

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.

# Annulation

a kinetic sculpture

design by Derek Hugger

# The Basics

## Contents

These plans include all the information required to build Annulation. 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 wood parts, and step-by-step assembly instructions.

## Before Building

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

## Build Process

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 the time to cut out the parts slowly and 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 all stainless steel tubes, stainless steel rods, brass tubes, and the Wind Key. Tap SS Tube Core.
5. Following the assembly instructions, build all subassemblies, and then build the Top Level Assembly, using the Wall Mount Template as a guide to mount Annulation to the wall following Top Level Assembly Step 4.
6. If desired, fully disassemble Annulation to finish the components. Stain and polyurethane will have a negligible effect on Annulation's balance and performance.

## Notes

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 sculpture's performance.

All Stainless Steel Rods must press firmly into their mating wood parts.

## The Fine Print

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# Tips + Tactics

## Spring Alternative

If a Spring cannot be obtained, a Weight can be used instead. The weight can be made from virtually any object meeting the requirements below.

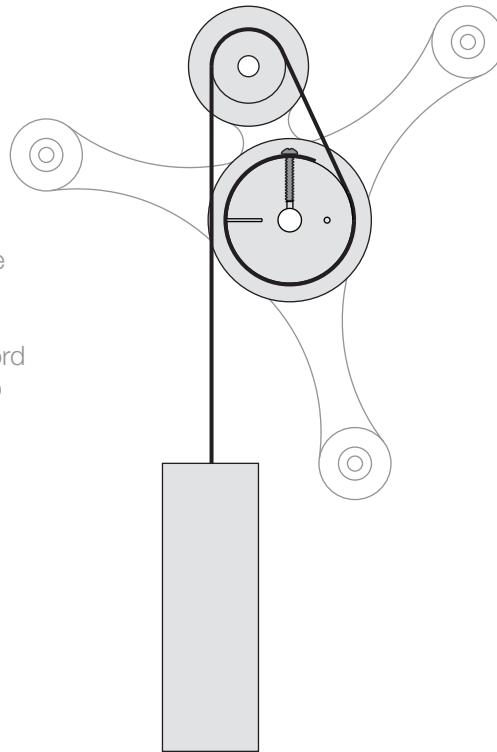
Hardware required:

Weight about 1 lb, less than 2" in diameter

PHSTS #2 x 5/8" cut or filed to 1/2" long

Nylon Cord about 0.050" in diameter, 6 - 8 ft long

Drill a 1/16" hole centered in the side of the Escapement Drum. Use the filed down PHSTS to secure one end of the Nylon Cord to the Escapement Drum. Wrap the Nylon Cord as shown, and then secure the weight to the loose end of the Nylon Cord.



Using a weight, Annulation's run time is dependent on its distance from the floor. The higher up on the wall it is mounted, the longer it will run.

Unlike a Spring, the Weight can be tuned to change Annulation's speed. Start with a Weight that is heavier than the requirement. Attach it to Annulation, and observe Annulation's rotation speed. If it is too fast, cut material from the Weight to remove mass and slow Annulation down.

# Tips + Tactics

## Clamping + Gluing

When clamping and gluing each ring segment together, clamp with just enough force to keep the ring segments from separating. Using too much clamp force can cause the ring segments to flex, potentially resulting in a final glued assembly that looks warped, skewed, or elliptical.

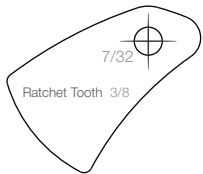
## Top Level Assembly Balance

Due to variations in cuts and in material densities, the length and/or number of Stainless Steel Tubes used as weights on each Weighted Ring Asm may vary. Balance Annulation (by adjusting the Stainless Steel Tubes) such that the Stainless Steel Rod in the Spinner comes to rest just to the left of the lower Ratchet Tooth when the upper Ratchet tooth is engaged on the Stainless Steel Rod protruding from the Frame.

## Pattern Syntax

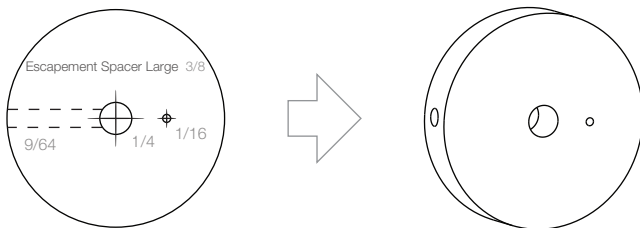
Patterns are labeled with a part name followed by a thickness dimension.

Example: Ratchet Tooth is cut from  $\frac{3}{8}$ " plywood. It also has a hole to be drilled with a  $\frac{7}{32}$ " bit.



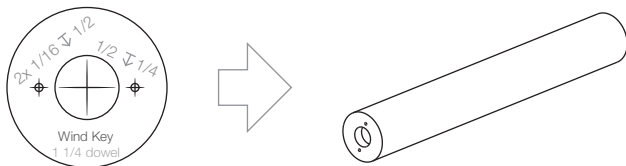
Dashed lines indicate a hole drilled from the side.

Example: Escapement Spacer Large has a  $\frac{9}{64}$ " hole drilled from the side. It also has a  $\frac{1}{4}$ " hole and a  $\frac{1}{16}$ " hole drilled from the front.



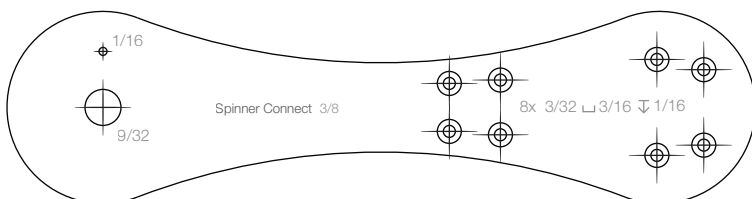
A  $\nabla$  symbol indicates drilling to a certain depth, not thru.

Example: Wind Key has a  $\frac{1}{2}$ " hole drilled  $\frac{1}{4}$ " deep and two  $\frac{1}{16}$ " holes drilled  $\frac{1}{2}$ " deep.



A circle around a hole indicates a counterbore.

Example: Spinner Connect has eight  $\frac{3}{32}$ " holes, each with a  $\frac{3}{16}$ " counterbore drilled  $\frac{1}{16}$ " deep. It also has a  $\frac{1}{16}$ " hole and a  $\frac{9}{32}$ " hole.



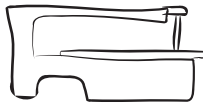
# Tools

Required

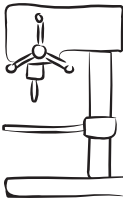
## Power Tools



bandsaw



scroll saw



drill press

## General



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



drill bit\* #29



tap\* 8-32



spade or forstner bit 1 1/16"



hacksaw



clamp  
min jaw opening 15"

## Drivers



phillips #1



hex 5/64"

## Supplies



sandpaper

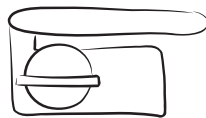


wood glue

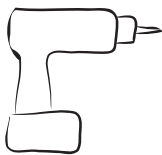


spray adhesive

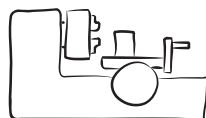
Recommended



belt/disc sander



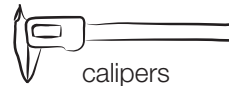
drill



metal lathe



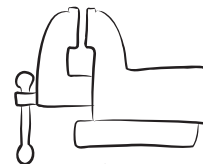
cnc router\*\*



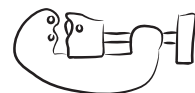
calipers



precision files



vice



tube cutter

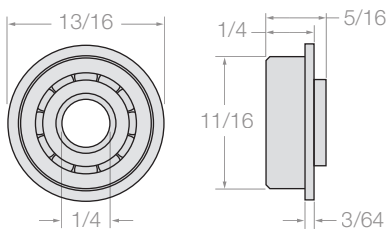
\* For drilling and tapping into stainless steel, cobalt steel drill bits and taps are required.

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

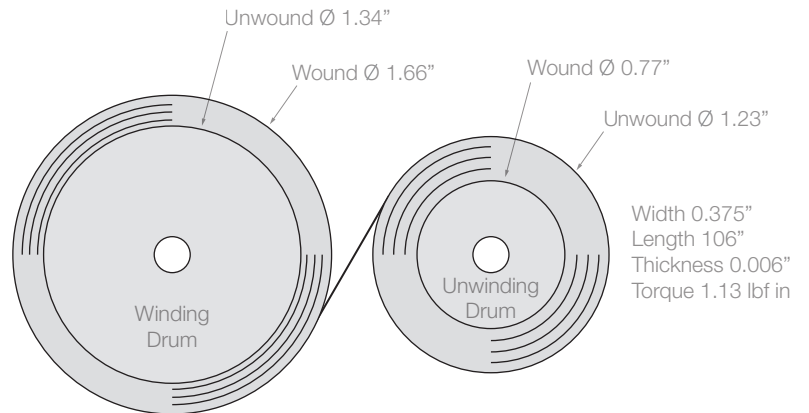
# Hardware

Description	Qty	McMaster Carr P/N *
Bearing (see image below)	4	6383k213
LSHCS 8-32 x 1/4"	5	93615A317
Monofilament ( $\varnothing$ 0.015" - 0.020")	-	9442T2
PHSTS #2 x 1/4"	6	92470A095
PHSTS #2 x 5/8"	24	92470A101
Set Screw 8-32 x 3/16"	2	92313A189
Shim (0.093" Thick, 1/4" ID, 3/8" OD)	2	3088a48
Spring (see image below)	1	A 3X51-20006 **
Washer #8	4	96659A103

Bearing



Spring NEG'ATOR Spring Motor (aka Constant Torque Spring)



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

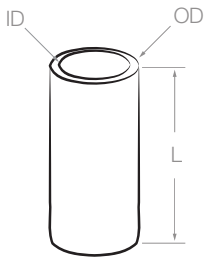
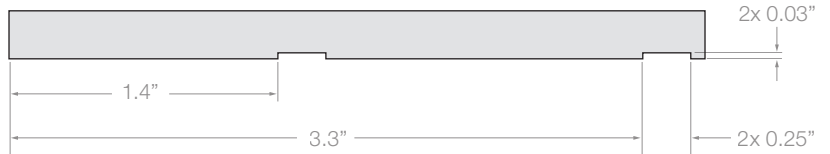
\* Part numbers referenced are from [www.mcmaster.com](http://www.mcmaster.com).  
 \*\* Part number referenced is from Stock Drive Products: [www.sdp-si.com/eStore](http://www.sdp-si.com/eStore)

# Metal

Type	OD x L	ID	Qty	McMaster Carr P/N *
Brass Tube	9/32" x 3/8"	0.253"	3	8859K25
Brass Tube	9/32" x 1 1/8" ***	0.253"	1	
Brass Tube	9/32" x 2 1/4" ***	0.253"	1	
Brass Tube	9/32" x 3 5/8" ***	0.253"	1	
Stainless Steel Rod	1/16" x 1/2"	-	3	88915k37
Stainless Steel Rod	1/16" x 1"	-	2	
Stainless Steel Rod	1/16" x 1 1/2"	-	1	
Stainless Steel Tube	1/4" x 2" 3/4	0.120"	6	B004XN81EM **
Stainless Steel Tube	1/4" x 2"	0.120"	1	
Stainless Steel Tube	1/4" x 3 1/8"	0.120"	1	
Stainless Steel Tube	1/4" x 4 1/2"	0.120"	1	
Stainless Steel Tube	1/4" x 3 5/8"	0.120"	1	

## SS Tube Core

Tap both ends for 8-32 thread, minimum thread depth 3/8".  
Cut or file the flats shown below (flats are for the set screws).

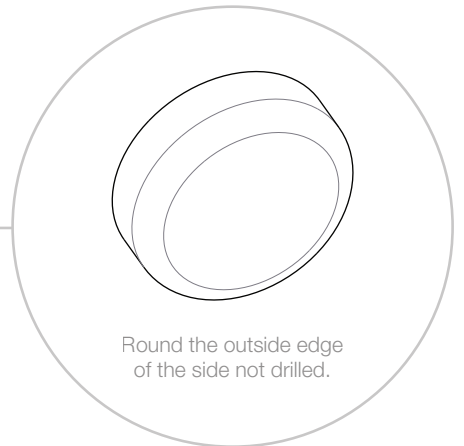
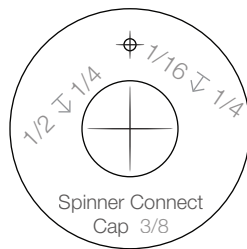
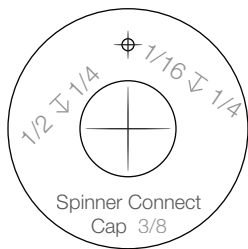
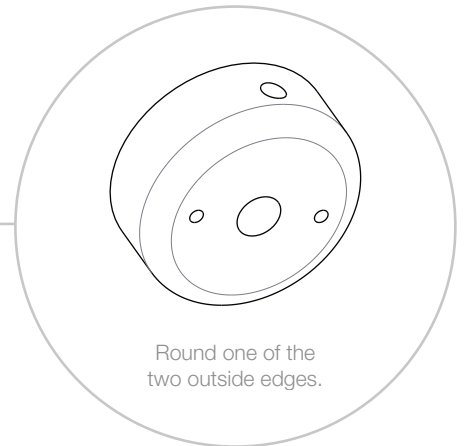
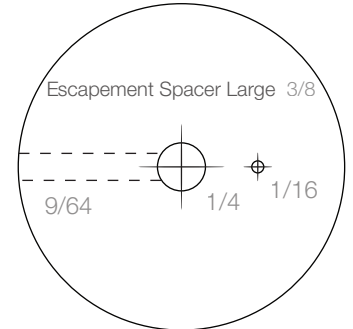
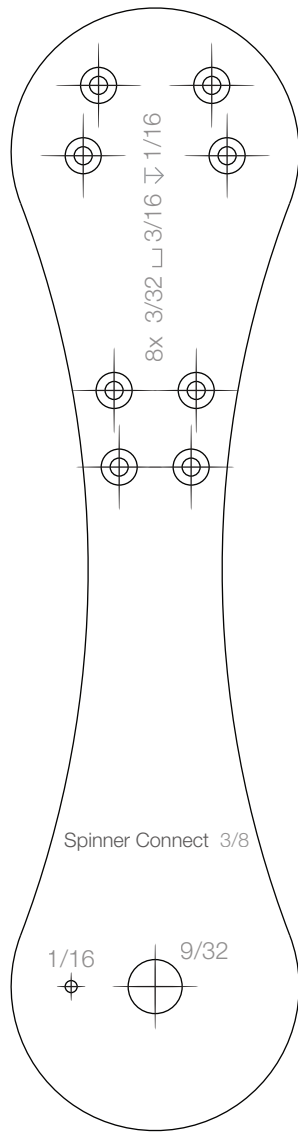
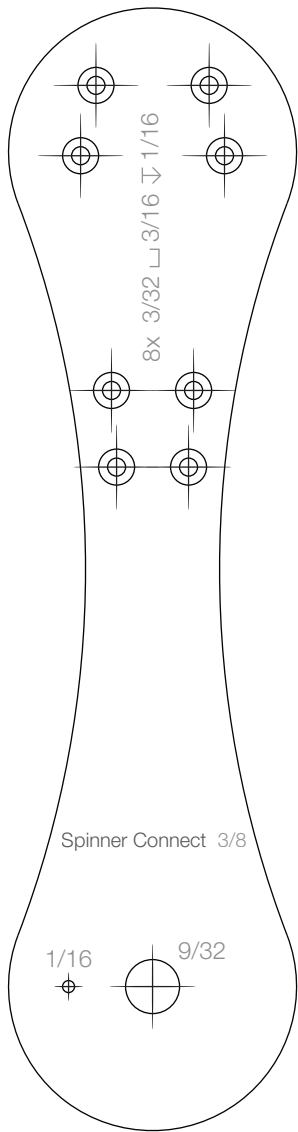


OD outer diameter  
ID inner diameter  
L length

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

\*\* Part number referenced is from Amazon Supply: [www.amazonsupply.com](http://www.amazonsupply.com)

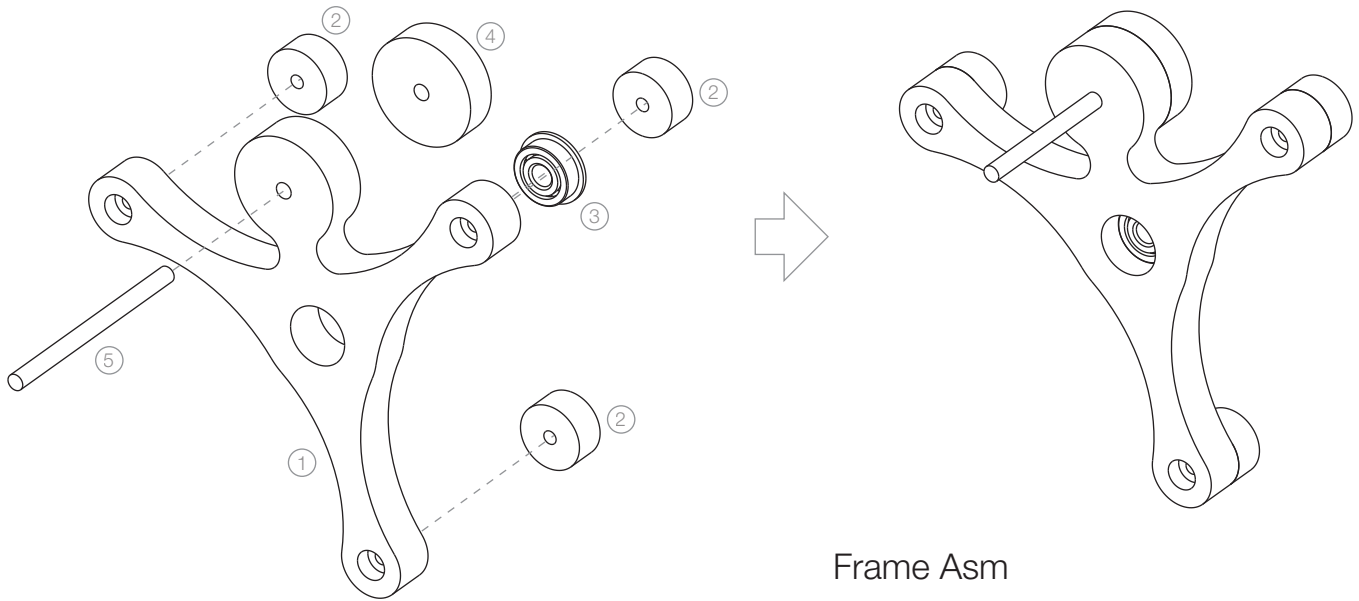
\*\*\* Due to variations in plywood thicknesses, brass tube lengths may need to vary to allow Weighted Ring Asms to spin freely.





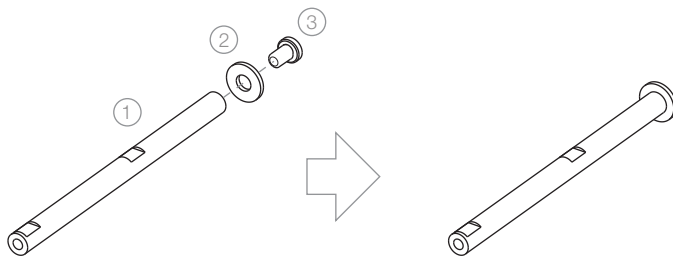
# Subassemblies

Steps 1, 2, 3



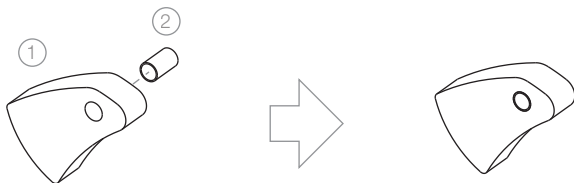
## Frame Asm

#	Required Parts	Qty
1	Frame	1
2*	Frame Foot Small	3
3	Bearing	1
4*	Frame Foot Large	1
5	SS Rod 3/16" x 2 3/4"	1



## Core Tube Asm

#	Required Parts	Qty
1	SS Tube Core	1
2	Washer #8	1
3	LSHCS 8-32 x 1/4"	1



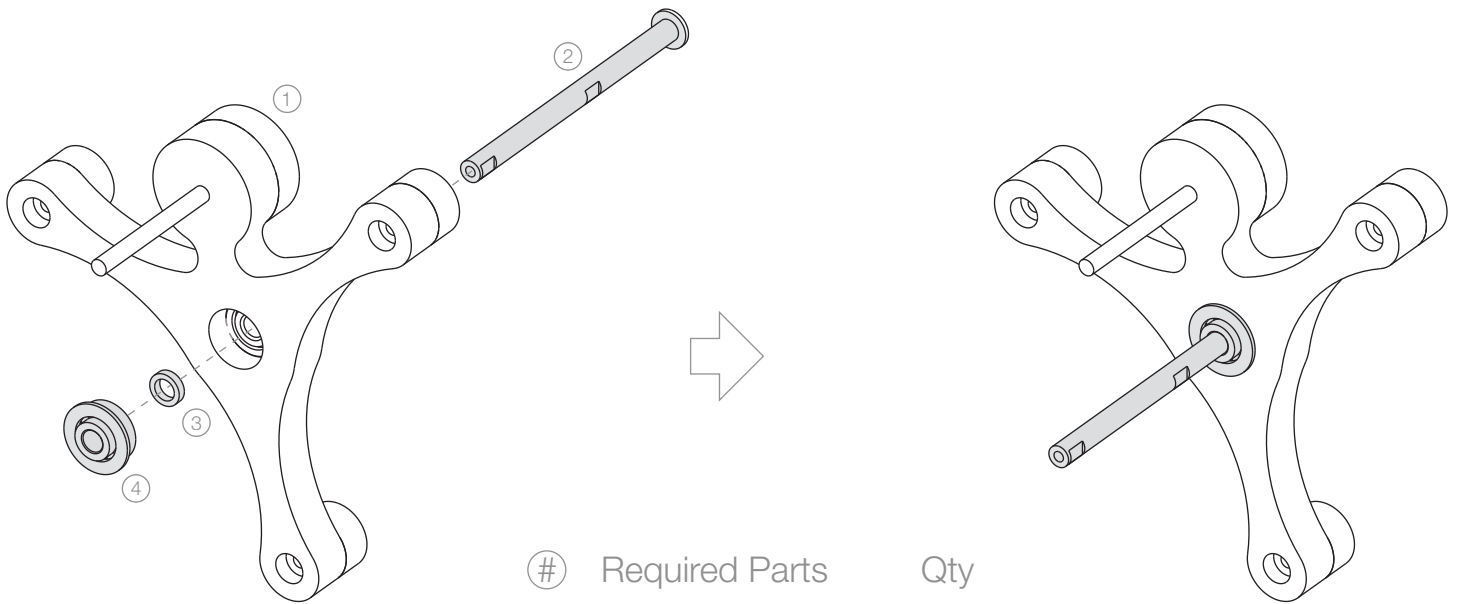
## Ratchet Tooth Asm (2x)

#	Required Parts	Qty
1	Ratchet Tooth	1
2	Brass Tube 7/32" x 3/8"	1

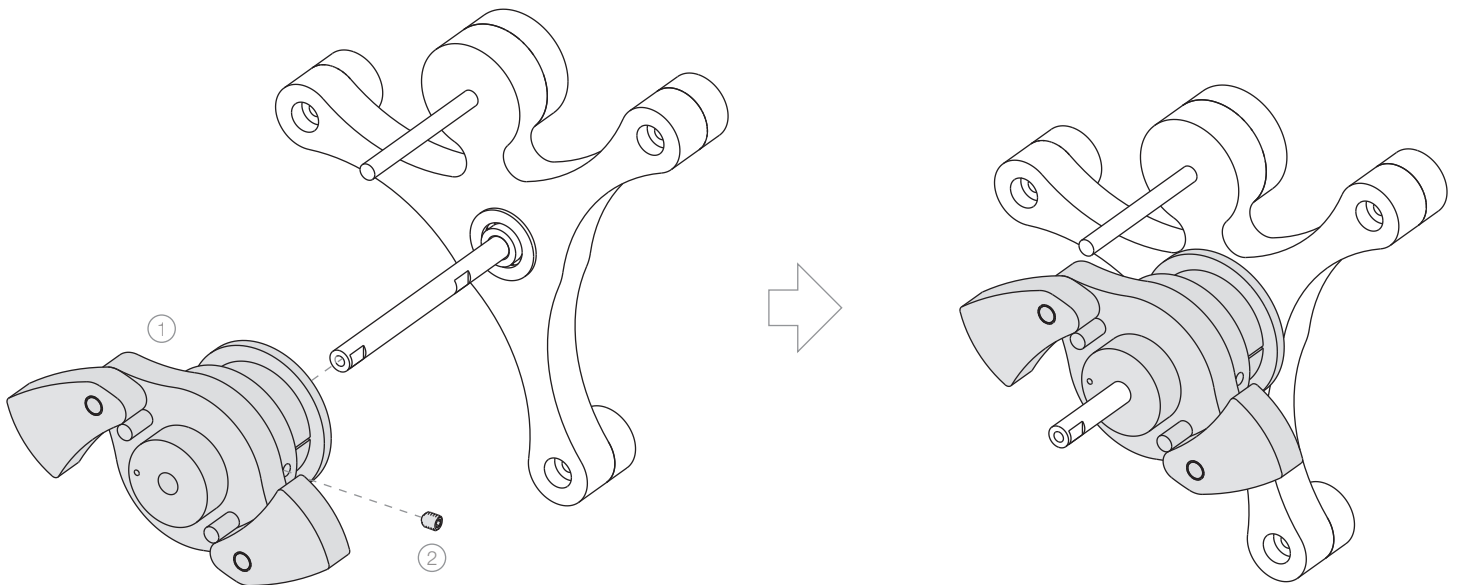
\* Glue to Frame.

# Top Level Assembly

Steps 1, 2



#	Required Parts	Qty
1	Frame Asm	1
2	Core Tube Asm	1
3	Shim	1
4	Bearing	1



#	Required Parts	Qty
1	Escapement Asm	1
2	Set Screw 8-32 x 3/16"	1