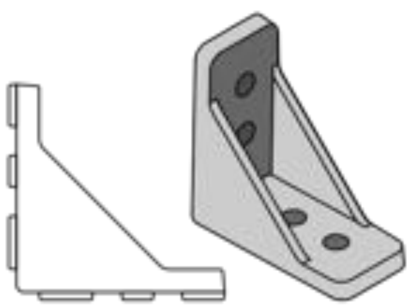
REV-41-1306
60° Bracket



REV-41-1312
150° Bracket

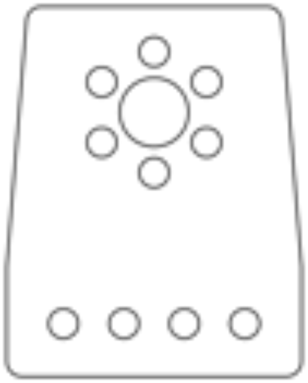


REV-41-1321
Lap Corner Bracket

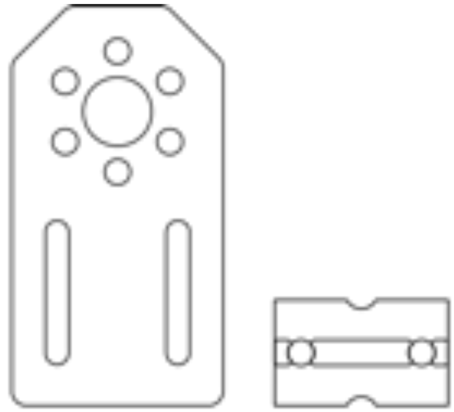


REV-41-1320
Inside Corner Bracket

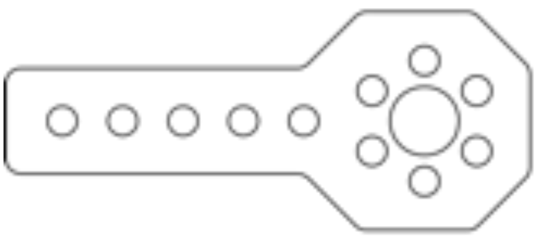
REV-41-1318
Variable Angle Bracket



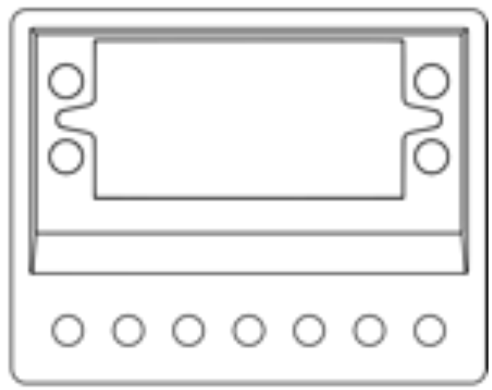
REV-41-1303
Motion Bracket



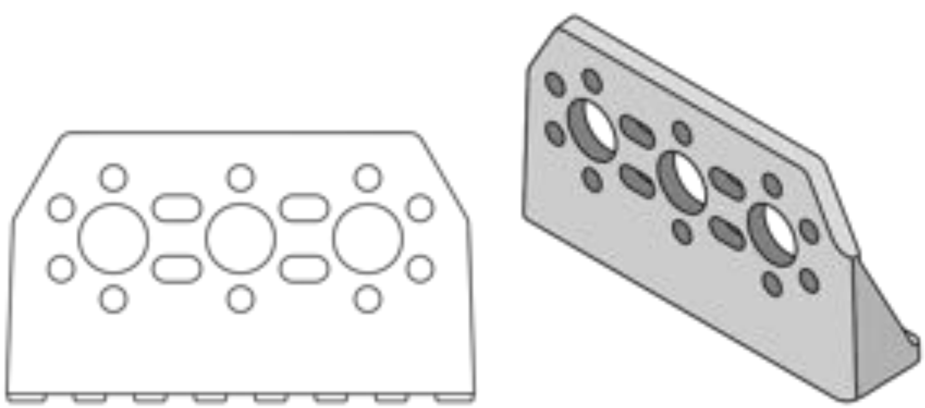
REV-41-1313
Indexable Motion Bracket



REV-41-1304
Rod End Motion Bracket



REV-41-1319
Servo Bracket



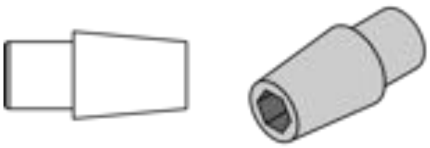
REV-41-1315
Gearbox Motion Bracket

PILLOW BLOCKS (1:1 Scale)

REV-41-1317
Bearing Pillow Bracket

REV-41-1316
Hex Pillow Bracket

BEARINGS (1:1 Scale)



REV-41-1322
End Cap Bearing

REV-41-1326
Short Through-bore Bearing

REV-41-1329
Long Through-bore Bearing

SPACERS (1:1 Scale)

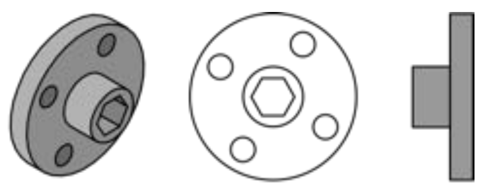
REV-41-1123
15mm Spacer

REV-41-1124
3mm Spacer

REV-41-1125
1.5mm Spacer

Adapters and Collars (1:1 Scale)

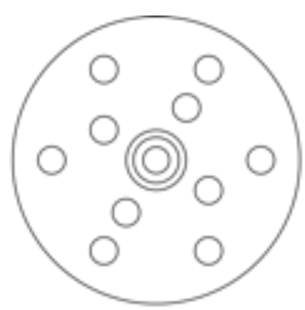
REV-41-1330
Shaft Collar



REV-41-1146
Hex Hub Adapter

REV-41-1364
Servo Gear Adapter

REV-41-1328
Servo Shaft Adapter



REV-41-1363
Aluminum Servo Horn

