

# 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.

Kinestrata  
a mechanical marble machine

design by Derek Hugger

# The Basics

## Contents

These plans include all the information required to build Kinestrata. 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 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 and tap all aluminum tubes, cut all brass tubes, stainless steel rods, and wood dowels, closely abiding by the Plywood Thickness Compensation steps described in Tips + Tactics.
5. Cut the Pendulum Weight, and cut, drill, and tap the Winder Weight.
6. Following the assembly instructions, build all subassemblies and then assemble the rest of Kinestrata with the exception of the Main Weight. It may be necessary to follow the guidelines for Escapement Binding described in Tips + Tactics.
7. Use the Wall Mount Template as a guide to mount the assembled Kinestrata.
8. Verify that all the tracks and mechanisms work properly, and then follow the Weight of the Weight steps described in Tips + Tactics to determine the appropriate amount of weight needed to run the system.
9. Cut, drill and tap the appropriately sized Main Weight, and then assemble the it to Kinestrata.
10. If desired, fully disassemble Kinestrata to finish the components. Stain and a thin layer of polyurethane may slightly increase the assembly's overall thickness, but should not affect system 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 system's performance.

5/8" plywood may be difficult to find. Gluing 1/4" and 3/8" plywood together is an acceptable alternative.

There are three gears in Kinestrata. They look nearly identical, but each is unique, helping to promote proper alignment of the Lifter Rings. Pay particular attention to positioning and orienting each gear correctly, as shown in the assembly instructions.

## The Fine Print

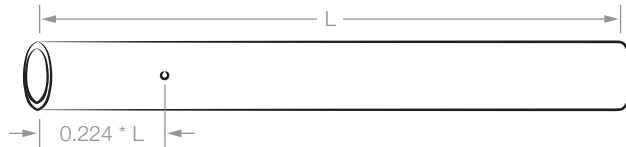
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# Tips + Tactics

## Chime Tuning

Each chime's length and node hole placement are critical for generating accurate, quality tones. The center of a chime's node hole must be located at exactly 22.4% the chime's length from the chime's top end. Also, due to variations in manufacturing, the actual cut length for each chime may vary. It is best to cut each chime longer than its specified theoretical length, and then slowly cut it back until the desired pitch is achieved. Note that each time the bottom end of the chime is cut back, the top end must be cut back such that the node hole remains 22.4% from the top end.



## Weight of the Weight

To ease the amount stress applied to the frame, reduce the likelihood of escapement binding, and to help increase run time, less weight is best. Kinestrata should run on 2.5 lbs and should never require more than 3 lbs to run. To determine exactly how much weight is required, assemble the entire system with the exception of the Main Weight. Hang an empty jar or canister from the nylon cord the Main Weight will ultimately attach to. Slowly add mass to the jar. Coins or BBs work well. Continue adding mass in small increments until a strong and consistent tick is achieved and until the Lifter Rings can sufficiently carry and hand off a full load of Stainless Steel Balls.

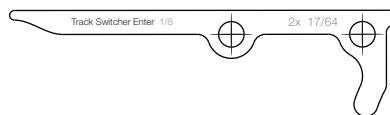
Weigh the jar of coins/BBs, and then weigh and measure the length of the 1 1/2" stainless steel cylinder. The cut length of the cylinder to make the Main Weight = ( jar weight / cylinder weight ) \* cylinder length

Note that when drilling and tapping the Main Weight, the hole must be centered. Any offset will cause the Main Weight to hang at a slant, restricting it from moving freely within Kinestrata's frame.

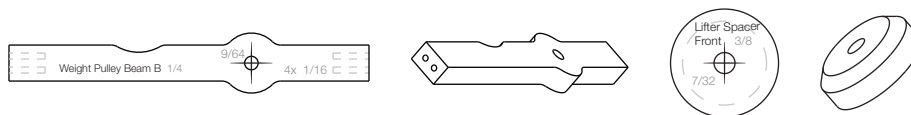
## Pattern Syntax

All patterns are labeled with a part name followed by a thickness dimension.

Example: Track Switcher Enter is cut from 1/8" plywood. Both holes are to be drilled with a 17/64" bit.

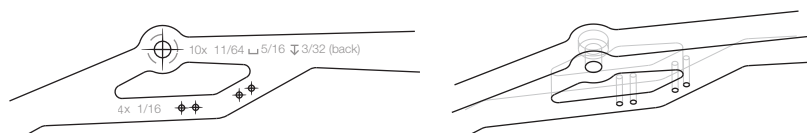


Dashed lines indicate holes drilled from the side, and dashed circles on circular parts indicate a 45° chamfer. Examples: Weight Pulley Beam B has 1/16" holes drilled in 4 locations, all of which are on the sides. It also has a 9/64" hole. Lifter Spacer Front is cut from 3/8" plywood, has a 7/32" hole, and a 45° chamfer up to the dashed circle.



Dashed or solid circles around a hole indicate a counterbore. A dashed circle indicates a counterbore drilled on the back side. A solid circle indicates a counterbore drilled on the front side.

Example: This partial view of Frame A calls out 11/64" holes in 10 locations, each with a 5/16" counterbore that is 3/32" deep. As indicated by the dashed line and reiterated in text, these counterbores are to be drilled from the back side. This view also calls out 1/16" holes in 4 locations.

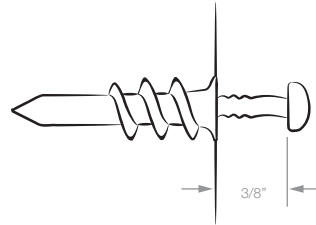


# Tips + Tactics

## Wall Mounting

Use the Wall Mount Template as a guide for locating Kinestrata's four mounting points on a wall. Mount into studs or use appropriate anchors to ensure that Kinestrata will not fall or otherwise separate from the wall. The mounts must support Kinestrata's weight plus the several additional pounds applied while winding.

Ensure that the mounting screws fully engage the studs or anchors while maintaining a 3/8" gap from the wall to the head of each screw.



## General Operation

To wind Kinestrata, pull the Wind Weight down until the Main Weight reaches the Brass Pulley. If the lift mechanism does not start upon release of the Wind Weight, gently push the Pendulum to one side to assist startup. The lift mechanism is designed to run for approximately one minute per wind.

When winding:

1. Pull the Wind Weight particularly gently until the Gear Lock engages on the Middle Gear.  
Failure to do so can lead to back-driving in the lift mechanism and can put undue stress on the Escapement Wheel and on the Pendulum.
2. If any binding or unexpected resistance occurs, do not simply pull the Wind Weight harder.  
Investigate and address the issue.
3. Always pull the Wind Weight slowly, and never allow the Main Weight to crash into the Brass Pulley.
4. Ensure the Ratchet Wings have engaged the Ratchet Wheel before letting go of the Wind Weight.  
Failure to do so may allow the Main Weight to free fall some distance, which may damage Kinestrata.

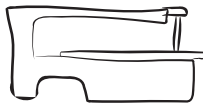
# Tools

Required

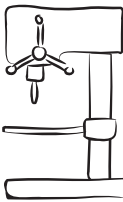
## Power Tools



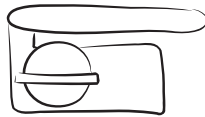
bandsaw



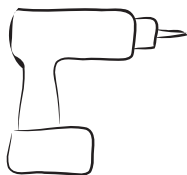
scroll saw



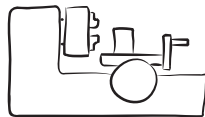
drill press



belt/disc sander



drill



metal lathe



cnc router\*\*

## General



drill index\*  
1/16" to 25/64"  
in 1/64" increments



taps\* 8-32  
1/4-20



calipers



clamp



hacksaw



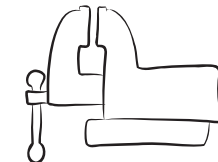
brad point drill index  
1/16" to 5/16"  
in 1/64" increments



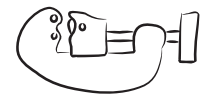
spade or forstner bits 1 3/8"  
1 1/2"



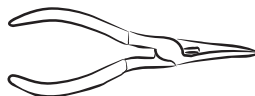
precision files



vice



tube cutter



needle nose pliers

## Drivers



phillips #1



socket 5/16"



hex 1/16"  
5/64"  
3/16"

## Supplies



sandpaper



wood glue



spray adhesive

Recommended

\* 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 *
LSHCS 6-32 x 3/4"	2	93615A217
LSHCS 8-32 x 1/4"	15	93615A317
LSHCS 8-32 x 1/2"	31	93615A320
PHSTS #2 x 3/8"	21	92470A097
PHSTS #2 x 1/2"	19 **	92470A098
PHSTS #2 x 5/8"	4	92470A101
VSHCS 1/4-20 x 1/2"	2	93235A537
Set Screw 8-32 x 3/16" ***	1	92313A189
Locknut 6-32	2	91831A007
Washer #6	2	96659A102
Washer #8	4	96659A103
Stainless Steel Ball 1/2"	15	9291K35
Rubber Band ~1" diameter	1	-
Brass Pulley 1" ****	4	-

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

\* Part numbers referenced are for stainless steel components from [www.mcmaster.com](http://www.mcmaster.com).  
Note the quantity per pack from McMaster; multiple packs may be required.

\*\* Cut the length of 18 of the PHSMS #2 x 1/2" screws to 5/16".

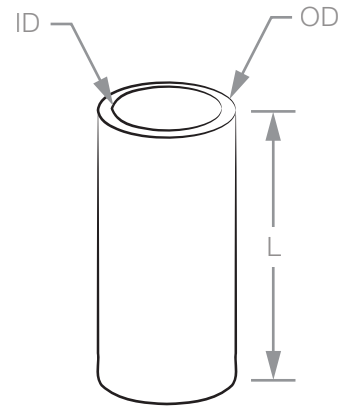
\*\*\* A set screw is required only if the Pendulum Weight does not sit tightly in the Pendulum.

\*\*\*\* Drill the pulley and bearing out of a sliding screen door tension roller.

# Brass Tubes

OD x L	ID	Qty	McMaster Carr P/N *
5/32" x 1/4"	0.128"	1	8859K21
5/32" x 3/8"	0.128"	5	
3/16" x 3/8"	0.160"	1	8859K22
3/16" x 3/4"	0.160"	1	
7/32" x 1 3/8"	0.191"	1	8859K23
7/32" x 1 1/2"	0.191"	2	
7/32" x 2 3/8"	0.191"	1	
9/32" x 1/4"	0.253"	1	8859K25
9/32" x 3/8"	0.253"	2	

OD outer diameter  
ID inner diameter  
L length



\* Part numbers referenced are for packs of 12" length brass tubes from [www.mcmaster.com](http://www.mcmaster.com).

# Aluminum Tubes

L	Qty
3/8"	3
5/8"	5
1 3/8"	1
1 5/8"	1
2 1/8"	1
2 1/2"	1
2 3/4"	5
3 3/4"	2
4 1/8"	1
4 5/8"	3

all Aluminum Tubes

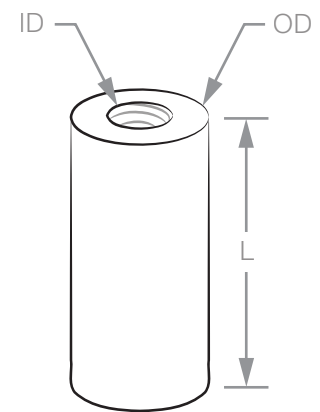
OD 1/4"  
ID 0.120"

Drill ends to increase ID to 9/64", 5/8" minimum depth.  
Tap ends for 8-32 UNC thread, 1/2" minimum depth.

McMaster Carr P/N \*

4568T11

OD outer diameter  
ID inner diameter  
L length



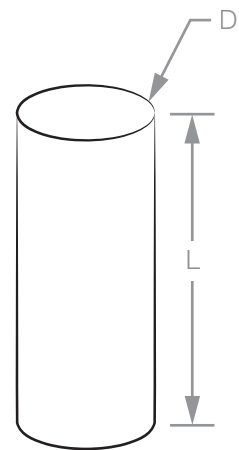
\* Part number referenced is for 72" length aluminum tube from [www.mcmaster.com](http://www.mcmaster.com).



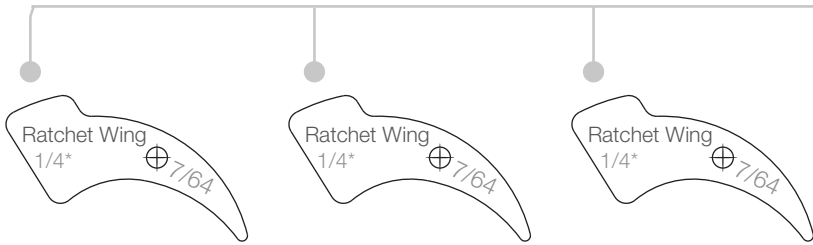
# Stainless Steel Rods

D	L	Qty	McMaster P/N*
1/16"	5/8"	8	88915k37
1/16"	3/4"	1	
1/16"	7/8"	3	
1/16"	1 3/8"	1	
1/16"	1 1/2"	1	
1/16"	2 1/4"	1	
1/16"	2 3/8"	1	
3/32"	19/32"	3	8984K92
1/8"	7/8"	2	89535K22
1/8"	1"	1	
1/8"	1 5/8"	1	
5/32"	1 1/8"	1	8984K95
5/32"	1 5/8"	1	
3/16"	1 1/4"	2	89535K24
3/16"	2"	2	
3/16"	4 3/8"	1	

D diameter  
L length



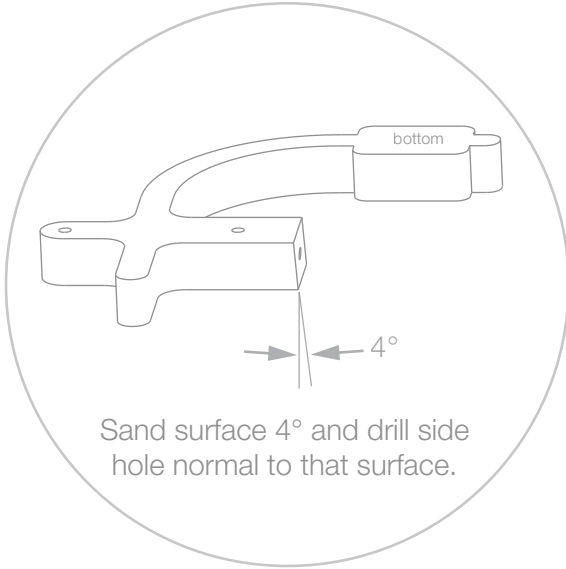
\* Part numbers referenced are for 72" length stainless steel rods from [www.mcmaster.com](http://www.mcmaster.com).



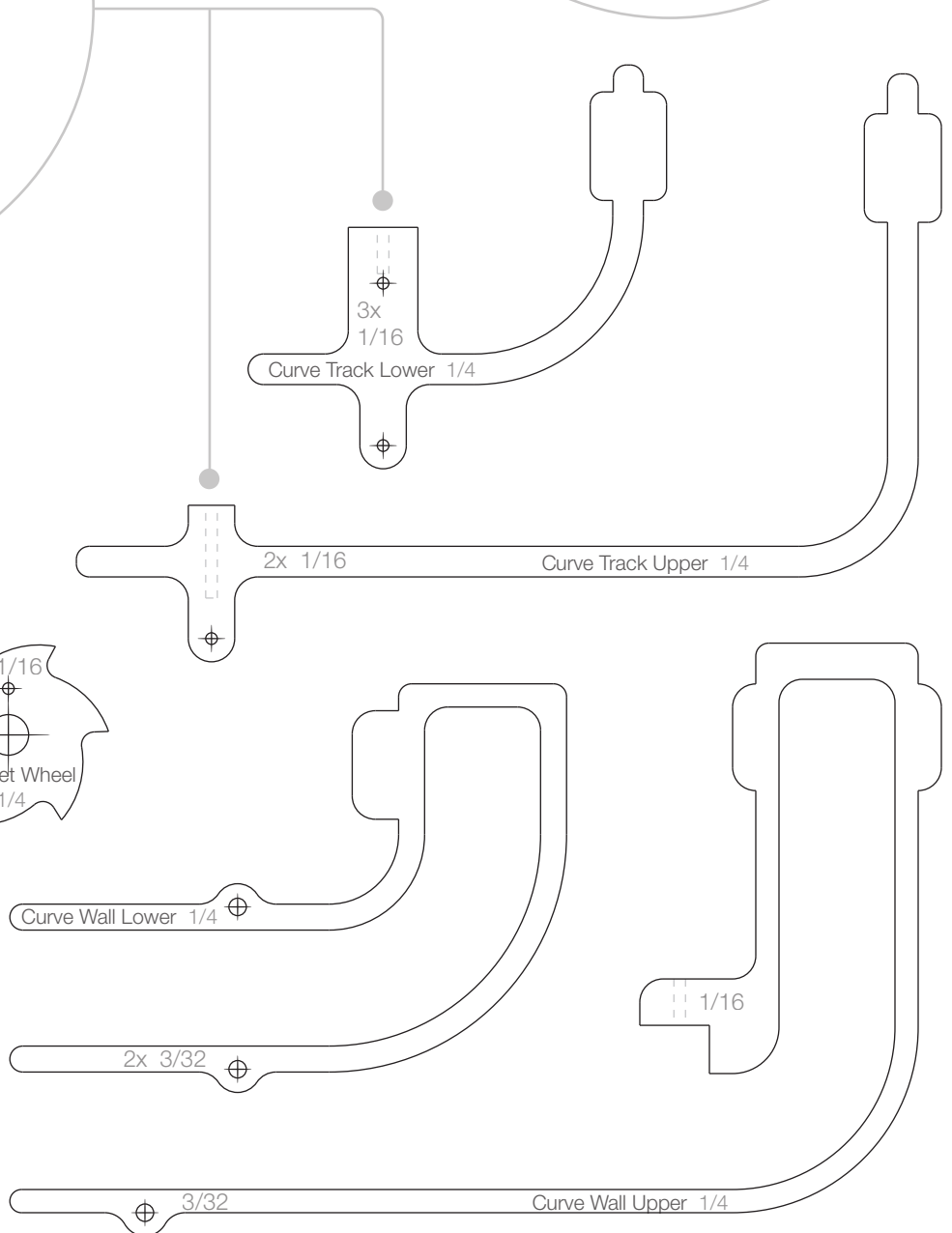
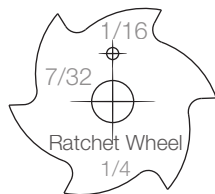
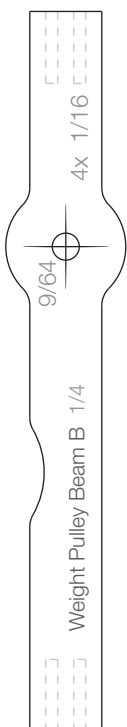
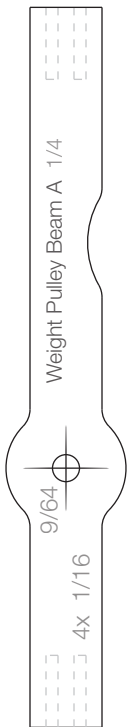
\* Sand 1/16" off Ratchet Wing's thickness.

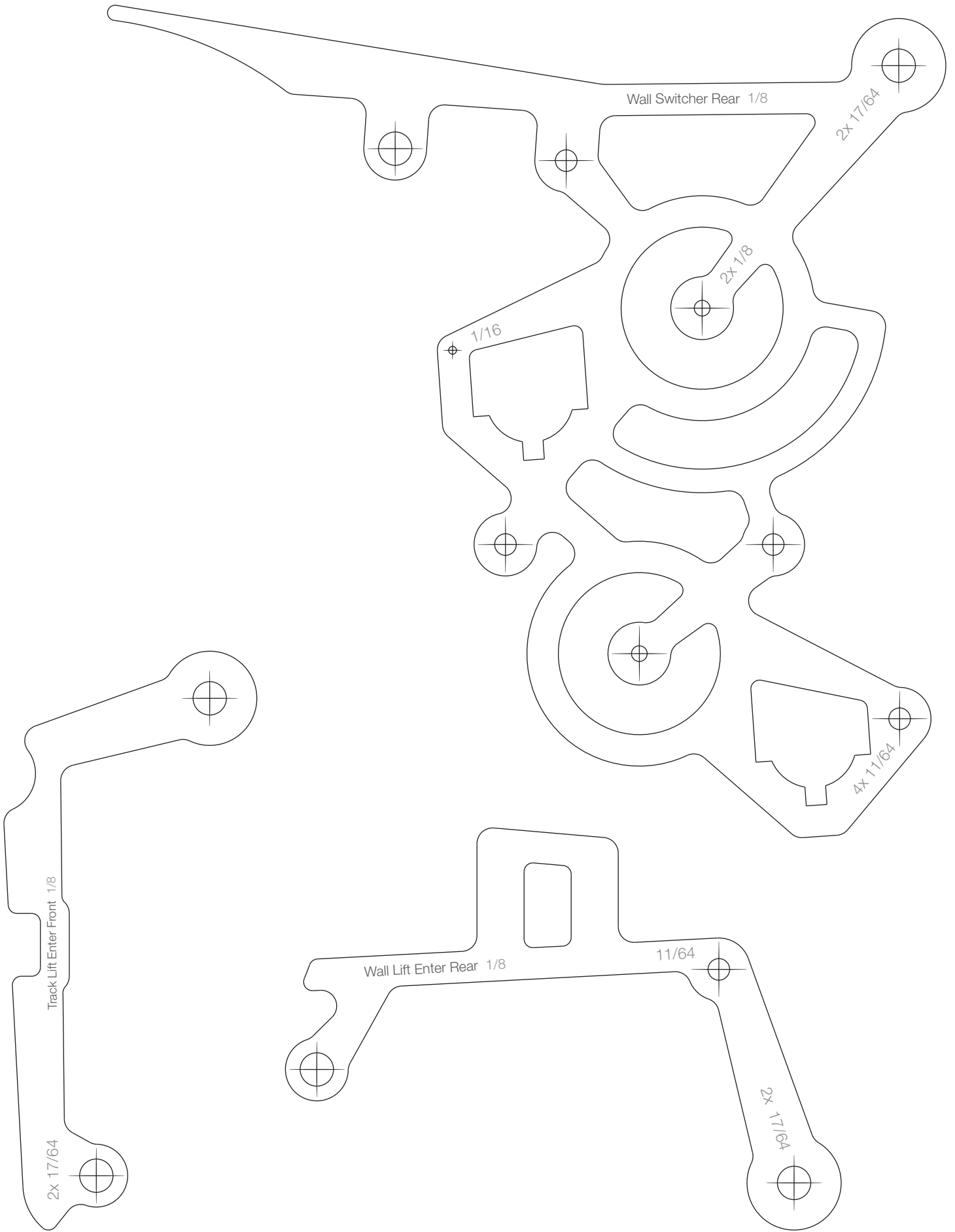


Cut a groove into the crest of each Ratchet Wing.



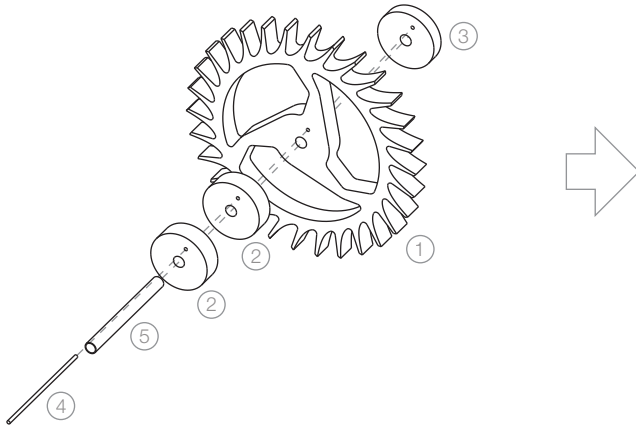
Sand surface 4° and drill side hole normal to that surface.





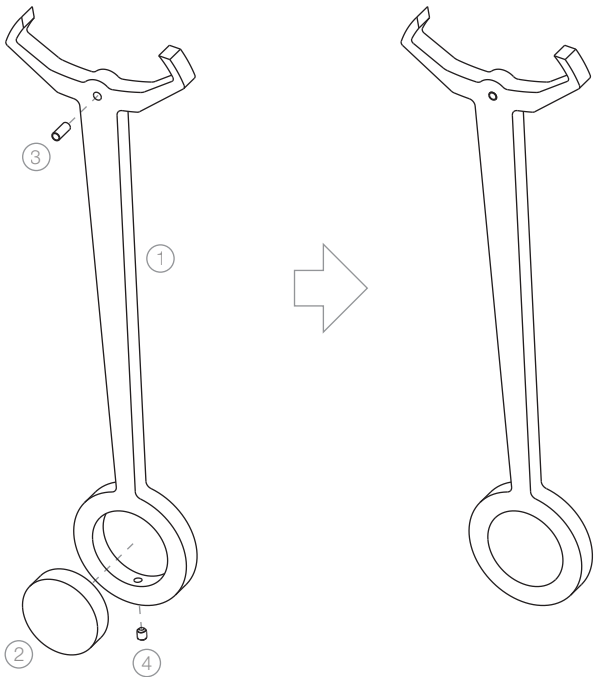
# Subassemblies

Steps 1, 2, 3



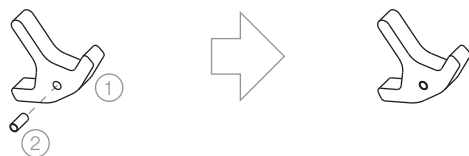
## Escape Wheel Asm

#	Required Parts	Qty
1	Escape Wheel	1
2	Spacer Escape Front	2
3	Spacer Escape Rear	1
4	Rod 1/16" x 2 3/8"	1
5	Tube 7/32" x 2 3/8"	1



## Pendulum Asm

#	Required Parts	Qty
1	Pendulum	1
2	Pendulum Weight	1
3	Tube 5/32" x 3/8"	1
4	Set Screw 8-32 x 3/16"	1

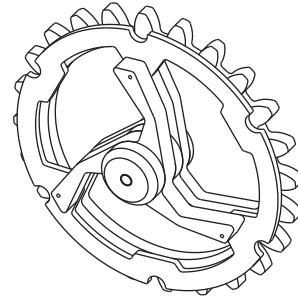
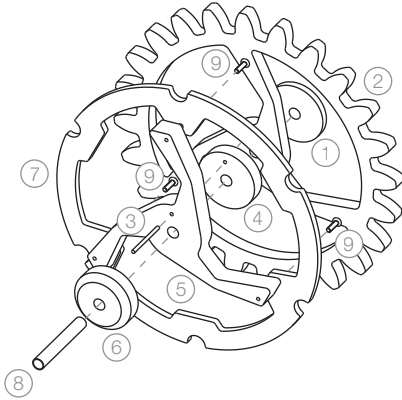


## Switcher Asm (3x)

#	Required Parts	Qty
1	Switcher	1
2	Tube 5/32" x 3/8"	1

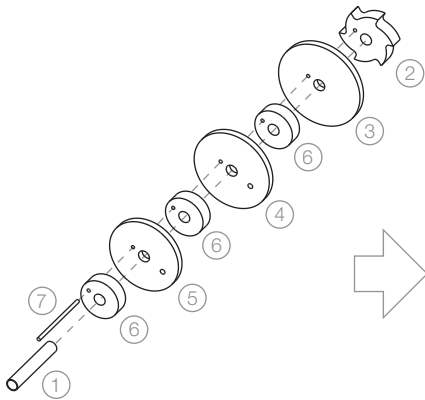
# Subassemblies

Steps 13, 14, 15



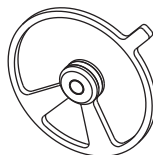
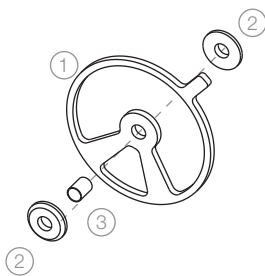
## Lifter Wheel Bottom Asm

#	Required Parts	Qty
1	Lifter Spacer Rear	1
2	Gear Bottom	1
3	Rod 1/16" x 7/8"	1
4	Lifter Spacer Middle	1
5	Lifter Wheel	1
6	Lifter Spacer Front	1
7	Lifter Ring	1
8	Tube 7/32" x 1 1/2"	1
9	PHSMS #2 x 1/2" Cut	3



## Ratchet Pulley Asm

#	Required Parts	Qty
1	Tube 7/32" x 1 3/8"	1
2	Ratchet Wheel	1
3	Ratchet Pulley Plate A	1
4	Ratchet Pulley Plate B	1
5	Ratchet Pulley Plate C	1
6	Ratchet Pulley Spacer	3
7	Rod 1/16" x 1 3/8"	1

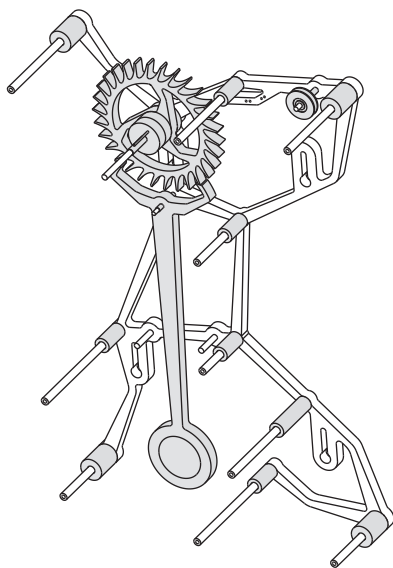
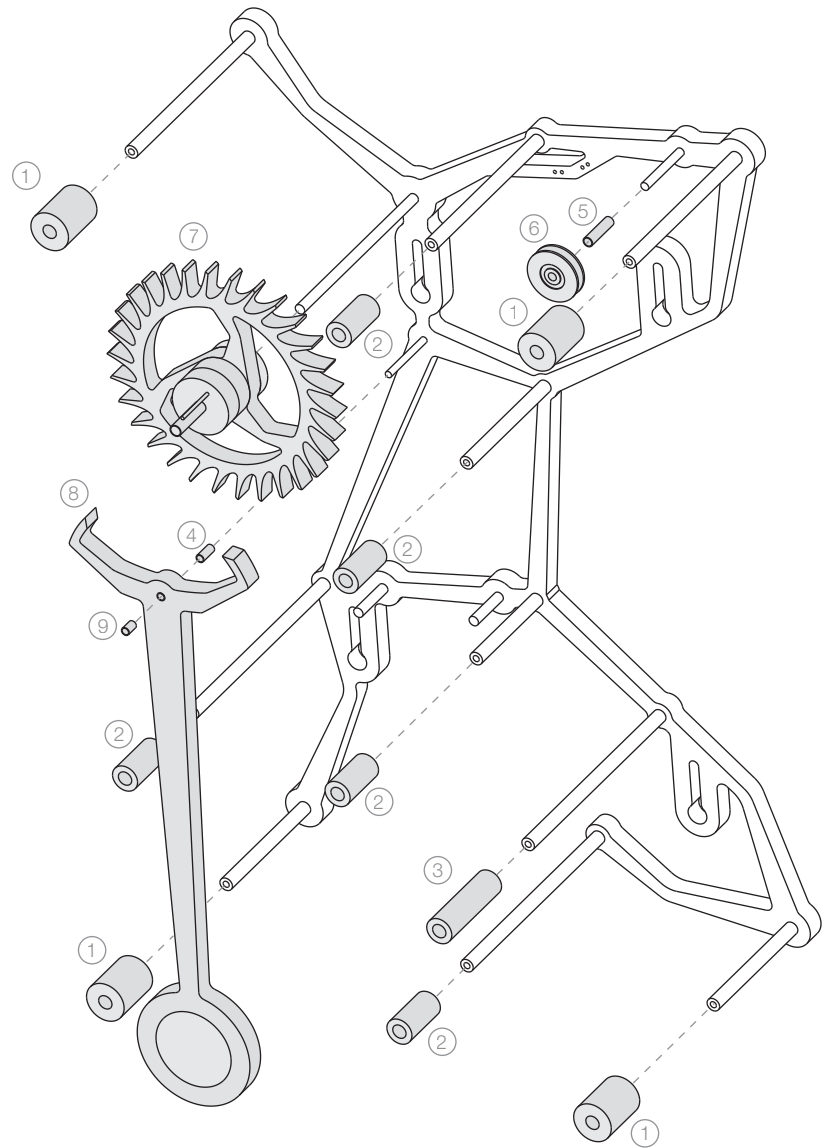


## Swing Wheel Asm (2x)

#	Required Parts	Qty
1	Swing Wheel	1
2	Swing Wheel Cap	2
3	Tube 7/32" x 3/8"	1

# Top Level Assembly

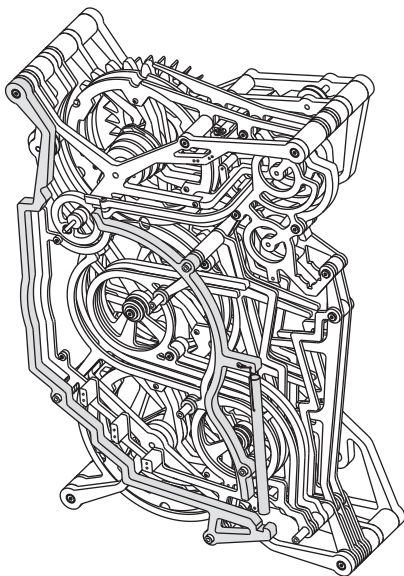
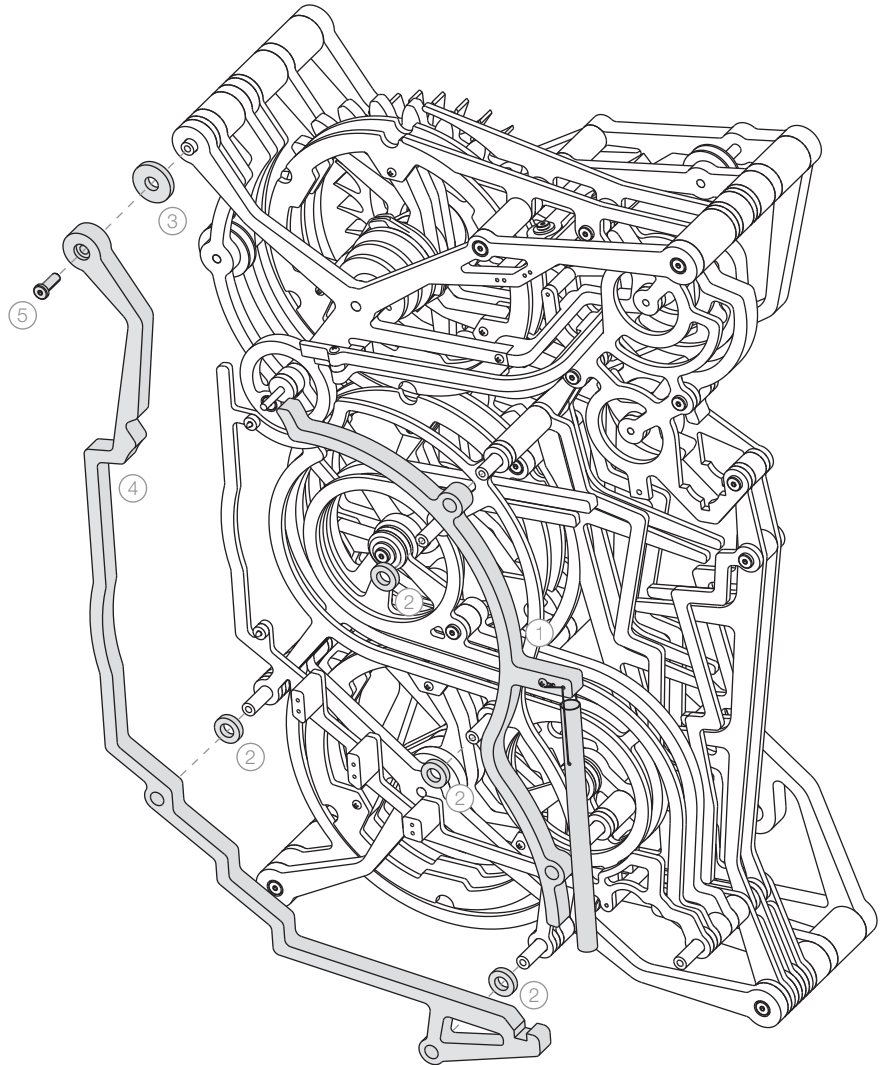
## Step 2



#	Required Parts	Qty
1	Spacer 3/4" x 1"	4
2	Spacer 1/2" x 1"	5
3	Spacer 1/2" x 1 3/4"	1
4	Tube 5/32" x 3/8"	1
5	Tube 3/16" x 3/4"	1
6	Brass Pulley	1
7	Escape Wheel Asm	1
8	Pendulum Asm	1
9	Tube 5/32" x 1/4"	1

# Top Level Assembly

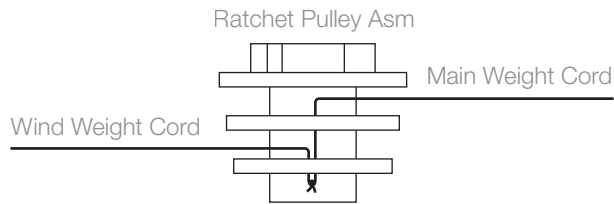
## Step 14



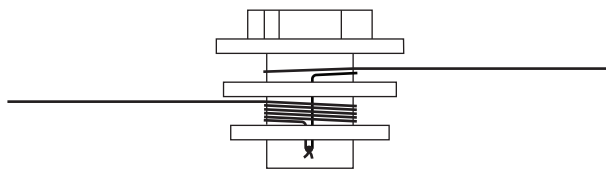
#	Required Parts	Qty
1	Track C Asm	1
2	Spacer 1/2" x 1/8"	4
3	Spacer 3/4" x 1/8"	1
4	Track D	1
5	LSHCS 8-32 x 1/2"	1

# Top Level Assembly

## Step 18

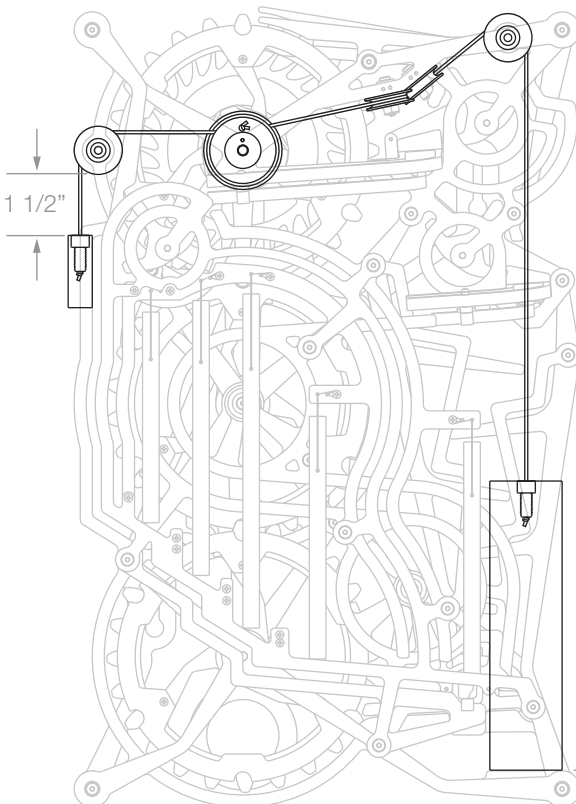


Thread the two cords through the Ratchet Pulley Asm. Tie their threaded ends together with a knot. The knot must not pull back through the hole.



Main Weight Cord  
Wrap clockwise, 1 revolution.

Wind Weight Cord  
Wrap counterclockwise, 5 revolutions.



Determine the Main Weight length. See Weight of the Weight described in Tips + Tactics.

Thread a VSHCS onto each cord, and tie a knot on each cord such that they match the image to the left. Knots must not pull back through the VSHCS holes.

Main Weight rests on Frame B.