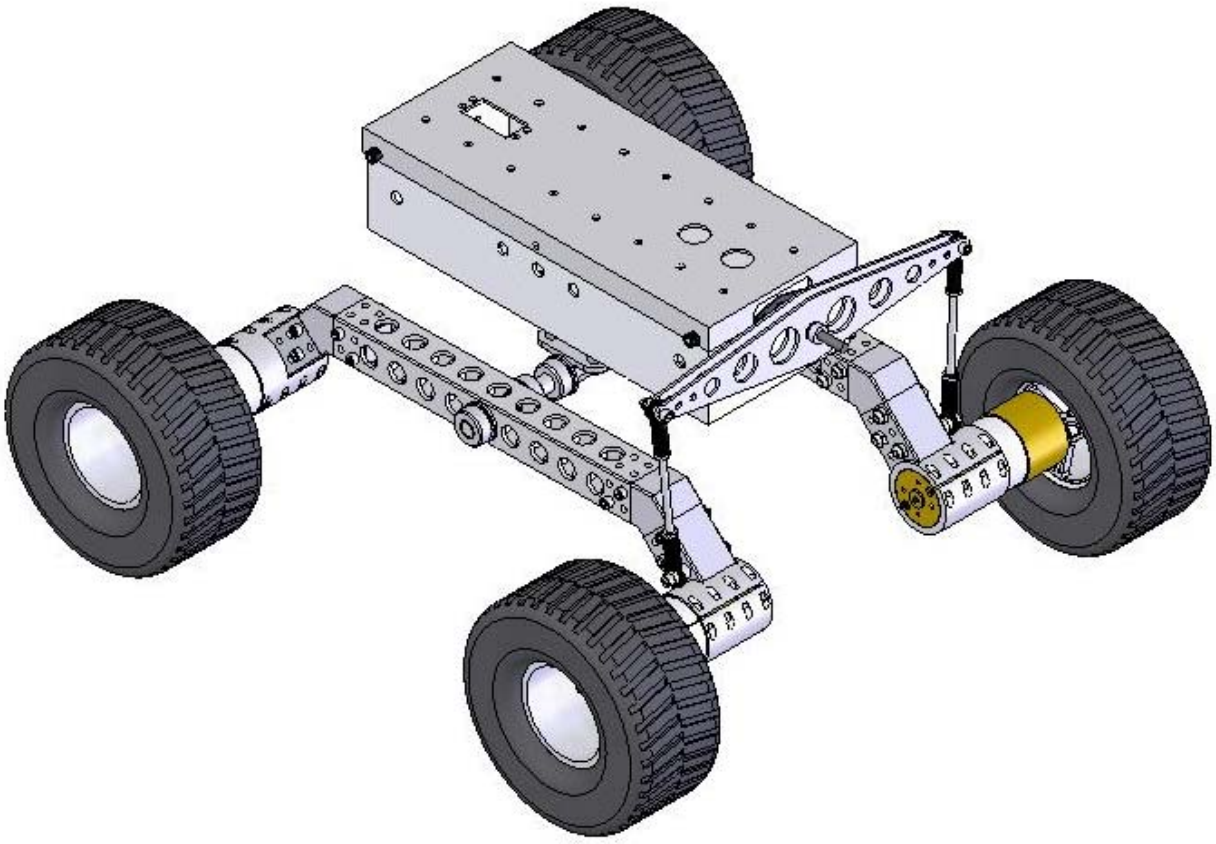
Gears
Educational Systems, LLC

Surface Mobility Platform

A rugged robotic research platform that is agile and easy to maintain



Rugged Titanium, Stainless and Aluminum Construction
Payload Capacity Exceed *30 Lbs.
High Mobility in Rough Terrain
Easy Access to Control Box and Electronics
Re-Configurable and Scalable
Stable Camera Platform
Efficient Motors
Easy to Repair and Maintain in the Field or in the Shop

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Surface Mobility Platform

Illustrated Assembly Guide

This is a user customizable platform. There are several ways to configure the control box and differential suspension. Final configurations are left to the user's discretion. The following guide provides general construction examples.

Required Tools

Hex Key wrench set
Open end or box end wrench (3/8" and 1/2")
Phillips head screw driver
Flat, dull table knives or the equivalent (2)
Electrical tape
Needle nose pliers
Gas pliers
Soldering iron and solder
Wire strippers
Crimping tool
3/4" socket and ratchet wrench

Component Inventory

2	9 Hole Chassis Tube
4	45 Degree Connector
4	Upper Motor Mounts
4	Lower Motor Mounts
2	0/090" x 10" differential arm and bearing assemblies
1	3" x 5" x 12" x 0.090" Pre-Punched aluminum control box (5052 alloy)
1	¾" x 5.25" x 12" control box cover
16	#10-32 x 1-1/2" stainless cap head screws
2	#10-32 x 1" stainless steel cap head machine screws
2	#10-32 x 2" stainless steel cap head machine screws
20	#10-32 stainless nylon lock nuts
4	2" x ¾" White PVC Motor Spacer
32	#4-40 x 5/8" Stainless Steel Cap Screws
32	#4-40 x 5/8" Stainless Steel Lock Washers
4	¼" Bore Threaded Hex Adapters
4	Wheel and Tire Assemblies
4	12mm Jamb Nuts
4	12mm Washers
12	#10-32 x1/2" Stainless steel phillip head machine screws
6	3/8" x 1 ¼" x #10-32 Round aluminum standoffs
2	½" Bore pillow blocks
1	½" x 10" Titanium axle (6AL4V alloy)
6	½" Zinc plated shaft collars
6	½" Zinc plated flat washers
2	¼" flanged sleeve bearings
16	#10 stainless steel split ring lock washers
4	#10 stainless steel flat washers
4	#10-32 x 1 ½" stainless steel threaded rod
4	#10-32 stainless steel hex nuts
4	#10-32 x 0.190" tie rod end
1	¼" x 4-1/2" stainless steel axle
2	#10-32 x 2" long round aluminum standoffs
3	¼" shaft collars
2	0.190" dia x ¼" nylon spacers
4	#12 self tapping stainless steel Phillips head screws
4	#10ss flat washers
4	Gearhead motors
1	SPST Toggle switch
2	5/8" x 3/8" x 0.090" rubber grommets
1	Velcro strip
2	¼" Mono phone jacks
2	¼" mono phono plugs
4	16-18ga x ¼" female spade quick connects
2	1/8" x 6" heat shrink
2	1/4" x 4" heat shrink
2	3/8" x 4" heat shrink
2	1' length 18ga. 3 conductor SJE00W cable
*1	12 volt battery
*1	Battery charger
*2	12 Ampere Electronic speed controllers
*1	9" length of 18ga (red) multi-strand wire

* Denotes Optional Items

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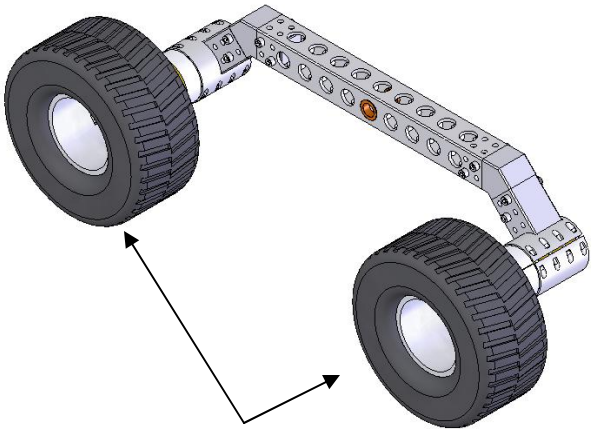
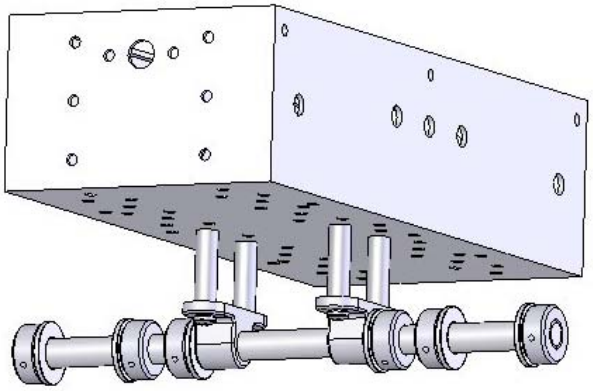
Surface Mobility Platform

The GEARS-SMP is created using three mechanical modules

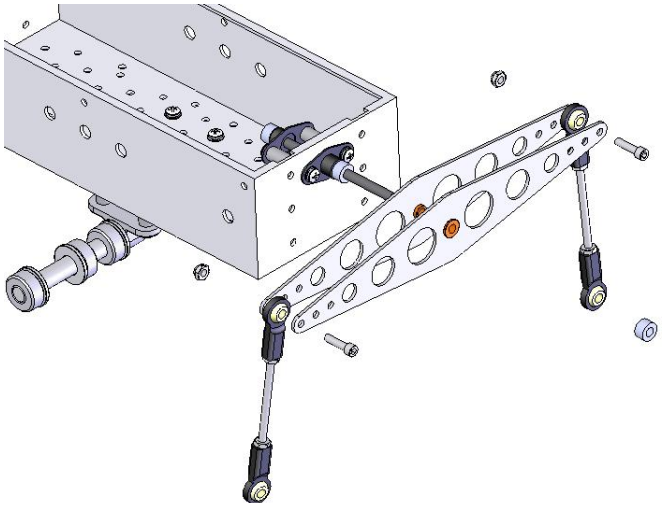


Note: The tire tread pattern is show aligned in a unidirectional configuration. This is one of several user selectable tread alignment options.

The Chassis and Motor Module
Fabricated using 1-1/4" x 0.125" wall 6061-T6 aluminum square tubing. This module includes the chassis structural components, motors, motor mounts and wheel and tire components.



The Control Box Module
0.090" aluminum alloy box protects electronic components and provides over 250 in^3 of payload capacity. The ½" diameter titanium main shaft offers maximum payload capacity and support for batteries, photovoltaic panels, cameras and sensors.



The Differential Arm Module
Supports the control box and dampens yaw and pitching motions. The differential arm provides maximum range of motion and allows the chassis and wheels to climb over obstacles nearly twice the wheel diameter**.**

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Build the Chassis Module(s)

Step One: Build the Chassis Module (2 required)

Necessary Components

Qty.	Description
2	9 Hole Chassis Tube
4	45 Degree Connector
8	#10-32 x 1-1/2" stainless cap head screws
8	#10-32 stainless nylon lock nuts

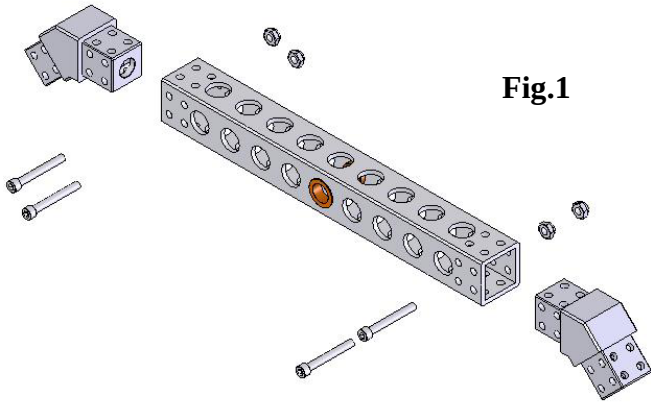

Fig.1

Procedure

Attach the two 45 degree connectors as shown in figures 1, 2 and 3.

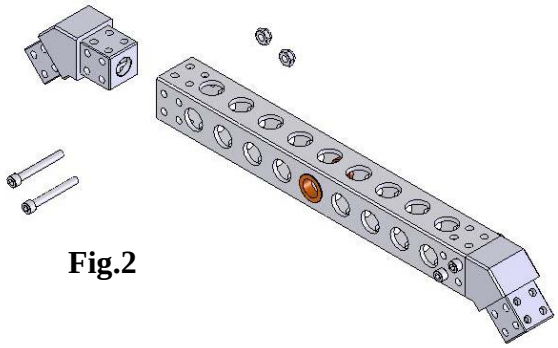

Fig.2

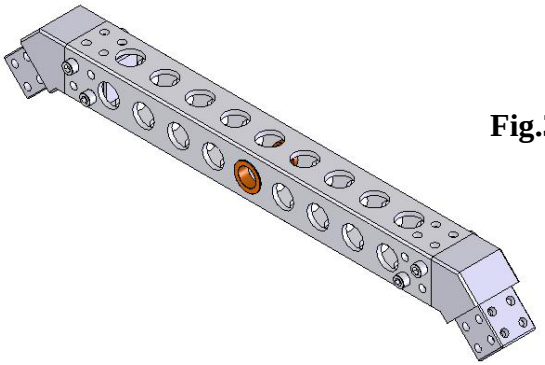

Fig.3

Step Two: Build Motor Mount Modules
(4 required)

Necessary Components

Qty.	Description
4	Upper Motor Mounts
4	Lower Motor Mounts
4	Gear Head Motors
4	2" x ¾" PVC Motor Spacer
33	#4-40 x 5/8" Stainless Steel Cap Screws
33	#4-40 x 5/8" Stainless Steel Lock Washers

Note: Do not begin assembling the motor and mount module until you have completely read the procedures for mounting the motor spacers. Failure to follow this procedure may result in irreparable damage to the motor leads.

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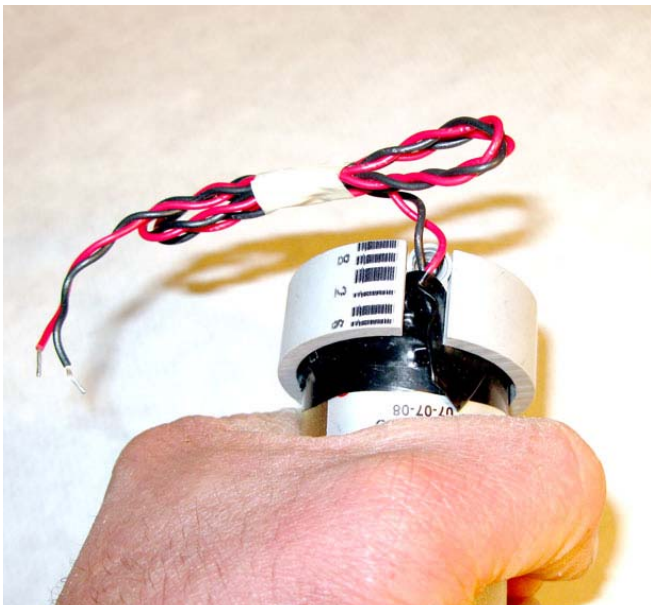
Step Two: Build Motor Mount Modules (continued from previous page)

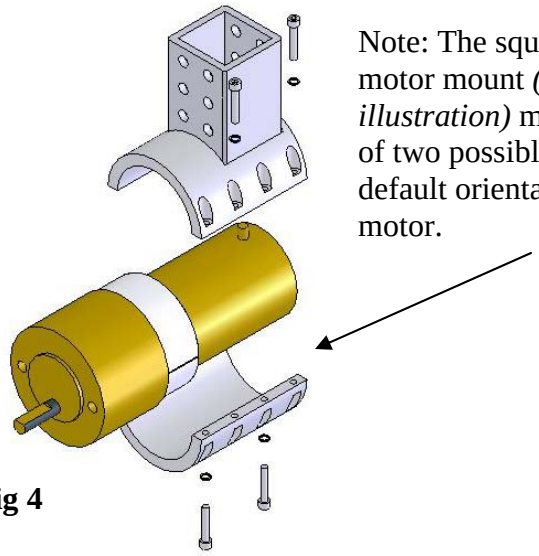
Procedure

Caution: The PVC spacer ring has a slit that allows it to be spread apart as it passes over the motor wires. Place a wrap of electrical tape around the end of the motor can and over the wire before attempting to pass the PVC spacer over the motor wires.

Take care to spread the split ring spacer so that the split clears the motor power leads while sliding the split ring PVC spacer onto the motor.. **Do not attempt to slide the spacer over the motor leads as this will damage the leads and void the warranty.**

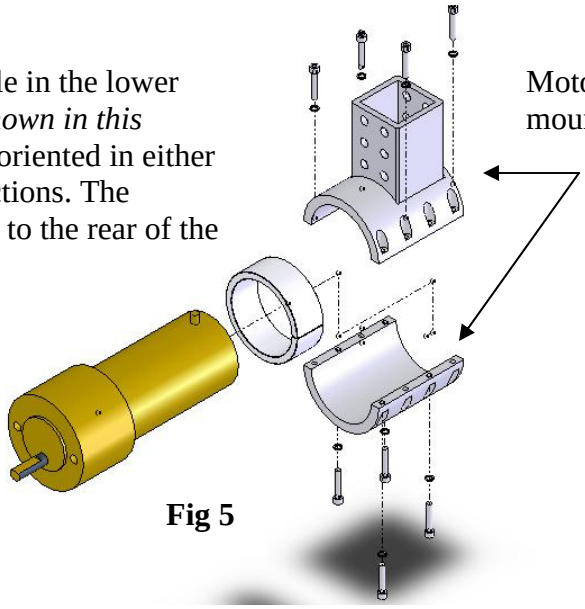


The images (above) illustrate the proper technique for assembling the split ring spacer using electrical tape and spreading the PVC ring enough to prevent damage to the wire leads. The picture on the right shows tape removed and the spacer in position



Note: The square hole in the lower motor mount *(Not shown in this illustration)* may be oriented in either of two possible directions. The default orientation is to the rear of the motor.

Fig 4



Motor mount rear

Fig 5

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Assemble the motor mounts using the #4-40 x 5/8" stainless steel cap screws.
Position the upper and lower motor mounts around the motor can, as shown in figures 6 and 7.

Place a lock washer under the head of each cap screw. Note that the cap screws are fastened to the motor mounts in an alternating (top/bottom) pattern. Take precautions to keep the seams between the top and bottom motor mounts equal on each side and parallel. Tighten the cap screws in several steps by tightening alternating (from one side to the other) set screws a little at a time. Tighten the cap screws gradually and in steps to create even clamping pressure around the motor can.

Tighten the cap screws in gradual steps, and alternate from one side of the motor mount to the other.

Keep the seams equal on both sides and parallel

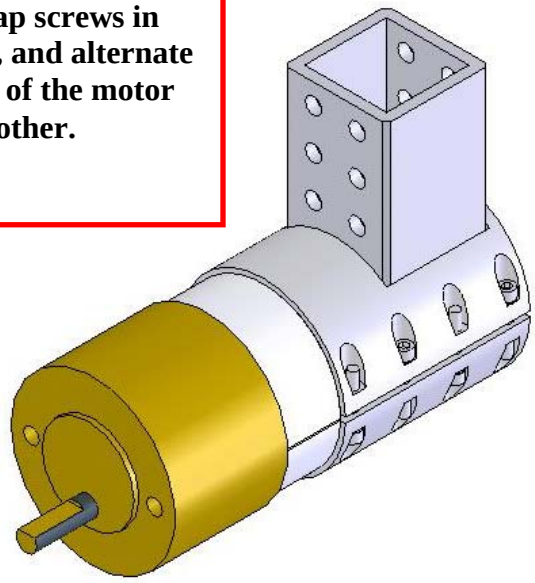

Fig.6

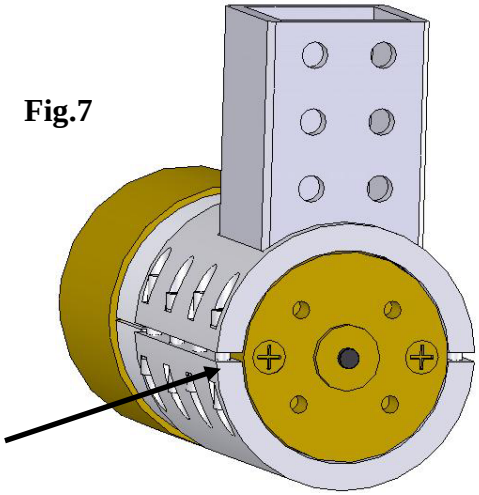

Fig.7

The motor can screws must line up with the motor mount seams as shown in figure 7. The motor lead wires must be centered in the top motor mount tube.

Step Three: Assemble the Motor Mount and Chassis Modules
(2 assemblies required)

Necessary Components

Qty.	Description
8	#10-32 x 1-1/2 Cap Screw (1.5")
8	#10-32 Nylon Locking Nuts

Procedure

Attach the motor mount modules to the 45 degree connectors on the chassis module. Carefully thread the motor lead wires (not shown) through the bore in the 45 degree

Note: Motor leads should exit one of two holes, either to the right or left of the axle bearing

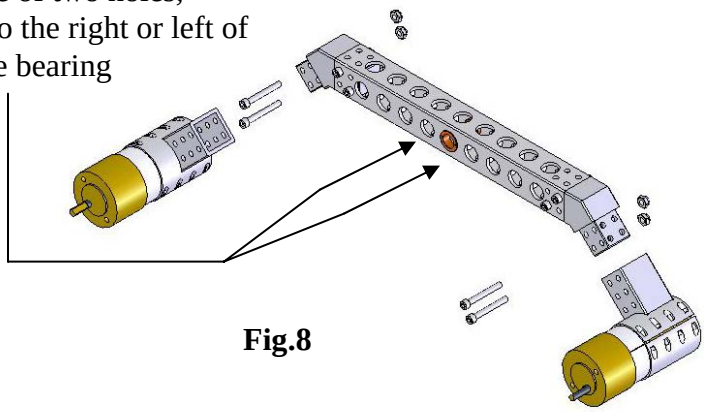

Fig.8

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connector and the chase formed by the 3 hole tube.

Do not pinch the motor lead wires or pull on them with excessive force. This will damage the wire leads and create a short circuit condition.

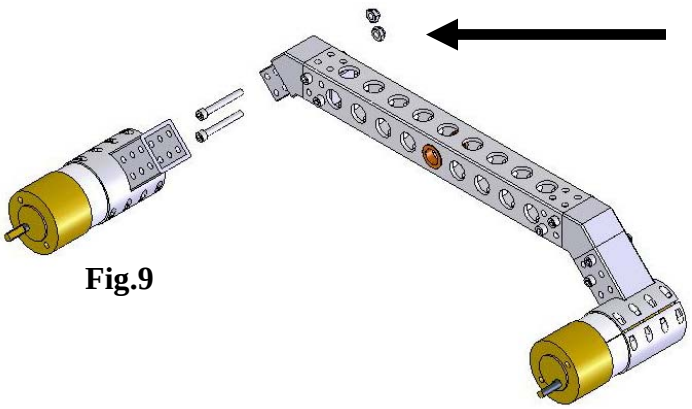

Fig.9

Use 2 #10-32 x 1-1/2” cap screws and nylon locking nuts , as shown in figure 8, to fasten the motor mount modules to the chassis connector module.

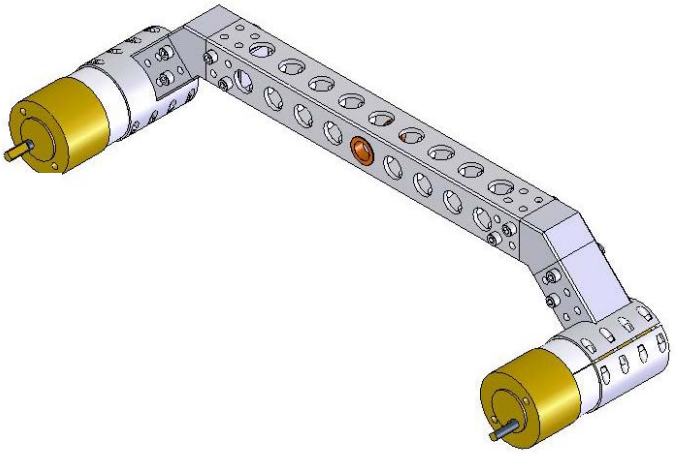

Fig.10

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Build the Control Box Module

Necessary Components

Qty.	Description
8	#10-32 x ¾" Stainless steel Phillips head machine screws
4	3/8" x 1 ¼" x #10-32 Round aluminum standoffs
8	#10 Stainless steel lock washers
2	½" Bore pillow blocks
1	½" x 10" Titanium axle (6AL4V alloy)
1	3" x 5" x 12" x 0.090" Pre-Punched aluminum control box (5052 alloy)
6	½" Zinc plated shaft collars
6	½" Zinc plated flat washers

Step One: Attaching the Main Shaft and Bearings

Procedure

Fasten the pillow blocks to the bottom (center) of the control box. Center the Titanium main shaft between the two pillow blocks assemblies as shown below.

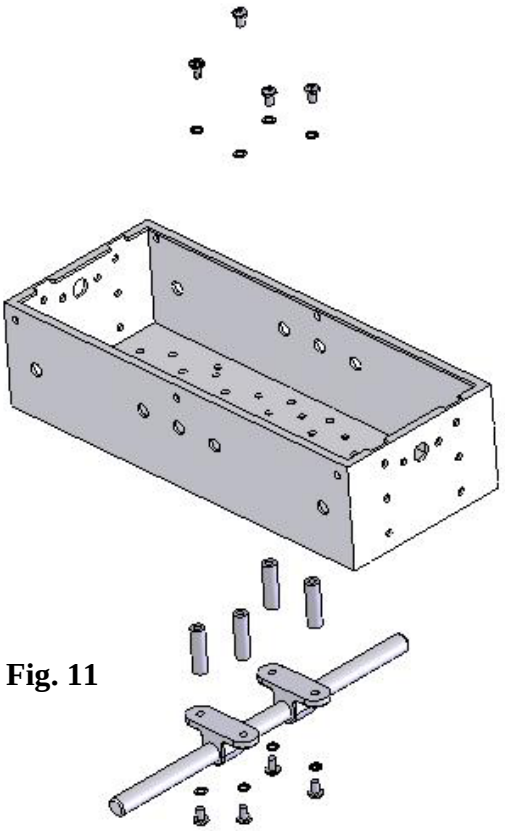

Fig. 11

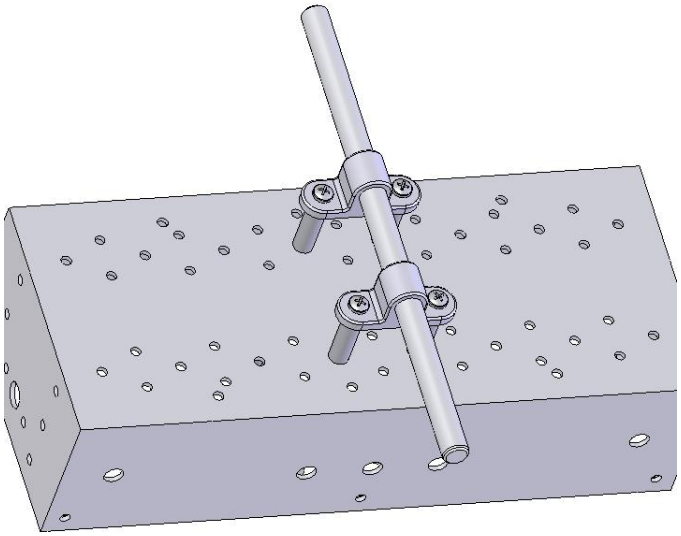

Fig. 12

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Step Two: Center the pillow blocks and main shaft. Slide (2) ½" shaft collars and washers up against the pillow blocks to secure the main shaft in position as shown in figure 13 below.

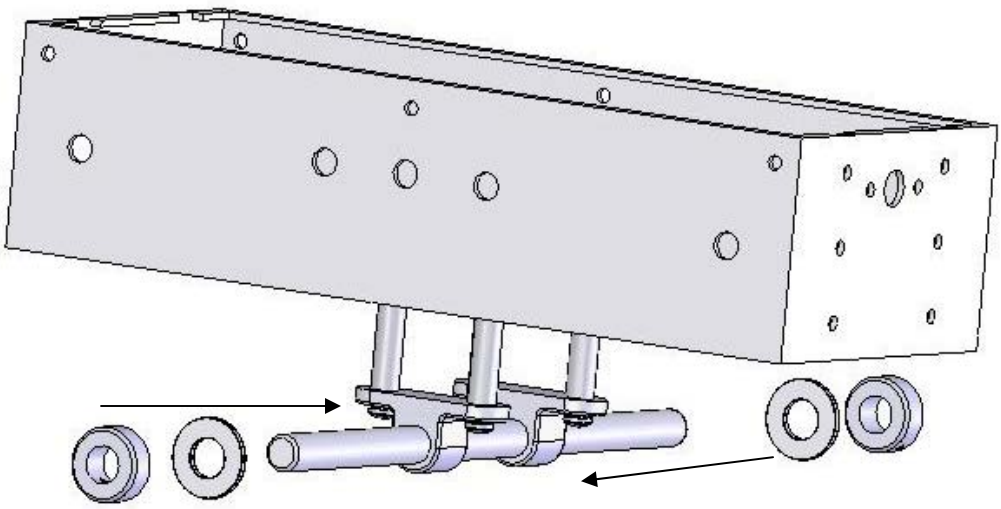

Fig. 13

Building the Differential Assembly

Note: The chassis modules and wheels have been omitted in order to more clearly illustrate the assembly sequence.

Step One: Attach the differential shaft bearings and aluminum standoffs

Necessary Components

Qty.	Description
2	¼" flanged sleeve bearings
2	3/8"round x 1-1/4" #10-32 female aluminum standoffs
4	#10-32 x ½" stainless steel pan head ph machine screws
4	#10 split ring lock washers
4	#10 stainless steel flat washers

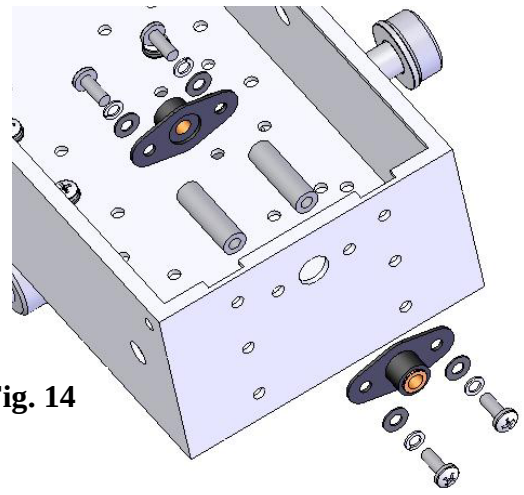

Fig. 14

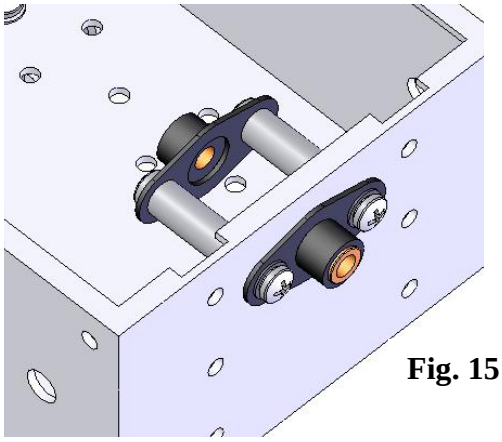

Fig. 15

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Attach the Chassis and Control box module

Necessary Components

Qty.	Description
2	Chassis modules *(Pages 4-7)*
1	Control box module *(Pages 8-9)*
4	½" Zinc plated shaft collars
4	½" Zinc plated flat washers

Procedure

Step One: Slide a ½" shaft collar and washer onto the main axle. Slide the chassis module onto the main shaft, and follow with a washer and ½" shaft collar.

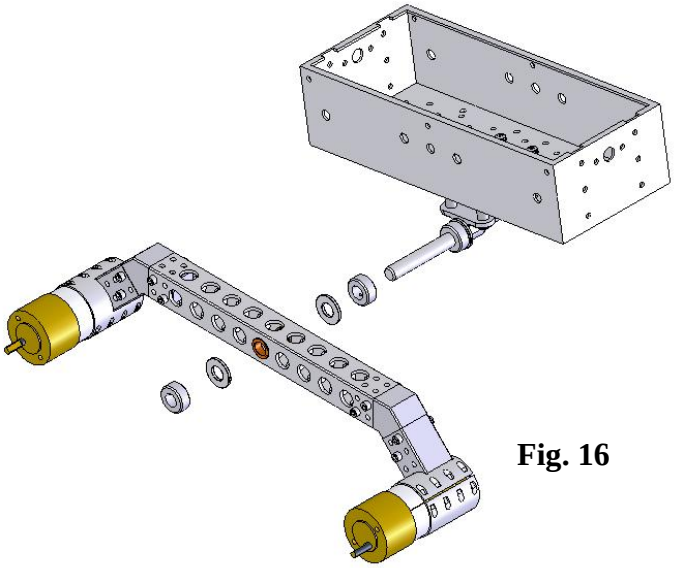

Fig. 16

Position the outboard shaft collar flush with the end of the axle and tighten the set screw to secure the shaft collar in position. Bring the chassis module up against the outboard shaft collar followed by the inboard washer and shaft collar. Tighten the set screw on the inboard shaft collar to secure the chassis module on the main shaft. The shaft collars, washers and chassis module should form a tight fit with as little end play as possible. It may be necessary to squeeze the assembly together before tightening the inboard shaft collar set screw.

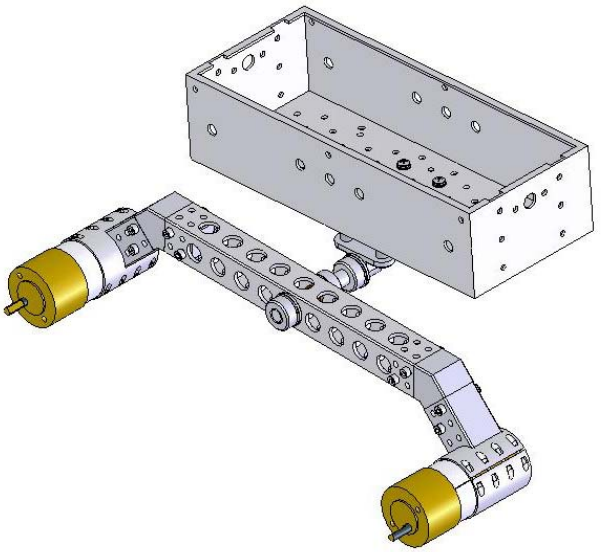

Fig. 17

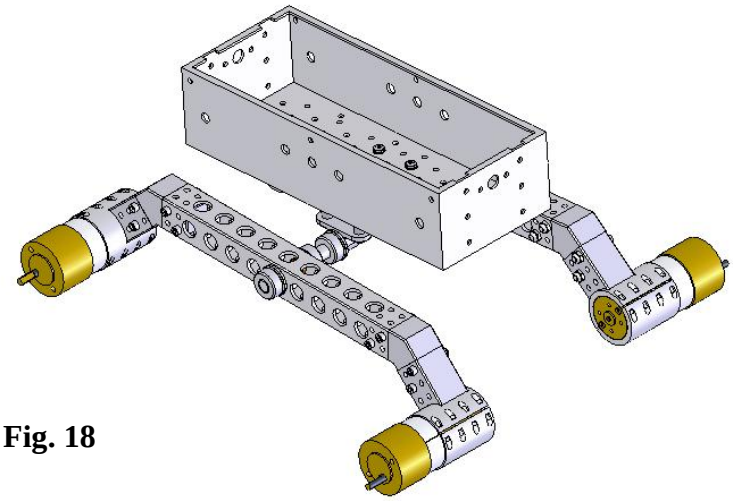

Fig. 18

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Step Two: Make up the tie rods used to support the differential arms

Necessary Components

Qty.	Description
4	#10-32 x 1 ½ ” stainless steel threaded rod
2	#10-32 x 2” aluminum standoffs (round)
4	#10-32 stainless steel hex nuts
4	#10-32 x 0.190” tie rod ends

Screw two (2) threaded rod sections approximately ½” into each end of the aluminum standoffs. Screw the hex nut onto the threaded rod so that approximately ½” of threaded rod remains exposed. Thread the tie rod ends onto the exposed end of the threaded rods. Allow approximately ½” of threaded rod to penetrate the tie rod ends. The distance between the face of the tie rod end and the face of the aluminum standoff should be ½”. Final adjustments can be made after the initial assembly is completed.

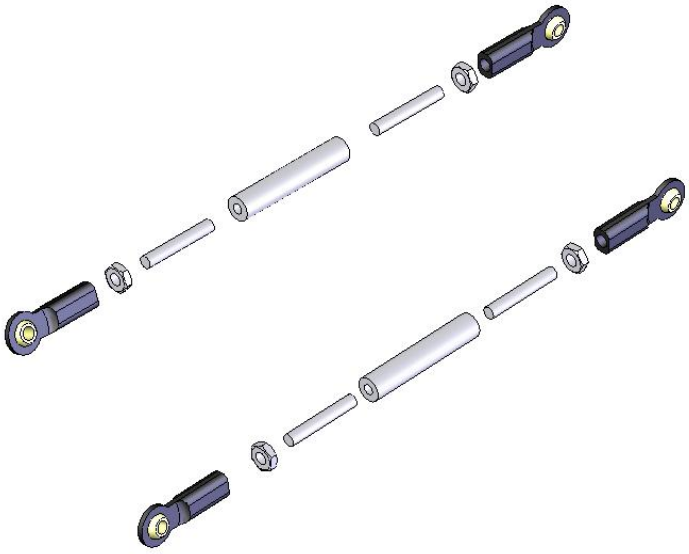

Fig. 19

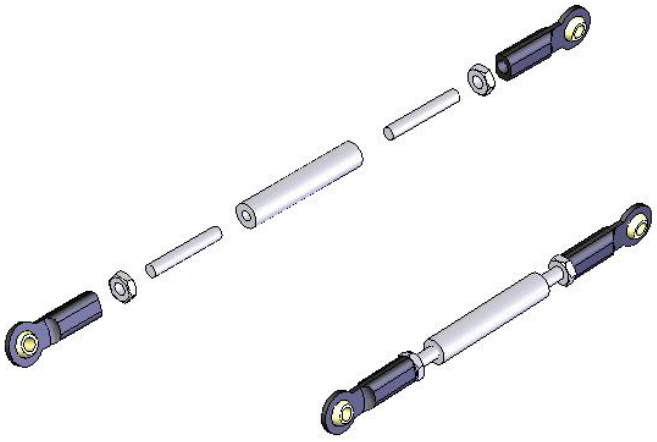

Fig. 20

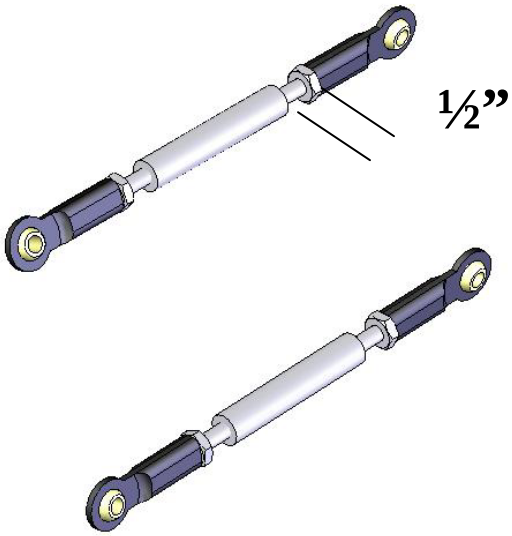

Fig. 21

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Step Three: Assemble the Differential, Axle and Tie Rods

Necessary Components

Qty.	Description
2	0/090” x 10” differential arm and bearing assemblies
1	¼” x 4-1/2” stainless steel axle
3	¼” shaft collars
2	#10-32 x 1” stainless steel cap head machine screws
2	#10-32 stainless steel nylon lock nuts

The ¼” stainless steel axle passes through both differential arms, a ¼” shaft collar and on through the flanged sleeve bearings. Each end of the ¼” axle is secured using a ¼” shaft collar.

The tie rod ends are fastened to the differential arms using 1” cap screws and nylon lock nuts as shown In figure 19 below. The cap head screws and nylon nuts should be brought up tight, and then backed of about ¼ turn. DO NOT OVERTIGHTEN or squeeze the plastic tie rod ends between the differential arms. This will damage the tie rod ends.

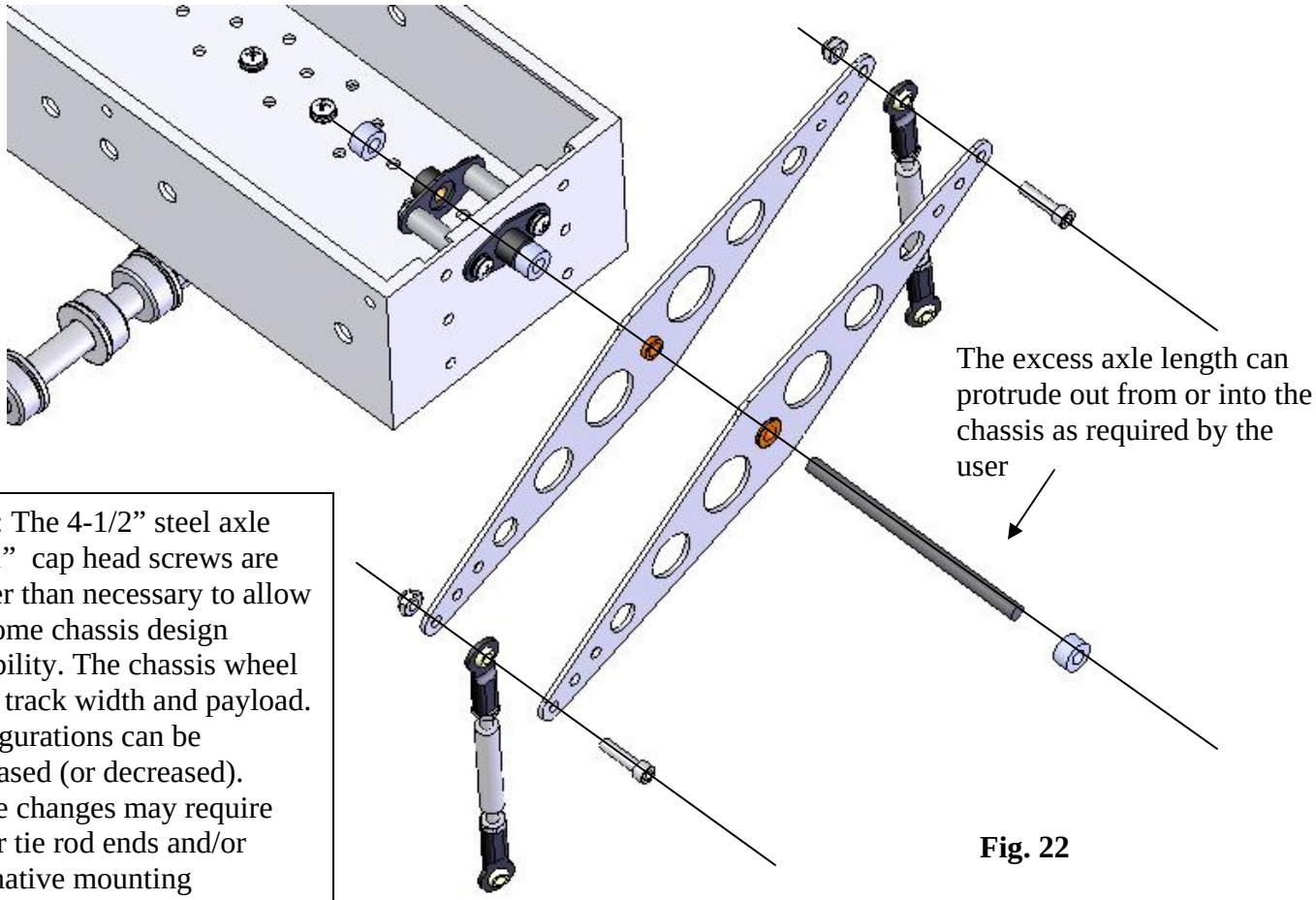

Fig. 22

Note: The 4-1/2” steel axle and 1” cap head screws are longer than necessary to allow for some chassis design flexibility. The chassis wheel base, track width and payload. configurations can be increased (or decreased). These changes may require larger tie rod ends and/or alternative mounting configurations.

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Step 4: Attach the bottom tie rod ends to the chassis modules

Necessary Components

Qty.	Description
2	0.190” dia x ¼” nylon spacers
2	#10-32 x 2” stainless steel cap head machine screws
2	#10-32 stainless steel nylon lock nuts

The bottom tie rod ends are attached to the chassis module using 10-32 x 2” long stainless steel cap head screws and nylon locking nuts. The ¼” nylon spacers are used to position the tie rod end outboard of the chassis module. This allows the tie rod end to have a full range of motion as the chassis and wheels traverse difficult terrain. Use caution when tightening the cap head machine screw and nylon nut. Over tightening the screw will crush both the tie rod end ball and the nylon spacer. Tighten the screw and nylon nut until they are just tight and then back off ¼ turn. There should be no “Play” or movement in the assembly.

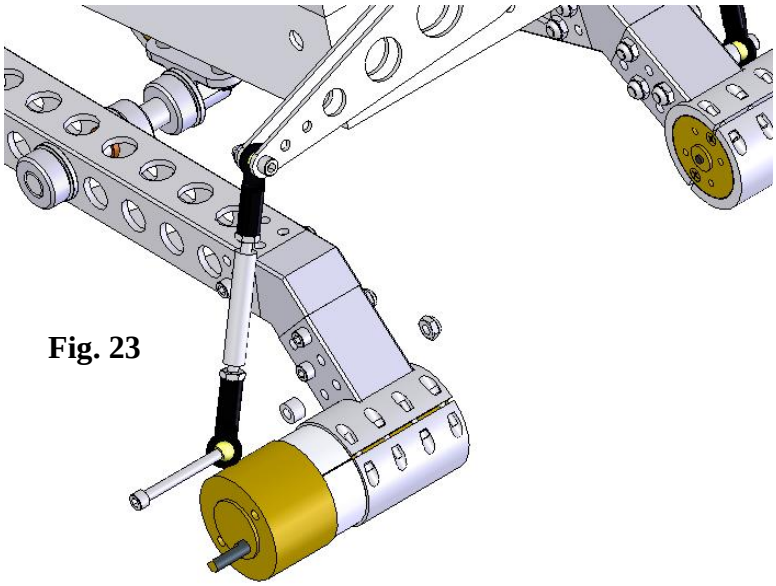

Fig. 23

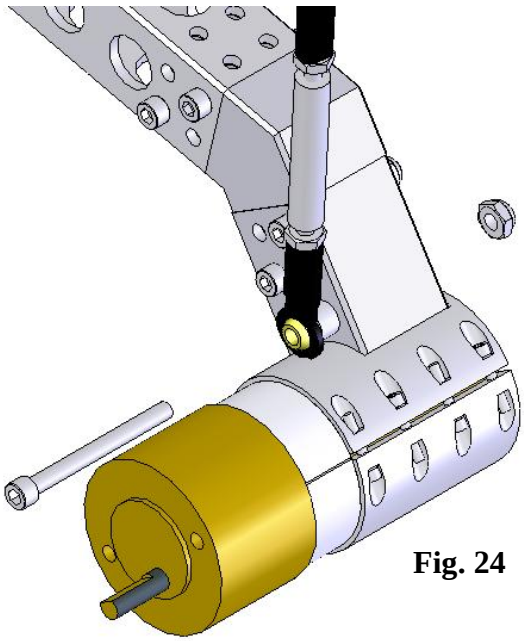

Fig. 24

The completed attachment of the differential arm is shown on the following page. The control box should be adjusted so that it is parallel with the long 1-1/4” square tube on the chassis module . See figure 27 (next page). The adjustment is made by detaching the tie rod end and turning the (bottom or top) tie rod end by screwing it in a counter clockwise direction to lengthen the tie rod or a clockwise direction to shorten the tie rod. Each tie rod should be set at the same length.

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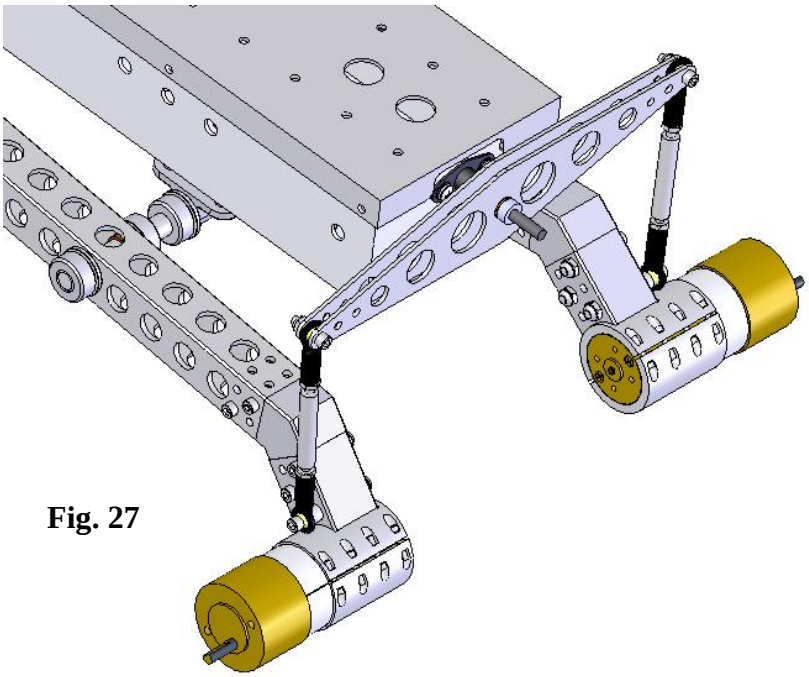

Fig. 27

Caution: Do not restrict the free movement of the tie rod ends by over tightening them. They should be just tight enough to remove any looseness or "play" in the connection.

Secure the Control Box Cover

Step 1: Attach the control box cover to the control box

Necessary Components

Qty.	Description
1	¾" x 5.25" x 12" control box cover
4	#12 self tapping phillips head screws

Note: Attach the wheels before securing the cover.

Fit the cover to the control box. There is no absolute reference for front or back, the cover fits either way. The square hole is sized to accommodate a standard Hi-tec servo. If the servo is inserted into the cover mounting hole, then the servo must face front, or opposite the differential as shown in fig. Below. The two round holes in the cover are sized to fit ½" threaded adapter fittings for PVC pipe or electrical conduit. These pre-punched holes make it easy to add cameras, GPS modules or a variety of other sensors.

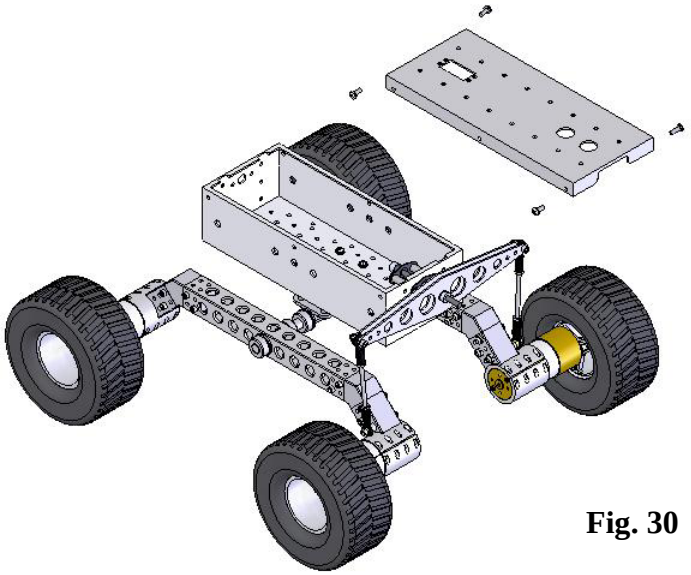

Fig. 30

Securing and removing the cover is easy. Simply screw 4 #10 self tapping phillips head screws into the four corners of the control box cover as shown in the figures below and left.

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Step Five: Mount the Wheels and Tires

Necessary Components

Qty.	Description
4	¼" Bore Threaded Hex Adapters
4	Wheel and Tire Assemblies (See page 24 for assembly instructions)
4	12mm Jamb Nuts
4	12mm Washers

Procedure

Slide the hex adapters onto the motor shaft. *(In some cases these are pre-assembled).* The set screw should slide as far onto the shaft as possible while remaining on the flat of the shaft. Tighten the setscrew on the hex adapters. Use Loctite™ or similar thread-locker on the hex adapter set screw for a more permanent assembly.

Slide the wheel onto the hex adapter. Make sure the hexagonal countersinks in the wheel rim, face the hex adapter. The hex adapter "keys" inside the countersink in the wheel rim.. Tighten the nuts holding the wheels to the hex adapter. Construct two *(1 left, 1 right)* chassis connector and motor mount modules.

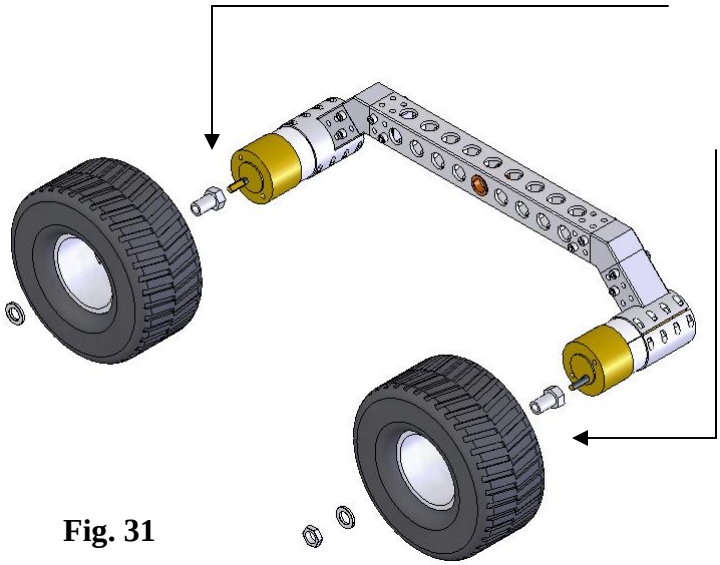

Fig. 31

Note: In some cases the threaded hex adapters, jamb nuts and washers are pre-installed on the gear head motor shafts

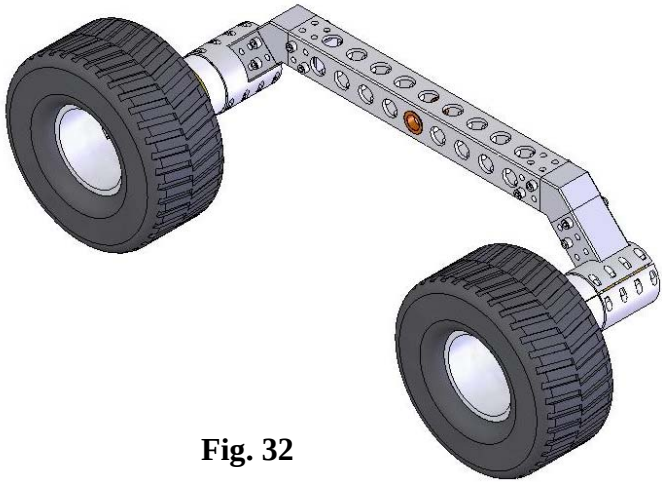

Fig. 32

Note: The tire tread pattern is show aligned in a unidirectional configuration. This is one of several user selectable tread alignment options.

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Electrical Assembly

Step One: Gather the components listed below.

Cut eight (8) three quarter inch long pieces of 1/8" diameter heat shrink.
Cut four (4) three quarter inch long pieces of 1/4" diameter heat shrink.
Cut Two (2) one inch long pieces of 3/8" diameter heat shrink.
Cut Two (1) lengths of the 3 conductor cable, 9" long.

Necessary Electrical Components

Qty.	Description
2	GEARS-IDS™ 12 ampere ESC's
1	SPST Toggle switch
2	5/8" x 3/8" x 0.090" rubber grommets
1	Velcro strip
2	¼" Mono phone jacks
2	¼" mono phone plugs
4	16-18ga x ¼" female spade quick connects
1	1/8" x 12" heat shrink
1	1/4" x 6" heat shrink
1	1/4" x 6" heat shrink
1	12 volt battery
1	Battery charger
1	9" length of 18ga (red) multi-strand wire
2	2' length 18ga. X 3 conductor SJE00W cable

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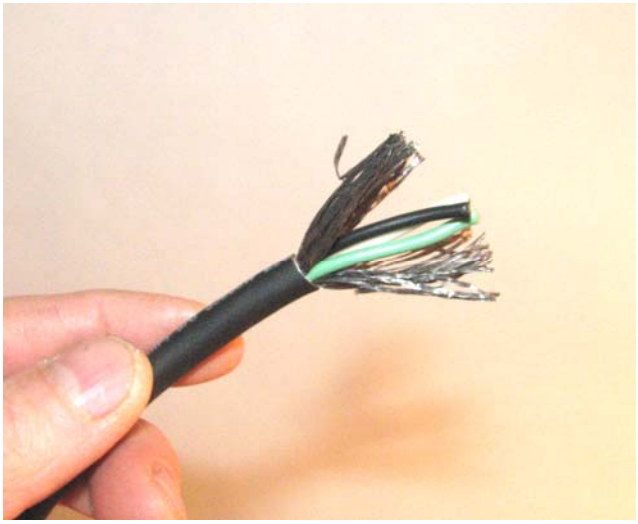
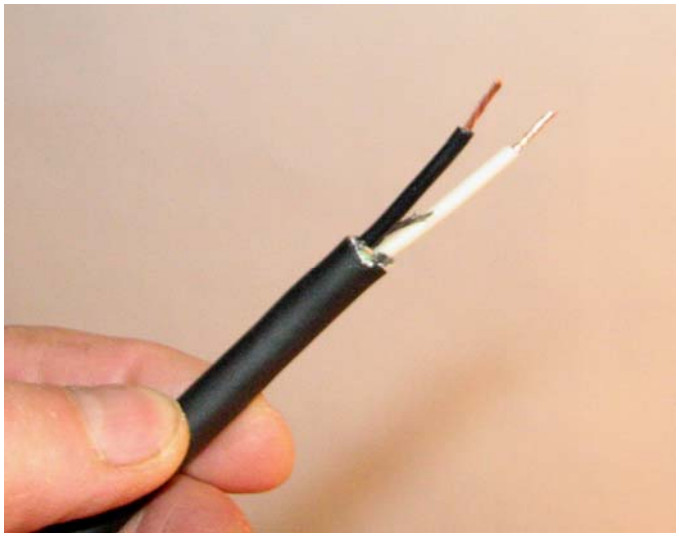
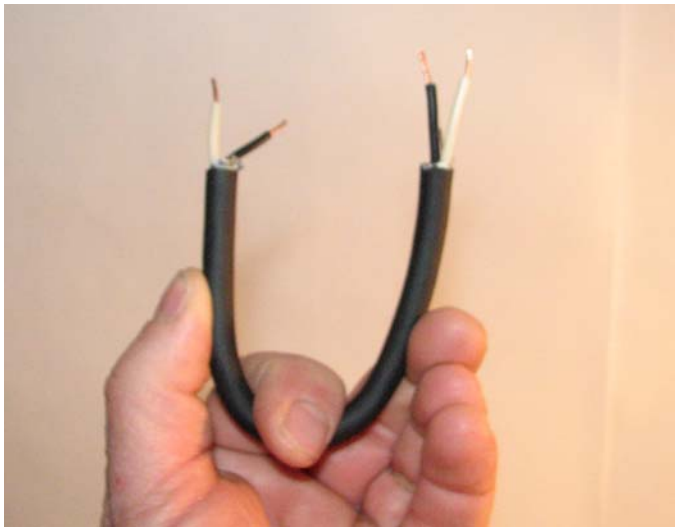
Step Two: Solder the ¼" phono plug to the three conductor cable.

Prepare the 3 Conductor Cable



Strip the black rubber insulation back , 1" to 1-1/4". This will expose the three conductors, black, white and green. We use a razor knife to strip away the rubber insulation, being very careful to NOT cut through the green, white or black wire insulation. This could possibly create a short circuit situation, should the white and black conductors touch during operation.





Cut away the black strain relief fiber and cut the green conductor flush to the cable end. The green conductor is not necessary for basic operation of the SMP. Strip the insulation off the black and white wires on both ends of the cable. Expose about ¼" to 3/8" of copper conductor.

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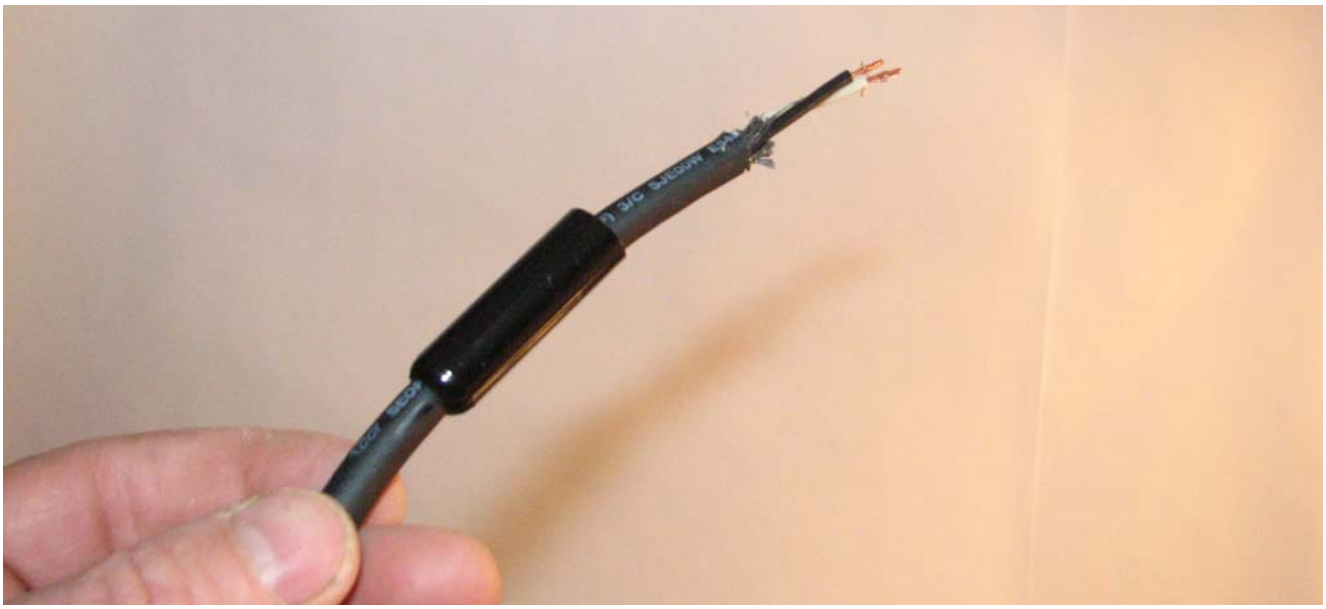
Slide the ¼" Phone plug cover onto the three conductor cable.



Unscrew the phone plug cover from the phone plug. Slide the phone plug cover over the black rubber jacket of the three conductor cable as shown above. The plug fits tight but it will go on. It is best to use a screwing motion as you push the cover onto the cable. A little liquid soap helps, but it is not necessary. Wipe it off completely after sliding the plug cover onto the cable.

Solder the ¼" phone plug onto the cable wires exactly as shown. Bend the phone plug strain relief over both wires using a pair of needle nose pliers.

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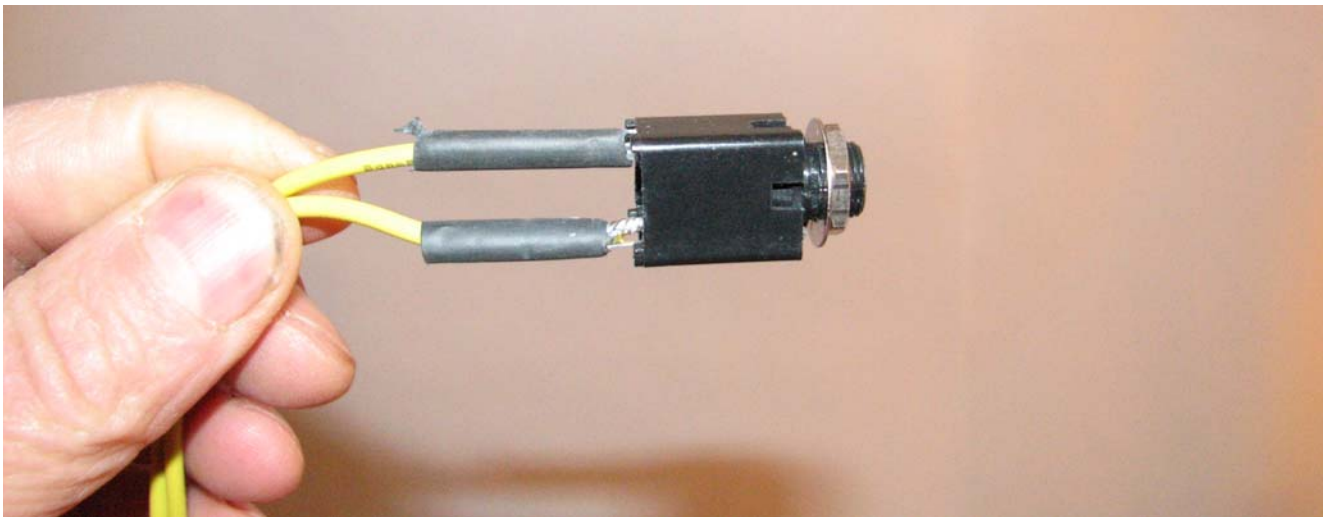
Complete the cable assembly by sliding two lengths of ¾" x 1/8" heat shrink over the black and white conductors, and one rubber grommet and one, 1" length of ½" heat shrink over the black cable jacket as shown above. Do not shrink the heat shrink at this point.



The (2) yellow wires on the speed controllers are the motor leads. Refer to the Speed controller wiring instructions supplied with the kit of parts. Since both wires are the same color, you will need to reference right and left wires as they emerge from the speed controllers. Strip about ¼" of insulation off the yellow wires. Slide a 1/4" diameter heat shrink over each of the two yellow wires and solder them to the phone jack as shown above. Shrink the heat shrink over the connections at this time.

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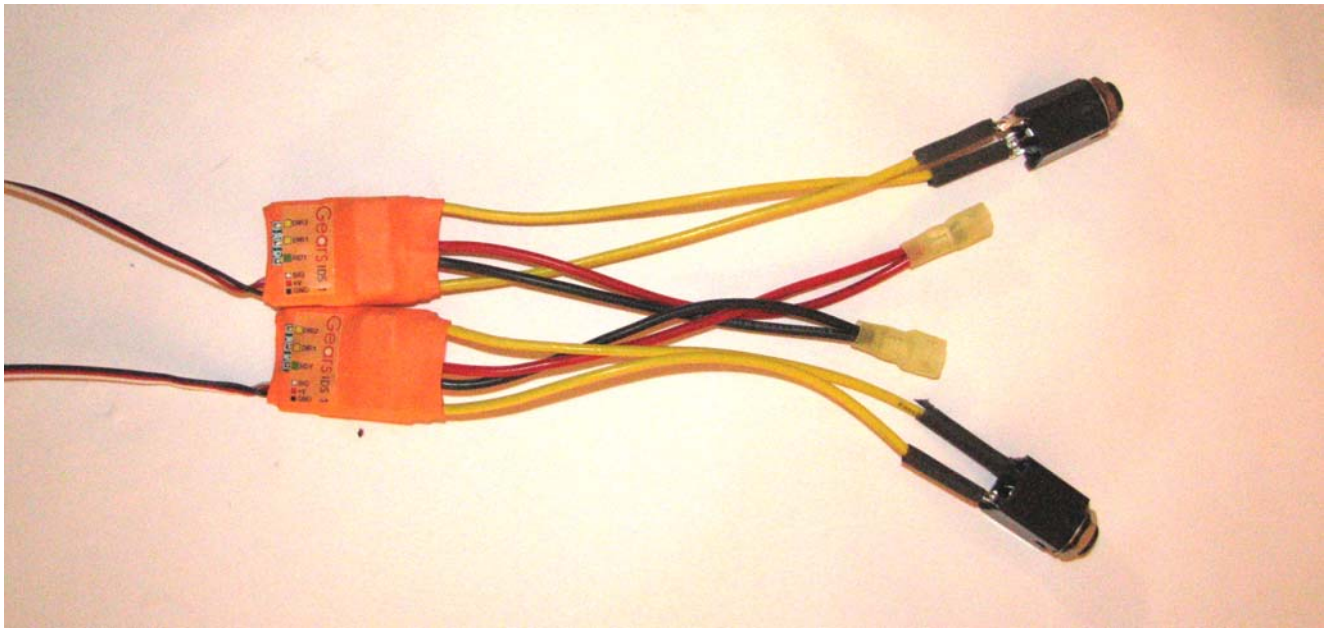
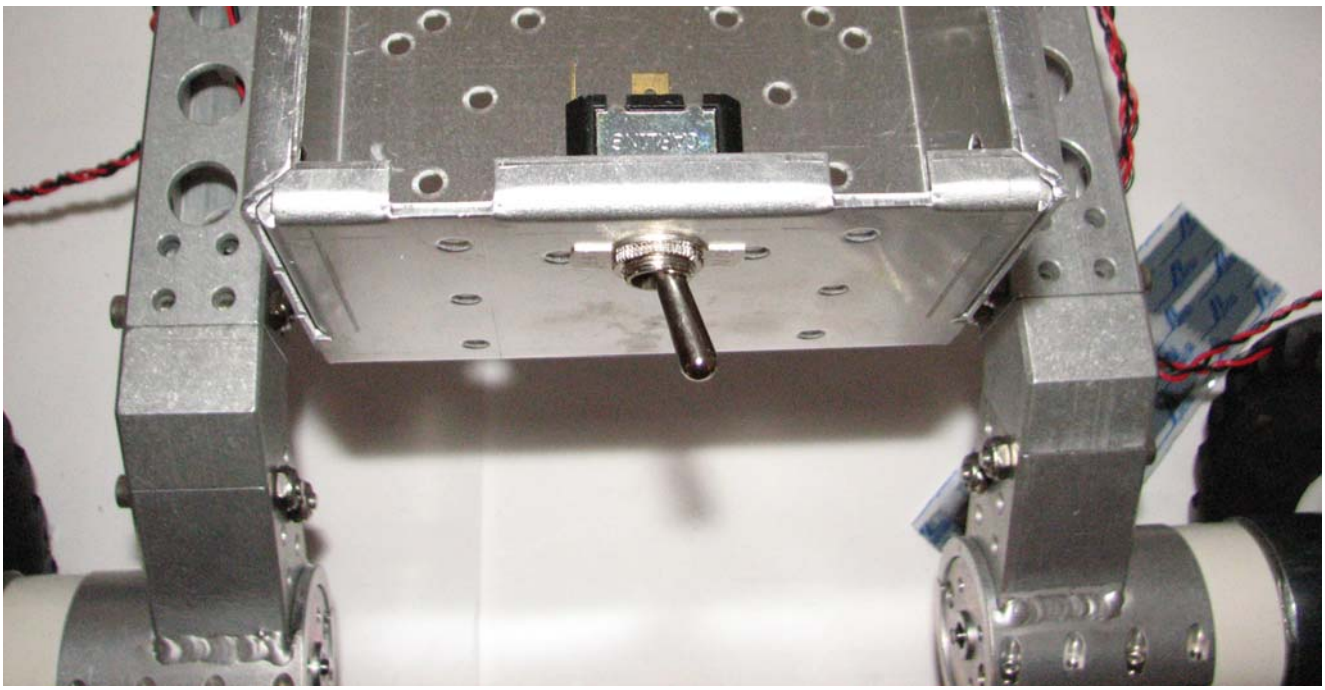


Strip 3/4” of insulation from each of the black and red leads on both speed controllers. Twist the two red leads together and crimp a ¼” insulated spade connector onto the end of the black leads. Repeat this step for the red leads. The finished assembly is shown above. Remember: Black to black and red to red! Failure to observe this instruction will damage the speed controllers and void the warranty. For best results, always refer to the documentation that comes with the specific speed controller you are using.



Fasten the single pole, single throw toggle switch to the front of the SMP as shown in the photo above.

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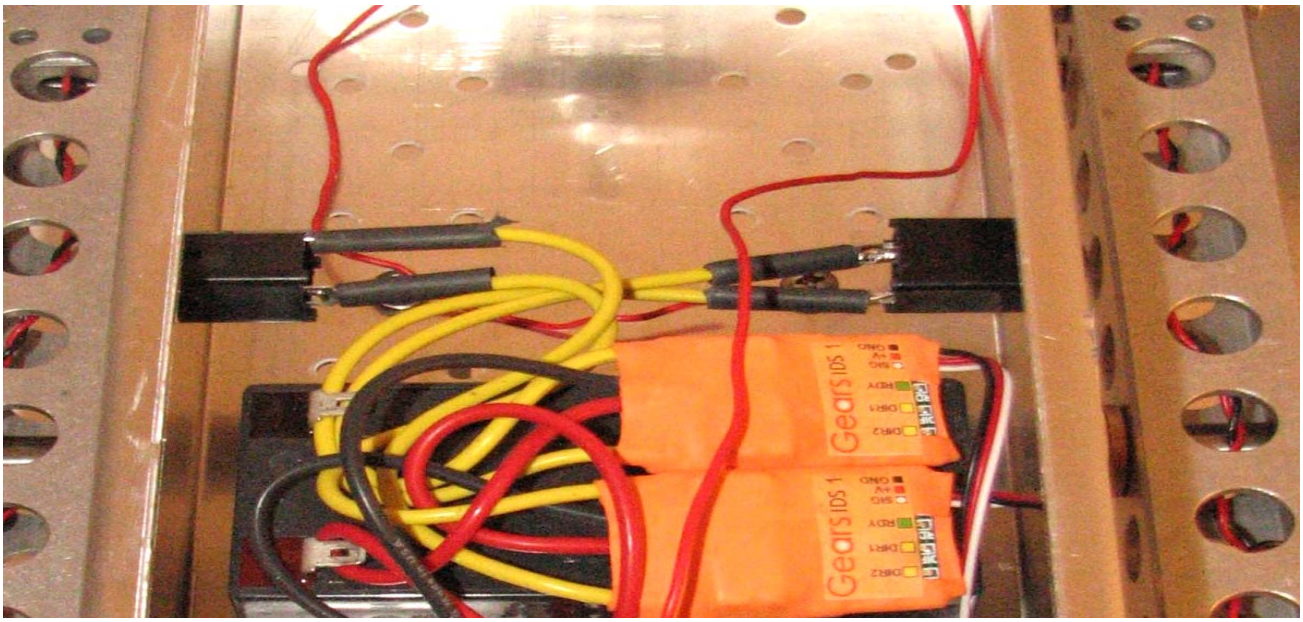
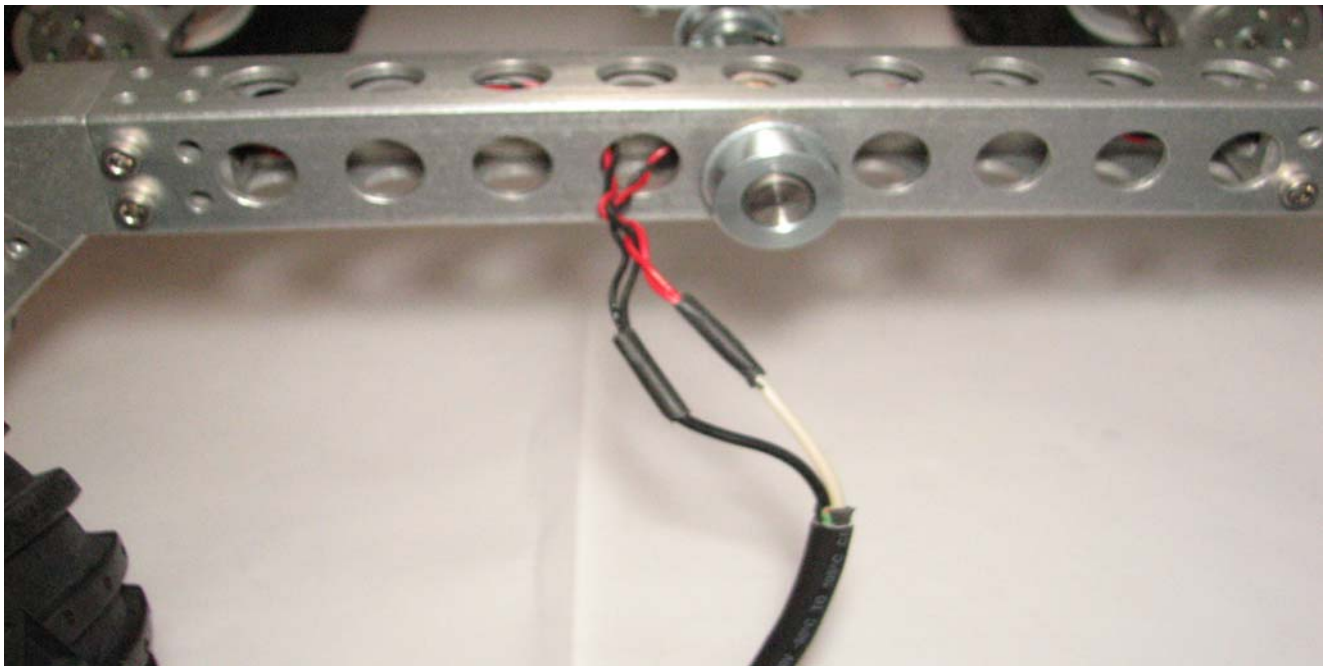
Fasten the phone jacks to the center hole in the side of the control box as shown below. Wire the ESC's, battery and switch per the instructions that come with ESC's. Use small square tabs of Velcro to secure the battery to the floor of the control box. Secure the ESC's to the battery (shown) or to the side wall of the control box using velcro squares cut from the strip provided in the kit.





Snake the front and rear motor leads through the chassis tube hole as shown. Strip back the motor lead insulation about ¼" and twist the red motor leads together. Do the same to the black leads. Slide a piece of 1/8" shrink wrap over each twisted pair. Solder the black motor leads to the black cable wire and the red motor leads to the white cable wire. Shrink wrap the connections making sure to cover all exposed conductor material to prevent shorts. Slide the 3/8" shrink wrap over both connections and shrink it.

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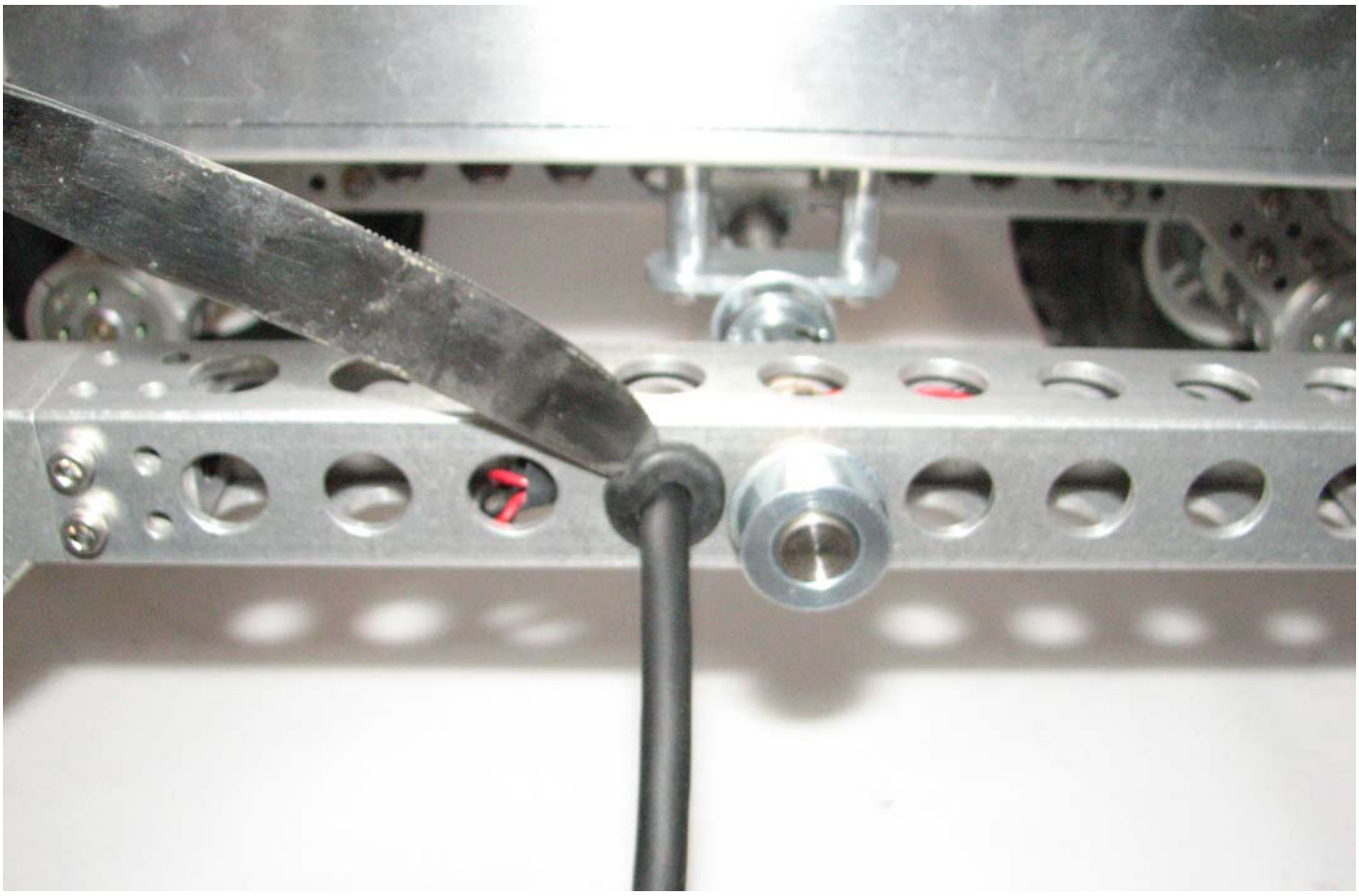
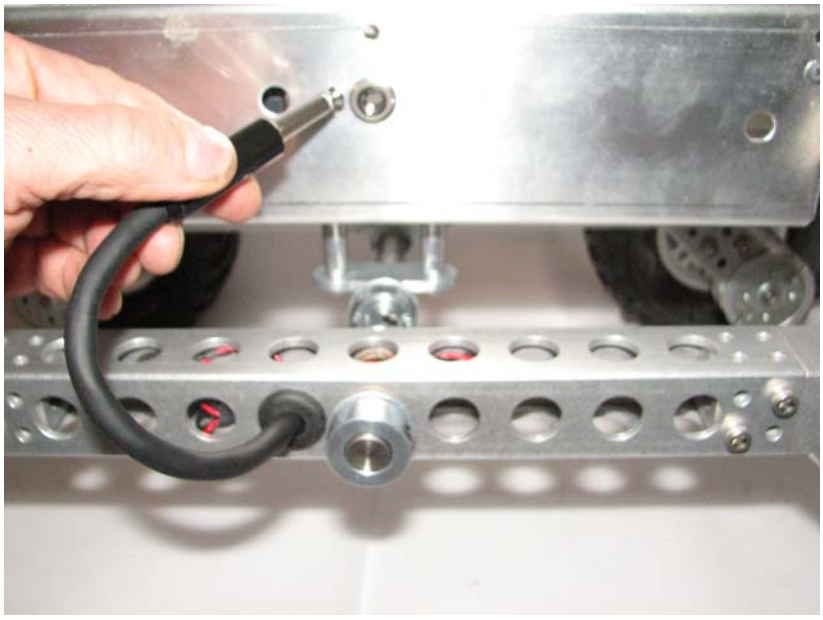


Slide the rubber grommet down the cable and force it firmly into the chassis tube hole using a dulled table knife or similar dull object. Make certain the grommet is evenly seated in the hole. If necessary, push the cable into the grommet hole and secure it with a few drops of Cyanoacrylate glue.



Insert the phone plug into the jack. Repeat for the other side.

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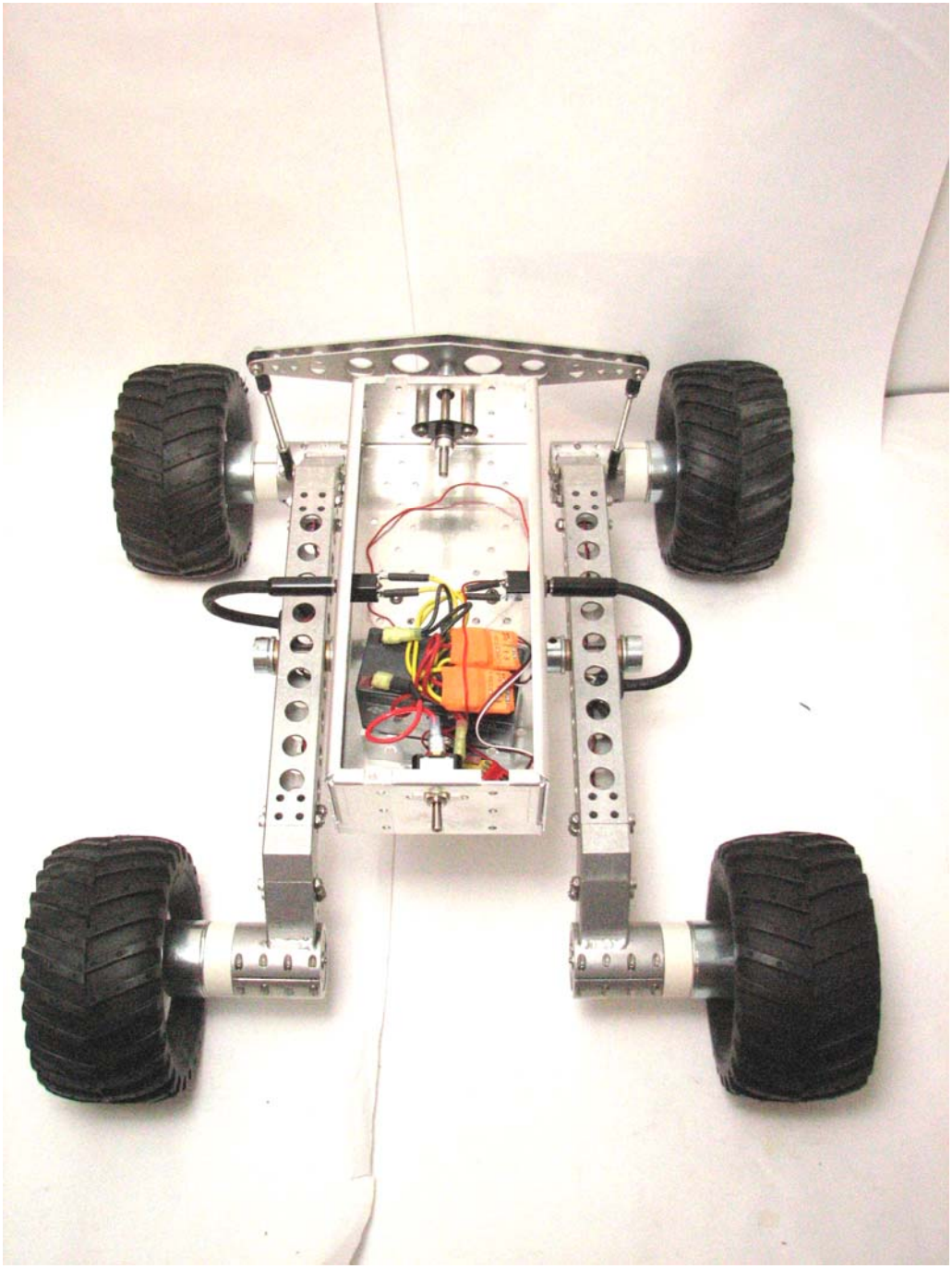

Complete the wiring of the receiver, battery and ESC's per the instructions provided with the ESC's. Turn on the transmitter and the robot when you are sure the wiring is completed correctly. It may be necessary at this point to configure the transmitter in order to customize the steering and vehicle performance. Read the instructions that came with the transmitter carefully in order to correctly configure the RC controls. Instructions differ for each brand of transmitter.

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Illustrated Assembly Tips

Mounting the Tires and Rims

The tires used on the GEARS-SMP are made from a medium soft rubber compound. These tires can support the weight of batteries, sensors and cameras. In addition, the tires can be partially filled with sand or lead shot in order to gain additional traction. Partially filling the tires with ballast will lower the SMP's overall center of gravity and provides additional stability over rough terrain.

The tires should be fitted to the rims and the foam inserts placed into the tire cavity. To accomplish this, push the rims into the tire hole. If necessary use 2 DULLED table knives or similar thin flat metal tools to fit the tire to the rim. This is where two people working together can make a difficult task easier. Be certain that the tire bead is fitted completely into the rim groove. The picture on the left shows the tire bead being fitted to the rim groove.

Make certain the tire bead is properly seated in the rim groove. Once the tires are properly mounted the tires can be permanently fixed to the rims using Cyanoacrylate glue.

To glue the tire to the rim you will need:

- An ampoule of Cyanoacrylate glue.
- Latex Gloves

Note: Do not allow your fingers to come in contact with the Cyanoacrylate glue. The glue can create a very strong bond between skin surfaces that can be painful and injurious to remove.

To adhere the tire to the rim, simply peel the tire bead away from the rim and allow a small amount of Cyanoacrylate glue to flow into the bead groove between the tire bead and the rim groove. Continue to work around the rim until the entire circumference of the tire bead and rim have been glued and properly seated. Repeat the operation for both sides of the tire. Note: The glue will set relatively quickly so it is important to practice setting the tire bead into the rim before attempting to use the Cyanoacrylate glue.

Note the direction of the V tread design. Remember to fit up two right side tires and two left side tires so the V tread point in the same direction.

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