

# Colibri

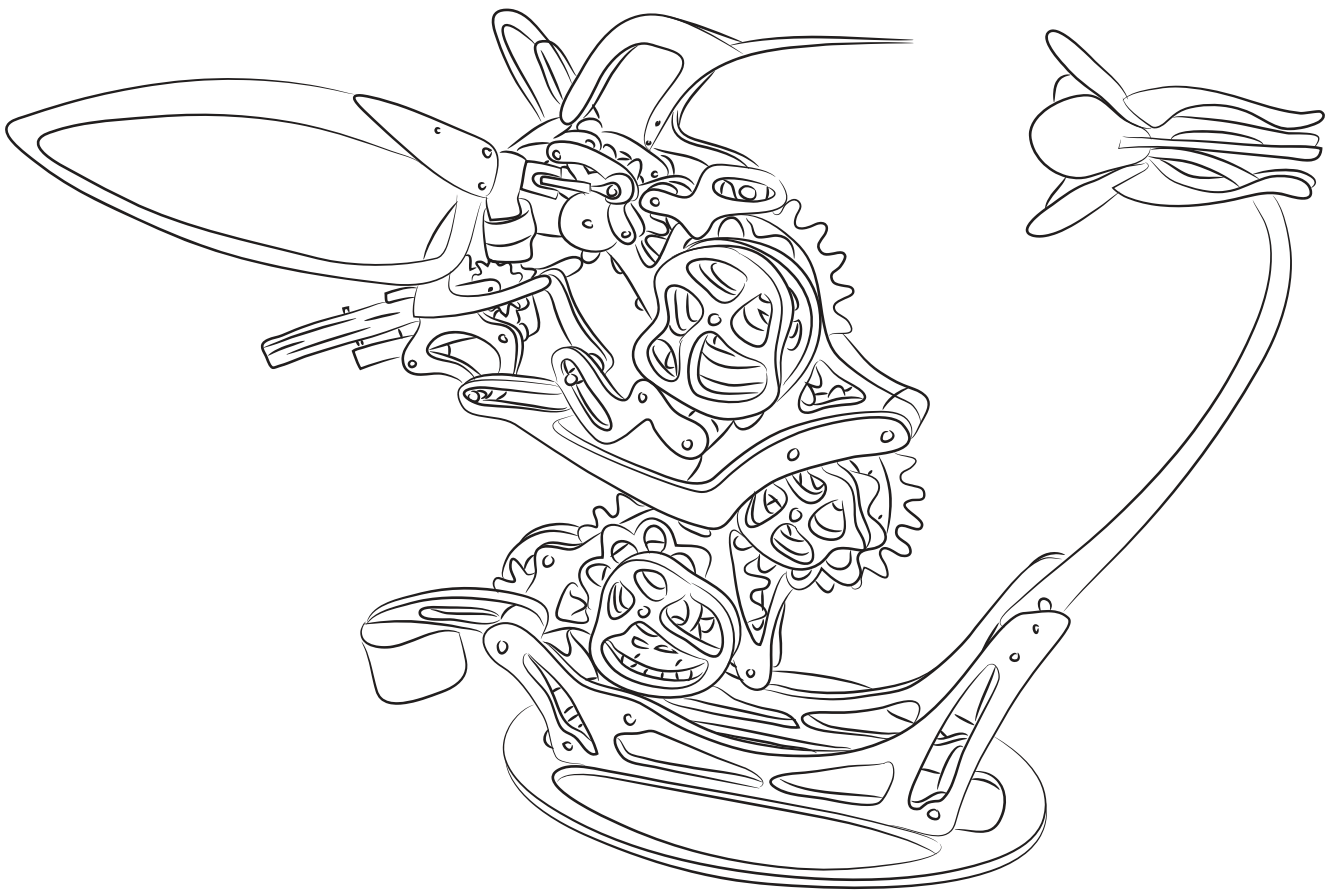
an organic motion sculpture

sample

Important:

McMaster Carr, a supplier whose part numbers are referenced throughout this document, can only ship within the United States. Builders outside of the U.S. must find an alternate supplier for the required hardware.

Hardware part numbers and availability are subject to change. Verify that all hardware or equivalents are obtainable prior to purchasing these plans.



design by Derek Hugger

# The Basics

## Contents

These plans include all the information required to build Colibri. They provide an outline of the build process, tips for an accurate and successful build, lists of required tools and off-the-shelf components, a complete parts list, full scale patterns for all plywood parts, and step-by-step assembly instructions.

## Before Building

Read and understand all instructions before building. Failure to do so will lead to increased frustration levels, lengthened build times, wasted material, and other vexing occurrences.

## Build Process

Always wear eye protection and any other necessary personal protective gear. Read, understand, and abide by all manufacturer instructions and warnings for all tools used.

1. Use a light duty/general purpose spray adhesive to temporarily bond the patterns to plywood. Apply the adhesive evenly and sparingly.
2. Drill the holes first, and then cut out the parts. Hole alignment between parts is critical to proper function, so care must be taken to drill the holes accurately. Take time to cut out the parts accurately. An accurately cut part will require less sanding and less modification later.
3. Remove the patterns from the cut plywood parts, and then sand the parts to remove rough edges and any residual adhesive. Sand all sliding or meshing surfaces with at least 400 grit sandpaper.
4. Cut and tap all aluminum and stainless steel tubes, brass tubes and stainless steel rods. See Plywood Thickness Compensation in Tips + Tactics.
5. Following the assembly instructions, build all subassemblies, the Frame Asm, and the Top Level Assembly.
6. Cut the Counterweight and assemble it to Colibri. See Weight of the Counterweight in Tips + Tactics.
7. If desired, disassemble Colibri to finish its components. Note that stain and other finish options can affect the thickness of parts and may also effect friction levels between moving parts.

## Notes

When printing the patterns, always print at 100% scale. Do not use the “scale to fit page” option.

Colibri contains many moving wood parts as well as wood parts that stack onto one another. As such, using a quality, flat Baltic birch plywood is very important. Cheaper, lower quality plywood, such as types often found at home improvement stores like Home Depot, can be warped and knotted.

Changing humidity levels can cause wood parts to swell and move. Some binding or changes in performance may occur with changes in humidity. As humidity levels return to normal, so too should the system’s performance.

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# Tools

## Power Tools

## General

## Drivers

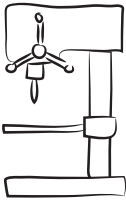
Required



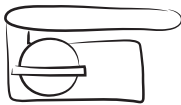
bandsaw



scroll saw



drill press



belt/disc sander



brad point drill index  
1/16" to 7/16"  
in 1/64" increments



drill bit #29\*



tap 8-32\*



spade or forstner bits  
7/8", 1-1/8"



hacksaw



clamps



calipers



precision files



phillips #1



hex 0.035"  
1/16"  
5/64"

## Supplies



sandpaper



wood glue

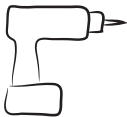


spray adhesive

Recommended  
(but not required)



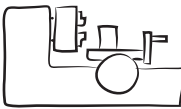
mini chop saw



drill



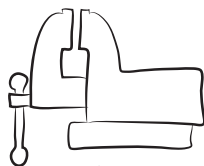
rotary tool



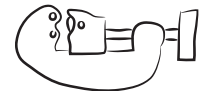
metal lathe



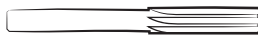
cnc router\*\*



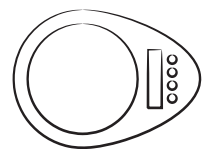
vice



tube cutter



reamers  
0.0650", 0.1280", 0.2530"



kitchen scale or balance

\* For drilling and tapping into stainless steel, cobalt steel drill bits and taps are required.

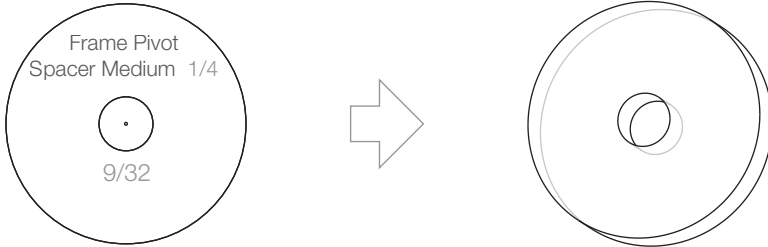
\*\* A CNC router is an optional replacement for the bandsaw and scroll saw for cutting the plywood parts.

# Tips + Tactics

## Pattern Syntax

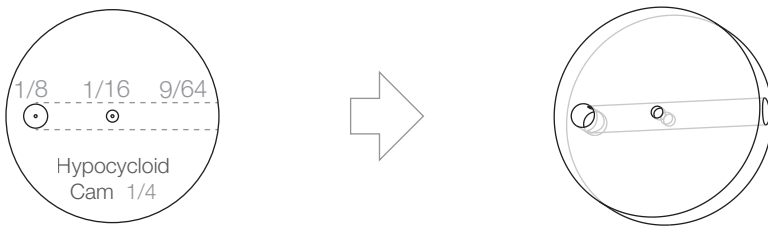
Patterns are labeled with a part name followed by a thickness dimension.

Example: Frame Pivot Spacer Medium is cut from 1/4" plywood. It also has a hole to be drilled thru with a 9/32" bit.



Dashed lines indicate a hole drilled from the side, centered on the thickness of the part.

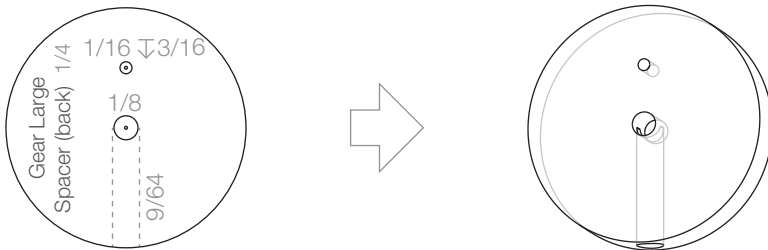
Example: Hypocycloid Cam has a 9/64" hole drilled from the side. It also has a 1/16" thru hole and a 1/8" thru hole drilled from the front.



A  $\Downarrow$  symbol indicates drilling to a certain depth, not thru.

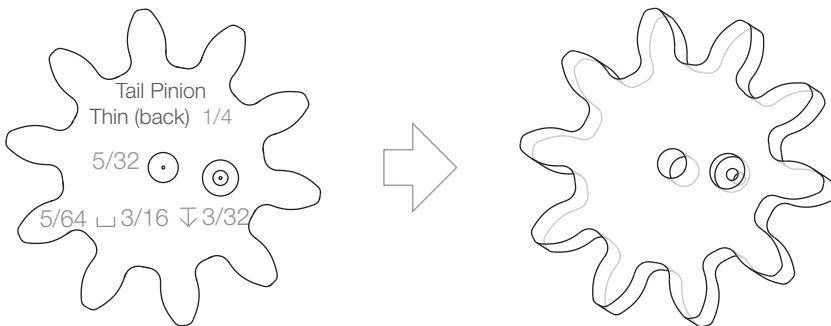
Example: Gear Large Spacer has a 1/16" hole drilled 3/16" deep. It also has a 1/8" thru hole as well as a 9/64" hole drilled from the side.

As indicated by "(back)", this pattern shows the back side of the part.



Two concentric circles indicate a hole with a counterbore.

Example: Tail Pinion Thin has a 5/64" hole with a 3/16" counterbore drilled 3/32" deep. It also has a 5/32" thru hole. As indicated by "(back)", this pattern shows the back side of the part.



On parts that say "sand thin", sand 1/32" - 1/16" off the thickness of the part. Sand evenly to keep the front/back of the part as parallel as possible.

# Tips + Tactics

## Tail Tuning

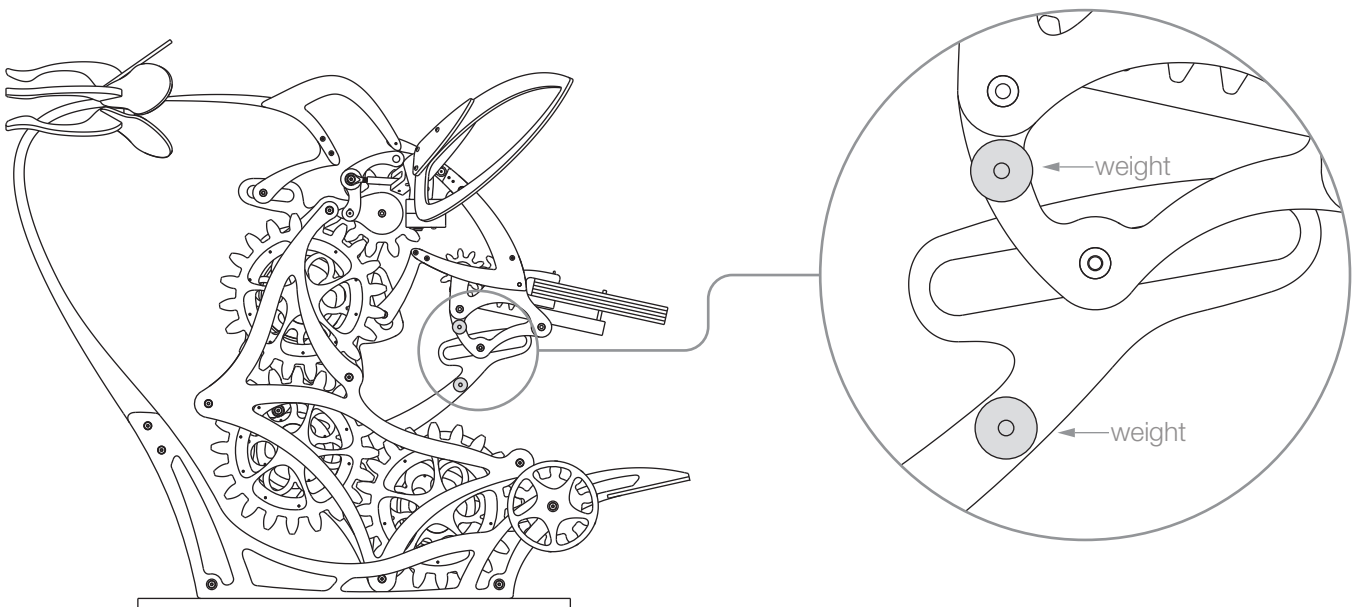
In terms of mechanisms and moving parts, a lot happens in the tail. Each part of the tail must move smoothly, with minimal force and minimal friction. Several of the tail patterns have an indication to “sand thin.” Sand 1/32” to 1/16” off the thickness of those indicated parts, being careful to sand evenly and keep the front/back of each part as parallel as possible.

Before assembling the Tail Asm into the Top Level Assembly:

- Sand the inside of the Tail Feathers Mount to accommodate the thickness of the five tail feathers. See Subassembly Step 35. Note that additional sanding may be required if the Tail Feathers are stained or finished.
- To test the function of the tail, hold the Tail Asm with your left hand, your thumb and middle finger gripping the 1/8” rod, and your index finger holding the Tail Fain Gear Asm stationary. With your right hand, push up on the Needle Bearings. The tail should rotate down and the Tail Feathers should flare. Let go of the Needle Bearings. The tail should rotate back up and the Tail Feathers should come back together. No force should be required for this to happen. If any force other than gravity is required to bring the tail back to its initial position, sand or modify its components until the problem is resolved. Verify the Rack and Pinion mesh smoothly, the Rack slides smoothly on the two Needle Bearings, and the Rod in the Rack smoothly follows the slot in each of the five Tail Feathers.

After assembling the Tail Asm into the Top Level Assembly:

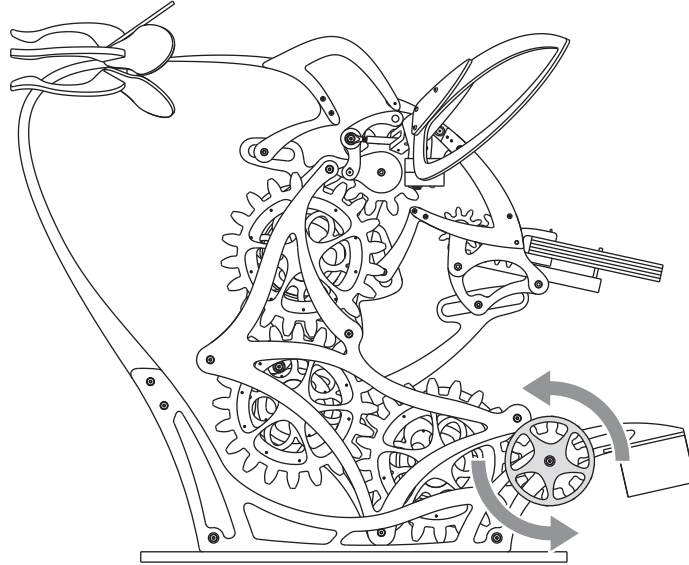
- If during operation, the tail's Rack collides with the aluminum tube connecting the two body pieces, sand down the tips of the Cam Wheel Tail. This will reduce the amount of travel in the tail and will ultimately increase the minimum distance between the Rack and aluminum tube.
- If the Tail Asm is binding on the body and cannot rotate freely, the space between the body can be increased. Remove the four #2 screws holding the two body pieces to the Hummer Body Cam Link Asm, and then reinstall the fasteners with a gap left in between the mating parts.
- Adding stain or a finish to the tail components may increase friction between parts. If this is the case, or if the tail does not return to its initial position after being tilted and flared with only the force of gravity, weights may be added to the back of the Tail Asm and/or to the back of the Cam Follower Tail as needed. Note that these weights can be added after the Counterweight is cut; they should have a minimal impact on the balance of the overall system.



# Tips + Tactics

## General Operation

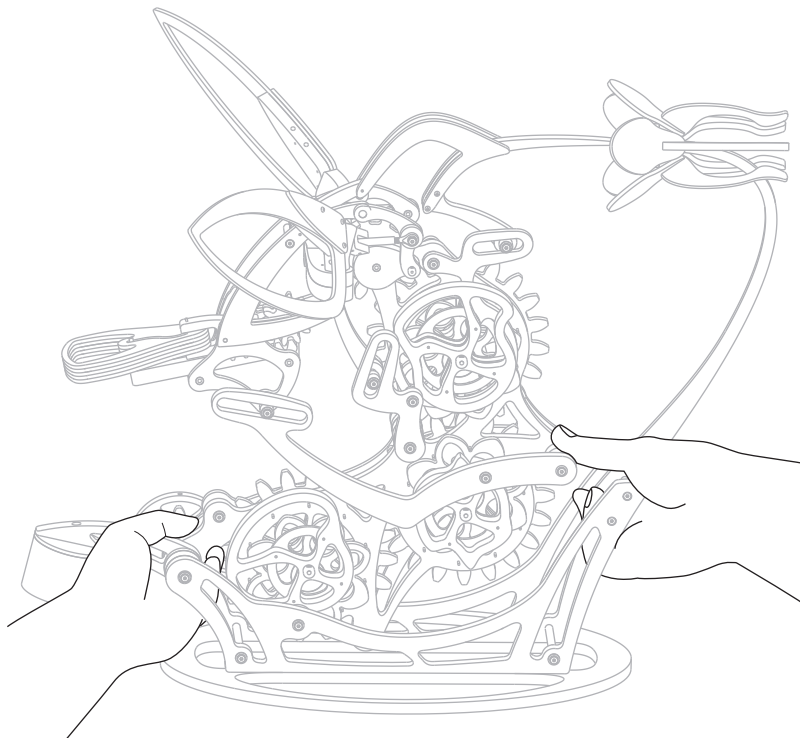
The Crank must only be turned one way. When looking at the Colibri from the Hummingbird's left side (Flower on the left, Counterweight on the right), the Crank must only spin Counterclockwise. Turning the Crank backwards can damage Colibri.



Only directly turn the Crank or the Gears. Never attempt to move a Cam Wheel, Hypocycloid Gear, or Wing directly. Doing so can damage the components.

The Crank should never require more than 3.5 in-lbs of torque to turn. Never force it to turn. See Assembly Tuning + Friction in Tips + Tactics.

To pick up or move Colibri, hold the pivoting section of the Frame Asm with one hand, and hold the aluminum tubes supporting the Flower Asm with the other. At the same time, gently hold the Frame Asm at the Cam Follower Tail to ensure the Frame Asm cannot rotate while Colibri is being moved.



# Tips + Tactics

## Weight of the Counterweight

Important: Before the Counterweight is assembled onto Colibri, do not turn the Crank or drive the system without lifting the Frame Asm manually; do not allow the Cam Wheel Bottom Asm to lift the weight of the Frame Asm and Colibri's other components without the Counterweight attached. Doing so could over stress and damage the components.

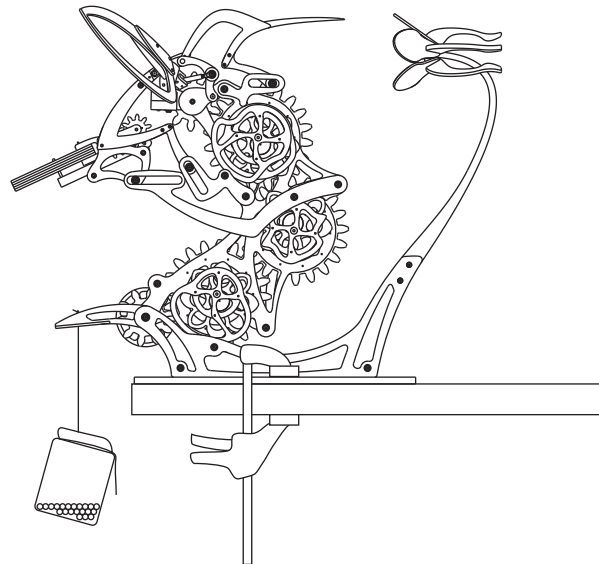
The counterweight may be made from Steel, Stainless Steel, or Brass. The Counterweight plays an important role reducing stress on Colibri's lower mechanisms as well as lowering the overall torque required to drive the system. It must be heavy enough to reduce the load on the Cam Wheel Bottom as much as possible, but light enough such that when the hummingbird is in its rear most position, the Frame Asm does not tip over backwards. As such, accurately determining the required mass of the Counterweight is important.

After completing Top Level Assembly Step 11, clamp Colibri's Base Asm to the edge of a table. To help ensure Colibri never gets damaged by tipping over backwards, it may be helpful to ask someone to assist with this process:

Using a small jar of BBs is the easiest way to determine the Counterweight's required mass. Empty the BBs into a bowl, and hang the empty jar with a piece of string or twine from center of the hole in the wooden Counterweight Asm. It is important to hang the jar from the center of the hole in the Counterweight Asm. If the jar hangs off center, the required mass of the Counterweight may not be accurately established.

Remove any scrap wood used to prop up the Frame Asm, and lift the Frame Asm such that there is still a small gap between the Cam Wheel Bottom and the Needle Bearing in the Frame Support A Asm. Then, rotate the Crank to drive the system until the hummingbird is in its rear most position. Gently lower the Frame Asm such that the Cam Wheel Bottom is resting on the Needle Bearing. Begin adding BBs into the jar in small increments. The correct amount of weight is in the jar when:

- the Frame Asm is lifted such that there is a 1/4" gap between the Cam Wheel Bottom and the Needle Bearing, and the hummingbird is perfectly balanced (does not fall forward or backward).
- the Cam Wheel Bottom contacts the Needle Bearing gently with minimal force when the hummingbird is in its rear most position, and it does not tip over backwards.



With the correct amount of weight hanging, turn the Crank and drive the system through several complete cycles. The torque required to drive the system must not exceed 3.5 in-lbs and the hummingbird must never tip over backwards.

When the correct amount of weight is determined, weigh the jar of BBs and then weigh the 2-1/2" diameter cylinder of metal from which the Counterweight will be cut.

Counterweight length = (jar of BBs weight / cylinder of metal weight) \* cylinder of metal length

Cut the Counterweight to the determined length, and then tap it, ensuring the threaded hole is centered. The weight's length will likely be about 2".



# Parts + Assemblies List

Type	Description	Qty	Type	Description	Qty	Type	Description	Qty
Aluminum Tube	A Tube 1/4" x 1/2"	2	Plywood 1/8"	Cam Wheel Body Spacer	1	Subassembly	Base Asm	1
Aluminum Tube	A Tube 1/4" x 1"	2	Plywood 1/8"	Cam Wheel Bottom Spacer	1	Subassembly	Cam Follower Body Asm	1
Aluminum Tube	A Tube 1/4" x 1-3/8"	1	Plywood 1/8"	Cam Wheel Head Spacer	1	Subassembly	Cam Follower Head Asm	1
Aluminum Tube	A Tube 1/4" x 1-5/8"	1	Plywood 1/8"	Cam Wheel Tail Spacer	1	Subassembly	Cam Follower Tail Asm	1
Aluminum Tube	A Tube 1/4" x 2-3/8"	1	Plywood 1/8"	Counterweight Flange	1	Subassembly	Cam Wheel Bottom Asm	1
Aluminum Tube	A Tube 1/4" x 2-3/4"	2	Plywood 1/8"	Flower Petal Front	5	Subassembly	Cam Wheel Middle Asm	1
Aluminum Tube	A Tube 1/4" x 2-7/8"	1	Plywood 1/8"	Shoulder Thin	2	Subassembly	Cam Wheel Top Asm	1
Aluminum Tube	A Tube 1/4" x 3-1/2"	2	Plywood 1/8"	Tail Feather A	2	Subassembly	Counterweight Asm	1
Aluminum Tube	A Tube 1/4" x 1-19/64" Hole	2	Plywood 1/8"	Tail Feather B	2	Subassembly	Flower Asm	1
Aluminum Tube	A Tube 1/4" x 1-7/8" Flats	1	Plywood 1/8"	Tail Feather C	1	Subassembly	Flower Petal Asm	5
			Plywood 1/8"	Wing	2	Subassembly	Frame Asm	1
Brass Tube	B Tube 3/32" x 1/4"	6				Subassembly	Frame Support A Asm	1
Brass Tube	B Tube 3/32" x 3/8"	1	Plywood 1/4"	Cam Follower Head	1	Subassembly	Frame Support B Asm	1
			Plywood 1/4"	Flower Petal Rear	5	Subassembly	Gear Large Asm	2
Brass Tube	B Tube 5/32" x 3/8"	3	Plywood 1/4"	Flower Stem	1	Subassembly	Gear Large Top Asm	1
Brass Tube	B Tube 5/32" x 5/8"	2	Plywood 1/4"	Frame Pivot Spacer Medium	2	Subassembly	Gear Small Lower Asm	1
Brass Tube	B Tube 5/32" x 11/16"	1	Plywood 1/4"	Frame Support A Spacer	1	Subassembly	Hummer Body Asm	1
Brass Tube	B Tube 5/32" x 3/4"	1	Plywood 1/4"	Gear Large	3	Subassembly	Hummer Body Cam Link Asm	1
Brass Tube	B Tube 5/32" x 13/16"	2	Plywood 1/4"	Gear Large Spacer	3	Subassembly	Hummer Body Left Asm	1
Brass Tube	B Tube 5/32" x 1-1/8"	1	Plywood 1/4"	Gear Small Lower	1	Subassembly	Hummer Body Right Asm	1
			Plywood 1/4"	Gear Small Lower Spacer Medium	1	Subassembly	Hummer Head Asm	1
Brass Tube	B Tube 9/32" x 3/32"	4	Plywood 1/4"	Gear Small Upper	1	Subassembly	Hummer Mount Asm	2
Brass Tube	B Tube 9/32" x 1/8"	1	Plywood 1/4"	Hummer Bill Spacer	1	Subassembly	Links Left Asm	1
Brass Tube	B Tube 9/32" x 3/16"	3	Plywood 1/4"	Hummer Body Left	1	Subassembly	Links Right Asm	1
Brass Tube	B Tube 9/32" x 1/4"	2	Plywood 1/4"	Hummer Body Right	1	Subassembly	Pivoting Wing Left Asm	1
Brass Tube	B Tube 9/32" x 3/8"	3	Plywood 1/4"	Hummer Body Spacer	2	Subassembly	Pivoting Wing Right Asm	1
Brass Tube	B Tube 9/32" x 5/8"	6	Plywood 1/4"	Hummer Head Left	1	Subassembly	Rod End Pivot Tube Asm	2
Brass Tube	B Tube 9/32" x 7/8"	2	Plywood 1/4"	Hummer Head Right	1	Subassembly	Shoulder Pivot Asm	2
Brass Tube	B Tube 9/32" x 1-7/8"	1	Plywood 1/4"	Hummer Mount	2	Subassembly	Spinner Link Thick Asm	1
			Plywood 1/4"	Hypocycloid Cam	3	Subassembly	Spinner Link Thin Asm	1
Stainless Steel Tube	S Tube 1/4" x 7/8"	1	Plywood 1/4"	Hypocycloid Gear	3	Subassembly	Tail Asm	1
Stainless Steel Tube	S Tube 1/4" x 25/32"	1	Plywood 1/4"	Spinner Link Thin	1	Subassembly	Tail Fan Gear Asm	1
Stainless Steel Tube	S Tube 1/4" x 1-5/64"	1	Plywood 1/4"	Support Frame	1	Subassembly	Tail Mount Left Asm	1
Stainless Steel Tube	S Tube 1/4" x 1-1/8"	1	Plywood 1/4"	Tail Fan Gear	1	Subassembly	Tail Mount Right Asm	1
Stainless Steel Tube	S Tube 1/4" x 1-1/4"	3	Plywood 1/4"	Tail Mount Left	1	Subassembly	Tail Pinion Asm	1
Stainless Steel Tube	S Tube 1/4" x 1-3/4"	3	Plywood 1/4"	Tail Mount Left Standoff A	1	Subassembly	Tail Rack Asm	1
Stainless Steel Tube	S Tube 1/4" x 3-7/8" Flats	1	Plywood 1/4"	Tail Mount Left Standoff B	1	Subassembly	Wing Frame Asm	1
			Plywood 1/4"	Tail Pinion Thin	1	Subassembly	Wng Left Asm	1
Stainless Steel Rod	Rod 1/16" x 1/4"	3	Plywood 1/4"	Wing Link Arc	2	Subassembly	Wing Link Arc Left Asm	1
Stainless Steel Rod	Rod 1/16" x 5/8"	30	Plywood 1/4"	Wing Link Arc Spacer	2	Subassembly	Wing Link Arc Right Asm	1
Stainless Steel Rod	Rod 1/16" x 3/4"	2	Plywood 1/4"	Wing Link Straight	2	Subassembly	Wing Link Straight Asm	2
Stainless Steel Rod	Rod 1/16" x 13/16"	8				Subassembly	Wing Right Asm	1
Stainless Steel Rod	Rod 1/16" x 7/8"	3	Plywood 3/8"	Base	1			
Stainless Steel Rod	Rod 1/16" x 15/16"	2	Plywood 3/8"	Cam Follower Body	1	Top Level Asm	Colibri	1
Stainless Steel Rod	Rod 1/16" x 1-13/64"	1	Plywood 3/8"	Cam Follower Head Spacer	1			
Stainless Steel Rod	Rod 1/16" x 1-5/16"	4	Plywood 3/8"	Cam Follower Tail	1			
Stainless Steel Rod	Rod 1/16" x 1-3/8"	1	Plywood 3/8"	Cam Wheel Head	1			
Stainless Steel Rod	Rod 1/16" x 1-7/8"	2	Plywood 3/8"	Crank	1			
Stainless Steel Rod	Rod 1/16" x 2-1/4"	1	Plywood 3/8"	Flower Center	1			
			Plywood 3/8"	Frame	1			
Stainless Steel Rod	Rod 1/8" x 1-1/4"	1	Plywood 3/8"	Frame Support A	1			
Stainless Steel Rod	Rod 1/8" x 1-19/32"	1	Plywood 3/8"	Frame Support B	1			
Stainless Steel Rod	Rod 1/8" x 1-7/8"	1	Plywood 3/8"	Hummer Back	1			
Stainless Steel Rod	Rod 1/8" x 2" Flats	2	Plywood 3/8"	Hummer Bill	1			
Stainless Steel Rod	Rod 1/8" x 2-1/2" Flats	1	Plywood 3/8"	Hummer Body Cam Link	1			
Stainless Steel Rod	Rod 1/8" x 3-1/4" Flats	2	Plywood 3/8"	Hummer Body Cam Link Spacer B	1			
			Plywood 3/8"	Shoulder Thick	2			
Steel/Stainless Steel/Brass	Counterweight	1	Plywood 3/8"	Tail Fan Gear Standoff	1			
			Plywood 3/8"	Tail Mount Right	1			
Hardware	LSHCS 8-32 x 1/4"	22						
Hardware	LSHCS 8-32 x 1/2"	13	Plywood 1/2"	Cam Follower Frame Spacer	3			
Hardware	LSHCS 8-32 x 3/4"	1	Plywood 1/2"	Cam Follower Spacer	2			
Hardware	Magnet	4	Plywood 1/2"	Cam Wheel Body	1			
Hardware	Needle Bearing	16	Plywood 1/2"	Cam Wheel Bottom	1			
Hardware	Rod End	2	Plywood 1/2"	Cam Wheel Tail	1			
Hardware	Screw #2 x 1/2"	24*	Plywood 1/2"	Counterweight Arm	1			
Hardware	Screw #2 x 3/4"	17*	Plywood 1/2"	Frame Pivot Spacer Thick	1			
Hardware	Set Screw	18	Plywood 1/2"	Gear Small Lower Spacer Thick	1			
Hardware	Shaft Collar 1/16"	4	Plywood 1/2"	Hummer Body Cam Link Spacer A	2			
Hardware	Shaft Collar 1/8"	3	Plywood 1/2"	Pivot Block	2			
Hardware	Washer	22	Plywood 1/2"	Shoulder Pivot	2			
Hardware	Weight, 1/4"	X*	Plywood 1/2"	Spinner Link Thick	1			
Hardware	Weight, 1/2"	X*	Plywood 1/2"	Tail Feathers Mount	1			
			Plywood 1/2"	Tail Pinion Thick	1			
			Plywood 1/2"	Tail Rack	1			
			Plywood 1/2"	Wing Frame	1			
			Plywood 1/2"	Wing Frame Support Left	1			
			Plywood 1/2"	Wing Frame Support Right	1			

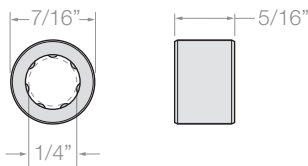
\*Quantities may vary. Weights and accompanying fasteners may or may not be required. See Tail Tuning in Tips + Tactics.



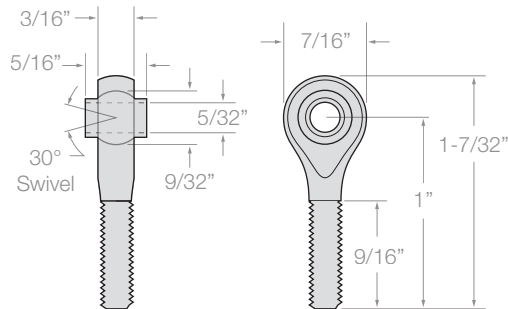
# Hardware

Description	Qty	McMaster Carr P/N *
LSHCS, 8-32 x 1/4" Low Socket Head Cap Screw	22	93615A317
LSHCS, 8-32 x 1/2" Low Socket Head Cap Screw	13	93615A320
LSHCS, 8-32 x 3/4" Low Socket Head Cap Screw	1	93615A323
Magnet Neodymium, 2.5 lbs max pull, Ø1/4" x 1/4"	4	58605K75
Needle Bearing (see image below)	16	5905K21
Rod End (see image below)	2	60645K98
Screw, #2 x 1/2" Pan Head Self Tapping Screw	24**	92470A098
Screw, #2 x 3/4" Pan Head Self Tapping Screw	17**	92470A103
Set Screw, 8-32 x 1/4"	18	92311A190
Shaft Collar 1/16" (see image below)	4	6432K71
Shaft Collar 1/8" (see image below)	3	6432K17
Washer #8	22	90107A010
1/4" Weight (see image below)	X**	90309A312
1/2" Weight (see image below)	X**	90309A315

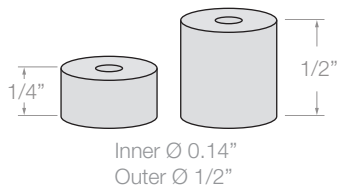
## Needle Bearing Steel, Open Bearing Style



## Rod End 8-32 Thread



## Weights Unthreaded Brass Spacers for #6 Screws



Note that although these spacers are designed for #6 screws, #2 screws may be used.

## Shaft Collars each with Set Screw



Inner Ø 1/16"  
Outer Ø 1/4"  
Width 3/16"

2-56 x 1/8" Set Screw



Inner Ø 1/8"  
Outer Ø 3/8"  
Width 1/4"

6-32 x 1/8" Set Screw

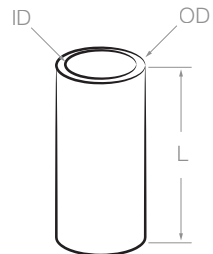
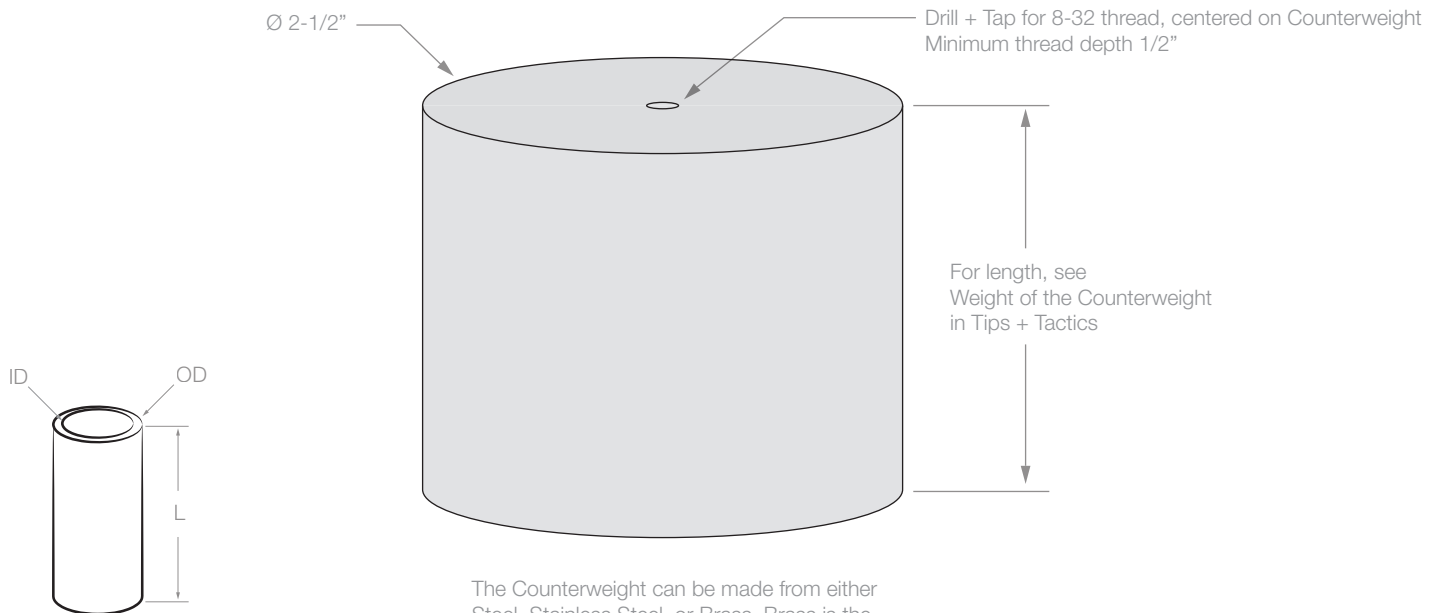
\* Part numbers referenced are from [www.mcmaster.com](http://www.mcmaster.com).

\*\* Quantities may vary. Weights and accompanying fasteners may or may not be required. See Tail Tuning in Tips + Tactics.

# Metal

## Brass Tubes, Counterweight

Description	OD x L *	ID	Qty	McMaster Carr P/N **
B Tube 3/32" x 1/4"	3/32" x 1/4"	0.066"	6	8859K18
B Tube 3/32" x 3/8"	3/32" x 3/8"	0.066"	1	
B Tube 5/32" x 3/8"	5/32" x 3/8"	0.128"	3	8859K21
B Tube 5/32" x 5/8"	5/32" x 5/8"	0.128"	2	
B Tube 5/32" x 11/16"	5/32" x 11/16"	0.128"	1	
B Tube 5/32" x 3/4"	5/32" x 3/4"	0.128"	1	
B Tube 5/32" x 13/16"	5/32" x 13/16"	0.128"	2	
B Tube 5/32" x 1-1/8"	5/32" x 1-1/8"	0.128"	1	
B Tube 9/32" x 3/32"	9/32" x 3/32"	0.253"	4	
B Tube 9/32" x 1/8"	9/32" x 1/8"	0.253"	1	
B Tube 9/32" x 3/16"	9/32" x 3/16"	0.253"	3	
B Tube 9/32" x 1/4"	9/32" x 1/4"	0.253"	2	
B Tube 9/32" x 3/8"	9/32" x 3/8"	0.253"	3	
B Tube 9/32" x 5/8"	9/32" x 5/8"	0.253"	6	
B Tube 9/32" x 7/8"	9/32" x 7/8"	0.253"	2	
B Tube 9/32" x 1-7/8"	9/32" x 1-7/8"	0.253"	1	
Counterweight <i>see image below</i>	2-1/2" x X"	-	1	Steel: 8927K58 Brass: 8953K26 Stainless Steel: 89535K69



OD outer diameter  
ID inner diameter  
L length

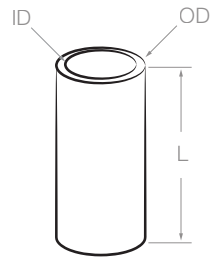
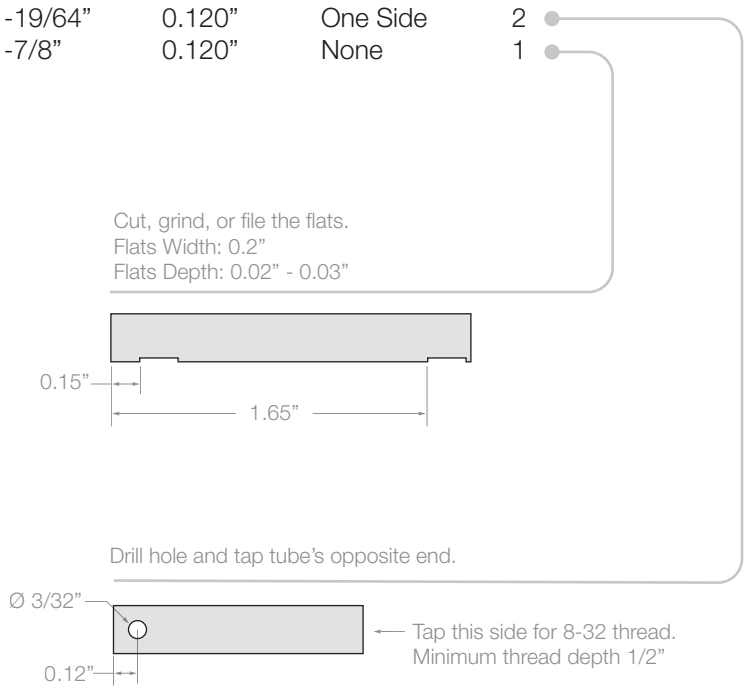
The Counterweight can be made from either Steel, Stainless Steel, or Brass. Brass is the easiest to cut, but the most expensive. The Steel listed is the lowest cost, but is more difficult to cut.

\* Due to variations in plywood thicknesses, required tube lengths may vary. See Plywood Thickness Compensation in Tips + Tactics.  
\*\* Part numbers referenced are from [www.mcmaster.com](http://www.mcmaster.com).

# Metal

## Aluminum Tubes

Description	OD x L *	ID	Tap**	Qty	McMaster Carr P/N ***
A Tube 1/4" x 1/2"	1/4" x 1/2"	0.120"	Thru	2	89965K23
A Tube 1/4" x 1"	1/4" x 1"	0.120"	Both Sides	2	
A Tube 1/4" x 1-3/8"	1/4" x 1-3/8"	0.120"	Both Sides	1	
A Tube 1/4" x 1-5/8"	1/4" x 1-5/8"	0.120"	Both Sides	1	
A Tube 1/4" x 2-3/8"	1/4" x 2-3/8"	0.120"	Both Sides	1	
A Tube 1/4" x 2-3/4"	1/4" x 2-3/4"	0.120"	Both Sides	2	
A Tube 1/4" x 2-7/8"	1/4" x 2-7/8"	0.120"	Both Sides	1	
A Tube 1/4" x 3-1/2"	1/4" x 3-1/2"	0.120"	Both Sides	2	
A Tube 1/4" x 1-19/64" Hole	1/4" x 1-19/64"	0.120"	One Side	2	
A Tube 1/4" x 1-7/8" Flats	1/4" x 1-7/8"	0.120"	None	1	



OD outer diameter  
 ID inner diameter  
 L length

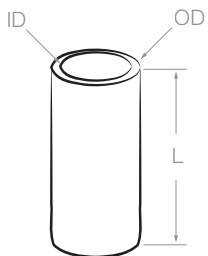
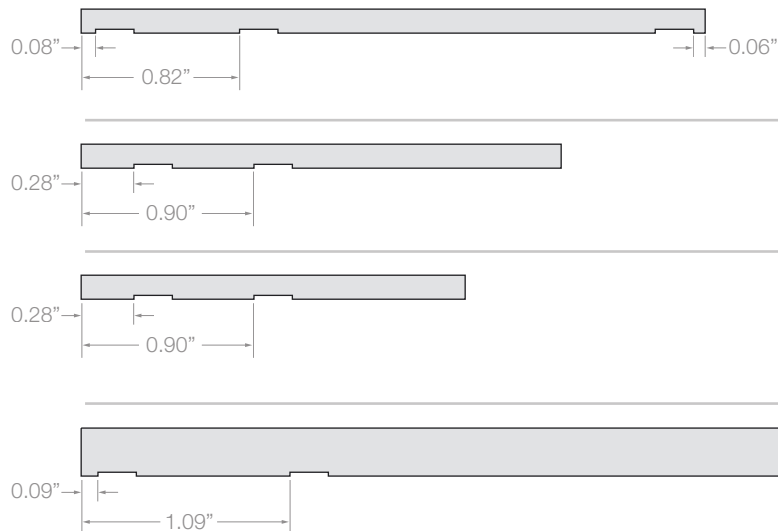
\* Due to variations in plywood thicknesses, required tube lengths may vary.  
 \*\* Expand 0.120" tube ID with a #29 drill bit and then tap for 8-32 thread. Minimum thread depth: 3/8" unless otherwise specified.  
 \*\*\* Part numbers referenced are from [www.mcmaster.com](http://www.mcmaster.com). © 2015 Derek Hugger

# Metal

## Stainless Steel

Description	OD x L *	ID	Tap**	Qty	McMaster Carr P/N ***
S Tube 1/4" x 7/8"	1/4" x 7/8"	0.120"	Both Sides	2	89895K726****
S Tube 1/4" x 1-5/64"	1/4" x 1-5/64"	0.120"	One Side	1	
S Tube 1/4" x 1-1/8"	1/4" x 1-1/8"	0.120"	Both Sides	1	
S Tube 1/4" x 1-1/4"	1/4" x 1-1/4"	0.120"	1x One side, 2x None	3	See Subassembly Step 33.
S Tube 1/4" x 1-3/4"	1/4" x 1-3/4"	0.120"	One Side	3	
S Tube 1/4" x 3-7/8" Flats	1/4" x 3-7/8"	0.120"	Both Sides	1	
Rod 1/16" x 1/4"	1/16" x 1/4"	-	-	3	8908K64
Rod 1/16" x 5/8"	1/16" x 5/8"	-	-	30	90145A421*****
Rod 1/16" x 3/4"	1/16" x 3/4"	-	-	2	
Rod 1/16" x 13/16"	1/16" x 13/16"	-	-	8	
Rod 1/16" x 7/8"	1/16" x 7/8"	-	-	3	
Rod 1/16" x 15/16"	1/16" x 15/16"	-	-	2	
Rod 1/16" x 1-13/64"	1/16" x 1-13/64"	-	-	1	
Rod 1/16" x 1-5/16"	1/16" x 1-5/16"	-	-	4	
Rod 1/16" x 1-3/8"	1/16" x 1-3/8"	-	-	1	
Rod 1/16" x 1-7/8"	1/16" x 1-7/8"	-	-	2	
Rod 1/16" x 2-1/4"	1/16" x 2-1/4"	-	-	1	
Rod 1/8" x 1-1/4"	1/8" x 1-1/4"	-	-	1	8984K2
Rod 1/8" x 1-19/32"	1/8" x 1-19/32"	-	-	1	
Rod 1/8" x 1-7/8"	1/8" x 1-7/8"	-	-	1	
Rod 1/8" x 2" Flats	1/8" x 2"	-	-	2	
Rod 1/8" x 2-1/2" Flats	1/8" x 2-1/2"	-	-	1	
Rod 1/8" x 3-1/4" Flats	1/8" x 3-1/4"	-	-	2	

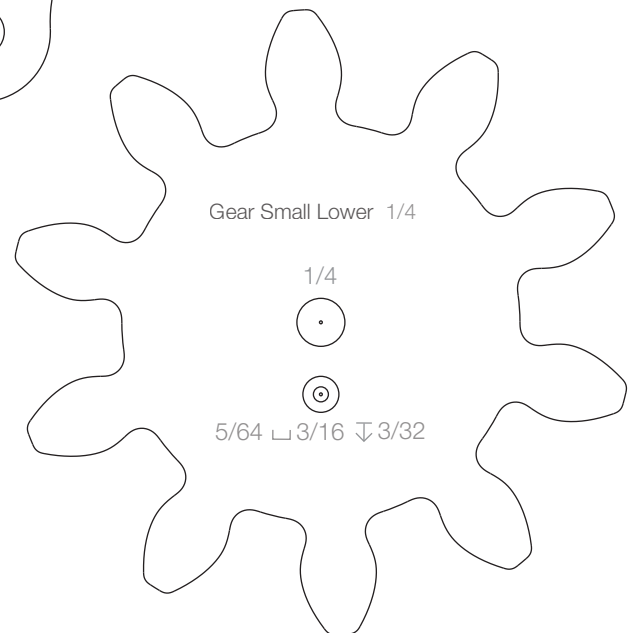
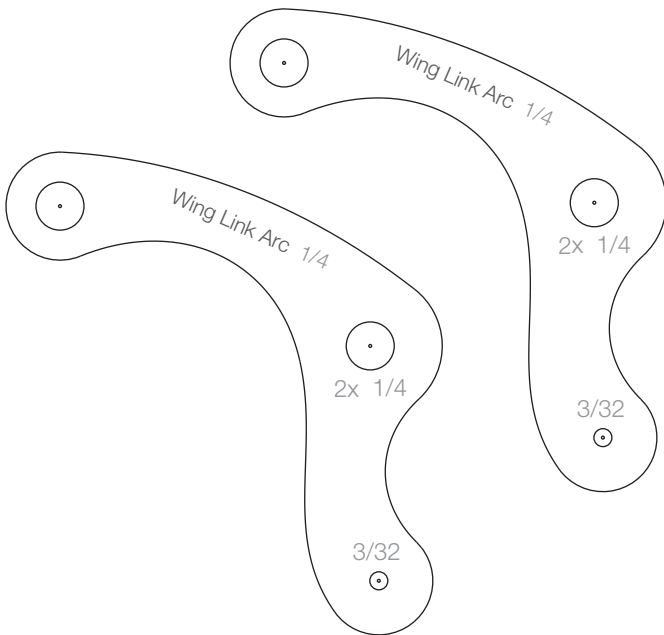
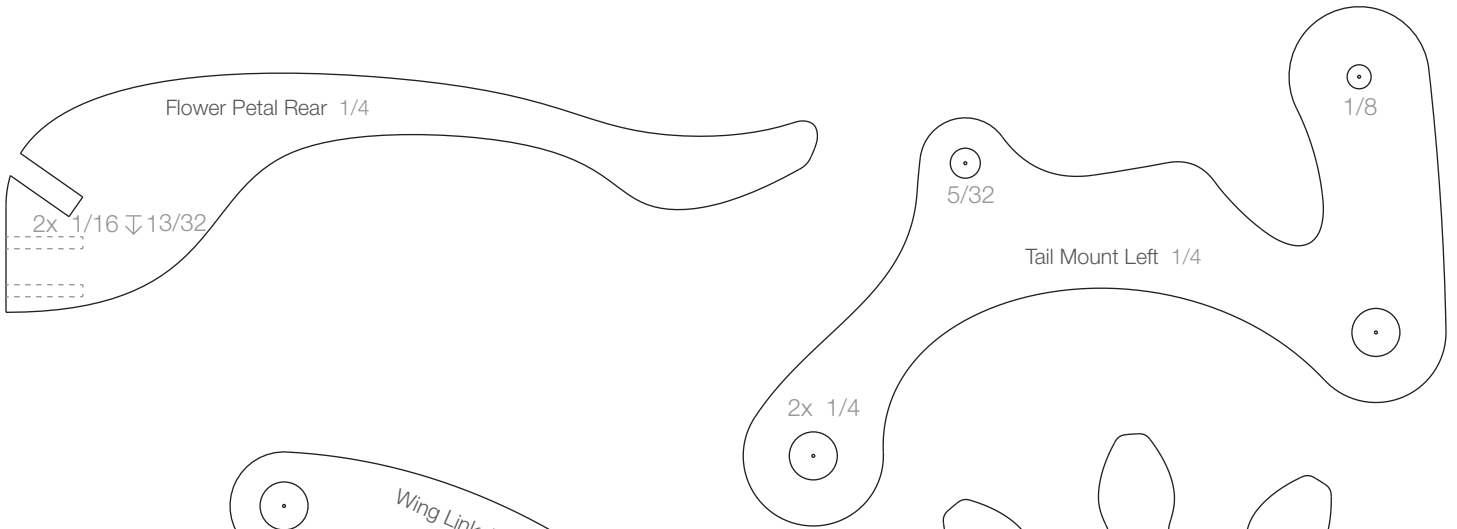
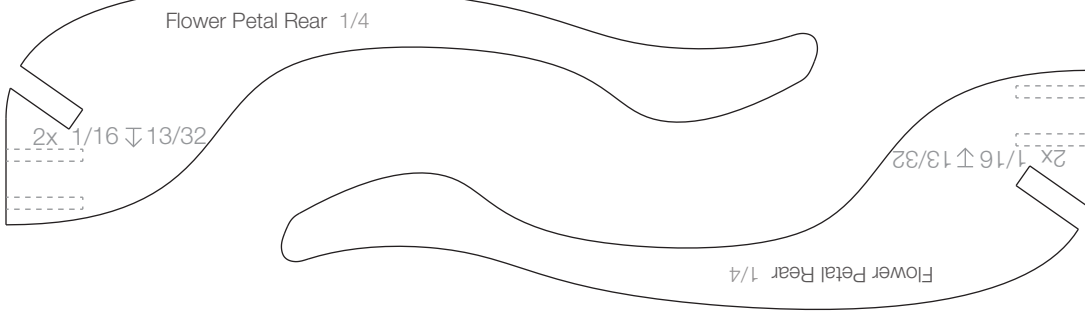
Cut, grind, or file the flats.  
 Flats Width: 0.2"  
 Flats Depth: 0.02" - 0.03"



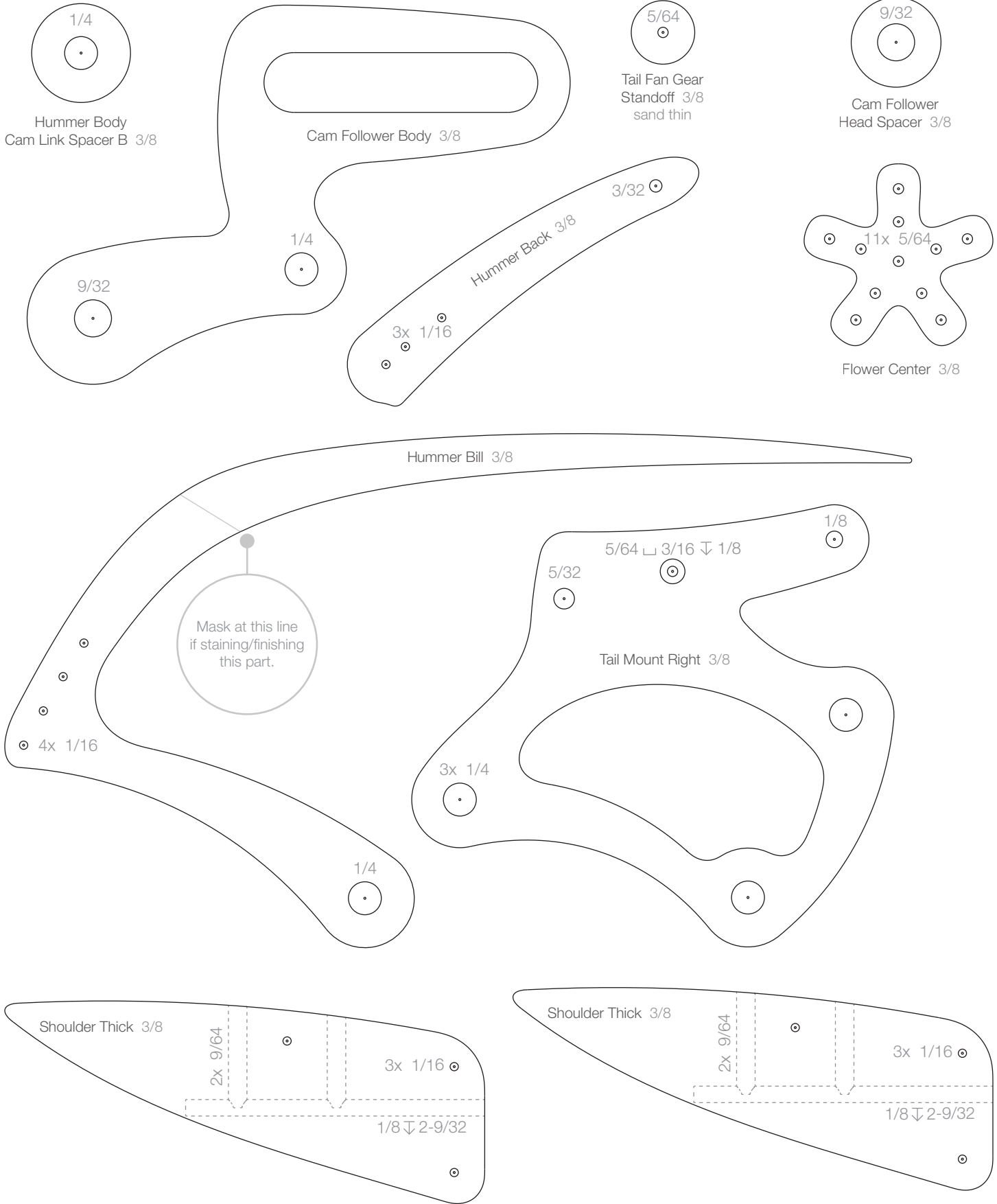
OD outer diameter  
 ID inner diameter  
 L length

\* Due to variations in plywood thicknesses, required tube lengths may vary.  
 \*\* Expand 0.120" tube ID with a #29 drill bit and then tap for 8-32 thread. Minimum thread depth: 3/8".  
 \*\*\* Part numbers referenced are from [www.mcmaster.com](http://www.mcmaster.com).  
 \*\*\*\* This part also available with tighter tolerances from [amazon.com](http://amazon.com), part number B004XN8ODA.  
 \*\*\*\*\* To save the time of cutting 30 of these Rods manually, this part is available as pre-cut dowel pins.

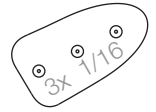
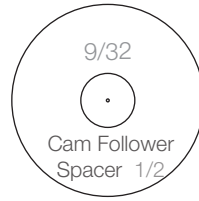
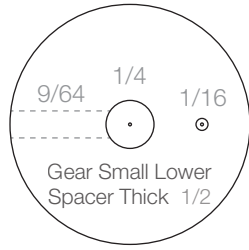
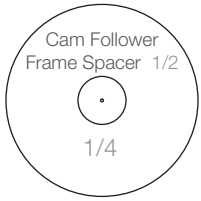
Scale reference. To measure exactly six inches when printed.



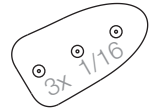
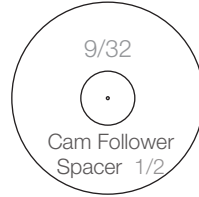
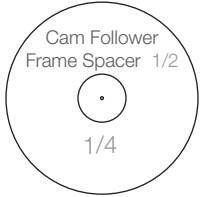
Scale reference. To measure exactly six inches when printed.



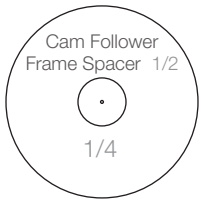
Scale reference. To measure exactly six inches when printed.



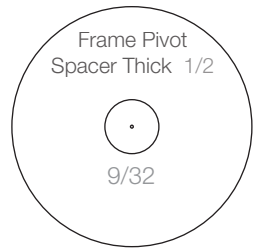
Hummer Body Cam Link Spacer A 1/2



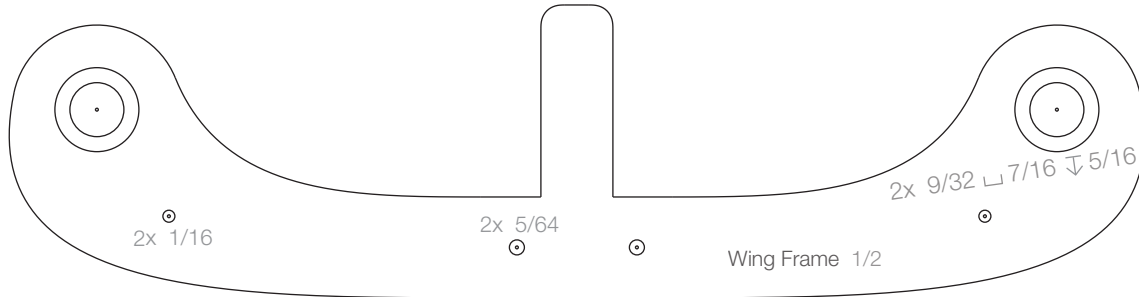
Hummer Body Cam Link Spacer A 1/2



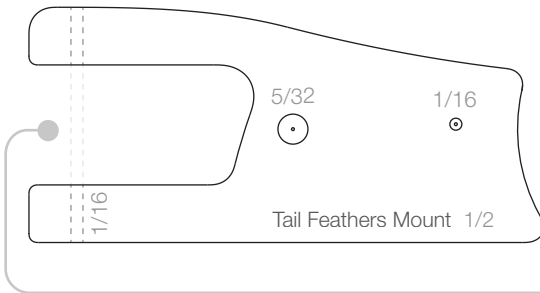
See Wing Frame Fit in Tips + Tactics before cutting the Wing Frame.



Frame Pivot Spacer Thick 1/2

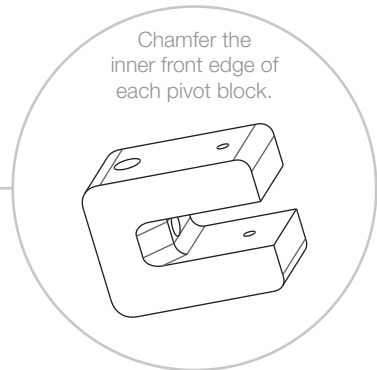


Wing Frame 1/2

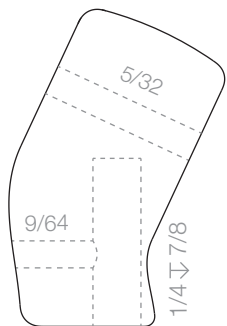


Tail Feathers Mount 1/2

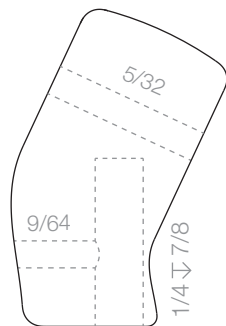
See Tail Tuning in Tips + Tactics.



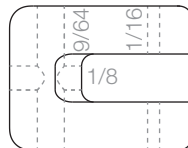
Chamfer the inner front edge of each pivot block.



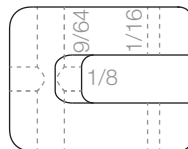
Shoulder Pivot 1/2



Shoulder Pivot 1/2



Pivot Block 1/2

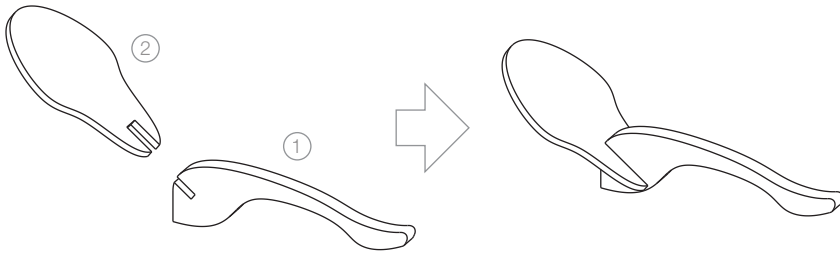


Pivot Block 1/2



# Subassemblies

Steps 1, 2, 3, 4, 5, 6



## Flower Petal Asm (5x)

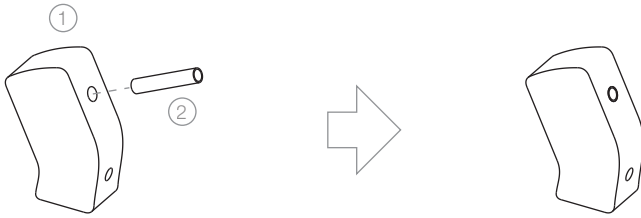
- |   |                    |    |
|---|--------------------|----|
| 1 | Flower Petal Rear  | 1x |
| 2 | Flower Petal Front | 1x |

Parts should hold together firmly without requiring glue.



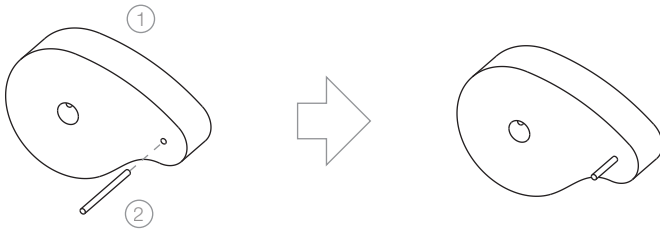
## Rod End Pivot Tube Asm (2x)

- |   |                             |    |
|---|-----------------------------|----|
| 1 | A Tube 1/4" x 1-19/64" Hole | 1x |
| 2 | B Tube 3/32" x 1/4"         | 1x |



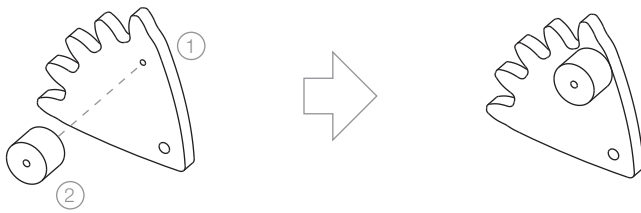
## Shoulder Pivot Asm (2x)

- |   |                       |    |
|---|-----------------------|----|
| 1 | Shoulder Pivot        | 1x |
| 2 | B Tube 5/32" x 13/16" | 1x |



## Spinner Link Thick Asm

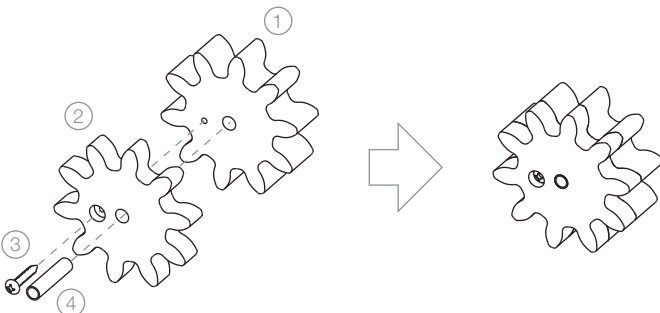
- |   |                    |    |
|---|--------------------|----|
| 1 | Spinner Link Thick | 1x |
| 2 | Rod 1/16" x 15/16" | 1x |



## Tail Fan Gear Asm

- |   |                        |    |
|---|------------------------|----|
| 1 | Tail Fan Gear          | 1x |
| 2 | Tail Fan Gear Standoff | 1x |

Glue Tail Fan Gear Standoff to Tail Fan Gear.

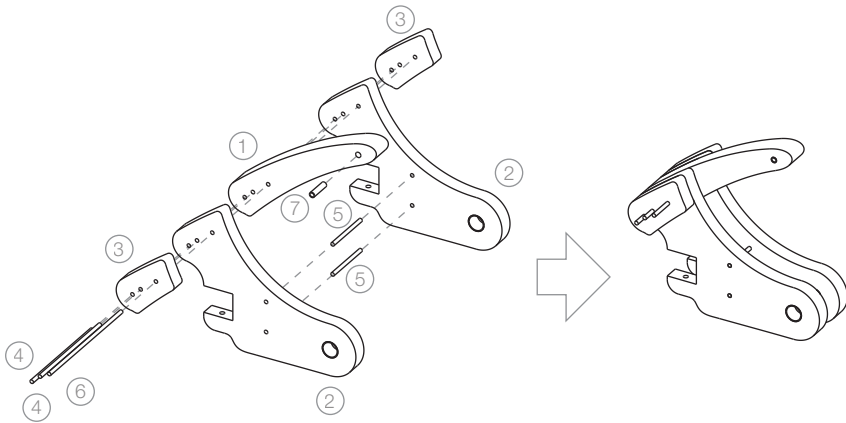


## Tail Pinion Asm

- |   |                       |    |
|---|-----------------------|----|
| 1 | Tail Pinion Thick     | 1x |
| 2 | Tail Pinion Thin      | 1x |
| 3 | Screw #2 x 1/2"       | 1x |
| 4 | B Tube 5/32" x 11/16" | 1x |

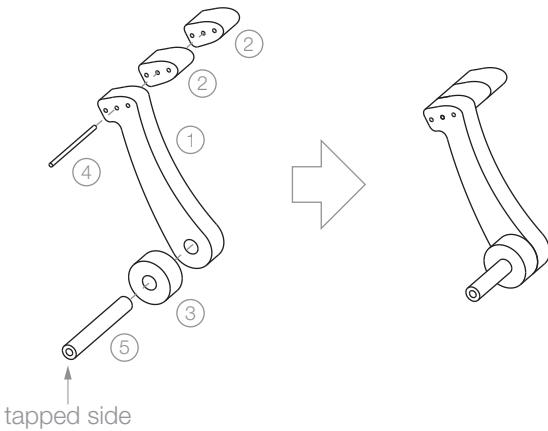
# Subassemblies

Steps 22, 23, 24



## Hummer Body Asm

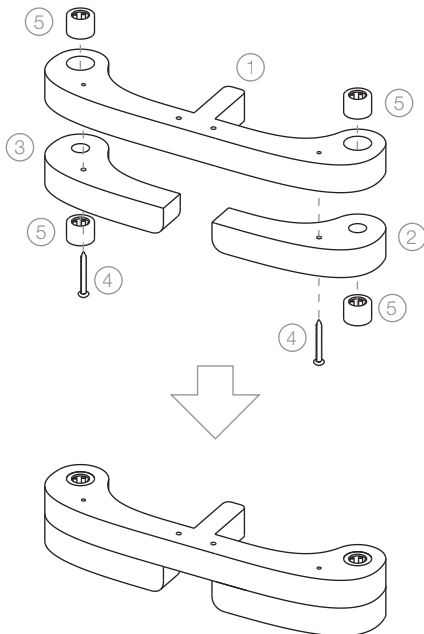
1	Hummer Back	1x
2	Hummer Mount Asm	2x
3	Hummer Body Spacer	2x
4	Rod 1/16" x 1-7/8"	2x
5	Rod 1/16" x 7/8"	2x
6	Rod 1/16" x 2-1/4"	1x
7	B Tube 3/32" x 3/8"	1x



## Hummer Body Cam Link Asm

1	Hummer Body Cam Link	1x
2	Hummer Body Cam Link Spacer A	2x
3	Hummer Body Cam Link Spacer B	1x
4	Rod 1/16" x 1-3/8"	1x
5	S Tube 1/4" x 1-3/4"	1x

Glue Hummer Body Cam Link Spacer B to Hummer Body Cam Link.

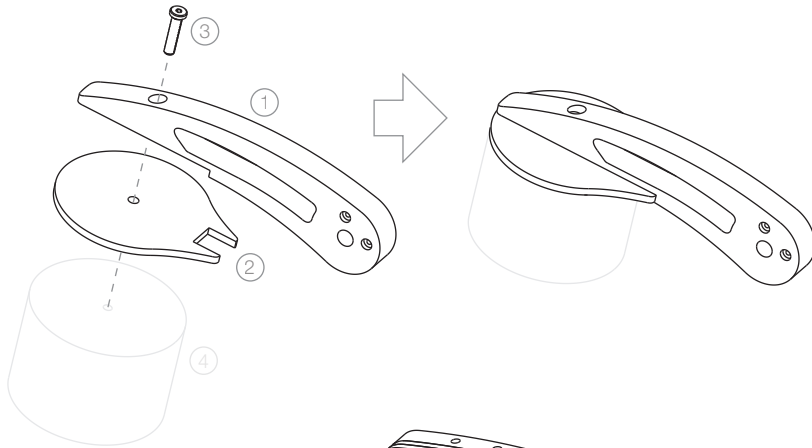


## Wing Frame Asm

1	Wing Frame	1x
2	Wing Frame Support Right	1x
3	Wing Frame Support Left	1x
4	Screw #2 x 3/4"	2x
5	Needle Bearing	4x

# Subassemblies

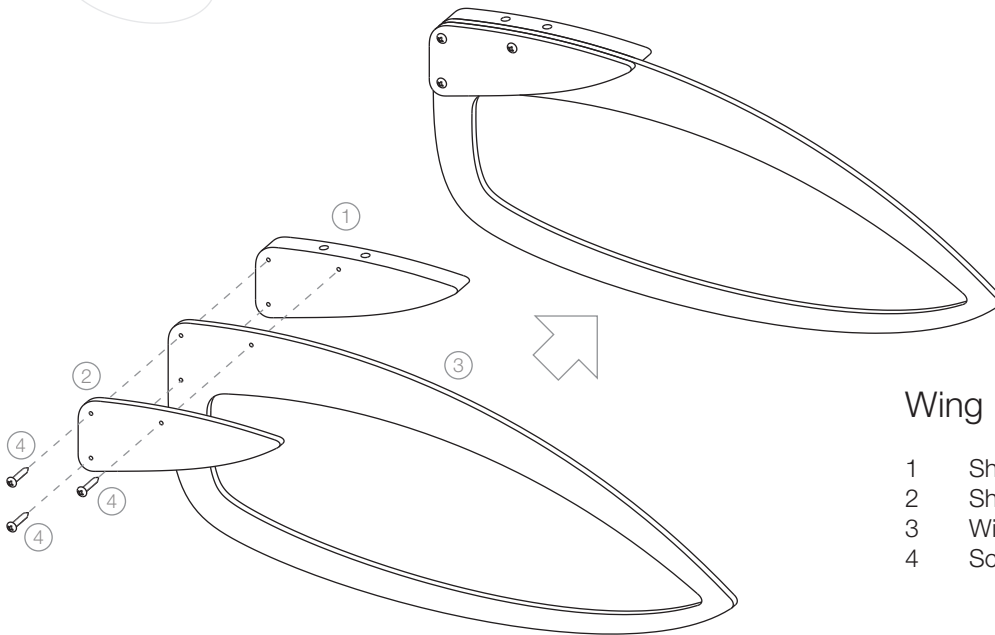
Steps 28, 29, 30



## Counterweight Asm

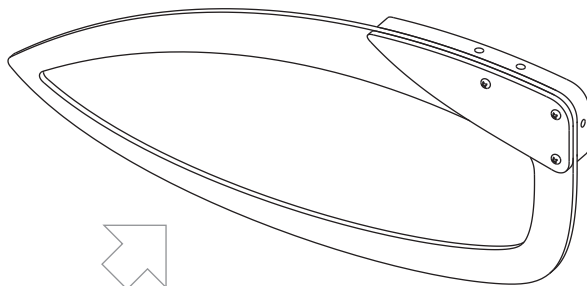
1	Counterweight Arm	1x
2	Counterweight Flange	1x
3	LSHCS 8-32 x 3/4"	1x
4	Counterweight	1x

Note that the actual Counterweight part cannot be made until Colibri is fully assembled. See Weight of the Counterweight in Tips + Tactics.



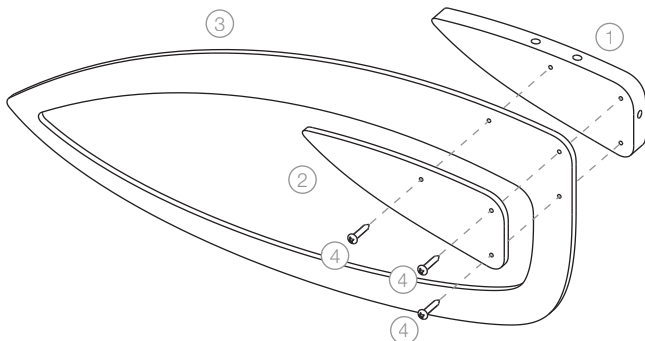
## Wing Left Asm

1	Shoulder Thick	1x
2	Shoulder Thin	1x
3	Wing	1x
4	Screw #2 x 1/2"	3x



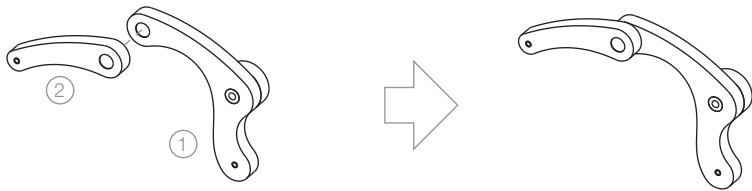
## Wing Right Asm

1	Shoulder Thick	1x
2	Shoulder Thin	1x
3	Wing	1x
4	Screw #2 x 1/2"	3x



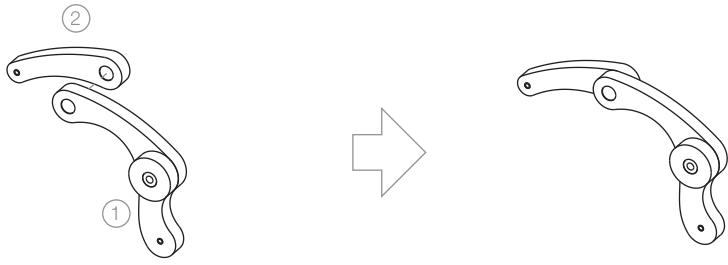
# Subassemblies

Steps 31, 32, 33, 34



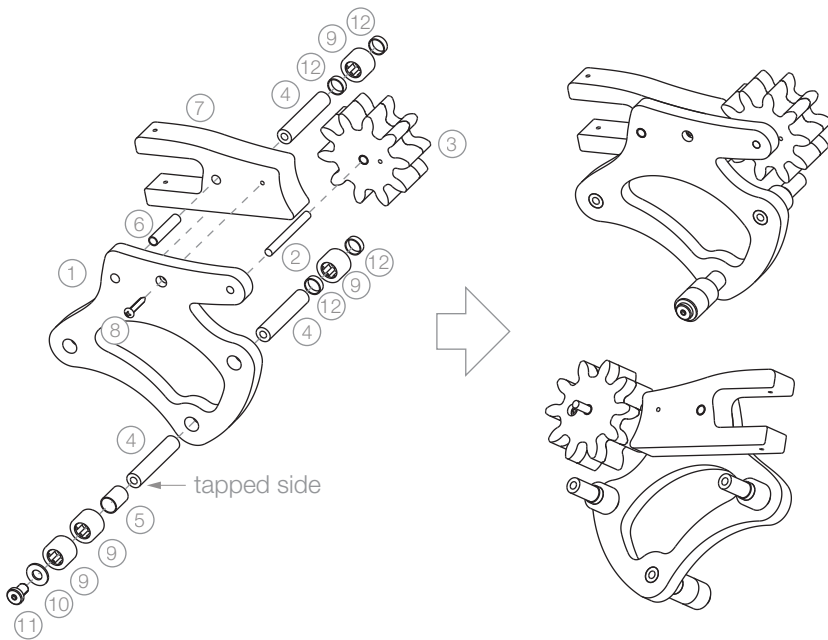
## Links Left Asm

- |   |                        |    |
|---|------------------------|----|
| 1 | Wing Link Arc Left Asm | 1x |
| 2 | Wing Link Straight Asm | 1x |



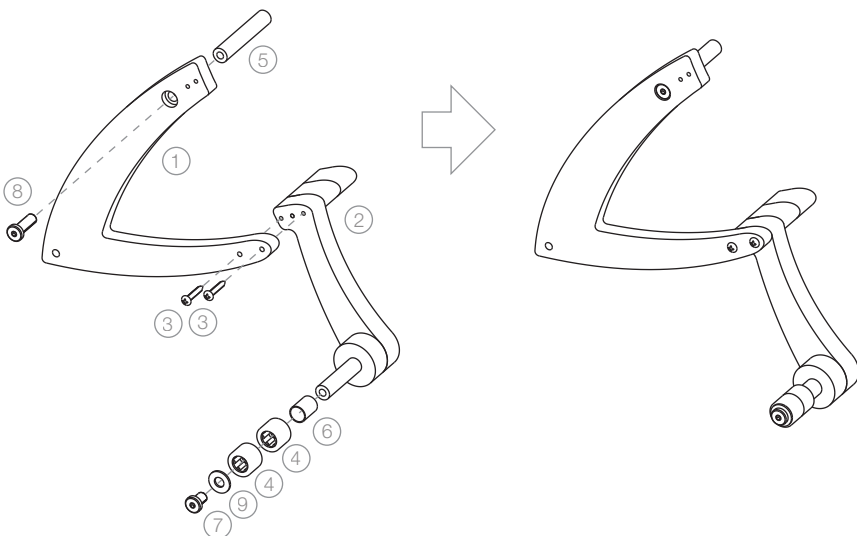
## Links Right Asm

- |   |                         |    |
|---|-------------------------|----|
| 1 | Wing Link Arc Right Asm | 1x |
| 2 | Wing Link Straight Asm  | 1x |



## Tail Mount Right Asm

- |    |                      |    |
|----|----------------------|----|
| 1  | Tail Mount Right     | 1x |
| 2  | Rod 1/8" x 1-1/4"    | 1x |
| 3  | Tail Pinion Asm      | 1x |
| 4  | S Tube 1/4" x 1-1/4" | 3x |
| 5  | B Tube 9/32" x 3/8"  | 1x |
| 6  | B Tube 5/32" x 3/4"  | 1x |
| 7  | Tail Feathers Mount  | 1x |
| 8  | Screw #2 x 1/2"      | 1x |
| 9  | Needle Bearing       | 4x |
| 10 | Washer               | 1x |
| 11 | LSHCS 8-32 x 1/4"    | 1x |
| 12 | B Tube 9/32" x 3/32" | 4x |

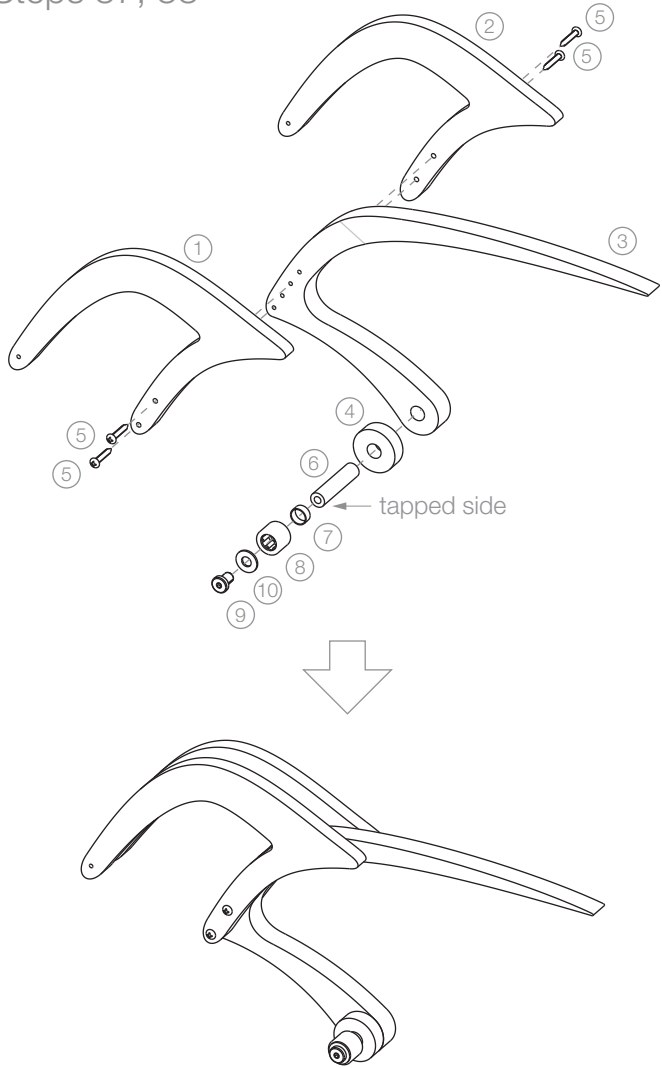


## Hummer Body Right Asm

- |   |                          |    |
|---|--------------------------|----|
| 1 | Hummer Body Right        | 1x |
| 2 | Hummer Body Cam Link Asm | 1x |
| 3 | Screw #2 x 1/2"          | 2x |
| 4 | Needle Bearing           | 2x |
| 5 | A Tube 1/4" x 1-3/8"     | 1x |
| 6 | B Tube 9/32" x 3/8"      | 1x |
| 7 | LSHCS 8-32 x 1/4"        | 1x |
| 8 | LSHCS 8-32 x 1/2"        | 1x |
| 9 | Washer                   | 1x |

# Subassemblies

Steps 37, 38



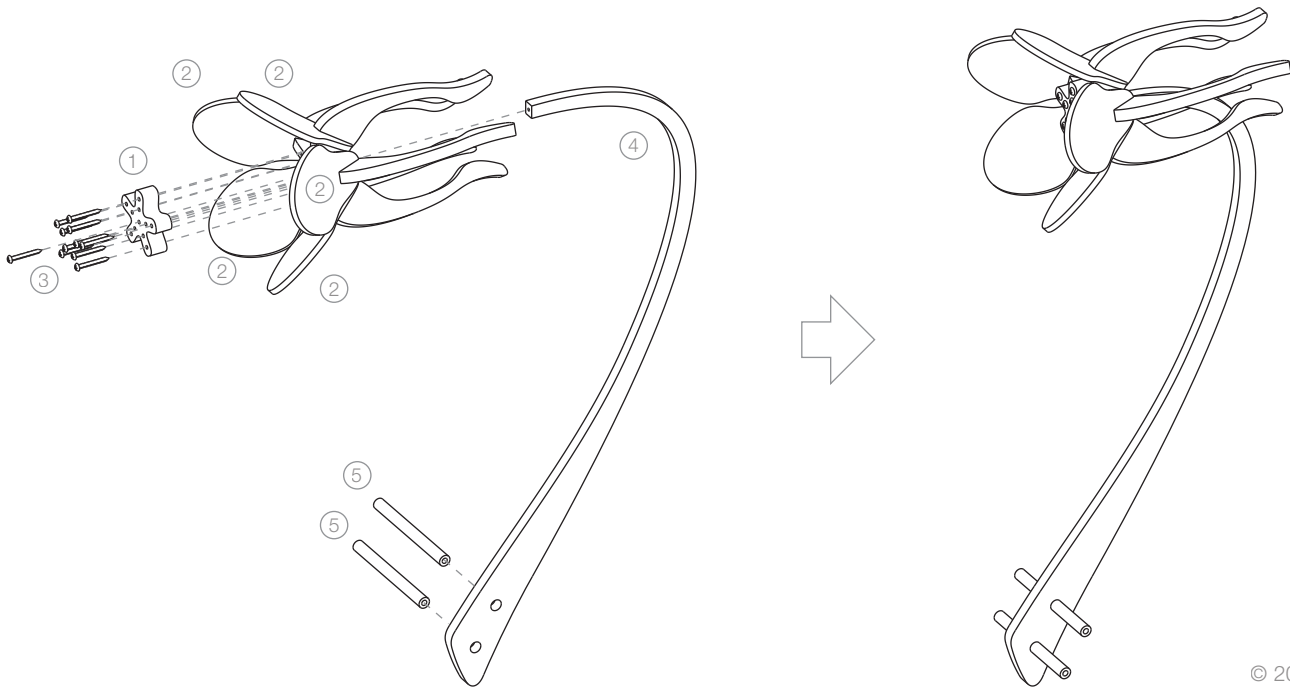
## Hummer Head Asm

1	Hummer Head Right	1x
2	Hummer Head Left	1x
3	Hummer Bill	1x
4	Hummer Bill Spacer	1x
5	Screw #2 x 1/2"	4x
6	S Tube 1/4" x 1-5/64"	1x
7	B Tube 9/32" x 1/8"	1x
8	Needle Bearing	1x
9	LSHCS 8-32 x 1/4"	1x
10	Washer	1x

Glue Hummer Bill Spacer to Hummer Bill.

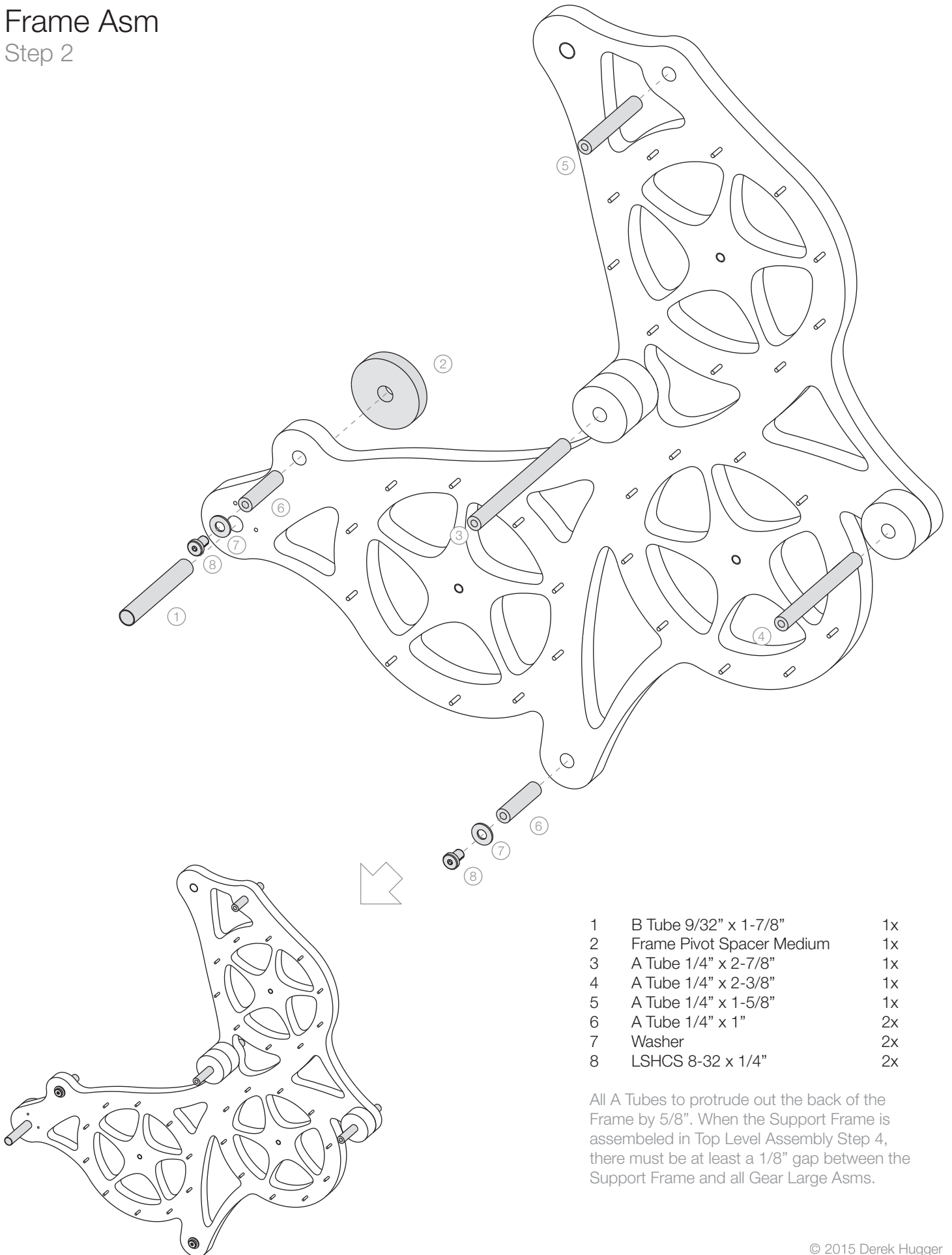
## Flower Asm

1	Flower Center	1x
2	Flower Petal Asm	5x
3	Screw #2 x 3/4"	11x
4	Flower Stem	1x
5	A Tube 1/4" x 2-3/4"	2x



# Frame Asm

## Step 2

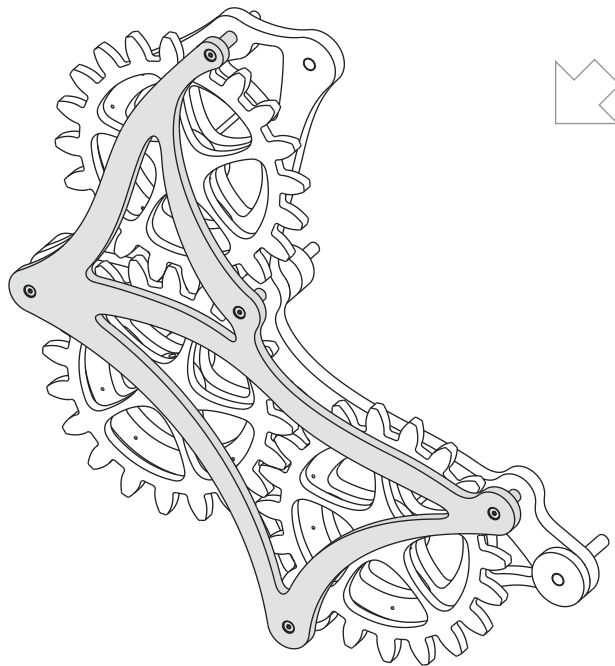
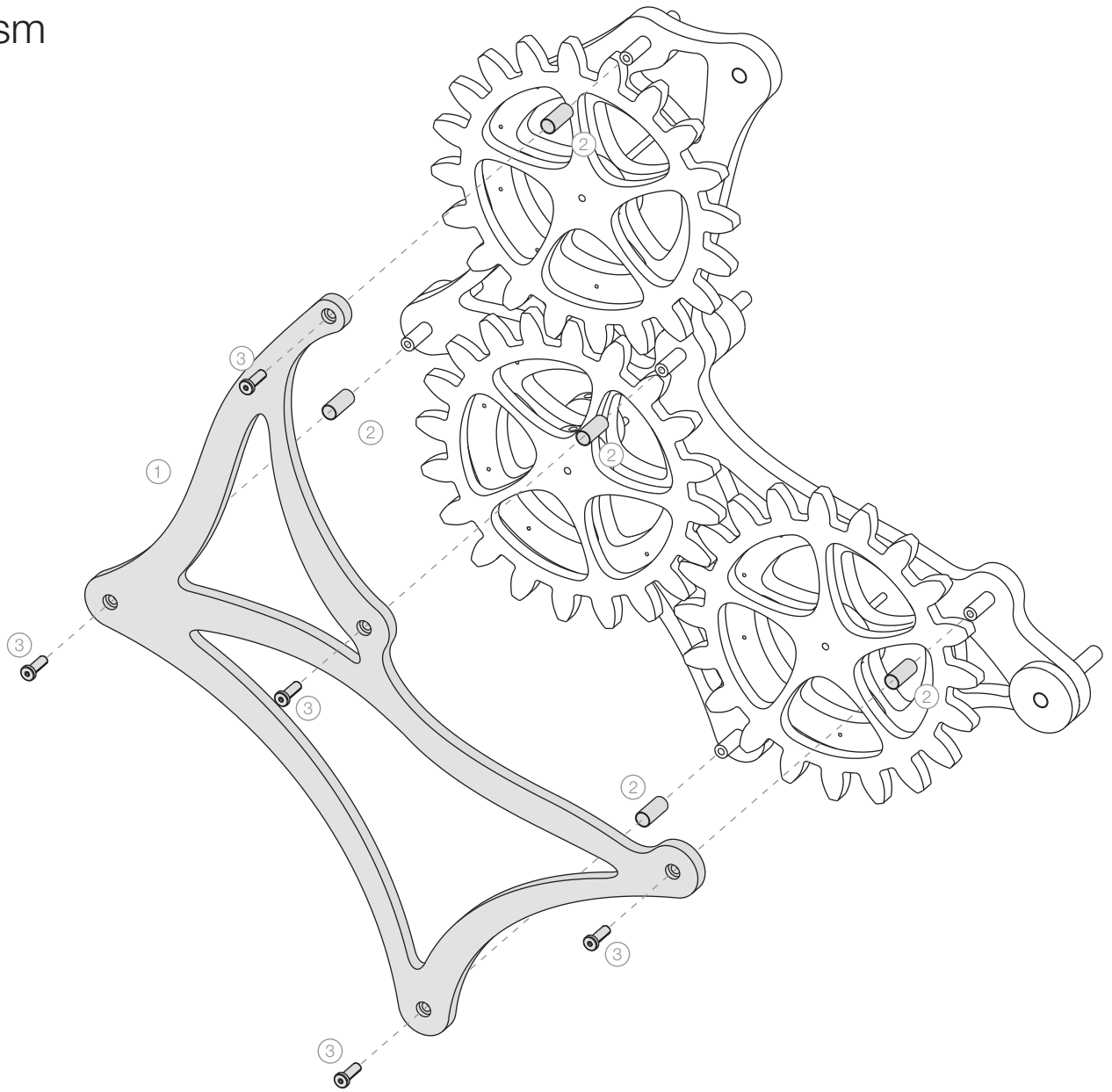


1	B Tube 9/32" x 1-7/8"	1x
2	Frame Pivot Spacer Medium	1x
3	A Tube 1/4" x 2-7/8"	1x
4	A Tube 1/4" x 2-3/8"	1x
5	A Tube 1/4" x 1-5/8"	1x
6	A Tube 1/4" x 1"	2x
7	Washer	2x
8	LSHCS 8-32 x 1/4"	2x

All A Tubes to protrude out the back of the Frame by 5/8". When the Support Frame is assembled in Top Level Assembly Step 4, there must be at least a 1/8" gap between the Support Frame and all Gear Large Asms.

# Frame Asm

## Step 4

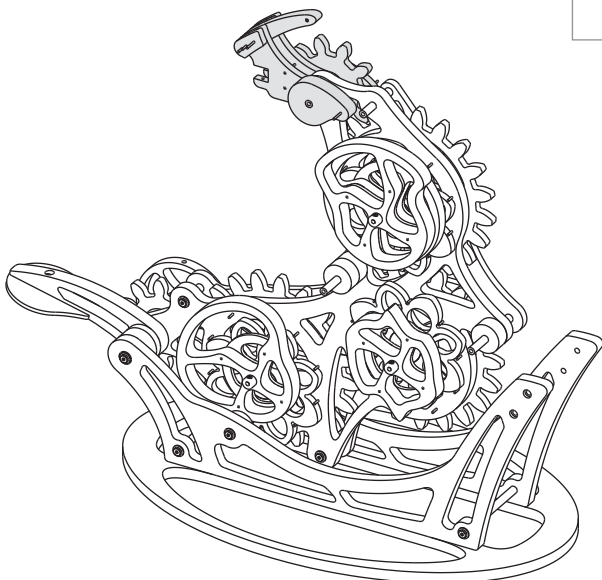
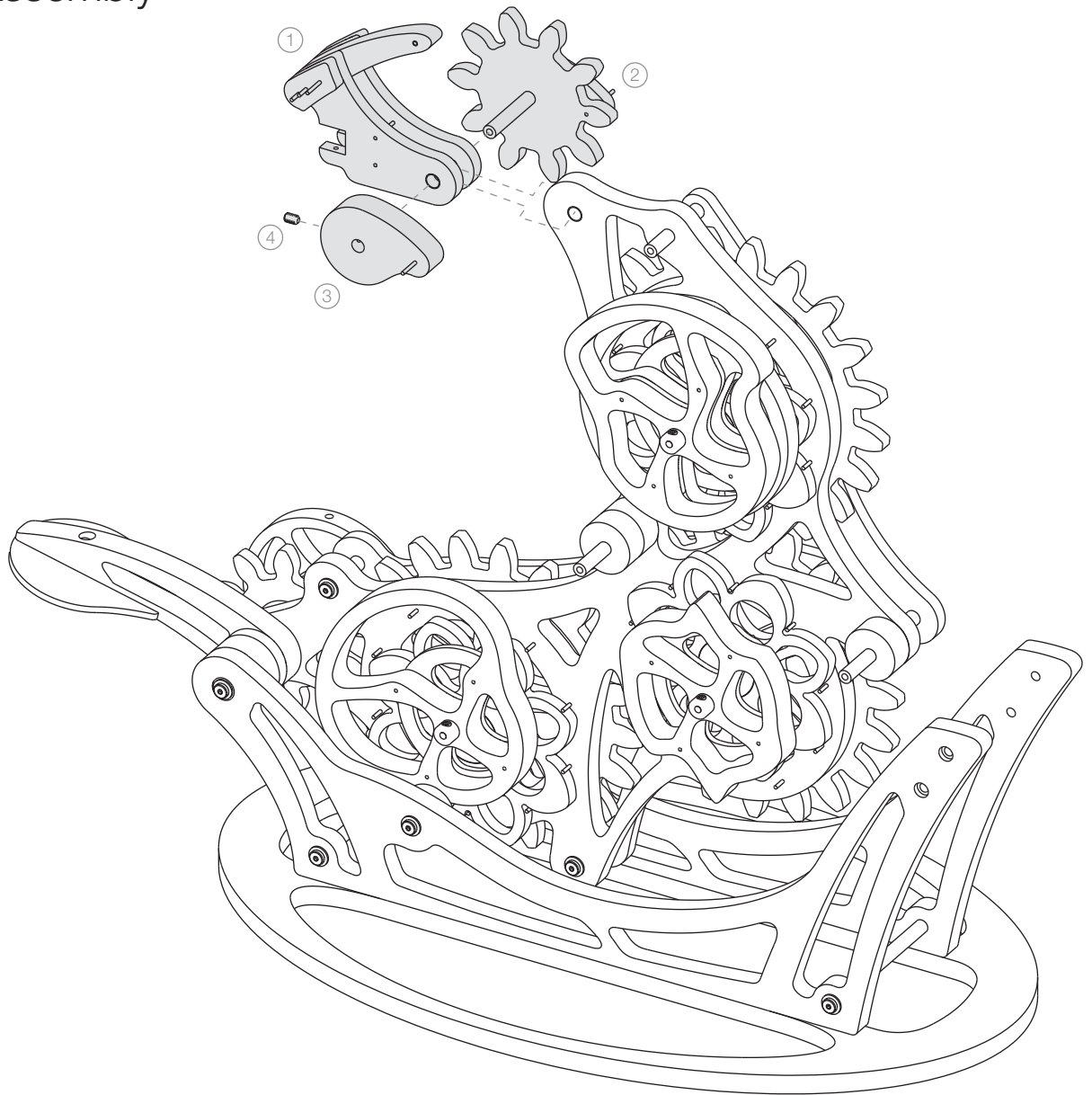


- |   |                     |    |
|---|---------------------|----|
| 1 | Support Frame       | 1x |
| 2 | B Tube 9/32" x 5/8" | 5x |
| 3 | LSHCS 8-32 x 1/2"   | 5x |



# Top Level Assembly

## Step 2



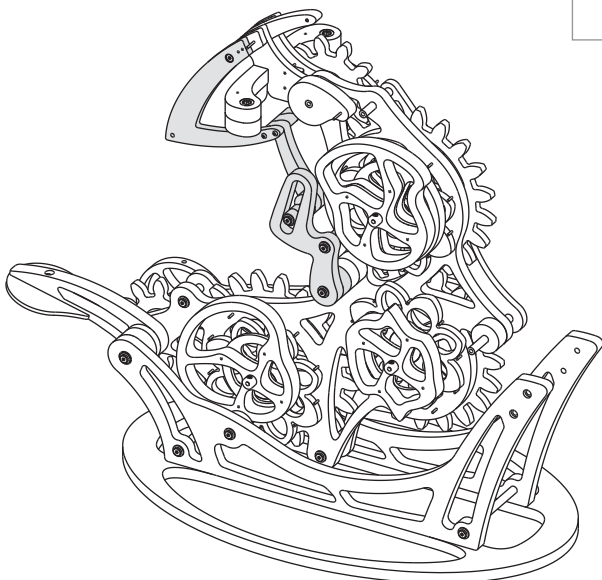
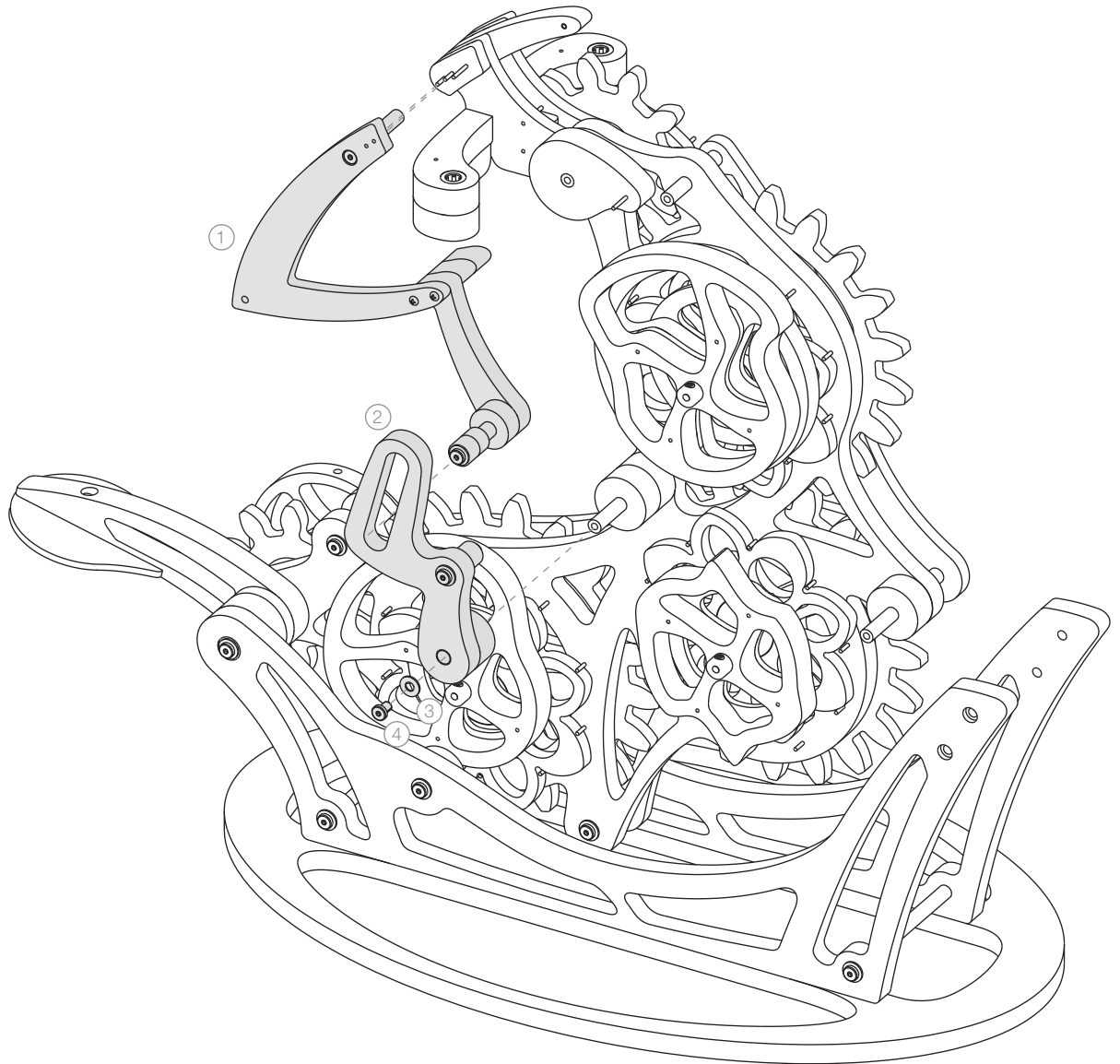
1	Hummer Body Asm	1x
2	Spinner Link Thin Asm	1x
3	Spinner Link Thick Asm	1x
4	Set Screw	1x

The Hummer Body Asm must fit snugly and cannot be loose. A small amount of friction between the Hummer Body Asm and the Frame is acceptable.

Note that the Hummer Body Asm may sag until the Top Level Assembly Step 4 is complete.

# Top Level Assembly

## Step 4



- |   |                       |    |
|---|-----------------------|----|
| 1 | Hummer Body Right Asm | 1x |
| 2 | Cam Follower Body Asm | 1x |
| 3 | Washer                | 1x |
| 4 | LSHCS 8-32 x 1/4"     | 1x |