

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.

Contrivance

a modular mechanism machine

design by Derek Hugger

The Basics



WARNING!

Contrivance is a mechanical demonstrator. It is not a toy intended for children. Contrivance has many small pieces that can pose a choking hazard, and it has sharp pieces that can cause injury when not handled properly. Keep Contrivance and its components out of reach of children.

Contents

These plans include all the information required to build Contrivance. 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.
4. Cut and tap all aluminum tubes, and cut all brass tubes and pins.
5. Follow the assembly instructions to assemble each component.
6. If desired, fully disassemble components to stain and finish them.

Notes

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

Using a quality, flat Baltic birch plywood is important. Cheaper, lower quality plywood, such as types often found at 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 each system’s performance.

The Fine Print

© 2014 Derek Hugger. All Rights Reserved.

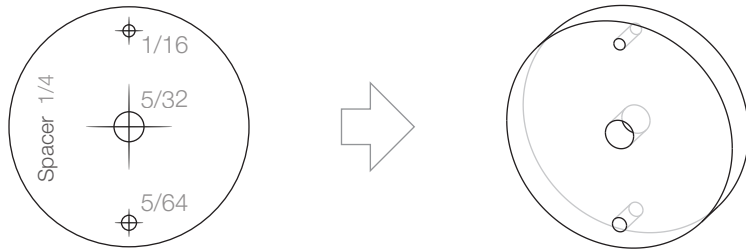
Reproduction of part or all of this document is prohibited except by the original retail purchaser for his or her own personal use. The contents of this document and associated documents, including but not limited to instructions, designs, illustrations, diagrams, and patterns are for personal use, and may not be included in any other work or publication, or be distributed, or be used for commercial purposes except with explicit written consent from the author. Any apparatus or work created using the designs, patterns, or instructions in this document is for personal use only and may not be used for commercial purposes nor sold for profit. The contents of this document are presented in good faith but without warranty and without guaranteed results.

Tips + Tactics

Pattern Syntax

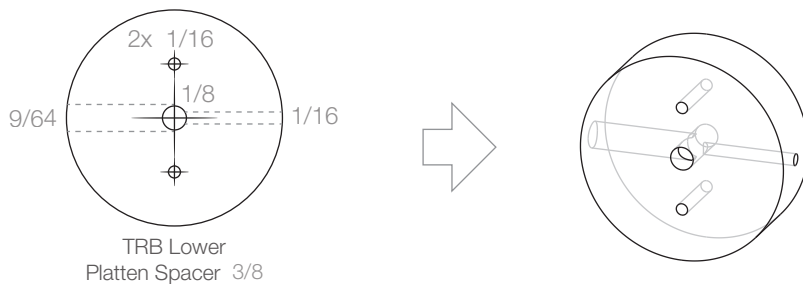
Patterns are labeled with a part name followed by a thickness dimension.

Example: Spacer is cut from 1/4" plywood. It also has a 1/16" thru hole, a 5/32" thru hole, and a 5/64" thru hole.



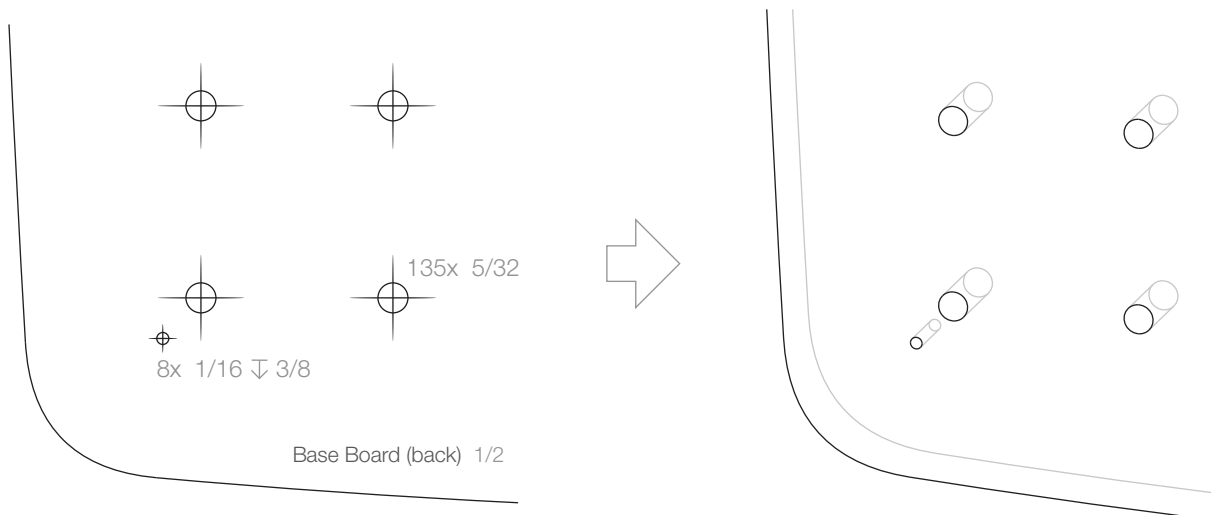
Dashed lines indicate a hole drilled from the side.

Example: TRB Lower Platten Spacer has two holes drilled on the side: one 1/16" and one 9/64". It also has a 1/8" thru hole and two 1/16" thru holes drilled from the front. Unless otherwise specified, holes drilled from the side are to be centered between the front and back of the part.



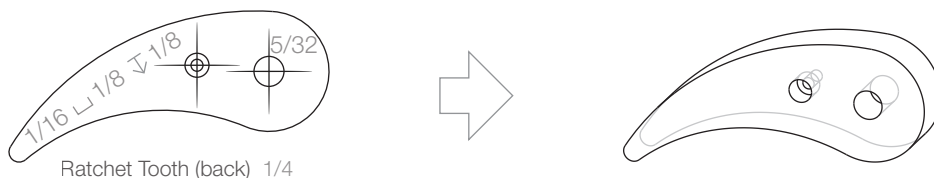
A ∇ symbol indicates drilling to a certain depth, not thru.

Example: The back side of the Base Board has eight 1/16" holes drilled 3/8" deep. It also has one hundred thirty five 5/32" thru holes.



Two concentric circles indicate a hole with a counterbore.

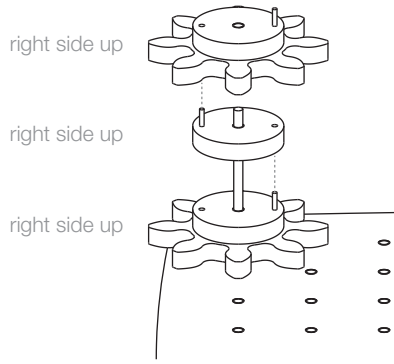
Example: The back side of the Ratchet Tooth has a 1/16" hole drilled thru, with a 1/8" hole drilled 1/8" deep. It also has a 5/32" thru hole.



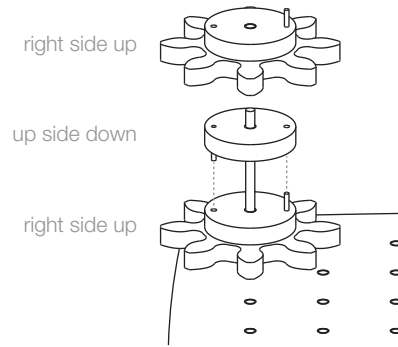
Tips + Tactics

Stacking

Many mechanisms have the ability to stack on one another. If the mechanisms stack in the same direction, they will all lock together and spin together. If two mechanisms stack such that the top one is upside down, the next mechanism to stack on top of the first two will not lock into the first two and will rotate independently.



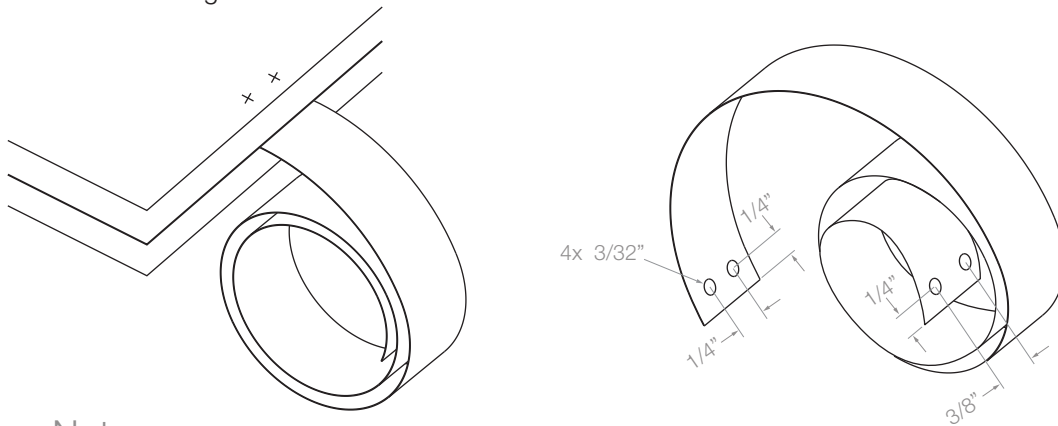
All three pieces lock together.
All three pieces spin together.



Top piece does not lock to bottom pieces.
Top piece will spin independently of bottom pieces.

Spring Holes

Two $\frac{3}{32}$ " mounting holes must be drilled into each end of the spring. The outer holes must be $\frac{1}{4}$ " apart, and the inner holes must be $\frac{3}{8}$ " apart. Carefully clamp the end of the Spring to be drilled between two pieces of scrap wood. Drill through the wood, into the spring. Do not try to drill through the Spring by itself, as this could cause the drill bit to catch on the Spring, twisting it and permanently deforming the Spring. When drilling the inner holes, pull the inner end of the Spring out as little as possible to avoid deforming it.



Miscellaneous Notes

Each Kooky Gear has a small hole near its perimeter. Align those holes, and the Kooky Gears will mesh with each other.

The Ratchet can be driven by hand or with the Scotch Yoke or the Linkage. For the Linkage to properly engage with the Ratchet, Link A and Link C must be parallel.

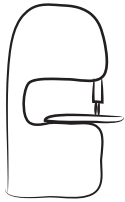
The Ratchet, Linkage, and Tourbillon Assemblies all use Magnets. Press all magnets into place such that they attract to their mating Magnet. Magnets must not repel each other when assembled. If a magnet is accidentally installed backwards, use a $\frac{1}{16}$ " Pin to press the Magnet out from the back side, then reinstall it correctly.

Plywood is typically thinner than its specification (i.e. $\frac{1}{4}$ " plywood may actually be 0.23" thick). Because of this, some or all Tubes may not sit flush in their mechanisms. When this is the case, bias the Tube downward, such that the Tube protrudes slightly out the bottom of the mechanism and is flush with the top.

Tools

Required

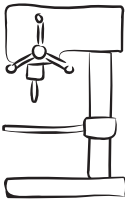
Power Tools



bandsaw



scroll saw



drill press

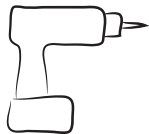
Recommended



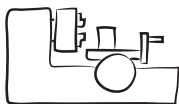
mini chop saw



belt/disc sander



drill



metal lathe



cnc router*

General



brad point drill index
1/16" to 1/2"
in 1/64" increments



drill bit #29



tap 8-32



spade or forstner bits
5/8", 3/4", 7/8", 1-1/8", 1-1/4"



hacksaw



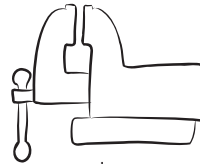
clamp



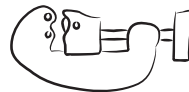
calipers



precision files



vice



tube cutter

Drivers



Phillips #1



hex 5/64"

Supplies



sandpaper



wood glue



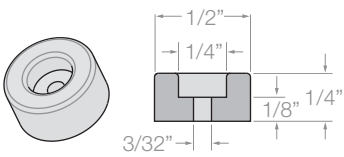
spray adhesive

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

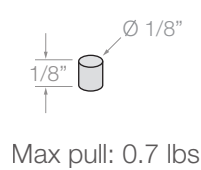
Hardware

| Description | Qty | McMaster Carr P/N * |
|--------------------------------------|-----|---------------------|
| Bumper (see image below) | 4 | 9540k662 |
| LSHCS 8-32 x 1/2" | 3 | 93615A320 |
| Magnet 1/8" x 1/8" (see image below) | 4 | 5862K61 |
| Magnet 1/4" x 1/4" (see image below) | 10 | 58605K75 |
| PHSTS #2 x 1/2" | 30 | 92470A098 |
| PHSTS #2 x 5/8" | 16 | 92470A101 |
| Set Screw 8-32 x 3/16" | 4 | 92313A189 |
| Spring (see image below) | 1 | 9293K19 |
| Washer #8 | 3 | 90107A010 |

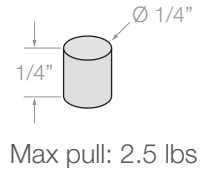
Bumper



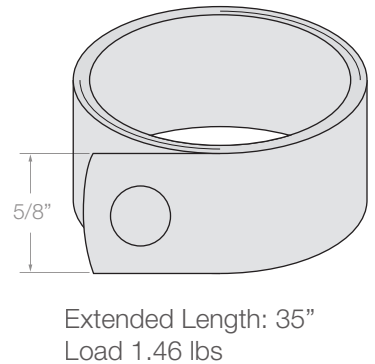
Magnet 1/8" x 1/8"



Magnet 1/4" x 1/4"



Spring Constant Force

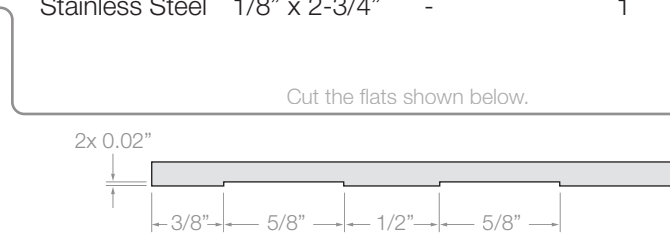


LSHCS low socket head cap screw
 PHSTS pan head self tapping screw

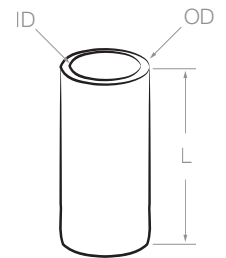
* Part numbers referenced are from www.mcmaster.com.

Metal

| Part | Material | OD x L | ID | Qty | McMaster Carr P/N * |
|-------------------------------|-----------------|-----------------|--------|-----|---------------------|
| Tapped Tube, Balance Wheel** | Aluminum | 1/4" x 2-21/32" | 0.120" | 1 | 1658T12 |
| Tapped Tube, Escape Wheel** | Aluminum | 1/4" x 1-3/8" | 0.120" | 1 | |
| Tapped Tube, Switch** | Aluminum | 1/4" x 1-3/8" | 0.120" | 1 | |
| Tube, 5/32" x 1/4" | Brass | 5/32" x 1/4" | 0.128" | 8 | 8859K21 |
| Tube, 5/32" x 3/8" | Brass | 5/32" x 3/8" | 0.128" | 2 | |
| Tube, 5/32" x 7/16" | Brass | 5/32" x 7/16" | 0.128" | 135 | |
| Tube, 5/32" x 1/2" | Brass | 5/32" x 1/2" | 0.128" | 19 | |
| Tube, 5/32" x 3/4" | Brass | 5/32" x 3/4" | 0.128" | 2 | |
| Tube, 9/32" x 1/4" | Brass | 9/32" x 1/4" | 0.253" | 1 | 8859K25 |
| Tube, 9/32" x 3/8" | Brass | 9/32" x 3/8" | 0.253" | 1 | |
| Tube, 9/32" x 3/4" | Brass | 9/32" x 3/4" | 0.253" | 1 | |
| Tube, 9/32" x 1-1/8" | Brass | 9/32" x 1-1/8" | 0.253" | 1 | |
| Pin, 1/16" x 13/32" | Stainless Steel | 1/16" x 13/32" | - | 14 | - |
| Pin, 1/16" x 1/2" | Stainless Steel | 1/16" x 1/2" | - | 7 | 90145A419 |
| Pin, 1/16" x 5/8" | Stainless Steel | 1/16" x 5/8" | - | 5 | 90145A421 |
| Pin, 1/16" x 3/4" | Stainless Steel | 1/16" x 3/4" | - | 22 | 90145A422 |
| Pin, 1/16" x 7/8" | Stainless Steel | 1/16" x 7/8" | - | 1 | 90145A424 |
| Pin, 1/16" x 1" | Stainless Steel | 1/16" x 1" | - | 3 | 90145A423 |
| Pin, 1/16" x 1-1/8" | Stainless Steel | 1/16" x 1-1/8" | - | 1 | - |
| Pin, 1/16" x 1-3/8" | Stainless Steel | 1/16" x 1-3/8" | - | 3 | - |
| Pin, 1/8" x 1/2" | Stainless Steel | 1/8" x 1/2" | - | 3 | 90145A471 |
| Pin, 1/8" x 3/4" | Stainless Steel | 1/8" x 3/4" | - | 2 | 90145A473 |
| Pin, 1/8" x 7/8" *** | Stainless Steel | 1/8" x 7/8" | - | 10 | 90145A474 |
| Pin, 1/8" x 1" | Stainless Steel | 1/8" x 1" | - | 2 | 90145A475 |
| Pin, 1/8" x 1-1/8" | Stainless Steel | 1/8" x 1-1/8" | - | 1 | 90145A882 |
| Pin, 1/8" x 1-3/8"*** | Stainless Steel | 1/8" x 1-3/8" | - | 13 | 90145A478 |
| Pin, 1/8" x 1-1/2"*** | Stainless Steel | 1/8" x 1-1/2" | - | 10 | 90145A884 |
| Pin, 1/8" x 1-7/8" | Stainless Steel | 1/8" x 1-7/8" | - | 1 | - |
| Pin, 1/8" x 2"*** | Stainless Steel | 1/8" x 2" | - | 10 | 90145A480 |
| Pin, 1/8" x 2-1/8" | Stainless Steel | 1/8" x 2-1/8" | - | 5 | - |
| Pin, 1/8" x 2-1/2"*** | Stainless Steel | 1/8" x 2-1/2" | - | 10 | 90145A487 |
| Pin, 1/8" x 2-3/4" with Flats | Stainless Steel | 1/8" x 2-3/4" | - | 1 | - |



Cut the flats shown below.



OD outer diameter
ID inner diameter
L length

For pin sizes that are not available, 6 ft rods can be cut to length:

1/16": 88915K11

1/8": 8984K2

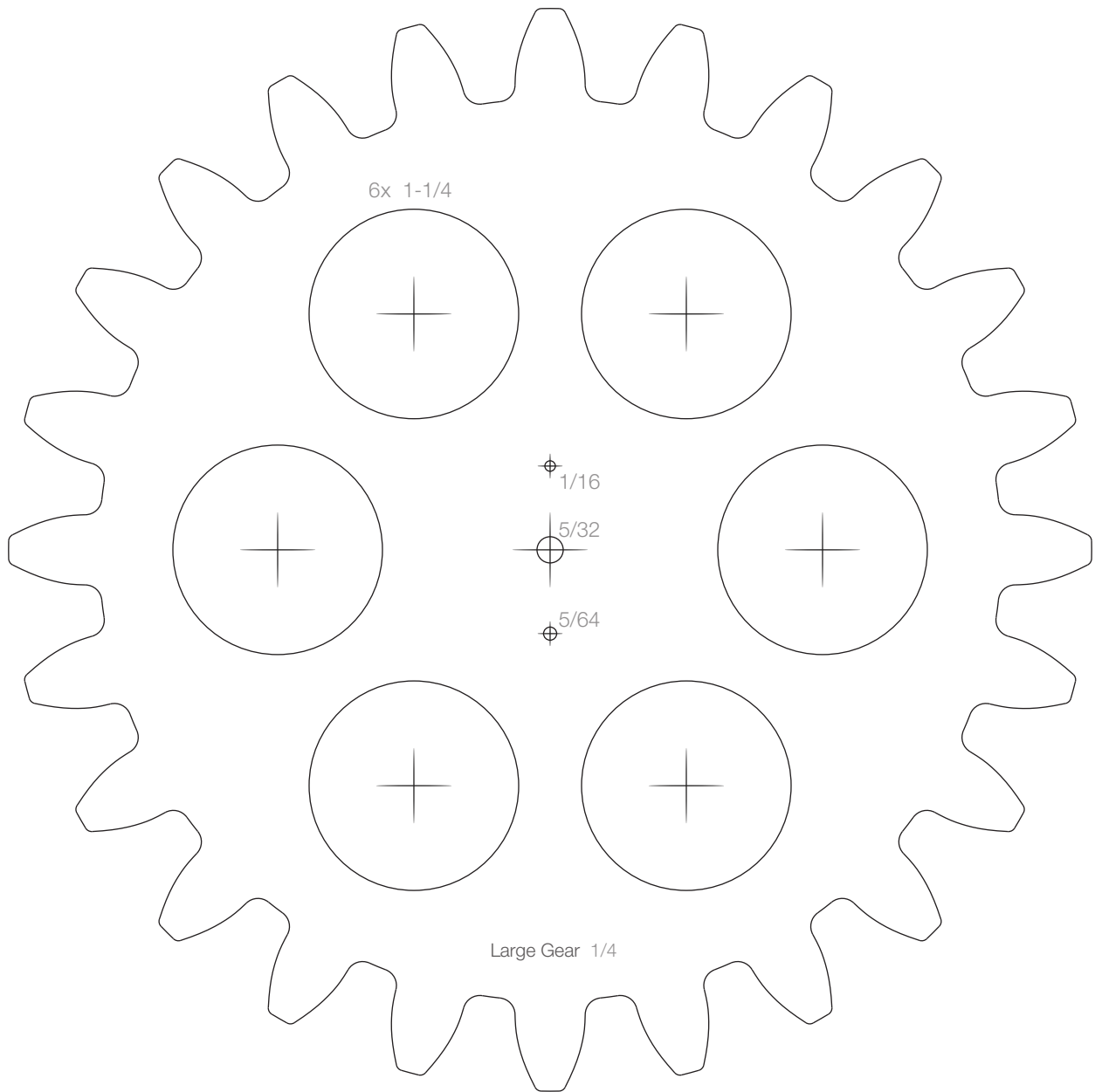
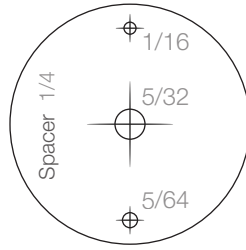
* Part numbers referenced are from www.mcmaster.com.

** Tap one end of each Tapped Tube, 8-32 thread, minimum thread depth 5/8".

*** There are 10 each of these Pins that are not part of an assembly. They can be inserted into the Base Board Asm and used to stack and link mechanisms.

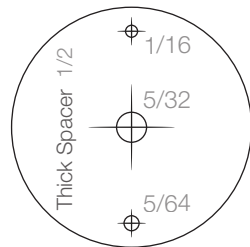
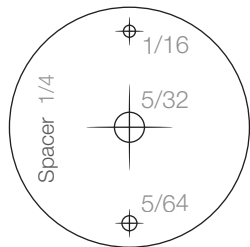
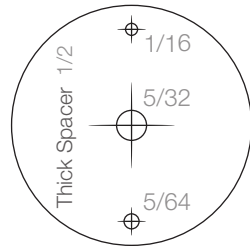
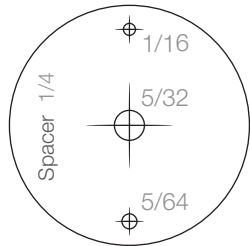
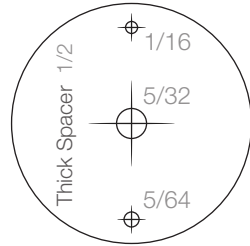
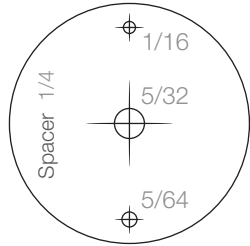
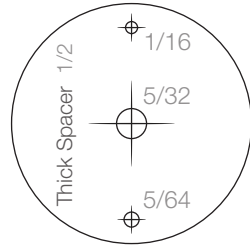
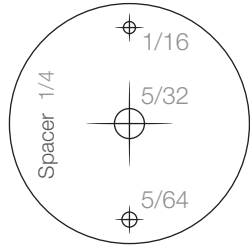


Large Gears 1 of 2



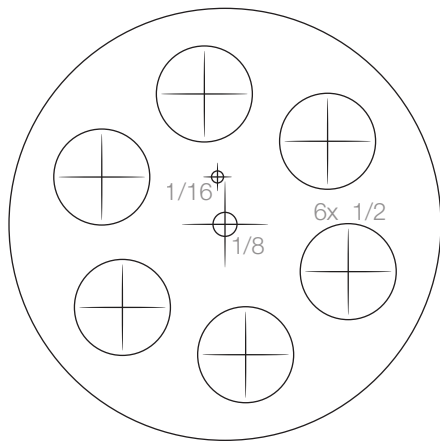
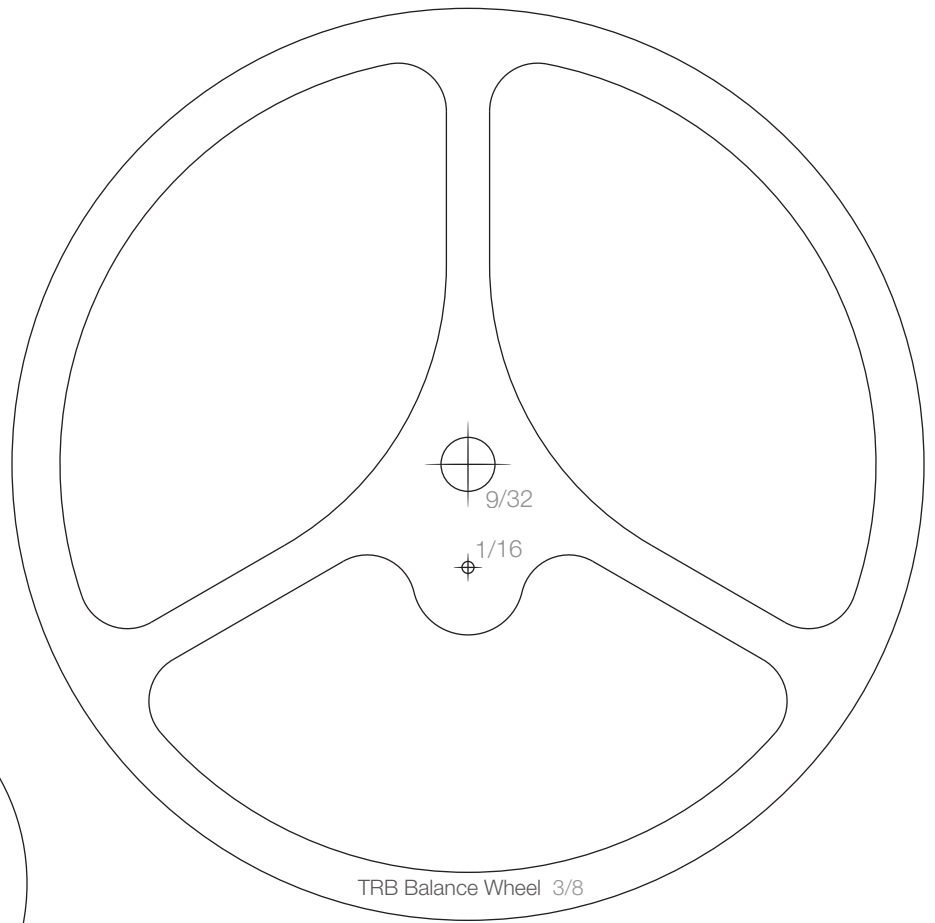


Spacers

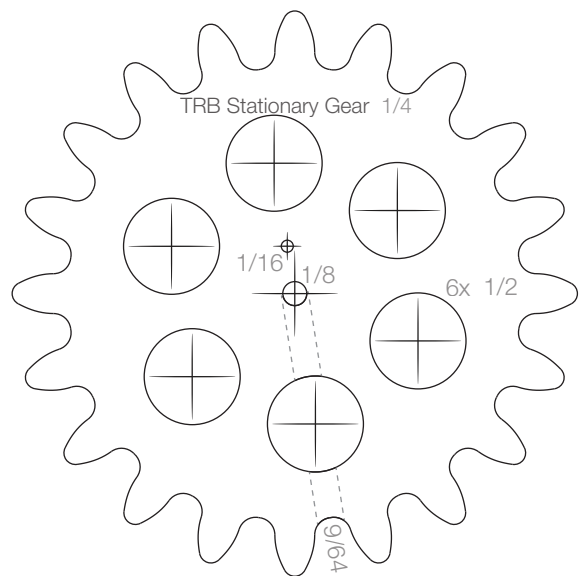
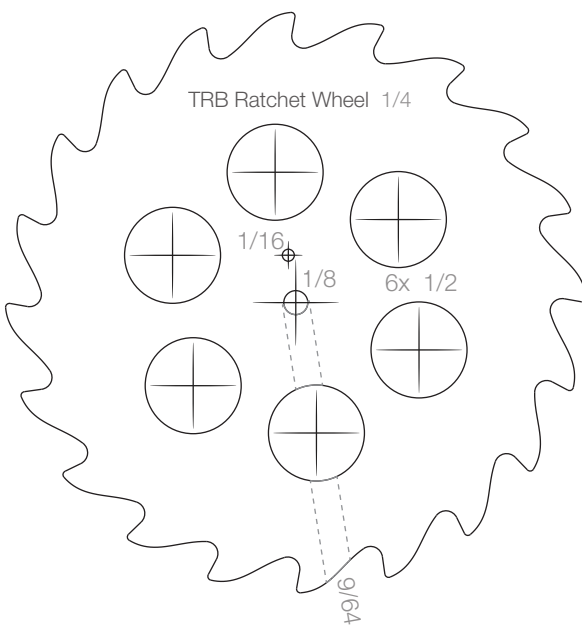




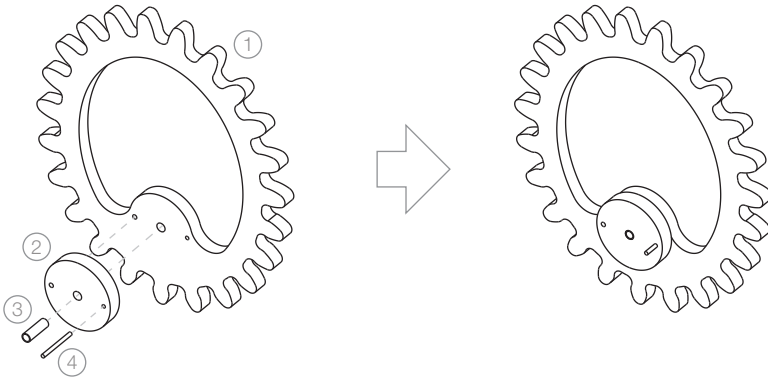
Tourbillon 3 of 5



TRB Stationary Gear Spacer 1/8

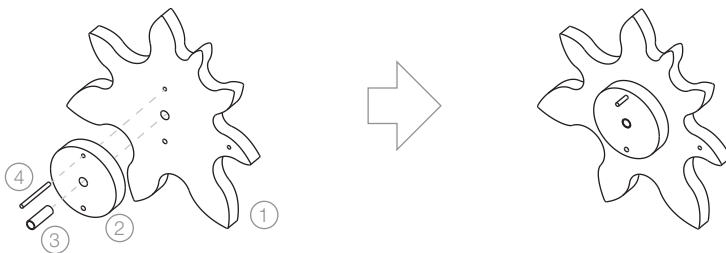


Gear + Spacer Assemblies



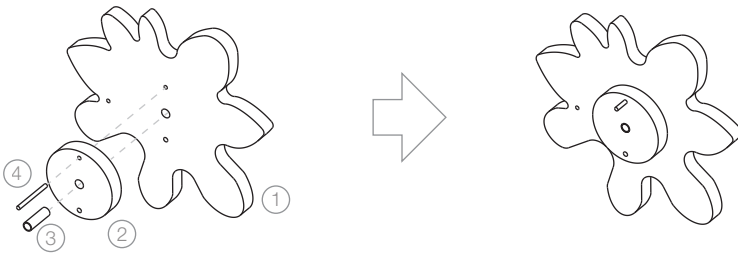
Elliptical Gear Asm (2x)

| # | Required Parts | Qty |
|---|--------------------|-----|
| 1 | Elliptical Gear | 1 |
| 2 | Spacer | 1 |
| 3 | Tube, 5/32" x 1/2" | 1 |
| 4 | Pin, 1/16" x 3/4" | 1 |



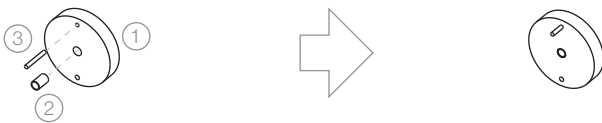
Kooky Gear A Asm

| # | Required Parts | Qty |
|---|--------------------|-----|
| 1 | Kooky Gear A | 1 |
| 2 | Spacer | 1 |
| 3 | Tube, 5/32" x 1/2" | 1 |
| 4 | Pin, 1/16" x 3/4" | 1 |



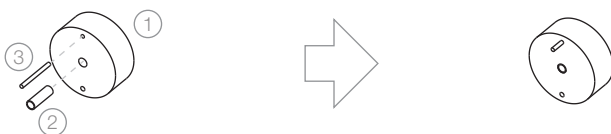
Kooky Gear B Asm

| # | Required Parts | Qty |
|---|--------------------|-----|
| 1 | Kooky Gear B | 1 |
| 2 | Spacer | 1 |
| 3 | Tube, 5/32" x 1/2" | 1 |
| 4 | Pin, 1/16" x 3/4" | 1 |



Spacer Asm (4x)

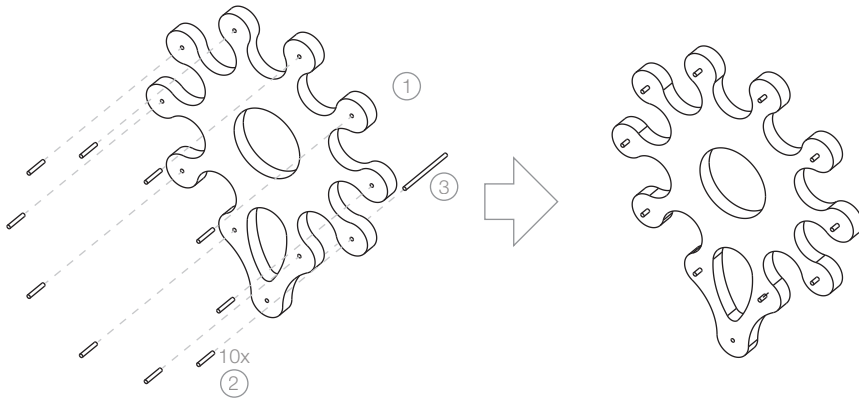
| # | Required Parts | Qty |
|---|--------------------|-----|
| 1 | Spacer | 1 |
| 2 | Tube, 5/32" x 1/4" | 1 |
| 3 | Pin, 1/16" x 1/2" | 1 |



Thick Spacer Asm (4x)

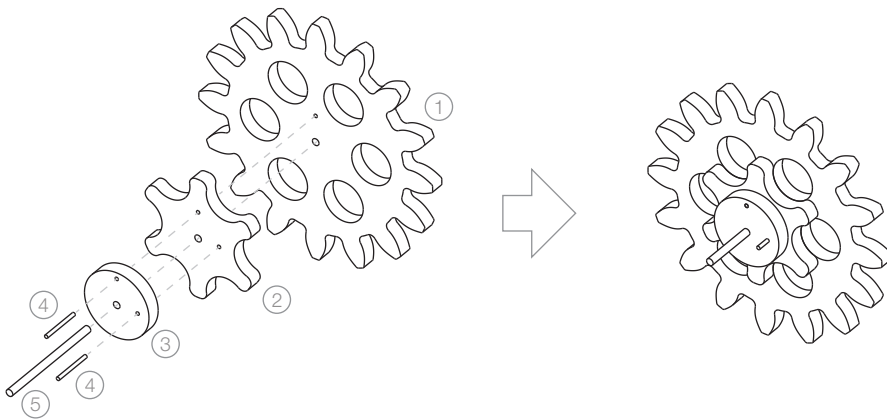
| # | Required Parts | Qty |
|---|--------------------|-----|
| 1 | Thick Spacer | 1 |
| 2 | Tube, 5/32" x 1/2" | 1 |
| 3 | Pin, 1/16" x 3/4" | 1 |

Hypocycloid Reducer Assemblies



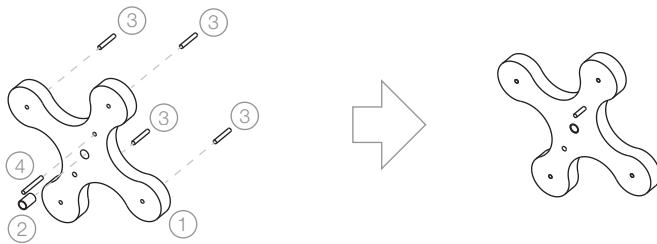
Hypocycloid Base Asm

| # | Required Parts | Qty |
|---|---------------------|-----|
| 1 | Hypocycloid Base | 1 |
| 2 | Pin, 1/16" x 13/32" | 10 |
| 3 | Pin, 1/16" x 1-1/8" | 1 |



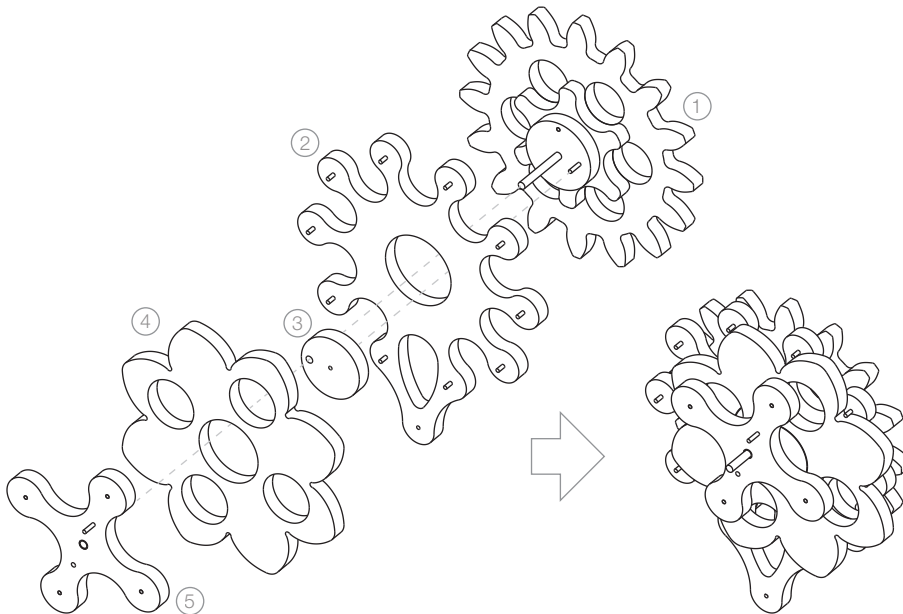
Hypocycloid Cam Input Asm

| # | Required Parts | Qty |
|---|-------------------------|-----|
| 1 | Medium Mechanism Gear | 1 |
| 2 | Hypocycloid Gear Spacer | 1 |
| 3 | Hypocycloid Input | 1 |
| 4 | Pin, 1/16" x 3/4" | 2 |
| 5 | Pin, 1/8" x 2-1/8" | 1 |



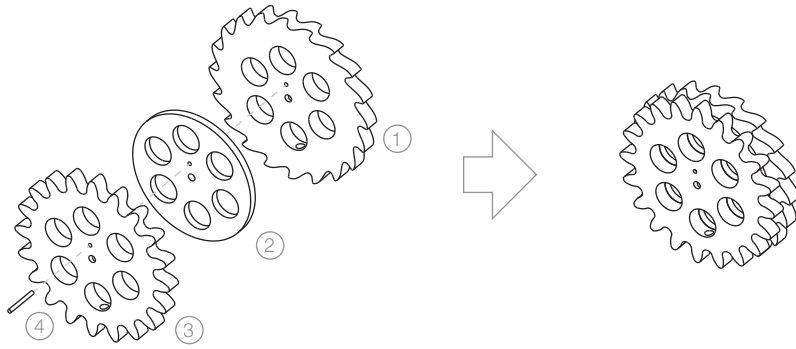
Hypocycloid Output Asm

| # | Required Parts | Qty |
|---|---------------------|-----|
| 1 | Hypocycloid Output | 1 |
| 2 | Tube, 5/32" x 1/4" | 1 |
| 3 | Pin, 1/16" x 13/32" | 4 |
| 4 | Pin, 1/16" x 1/2" | 1 |



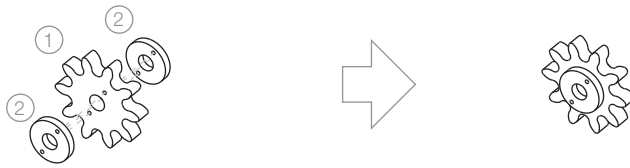
Hypocycloid Reducer Asm

| # | Required Parts | Qty |
|---|---------------------------|-----|
| 1 | Hypocycloid Cam Input Asm | 1 |
| 2 | Hypocycloid Base Asm | 1 |
| 3 | Hypocycloid Cam | 1 |
| 4 | Hypocycloid Wobbler | 1 |
| 5 | Hypocycloid Output Asm | 1 |



TRB Gear Asm

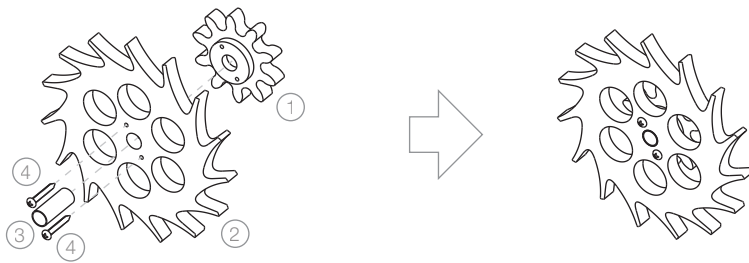
| # | Required Parts | Qty |
|---|----------------------------|-----|
| 1 | TRB Ratchet Wheel | 1 |
| 2 | TRB Stationary Gear Spacer | 1 |
| 3 | TRB Stationary Gear | 1 |
| 4 | Pin, 1/16" x 5/8" | 1 |



TRB Escape Wheel Gear Asm

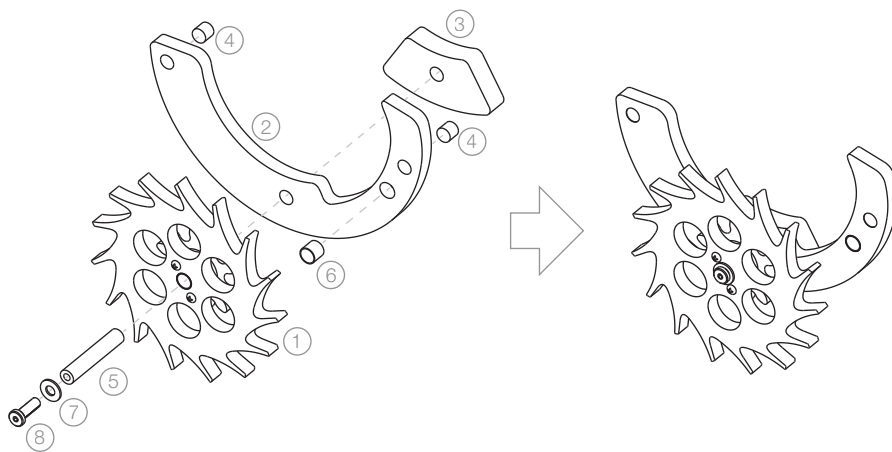
| # | Required Parts | Qty |
|---|-------------------------|-----|
| 1 | TRB Escape Wheel Gear | 1 |
| 2 | TRB Escape Wheel Spacer | 2 |

Glue all three pieces together. Pins may be used to ensure alignment while gluing (1/16" and 1/8" pins).



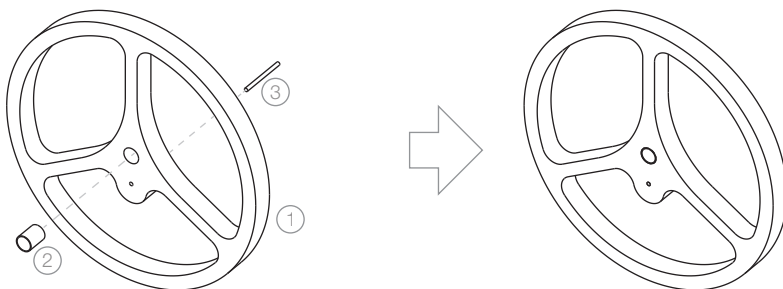
TRB Escapement Asm

| # | Required Parts | Qty |
|---|---------------------------|-----|
| 1 | TRB Escape Wheel Gear Asm | 1 |
| 2 | TRB Escape Wheel | 1 |
| 3 | Tube, 9/32" x 3/4" | 1 |
| 4 | PHSTS, #2 x 5/8" | 2 |



TRB Switch Asm

| # | Required Parts | Qty |
|---|---------------------------|-----|
| 1 | TRB Escapement Asm | 1 |
| 2 | TRB Switch | 1 |
| 3 | TRB Switch Hard Stop | 1 |
| 4 | Magnet, 1/4" x 1/4" | 2 |
| 5 | Tapped Tube, Escape Wheel | 1 |
| 6 | Tube, 9/32" x 1/4" | 1 |
| 7 | Washer, #8 | 1 |
| 8 | LSHCS, 8-32 x 1/2" | 1 |



TRB Balance Wheel Asm

| # | Required Parts | Qty |
|---|--------------------|-----|
| 1 | TRB Balance Wheel | 1 |
| 2 | Tube, 9/32" x 3/8" | 1 |
| 3 | Pin, 1/16" x 7/8" | 1 |