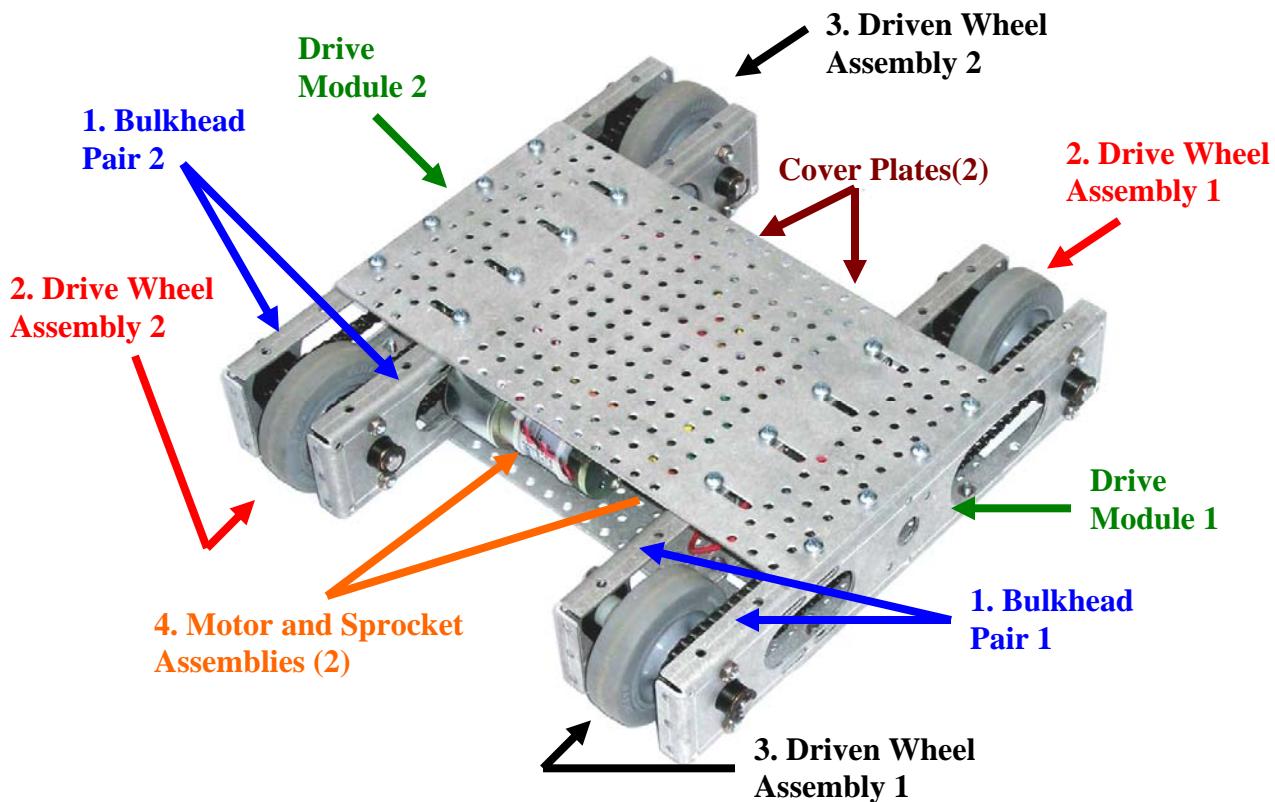


The HMC Heavy Metal Chassis Construction Guide

The Heavy Metal Chassis is constructed using two identical drive modules. The drive modules are constructed using 4 mechanical sub-assemblies. The drive modules are easily integrated into a single chassis using two cover plates.



1. Bulkhead Sets (2 required)

There are four (4) bulkheads paired in two (2) sets. 2 students working together can construct all four bulkheads (both sets) in about 10 - 15 minutes.

2. Drive Wheel Assembly (2 required)

There are two (2) drive wheel assemblies. 2 students working together can construct both assemblies in about 10 - 15 minutes.

3. Driven Wheel Assembly

There are two (2) driven wheel assemblies. 2 students working together can construct both assemblies in about 10 - 15 minutes.

4. Motor and Sprocket Assembly

There are 2 motor and sprocket assemblies. 2 students working together can construct both assemblies in about 10 - 15 minutes.

Total chassis construction time for two students: 70 – 90 minutes.

Necessary Tools

Safety Glasses	3/8 "Wrench
Phillips Head Screwdriver #1 pt. And #2 pt.	Wire Strippers and Crimpers
Allen Wrench or Hex Key (sizes .050, 1/16, 5/64, 3/32, and 1/8)	Smooth File (Small)
	3/16" round file (Similar to a chain saw file)

Materials

Structural/ Mechanical

Qty.	
2	Cover Plates
4	Bulkheads
4	3/8" dia x 4" keyed axles
4	3" Dia. Rubber Caster Wheel Assemblies
	With broached aluminum bushings
6	#25 Pitch, 20 Tooth Steel Sprockets
	With (2) #8-32 Set Screws
2	#25 Pitch, 16 Tooth Steel Sprockets
	With (2) #8-32 Set Screws
2	#25 Pitch, 100 Link Chain and Connecting Link assembly
2	#25 Pitch, 42 Link Chain and Connecting Link assembly
8	3/8" ID Flanged Bearings
2	9.6 Volt x 19.7:1 Competition Gearhead Motors
2	3/32" x 3/32" x 2.3" Round End keyways
2	3/32" x 3/32" x 1.75" Round End keyways

Hardware

Qty.	
4	#10-24 x 1/8" cup point set screws
8	3/8" (Nominal) "E" Retaining Clips
18-20	3/8" ID x 5/8" OD x 0.125" Nylon Spacer Washers
50	#10-32 x 3/8" Machine Screws
40	#10 Lock Washers
4	#10 Flat Washers
18	#10 Nylon Locking Nuts

Electrical

2 ea.	Wire Nuts (grey and blue)
4	1/4" Female Quick Disconnects
2	1/4" Male Quick Disconnects
2	0.201" Female Quick Disconnects
8"	16 ga Insulated Wire (blk and red)
1	Electronic Speed Controller
1	SPST Toggle Switch
1	Battery

Instructional Information

Power point Introducing the educational purpose and performance objectives of the heavy metal chassis project, as well as the components, sub-assemblies and construction steps involved in the project.

Estimates of the average time required to construct the assemblies, modules and chassis integration once the students have been provided the parts and an overview of the performance objectives.

Note: In order to maximize the educational benefit to the students and minimize the time on task, it is advisable to introduce all the components and review this document with the students before beginning the assembly of the HMC.

Sub -Assembly 1

Bulkhead Sets (2 sets required)

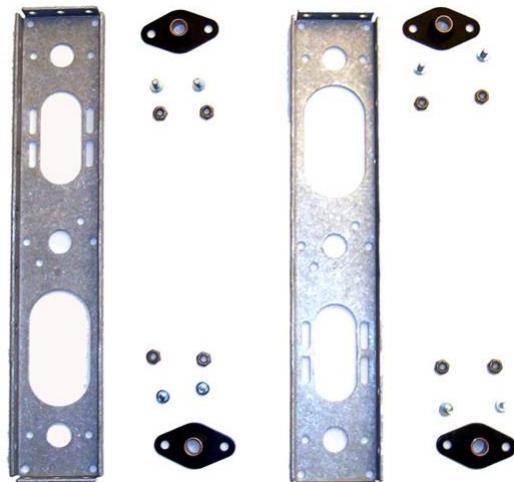
(Average assembly time: 1 student about 10 - 15 minutes)

Note: Since it is necessary to assemble 2 identical modules it might be helpful to assign two students to assemble this module and two other students to assemble the other identical module.

Necessary Components and Tools

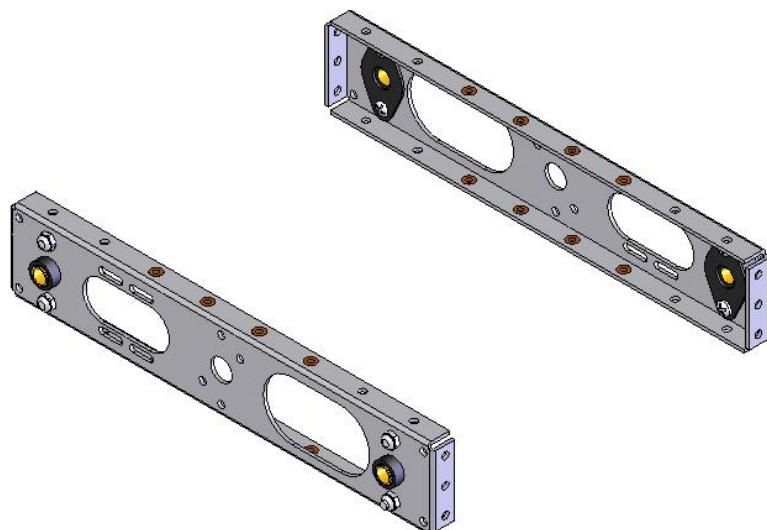
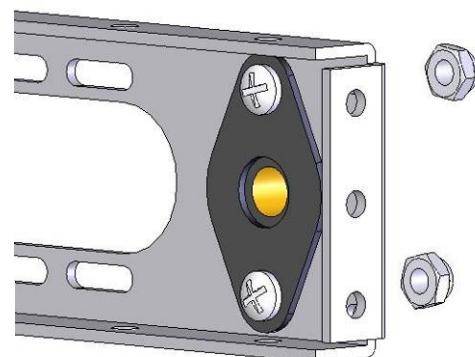
Qty. Description

8	#10 Nylon Locking Nuts
8	#10-32 x 3/8" Machine Screws
2	Bulkhead Plates
4	3/8" ID Flanged Bearings
1	3/8" Combination Wrench (not shown)
1	#2 Phillip Head Screwdriver (not shown)



Procedure

1. Place the 3/8" flanged bearings into the mounting holes on the bulkhead as shown in the illustration below. Place the bearings through the bulkhead plates from the inside, to the outside as illustrated.
2. Attach the flanged bearings using (2) #10-32 x 3/8" Phillips head machine screws, and (2) #10-32 nylon locking nuts. Secure the nuts firmly onto the machine screws using a 3/8" wrench and a #2 phillip head screwdriver. The approximate



torque (Tightening) specification is about 22 - 26 inch pounds. If this specification is not familiar to you then take a moment to research torque specifications online or ask someone who knows.

3. Repeat the procedure for 2 additional assemblies (4 total).

Sub -Assembly 2

Drive Wheel (2 required)

(Average assembly time: 2 students about 10 -15 minutes)

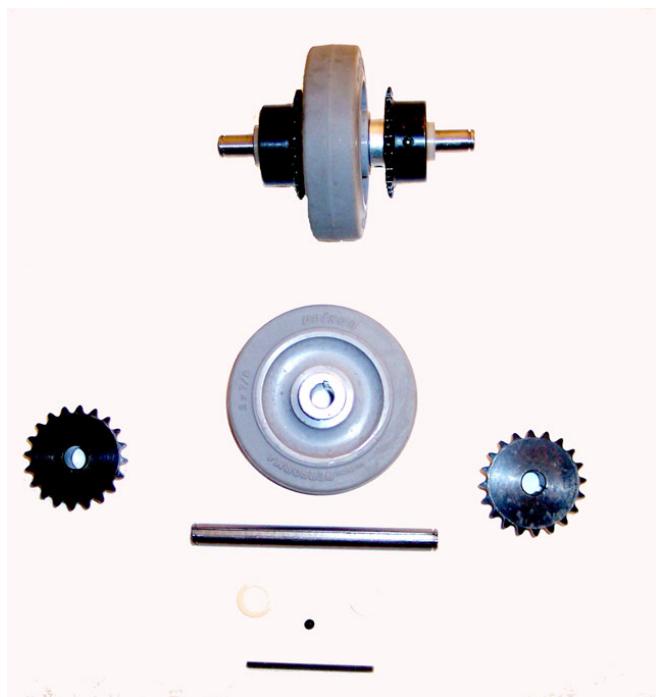
Necessary Components and Tools

Qty. Description

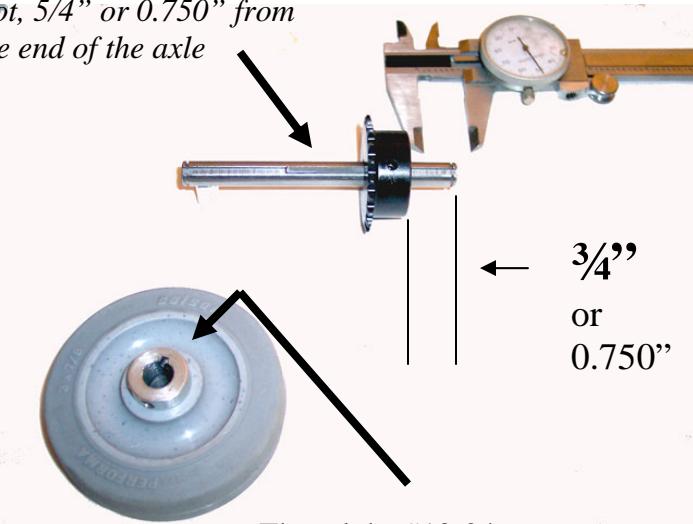
1	3" Wheel and Keyed Aluminum Bushing Assembly
1	#10- 24 Cup Head Set Screw
1	3/8" Dia. x 4" Long Machined Axe with Key Slot
2	#25 Pitch, 20 Tooth Steel Sprockets With 3/32" Internal Broach and (2) #8-32 Set Screws
2	3/8" ID x 5/8" OD x 0.125" Nylon Spacer Washers
2	#25 Pitch, 20 Tooth Steel Sprockets With (2) #8-32 Set Screws
1	3/32" x 3/32" x 2.3" Round End keyways
1	5/64" (0.078") Allen Wrench or Hex Key
1	3/32" Allen Wrench or Hex Key
1	6" Flat File (Fine)
1	Dial Calipers

Procedure

1. Use the flat file to break the edges of the key slot along the entire length of the 3/8" dia. x 4" long machined axle. This will help ensure there are no burred metal edges on the axle key slot, and will allow the key stock to slide smoothly in the axle key slot.
2. Clean the axle key slot removing any dirt or foreign matter.
3. Insert the 3/32" x 3/32" x 2.3" (The longer of the 2) key stock into the key slot on the axle shaft. Position the 3/32" key stock so that one end is 0.750" from one end of the axle.
4. Slide one of the #25 Pitch, 20 Tooth sprockets onto the shaft and key stock assembly as shown. Position the sprocket boss so that it is flush to the end of the key stock and also 3/4" or 0.750" from the end of the axle.



3/32" x 2.3" long key stock positioned in the key slot, 5/4" or 0.750" from the end of the axle



Thread the #10-24 set screw into the aluminum insert on the broach side.

Construct the Drive Wheel Continued.

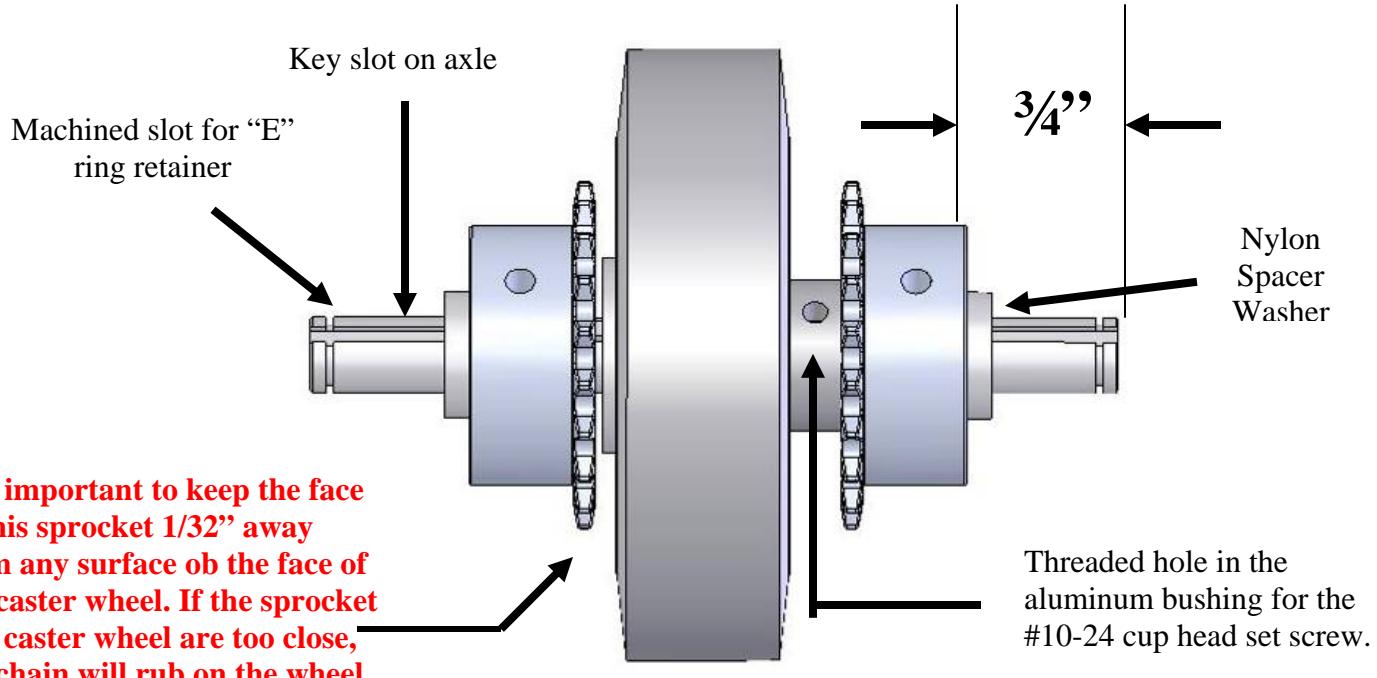
Note: Always check that the set screws are backed off before sliding any component onto the axle and key stock. Otherwise the set screw may hang up on the key stock.

- Fasten the sprocket to the shaft by first tightening the set screw on the key stock. Then tighten the second set screw on the sprocket. Notice there are two (2) set screws on each sprocket boss, These set screws are positioned 90 degrees from each other. Use approximately 6 – 8 inch lbs of torque when tightening the set screws.

Note: If the assembly is to be left in place semi permanently, then it is advisable to use a small drop of blue Loctite® 243.

Remember that blue Loctite® comes in a red bottle! Look it up online and learn why it is used and how best to apply it!

- Thread a #10-24 x 1/8" cup point set screw into the aluminum bushing on the 3" wheel and bushing assembly. Be careful to consider these two steps; One: Thread the set screw into the hole that is in line with the internal broach in the aluminum bushing. Two: Turn the set screw in only one complete turn, no more. Turning the set screw in too far will cause it to hang up on the key stock and it will not be possible to slide the wheel assembly onto the shaft.



Make two (2) of the assemblies illustrated above

Construct the Drive Wheel Continued.

7. Slide a second #25 pitch, 20 tooth sprocket onto the axle on the opposite side of the wheel. Refer to the illustrations on the previous page. Notice the alignment of the second sprocket. The sprocket face is adjacent to the 3" caster wheel. Look closely at the large illustration on the bottom of the previous page, and notice that the face of the left side sprocket is not touching the face of the wheel. In fact the sprocket face must be secured onto the axle at **a distance of 1/32"** from the nearest face of the caster wheel. If the sprocket face is too close, the chain will rub on the wheel. If the sprocket face is too far from the face of the wheel, the axle assembly will bind on the bearing faces and the added friction will degrade the performance of the Heavy Metal platform.
8. Check that all the set screws are securely tightened and the critical spacing from the end of the shaft (3/4") and the face of the sprocket on the left side of the assembly, (1/32") are correct.
9. Add a 3/8" ID x 1/8" (0.125") nylon spacer washer to each end of the axle assembly.
10. Assemble another, identical unit since two of these assemblies are required to complete the Heavy Metal Chassis.

Sub -Assembly 3

Driven Wheel (2 required)

(Average assembly time: 2 students about 10 - 15 minutes)

Necessary Components and Tools

Qty. Description

1	3" Wheel and Keyed Aluminum Bushing Assembly
1	#10- 24 Cup Head Set Screw
1	3/8" Dia. x 4" Long Machined Axle with Key Slot
1	#25 Pitch, 20 Tooth Steel Sprockets With 3/32" Internal Broach and (2) #8-32 Set Screws
7	3/8" ID x 5/8" OD x 0.125" Nylon Spacer Washers
2	#25 Pitch, 20 Tooth Steel Sprockets With (2) #8-32 Set Screws
1	3/32" x 3/32" x 1.75"" Round End keyway
1	5/64" (0.078") Allen Wrench or Hex Key
1	3/32" Allen Wrench or Hex Key
1	6" Flat File (Fine)
1	Dial Calipers

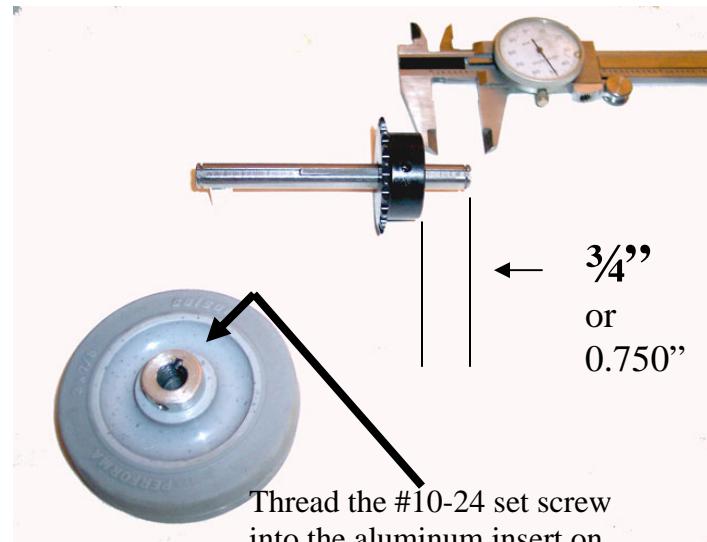
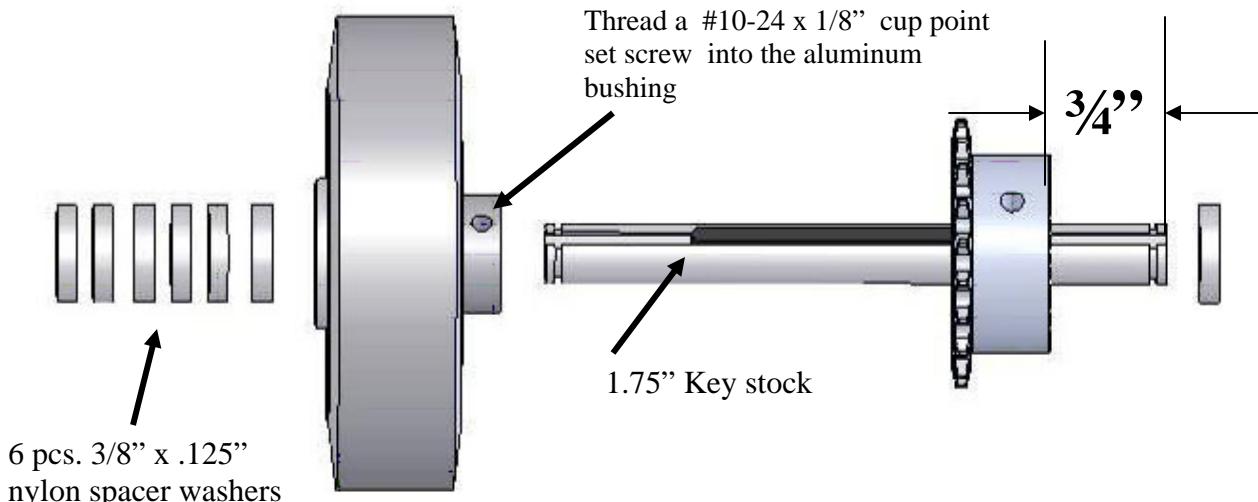


Procedure

1. Use the flat file to break the edges of the key slot along the entire length of the $3/8"$ dia. $\times 4"$ long machined axle. This will allow the key stock to slide smoothly in the axle key slot.
2. Clean the axle key slot removing any dirt or foreign matter.
3. Insert the $3/32" \times 3/32" \times 1.75"$ (The shorter of the 2) key stock into the key slot on the axle shaft. Position the $3/32"$ key stock so that one end is $0.750"$ from one end of the axle.
4. Slide the #25 Pitch, 20 Tooth sprocket onto the shaft and key stock assembly as shown. Position the sprocket boss so that it is flush to the end of the key stock and also $3/4"$ or $0.750"$ from the end of the axle.
5. Fasten the sprocket to the shaft by first tightening the set screw on the key stock. Then tighten the second set screw on the sprocket. Notice there are two (2) set screws on each sprocket boss, These set screws are positioned 90 degrees from each other. Use approximately 6 – 8 inch lbs of torque when tightening the set screws.

Note: If the assembly is to be left in place semi permanently, then it is advisable to use a small drop of blue Loctite® 243. Remember that blue Loctite® comes in a red bottle! Look it up online and learn why it is used and how best to apply it!

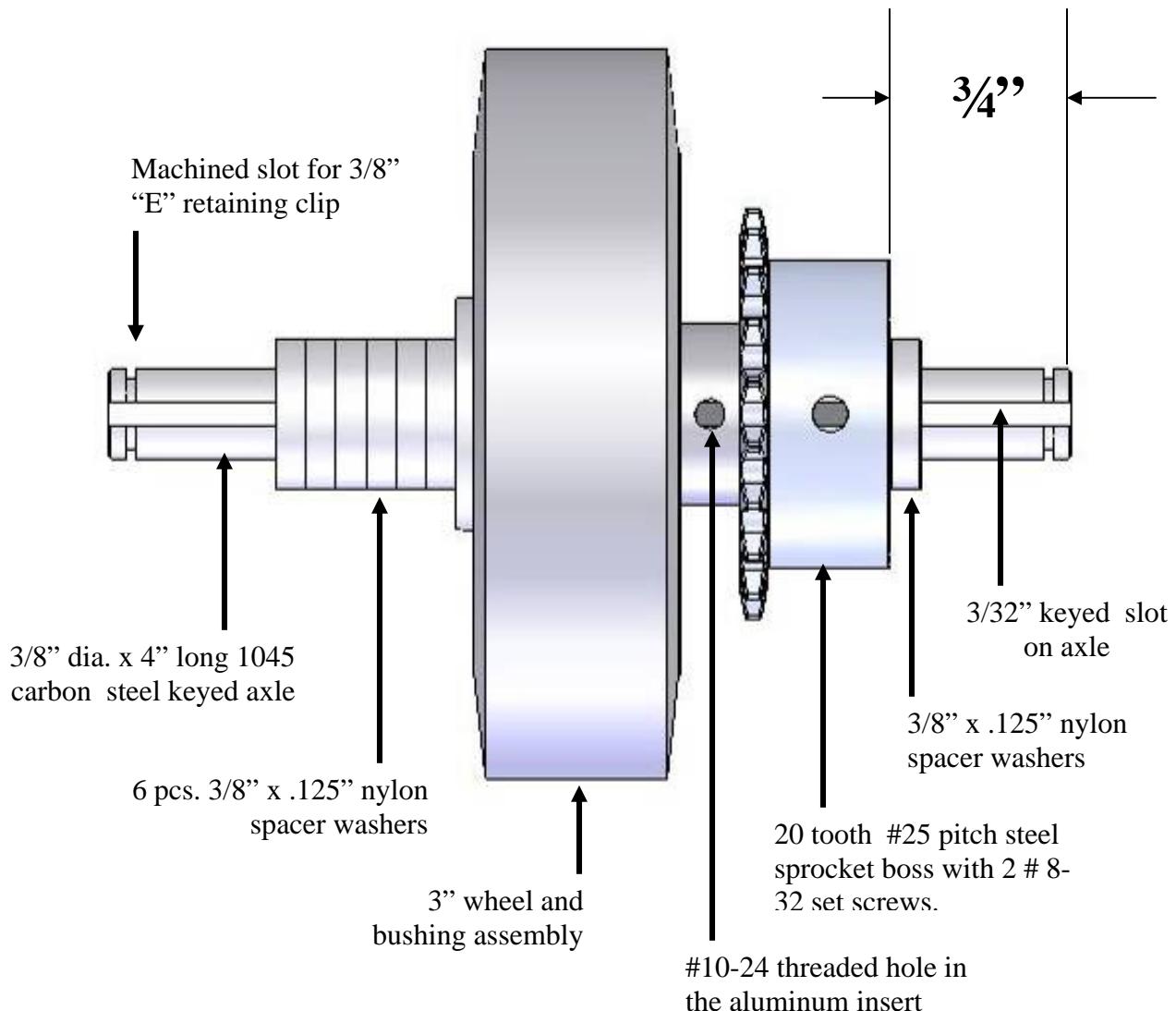
6. Thread a $\#10-24 \times 1/8"$ cup point set screw into the aluminum bushing on the $3"$ wheel and bushing assembly. Be careful to consider these two steps; One: Thread the set screw into the hole that is in line with the internal broach in the aluminum bushing. Two: Turn the set screw in only one complete turn, no more. Turning the set screw in too far will cause it to hang up on the key stock and it will not be possible to slide the wheel assembly onto the shaft.



Thread the $\#10-24$ set screw into the aluminum insert on the broach side.

Driven Wheel continued

7. Check that the wheel and bushing assembly is securely fastened to the axle and key stock. Slide six (6) 3/8" ID x 0.125" thick nylon spacer washers onto the shaft as shown.
8. Recheck that the sprocket boss is $\frac{3}{4}$ " (0.750") from the end of the shaft and the key stock is not extending out past the face of the sprocket boss. Note: Even the slightest extrusion of the key stock past the sprocket boss will introduce unnecessary friction and wear on the spacer washer, and ultimately cause the motor and batteries to consume more energy and less motive power.



Construct two (2) of the assemblies illustrated above

Sub -Assembly 4

Motor and Sprocket (2 required) (Average assembly time: 2 students about 5 minutes)

Necessary Components and Tools

Qty. Description

- 1 Gearhead motor
- 2 #10- 32 x 3/8" Phillips head machine screws
- 2 #10 lock washers
- 2 #10 flat washers
- 1 16 tooth, 25 pitch steel sprocket with 1/4:" bore and (2) #8-32 cup head set screws
- 1 12" – 14", #2 point Phillips head screwdriver
- 1 3/32" Allen Wrench or Hex Key



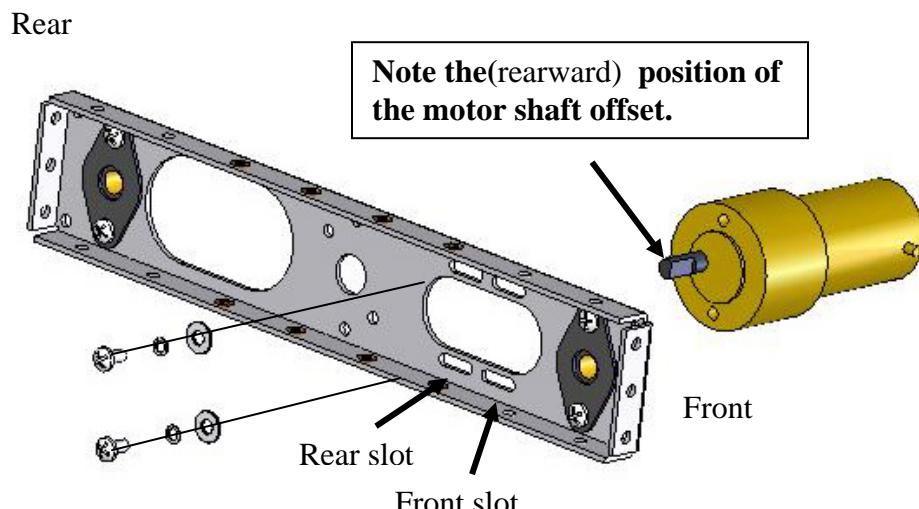
Procedure

1. Fasten the

gearhead motor to the bulkhead by threading the #10-32 x 3/8" Phillips head screws, lock washers and flat washers through the **middle** of rear most slot.

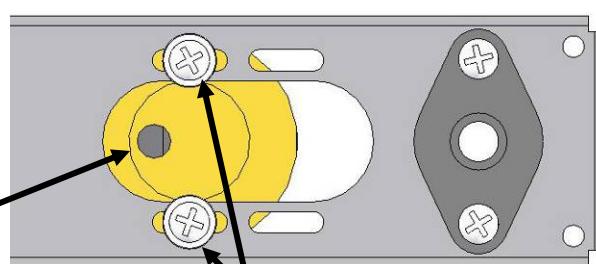
Note: Always use flat washers to mount the gearhead motors. They are used to spread the clamping force evenly over a wider area.

2. Take care to position the motor shaft offset to the rear (left as shown in the illustrations above and below). DO NOT POSITION THE SHAFT TO THE FRONT OR RIGHT SIDE.



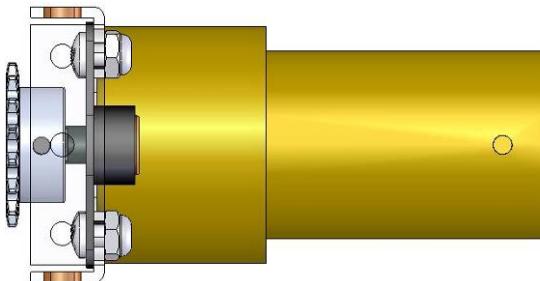
Rear/left
Offset motor shaft to the rear/left of the bulkhead

Front/right

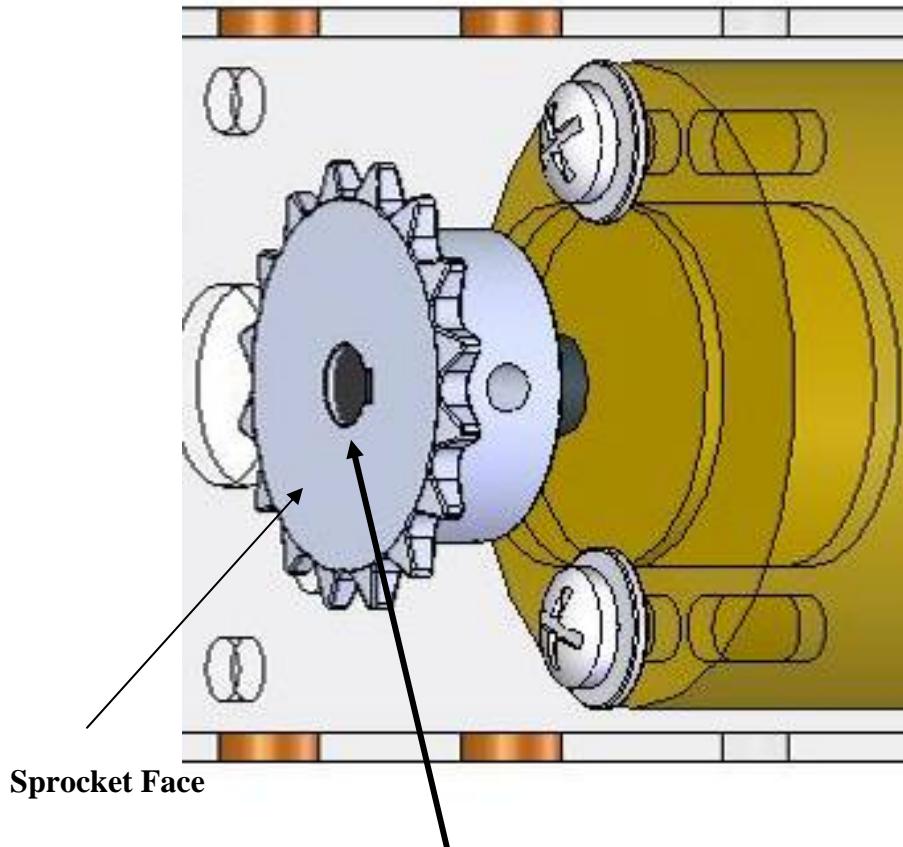


Both, #10 machine screw positioned in the center of the slot

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3. Tighten the #10-32 Phillips head machine screws, lock washer and flat washer assemblies while keeping them centered in the slot. Use approximately 20-25 inch lbs of torque.
4. Position the 16 tooth, 25 pitch sprocket onto the motor shaft with the sprocket boss facing inward towards the motor gearbox as shown above/left. Make sure that both #8-32 set screws are backed off enough to allow the sprocket to slide easily onto the motor shaft.
5. Identify the flat on the motor shaft and position one of the set screws directly over the flat on the shaft. Slide the sprocket onto the motor shaft and gently tighten one set screw onto the flat of the motor shaft in such a way that the sprocket face extrudes 0.025" beyond the end of the motor shaft. Use the tail end of the dial calipers to make this measurement. (See below/right)
6. Tighten the set screw on the flat of the motor shaft to hold the sprocket in the correct position (0.025" past the end of the motor shaft).
7. Remove the second set screw and place a small drop of blue Loctite™ thread locker onto the set screw threads and thread the set screw into the sprocket boss and tighten firmly (approximately 12 inch lbs.) Repeat this procedure for the second set screw. Be careful to check the sprocket shaft offset and maintain the 0.025" specification. Use dial calipers to measure and confirm the distance.



Be careful to position the face of the sprocket so that it is offset 0.025" from the end of the motor shaft, and that one set screw is secured to the flat on the motor shaft. Use a small drop of Loctite™ thread locker on each set screw for best results.

Drive Module Construction

Integrate Motor/Sprocket and Drive Wheel (2 required)

(Average assembly time: 2 students about 10 minutes per assembly)

Necessary Components and Tools

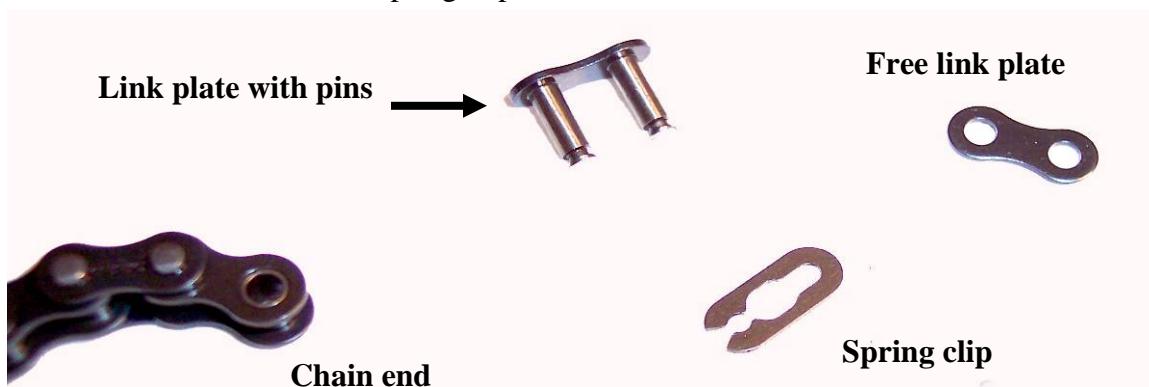
Qty. Description

- 1 Pre-made motor and Bulkhead Assembly (See step 7-8)
- 1 Pre-made Drive Wheel assembly (See step 3 and 4)
- 1 Pre-made bulkhead assembly. (See step 1 and 2)
- 1 42 link, #25 pitch chain assembly.
- 1 #25 pitch connecting link (on chain end)
- 1 Pair (Small) needle nose pliers (not shown)
- 1 Small (Jewelers' size) flat screwdriver
- 1 "E" retaining clip (not shown)

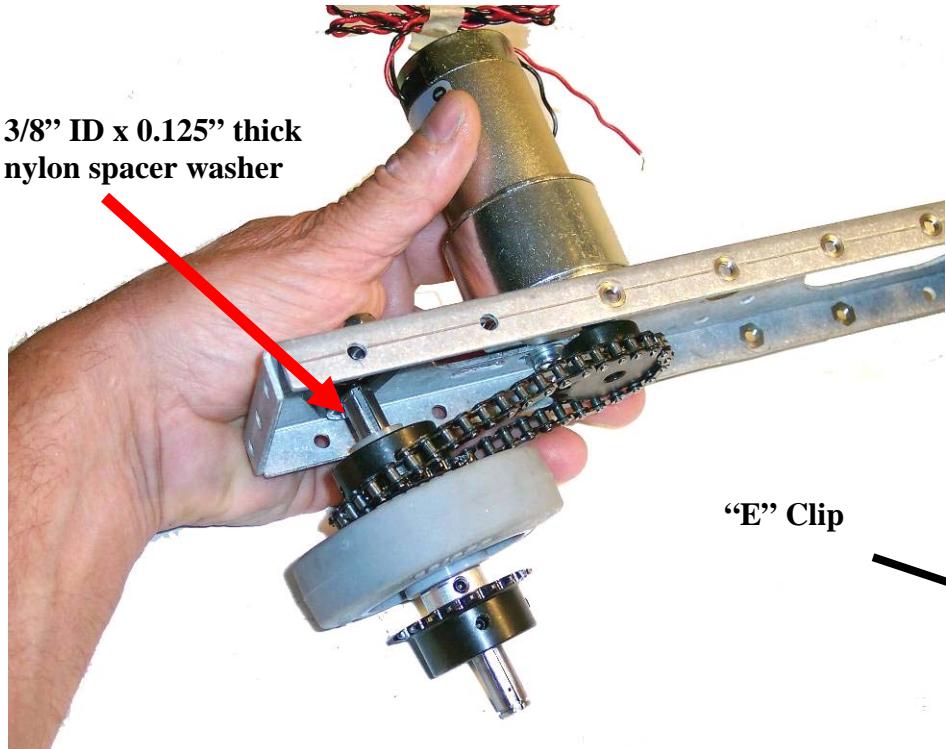
Procedure

1. Assemble the 42 link chain (*this is the shorter of the two chain lengths*) into a continuous loop. In order to do this it will be necessary to remove the connecting link from the end of the length of chain. There are several ways to do this. One way is illustrated below
2. Use a pair of small needle nose pliers to simultaneously grip one end of the chain pin and one end of the spring clip retainer on the connecting link.
3. Slowly squeeze the pliers closed in an effort to slide the retaining clip to the right, and off the front pin. Then disassemble the connecting link.

The connecting link is comprised of three parts; Link plate with pins, free link plate with oversized holes and a spring clip.



4. Use the connecting link to attach the two ends of the chain in a continuous loop and re-assemble the connecting link using the pliers to slide the spring clip onto the pins.
5. Wrap the 42 link chain around the motor sprocket and the drive wheel sprocket as shown below. Make certain there is a $3/8"$ ID x $0.125"$ thick nylon spacer washer on the bearing end of the axle.

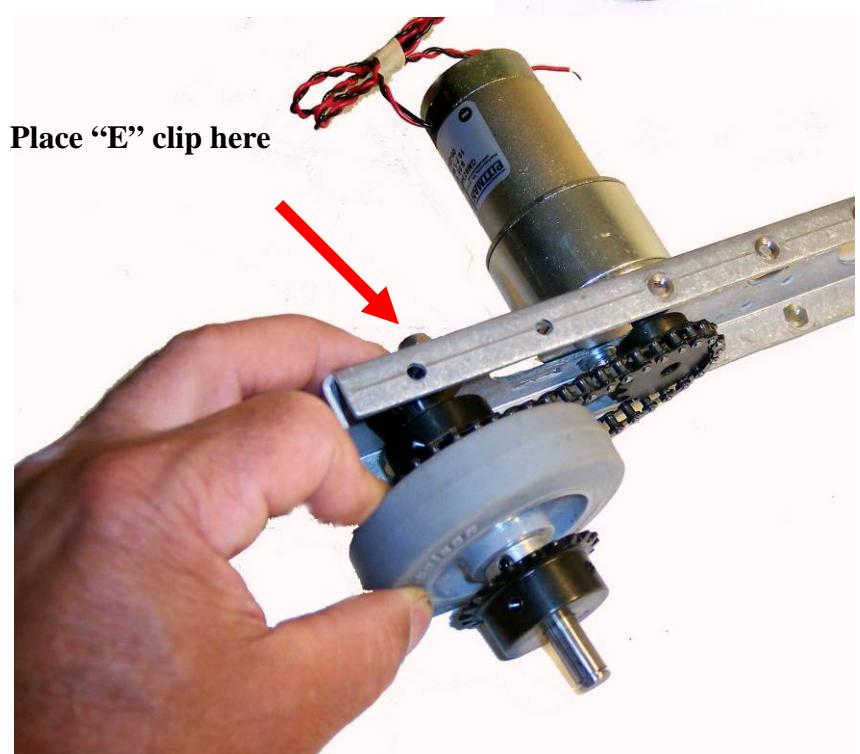


6. Insert the axle into the flanged bearing and fasten an "E" (retaining) clip onto the end of

"E" Clip



The "E" clip can be pushed into the machined groove on the axle end with just thumb pressure. Remove it by prying it off with a screw driver



Drive Module continued

Integrate Driven Wheel and Chain

(2 required) (Average assembly time: 2 students about 10 -15 minutes)

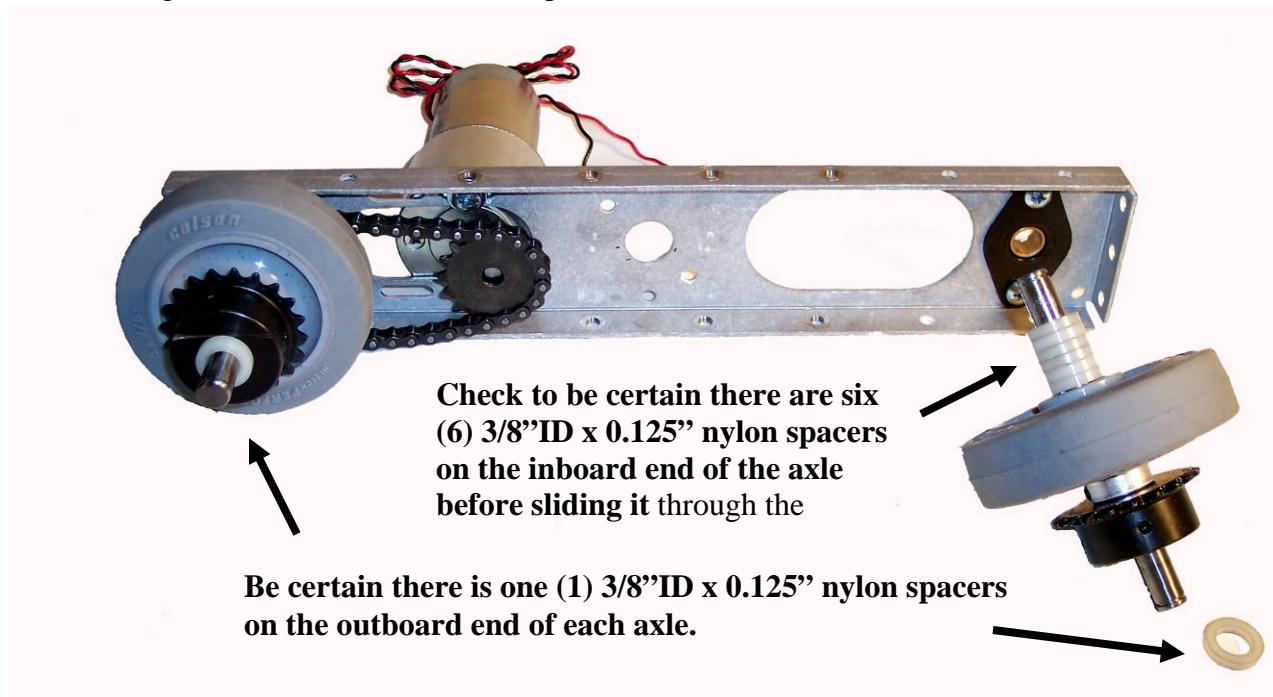
Necessary Components and Tools

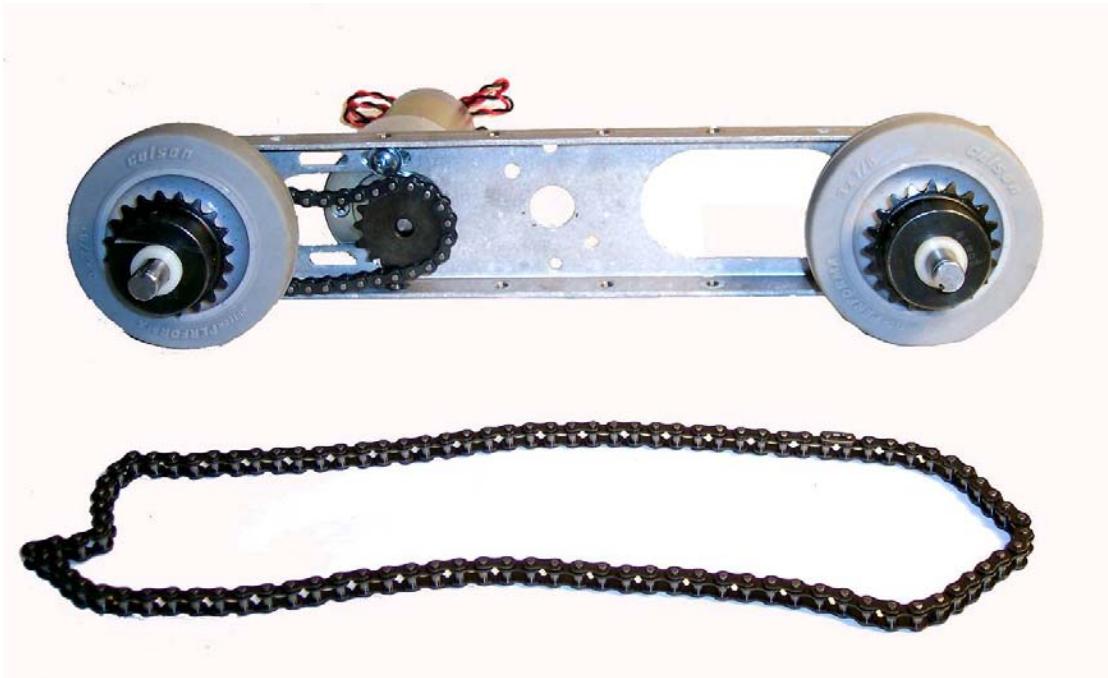
Qty. Description

- 1 Pre-made motor, bulkhead and drive wheel assembly (See 9-10)
- 1 Pre-made driven wheel assembly (See 5 -6)
- 1 100 link,#25 pitch chain assembly.
- 1 #25 pitch connector link
- 1 Pair (Small) needle nose pliers (not shown)
- 1 Small (Jewelers' size) flat screwdriver (not shown)
- 1 12" – 14", #2 point Phillips head screwdriver (not shown)
- 1 Pre-made motor, bulkhead (see 1-2) (not shown)
- 3 "E" retaining clips (not shown)

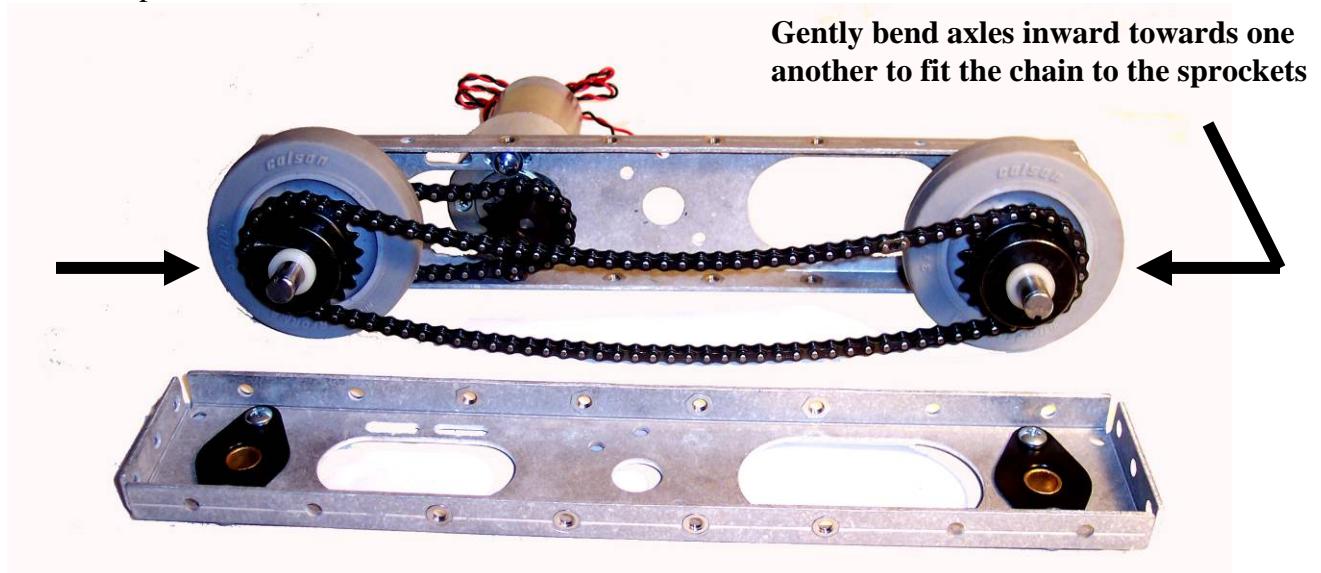
Procedure

1. Fit the driven wheel assembly to the pre-made motor, bulkhead and drive wheel assembly (See 9-10) Be certain that there are six (6) 3/8" ID x 0.125" thick nylon spacer washers on the inboard end of the axle. Guide the axle end through the flanged bearing and secure it with an "E" clip.





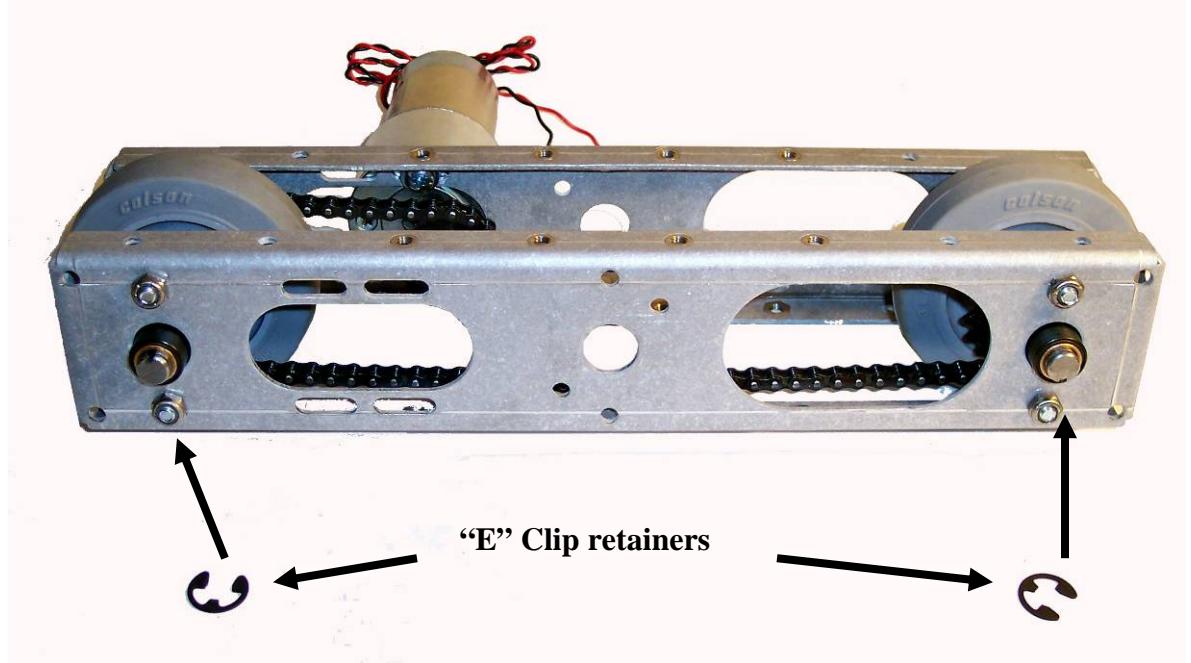
2. Connect the #25 pitch, 100 link chain using the connecting link on the end of the chain. See instructions for disconnecting and connecting the link and chain in Assemblies 9-10.
3. With the two wheel assemblies positioned in the flanged bearings and secured with “E” clips; bend the axles towards one another as shown. The flanged bearings are self aligning bearings, and they allow for up to 5 degrees of axial rotation. Bending the axles brings the sprockets closer together making it easier to fit the 100 link chain to the sprockets.



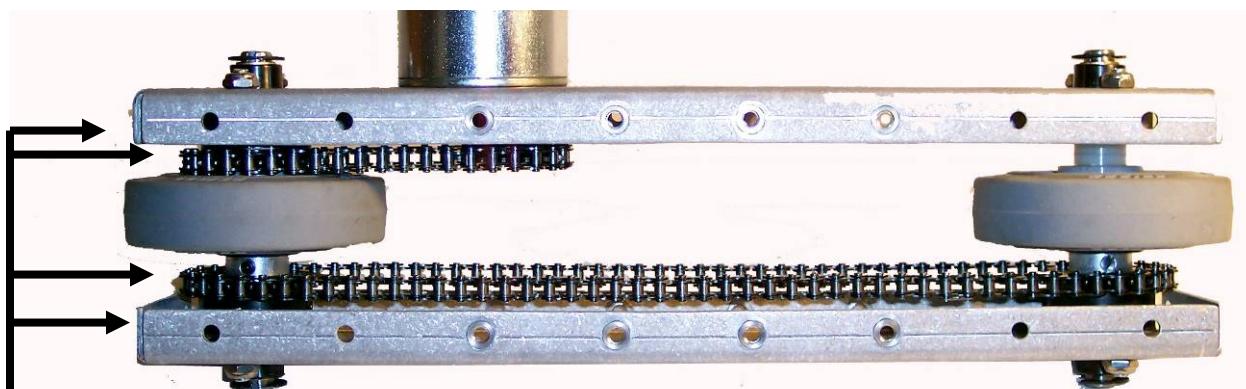
4. After the chain has been fitted to the sprockets, bend the axles outward and slide the axle ends into the flanged bearings on the outboard bulkhead assembly.

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5. Secure the axles onto the outboard bulkhead using the “E” clips as illustrated in 9-10.



6. After completing the initial assembly of the drive module, it is necessary to perform both a visual check and a operational check to ensure correct alignment and tension of the chain and sprocket pairs. The visual inspection ensures the paired sprockets are parallel and on the same plane, and that the chains are running straight with respect to the sprocket pairs. An easy way to do this is to look at the drive module assembly from directly above. Visually line the chains up with the edges of the bulkheads and check to see that the chain path and the bulkhead edges are parallel. If either of the chain and sprocket pairs are not running straight and true, then the module will need to be disassembled and the necessary components repositioned in order to ensure correct (parallel) chain drive alignment.

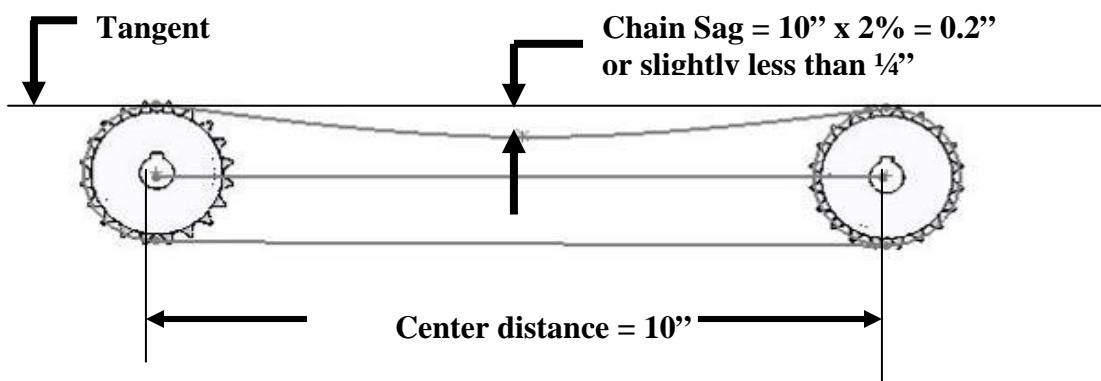


The visual check is necessary to ensure the proper and parallel alignment of the chain and sprocket pairs as well as proper chain tension

7. Proper chain tension can be determined by measuring the chain sag as follows.
 - A. Rotate the paired sprockets so that the bottom chain chord is tight.
 - B. Measure the amount of chain sag from the center of a reference line tangent to each of the paired sprockets.
 - C. The measured amount of chain sag should be at least equal to two or three percent of the tangent length between the sprockets.

Note: The motor and drive wheel chain tension can be adjusted by loosening the motor mounting screws and sliding the motor along the mounting slots on the bulkhead. The drive and driven wheel axles are on fixed centers and the correct sprocket distance and chain tension has been predetermined.

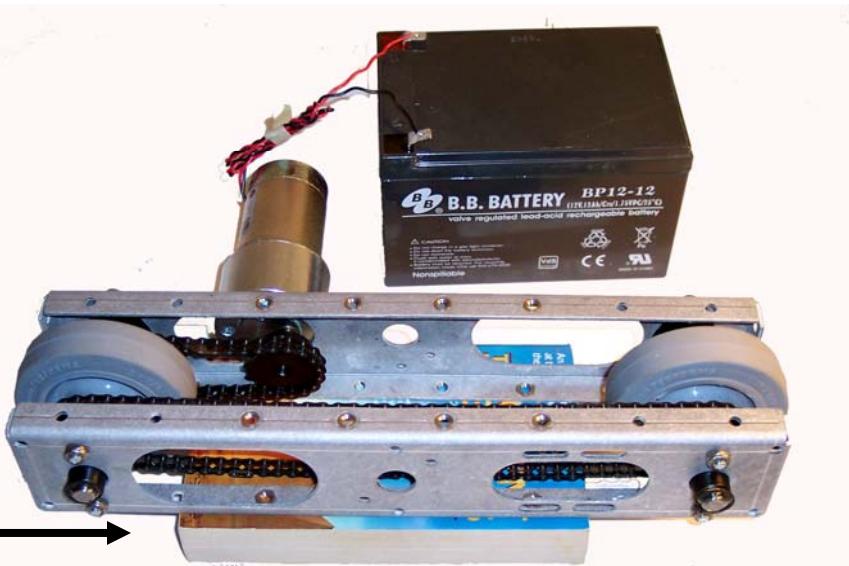
The chain tension check for the GEARS Heavy Metal Chassis is illustrated below.



8. An operational check can be made by setting the drive module on a stable platform such as a book, or wood block and energizing the motor by connecting it to a 9-12V battery. **Note: It is always advisable to have two people perform the operational check. The drive module wheels should not be in contact with any surface or object. Never hold the module while it is being energized. Keep hands free of the rotating chain and sprockets**

Note: The 100 link chain will occasionally slap against the bottom of the chassis. This is due to the low profile of the bulkheads, and the necessity for some sag in the chain.

Book or wood block used to lift the wheels well off any surface



Chassis Integration

Drive Modules (2) and cover plates (2) (Average assembly time: 2 student about 10 -15) minutes)

Necessary Components and Tools

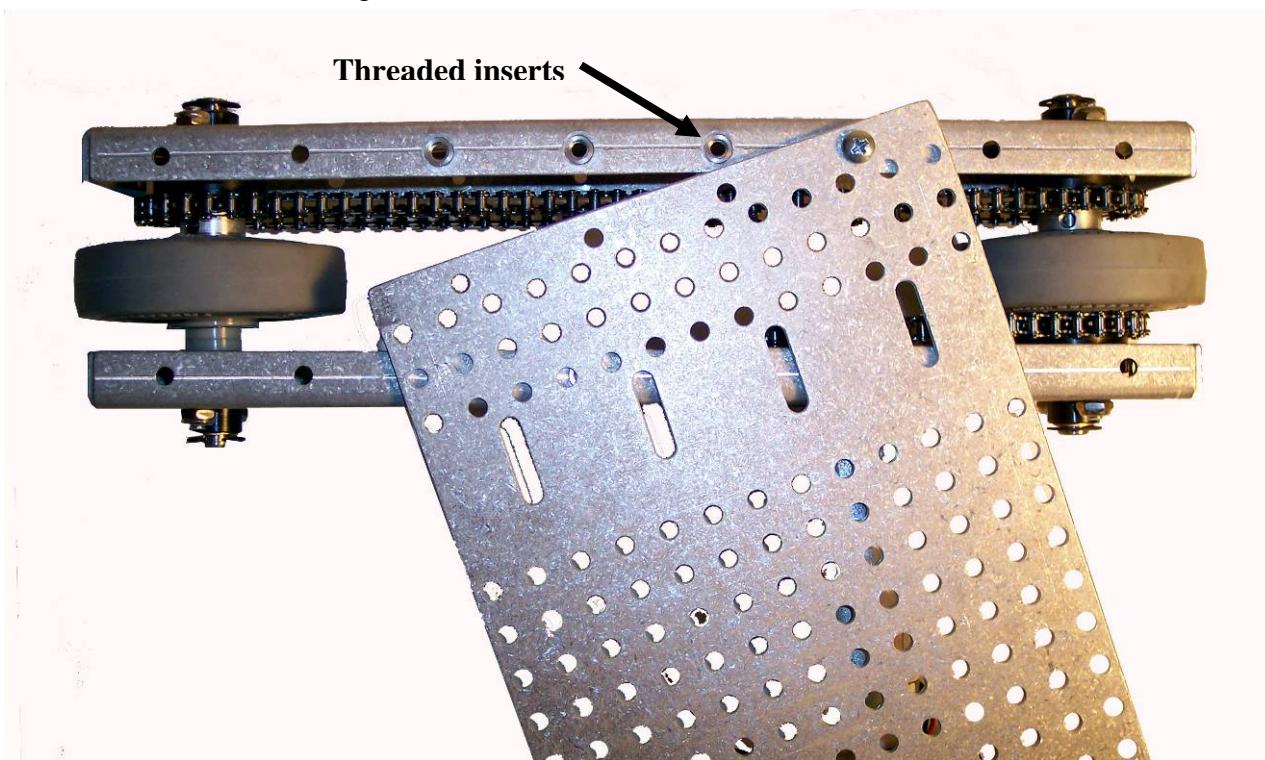
Qty. Description

2 Pre-made drive module (See 11-12)
2 Cover plates
32 #10-32 x 3/8" Phillips head machine screws
32 #10 lock washers
1 12" – 14", #2 point Phillips head screwdriver (not shown)
1 3/16" diameter rat tail file (Not shown)

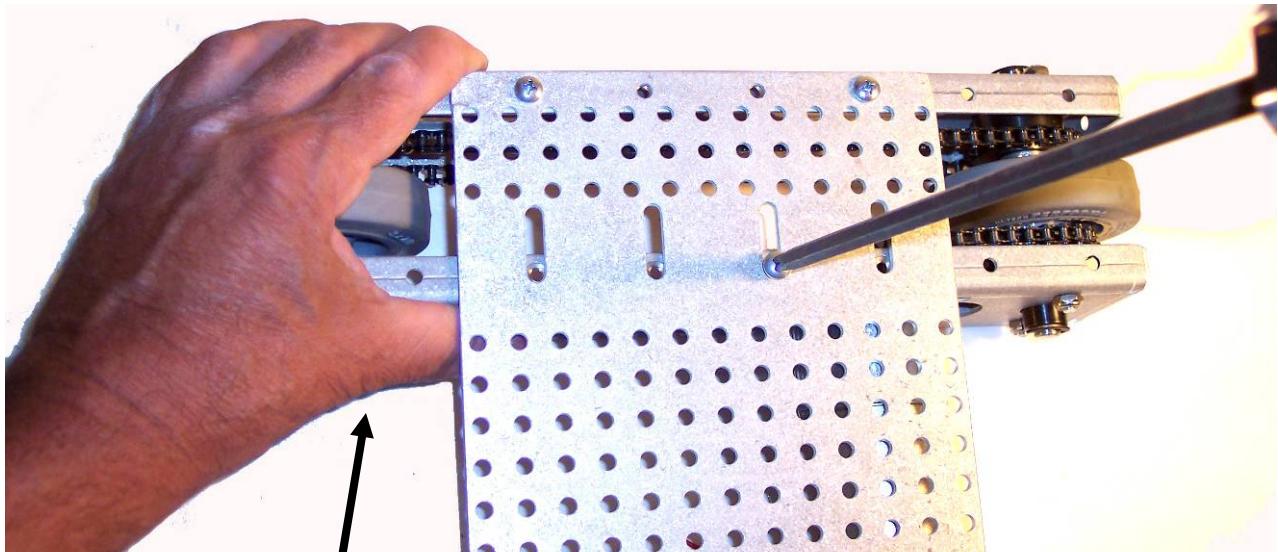
Procedure

Note: This is the final step in the mechanical assembly of the Heavy Metal chassis. It will be necessary to fit up the completed machine, check and adjust fits and interferences and then remove one of the cover plates in order to wire the motors and control components. However, assembly and disassembly is quickly and easily accomplished since the Heavy Metal chassis makes efficient use of threaded inserts to secure the cover plates.

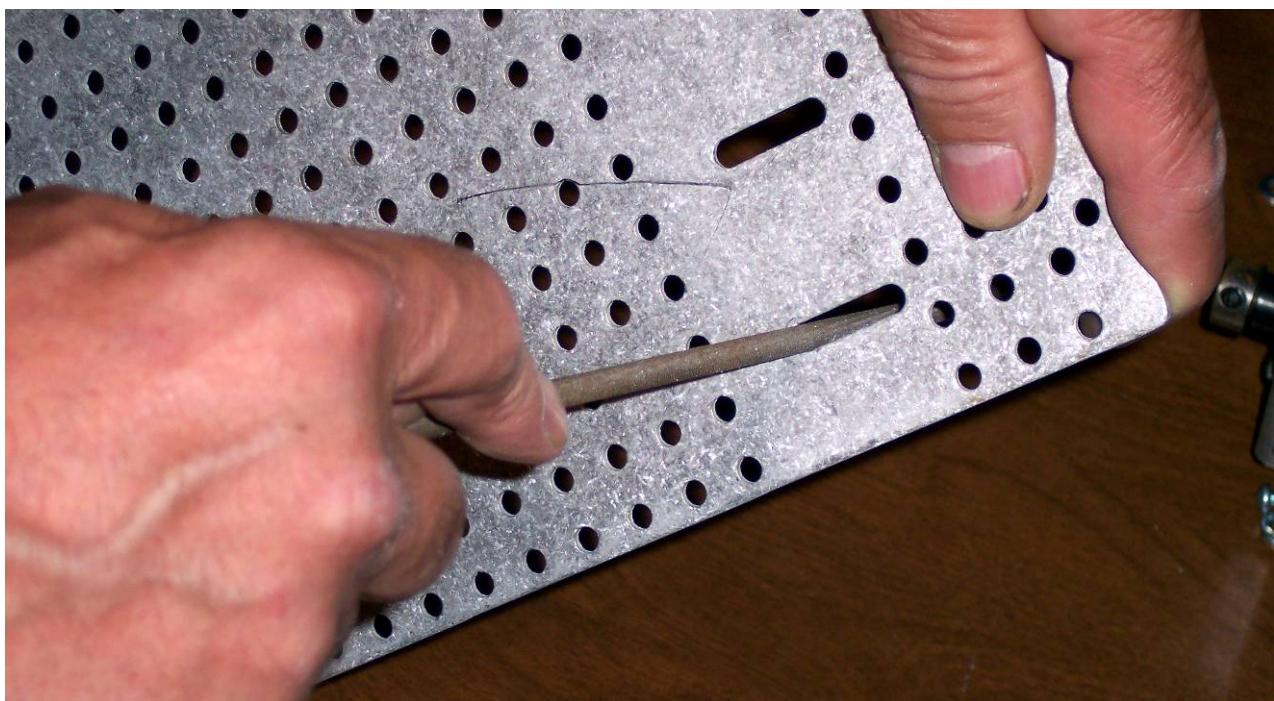
1. Align the 4 outside holes of the cover plate with the 4 outboard threaded inserts along the top of the bulkhead and attach the cover plate with 4 machine screws and lock washers. Do not tighten the screws at this time.



2. Align the 4 slots on the cover plate with the 4 threaded inserts on the inboard side of the bulkhead. In order to do this, it may be necessary to gently squeeze the bulkheads together. If the squeeze force necessary to align the cover plate slots with the threaded inserts becomes too great, it will add unnecessary friction to the drive system. To alleviate this problem increase the length of the slots by filing them with a $3/16"$ diameter round or rat tail file similar to those used to sharpen a chain saw (see the illustration below). When lengthening the slot becomes necessary, it is usually only a matter of increasing the length by $0.015" - 0.025"$.

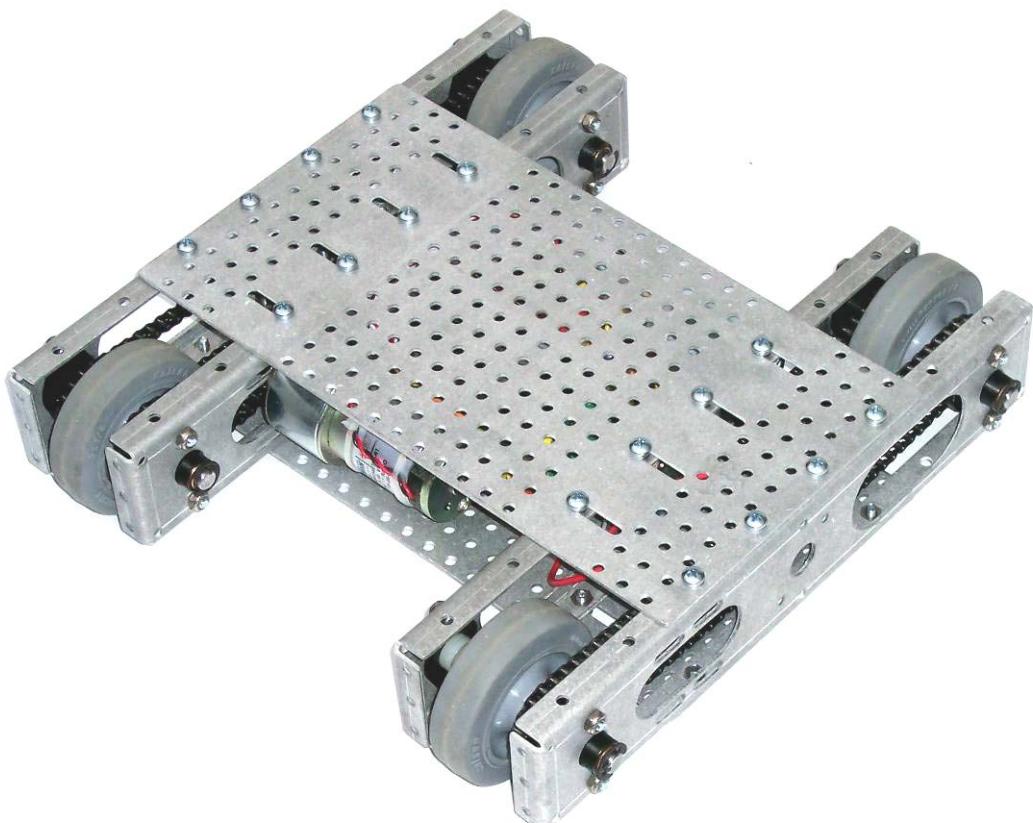


Gently squeeze the bulkheads together to bring the slots and threaded inserts into alignment.



If necessary, lengthen the slots by filing them with a $3/16"$ round file

3. Repeat the process described to attach the second drive module and the second cover plate. When both cover plates have been attached and the Phillips head screws have been tightened to approximately 22 -26 inch pounds of torque, it will be necessary to check the drag on the drive train components. Excessive drag is usually caused by too much squeeze between the bulkhead plates, or a misalignment in the drive train components. To test for excessive drag simply hold the completed chassis and turn the wheels by hand. First one side, then the other. Compare the force needed to turn them. The force should be equal, and it should "Feel" smooth and loose. The only force you will be turning against are the forces of the chain drives, the gear box friction and the magnetic drag of the motor on the steel armature plates. Less drive train drag means better performance, smoother throttle response and longer run times from a charged battery!



Heavy Metal Wiring Guide

Using the GEARS I Single Channel Speed Controller with an RC Radio

Necessary Tools

Safety Glasses	Side Cutters
Wire Strippers	Pliers
Wire Crimping Tool and or Wire Nuts (Blue/Grey)	Solder Iron (Optional)

Materials

Qty.

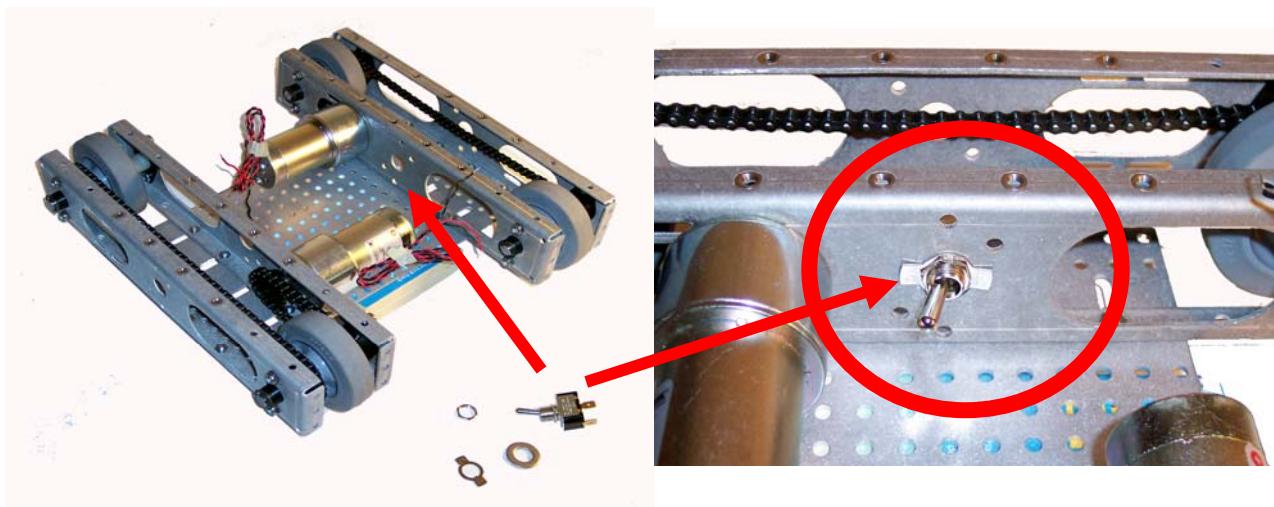
2	GEARS I Single Channel Speed Controllers	1	SPST Toggle Switch
1	12 Volt Battery	1	7/16" Flat Washer
1	RC Radio Transmitter	8-12"	16ga Insulated Wire (Red)
1	RC Radio Receiver	8-12"	16ga Insulated Wire (Black)
4	1/4" Female Quick Connects (Insulated)		Solder and heat shrink (optional)
4-8	6" Zip Ties		

Note: Please refer to the speed controller product document at the end of this manual before beginning to wire the chassis. The documentation provided here is only one (specific) example of how a given pair of speed controllers may be wired to the chassis. Since there are many speed controller, battery, radio, microcontroller combinations, it will be necessary to make specific decisions "In the field". Therefore it is important to become familiar with the specific product requirements for the speed controller/battery/radio/microcontroller combinations you plan to employ. Take the time to read and understand the manuals before you unknowingly damage expensive components.

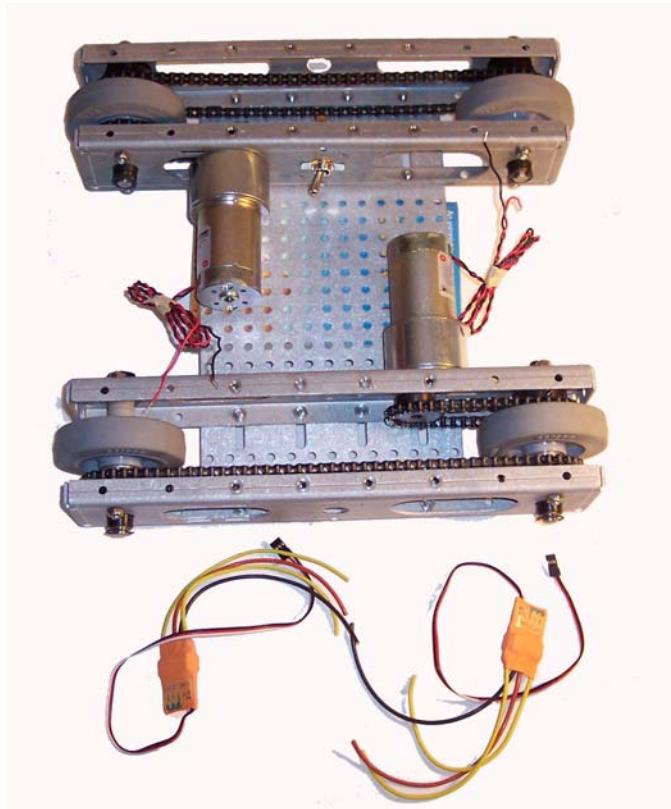
Procedure

1. Using the 7/16" flat washer, fasten the SPST toggle switch to the interior bulkhead of the Heavy Metal Chassis.

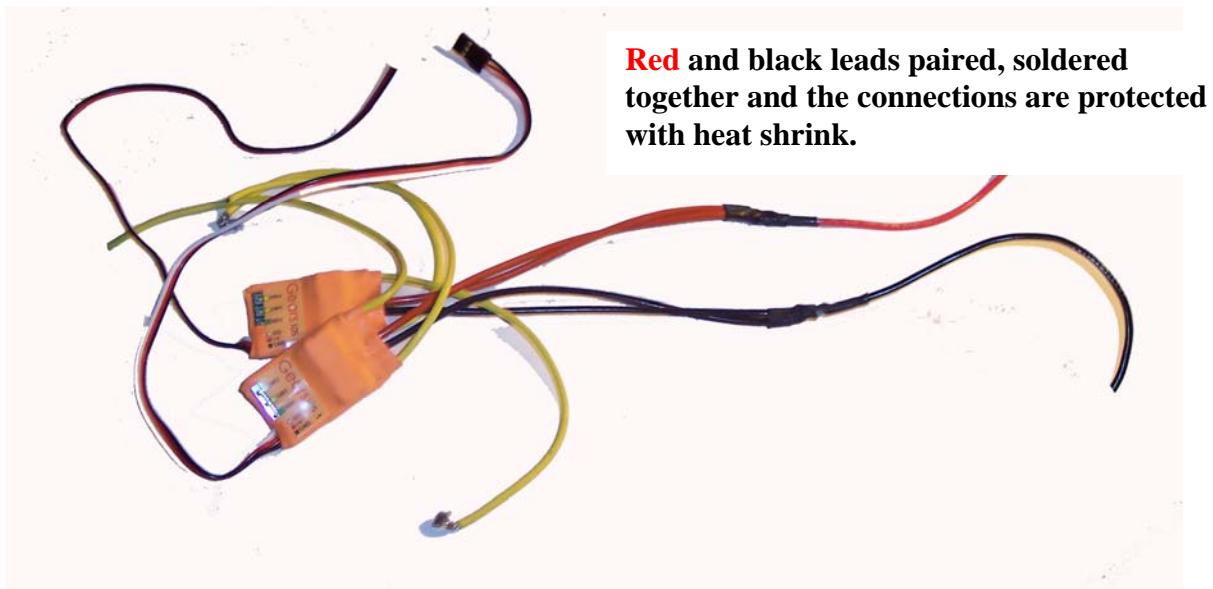
Note: With the switch in this position it is necessary to cut a length of coat hanger wire and bend a loop on the end with a pair of needle nose pliers in order to easily reach and activate the switch.



2. Connect the red and black power leads of the two (2) GEARS I speed controllers by twisting them together. Crimp a $\frac{1}{4}$ " Female quick disconnect onto each end of the twisted pairs. Connect the red lead to one side of the toggle switch. (It does not matter which side). Connect the black twisted pair to the negative battery terminal. (*In this example we assume the battery terminal is a $\frac{1}{4}$ " spade connector. Since there are many types of battery terminals it will be necessary to make this selection in the file*)



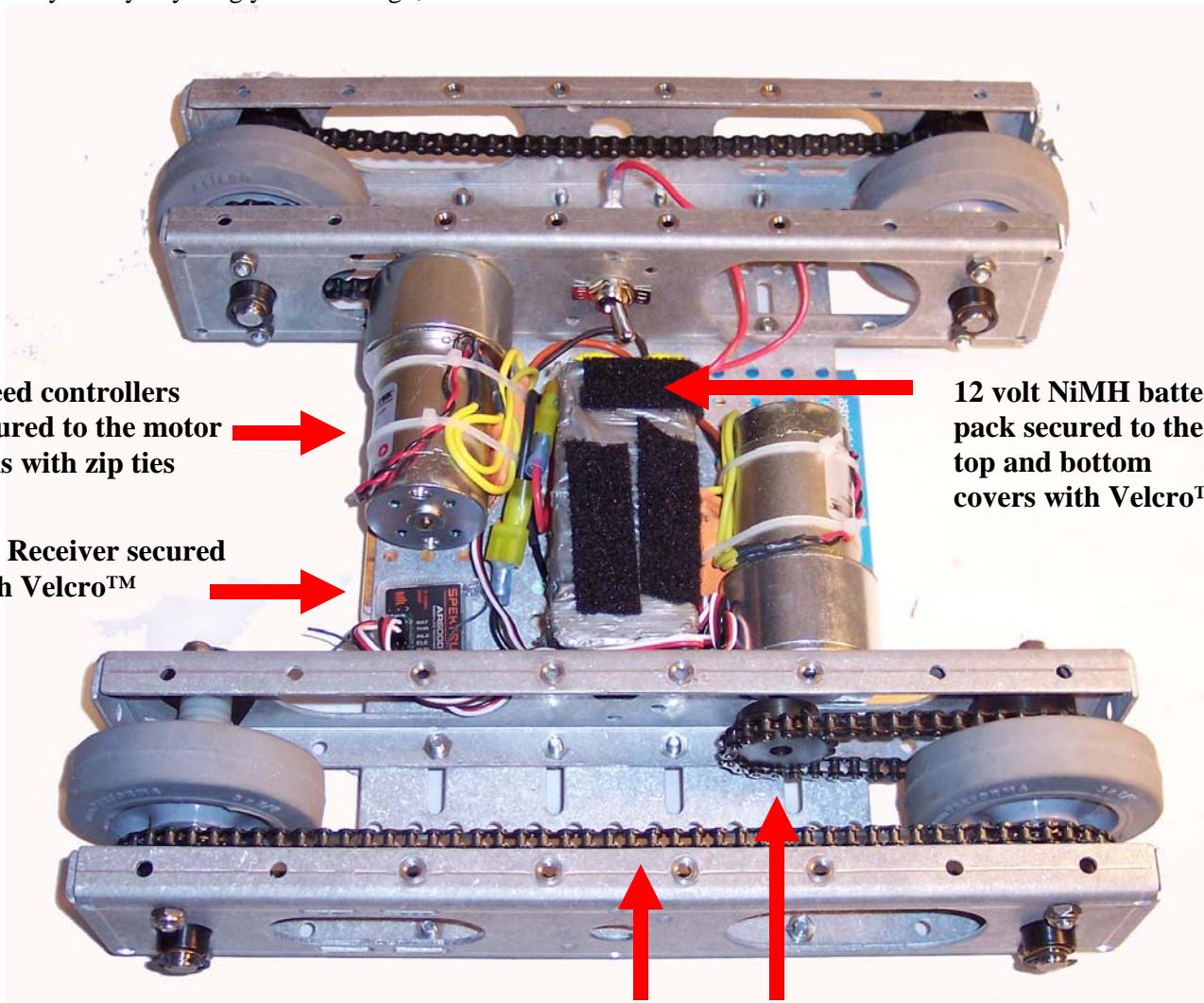
7. Connect the signal wire (3 wire leads white/red/black) to the radio receiver.



3. Make up a length (approximately 6") of **red wire** by stripping both ends and crimping on a $\frac{1}{4}$ " female quick connect to each end. (This depends on how you plan to connect to your battery. (*In this example we assume the battery terminal is a $\frac{1}{4}$ " spade connector. Since there are many types of battery terminals it will be necessary to make this selection in the file*) One end of the wire connects to the remaining pole of the toggle switch and the other end connects to the positive battery terminal.
4. Cut the red and black motor leads to approximately 4" and strip the ends.
5. Strip the ends of each pair of yellow motor leads on the GEARS-I single channel speed controllers.
6. Connect each pair of the yellow leads to pair of (red/black) motor leads. Remember to match one speed controller to one motor.

The illustration below is an example of a completed and secured wiring installation. The SPST toggle switch is fastened to the center hole of the bulkhead. The speed controllers are zip tied to the motors, the custom made 12 volt Nickel Metal Hydride battery pack is secured in the center of the chassis with Velcro™ strips top and bottom. The RC receiver is also secured with Velcro™

At this point the chassis (Top) cover can be fitted with any number of options such as an arm, a pan tilt camera, sensors, solar panels or any other number of robotic creations!...this chassis is tough enough to carry nearly anything you can design, build and bolt to it!





Description

The Gears IDS 1 is a self protected brushed PM motor controller that provides forward, reverse (no delay) and brake with proportional speed control. The control is obtained from the output signal from a standard hobby RC receiver. The Gears IDS 1 includes motor direction and status indicators, +5Vdc BEC (Battery Elimination Circuit) for the hobby receiver, battery and motor lead wires and receiver cable with universal connector.

Main Features

- Ultra compact size and light weight.
- High Current Capability: 45 Amps peak, 12 Amps continuous.
- Full over current, short circuit and thermal protection on all outputs and BEC.
- Receiver cable with universal plug.
- 16 AWG high-strand Silicone Power and motor lead wires.
- Safety start-up and lost signal shut-down.
- Motor brake on direction change. Helps protect gears from over stress. This feature is not noticeable to the user.

General Specifications

Size including heat shrink: 1.7" X 1.1" X .5"

Weight including wires: 0.88 oz. = 25 grams

Operating Voltage: 6 to 24Vdc

Current Capability:

Test Conditions: +24Vdc, +22°C no air flow, Full Throttle		
Amps	Duration	Limiting Factor
12	Continuous	None
15	~ 2 minutes	Thermal Protection
45	Peak	Over Current Protection

BEC (Battery Elimination Circuit)

Output: +5Vdc

BEC Current Output Derating:

250mA @ +6Vdc Battery Input Voltage
25mA @ +24Vdc Battery Input Voltage

Speed Control: 0-100% PWM Proportional forward and reverse.

Self Protection Features

The Gears IDS 1 features full current limit and thermal protection on all outputs. All protection is 'built into' the devices, there is no lag time due to monitoring or feedback which can allow destructive conditions to occur and damage FETs. Over voltage clamping on the outputs helps protect the controller from voltage spikes and over voltage.

The BEC (Battery Elimination Circuit) incorporates thermal protection and short circuit / overload protection.

Safety Features

- Auto safety shutdown when the signal is lost or extreme interference is present. The controller will automatically reactivate when the signal returns.
- 'Center stick' safety start-up. Requires the throttle to be in the center or 'neutral' position before the controller is activated.

Basic Functional Description

Power Up:

The controller will activate after power is applied when neutral throttle position signals are received. This is a built-in safety feature. The READY LED will blink rapidly until these signals are received. When the controller has received these neutral position signals, the READY LED will stay on continuously. The DIR LEDs will activate individually depending on the motor direction.

Lost Signal:

When extreme radio interference is present or if the signal is lost, the controller will shut down the motor. Normal operation will resume when several good signals are received.

Over Temperature/Current limit:

When any of the motor control FETs reach an over temperature or over current condition, they will enter into a protection mode and shut down. Normal operation will return when the cause of the over temperature or over current is removed. If the over temperature protection was activated, normal operation will resume when the temperature of the FET(s) has cooled.

Shorted or Stalled Motor:

If this condition occurs and the resulting current draw is greater than 45 Amps typical, the controller will enter into a current limit condition. The time it takes for the controller to enter into temperature limit is based on the amount of current draw if this current is less than 45 Amps.

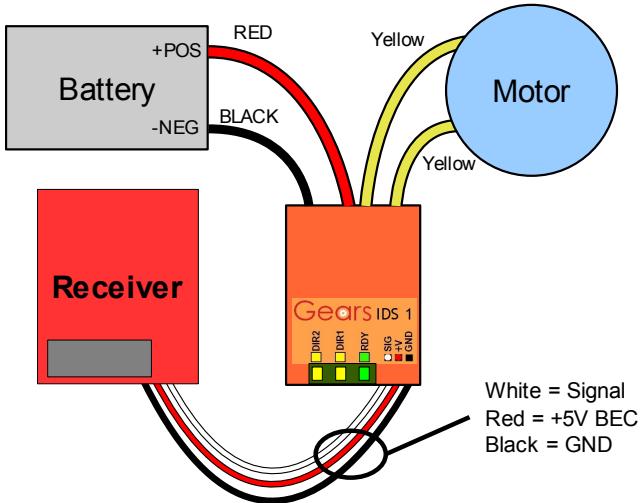


Warnings and Precautions

- The controller may be HOT after use. Use precautions when handling the controller after use.
- Do NOT reverse the battery polarity. This product does not have reverse polarity protection.
- Placing this controller near batteries or motors that increase in temperature when operating will decrease the maximum capability of the controller. This controller has over temperature protection. Close proximity to hot components will reduce the controller capability.

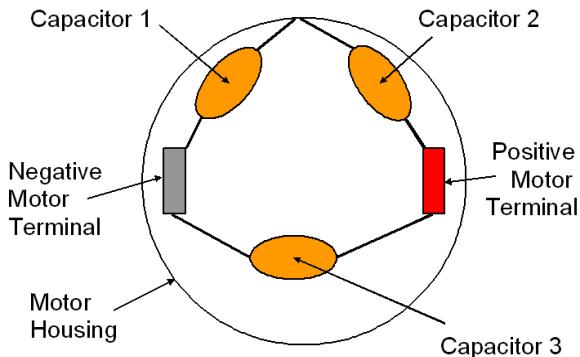


Connections and Hook-Up Instructions



Additional Considerations

It may be necessary to reduce the noise generated from the motor brushes by installing capacitors on the rear of the motor (see diagram below). Typically, three $.1\mu\text{F}$ 50V ceramic capacitors are sufficient.



Troubleshooting

In the dual configuration, one motor turns on before the other motor when going forward/reverse – or – one motor seems to go faster than the other motor when they should be going the same speed.

First, make sure that the motors are un-timed motors. Timed motors will have different speeds in the clock wise (CW) and counter clock wise (CCW) directions. If the motors are un-timed, the center stick timing from the receiver may be slightly different for each channel. Use the trim adjustments on the

transmitter and the DIR LEDs on the controller to adjust the trim.

When the transmitter throttle is in the center position (center stick), the motor turns on.

Adjust the transmitter trim settings on the transmitter until the motor stops in the center stick position. The DIR LEDs on the Gears IDS 1 can be used to aid in setting the trim adjustment.

Everything seems to be wired correctly but nothing happens and the LEDs do not come on.

Disconnect the power immediately. Make sure that a power leads are not connected to a motor output on the Gears IDS 1. Next, make sure that the battery connections are not reversed. Double check that the receiver-to-controller servo leads are correct.

Nothing happens when power is applied and the READY LED blinks continuously.

If all the connections look correct, make sure that the trim adjustments on the transmitter are correct and that the throttle is in the center or neutral stick position. If the READY LED still blinks, slightly adjust the transmitter trim settings until the READY LED stays on continuously.