

# TETRIX™

BY PITSCO



# **TETRIX™ by Pitsco**

## **Creator's Guide**

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### **On the Cover**

Roaming over a simulation of frozen tundra with the aurora borealis lighting the sky, the robot on the cover is built from one TETRIX Base Set, a DC motor controller, and an R/C unit. This robot features a double-decker design so that some of the electronics and batteries are not exposed.

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## Materials Included

For pictures of the TETRIX™ parts, see the top card in the TETRIX Base Set bin lid. **Note:** Additional pieces of all the parts below can be purchased separately at [www.shop.pitsco.com](http://www.shop.pitsco.com).

- 2 single-servo motor brackets
- 8 flat brackets
- 12 L brackets
- 2 servo joint pivot brackets with included hardware
- 1 dual-servo motor bracket
- 4 – 32 mm channels
- 2 – 96 mm channels
- 2 – 160 mm channels
- 4 – 288 mm channels
- 2 – 288 mm flat bars
- 2 – 144 mm angles
- 2 – 288 mm angles
- 2 – 64 x 192 mm flat building plates
- 2 – 80 mm tubes
- 2 – 145 mm tubes
- 2 – 220 mm tubes
- 6 tube reinforcers
- 6 tube clamps
- 6 set screw axle hubs\*
- 2 motor hubs\*
- 2 servos with horns
- 2 servo extensions
- 1 servo Y connector
- 2 DC drive motors
- 2 DC motor power cables
- 1 on/off switch
- 4 – 3" wheels
- 2 – 3" omniwheels
- 2 – 80-tooth gears
- 2 – 40-tooth gears
- 6 – 100 mm axles
- 2 motor mounts with included hardware
- 2 gear hub spacers with included hardware
- 12 bronze bushings
- 6 axle set collars
- 200 kep nuts
- 50 – 3/8" button head cap screws (BHCS)
- 100 – 1/2" socket head cap screws (SHCS)
- 100 – 5/16" socket head cap screws (SHCS)
- 12 – 1/8" axle spacers
- 6 – 3/8" axle spacers
- 12 – 1" stand-off posts
- 12 – 2" stand-off posts
- Hex key pack (7/64", 3/32", 1/16", and 5/64")
- 12 – 11" zip ties
- Blue storage bin with sorting tray

## Tools and Materials Not Included

**Note:** The TETRIX system enables you to create your own robot design, and you can build a robot with just the base set. However, additional parts and tools can be added. Many of the optional items below are available at [www.shop.pitsco.com](http://www.shop.pitsco.com) or [www.LEGOeducation.us](http://www.LEGOeducation.us).

### Required

- Remote control (R/C) or LEGO® NXT Intelligent Brick with Hard-Point Connectors and various Technic beams\*
- 8 AA batteries
- DC motor speed controller with 8-cell battery holder (34244)
- Extra small (#3) flathead screwdriver
- Small Phillips screwdriver

### Optional

- 416 mm channels (39069)
- 120-tooth gears (39085)
- Drill or drill press with bits for metal
- Hacksaw or band saw with metal-cutting blade
- Tubing cutters (34724)
- Multi nut pliers (39130)
- Hook-and-loop fastener (such as Velcro) (51974)
- Rubber bands
- Synthetic lubricant (20821)

### TETRIX Tip: Visit the Blog

To learn tips and new ways to use the TETRIX Robotic Design System, visit the TETRIX blog at <http://community.pitsco.com/blogs/tetrix/default.aspx>. At this online community, see posts from TETRIX robotics experts.

\*A robot can be operated with an R/C. Another option is the LEGO® NXT Intelligent Brick. The NXT is attached with Hard-Point Connectors and Technic beams, which are sold separately.

## Construction Tips

**Aligning to the holes** – The patented hole pattern on the TETRIX structural pieces enables you to attach pieces together at an angle, not just horizontally and vertically from each other. For example, you can attach a piece at 45° (Figure A).

**Tightening screws** – The TETRIX hole pattern is on all sides of the structural pieces – making it easy to tighten the screws with the hex key by simply putting the wrench through the other side as shown at right.

The screws in the TETRIX system are fastened with kep nuts, which feature a toothed side. This toothed side should face toward the screw so the teeth can grab onto the metal, which helps it hold better.

**Selecting screws** – There are two sizes of socket head cap screws (SHCS) in the base set: 1/2" and 5/16". As a rule, use the 1/2" screws for joining two structural elements together. Use the shorter 5/16" screws to attach tube clamps to structural pieces or when there isn't much clearance on the inside of parts.

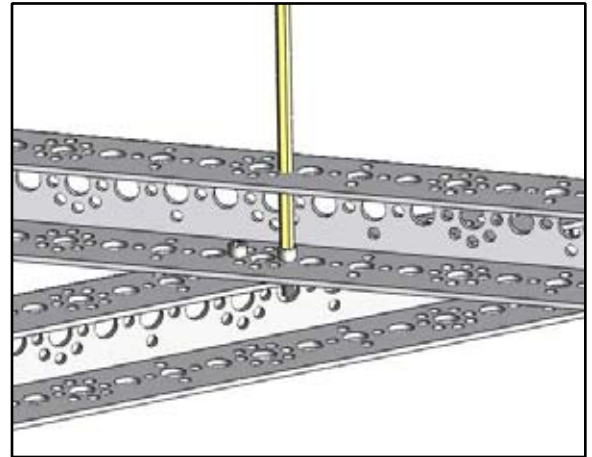


Figure A

The 3/8" button head cap screws (BHCS) are useful when the SHCSs might stick out too far from the body and rub against a moving part, such as a gear. Use BHCSs to attach servos to servo brackets.

**Tightening tube clamps** – For maximum clamping grip, tighten the clamp screws in stages. First, snug the set screw on the clamp – but not too tight. Then, attach the clamp to the structural element with four screws and tighten them partway. Finish tightening the set screw, and then finish tightening the four other screws. This will keep the clamp in the proper shape for attaching to structural elements while ensuring proper grip on axles and tubes.

**Tightening the set screw axle hubs** – When tightening these hubs, be sure to tighten the set screw – using the 3/32" hex key – against the flat side of the axle.

## Safety

- To avoid possible injury, keep your fingers clear of metal gears and other pinch points while they are moving (Figure B).
- Never pick up the robot when it is moving.
- Be sure power is off when the robot is not in operation.
- Do not operate the robot in wet environments.

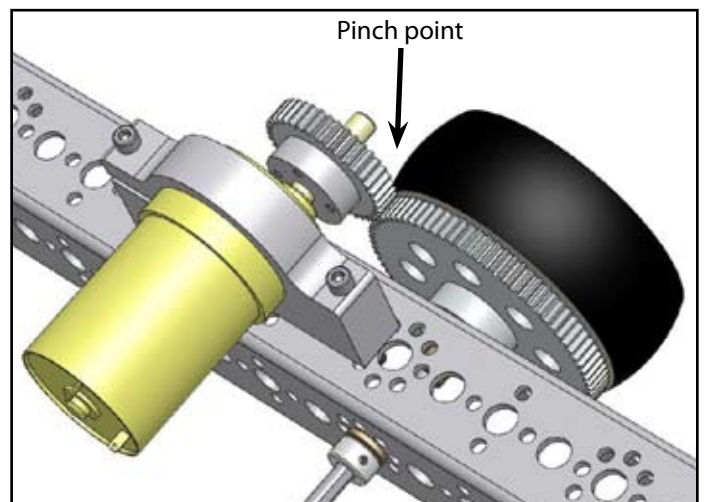


Figure B

# A – Building a Basic Chassis with Indirect Drive

The chassis constructed in this section is a basic rectangular chassis with four wheels and two drive motors. This provides basic construction information. You can use different channel pieces, have three wheels instead of four, or otherwise change this chassis to fit your design.

## Chassis

- 1) Set two 288 mm channel pieces side by side with the open end of the U-shape facing down. Set two more 288 mm channel pieces across the first two, but with the open end of the U facing in toward each other (Figure A1).
- 2) Align the holes of the top channels to the holes of the bottom channels where you'd like them to be (in the model pictured, the top channels are fastened at the four large holes from each end to create a bumper). At each corner, drop two SHCSs down through the two small holes on either side of the large hole (Figure A2).
- 3) Thread the kep nuts on the end of the screws. Using the 7/64" hex wrench, tighten the screws.
- 4) Repeat Steps 2-3 for the other three corners.

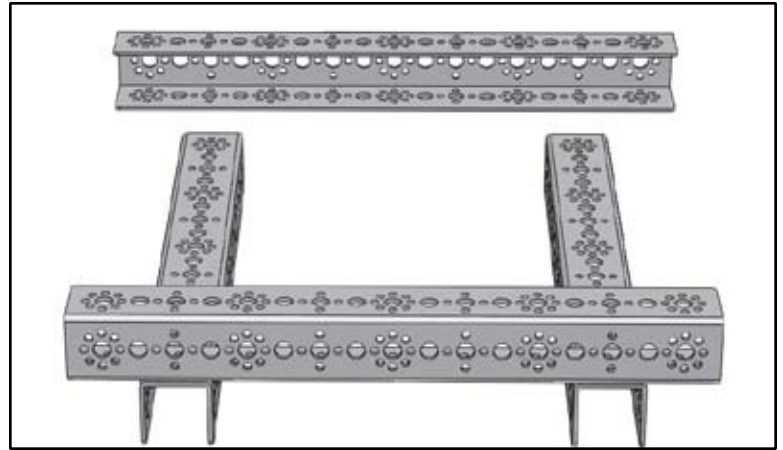


Figure A1

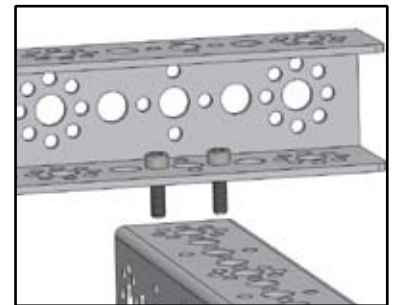


Figure A2

## Motor Mounts and Drive Wheels

In this model, the motors are not directly driving the wheels but instead are turning gears that will connect with gears on the wheels. A direct-drive setup is covered on page 8.

- 1) Set one motor mount along the top of one bottom piece of channel. Determine where you want the motor to rest – be sure to allow space for the wheel and the gears. Note that the motor mount holes align with the smaller holes on the channel and that you can use any two parallel holes in the circle (Figures A3 and A4).
- 2) Using the 1-1/2" screws that come with the mount, bolt down the unclamping end. Bolt the other side, but do not tighten it all the way (Figure A5).
- 3) Place a gear hub spacer on the center hole of a wheel and line up their holes. Thread a 1-1/4" screw that comes with the hub through a small hole on the other side of the wheel (Figure A6).

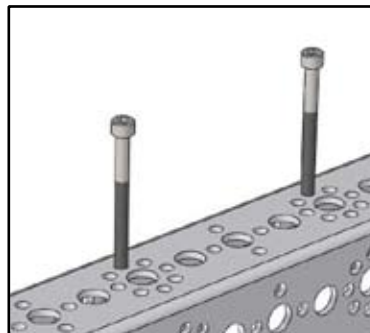


Figure A3

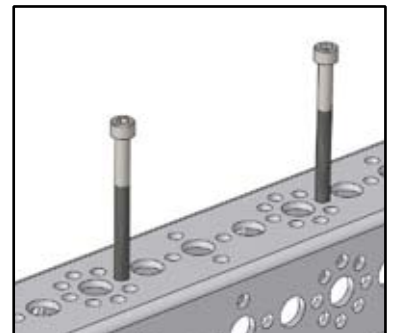


Figure A4

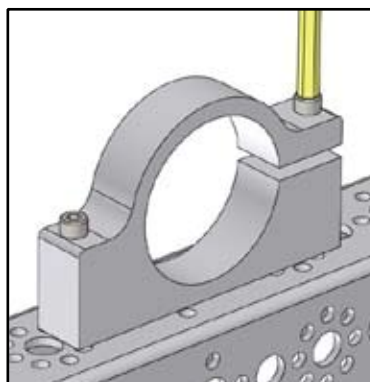


Figure A5



Figure A6

4) Drop an 80-tooth gear over the screw end, followed by a set screw axle hub (Figure A7). Thread the screw through all four parts. Repeat this with the other three screws.

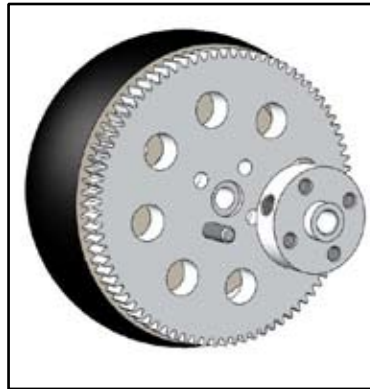


Figure A7

5) Slide an axle about 1/4" in the hub and hold it while tightening the screw using the 3/32" hex key (Figure A8). Be sure to tighten it against the flat side of the axle. Do not overtighten.

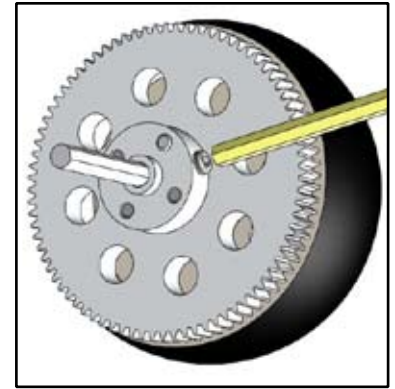


Figure A8

6) Insert the bushings in the hole where you want to place the axle – there will be one on each side (Figure A9). Push the end of the axle into the axle hole.

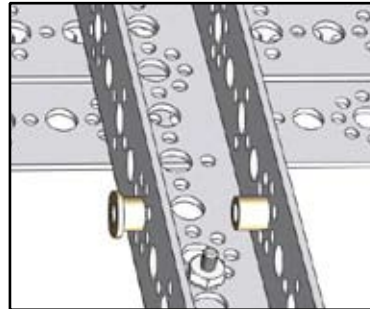


Figure A9

7) To lock the axle in place, put an axle set collar over the end and push it against the bushing (Figure A10). Turn the collar until the screw is facing the flat side of the axle. Use the 1/16" hex wrench to secure it to the axle.

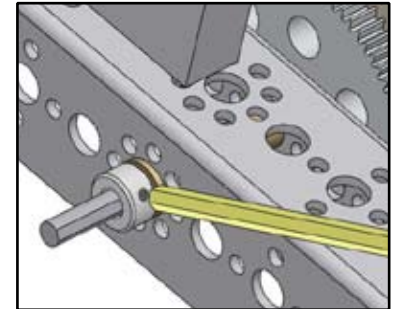


Figure A10

8) Repeat Steps 1-7 for the other side of the chassis.

## Motors and Gears

1) Attach a 40-tooth gear to a motor hub using four 1/2" SHCSs (Figure A11). If you think the screw heads might rub against other parts, you can use BHCSs instead.

2) Take a DC motor and place it through the back of the motor mount so the motor shaft points toward the wheel.

3) Take the gear assembly and slide it on the motor shaft with the gear facing out. Adjust the motor until its gearbox is centered in the motor mount. Slide the gear assembly on the motor shaft until the 40-tooth gear is aligned with the 80-tooth gear (Figure A12). Tighten the hub screw with a 3/32" hex wrench.

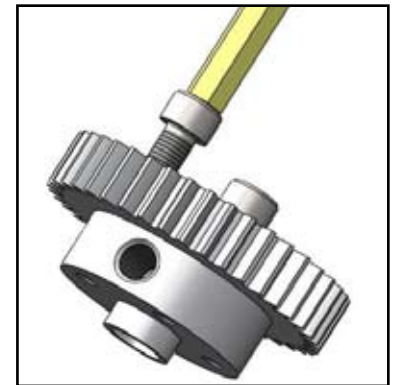


Figure A11

4) Turn the motor until the 40-tooth gear meshes with the 80-tooth gear (Figure A12). Tighten the clamping end of the motor mount with the 7/64" hex wrench.

5) Repeat Steps 1-4 for the other side of the chassis.

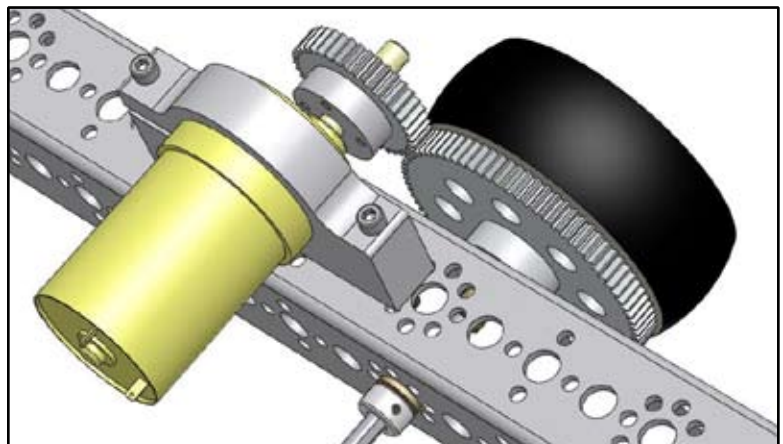


Figure A12

## Back Wheels

- 1) Slide an axle into a set screw axle hub until it is flush with the flat side of the hub. Tighten the set screw using the 3/32" hex key (Figure A13). Place the set screw axle hub on the wheel and align the holes so the set screw faces the flat side of the axle. Use 1/2" SHCSs to fasten the wheel to the set screw axle hub.



Figure A13

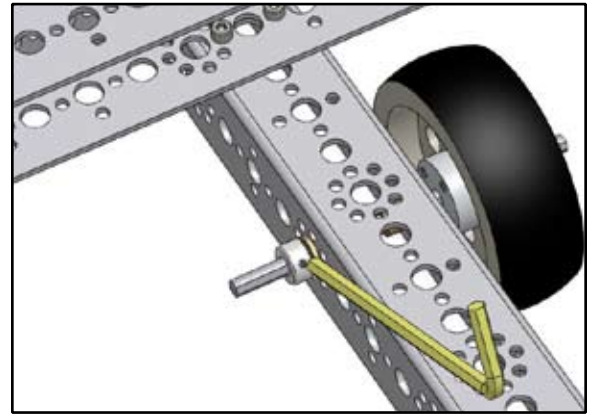


Figure A14

- 2) Insert two bronze bushings in the hole where you want to place the axle – there will be one on each side. Push the end of the axle into the axle hole. Lock the axle in place by placing an axle set collar over the end and pushing it against the bushing (Figure A14). Turn the collar until the screw is facing the flat side of the axle. Use the 1/16" hex wrench to secure it to the axle.
- 3) Repeat Steps 1-2 for the other side.

## Direct Drive Alternative

With direct drive, small wheels need to be mounted under the chassis. Be sure to plan for this when constructing the chassis so the channel pieces are oriented with the open part or one of the two sides facing up (the model shown uses L brackets to construct such a chassis).

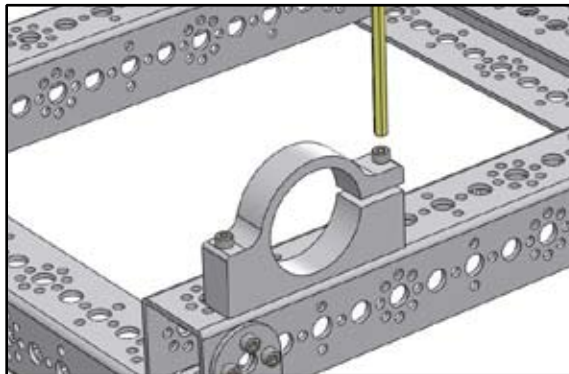


Figure A15

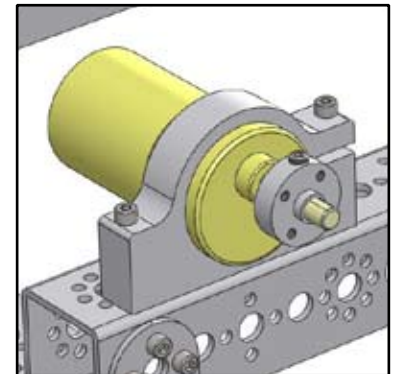


Figure A16

- 1) Set a motor mount on one bottom piece of channel. Determine where you want the motor to rest (Figure A15). Note that the motor mount holes align with the smaller holes on the channel.
- 2) Using the 1-1/2" screws that come with the mount, bolt down the unclamping end. Bolt the other side, but do not tighten it all the way.

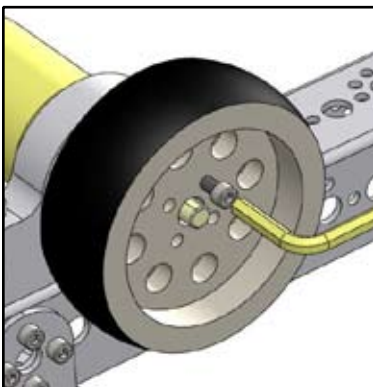


Figure A17

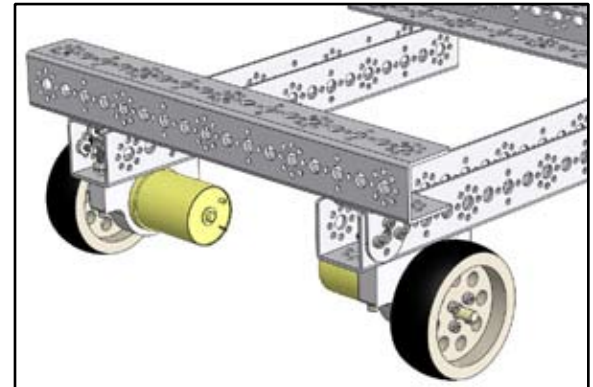


Figure A18

- 3) Slide a motor hub over a DC motor shaft; tighten the hub's screw. Slide the motor into the motor mount with the shaft and hub facing out. Adjust the motor until the gearbox is centered in the motor mount and the motor shaft is at the bottom of the mount (Figure A16). Tighten the clamping end of the motor mount.
- 4) Attach the wheel to the hub with four 1/2" SHCSs (Figure A17). Flip over the chassis (Figure A18).
- 5) Repeat Steps 1-4 for the other side.

## B – Servos and Pivots

Servos can be used in many different ways – one is to create robot parts that pivot. This section covers how to mount a basic servo and several ways to create a pivot. However, you should explore other ways to create a pivot as needed for your design.

**Note:** All the servos come with a plastic servo horn on them. Remove these plastic horns and replace them with the metal servo horns that come with the kit. The plastic horns can be disposed of or used with robotics and electronics other than TETRIX.

### TETRIX Tip: Servos

When determining the placement of servos for pivots, always check the servo's range of motion. The TETRIX servos can pivot 180°.

### Single-Servo Mount

- 1) Determine where on the chassis you want to place the servo. Using 1/2" SHCSs and kep nuts, attach the single-servo motor bracket to the chassis – note that the side with one long piece standing up is where the back of the servo faces (Figure B1).
- 2) Slide the servo into the bracket. The flanged sides on the front of the servo should go on the outside of the two prongs of the bracket (Figure B2). Using 3/8" BHCSs and kep nuts, attach the servo to the mount.
- 3) At this point, it is possible to attach other pieces – such as channels, angles, and flat bars – directly to the servo horn (Figure B3). However, using a pivot bracket will make a stronger pivot (see section below).

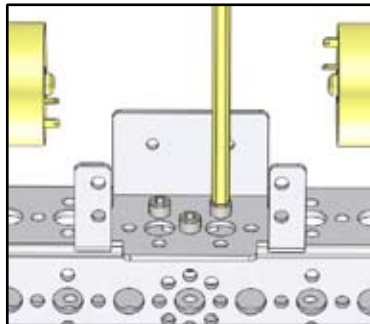


Figure B1

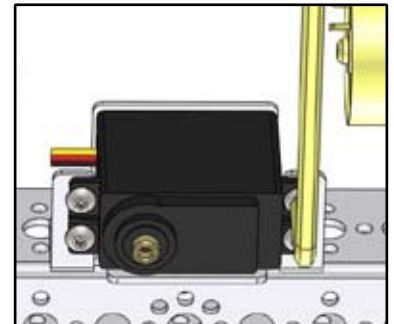


Figure B2

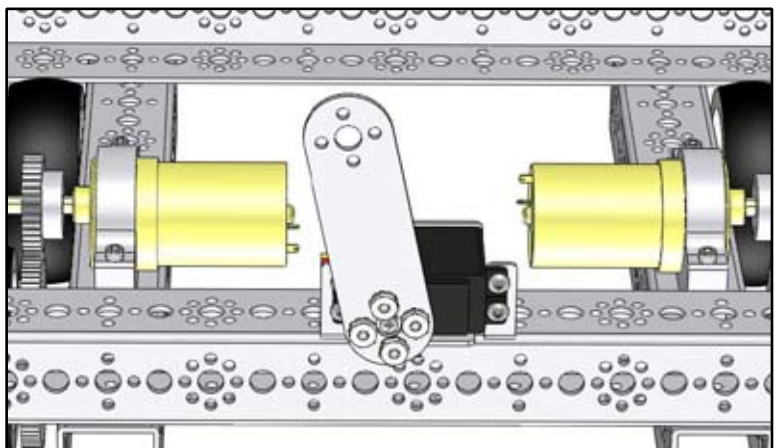


Figure B3

### Single Servo with Pivot Attachment

- 1) Remove the servo horn. Place the horn's flat side to the inside of one end of a joint pivot bracket. Using four 5/16" SHCSs, attach the horn to the pivot bracket and secure it with kep nuts (Figure B4). The kep nuts should be on the outside of the bracket. Set aside the servo horn screw.

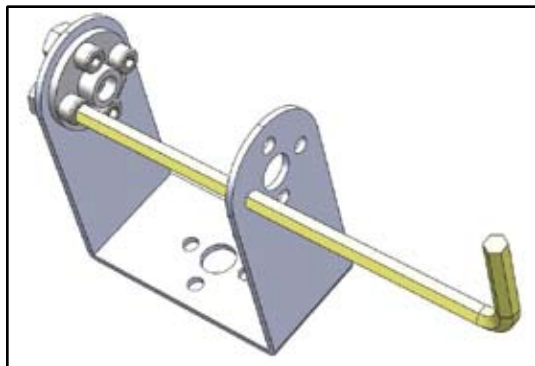
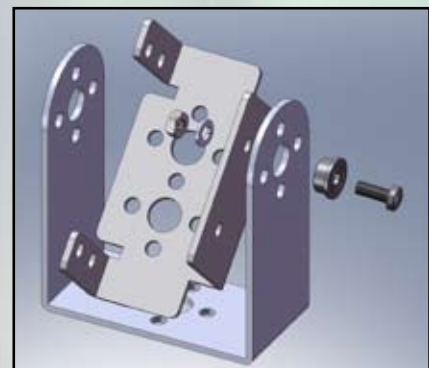


Figure B4

### TETRIX Tip: Pivot Bearing

This diagram illustrates how to put a pivot bearing into a pivot and servo bracket.



- 2) Find the pivot bearing, screw, nut, and washer that comes with the pivot bracket. Place the bearing flange-side down on a flat surface. Place the side of the pivot bracket opposite the horn over the bearing and align the bracket hole to it (Figure B5a). Press down firmly to pop the bearing into the bracket hole (Figure B5b).

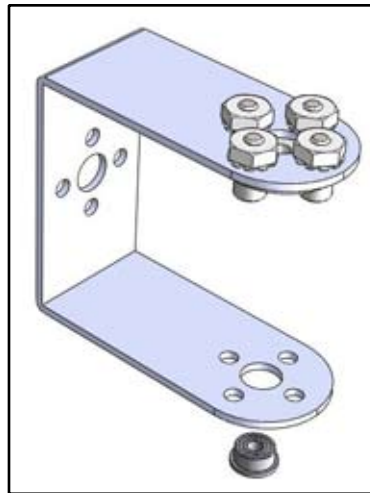


Figure B5a

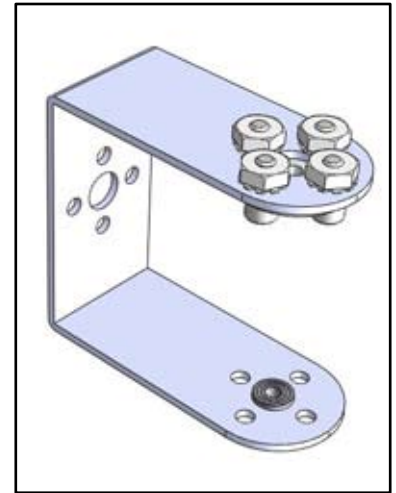


Figure B5b

- 3) Place the bearing screw through the bearing from the outside of the pivot bracket. Insert the screw into the back of the motor bracket (Figure B6). Secure the pieces together with the washer and nut – but do not overtighten.

- 4) Place the servo into the motor bracket, stretching the unattached side of the pivot bracket so the horn fits into the servo's motor shaft. Secure the servo to the motor bracket with 3/8" BHCSs (Figure B7).

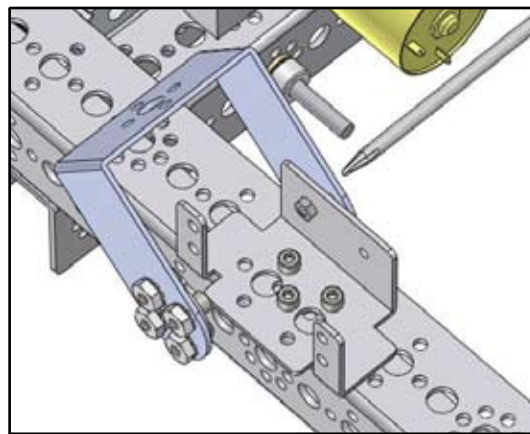


Figure B6

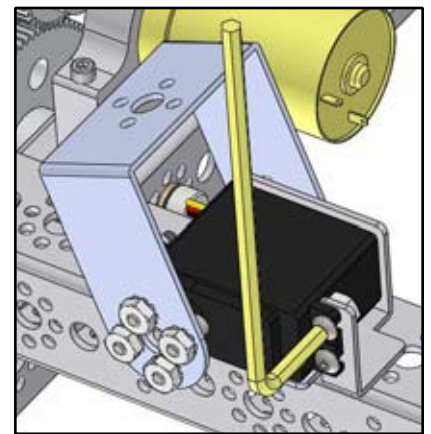


Figure B7

- 5) Adjust the servo's range of motion as needed (see TETRIX Tip on this page). Thread the servo horn screw through the pivot bracket and horn and secure to the servo.

## Double-Servo Mount and Pivot

- 1) Determine where on the chassis you want to place the servos. Using 1/2" SHCSs and kep nuts, attach the double-servo motor bracket to the chassis (Figure B8).

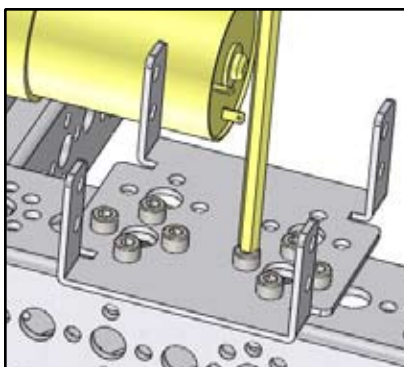


Figure B8

- 2) Remove servo horns from two servos. Attach these to a joint pivot bracket – each with two 5/16" SHCSs and kep nuts – so one is on the inside of the bracket and the other is on the outside and opposite end (Figure B9).

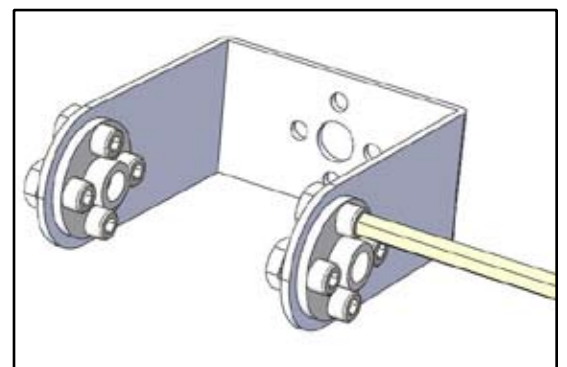


Figure B9

### TETRIX Tip: Range of Motion

To adjust a servo's range of motion, you must first find its mechanical stop. Push the bracket or structural element attached to the servo until it won't go any further – this is the mechanical stop. Without moving the servo motor shaft, detach the bracket or element and position it where you want it to stop. Reattach it to the servo, taking care not to move the servo motor shaft. Secure the bracket or element to the servo with the servo horn screw.

- Place one servo into the double-servo motor bracket so it faces into the bracket (Figure B10). Secure the servo in the bracket with four 3/8" BHCSs and kep nuts.

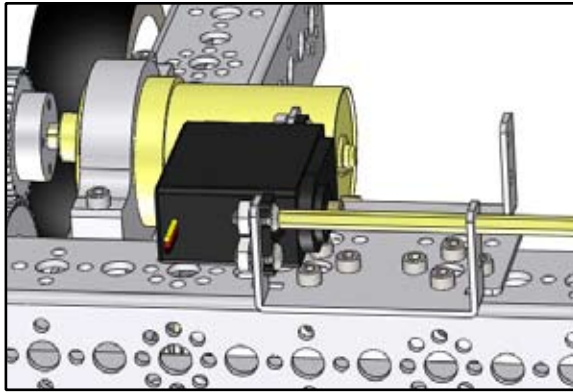


Figure B10

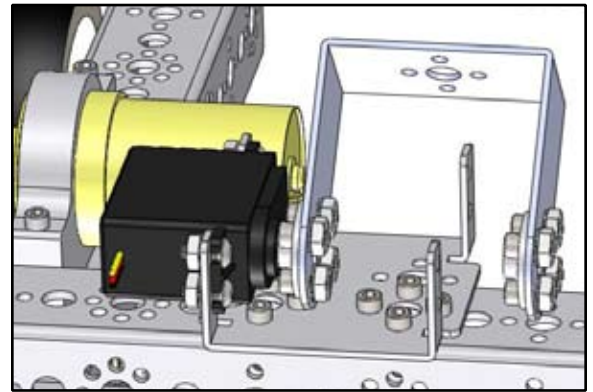


Figure B11

- Place the pivot bracket so the horn on the outside of the pivot bracket connects with the servo on the motor bracket (Figure B11). Secure the servo horn to the servo with the servo horn screw.

- This is a good time to set the servos' range of motion and to center them together. Attach the two servos to the Y connector, and then attach the connector to the remote control. Power up the remote control and the servos' shafts will be centered to the same position. **Note:** This step is very important when servos are linked together mechanically – it ensures that they do not work against each other.

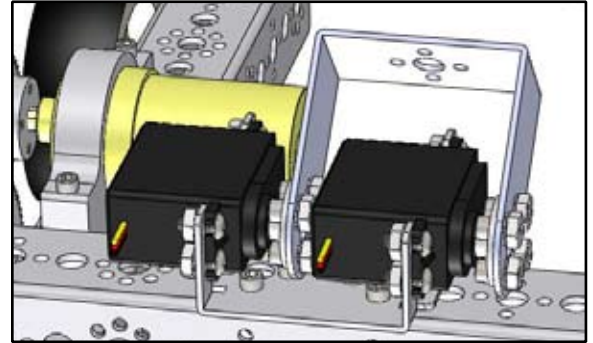


Figure B12

- Place the second servo so it faces out of the motor bracket and is parallel to the other servo (Figure B12). Use four 3/8" BHCSs and kep nuts to secure the second servo to the bracket.
- Using the other servo horn screw, secure the second servo to the other side of the bracket.

### TETRIX Tip: Y connector

The Y connector can be used whenever you need two servos to work in tandem.

## Pivot with Structural Elements

Strong pivots can be achieved using structural elements such as channels and axles. This section shows one way to make such a pivot.

- Determine where you need to place the pivot. This will be the center of this pivot configuration. Count over three large holes to one side of the center. With two 5/16" SHCSs, attach two stand-off posts on top of the chassis so they are parallel to each other (Figure B13). Whether you use 1" or 2" stand-off posts depends on how tall you want the pivot to be.
- Now, count three large holes to the other side of the center. Attach two more stand-off posts of the same height as those in Step 1. They should be in holes parallel to the first pair of posts.

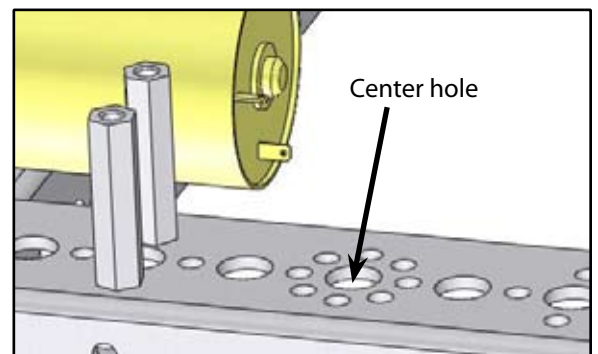


Figure B13

- 3) Mount a single-servo motor bracket on top of one set of stand-off posts with two SHCSs – make sure the bracket is attached so the servo faces the center. Remove the horn from the servo. Place the servo into the bracket so the servo shaft is centered with the channel piece on which the bracket is mounted. Secure the servo with four SHCSs and kep nuts (Figure B14).

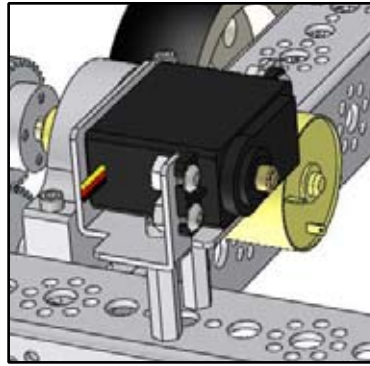


Figure B14

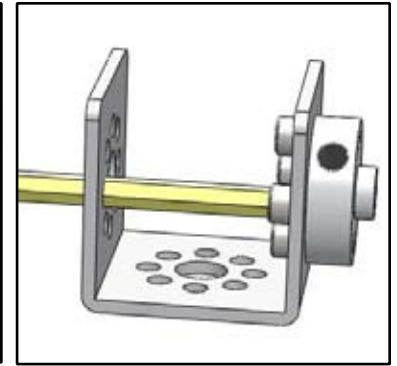


Figure B15a

- 4) Using 1/2" SHCSs, attach a set screw axle hub to the outside of a 32 mm channel piece (Figure B15a), but do not tighten them all the way. Insert an axle into the hub so it is flush with the outside of the hub. Turn the axle so the set screw faces the axle's flat side and tighten the set screw.

**Note:** Take care not to push down on this piece as it is connected to the servo.

- 5) Attach any structural element – such as a tube – to the top of the 32 mm channel piece at this time. On the side opposite the set screw axle hub, attach the servo horn to the outside of the 32 mm channel piece with four 3/8" BHCSs and kep nuts (Figure B15b). Attach the side with the horn to the servo on the bracket and secure with the servo screw (Figure B16).

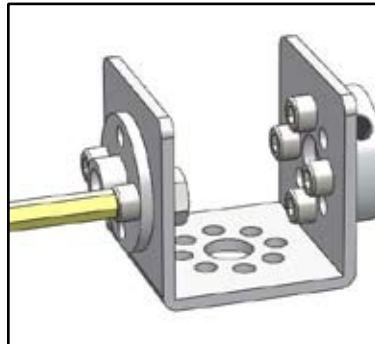


Figure B15b

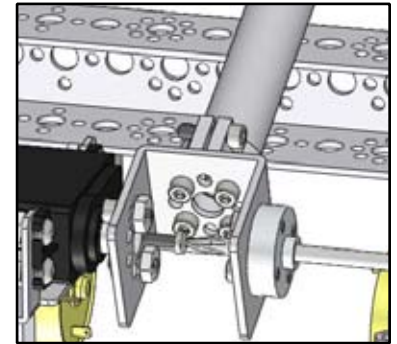


Figure B16

- 6) Find the second piece of channel you want to use. Another 32 mm piece is good if you don't want it to extend over either side of the chassis channel (Figure B17). Alternatively, a longer piece can be used to reach the other side of the chassis and be another part of the construction (Figure B18).

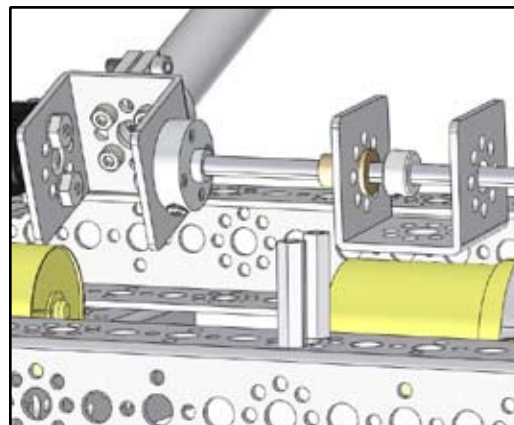


Figure B17

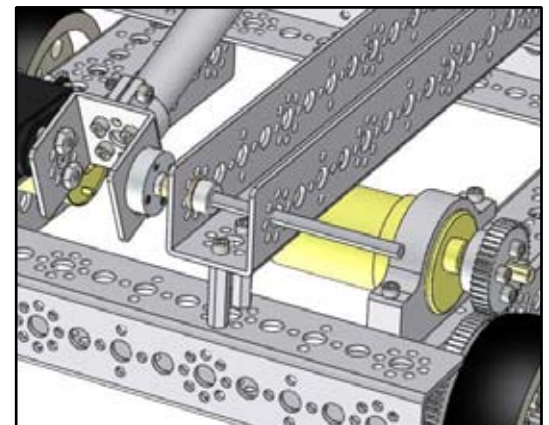


Figure B18

- 7) After finding the piece you want, place a bronze bushing into a large hole where you intend to place the axle.
- 8) Push this side onto the axle. Before pushing it out the other side, place an axle set collar on the axle. Then, push the piece until the channel piece holes line up with the two stand-off posts beneath it. Use two 5/16" SHCSs to attach the channel to the posts. Push the set collar against the bushing and tighten the screw (Figure B19).

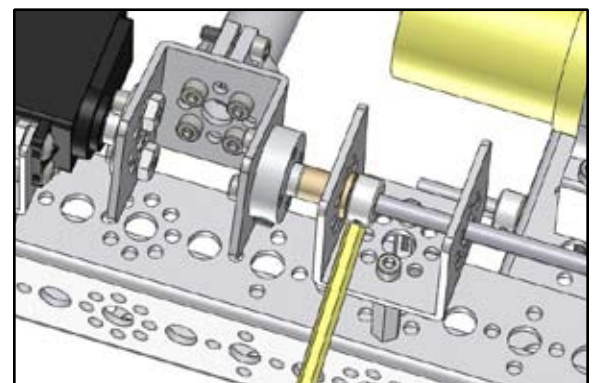


Figure B19

# C – Tubes

Tubes can be used many ways. They make a strong and lightweight lever arm. Tubes can be part of the structural body of the robot; for example, connecting two sides of a chassis. Or, they can be used as an extension. You can attach them directly to a servo horn or a gear to tube ends.

When more strength is needed for a tube and you must tighten the tube clamp really tight, the tube can become bent. To avoid this, insert a tube reinforcer into the end of the tube being clamped and then tighten the clamp. The reinforcer will prevent the tube from being bent.

Try attaching a sensor or a gripper or another end effector on the end of a tube – run any wires inside the tube to hide them and keep your robot design looking clean.

## Attaching Tubes

- 1) Insert a tube into a tube clamp (Figure C1). Insert a 5/16" SHCS on the unthreaded side of the clamp. Be sure not to overtighten this or you might bend the tube end.
- 2) To attach a tube to a structural element such as a channel, align the element's holes with the clamp holes. Insert 5/16" SHCSs from the underside of the element and tighten (Figure C2).
- 3) To attach the tube to a servo, align the clamp holes with the servo horn holes and secure them with 5/16" SHCSs (Figures C3 and C4).
- 4) To attach the tube to a gear, attach a tube clamp to the other end of the tube and secure that end to the gear with screws (Figures C5 and C6).

### TETRIX Tip: Gears and Ratios

By attaching one end of a tube to a servo and the other to a gear, the gear will have the same rotation as the servo (servos in the base set come with 180° rotation). But you can mesh a different-size gear to the gear on the tube to create a different rotation. For example, attaching an 80-tooth gear to the tube and meshing it with a 40-tooth gear will provide a 2:1 ratio – and the 40-tooth gear will have a 360° rotation.



Figure C1

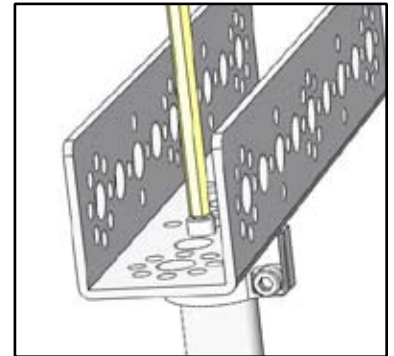


Figure C2



Figure C3



Figure C4



Figure C5

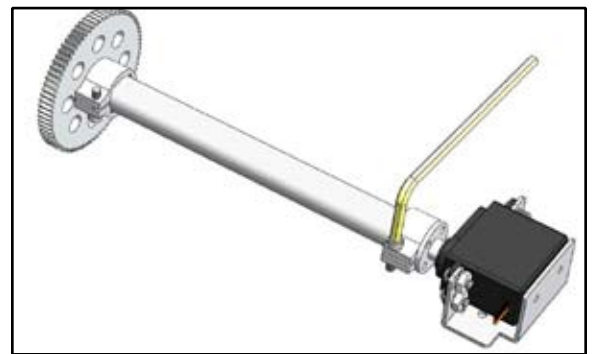


Figure C6

# D – Grippers

## One-Motor Gripper

- 1) Determine where you want your gripper to be placed. Also determine what kind of structural element you will use to make the arm of the gripper (the model shown uses a tube).

- 2) Align one side of a flat bracket to the back of a single-servo motor bracket. Hold those together and attach whatever structural element you are using – shown here is a tubing clamp. Connect these three together with four 1/2" SHCSs (Figure D1).

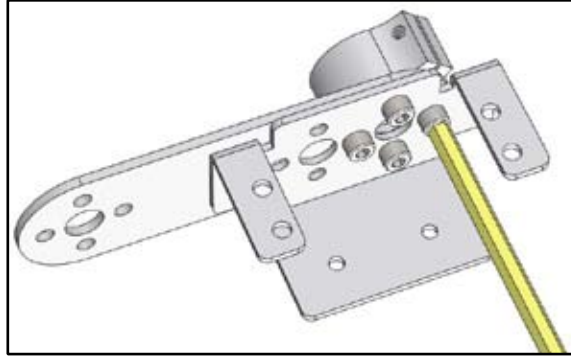


Figure D1

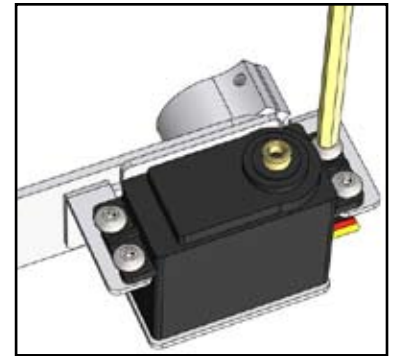


Figure D2

- 3) Making sure the servo shaft is in line with the structural element, place the servo in the motor bracket and secure it with four 3/8" BHCSs and kep nuts (Figure D2).

- 4) Using four screws and kep nuts, attach an L bracket to the other end of the flat bracket (Figure D3). One side of the L bracket should extend from the top of the flat bracket. Now, attach another flat bracket straight out from the top of the L bracket (Figure D4).

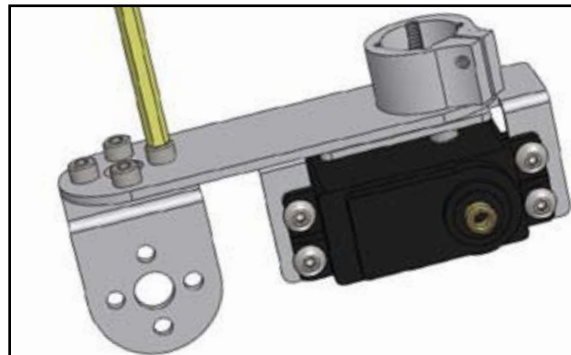


Figure D3

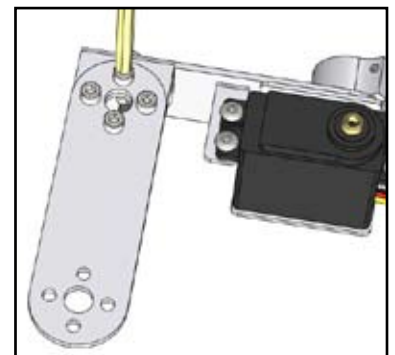


Figure D4

- 5) Take two more flat brackets and connect them with screws to make a 90° angle. Remove the servo's horn. Using four 5/16" SHCSs and kep nuts, attach the horn to one of the flat brackets so it will be the one on top after attaching it to the servo (Figure D5).

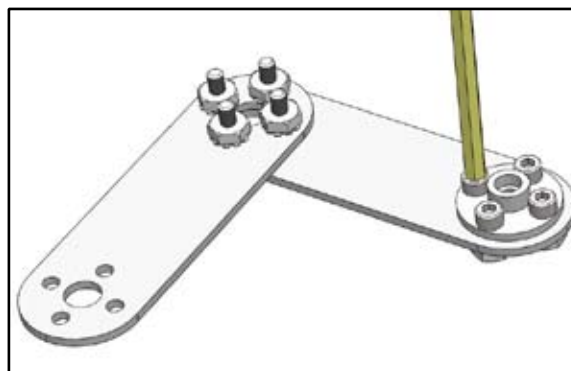


Figure D5

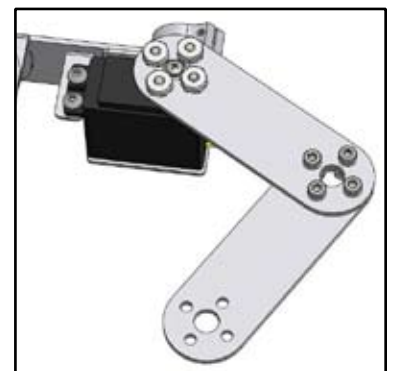


Figure D6

- 6) Check the servo's range and adjust it if necessary. Attach the horn to the servo with the servo horn screw (Figure D6).

## Two-Motor Gripper

This gripper was designed for two servos to be joined by a Y connector and to be run on the same channel. Because this makes the two servos move in the same direction (both left or right, rather than toward or away from each other), the pivot brackets that make up the gripper arms need to be offset and facing the opposite direction. Grippers with servos running on different channels can be designed differently.

1) Attach a servo horn – on the inside – to one side of a pivot bracket with four screws and kep nuts (Figure D7). Repeat this with a second servo horn and pivot bracket.

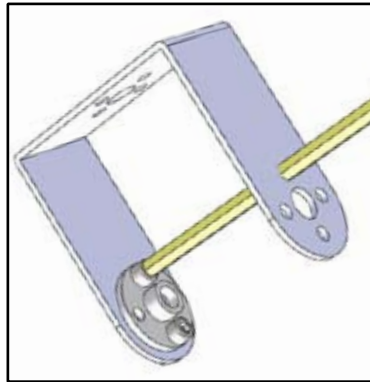


Figure D7

2) Place a pivot bearing flange-side down on a flat surface. Place the side of the pivot bracket opposite the horn over the bearing and align the bracket hole to it. Press down firmly to pop the bearing into the bracket hole. Set aside the pivot bearings' screws, nuts, and washers until Step 5.

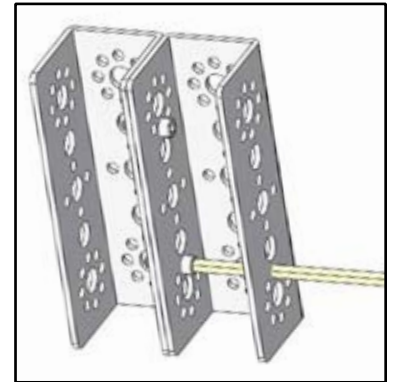


Figure D8

3) Connect two channel pieces (the model shown uses 96 mm channels, but different sizes can be used depending on how high you need the gripper to be) side by side with at least four SHCSs and kep nuts – two on each end (Figure D8).

4) To each side of the connected channel pieces, attach one single-servo motor bracket. The two should be directly across from each other, but one should be facing up and the other facing down.

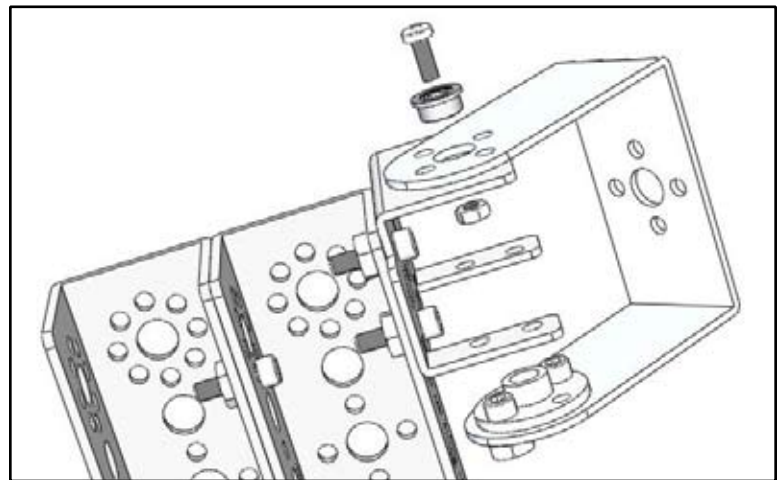


Figure D9

5) Thread the bearing screw through the bearing from the outside of the pivot bracket. Insert the screw into the back of one motor bracket (Figure D9). Secure the pieces together with the washer and nut and tighten the screw – but do not over-tighten. Repeat this with the other motor bracket, keeping in mind that the servos will face in opposite directions (Figure D10).

6) Connect the two servos with the Y connector. Attach the Y connector to the remote control system and power it up. This will synchronize the centering of the two servos. Leave the remote control powered up.

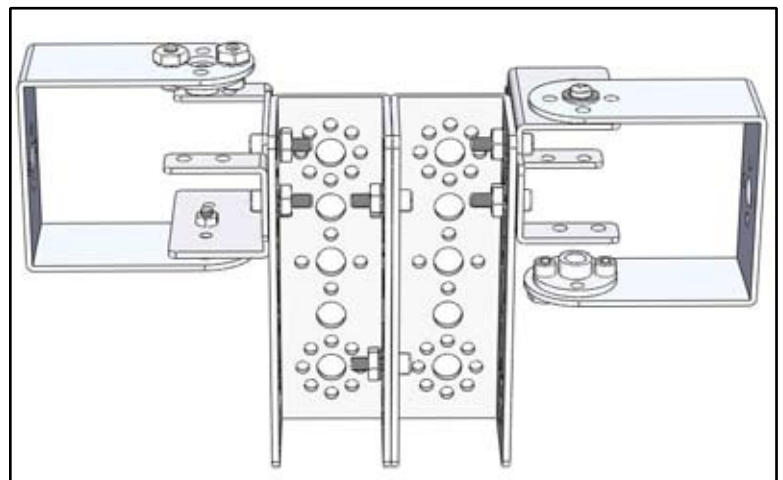


Figure D10

- 7) Place the servos into the brackets with the servo motor shafts facing toward the servo horn on the bracket. Secure each servo to the motor bracket with 3/8" BHCs. With the servos still connected to the powered R/C system, attach the pivot brackets to each servo where you want them – you will have to stretch the end with the horn over the servo (Figure D11). Power down the R/C and detach the Y connector from it. Secure the servo to the horn with the servo screw.

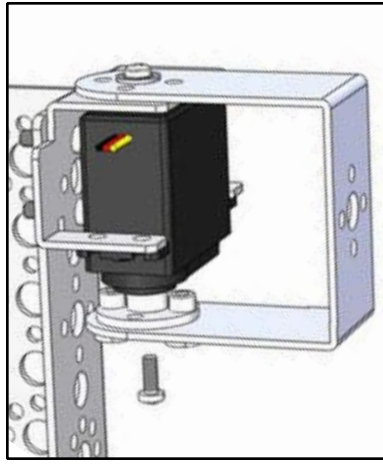


Figure D11

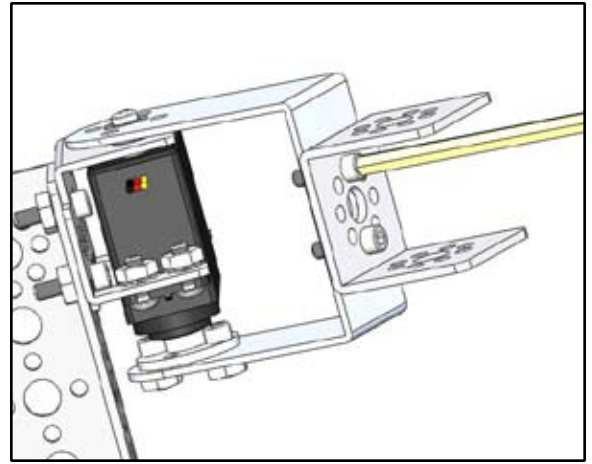


Figure D12

- 8) To the end of each pivot bracket, attach a 32 mm channel with the open side facing away from the bracket (Figure D12).
- 9) On the top of each side of one 32 mm channel piece, attach a flat bracket at a 45° angle toward the open side of the connected channel pieces (gripper arm) (Figure D13). Repeat this on the other 32 mm channel piece, but place the flat brackets on the underside of the 32 mm channel ends – this will compensate for the difference in height. Be sure to angle the flat brackets toward the other side of the gripper.

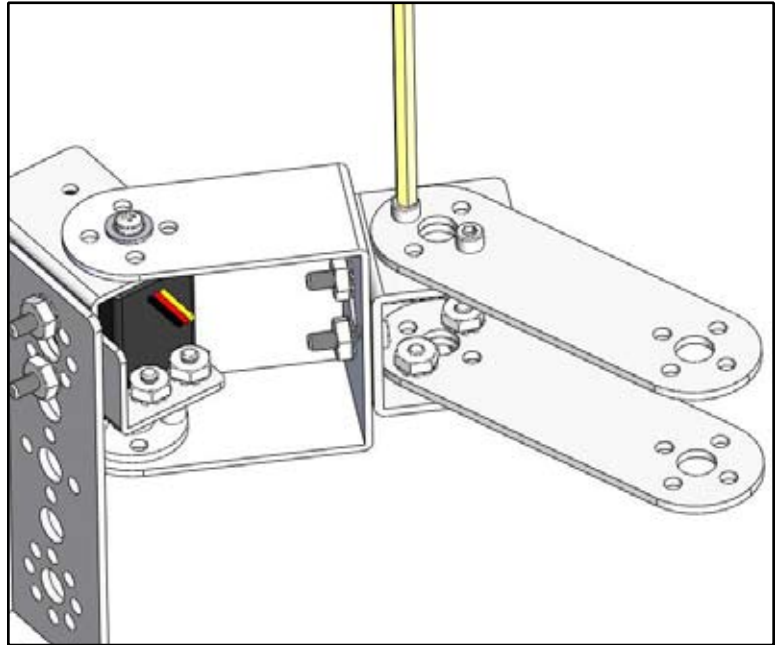


Figure D13

# E – Advanced Construction Techniques

The TETRIX Robotic Design System is intended to be used as it comes – the structural elements come in a variety of shapes and sizes to provide building flexibility. However, advanced robot builders can go a step further and customize the metal structural elements by cutting them to different lengths and angles and by drilling – or even bending.

**Caution:** Do not cut or drill any TETRIX parts without the consent of your teacher or project leader. If they intend to use the system for several classes or teams, they may not want parts altered.

## Cutting Metal Parts

All the aluminum structural pieces in the TETRIX Design System – such as channels, angles, or flat bars – can be cut using a hacksaw or band saw with a metal-cutting blade. If you do cut any metal pieces, you should smooth off any burrs with sandpaper or a file.

## Cutting Tubes

- 1) Using a marker or pen, make a line on the tube where you wish to cut it.
- 2) Adjust the wheel of a tubing cutter so the tube can fit into the cutter. With the tube fitted into the curved side, line up the mark on the tube to the small wheel blade in the cutter (Figure E1). Adjust the wheel so the cutter is snug – but not too tight – on the tube.
- 3) Twist the cutter around the tube several times. Tighten the wheel a little and twist the cutter several times. Continue to do this until the tube is cut in two pieces (Figure E2). This could take five to 10 times.
- 4) If needed, use sandpaper to smooth off any burrs where you cut the tube.

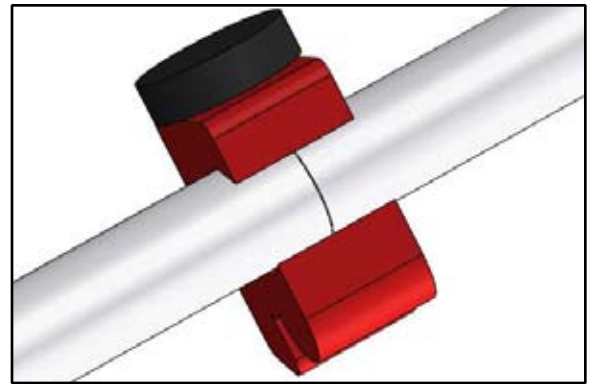


Figure E1

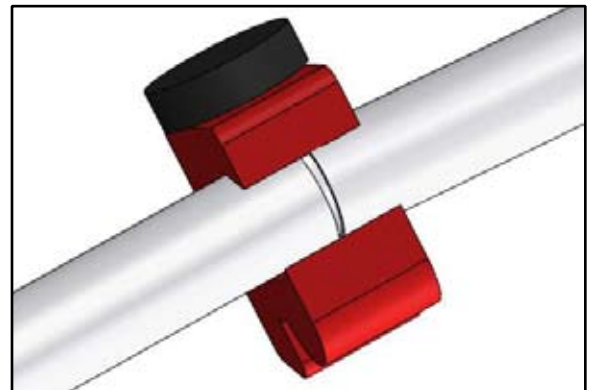


Figure E2

## Safety

If cutting or drilling metal parts, be sure to use proper safety gear – such as safety goggles and gloves – for the machinery you are using. Be sure to use any safety instructions or physical guards that come with the tools you are using.

## F – Using the R/C

Several R/C units will work with the TETRIX system. Shown in this section is the Futaba T6EX (Pitsco product 34243). The instructions below are general, and you should refer to your R/C's instructions for more information.

**Note:** The way you connect your robot and R/C unit will vary depending on the function and design of your robot. Below is a basic setup for a robot with two drive wheels and a two-motor gripper run on one Y connector.

- 1) If needed, add structural plates on which to place the electronics.
- 2) Determine where you want to place the electronics. The R/C receiver and its battery pack should be placed near each other; the DC motor controller should be close to the receiver as well.
- 3) Using the Velcro-like fasteners, zip ties, and screws that come with the electrical components, attach them to the robot body (Figure F1). The DC motor controller can be attached with screws, but you might have to use just two screws or angle the controller to align to the holes on the body. Items attached in the model include the receiver, receiver battery pack, on/off switch, DC motor controller, and the DC motor and controller battery pack (Figure F2).
- 4) Make sure the on/off switch is turned to the Off position. Insert the batteries into the battery holder.
- 5) Connect the two folded metal ends of the DC motor power cables to the posts of one DC motor (Figure F3). Repeat with the other cables and motor. Insert the free ends of the cables for one motor to the DC motor controller where it is labeled M1A and M1B (Figure F4). Tighten the screws down onto the cables. Insert the other motor's cable ends into the controller where it is labeled M2A and M2B and tighten the screws.
- 6) Insert the free end of the Y connector on the gripper servos to the receiver's Channel 3.

### TETRIX Tip: Wires

Wires from servos and other electrical components can get messy and tangled. To keep things cleaned up, you can secure wires out of the way with zip ties or rubber bands.

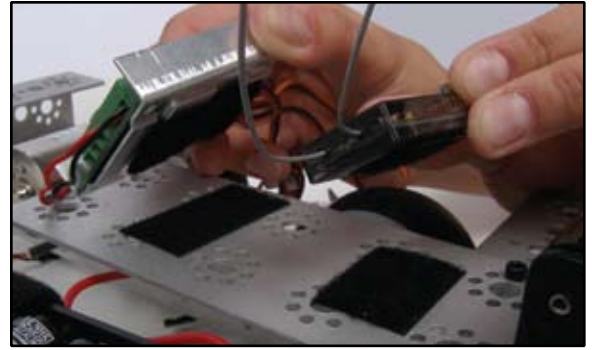


Figure F1

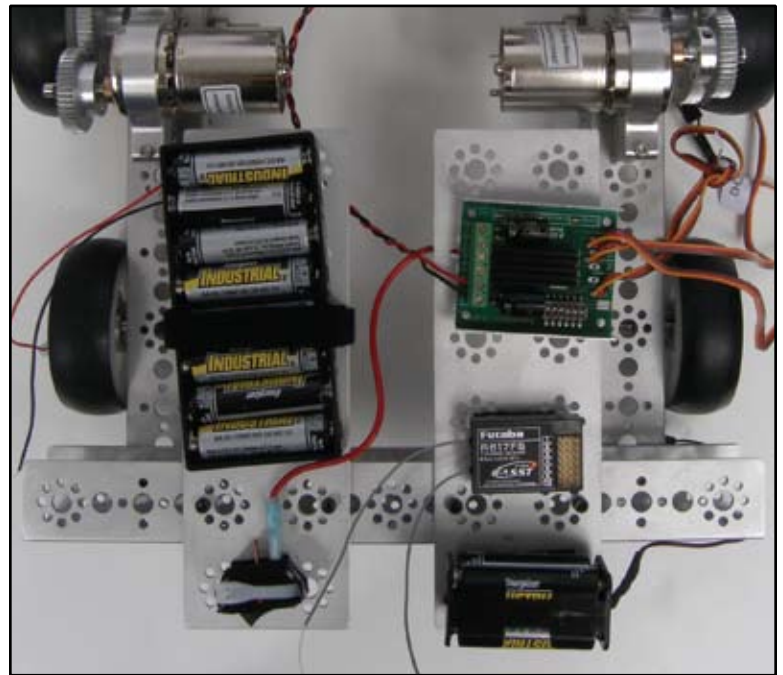


Figure F2



Figure F3



Figure F4

7) Insert the free end of the on/off switch into the controller where it is labeled B+ and tighten the screw (Figure F5).

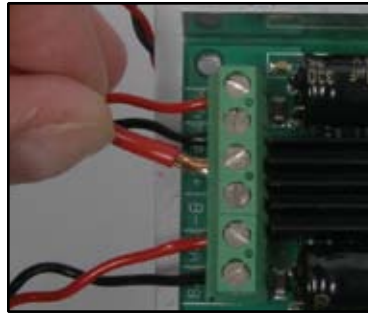


Figure F5

8) Insert the black wire from the battery holder into the controller where it is labeled B- and tighten the screw (Figure F6).

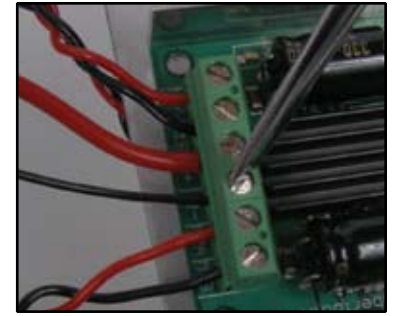


Figure F6

10) Locate the three-strand wires connected to the DC motor controller. Plug in the free end of the wires labeled CH1 and CH2 into the receiver slots for Channels 1 and 2, respectively (Figure F7). The wire labeled Flip is not used here and can be tucked out of the way.



Figure F7

11) On the DC motor controller, flip the switches so 1, 2, and 3 are flipped up (on) and 4, 5, and 6 are flipped down (off) (Figure F8).

12) If your robot needs anything else connected to the receiver, connect it at this time.

13) Turn on the R/C hand set, and plug in the wire from the receiver battery pack into the receiver (Figure F9) – an LED light should come on. Turn the on/off switch to the On position. Now, you can use the right steering control to move the robot forward, backward, and side-to-side. The left steering control will open and shut the grippers.

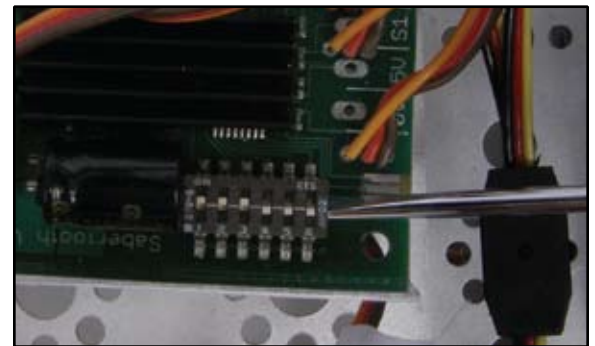


Figure F8

14) At this time, test the robot and make sure the gears and wheels turn smoothly. If not, you can loosen the motor mount screw and turn the motors until the gears mesh better. Retighten the screw and test the robot again.

Also, if a motor is running backward, you can correct this either by switching the ends of the DC motor power cables on the motor terminals or by switching the red and black ends of the motor power cables where they attach to the DC motor controller (either M1A and B or M2A and B).

### TETRIX Tip: R/C Programming

Some radio systems – including the Futaba T6EX – have programmable features. Depending on your robot design, these options may need to be programmed to achieve desired motor operation, such as motor reversing, mixing, and so forth.

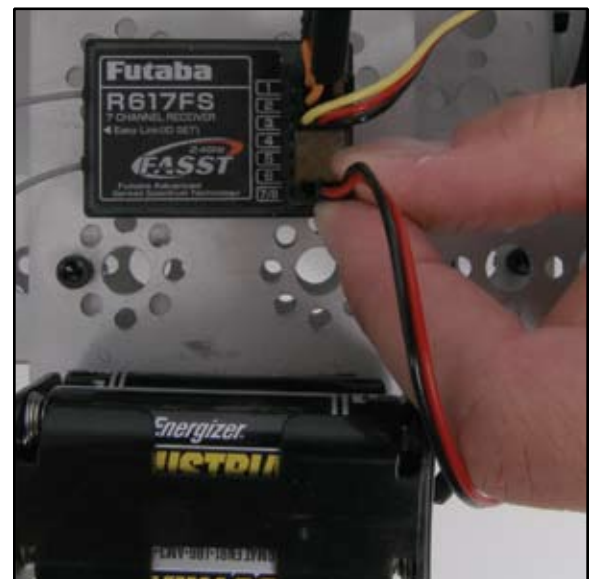


Figure F9

# G – Using the LEGO® NXT Intelligent Brick

To create an autonomous TETRIX robot, you can use the LEGO® NXT Intelligent Brick. The Hard-Point Connectors to enable this are available at [www.LEGOeducation.us](http://www.LEGOeducation.us). You will also need the HiTechnic Servo Controller, HiTechnic DC Motor Controller, 10-cell battery pack, and enough Studless Technic Beams, Angle Beams, and Long Connector Pegs to attach the NXT elements to a TETRIX robot design.

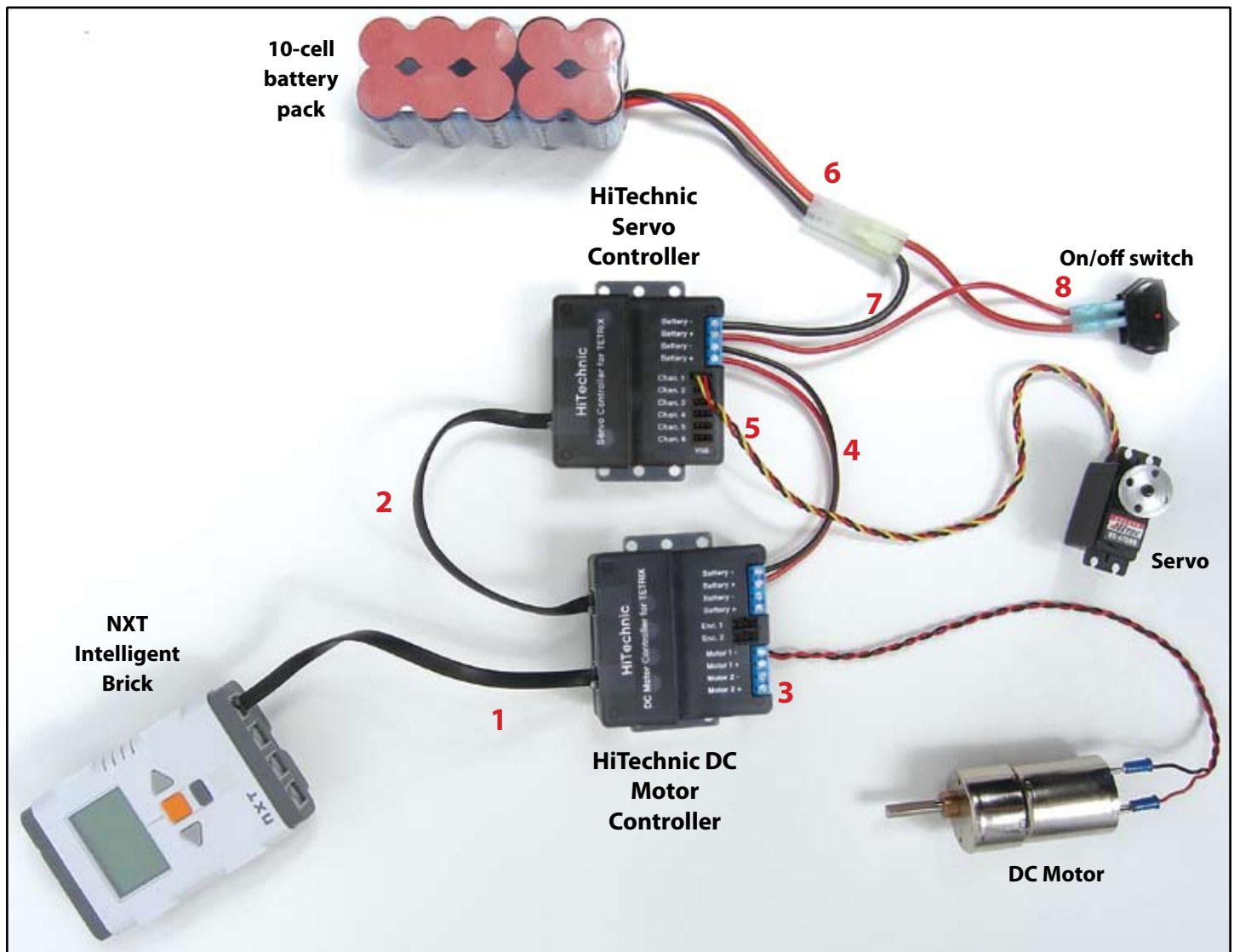


Figure G1

## Connecting the NXT Components

Figure G1 shows the connections described in this section. The red numbers correspond with the steps below.

- 1) Connect the NXT Intelligent Brick to the bottom connection on the HiTechnic DC Motor Controller.
- 2) From the top connection of the HiTechnic DC Motor Controller, connect it to the HiTechnic Servo Controller's bottom connection.
- 3) One or two DC motors can be connected to the HiTechnic DC Motor Controller where it is labeled Motor 1-, 1+, 2-, and 2+. The black wire from a motor goes into the negative position, and the red wire goes into the positive position. After inserting each wire, tighten the screw on top of the control box to hold the wire in place. Loosen the screw first if you need to remove the wire.

- 4) Using a red and black wire from the set, connect the HiTechnic DC Motor Controller to the HiTechnic Servo Controller. To do this, insert an end of the red wire into the motor control box where it is labeled Battery+ and tighten the screw. Insert an end of the black wire into the motor control box where it is labeled Battery- and tighten the screw.

Now, insert the other end of the red wire into the servo control box where it is labeled Battery+ and tighten the screw. Insert the other end of the black wire into the servo control box where it is labeled Battery- and tighten the screw.

- 5) Insert the wires of any servos you need to connect into the HiTechnic Servo Controller in any of the six positions labeled starting with Chan. These wires have plastic ends that insert into slots on the control box.
- 6) Connect the battery pack into the battery pack connection. Take the connection's red wire and plug it into the on/off switch.
- 7) Insert the black wire from the battery pack connection into the HiTechnic Servo Controller where it is labeled Battery-. Tighten the screw.
- 8) Insert the red wire from the on/off switch into the HiTechnic Servo Controller where it is labeled Battery+. Tighten the screw.

## Connecting the *NXT* to TETRIX Elements

Connecting the *NXT* to TETRIX elements requires a Hard-Point Connector designed for this purpose. The HiTechnic Servo Controller (Figure G2a) and the HiTechnic DC Motor Controller (Figure G2b) can be connected to the structural elements with screws and nuts or with the Hard-Point Connector and LEGO® Technic Beams, Angle Beams, and Long Connector Pegs.

**Attaching the Hard-Point Connectors** – These can be attached to the TETRIX structural elements with SHCS screws and kep nuts (Figure G3).

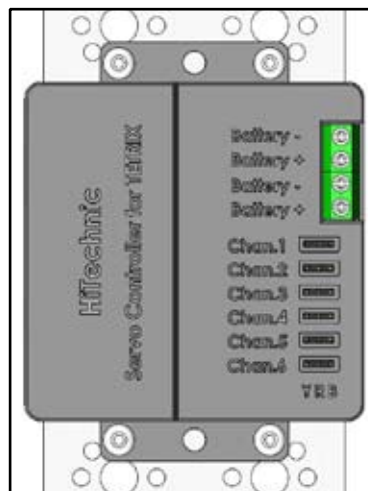


Figure G2a

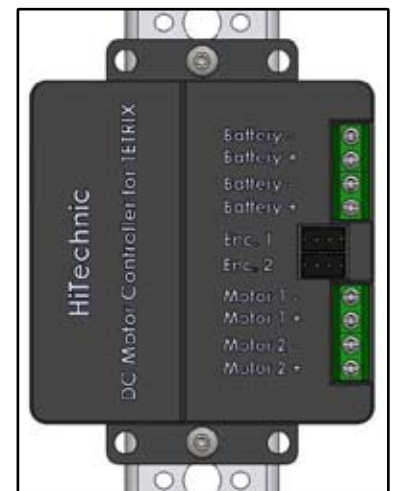


Figure G2b

Then, determine what length of Studless Technic Beams are needed to attach whatever *NXT* component you are using. Slide the beams into the Hard-Point Connector (Figure G4). This beam is secured by two Long Connector Pegs snapped into place through the Hard-Point Connectors and the beams (Figure G5).

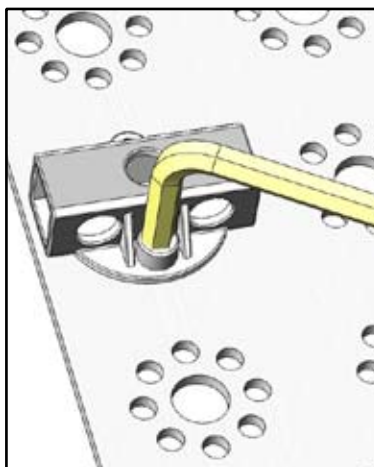


Figure G3

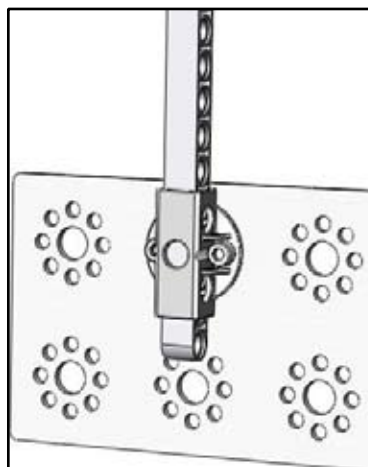


Figure G4

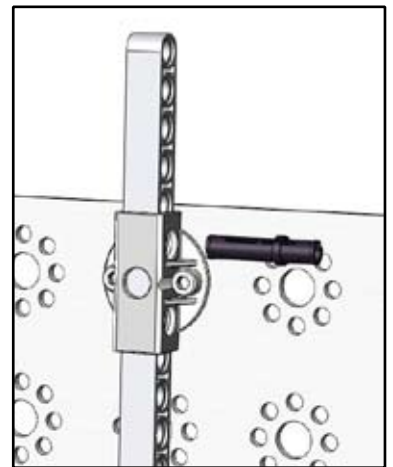


Figure G5

**Attaching the NXT and Controllers** – Place Hard-Point Connectors, Studless Technic Beams, and Long Connector Pegs where you want to attach the NXT component (Figure G6).

Using Technic Angle Beams and Long Connector Pegs, build side supports to attach the NXT brick (Figure G7). The configuration needed will vary depending on the design of your robot and where you want to place the NXT components.

The two controllers can also be attached using the Hard-Point Connectors, Technic Beams, and Long Connector Pegs (or Connector Pegs with Axles and Small Pulleys) if needed (Figures G8 and G9).

**Attaching NXT Sensors** – The sensors that come with the NXT Intelligent Brick can also be used with the TETRIX system. They attach to the structural elements the same way as the NXT brick and HiTechnic DC Motor Controller and Servo Controller – using Hard-Point Connectors, Studless Technic Beams, and Long Connector Pegs.

**Operating the NXT Intelligent Brick** – Please refer to the NXT's instruction manual and software.

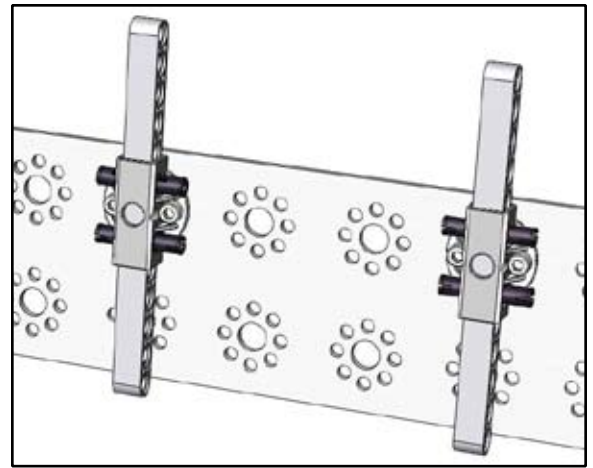


Figure G6

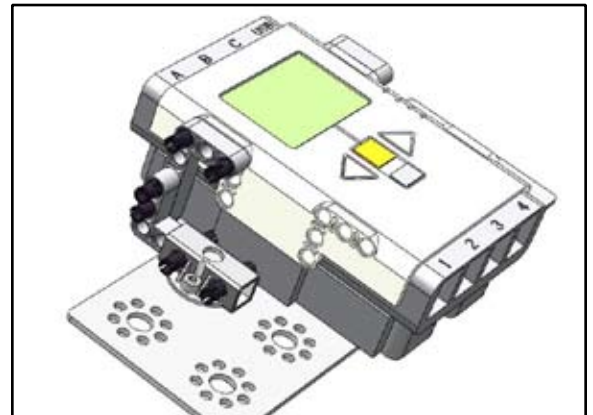


Figure G7

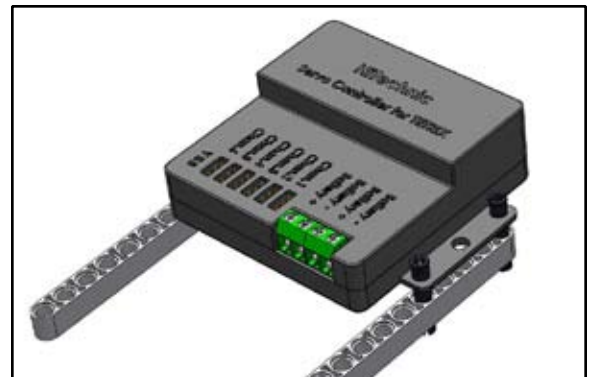


Figure G8

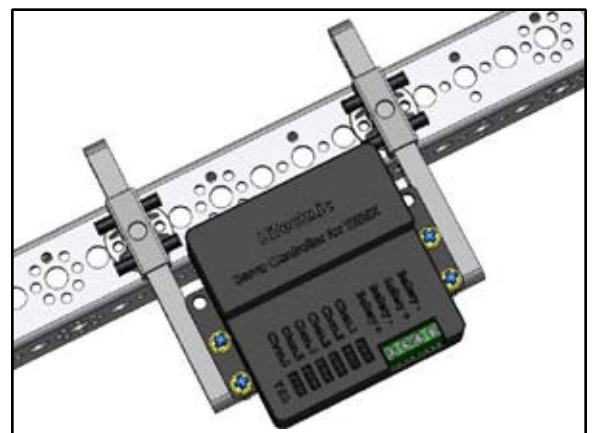


Figure G9

# Want more TETRIX™ stuff? We got ya' covered.



## TETRIX™ GEARS

TETRIX™ Gears are a step above kits and systems with plastic gears – these are made of heavy-duty aluminum and really stand up to wear and tear. Three sizes available.

**39028 40-tooth (pkg of 2)**

**39086 80-tooth**

**39085 120-tooth**

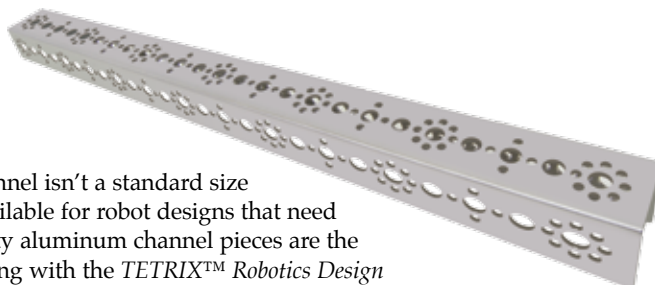


## TETRIX™ WHEEL

Add some mobility to your TETRIX™ robot with these wheels that come in two sizes.

**39025 3"**

**39055 4"**



## TETRIX™ CHANNEL

This super-long channel isn't a standard size in the base set, but is available for robot designs that need longer pieces. Heavy-duty aluminum channel pieces are the structural base for building with the TETRIX™ Robotics Design System.

**39069 416 mm**



## TETRIX™ R/C CONTROLLER

Get ultimate control of your TETRIX™ robot with this six-channel remote control. Featuring interference-free performance and a 2.4 GHz system, this advanced system also includes servo reversing on all six channels. Unlike the commercial version of this controller, ours includes a receiver, transmitter with charger, on/off switch, and battery holder.

**34243**



## PERMATEX SUPER LUBE

This synthetic lube contains SYNCOLON, the slipperiest surface known to humankind, so it's great for keeping robot gears running without a hitch.

**20821**

## WIDE RUBBER BANDS

Approximately 1/2" width x 2" length.

**56136**



## HOOK-AND-LOOP FASTENER

Great for a multitude of applications! One 10-foot strip of each material. 3/4" wide.

**51974**



## TETRIX™ MULTI NUT PLIERS

Designed to hold nuts while bolts are tightened. The long, narrow neck reaches into tight places.

**39130**

## TETRIX™ DC MOTOR SPEED CONTROLLER WITH BATTERY HOLDER

Get control of your DC motors – this controller plugs into your robot's radio systems to enable you to control the speed and direction of two motors. Comes with an 8-cell battery holder.

**34244**



**To order these products and other TETRIX components,  
visit [www.shop-pitsco.com](http://www.shop-pitsco.com).**

