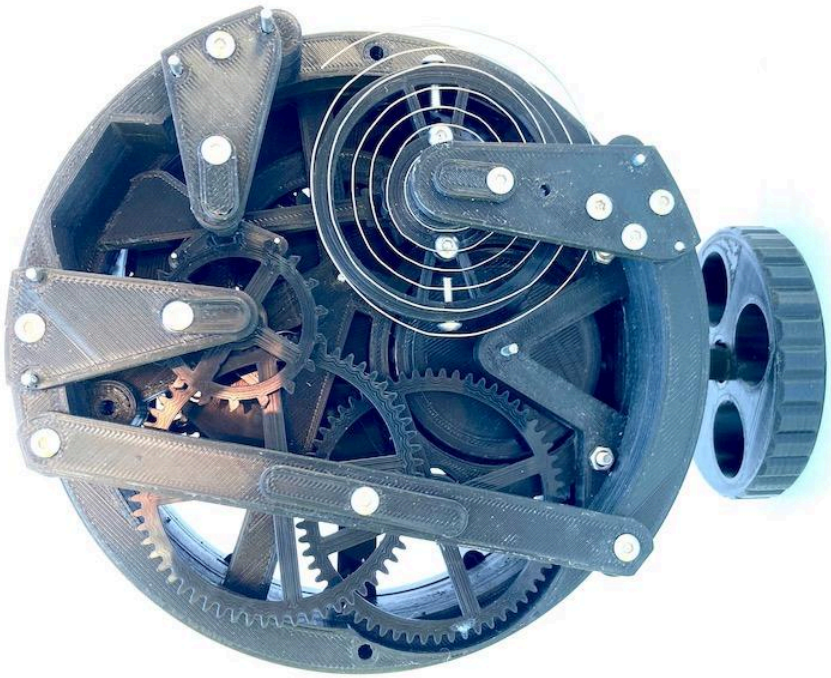
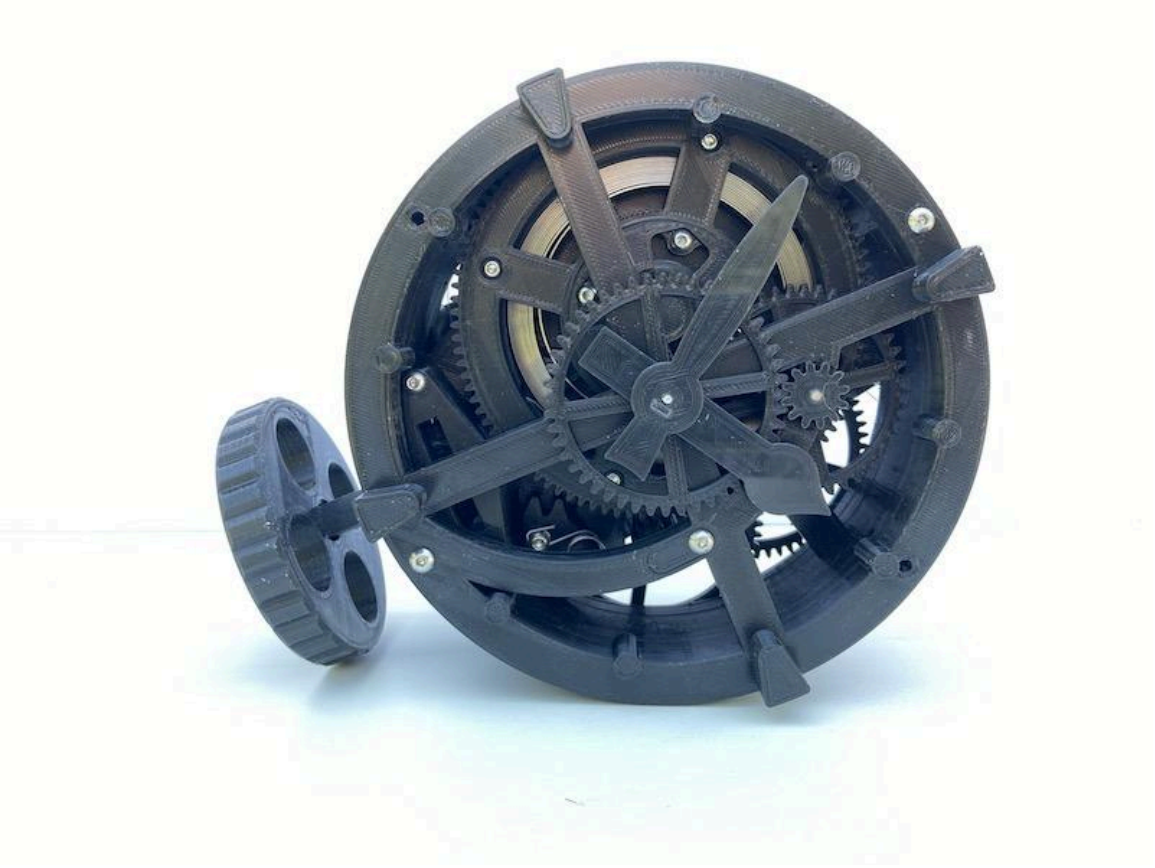
Roskopf Watch Build Instructions





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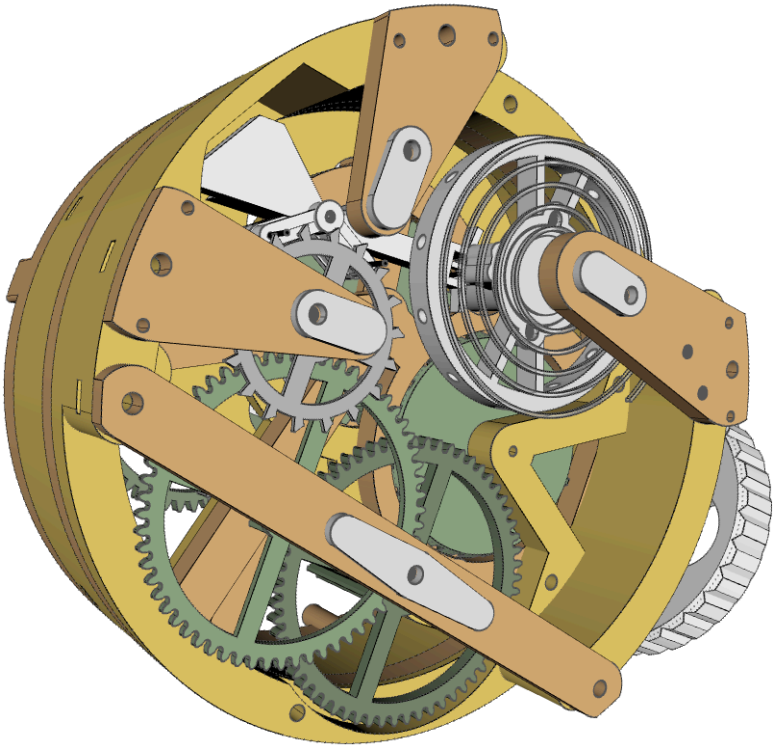
3D view

https://jacprog.github.io/roskopf3Dmodel/watch8.xhtml

Use the mouse to rotate, move, zoom in and out
All the 3D printed parts are included in the model, some of the hardware is missing



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Hardware needed

Arbor Ø2 mm can be polished steel or brass, suggest piano wire for Ø 1 mm for stiffness

Arbors

gear 60-12	1x	Ø 2mm x 72
drum	1x	Ø 2mm x 40
ratchet	1x	Ø 2 x 40
rewind gear	1x	Ø 2mm x 19
rewind pinion	1x	Ø 2 mm x 30
hands	1x	Ø 2 mm x 28 (25 + 3 for bend)
to hand gear	1x	Ø 2mm x 17
top plate pins	6x	Ø 2 mm x 30
escape and gear 60-10	2x	Ø 1 mm x 38
balance and anchor	2x	Ø 1 mm x 41
pins anchor	2x	Ø 1mm x 19
pins balance wheel	2x	Ø 1mm x 16

Springs

spiral spring	1x	Ø 0.4 x 1000
ratchet spring	1x	Ø 1 x 180- 200

screws M3

spring barrel	4x	M3 x 10 + nuts
friction plate	4x	M3 x 6
3 plates joiner	2x	M3 x 45 - 50 + nuts
	1x	M3 x 25 + nut
top plate bridges	5x	M3 x 20 + nuts
cover to top plate	4x	M3 x 6
cover to dial	1x	m3 x 8 (10)+ nuts
dial plate	4x	M3 x 20 +nuts
rewind pin	1x	M3 x 12 (10-15) + nut
ratchet	1x	M3 X 2 nuts
min hand	1x	M3 x 10 + nut
spiral to bridge	2x	M3x12
collet to balance	2x	M3 x 6
spiral to collet	1x	M3 x 6
balance wheel weight as needed		M3 x 6 - 16
nuts	20x	M3 nuts
Washers as needed		

Main Spring is Sthil chainsaw pullstart recoil spring (found on eBay)
Recoil Pull Start Spring Replace Fits STIHL MS380 MS381 038 # 041 045 051
Spring specs: 0.78 x 5.2 x 2800 mm

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Parts Prep

View of all parts

All Parts printed in PLA +
0.4 nozzle, 0.2 mm layer, 3 walls, no support needed
I used Initial layer expansion set at - 0.3 mm to avoid elephant foot
Except for the spiral spring, set to 0 for adhesion, also position the spiral so the print start a the end of outer loop
I usually print the gears one by one to minimize stringing

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Tools

Utility knife
Pliers
Small files
Hand drills, 1 mm and 2 mm drill bits
Diamond sharpening stones to polish ends of arbors or emery cloth 400 to 1000 grit
Hex wrenches for screws

3D printed tools that will help with the assembly

Reaming tools, 1 mm and 2 mm
Guide tools for bridges
Guide tool for anchor
Support balance wheel
Support minute gear
Ring spacer

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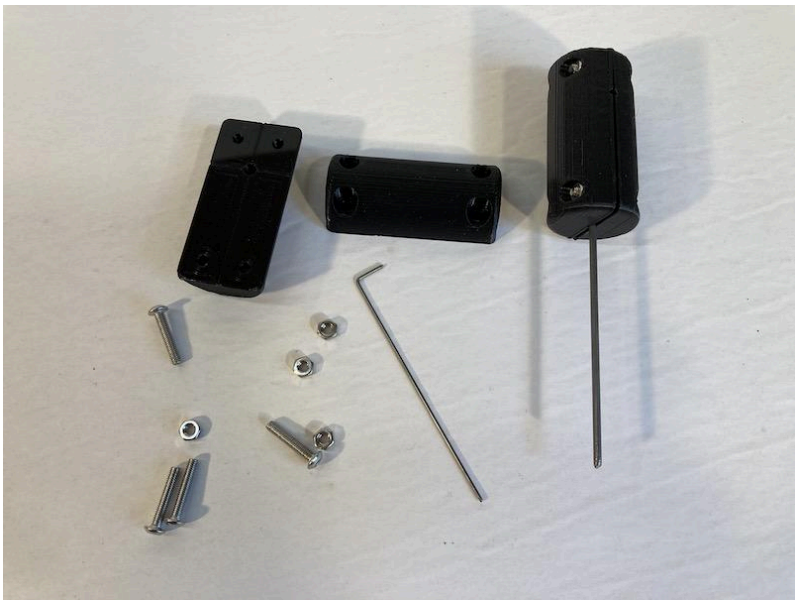
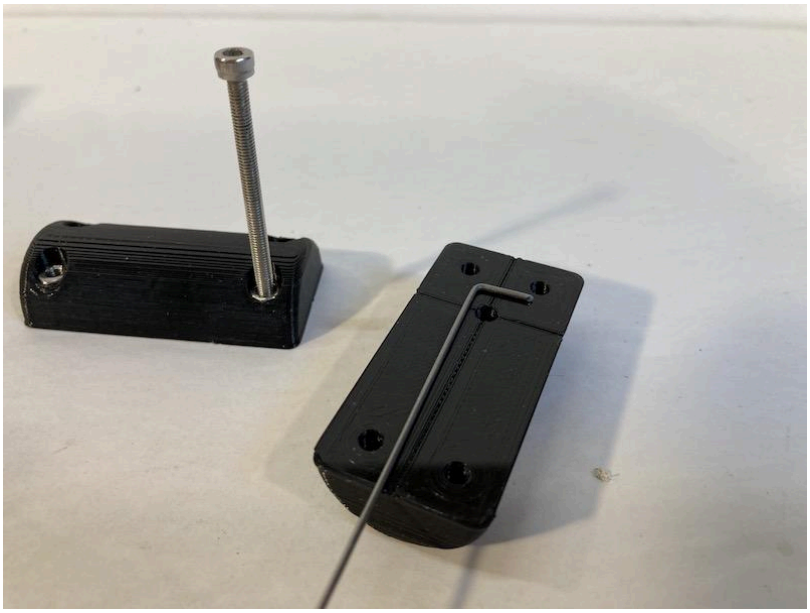
Tools that I use for reaming the holes



Insert nuts
Bolt two parts together



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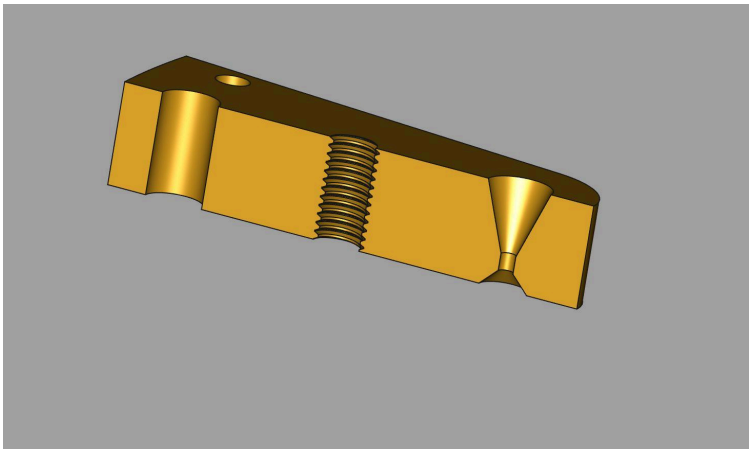
Bridges

Prep, 3 steps

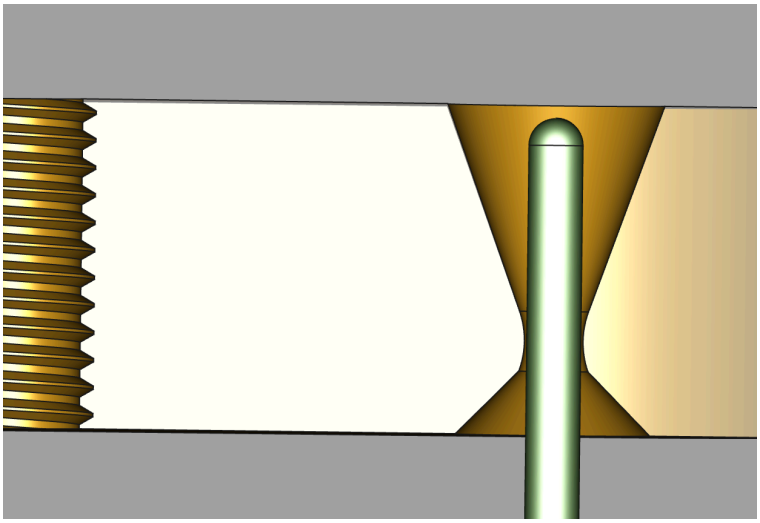
1. Reaming 1 mm arbor hole (loose, no play)
2. Reaming 2 mm pin hole(tight)
3. Threads using guide tool

1- Reaming 1 mm arbor hole (loose, with minimal play)

Goal: have holes where the arbors move freely with close to no play
This is how the plate get printed with a tight hole:



And this is the goal after reaming the holes
Rounded surface to minimize friction, about 0,01 to 0.03 mm of play between arbor and hole, Also note rounded end on arbor.



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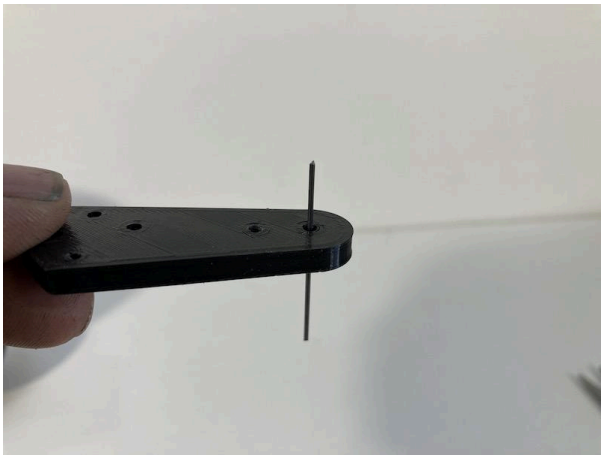
Use the 1 mm tool for reaming the hole, use a a rotating motion to slowly enlarge and round the edge of the hole

The goal is to have the pin drop by its own weight when wiggling the bridge



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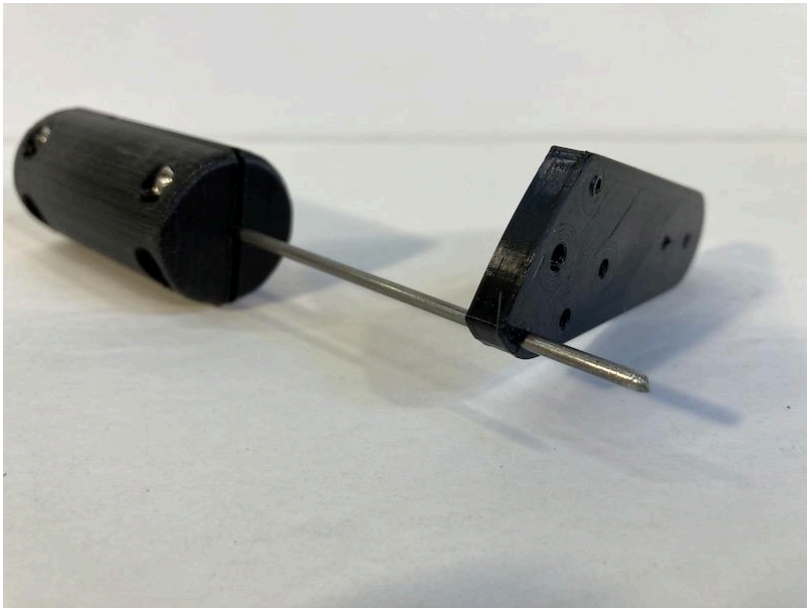
Repeat for all remaining bridges (3 total) and for the gear bridge

There is a 1 mm hole and a 2 mm hole, both with a loose fit

2 - Reaming the pins holes

Tight fit, this insure a precise positioning



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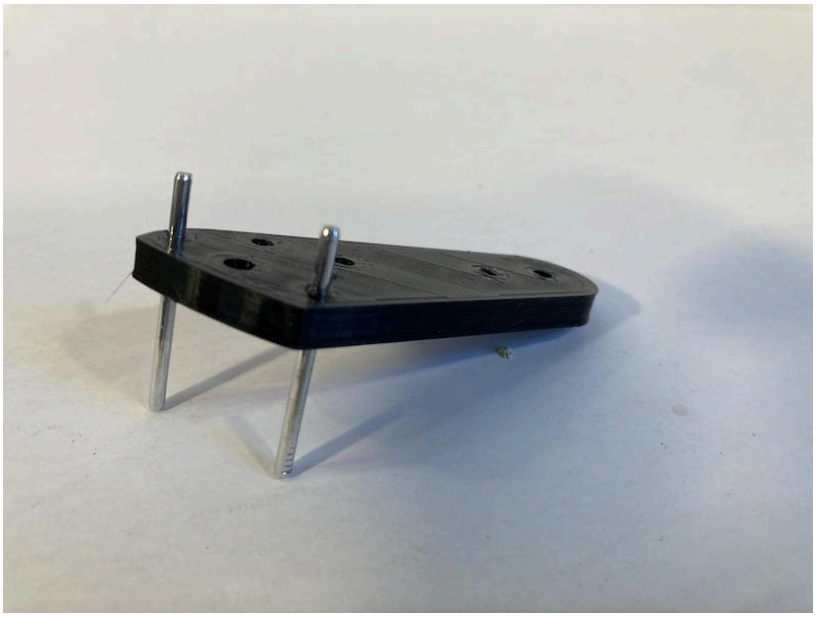
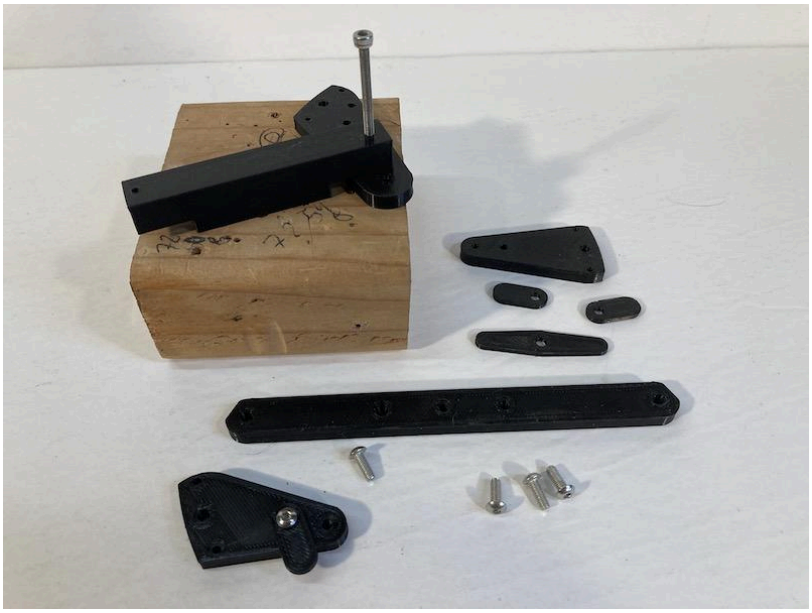


Do the same for all 3 bridges

3 - Treads prep

Using the guide tool, drive a screw and shape the treads



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And bolt on the cover plates

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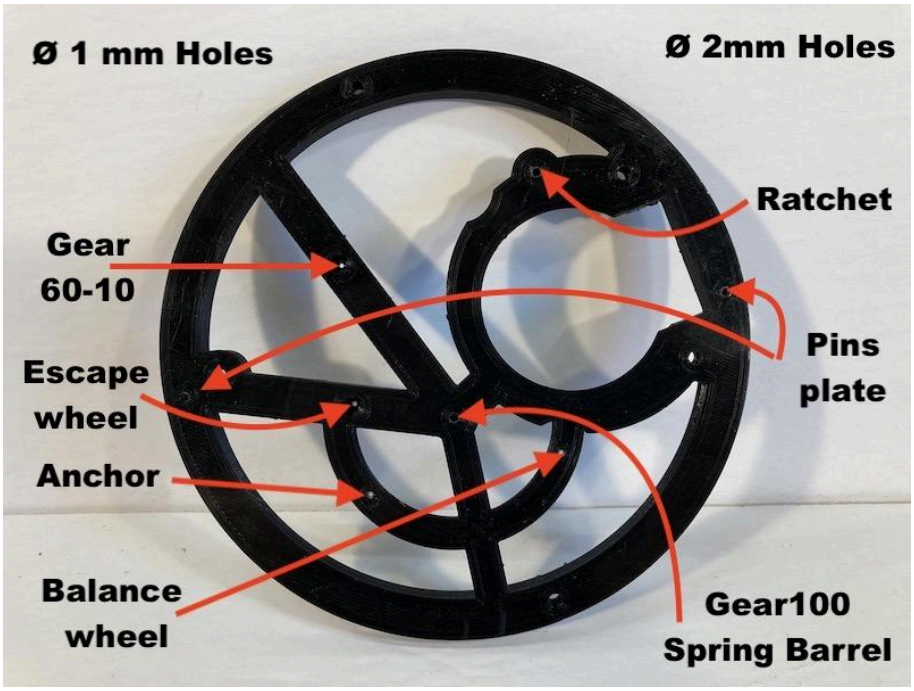
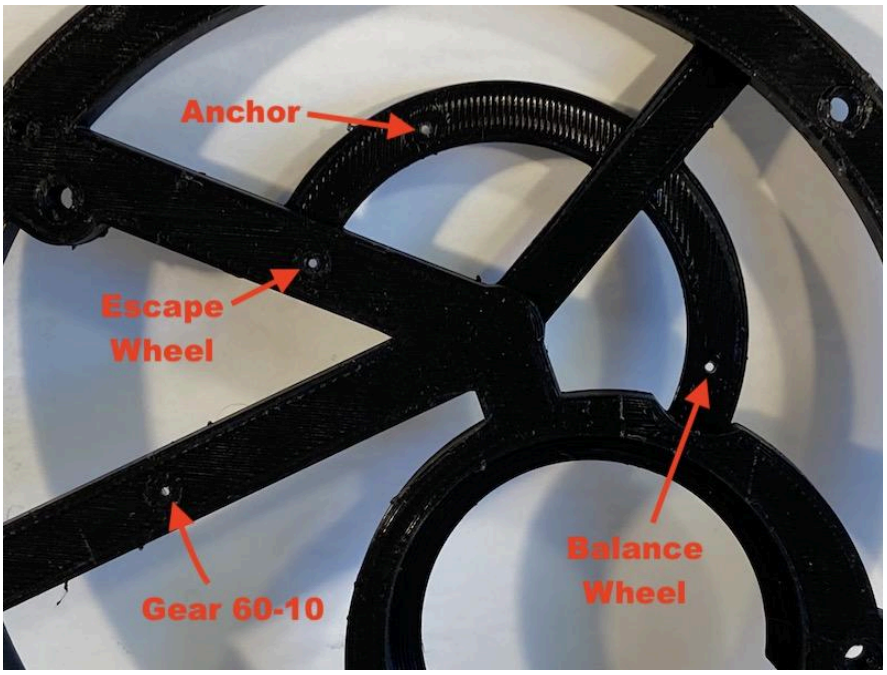
Plates Prep

Second Plate

Ø 1 mm holes, indicated on left side, are reamed like the bridges
Ø 2 mm holes, indicated on left are adjusted to fit 2 mm pins, lightly tight



Close up on 1 mm holes, loose with minimal play



Work the hole until the tool can fall out from its own weight

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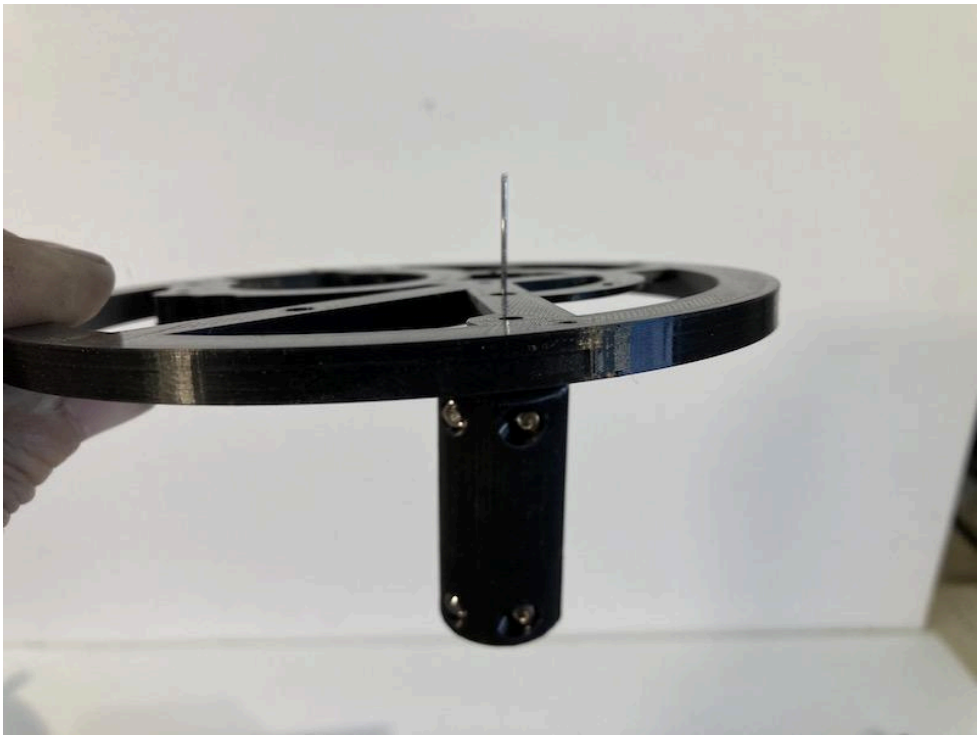

Then continue until the pin gets loose

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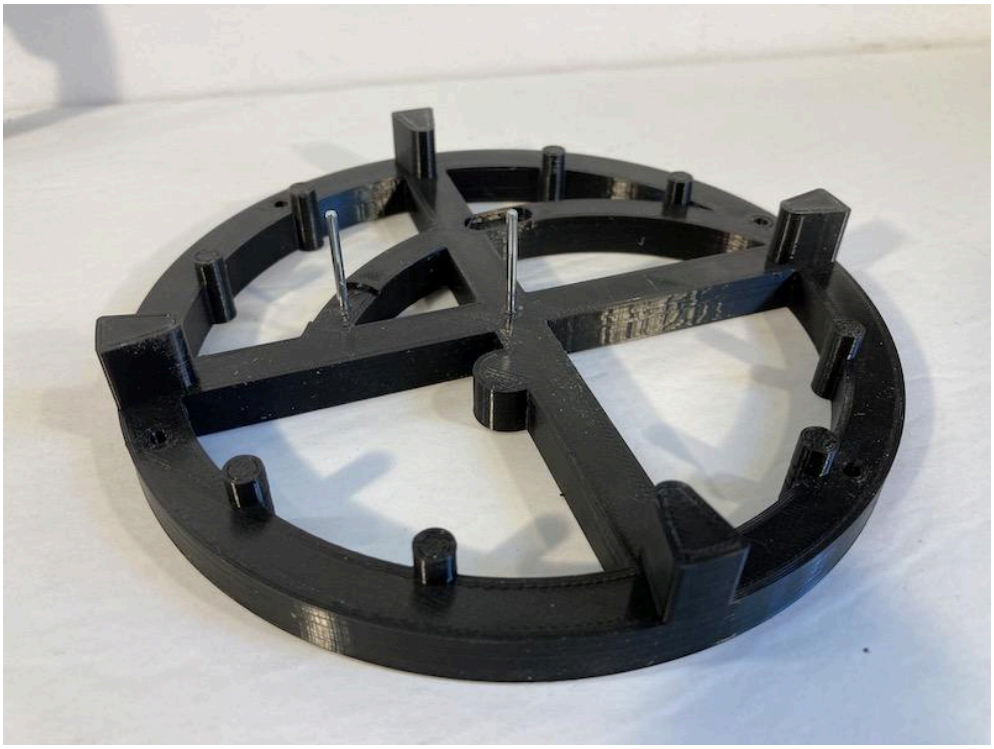
Dial plate

These two holes are a 2 mm loose fit for hands and hour gear arbors



These two holes are a 2 mm light tight fit for the barrel gear and the ratchet

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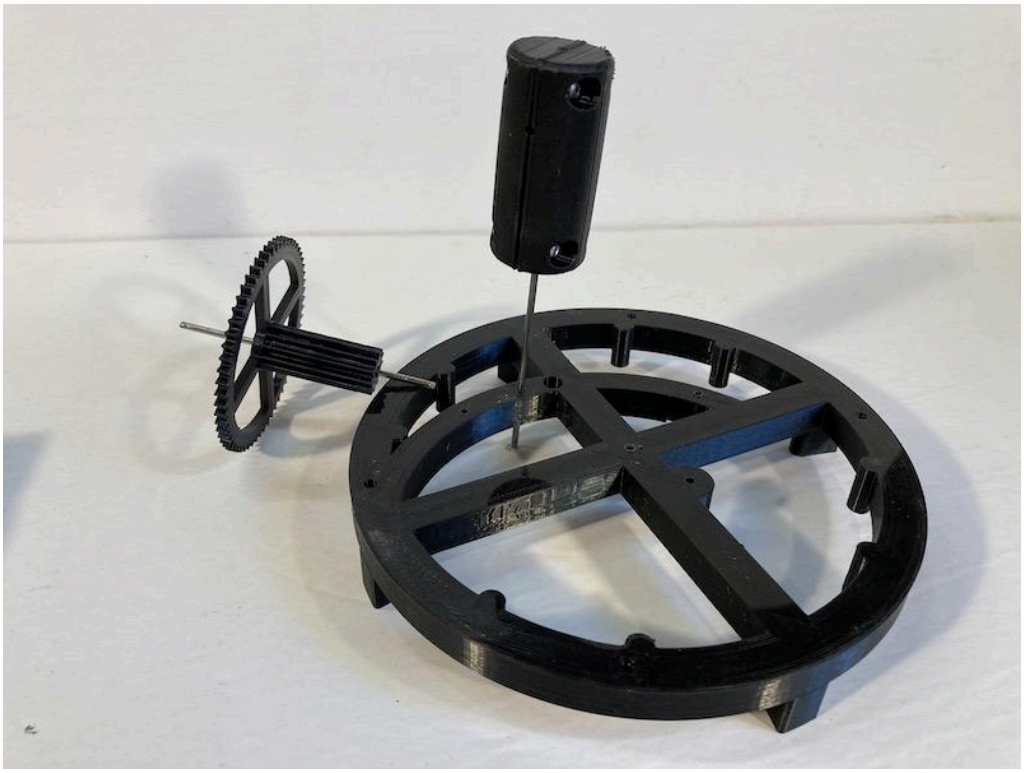
This last hole will have a 2 mm loose fit for the gear 60 -12



Proceed as for the bridges, rolling the tool until the tool slides out with its own weight

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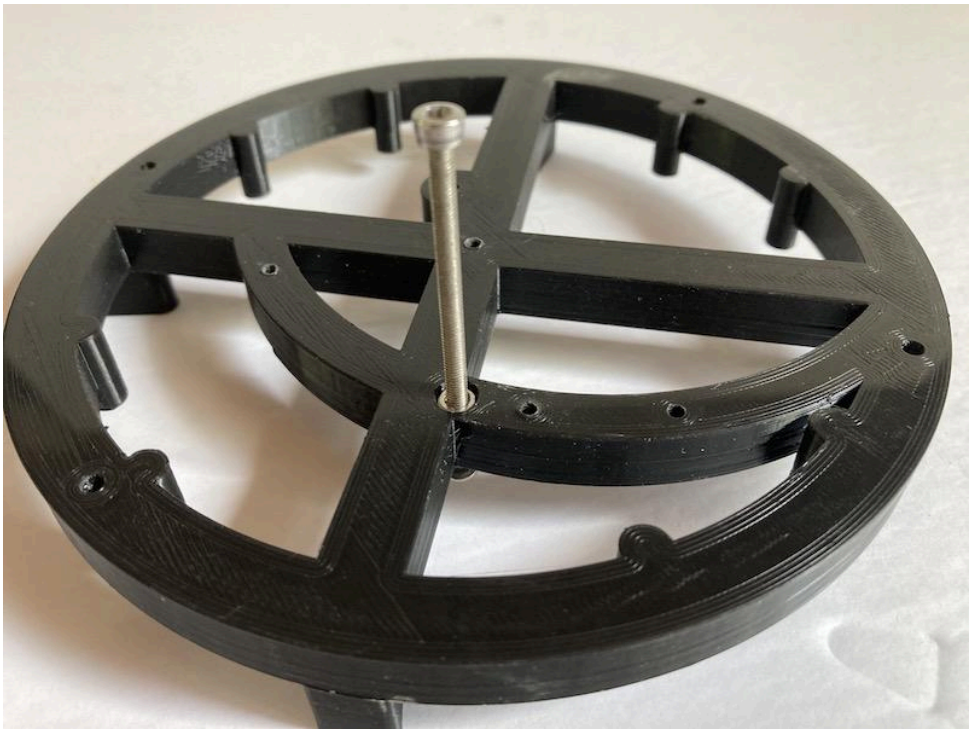
Install nut in recess



Install plate to close the end

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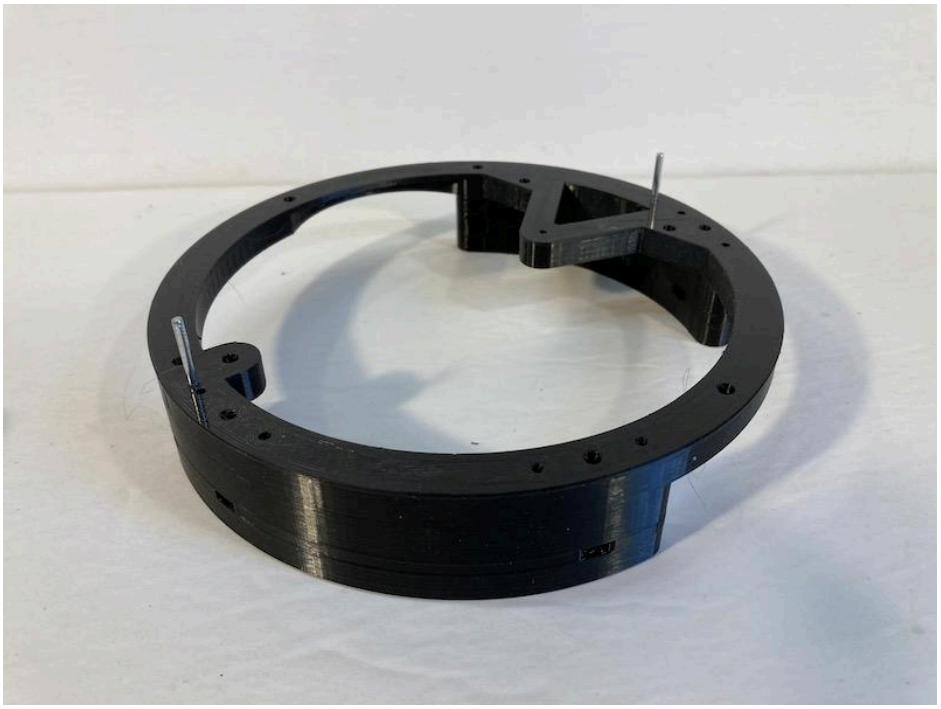
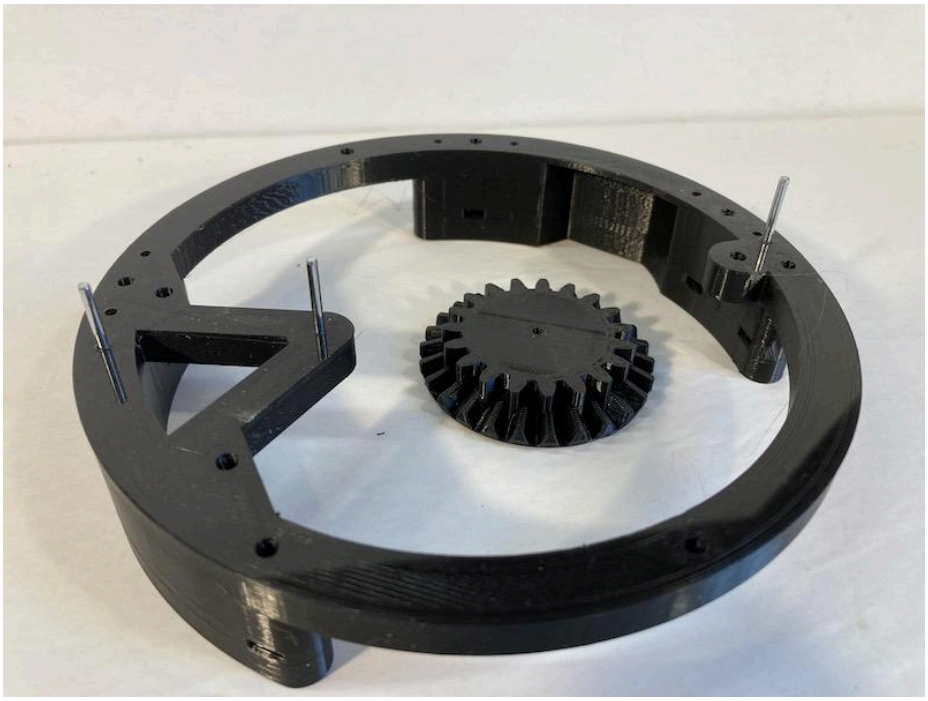
Third Plate

Install two 30 mm pins to align all plates, tight fit here



Install short pin for the bevel gear, tight fit



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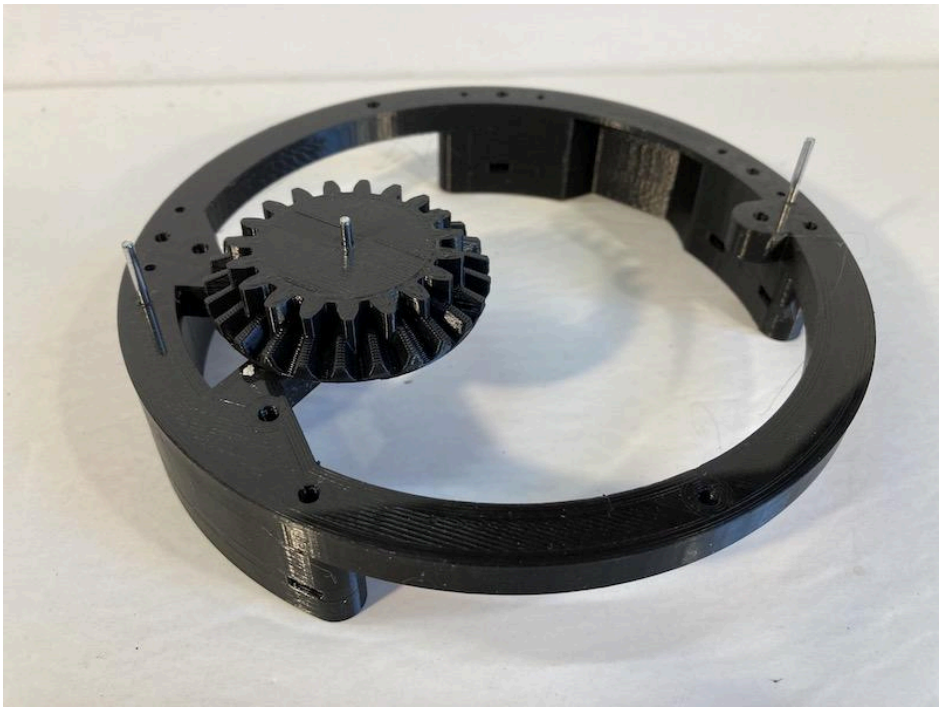
Pin will need to be pushed to be flush with gear!



Or even slightly below like in this picture

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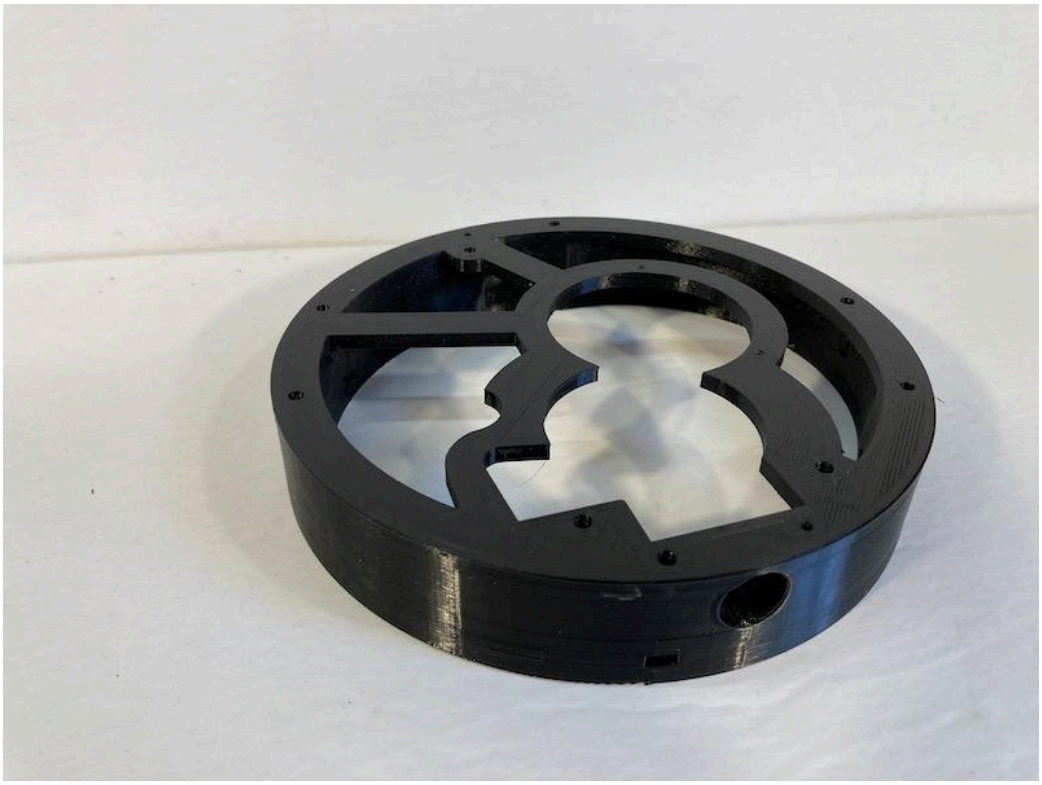
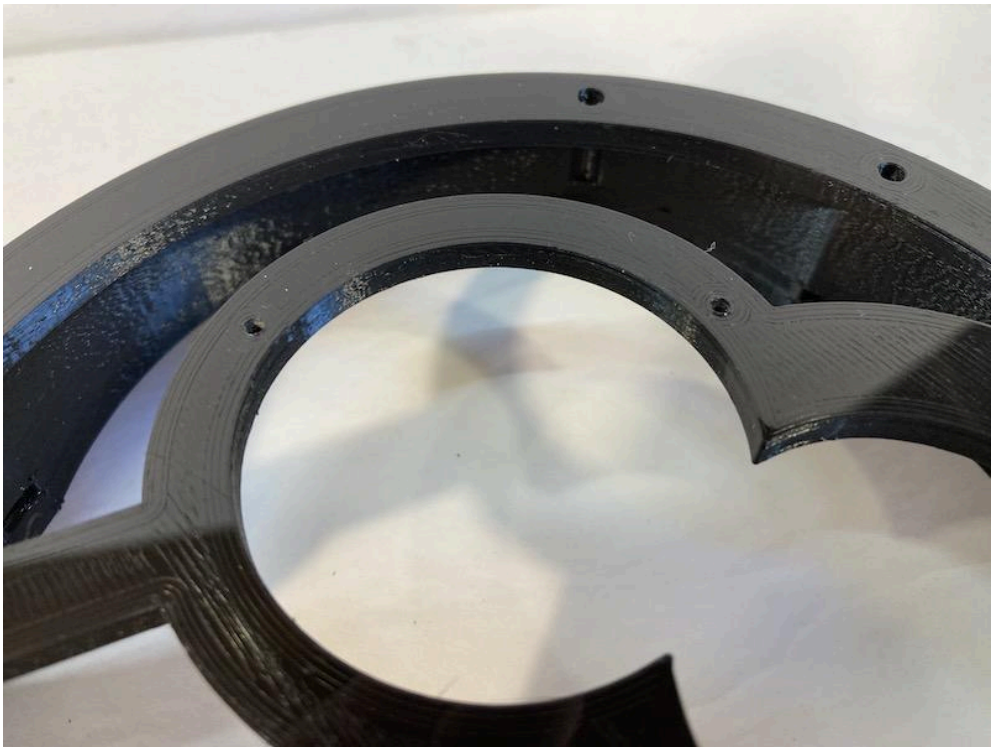


Clean two holes receiving the anchor and balance arbors



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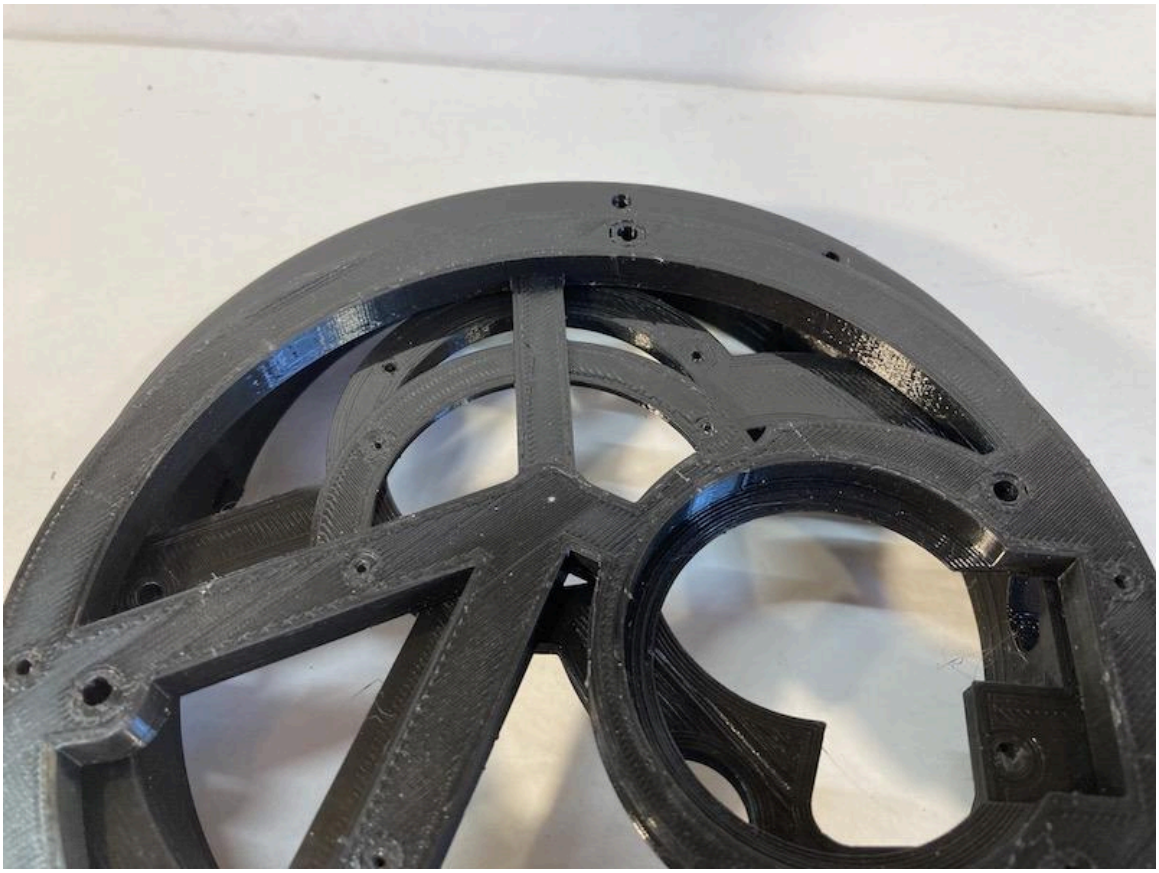

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Joining the 3 plates

Need:
2X M3 x 45 - 50 bolts
1x M3 x 25 bolt
3x M3 nuts

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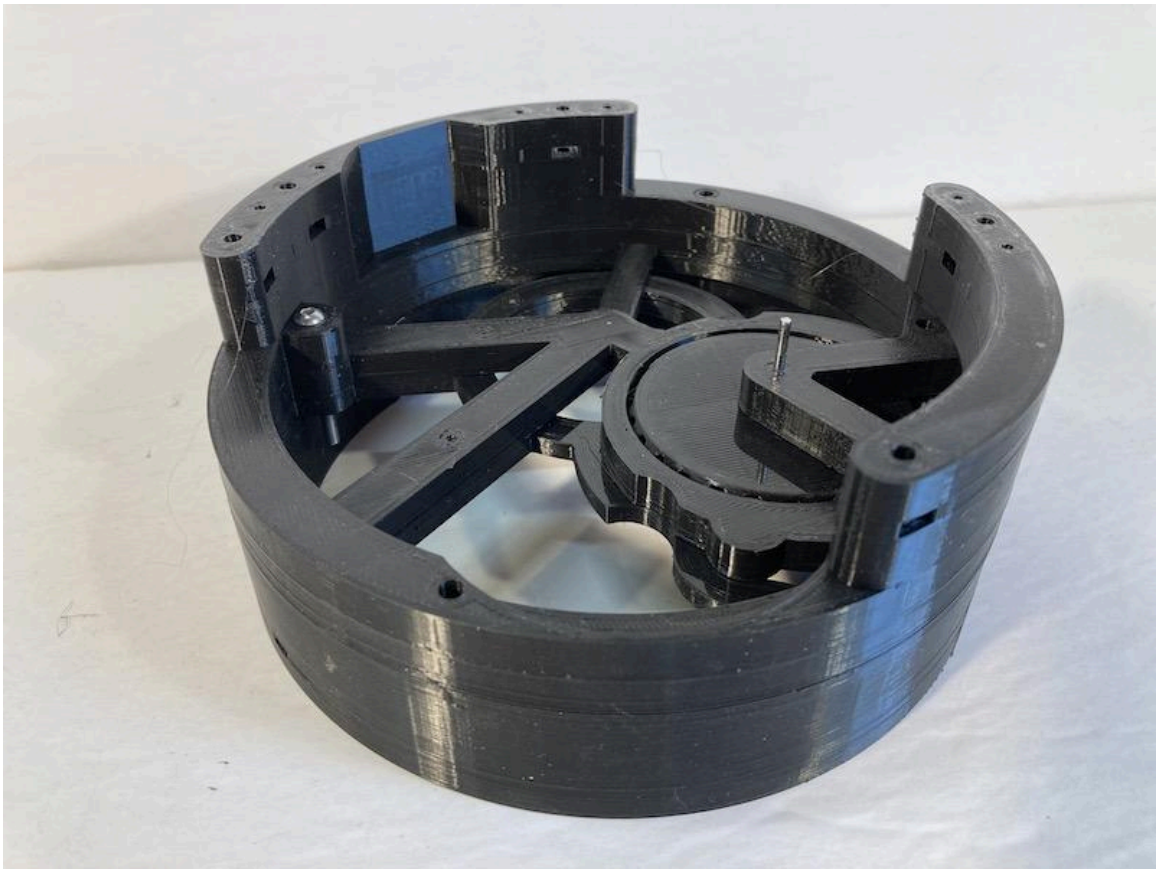
Do not tighten bolts at this time



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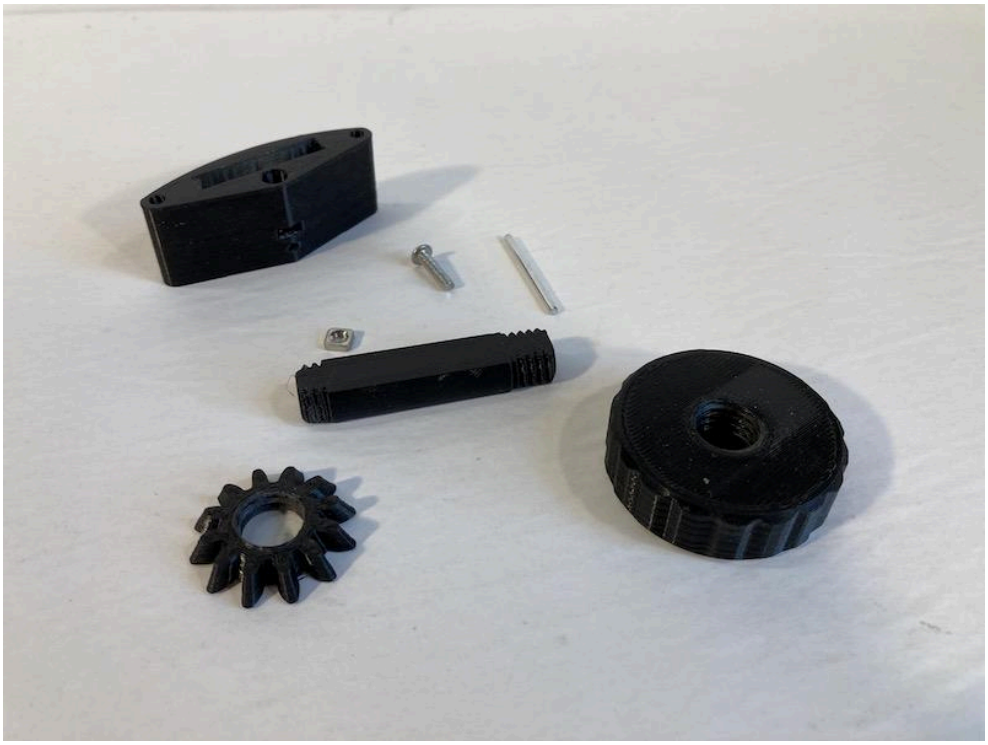
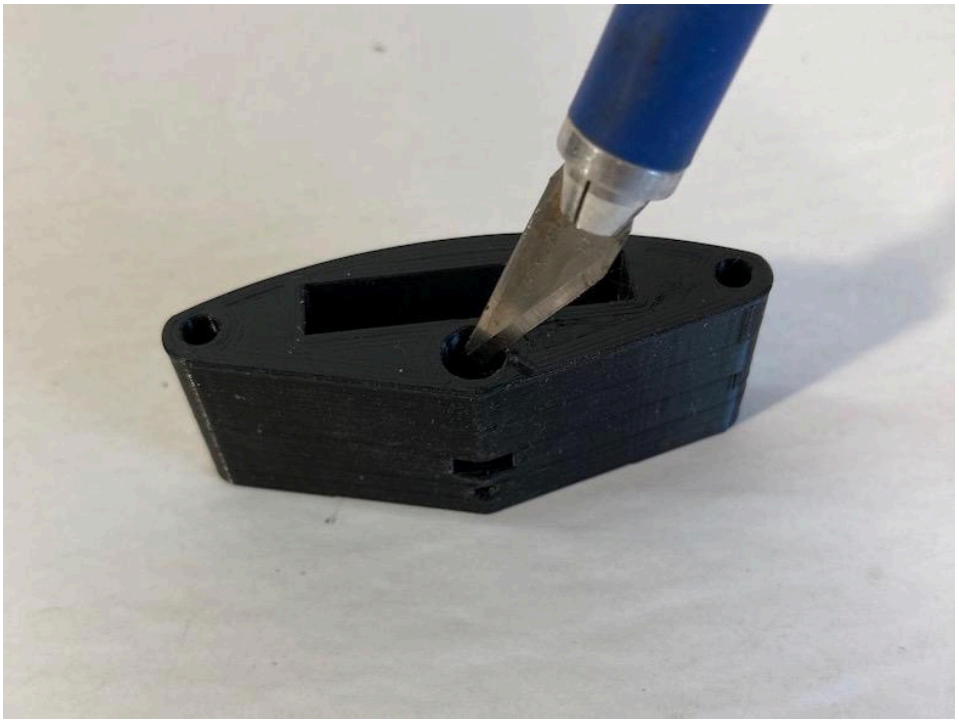
Prep rewind Gear/ stem

M3 x 12 screw
M3 nut
30 mm pin



Clean lip if needed to help in installing screw



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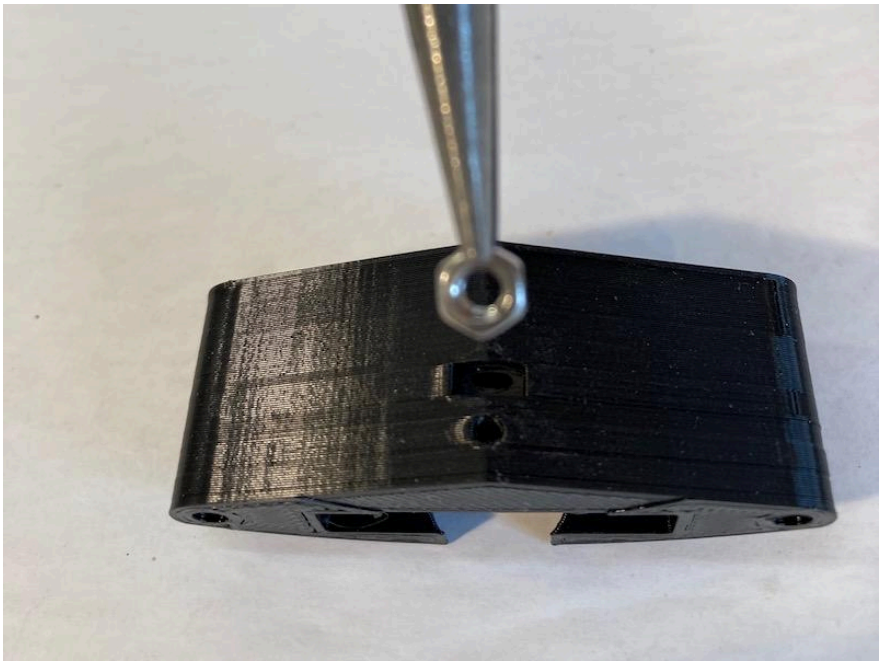
Insert M3 nut



PLace pin
Screw pinion to stem, hand tight

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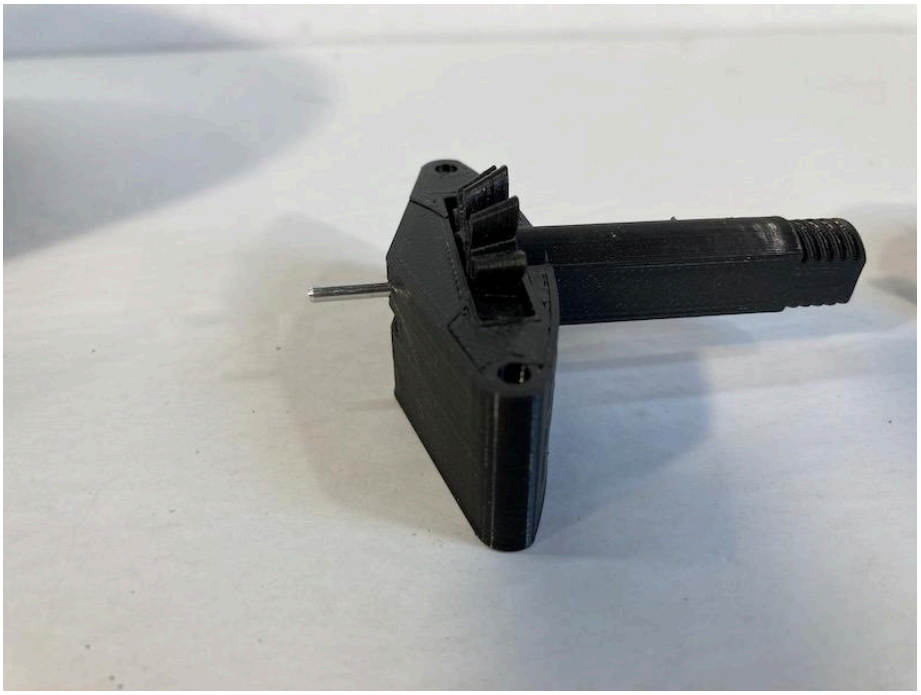
Place stem in bracket
Push pin in stem screw



Tighten M3 screw to lock pin in place

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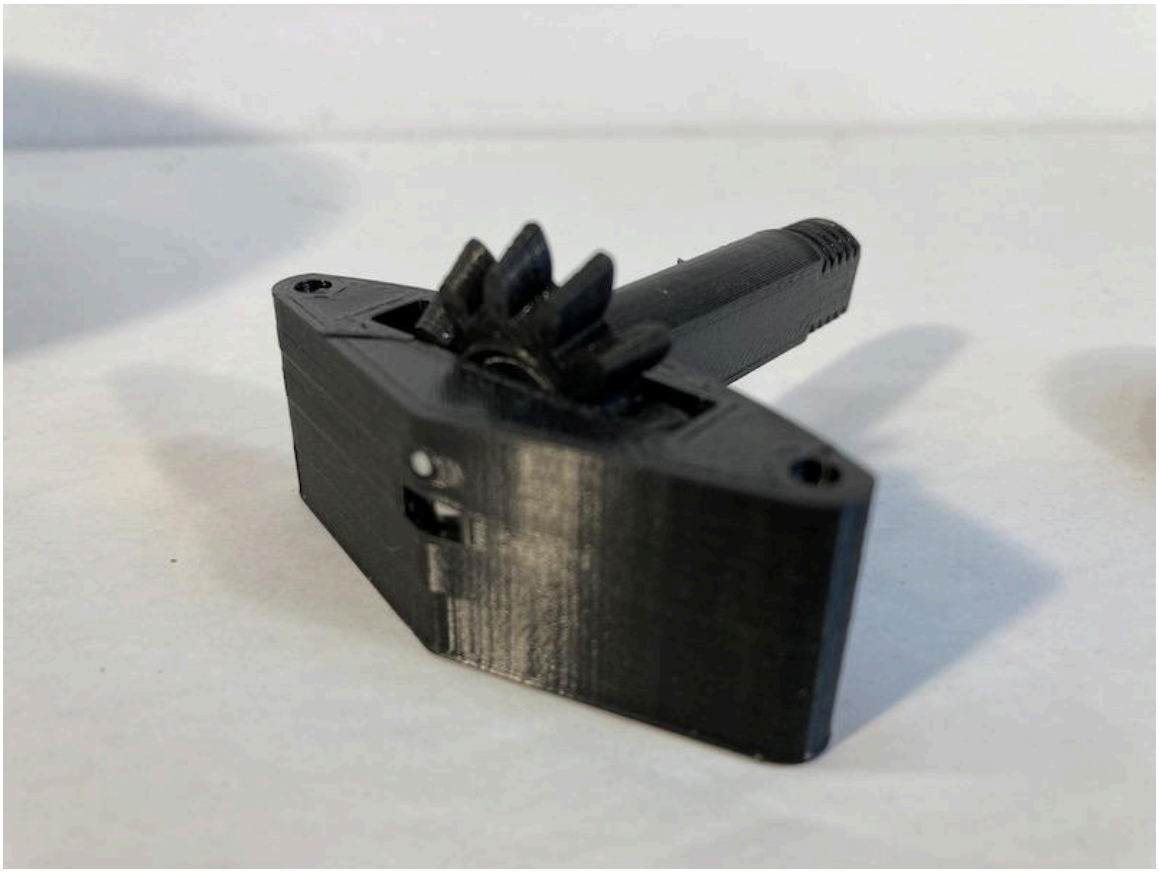
Pin is flush with bracket



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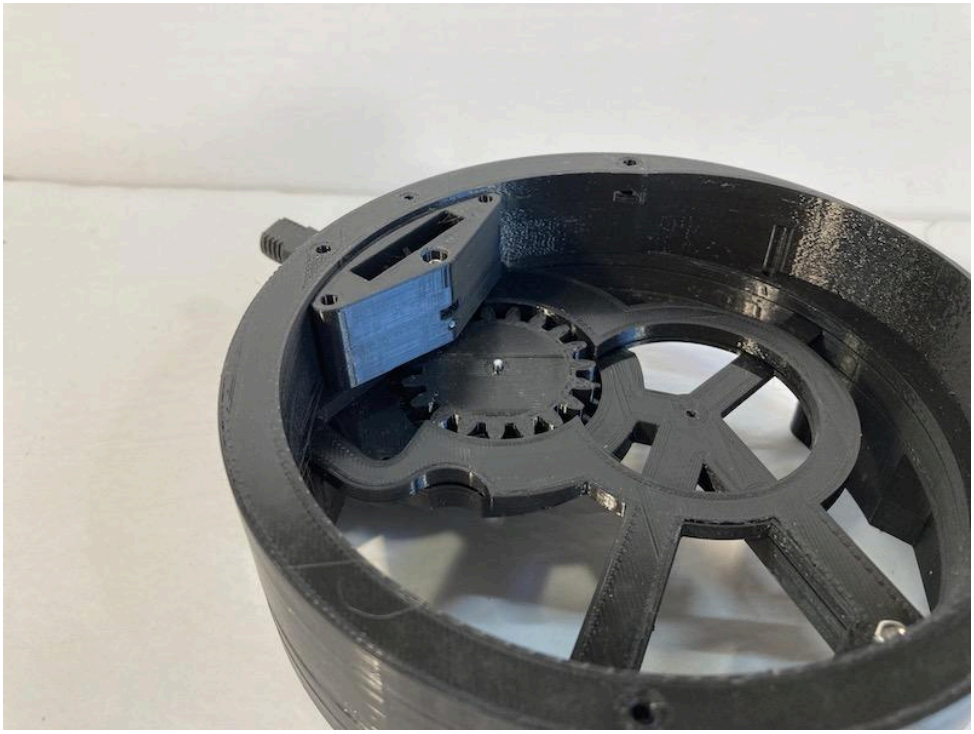
Install stem Assembly

Slightly lift plate and install stem assembly



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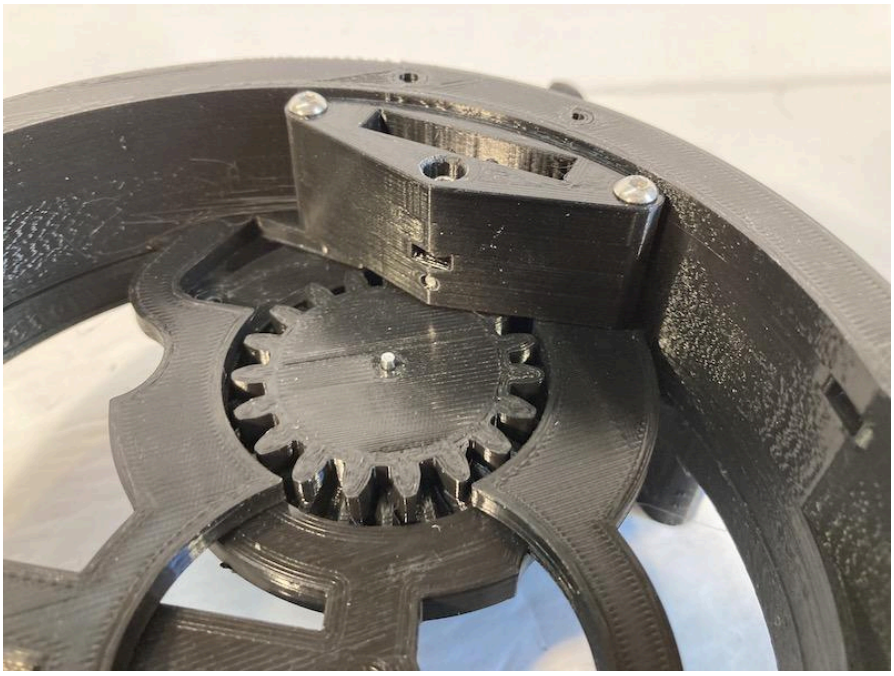
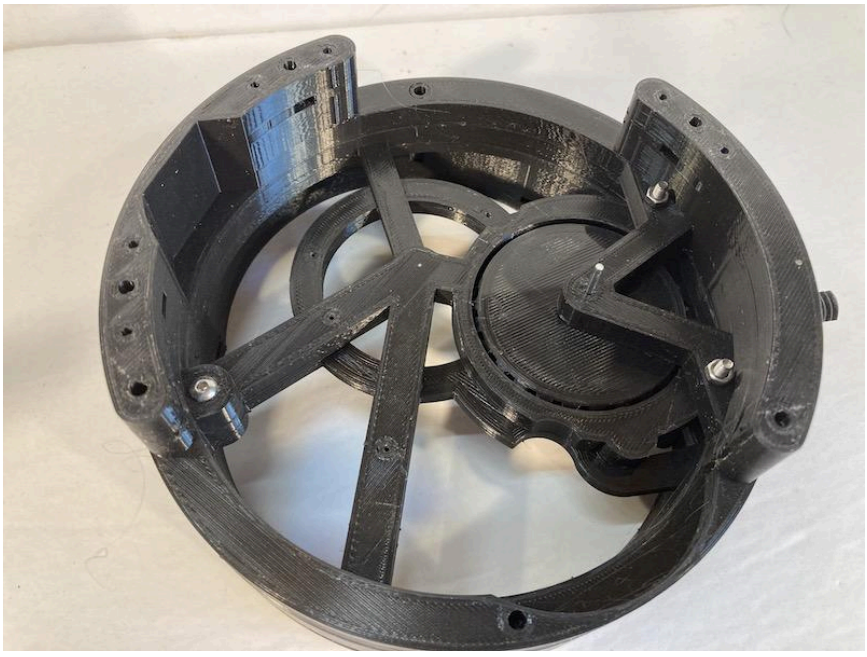
Install all 3 plates assembly screws
2 X M 3 x 45-50m to secure stem assembly and plates



And M3 x 25 on other side



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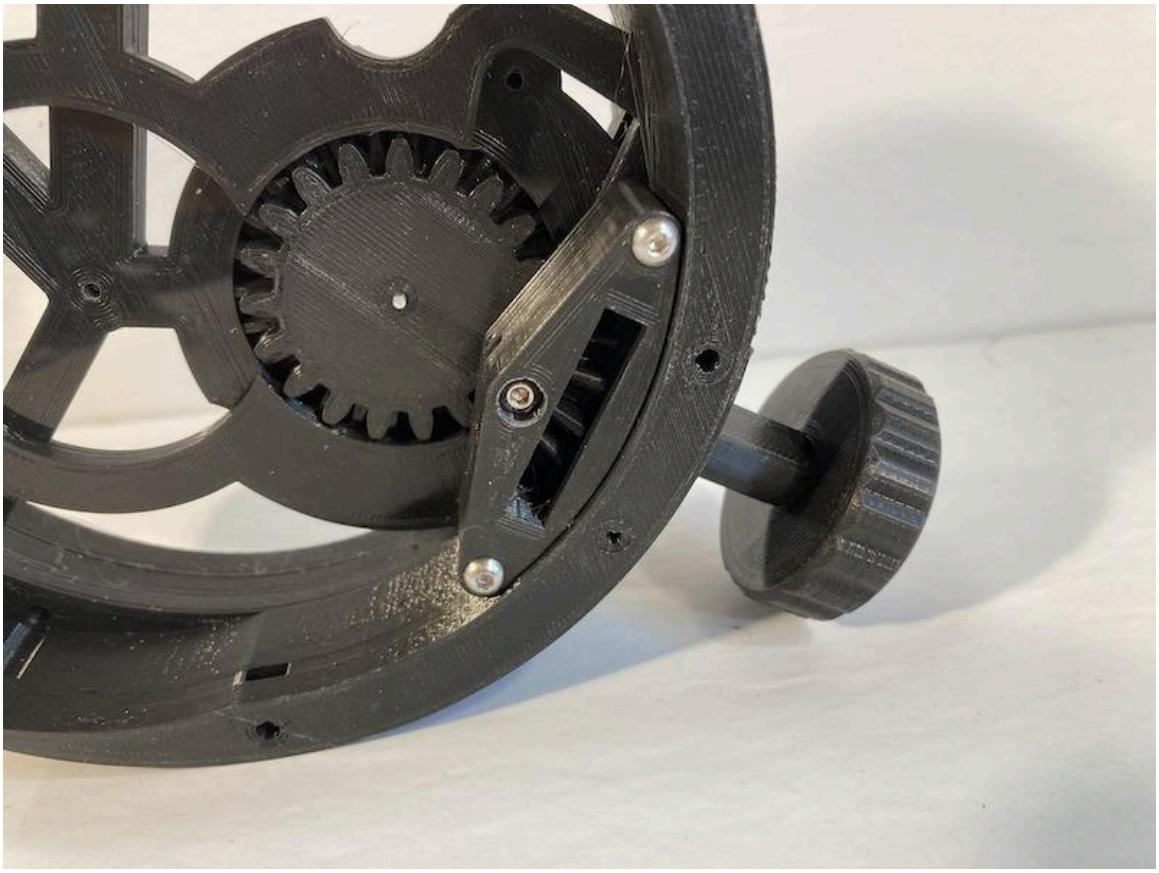
Screw on the crown and test the bevel gear motion



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Mobiles Prep and assembly

Spring barrel, gears, ratchet, hands, this is as all the moving parts

Spring Barrel and gear 100

Gear 100, gear 18, friction plates
4x M3 x 6 screws

Ream the center 2 mm holes for a loose fit on 2 mm arbor

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Thread M3 holes, using the guide tool for help

Check that gear 18 has a loose fit on gear 100
Install friction plate with the 4 screw
Adjust friction to a very light drag
Gear 18 must easily turn by hand with a constant friction

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Install 4 nuts in spring barrel

Wind up and install spring in the correct orientation
Use gloves, safety glasses and caution while doing
The spring will jump out if let loose

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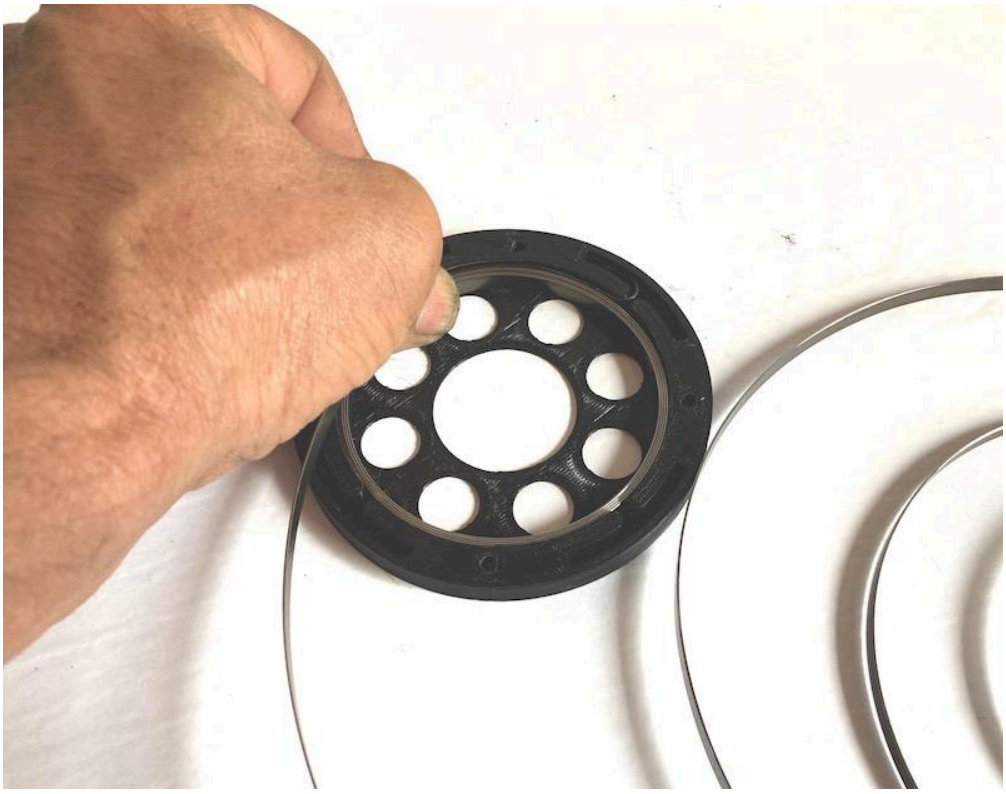
Turn and coil the spring
Use two hands
I was using one to take the picture!



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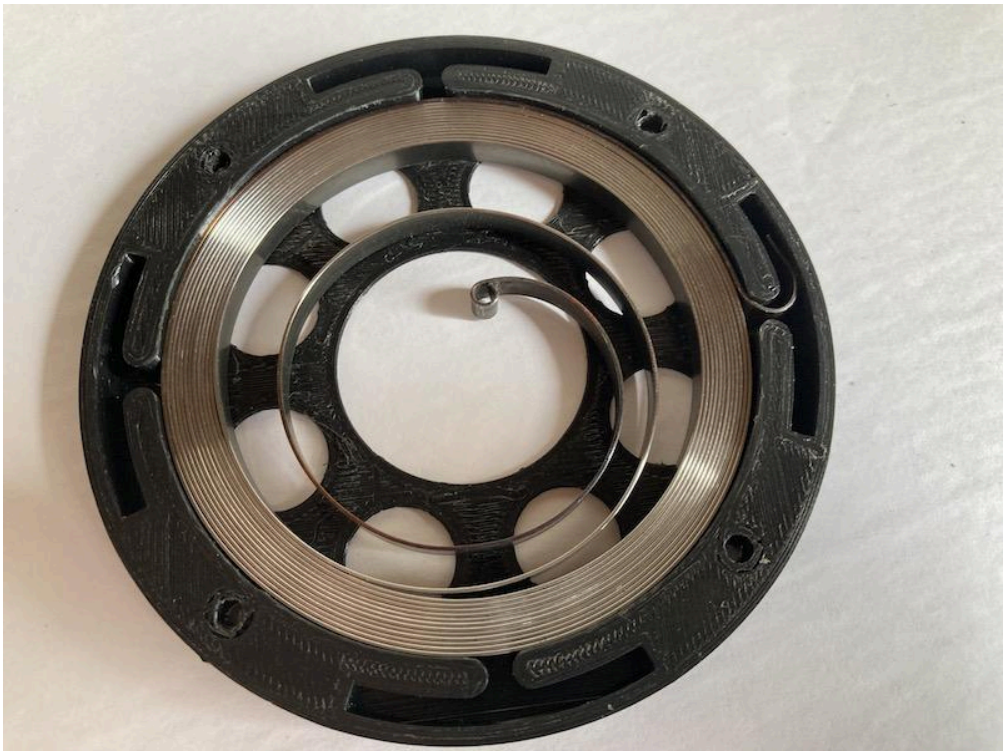
Done



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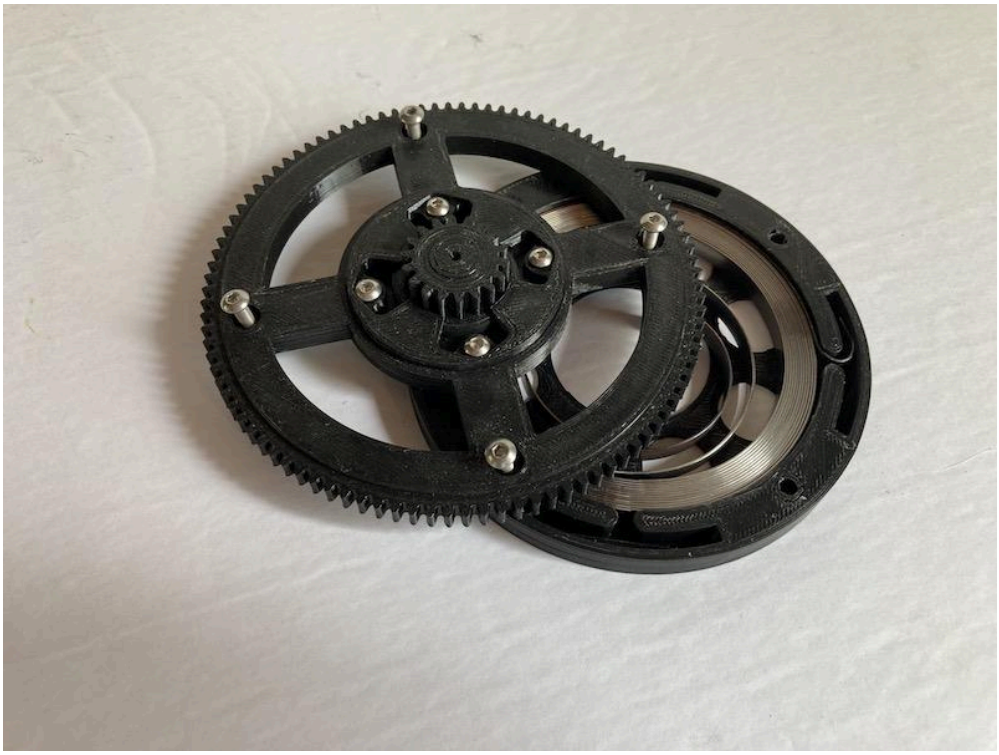
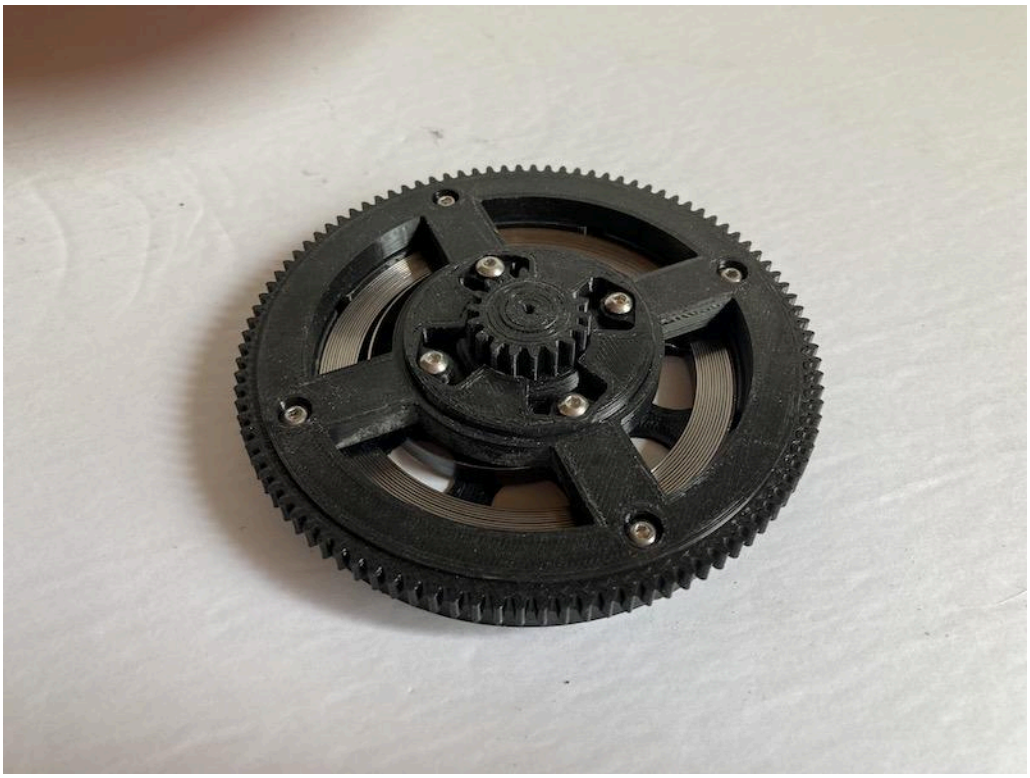
Bolt the gear to the barrel with M 3 x 10



Complete Barrel Gear assembly



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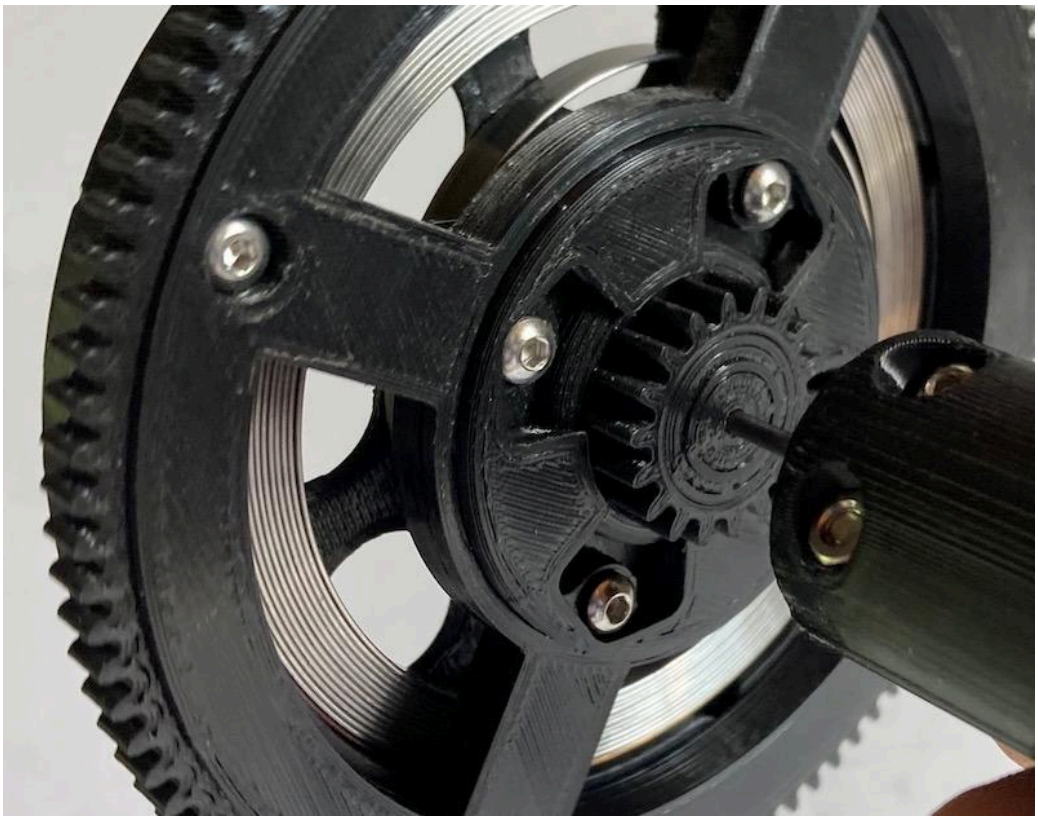
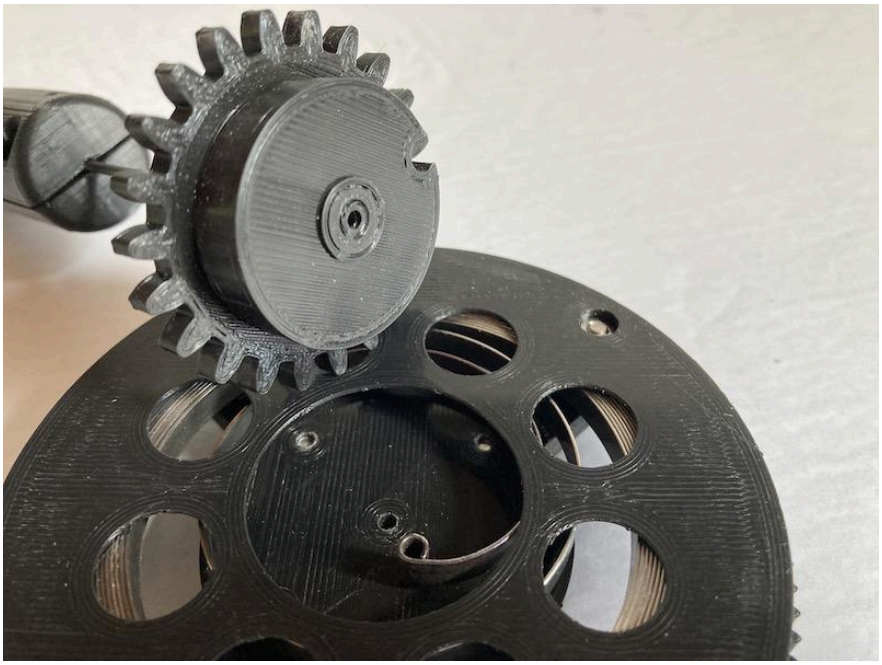
Test free rotation



Ream the rewind pinion for loose fit on 2mm pin



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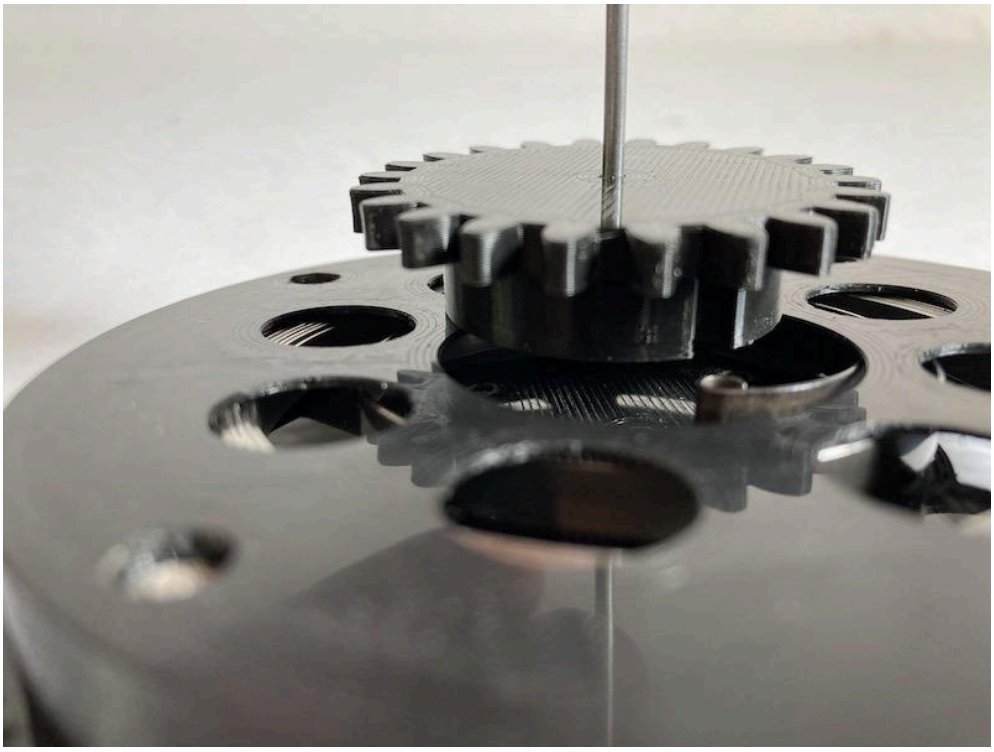
Align notch with spring



Using the 2 mm as guide, place rewind gear in barrel

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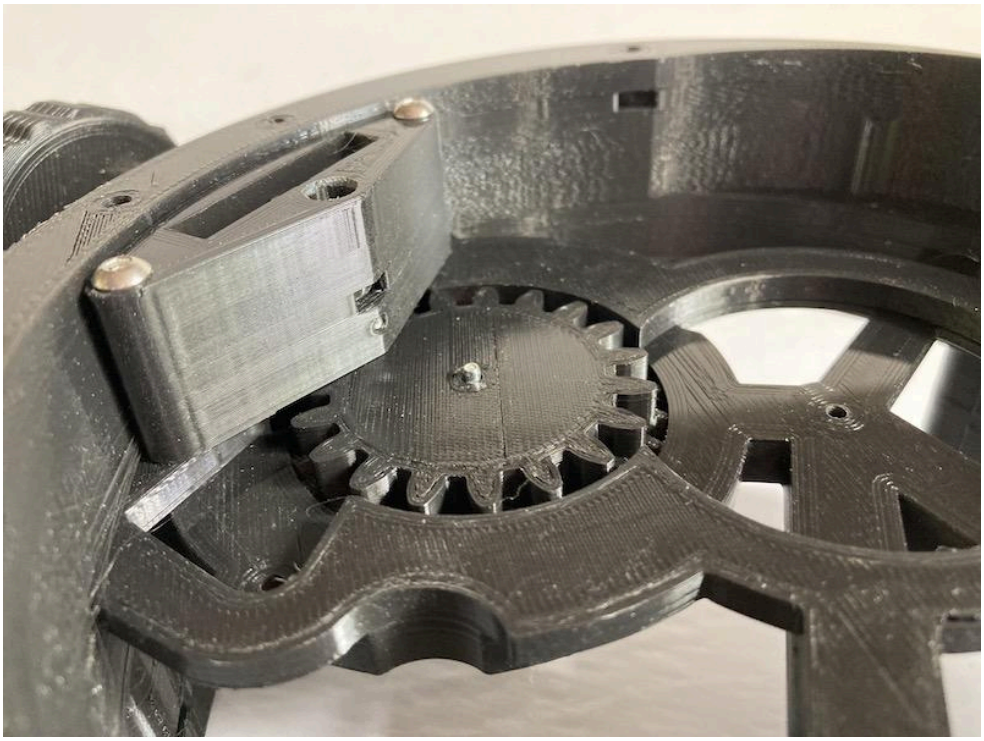
Replace the tool with the 2mm x 40 mm arbor

Again, remember to push the pin back flush with the gear



Test the assembly of th barrel gear

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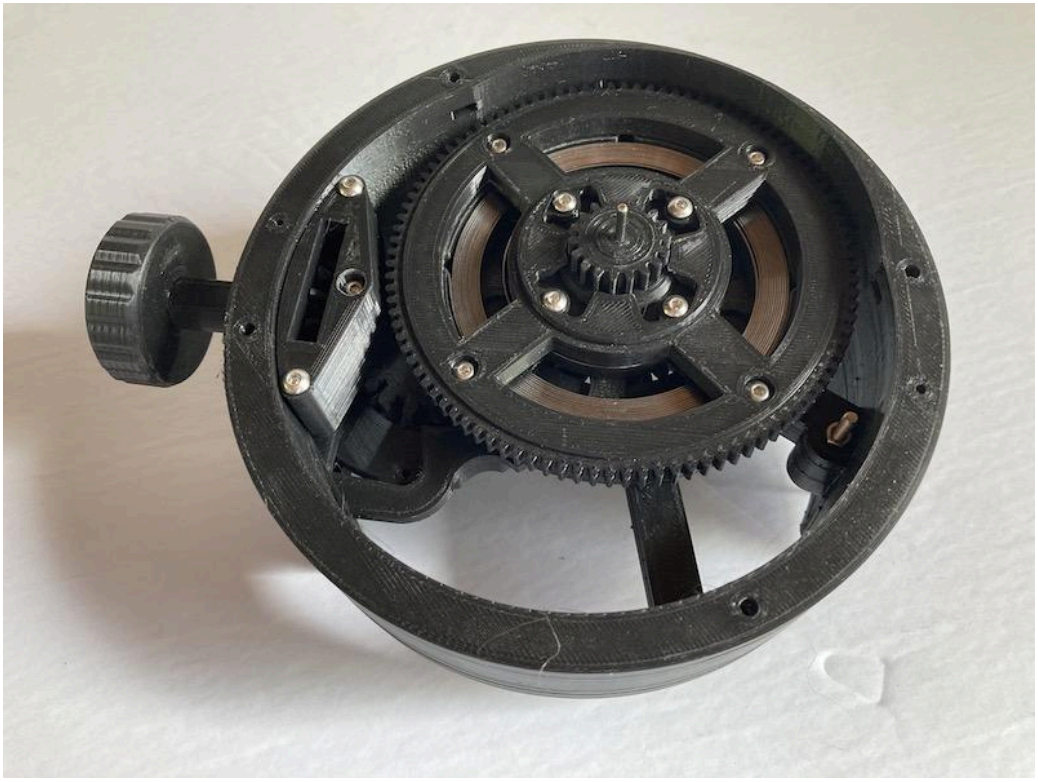

Ratchet

I use the guide tool to help shaping the ratchet spring made out of 1 mm piano wire

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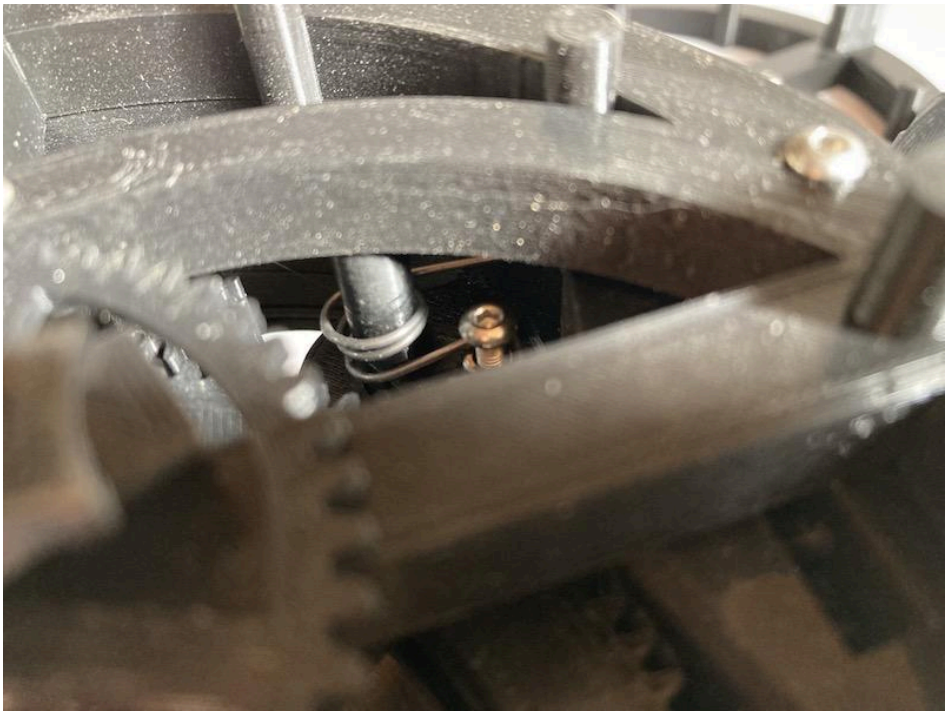
This the final result



Install the ratchet on the tool with a 2 mm and a long screw

Make a loop at the end of a 1 mm piano wire, about 170 to 200 mm in length

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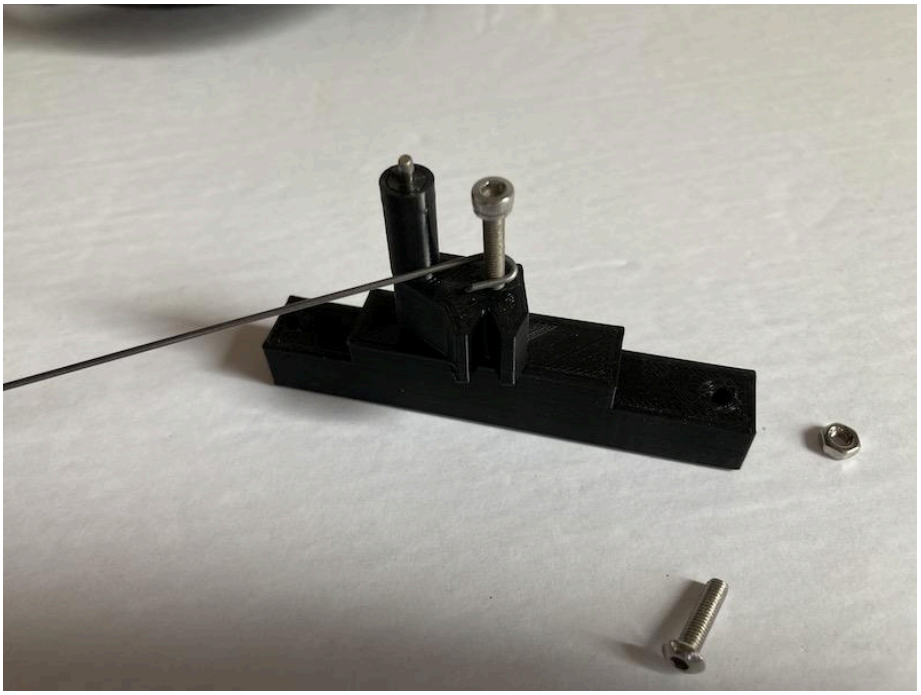
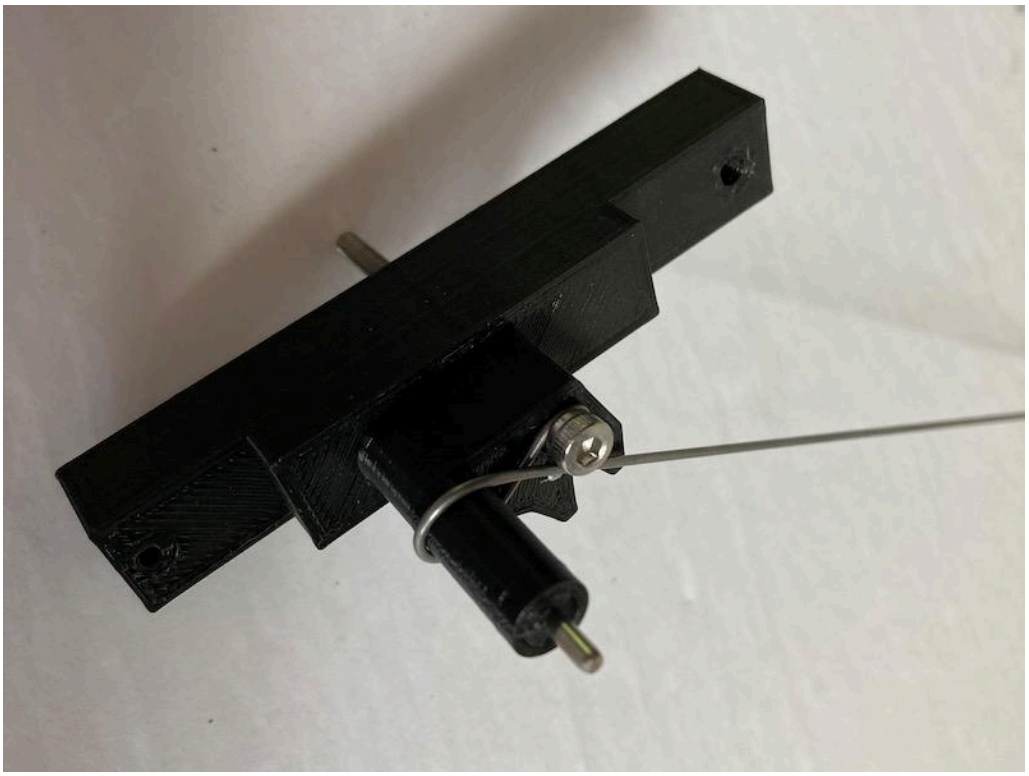


First loop



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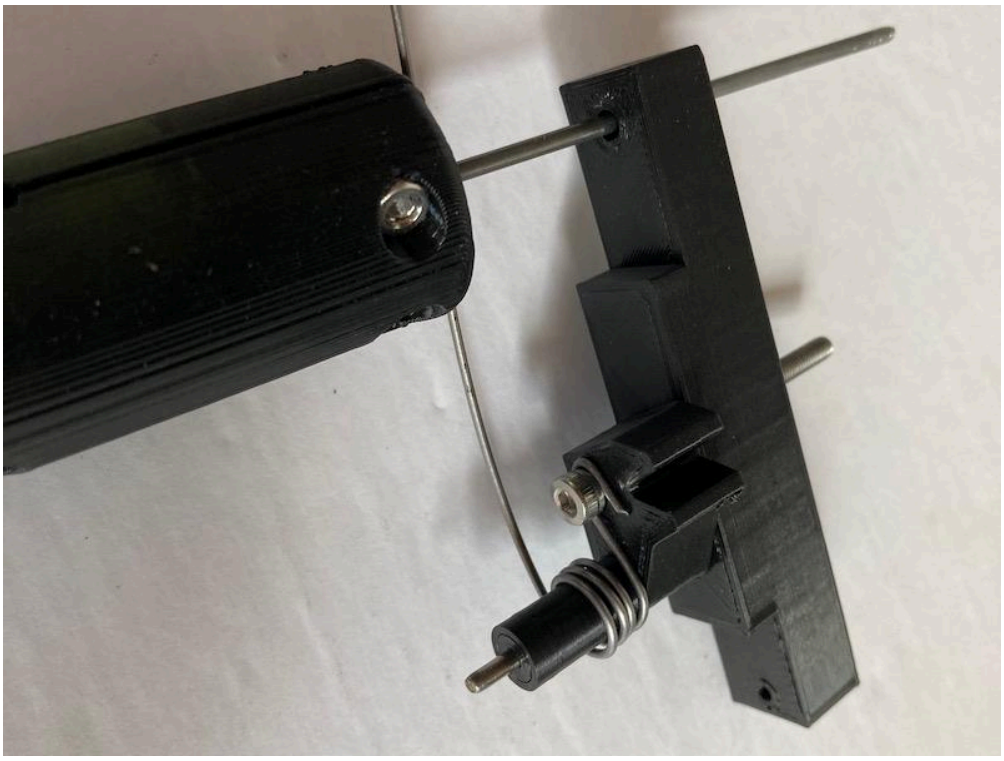
I go for 4 loops minimum



THis is about the dimension and angle that works
Test the length when installing the ratchet

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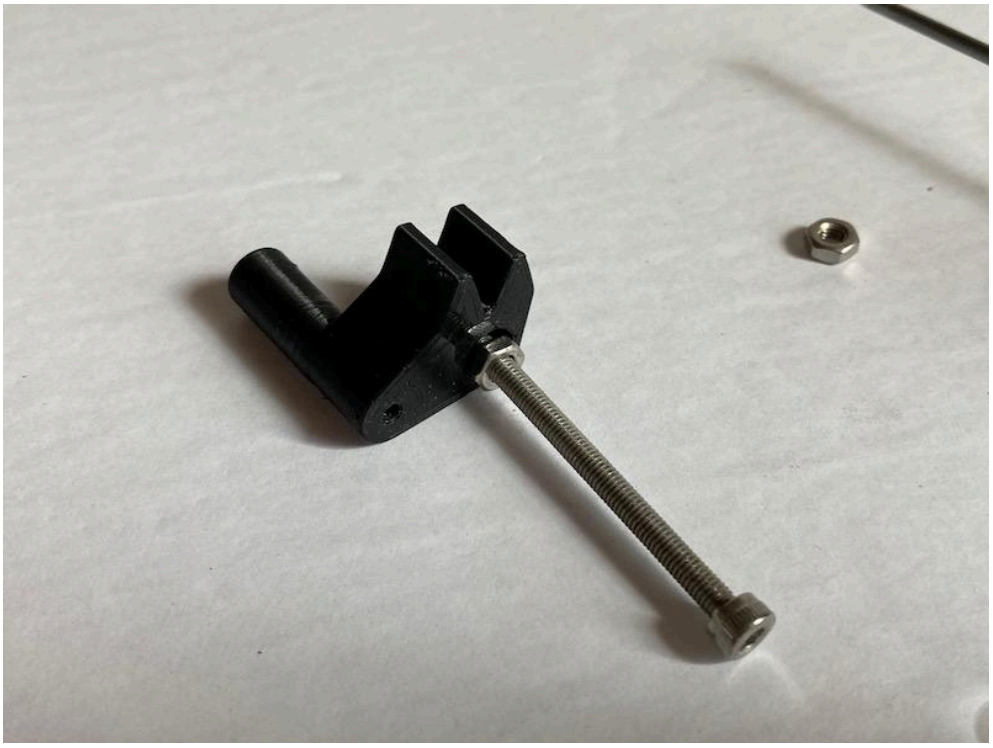
Install a nut



And a screw with an additional nut completes the assembly

Ratchet ready to install

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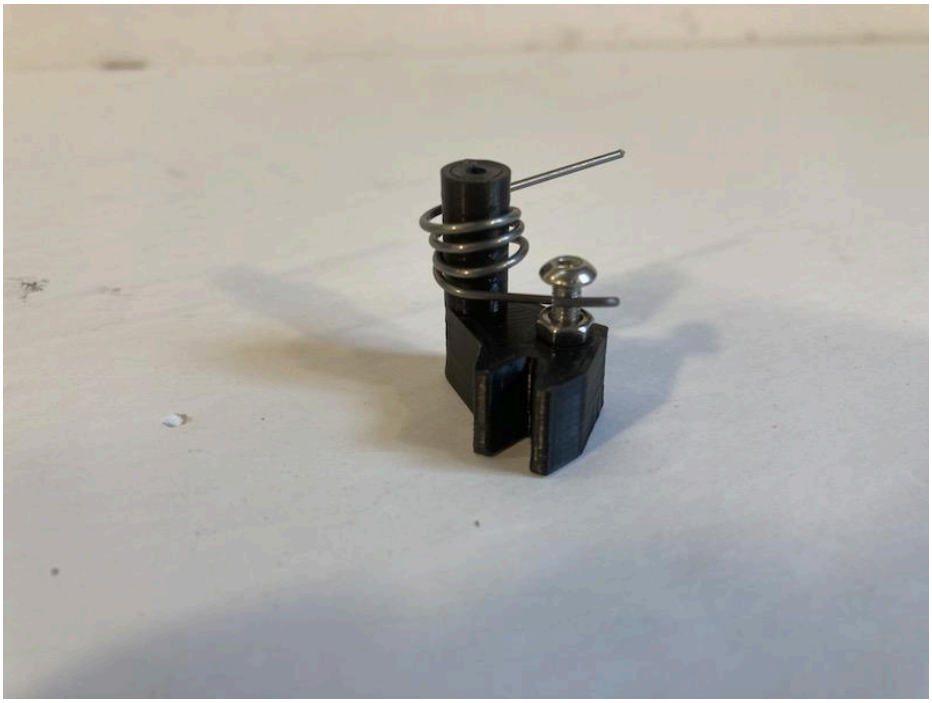
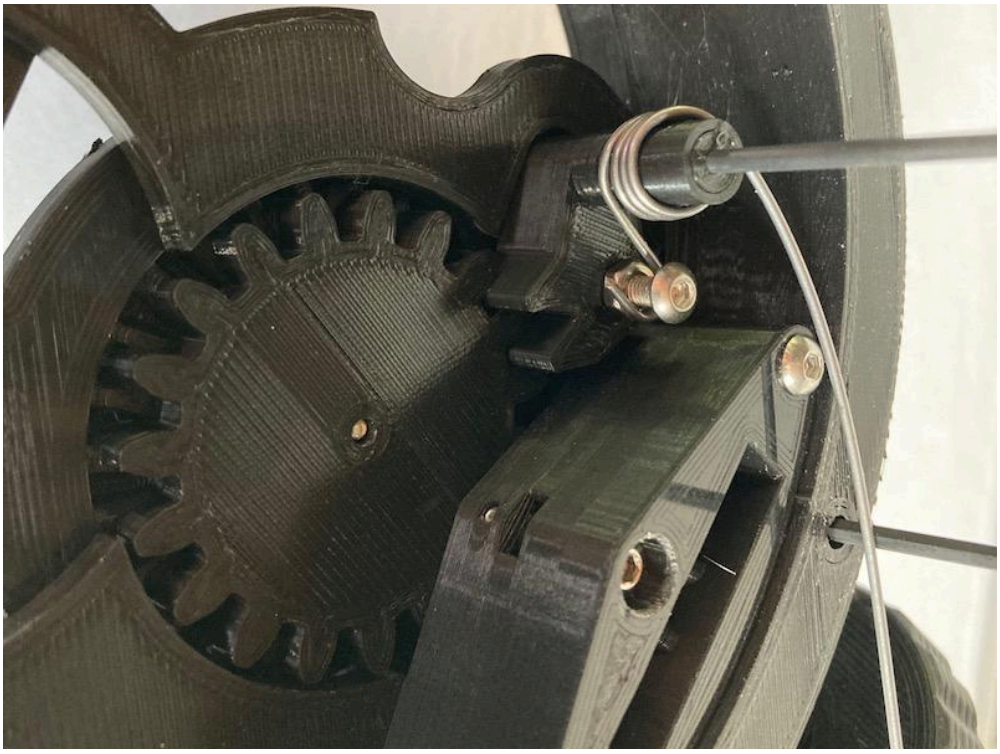


Check the spring length and cut to length



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Ratchet in place with the 40 mm pin
Notice the pin for the gear pushed below the surface of gear

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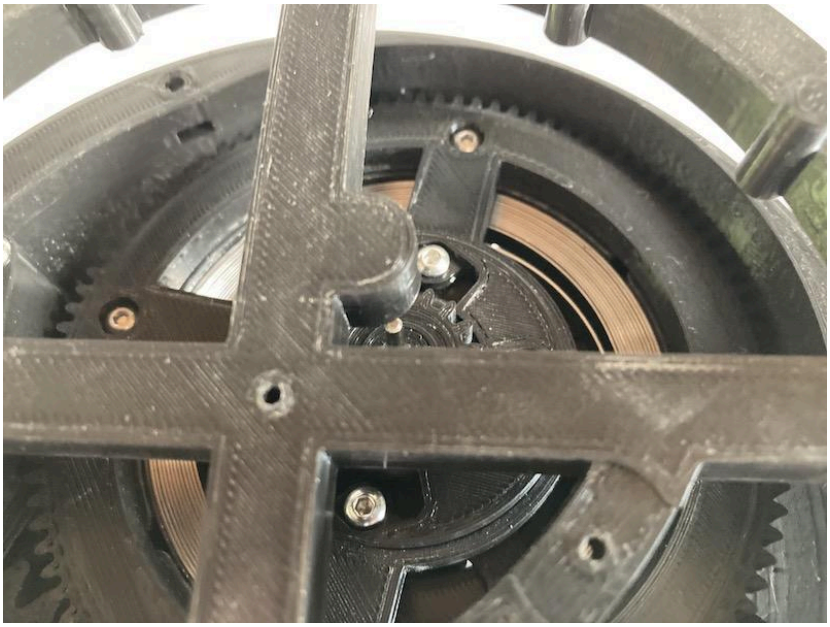
Dial plate install test

I like to do a test at this time
Line up the ratchet pin first

Then line up the barrel gear



And push dial frame in place

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Install 2 screws and test rewinding ratchet and free motion of the barrel gear

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Hands Gears

Identify the correct gears

Place a nut and screw in the minute hand
Ream the center hole to be loose on 2 mm pin

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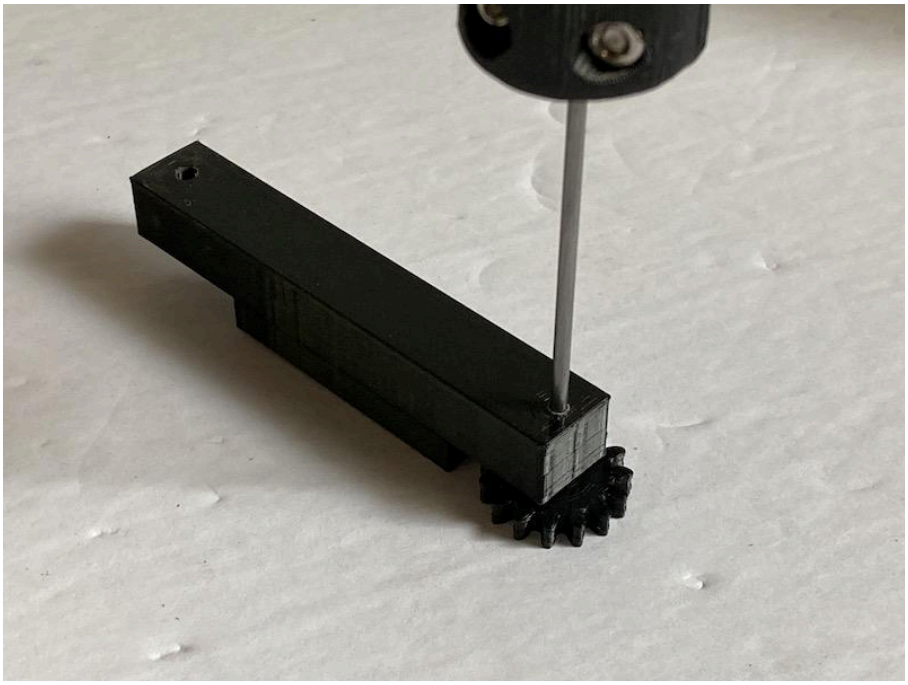
Ream the gear 15 with a slight tight fit
Use the guide tool to be square



Make a L bend at the end of a 30 mm pin
Ideally 25 for the long end and 3 mm for the short end
To be adjusted later
The tool will indicate the ideal length

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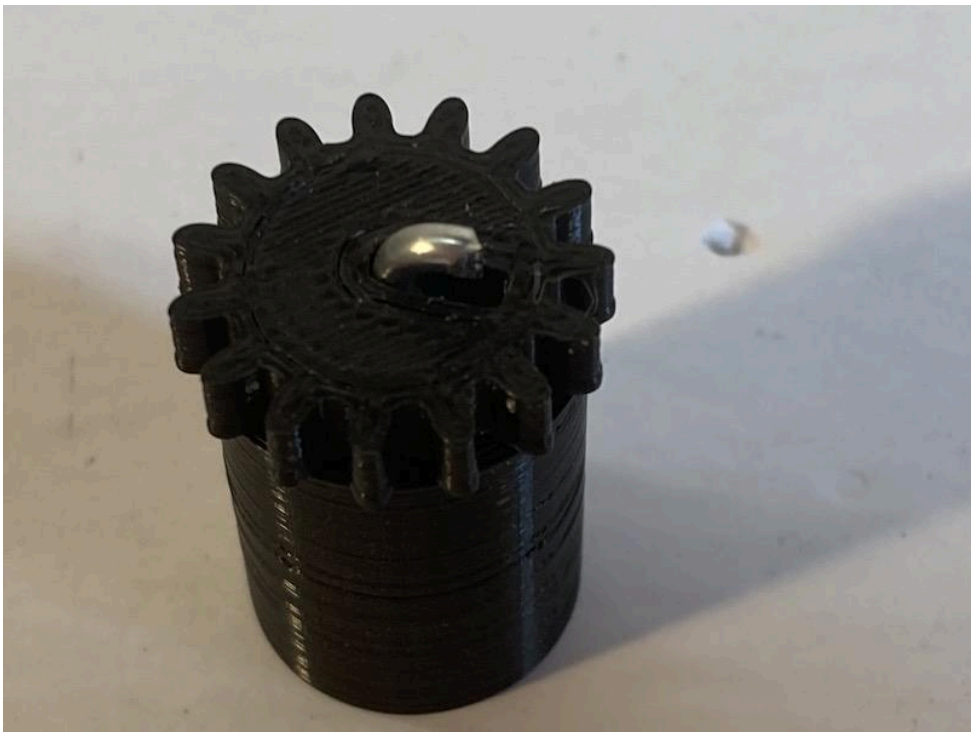
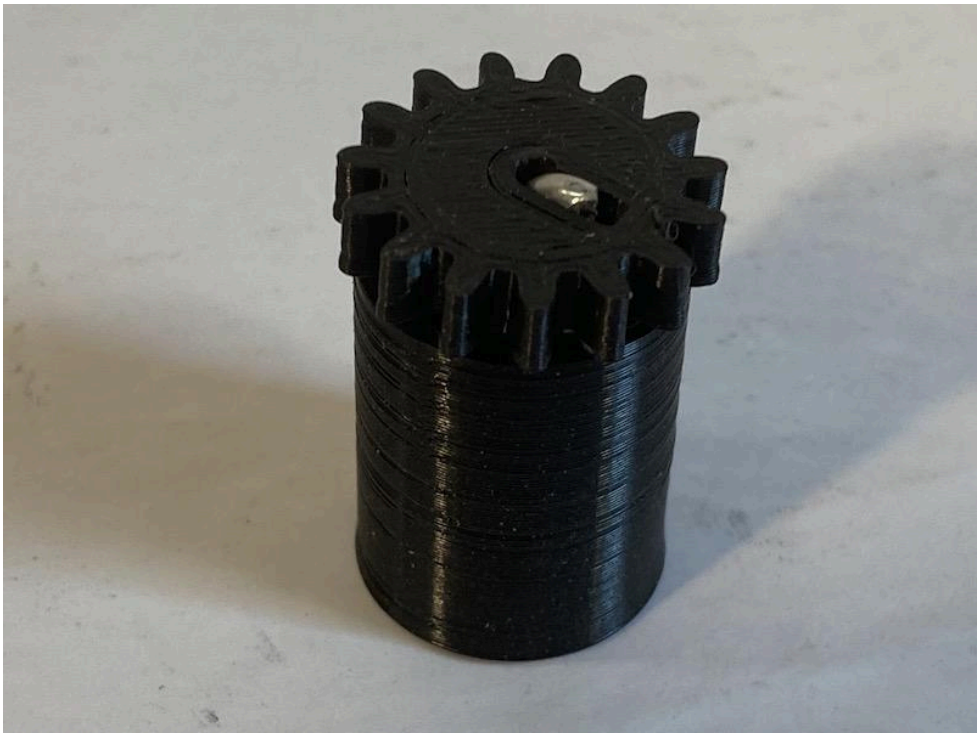
Place the gear, adjust the length of the L to fit in the notch



Hammer the pin in the gear



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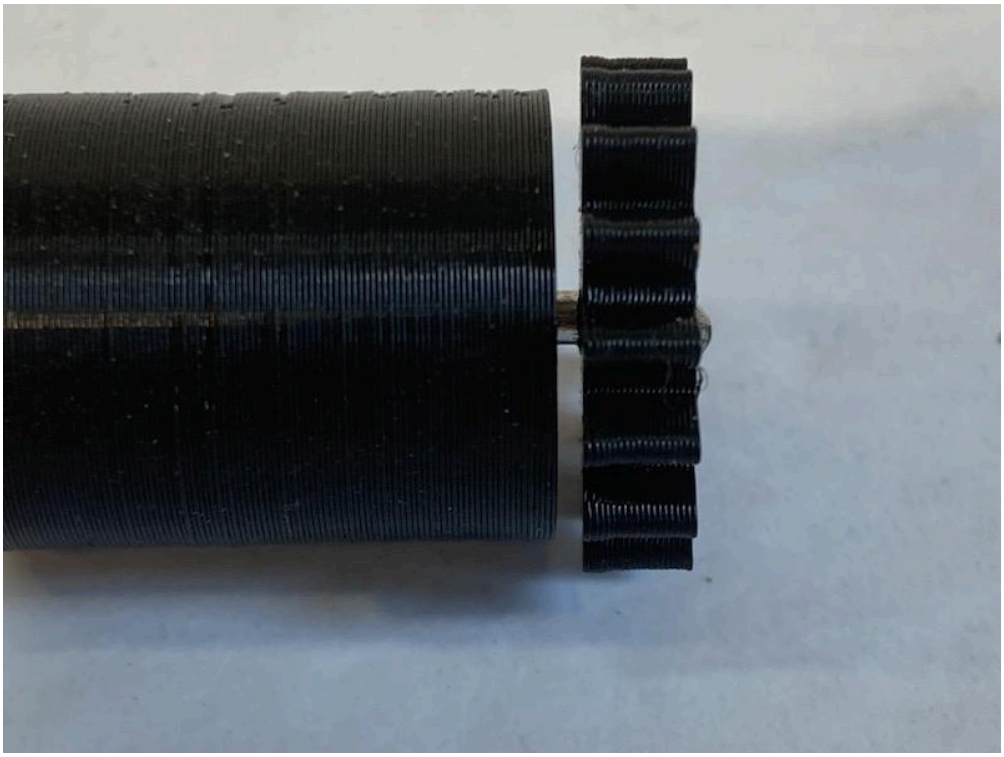
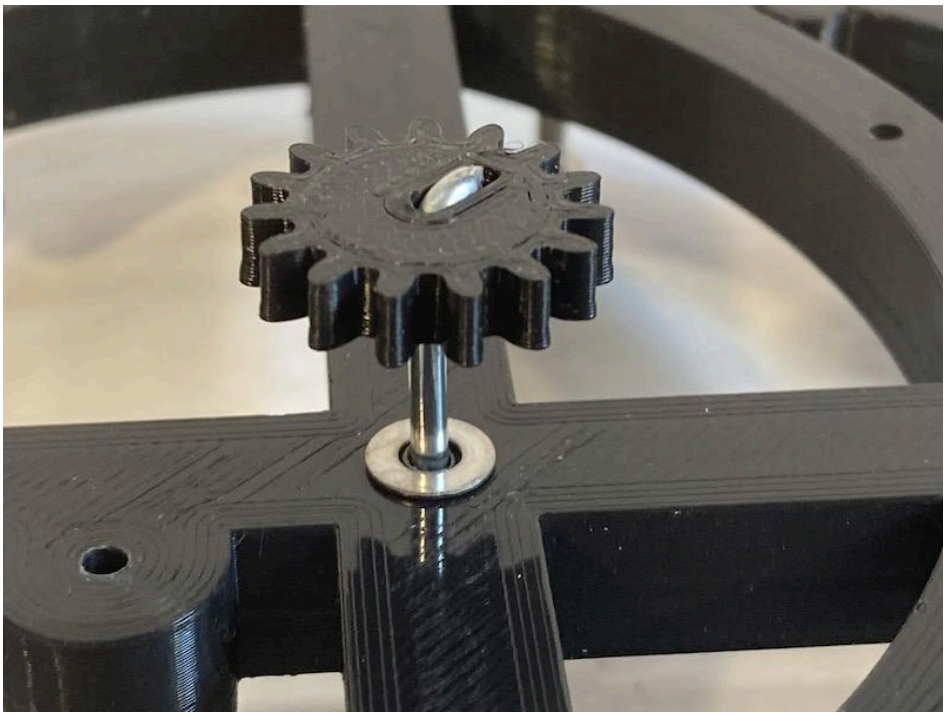
Check for square and true
Pin can stick out a little out of gear



Place the gear and pin in the center of dial plate with a washer



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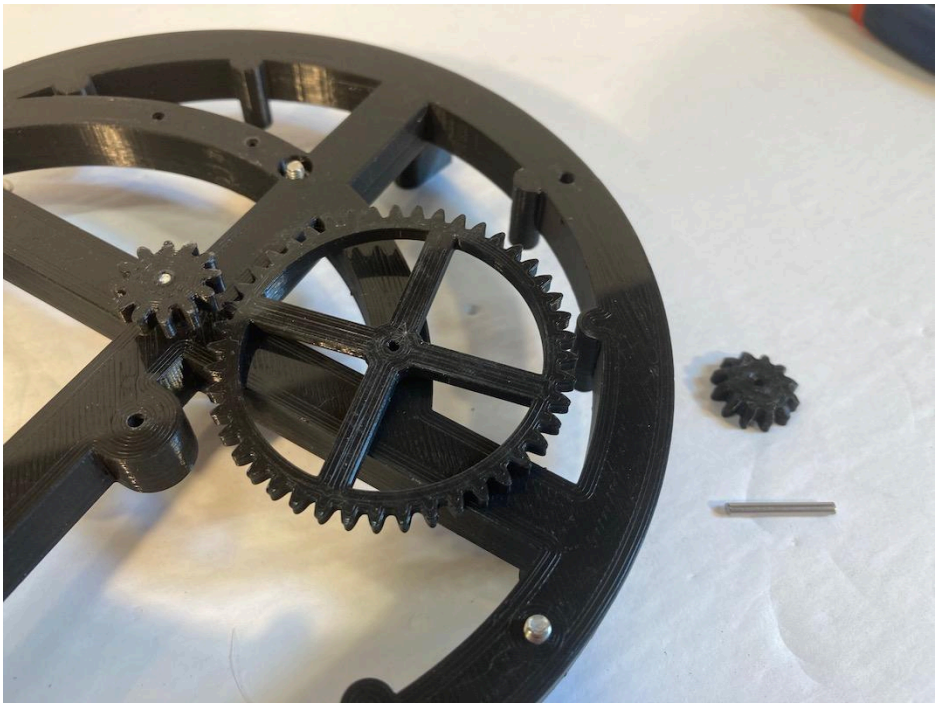
Prep the transmission gears, gear 45, gear 12, and 2mm x 17 pin



Use the guide tool to instal the pin in gear 12
Note the orientation

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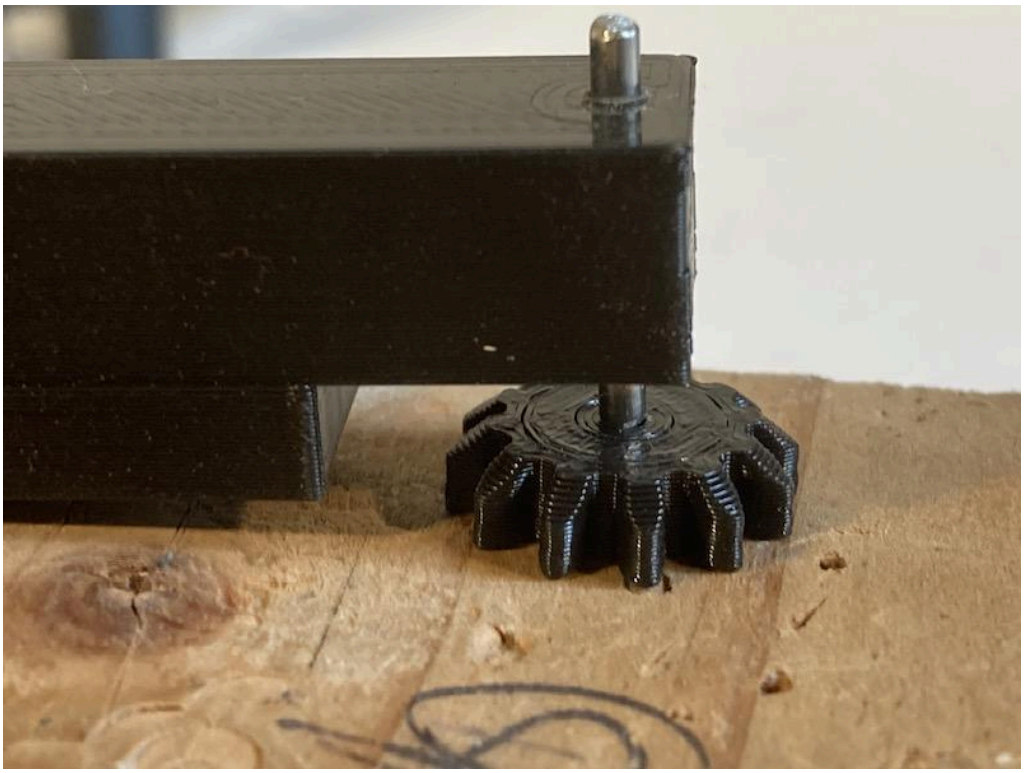
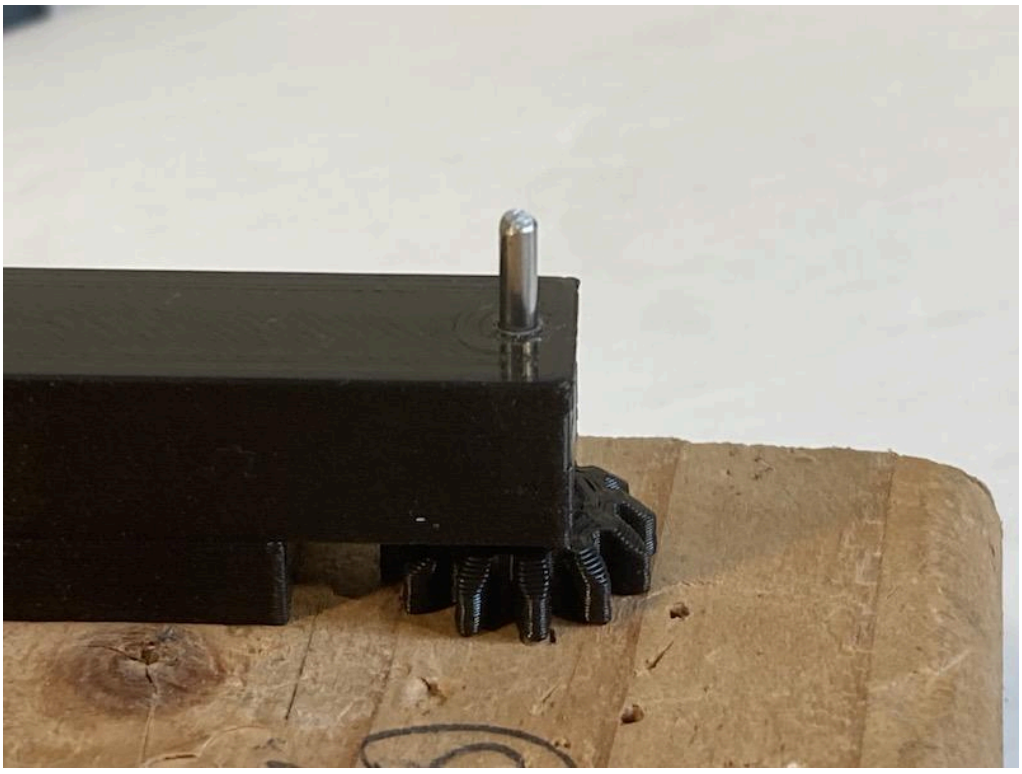


Hammer or press the pin in place



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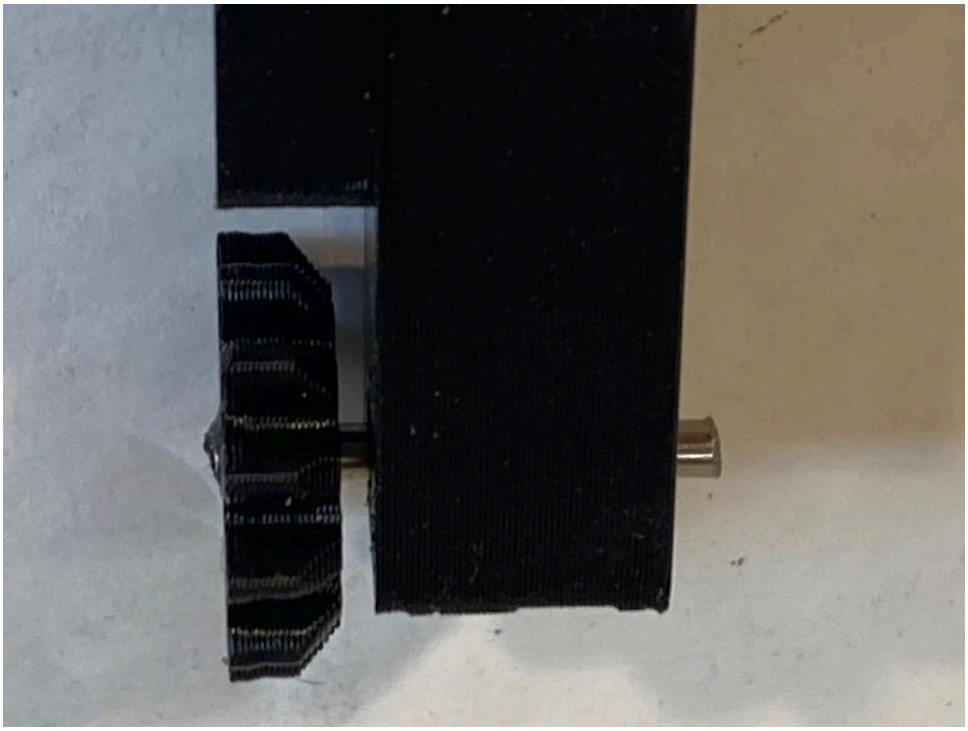
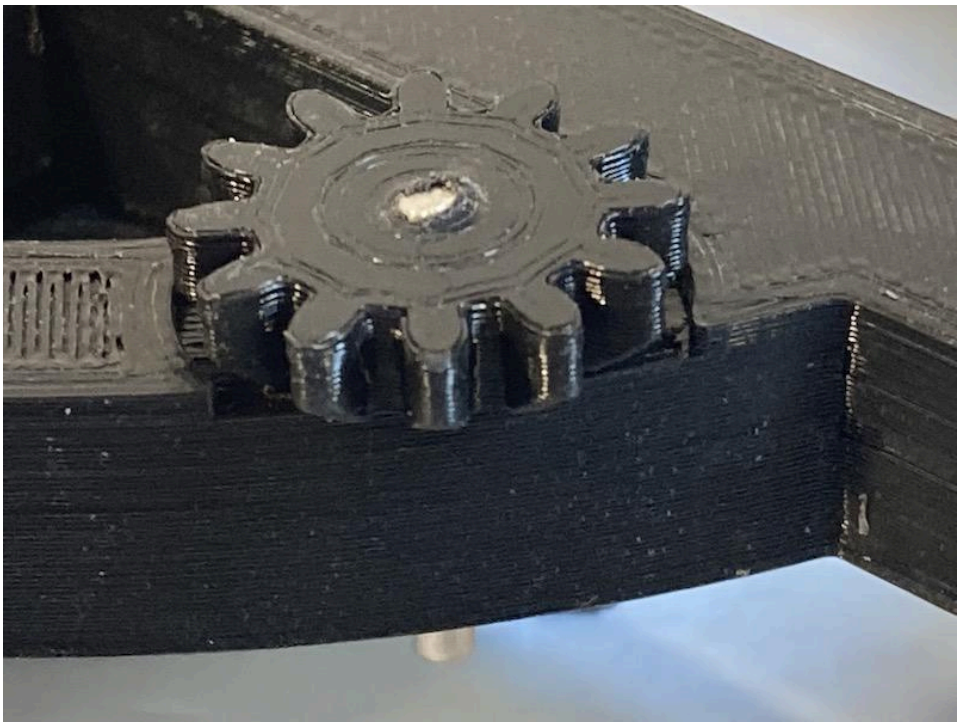
Check the gear is square and true



Install



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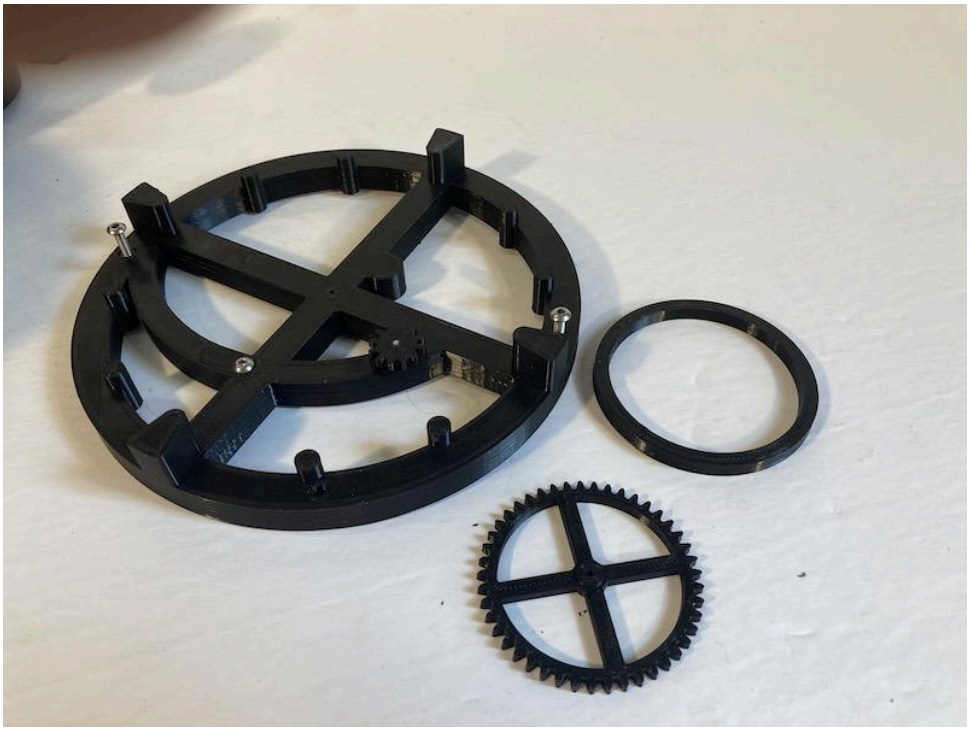
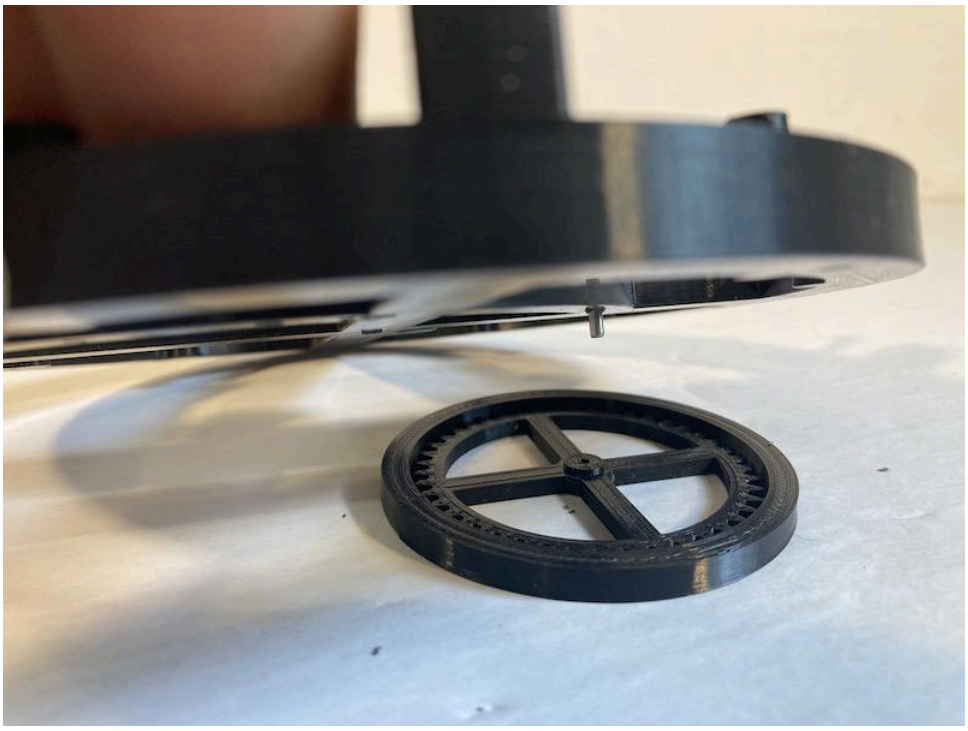
Use the ring tool and place it around the gear 45



Place the dial frame and gear
Line up arbor and gear



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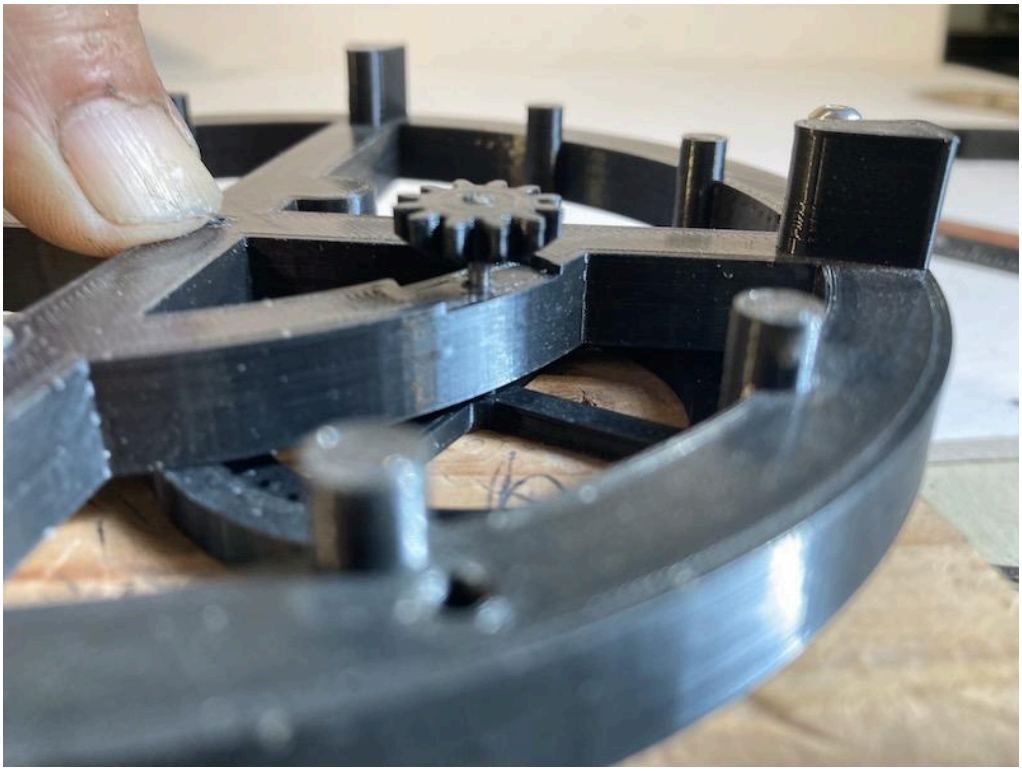
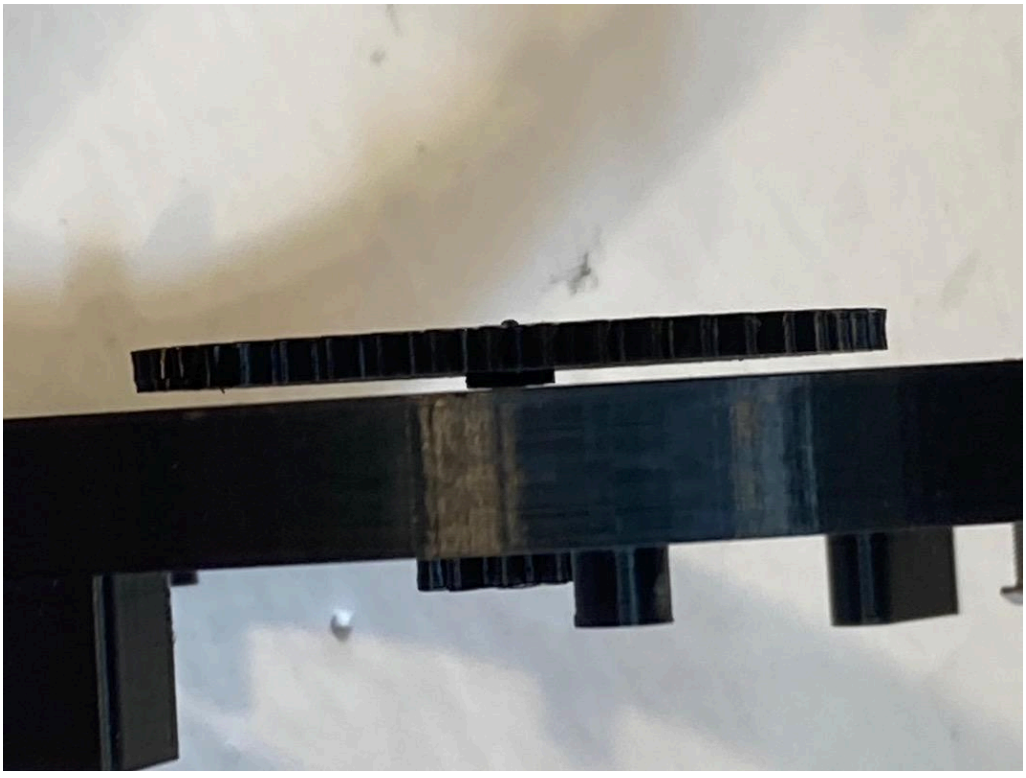
Hold the frame flat on the circle tool



Hammer or press arbor in gear 45
Leave just a small play for free spinning
Check for square and true gear



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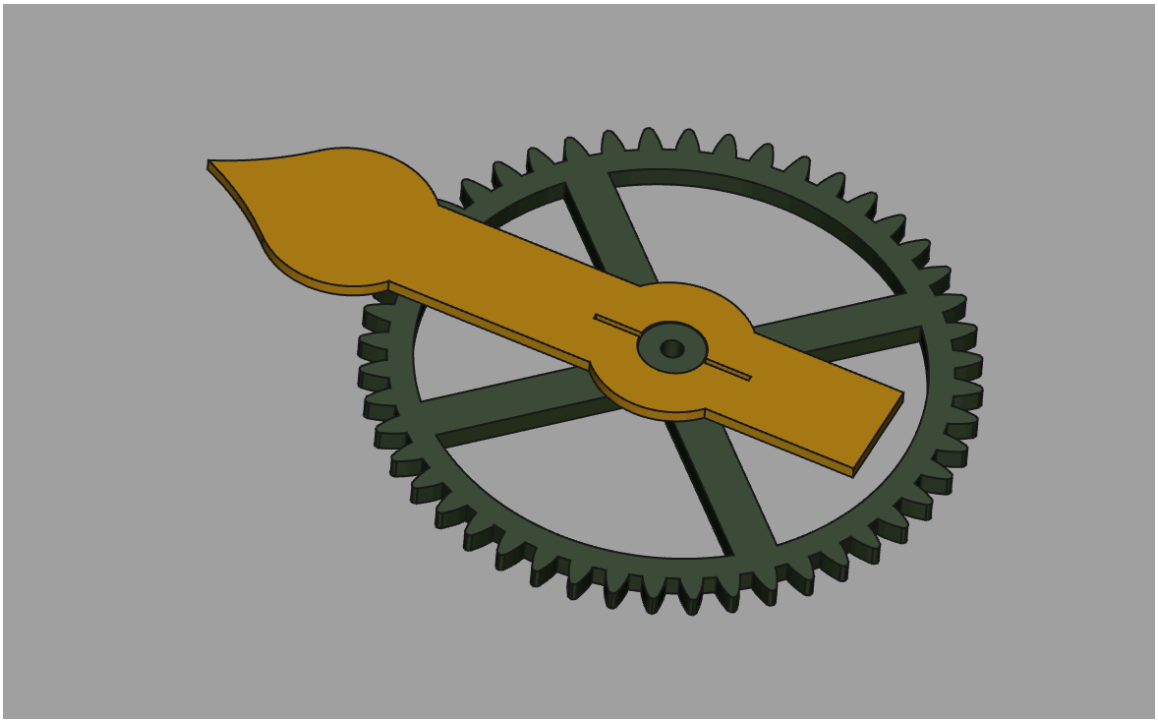
Ream the gear 48, that is the hour gear

Press the hour hand on the gear



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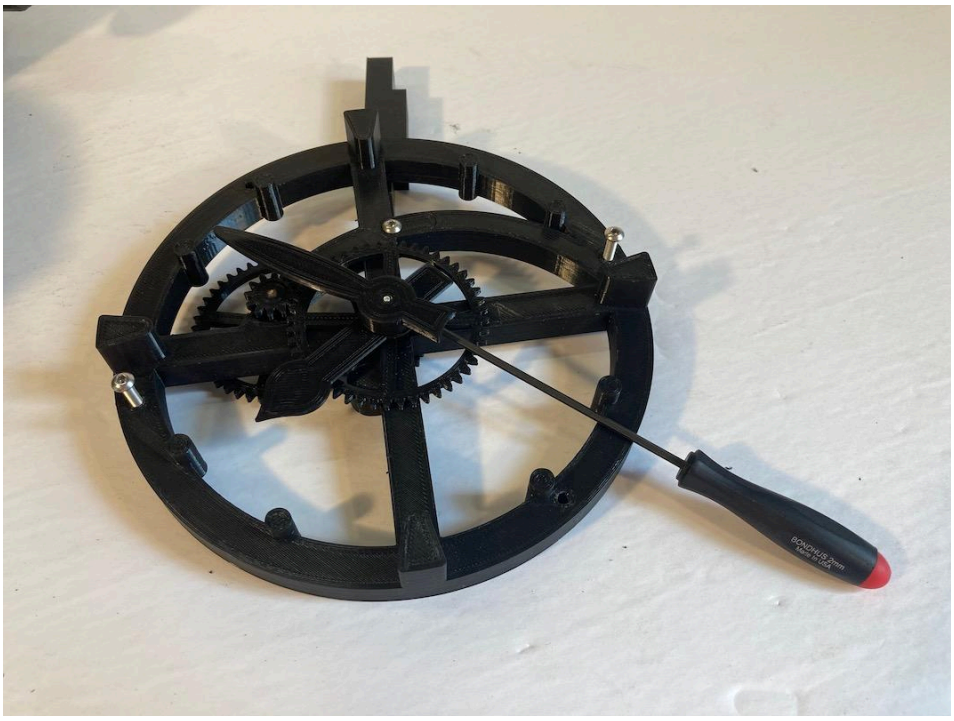
Install the hour gear and hand
Finish with the minute hand
Tighten the minute hand screw
Check smoothe motion and meshing of all gears
Adjust the respective position of hour and minute hand as needed



There should be a little gap between the front of minute hand and top of dial plate
Trim/file the end of hand arbor if needed

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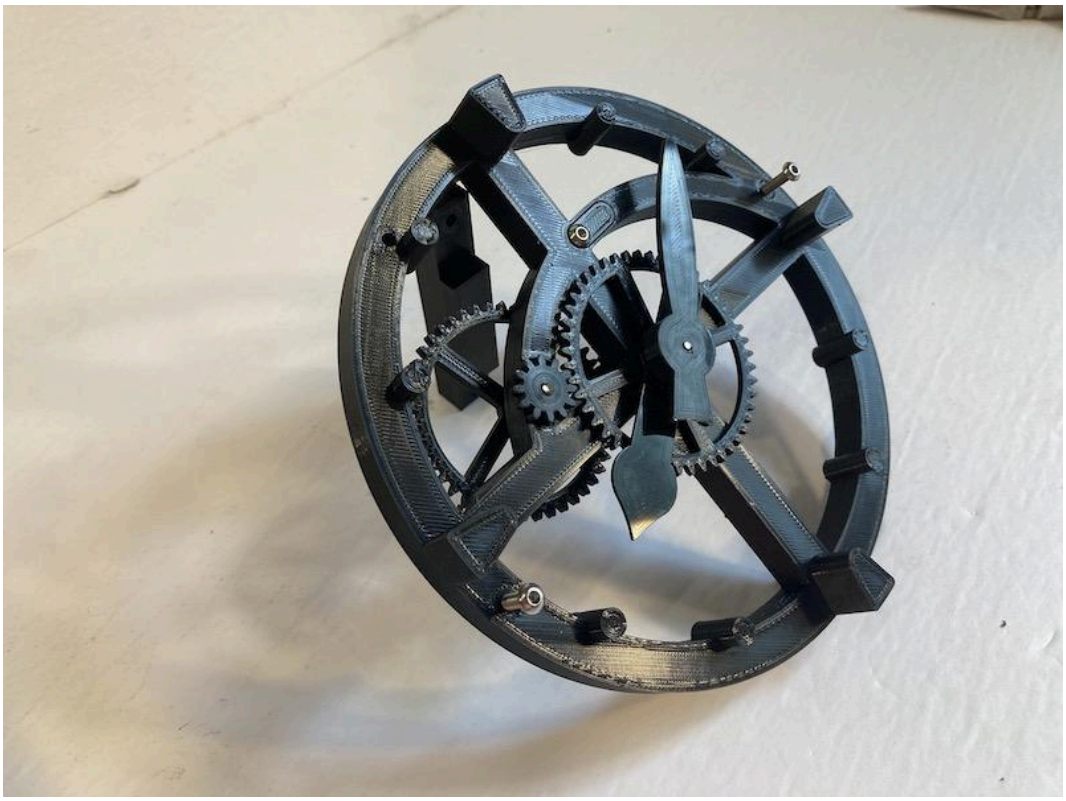

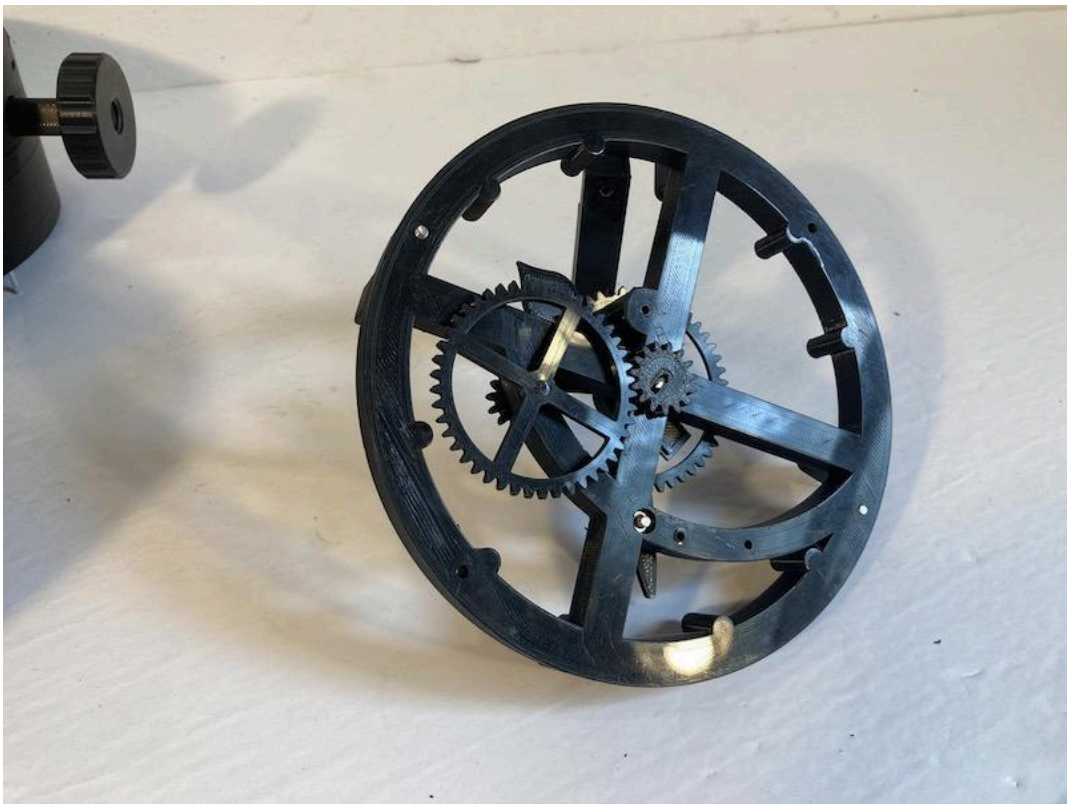

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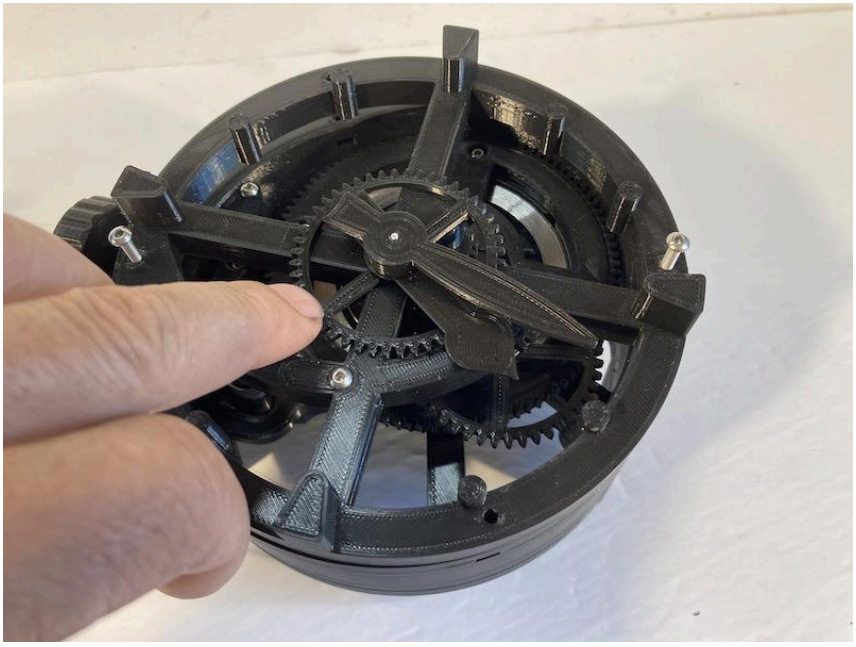
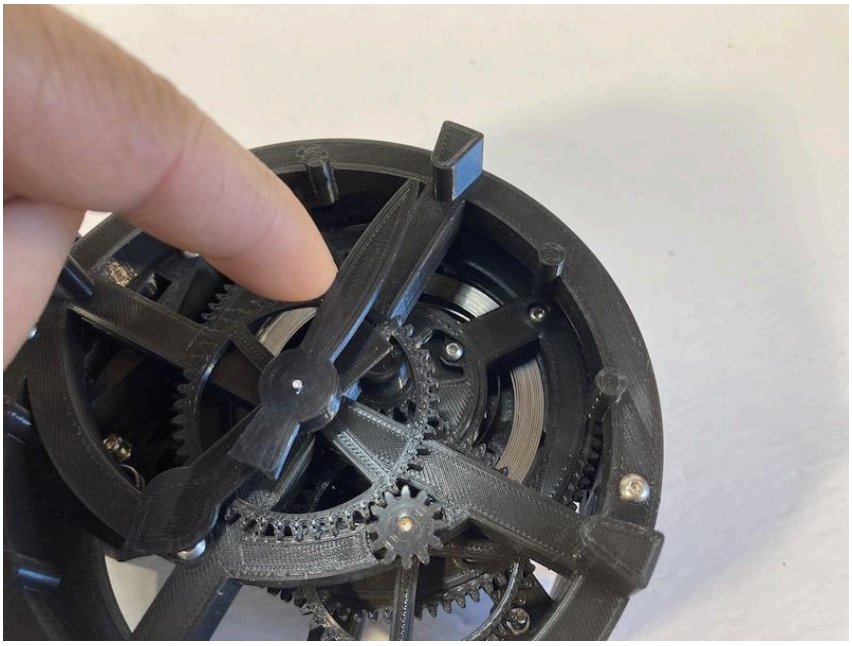
Install Dial Plate

Line up the ratchet pin, then the barrel pin, wiggle the hand gears to engage teeth and install plate in place, tighten screws



Test friction plate by moving the minute hand



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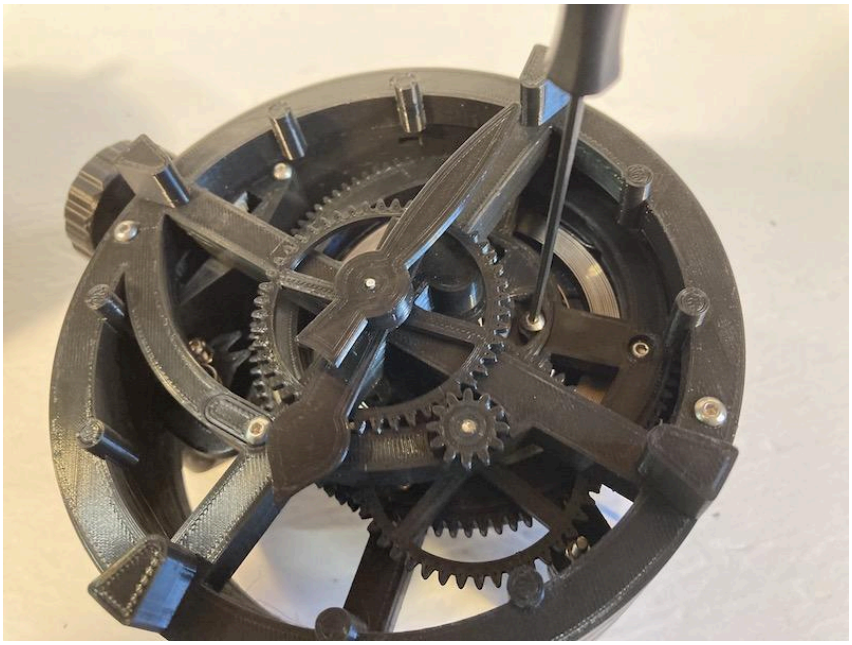
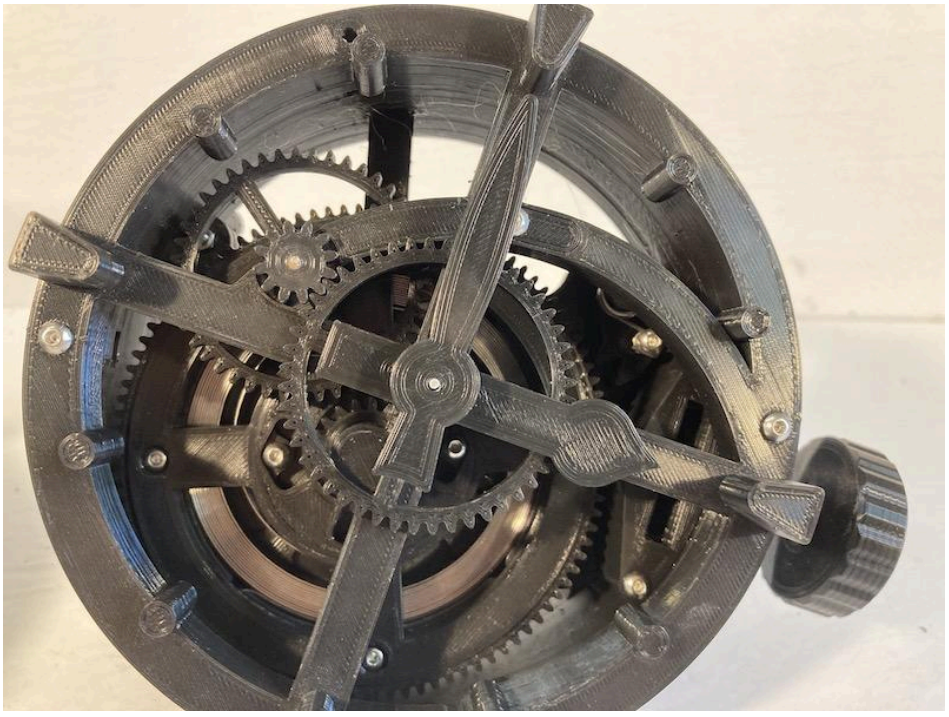
Adjust friction plate screws as needed



Adjust the respective position of hour and minute hand if needed



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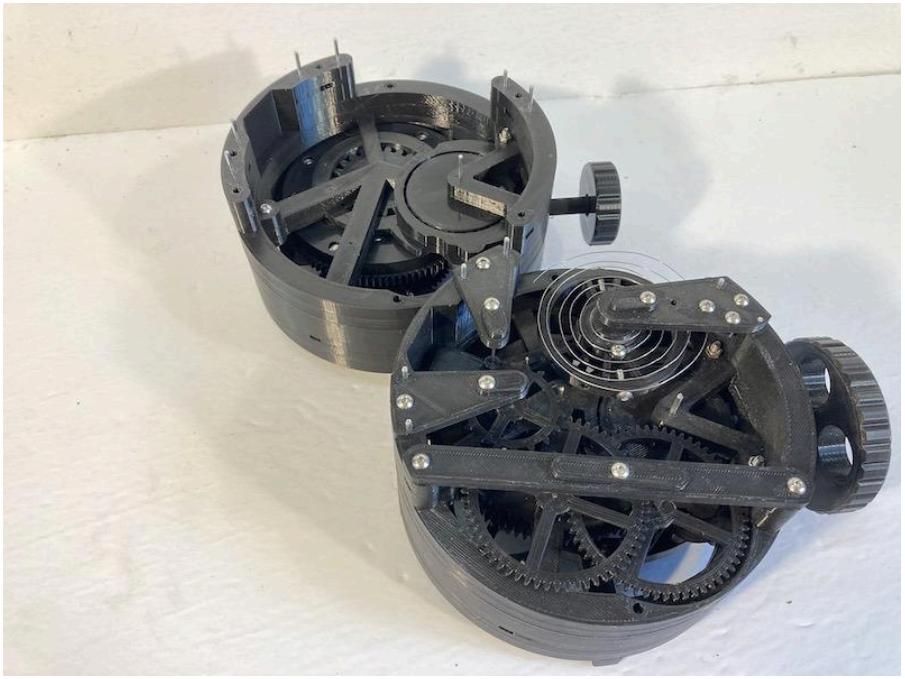
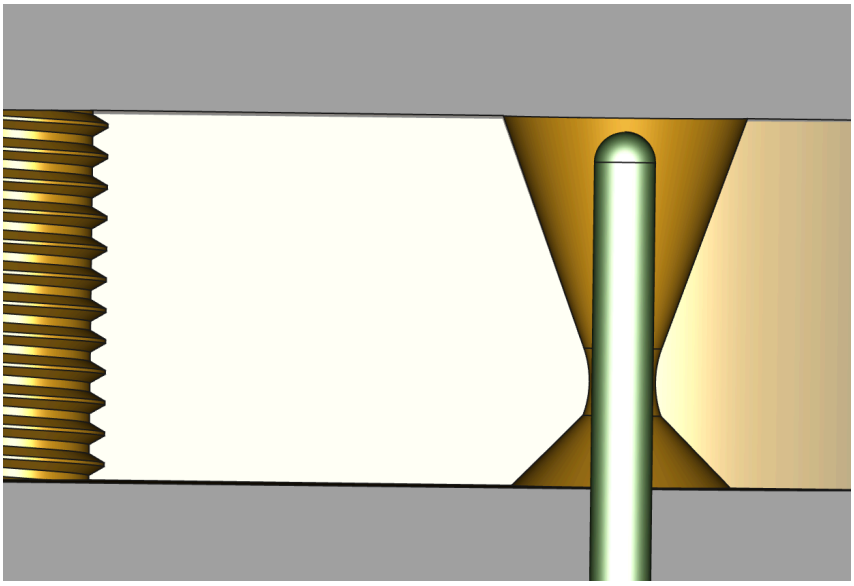
Going train



Arbors

Cut all to length and need to have a nice rounded end, see picture below



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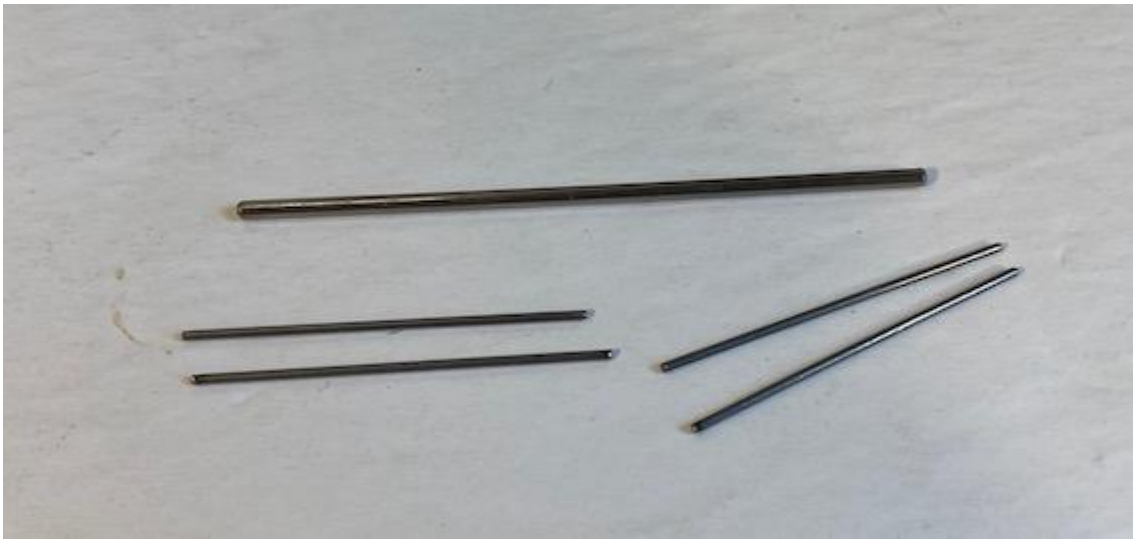
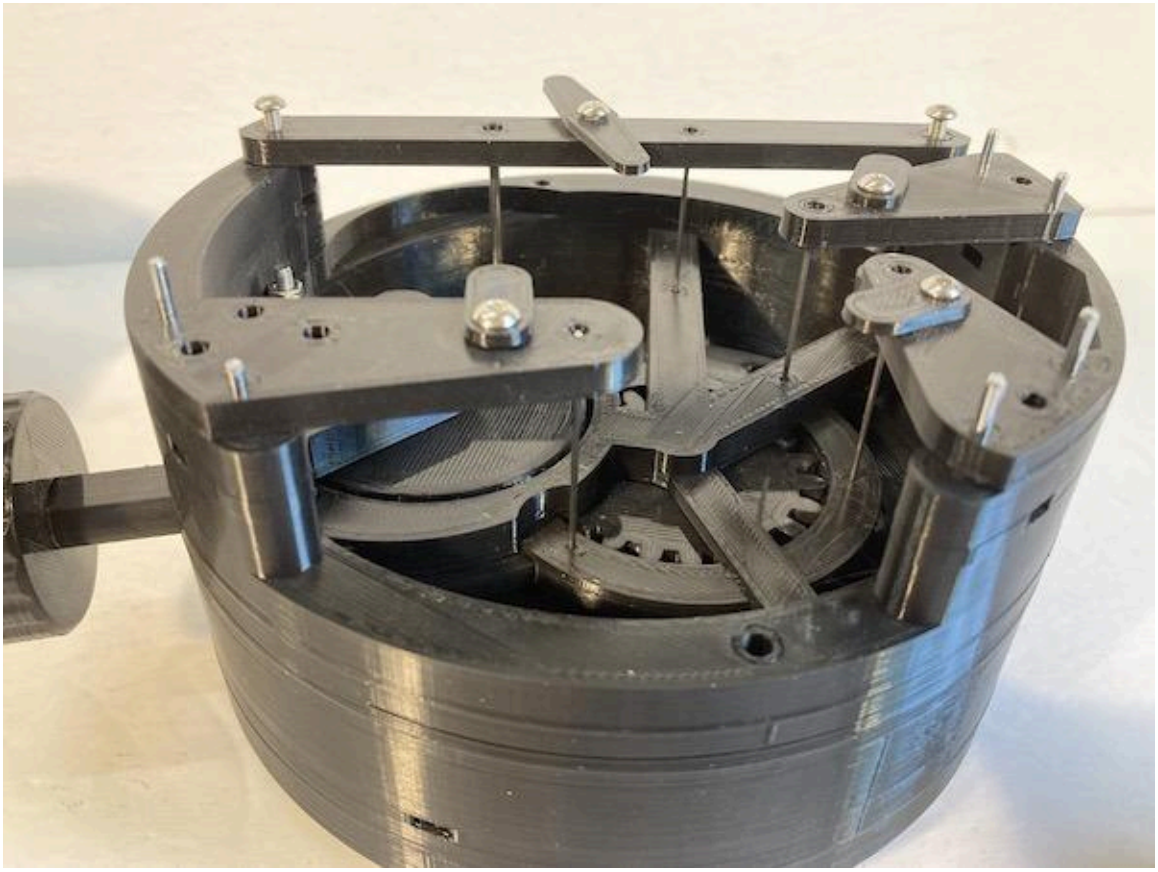
1x 2 mm x 72 mm
2x 1 mm x 38 mm
2x 1 mm x 41 mm



Install and check length and free play



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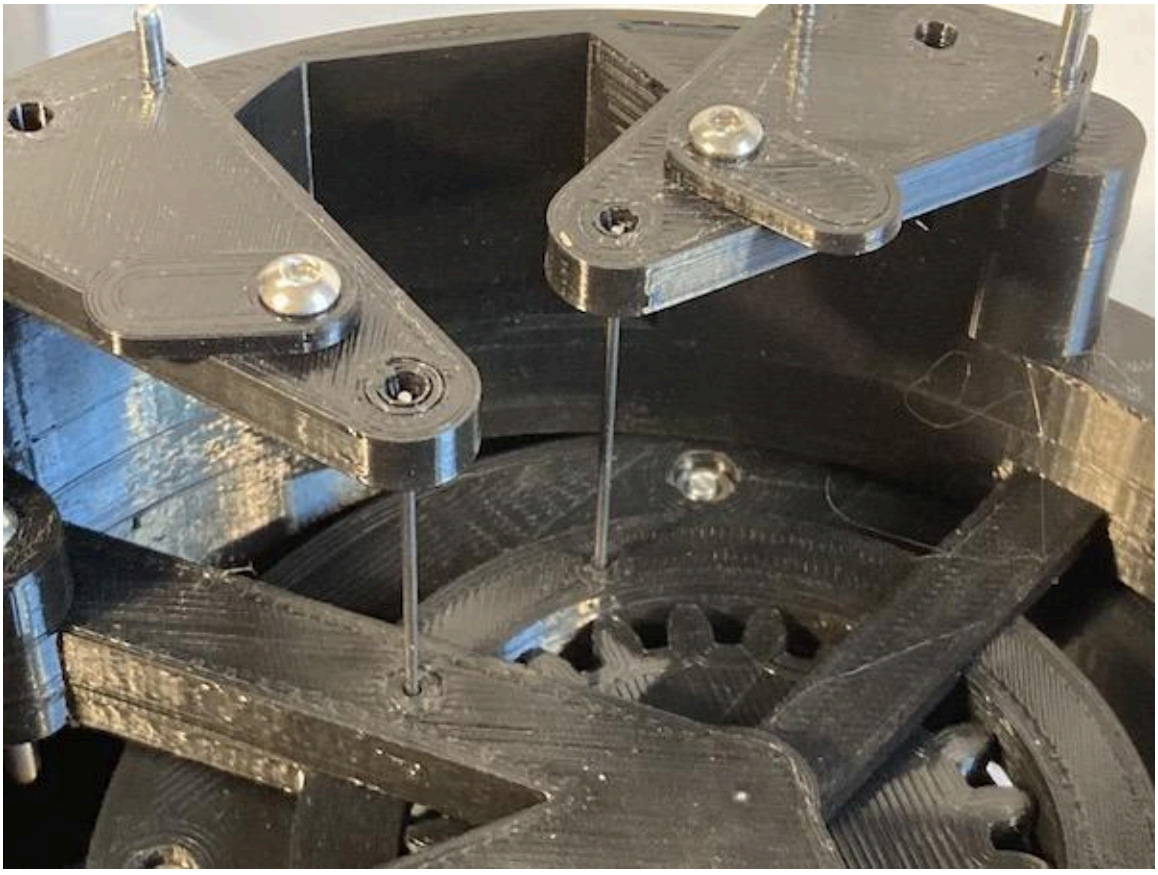
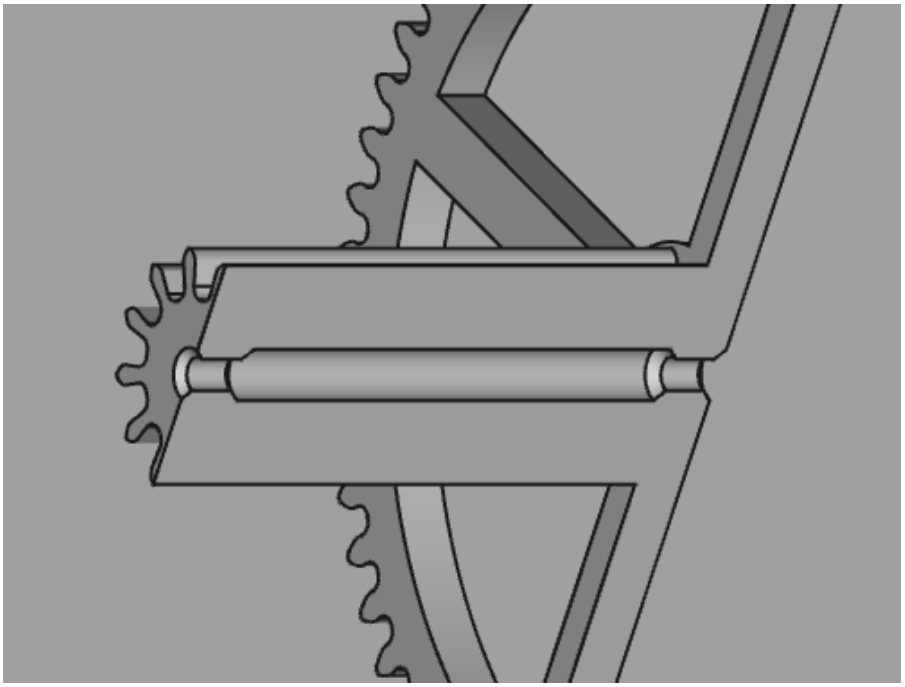
With the plates on, there should about 0.5 mm axial play



To facilitate the insertion of arbors in gears
The center part is hollowed and both ends have a chamfer



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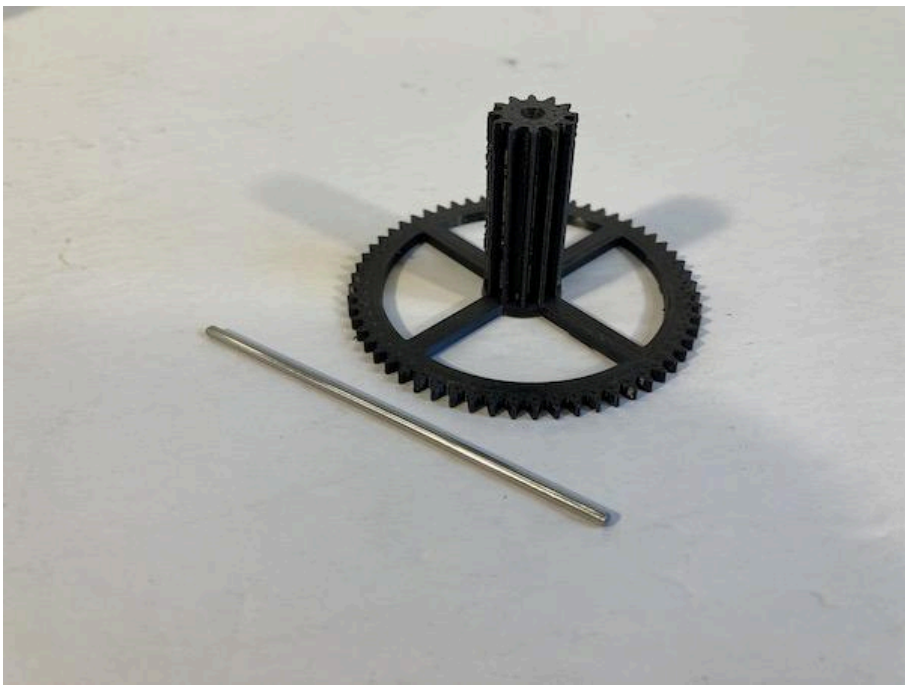
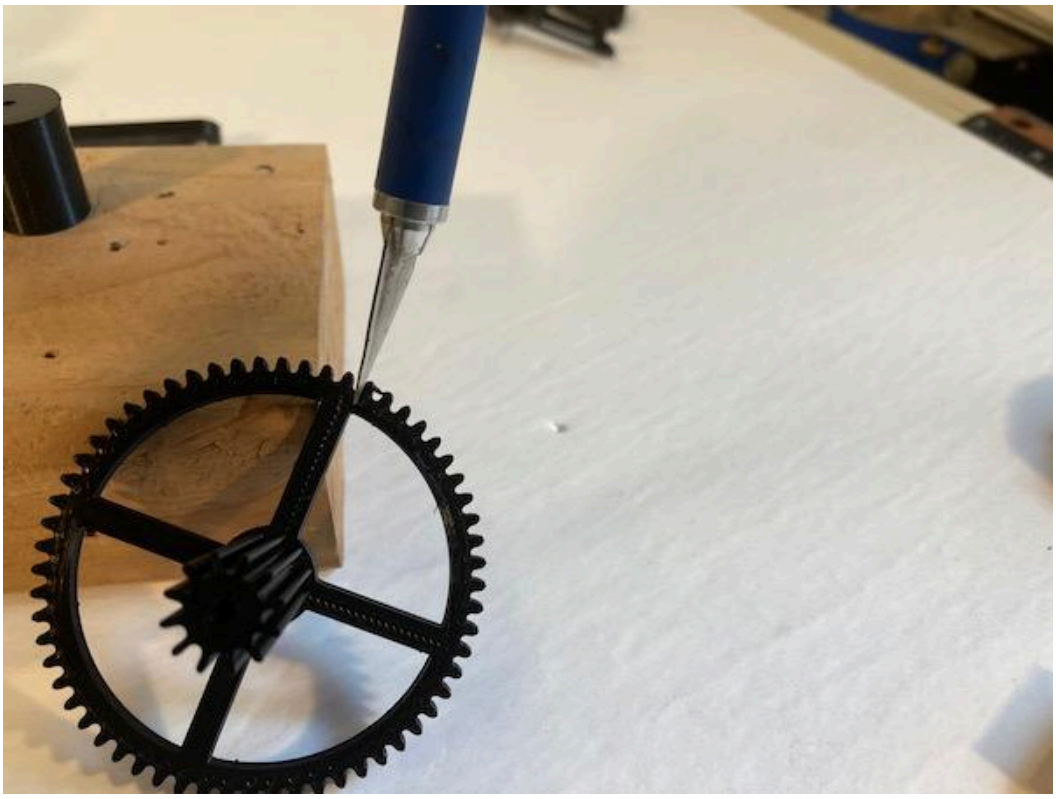
Gear 60-12



Check carefully all gears for unwanted stringing or unwanted residue



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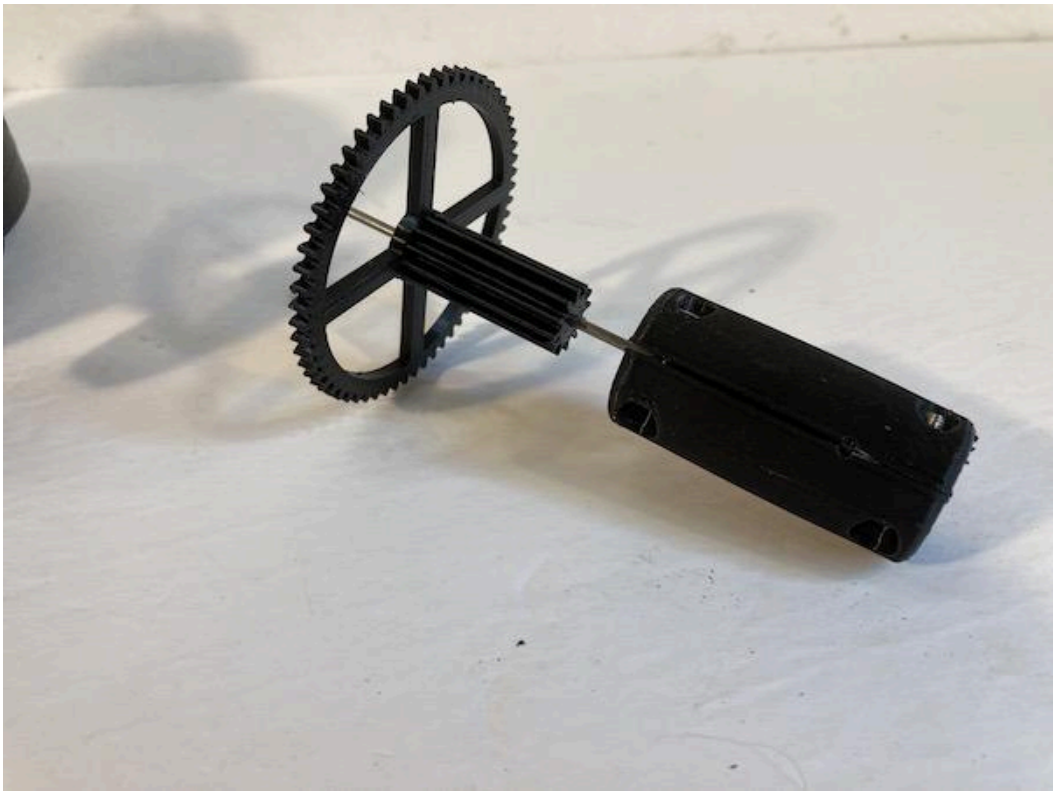
Ream the gear and install the arbor with a tight fit



This is the distance at low end for positioning

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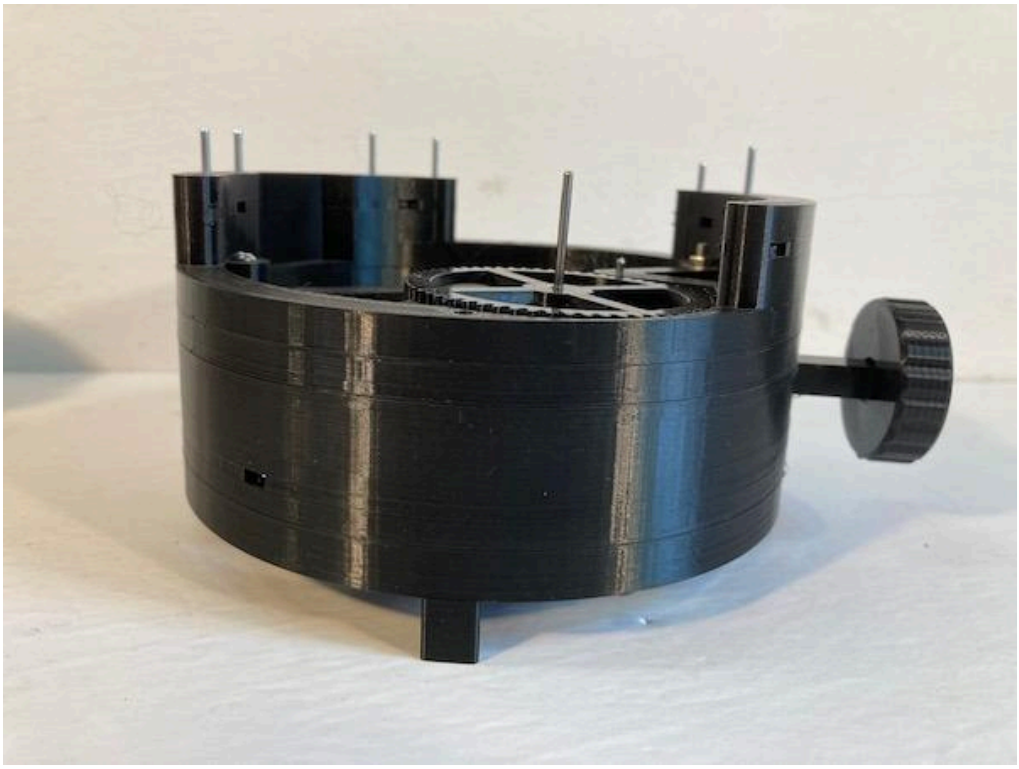
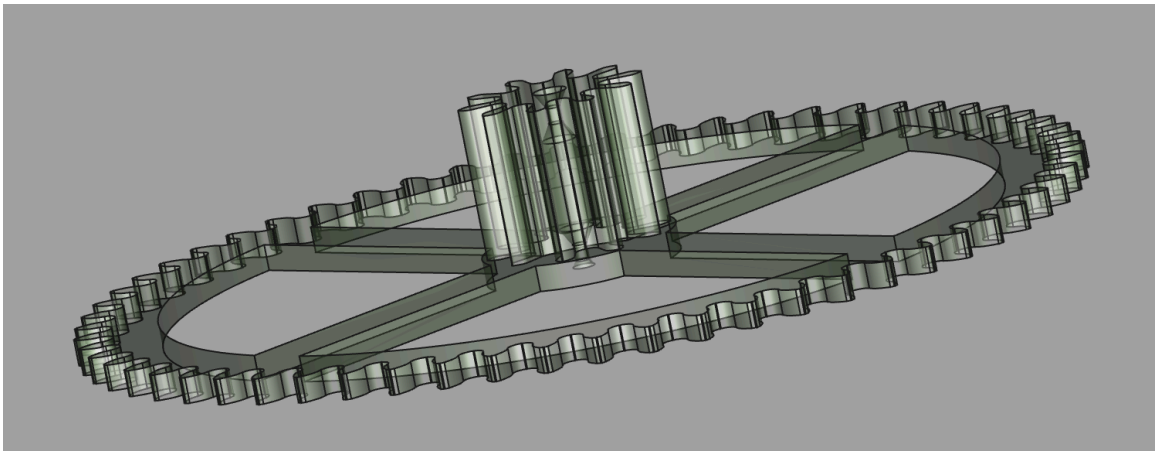
Gear is flush with frame



Gear 60-10

Same principle for gear with a 1 mm tool
Ream the hole for a tight fit



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Press a 38 mm arbor

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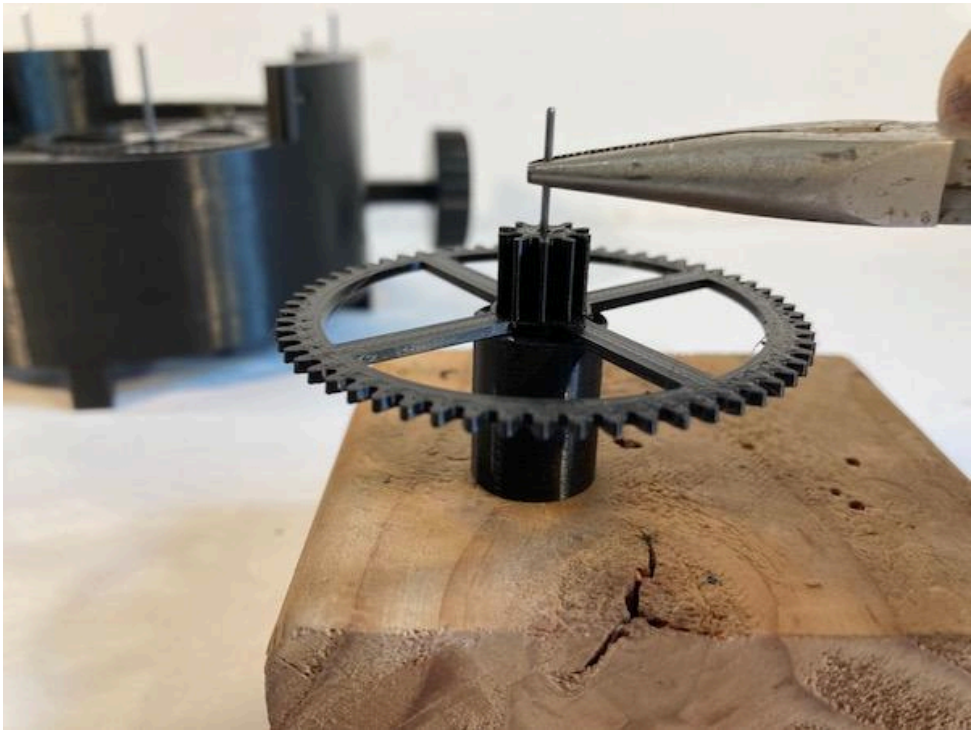
Hand tool is helpful here



Check the end distance

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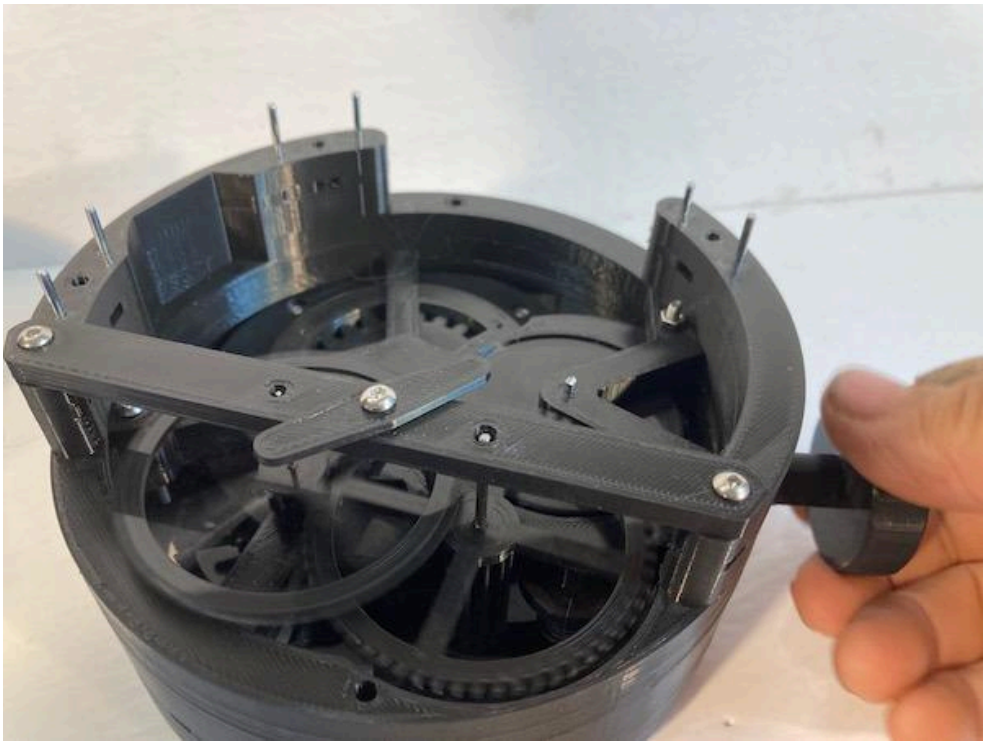
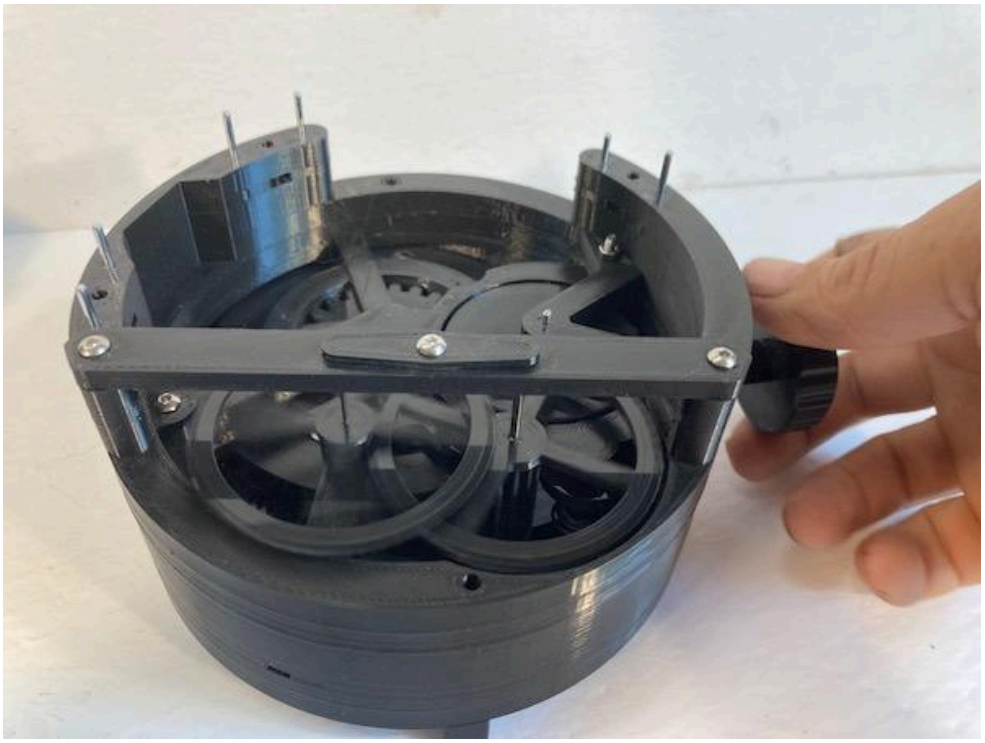
Install the two gears and top bridge, test the gears



Gears should turn free, with no binding



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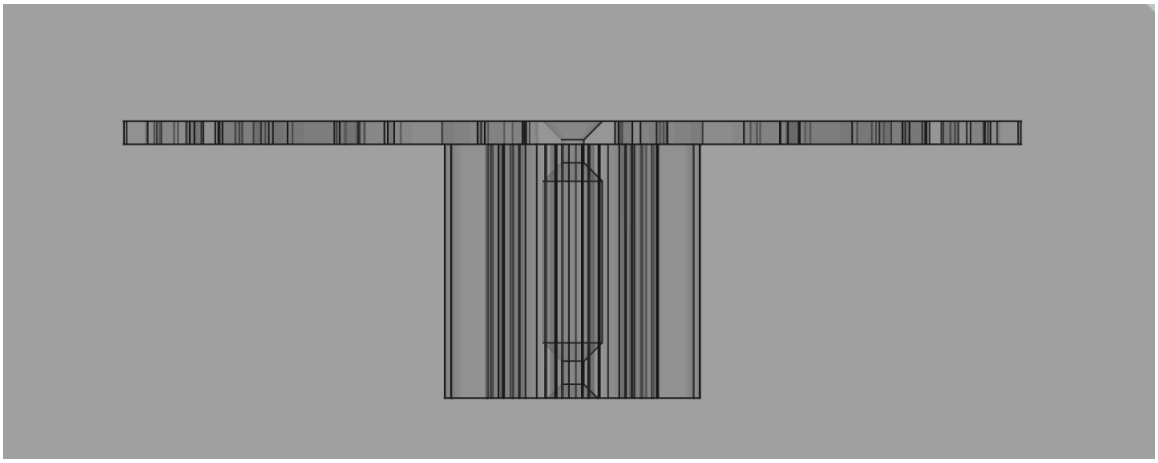
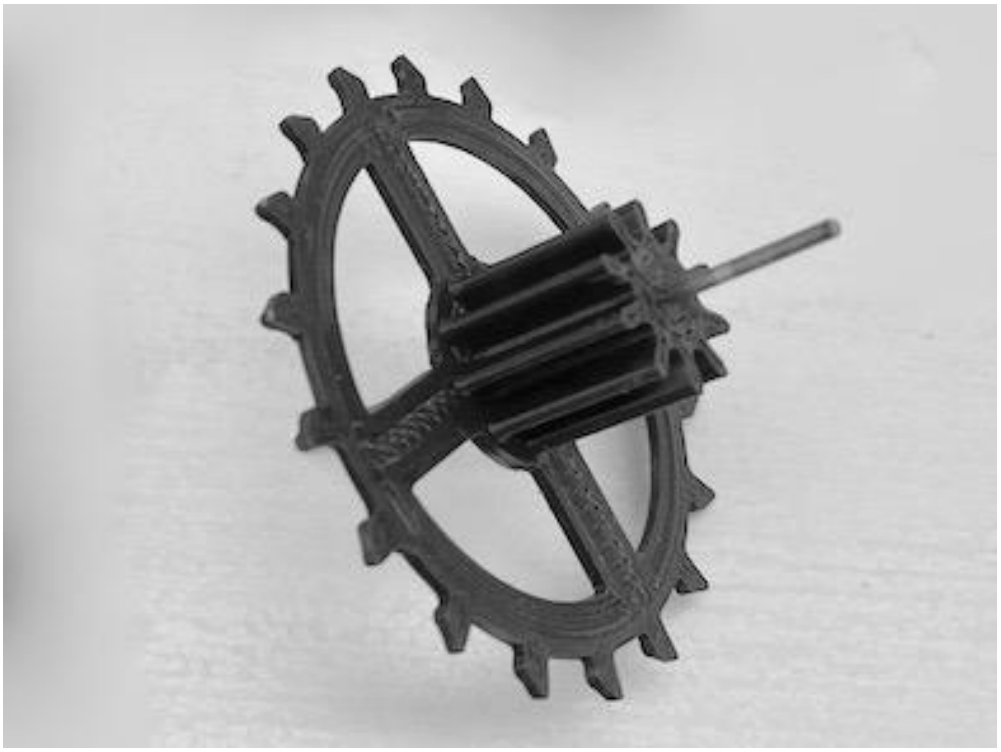
Same principle
Ream a tight 1 mm hole, install a 38 mm arbor





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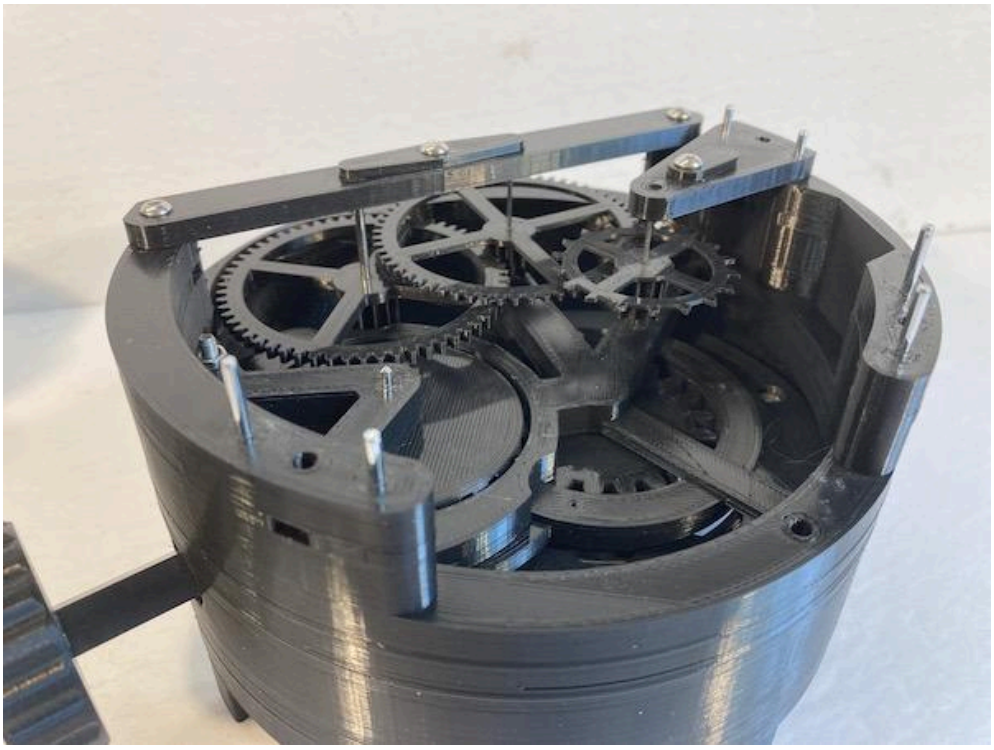
Install and test



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The bridge should hold in place without the screw

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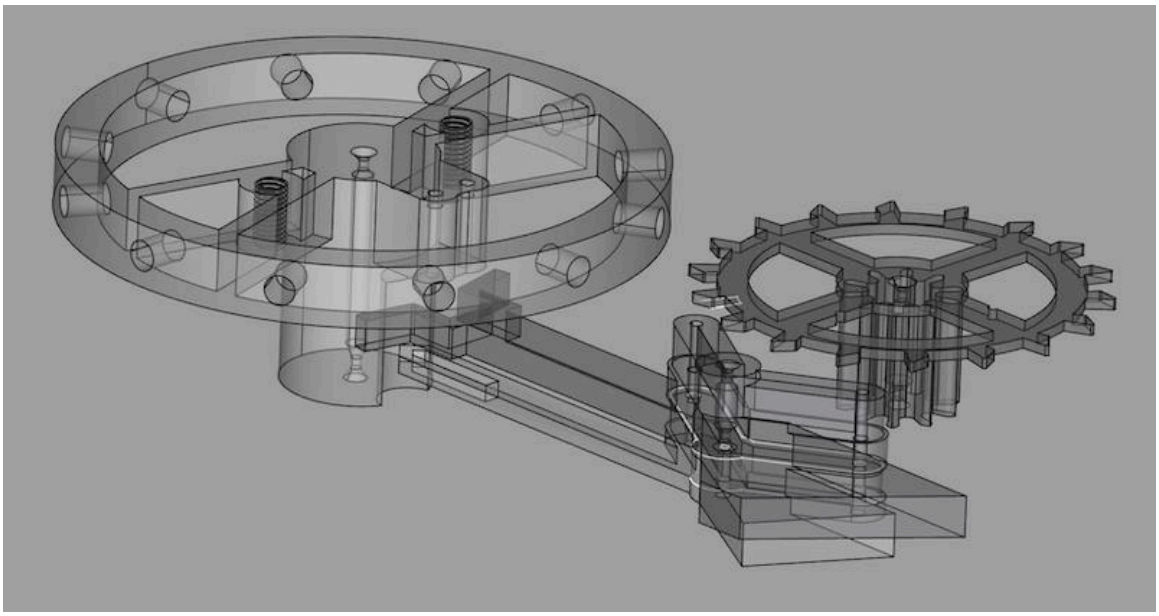
Escapement



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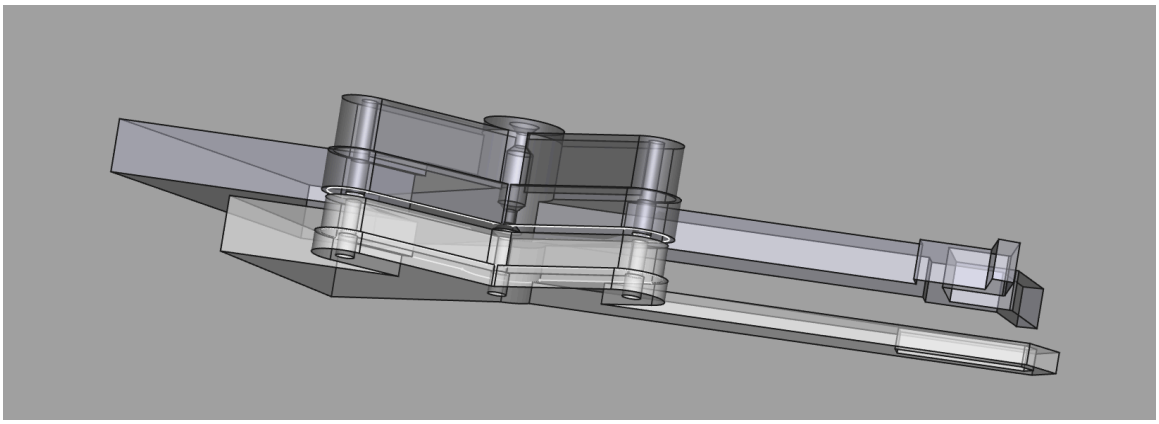
Anchor
Anchor dart
Arbor 1 mm x 41 mm
2 pins 1 x 19 mm
Anchor tool

Side view from CAD



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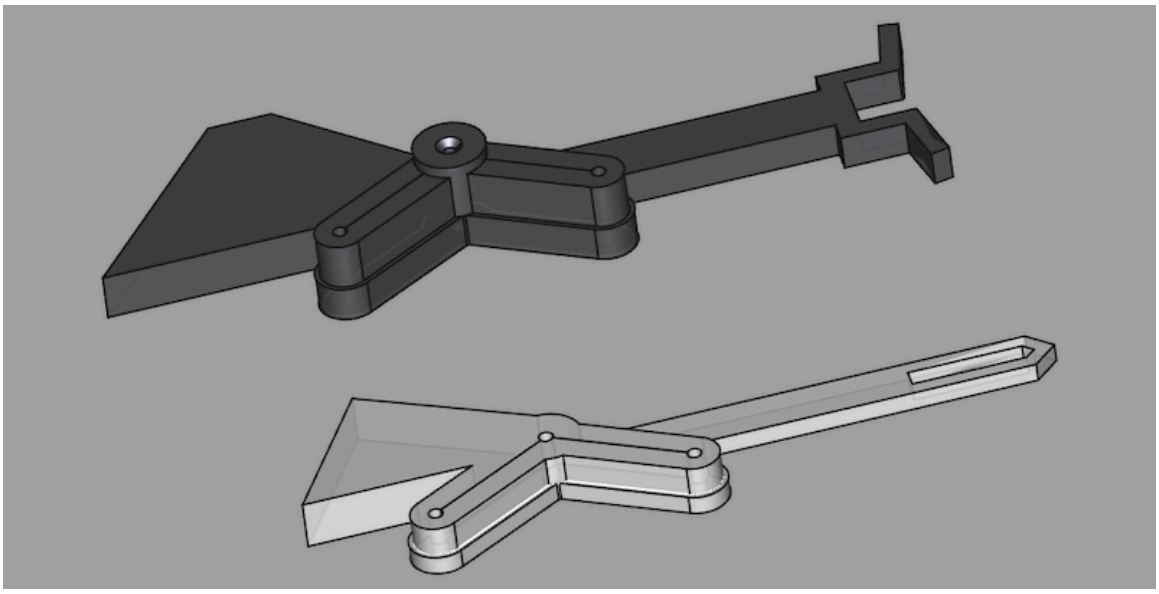
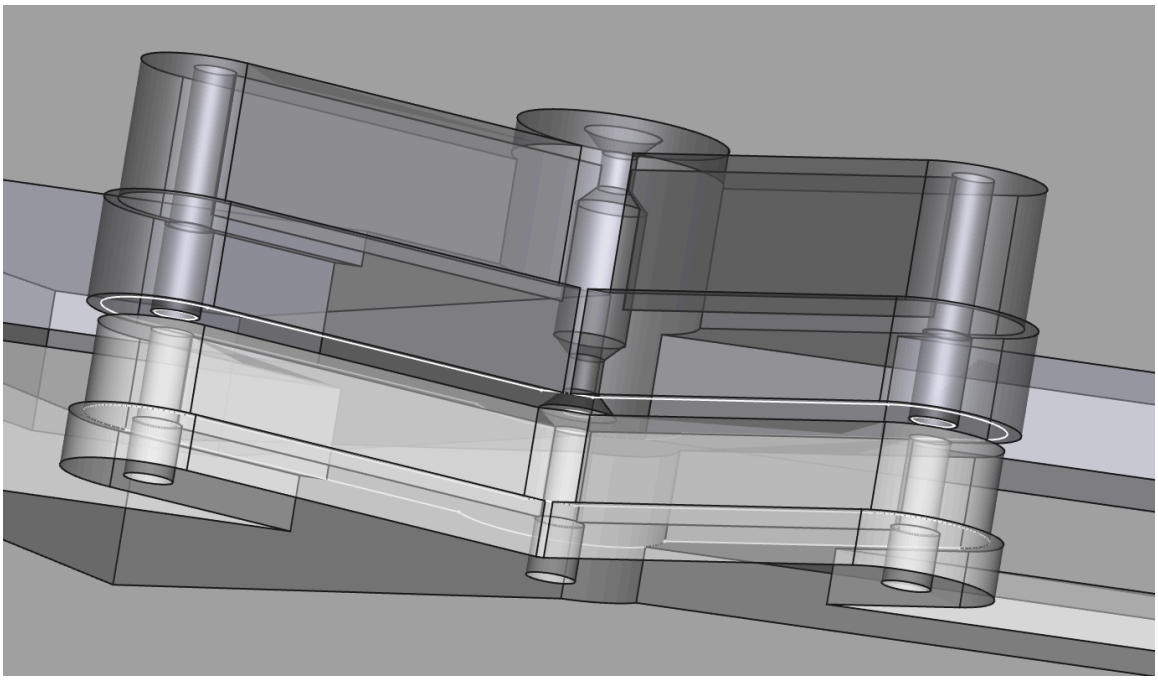


Focus on holes
Notice that the holes are bigger on the bottom side to help guide the pins in place



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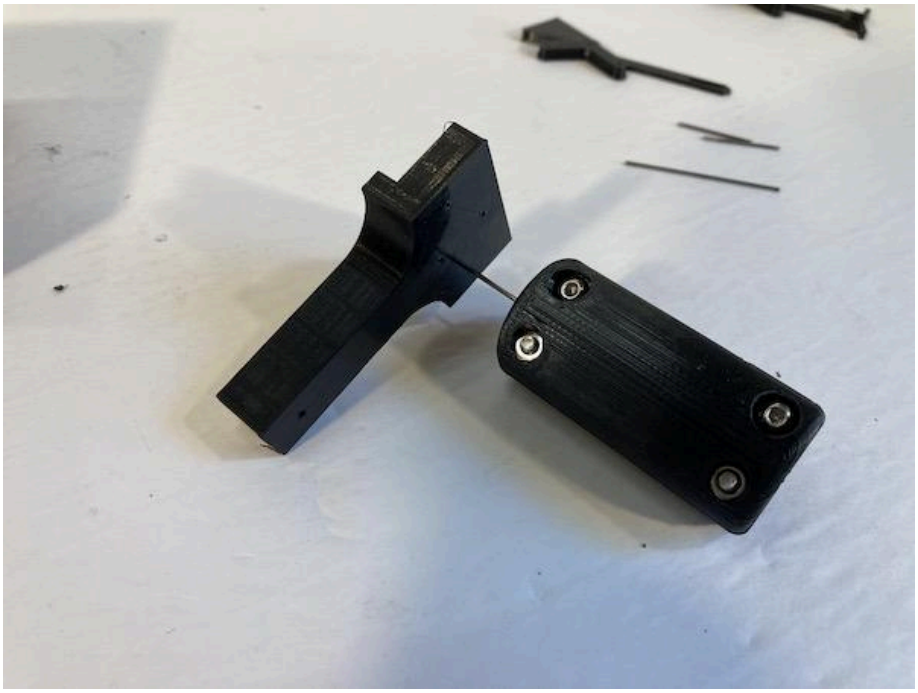
Starting with the tool, get the 1 mm holes
Work until you get a very light fit



Install pins in the tool and measure the distance between them
There should be even distance right and left, and back to front
Exact dim should be 13.62
What is important is they are all even

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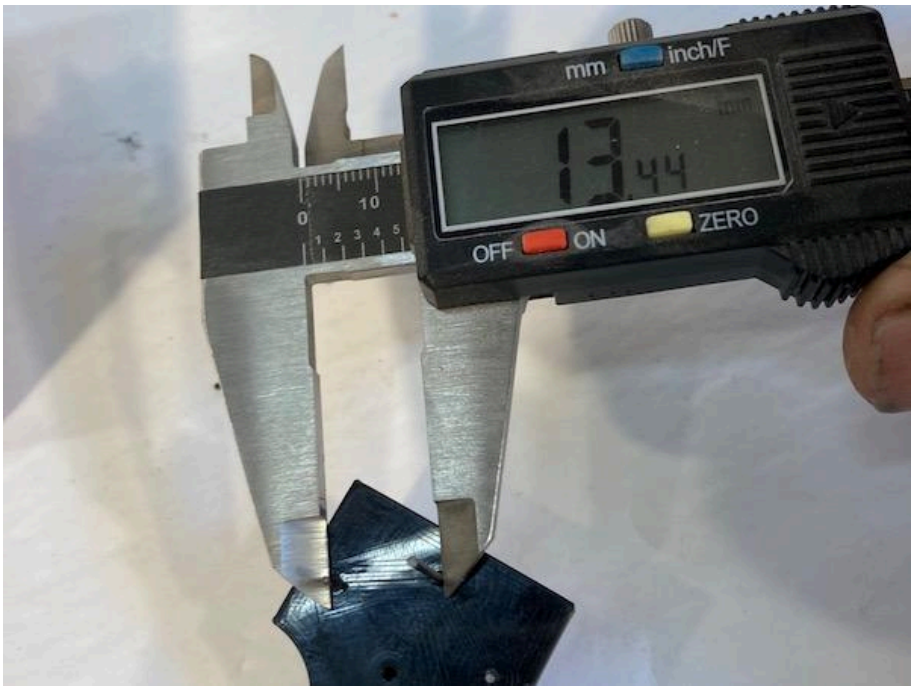

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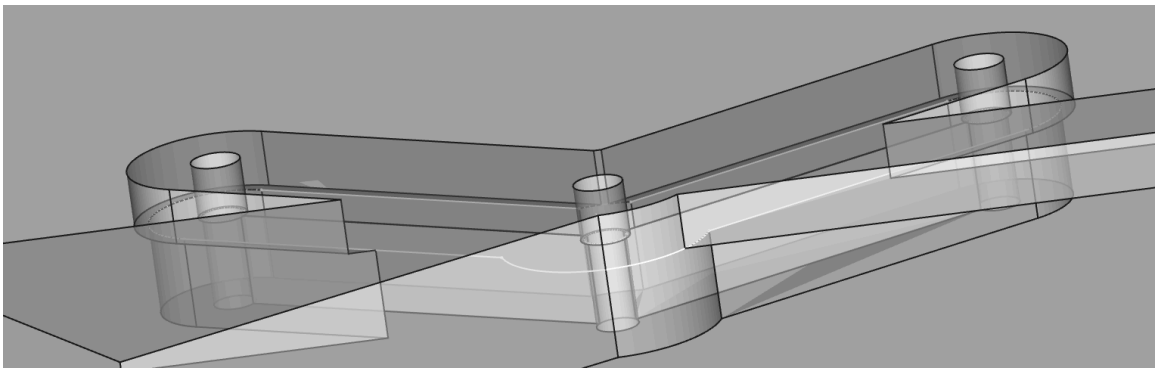
Ream the hole, starting from the back side
Holes are slightly bigger on back side



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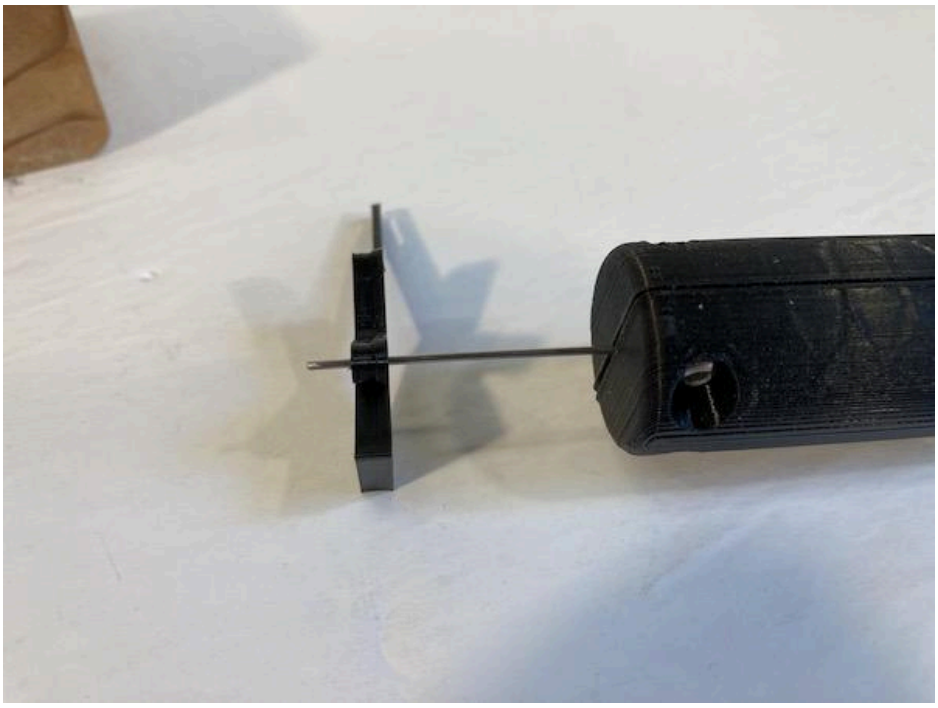
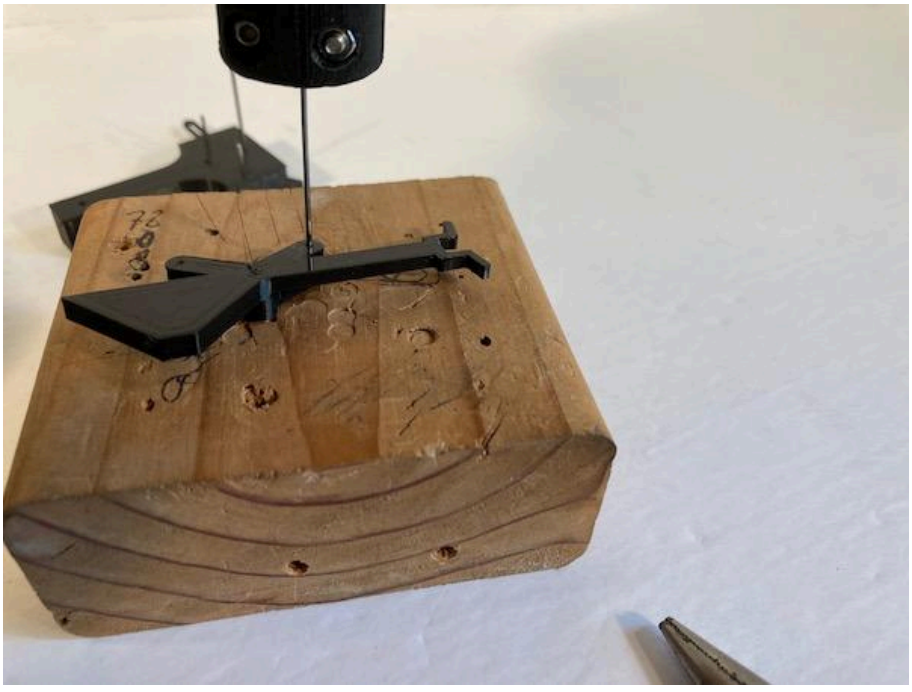


Start the holes for the pins but do not go all the way thru



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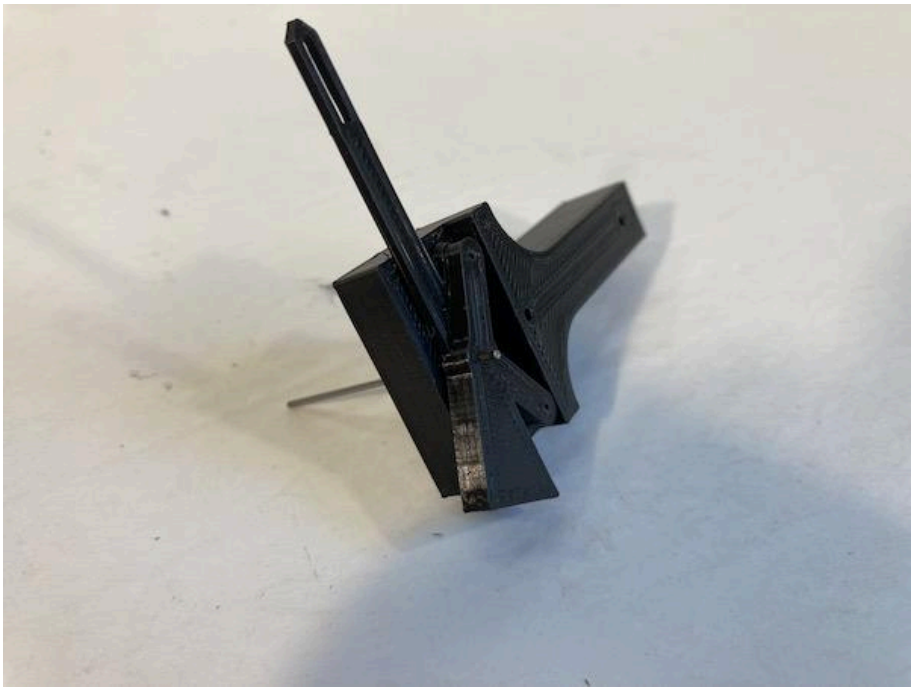
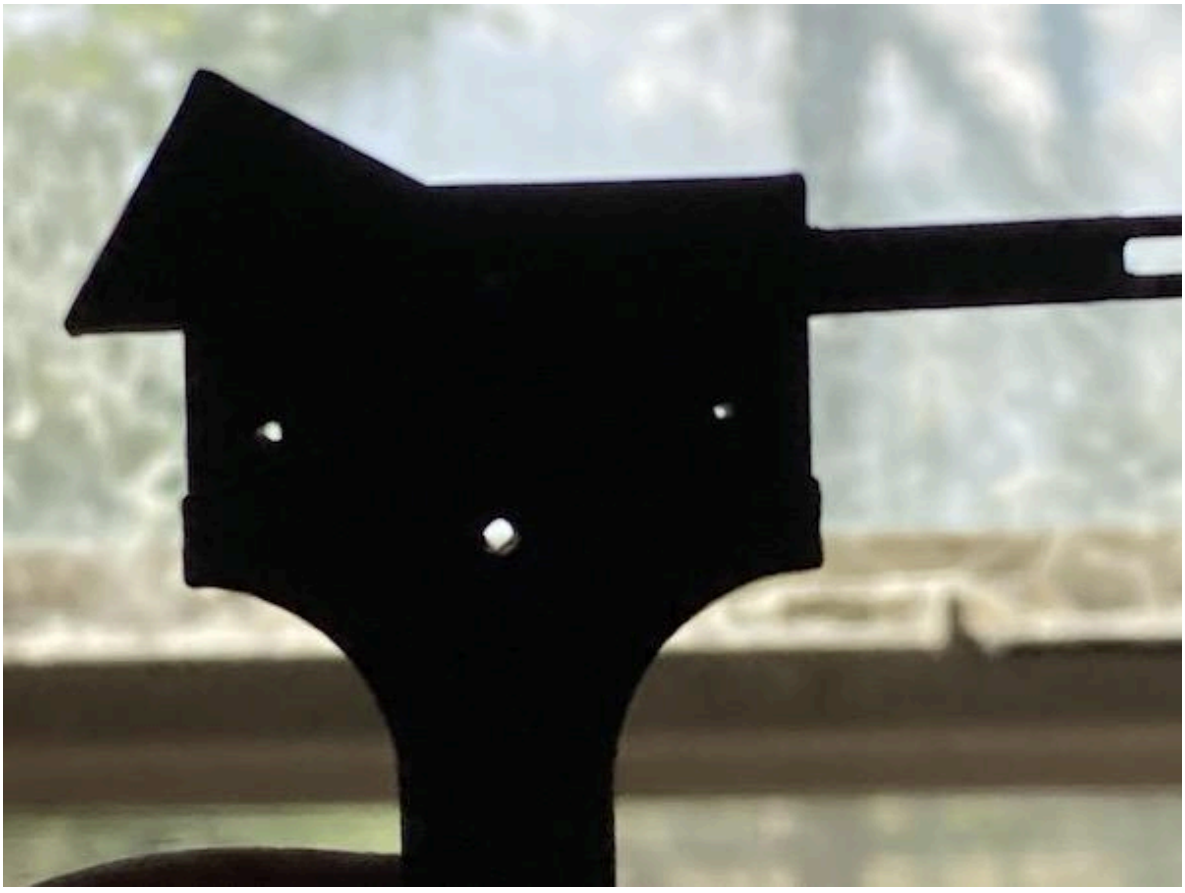
Install as shown below with the 38 mm arbor



Check that all holes line up well



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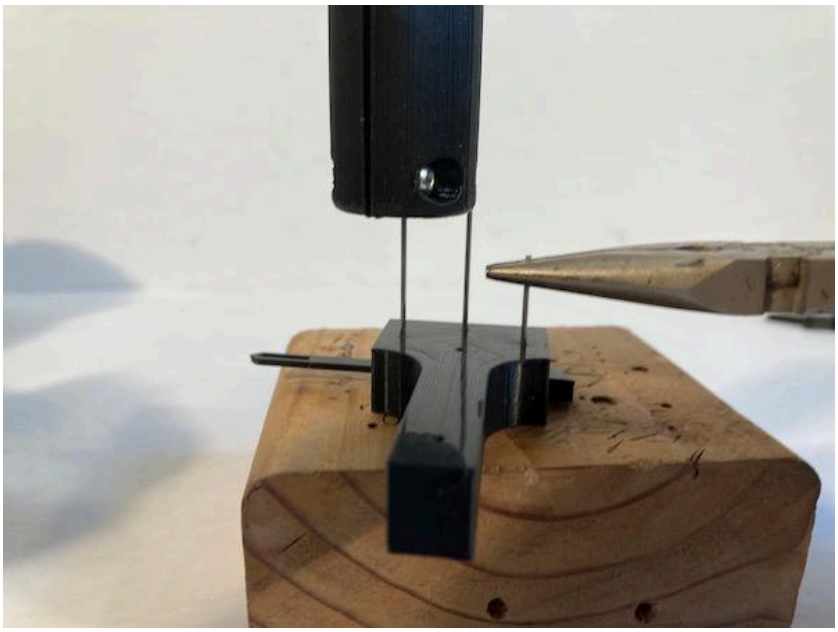
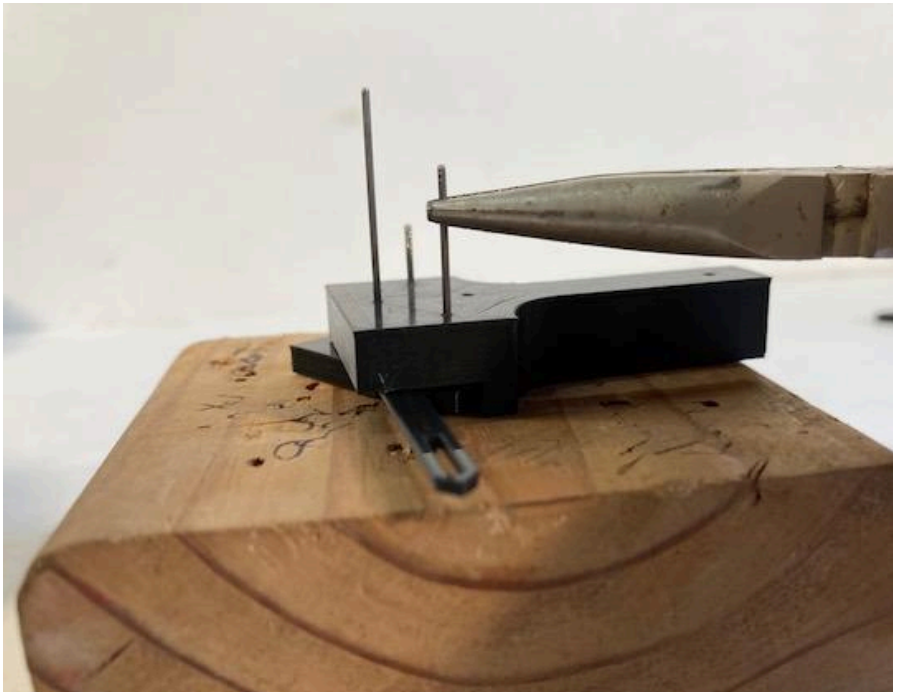
Press pins in
I used the 1 mm tool to make sure the anchor is in place



Install second pin



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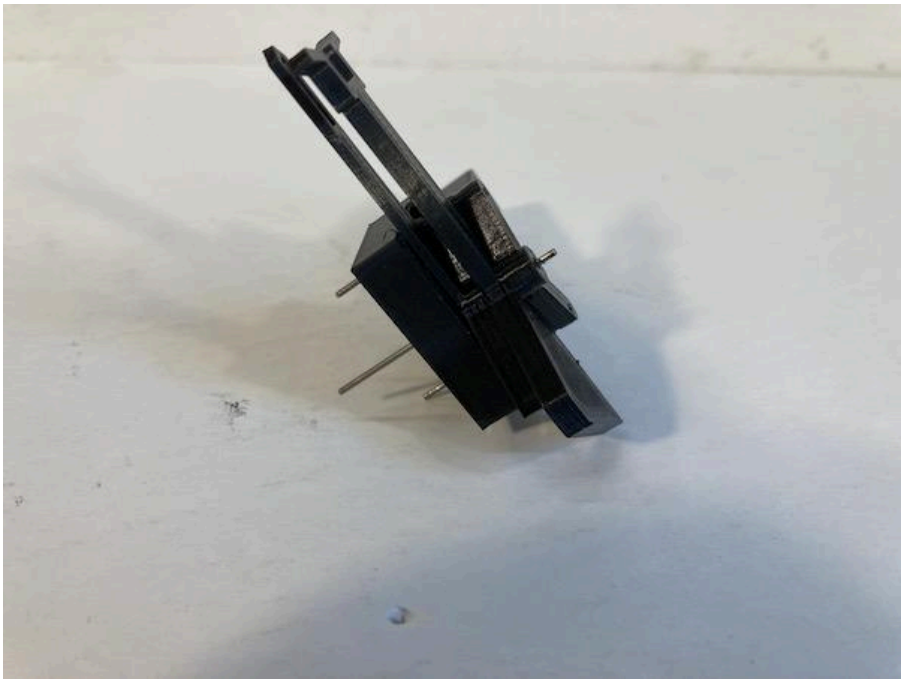
Install the anchor against the dart on the anchor arbor



Line up both anchor parts

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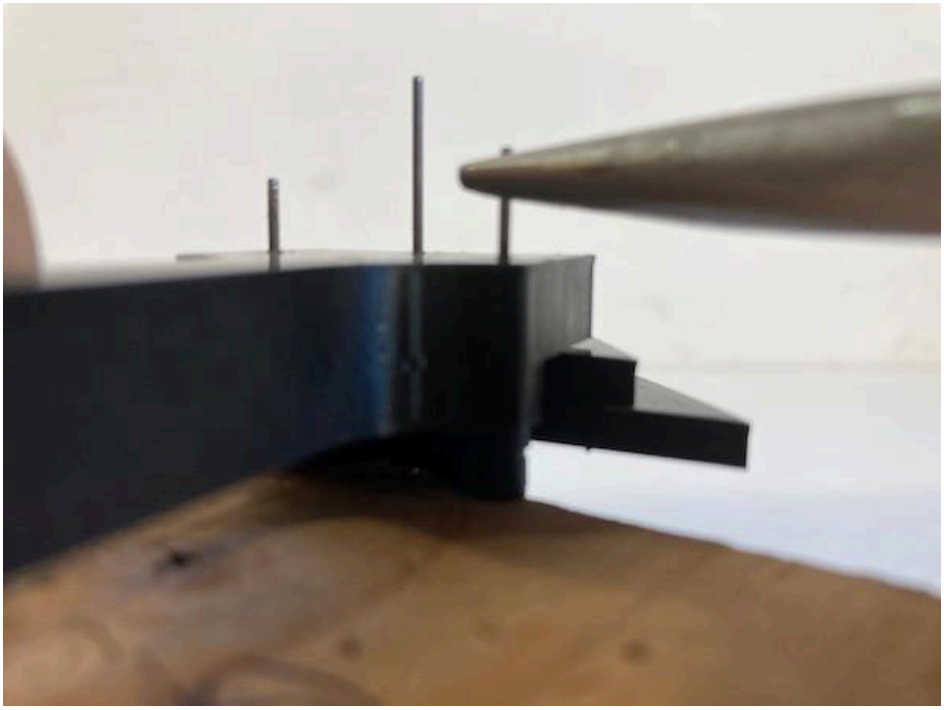
And press the pins

Engage both pins



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And hammer thru

Till they came out

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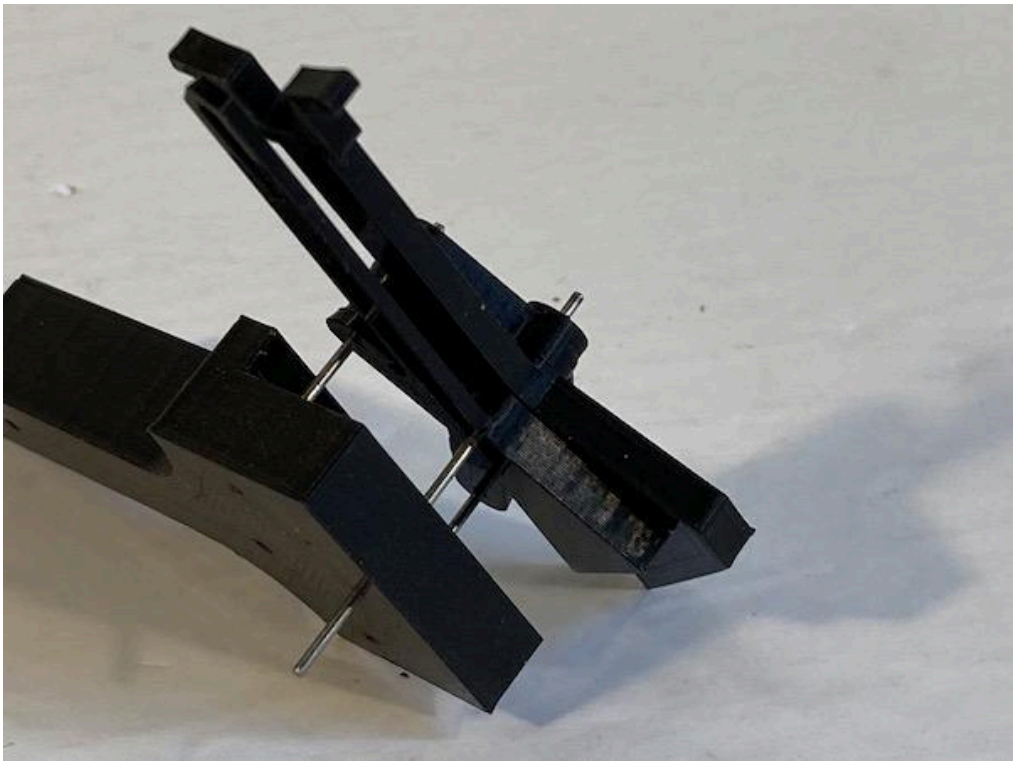
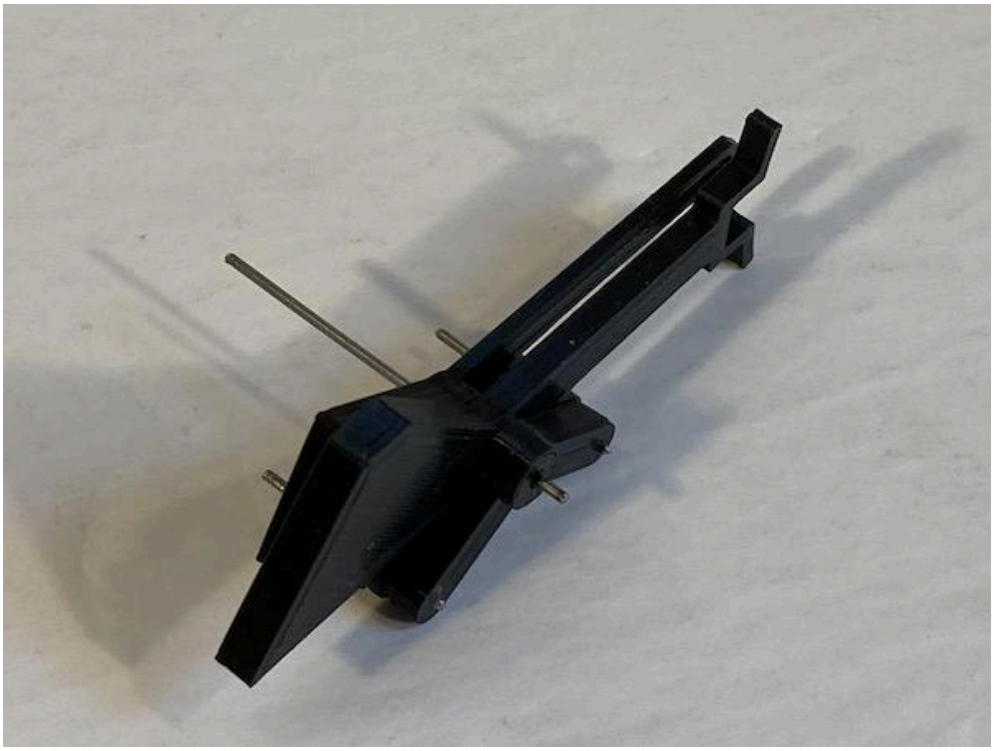
Remove from tool



Pins will need to be pushed in more



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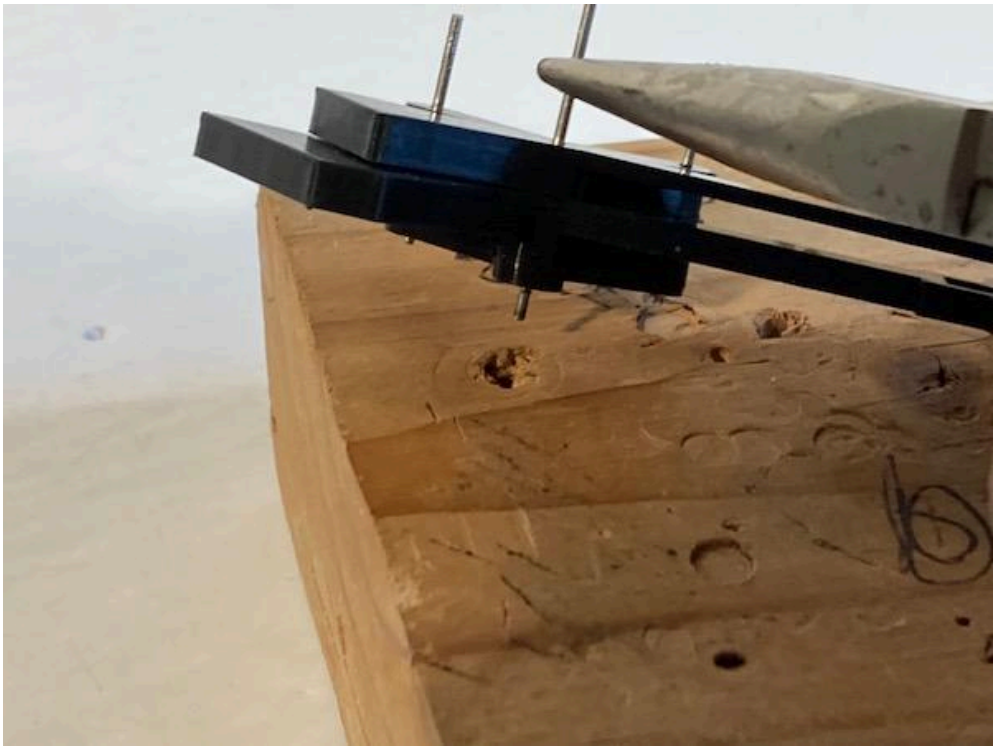
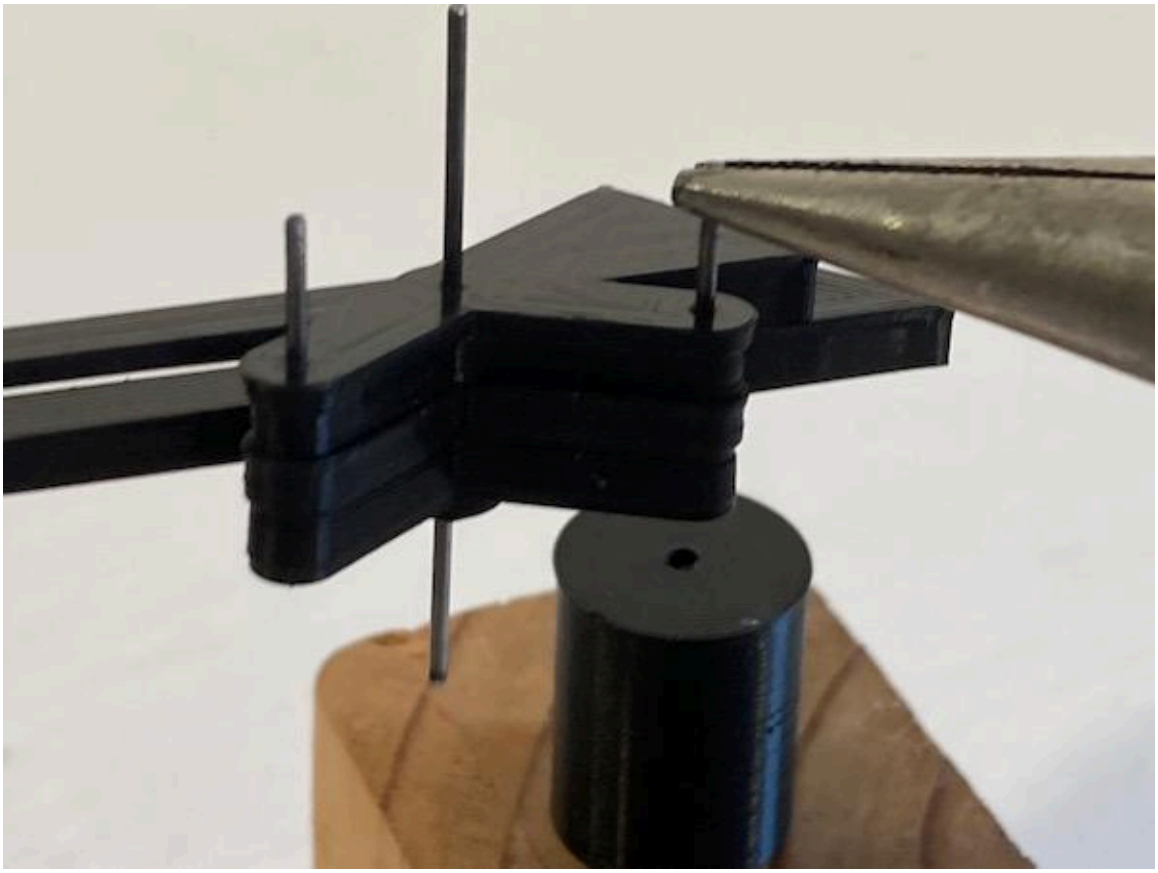


The hand tool will work well here



Push pin all the way in

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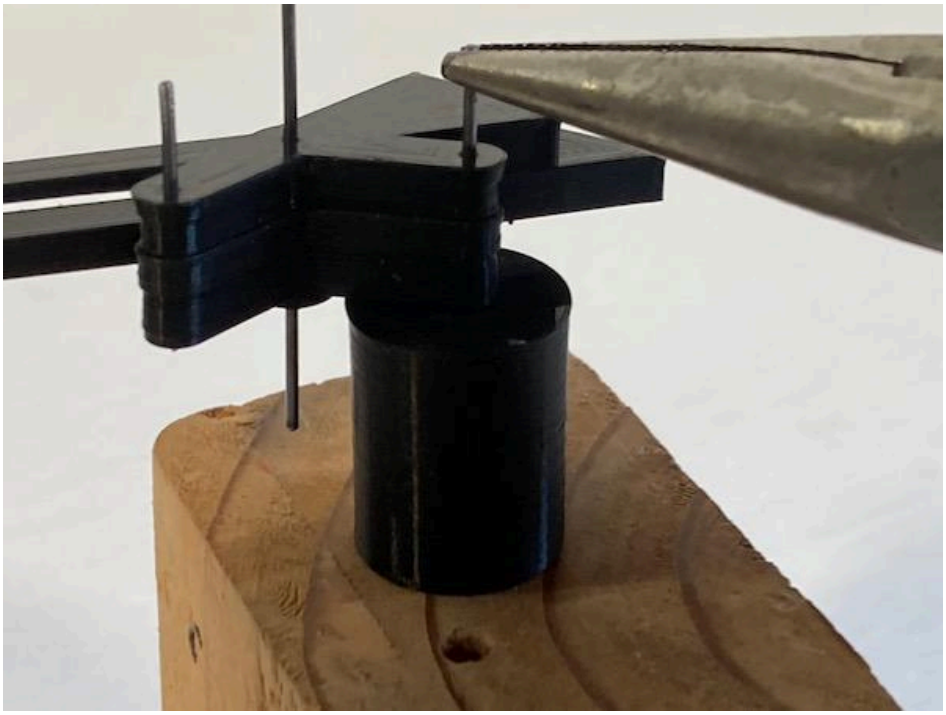

Check that distance match earlier measurement

Close enough

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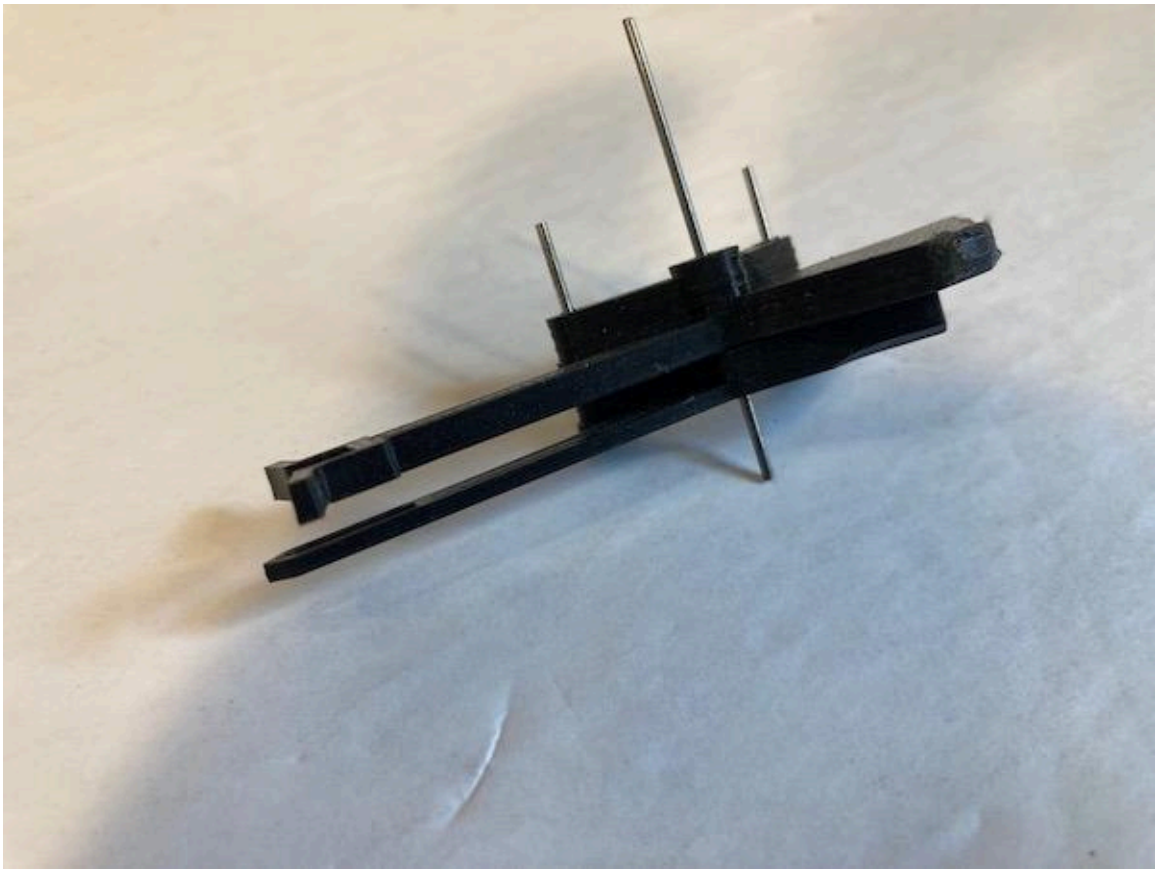
Finished anchor assembly



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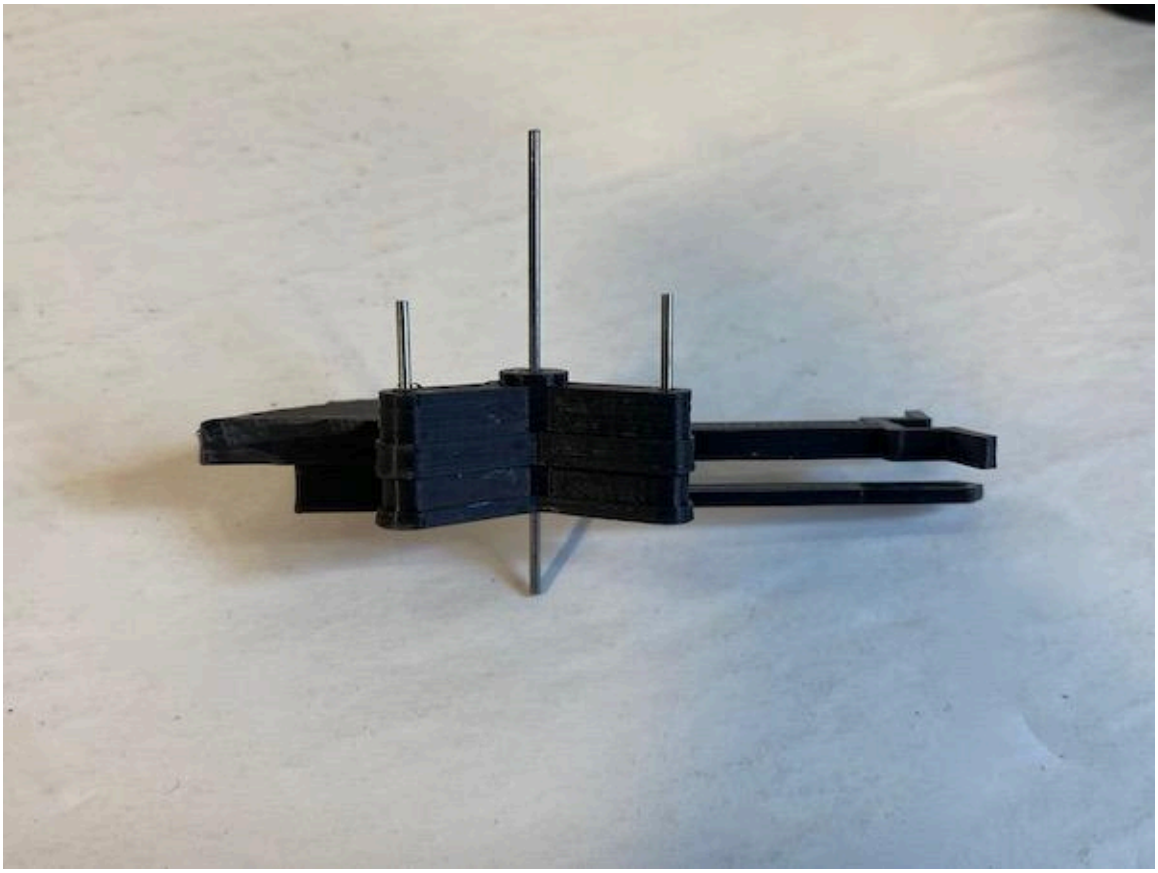
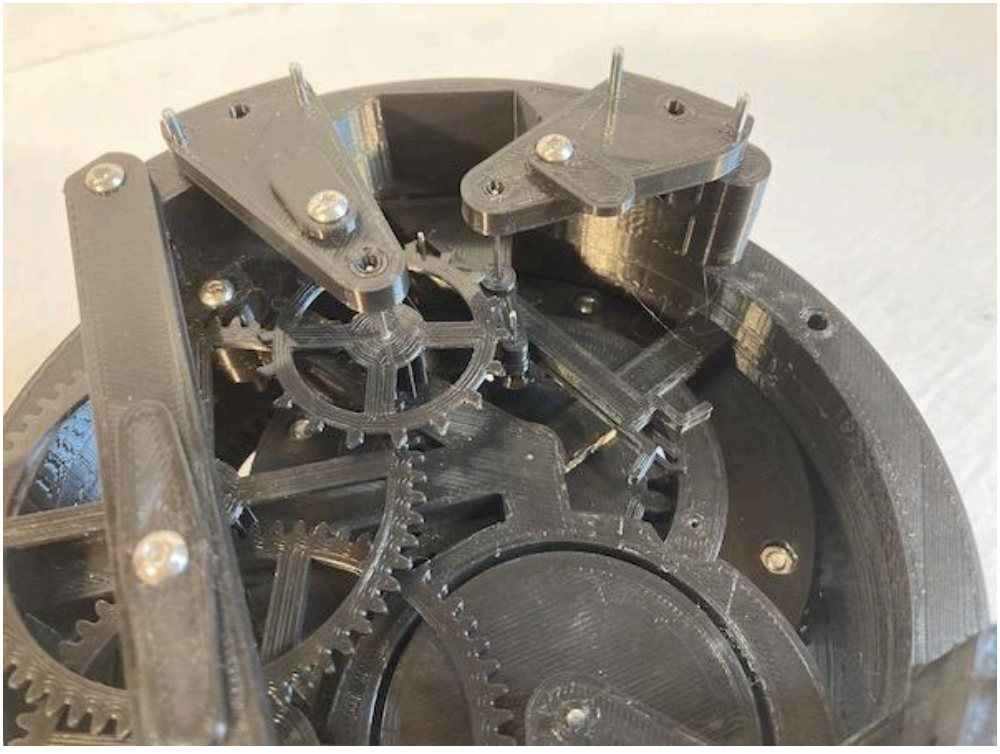


Install and test the anchor



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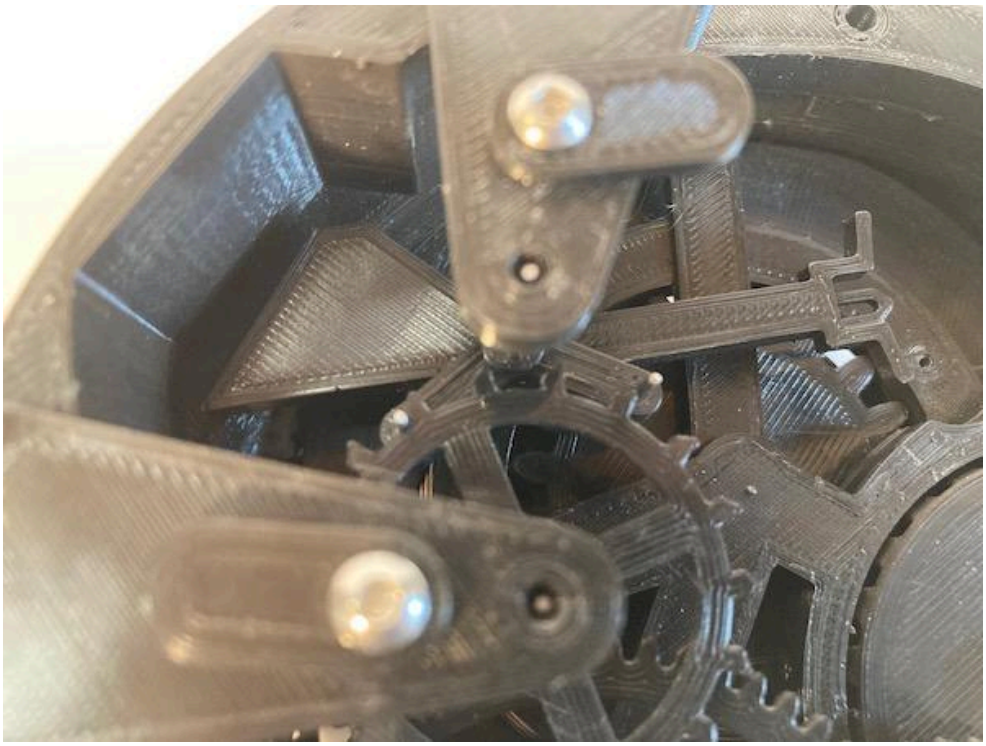
Move anchor and test entry and exit pin

Entry



Exit

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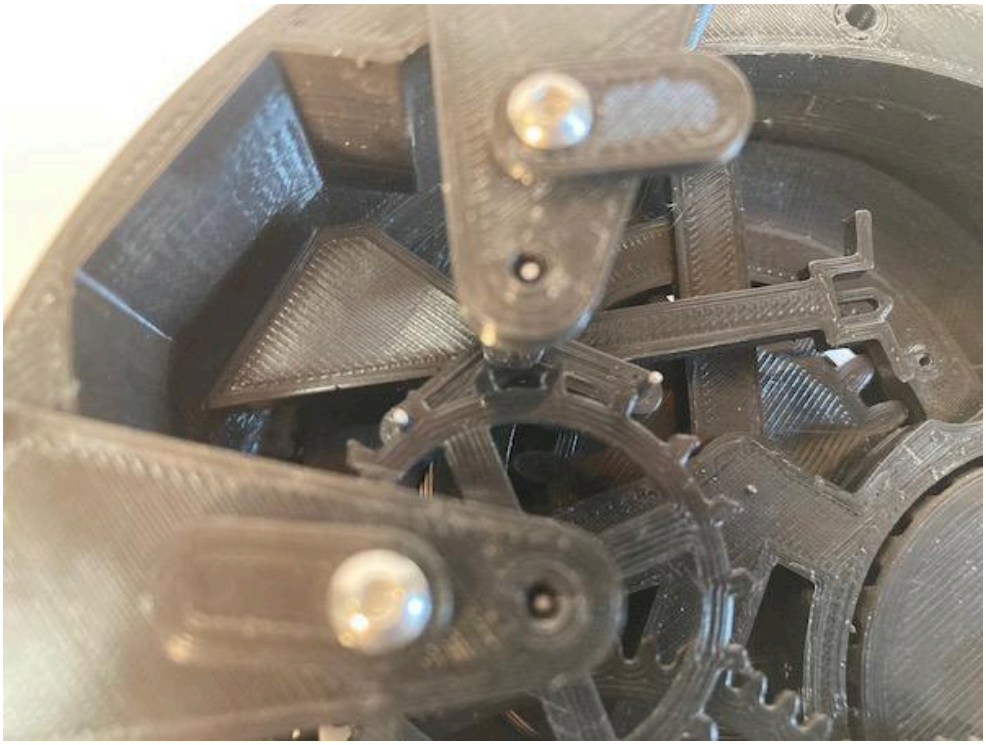
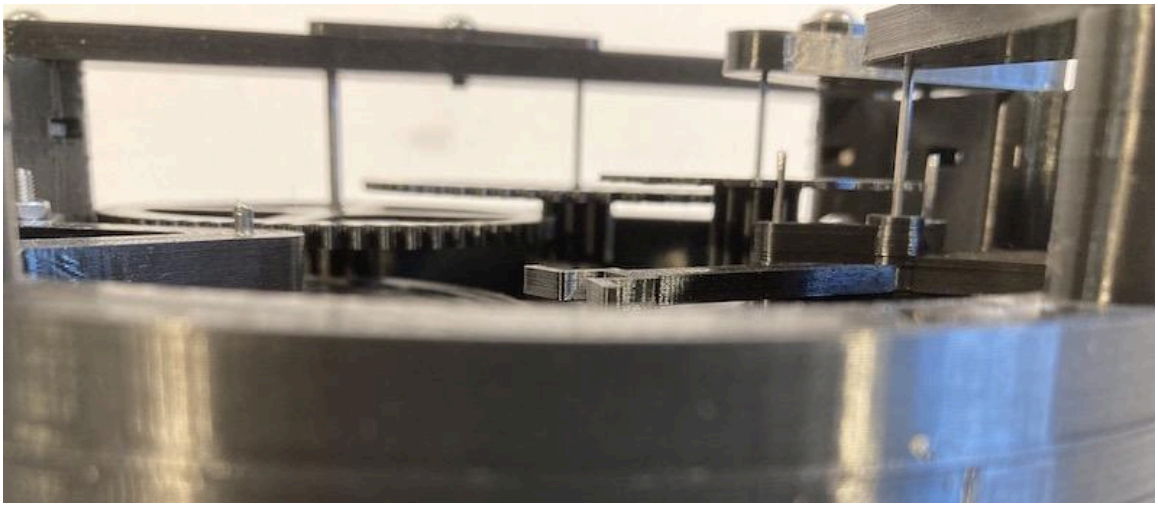
Entry



Check all clearances, gear, escape wheel, anchor



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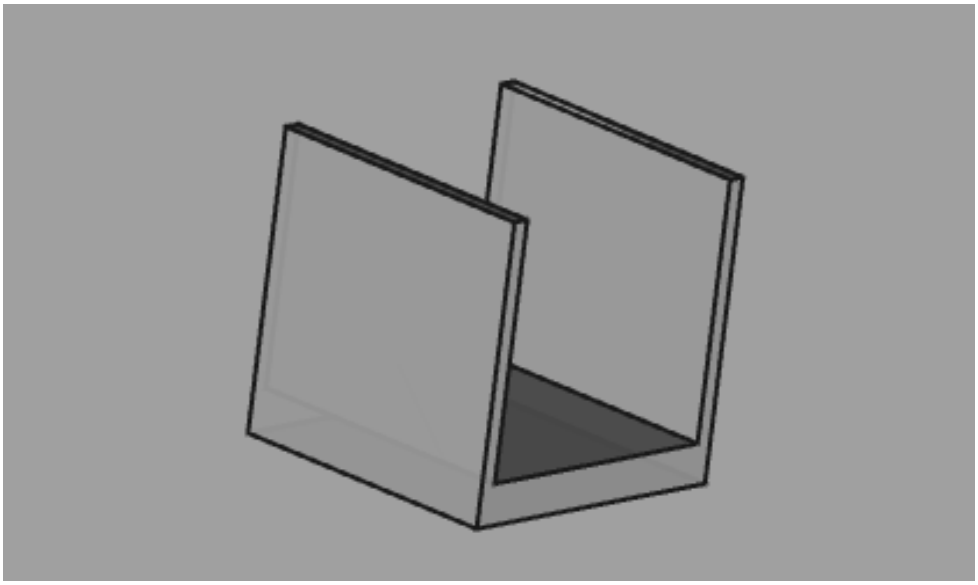
Balancing the anchor

In order to improve the time keeping in various position , it is best to balance the anchor
I used the balancing tool, and placed the finished anchor on two straight edge
Then I scrape/file off some material on the heavy side



Place the anchor on the balancing tool, and observe the motion
This looks quite ok

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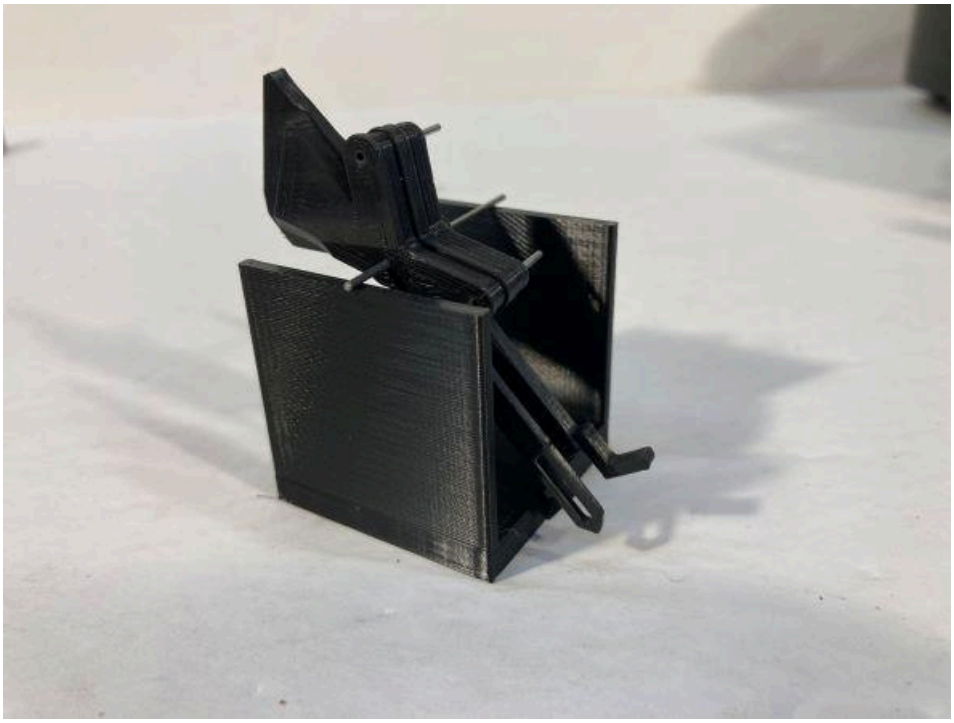
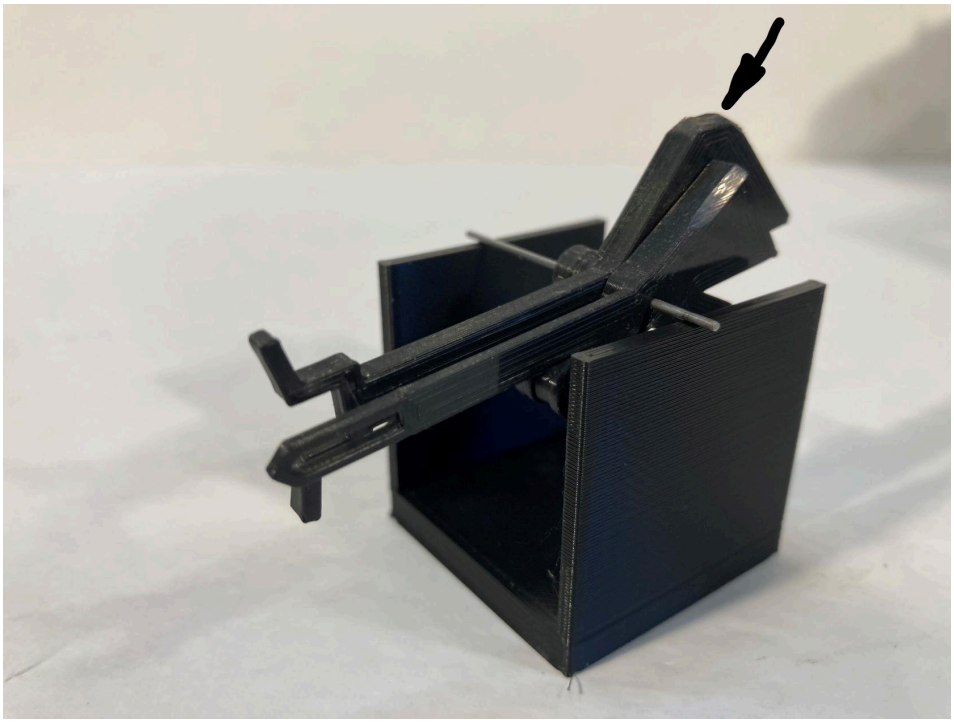
This not so much



More weight could be added at the top end of counter weight



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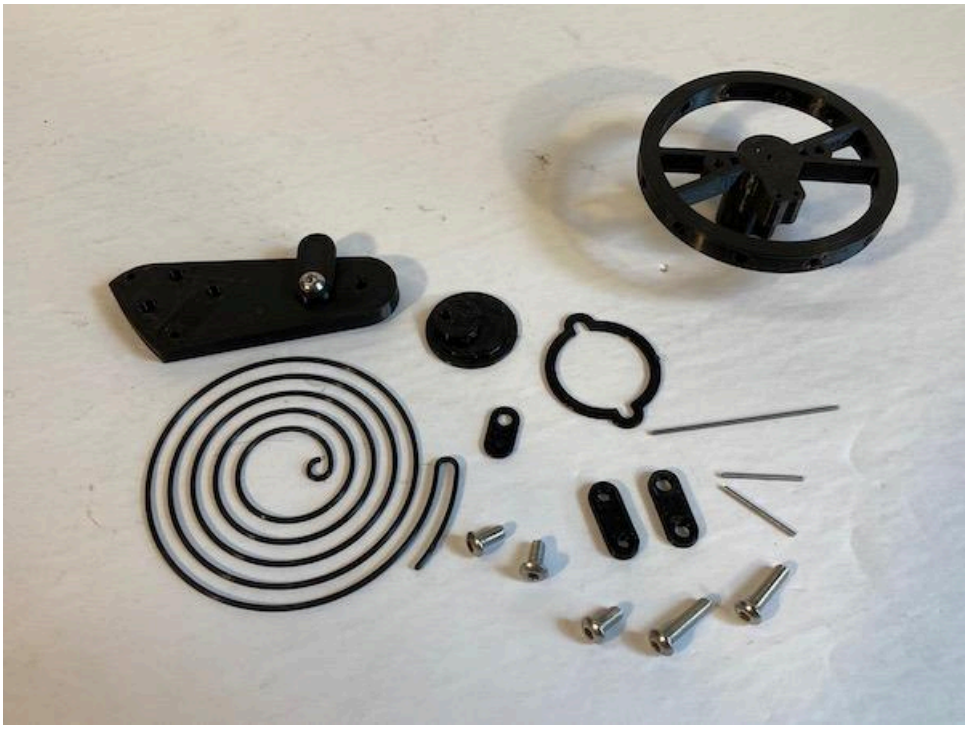
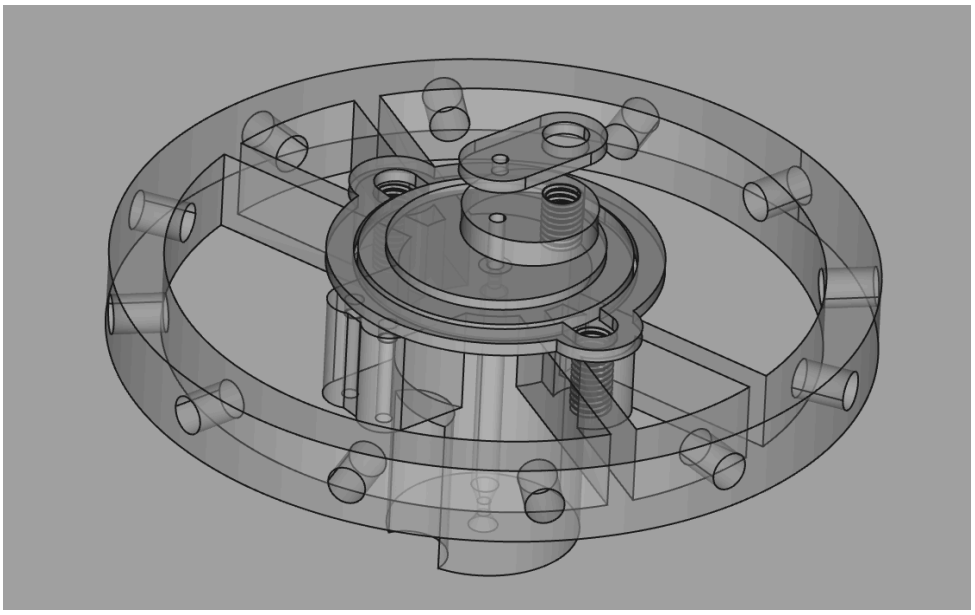
2x 1mm x 16 mm pins
1x 1mm x 38 mm arbor
2x M3 x 5 screw
1x M3 x 5 for collet



Pic CAD



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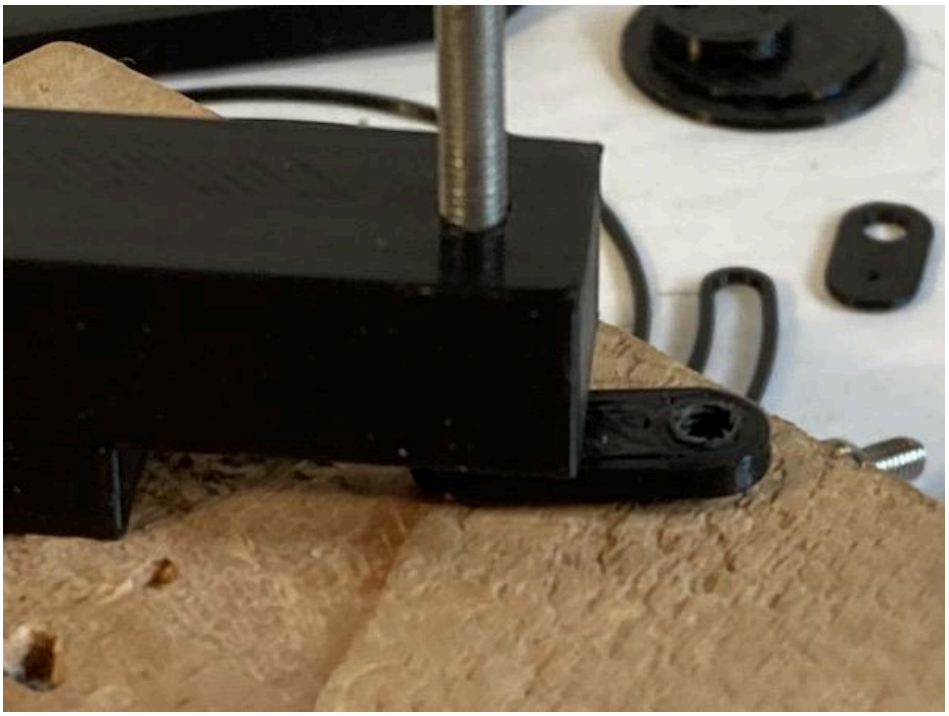
Using the guide tool, adjust the thread on the M3 plate



Install spacer and plate on the under side of Balance bridge With M3x 12 screw

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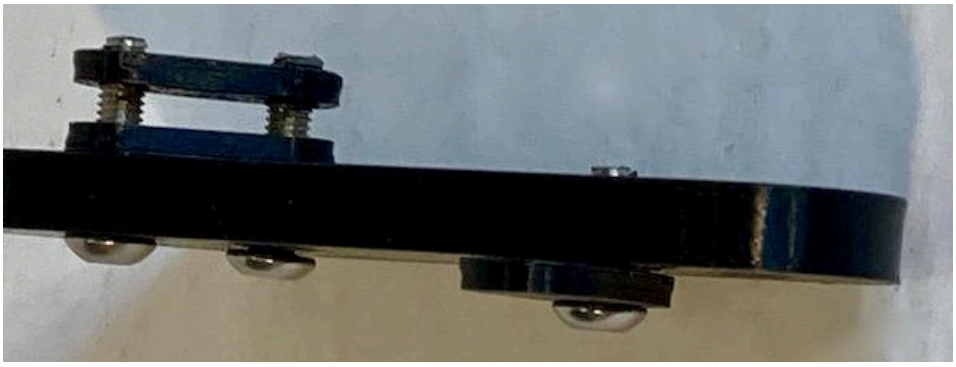
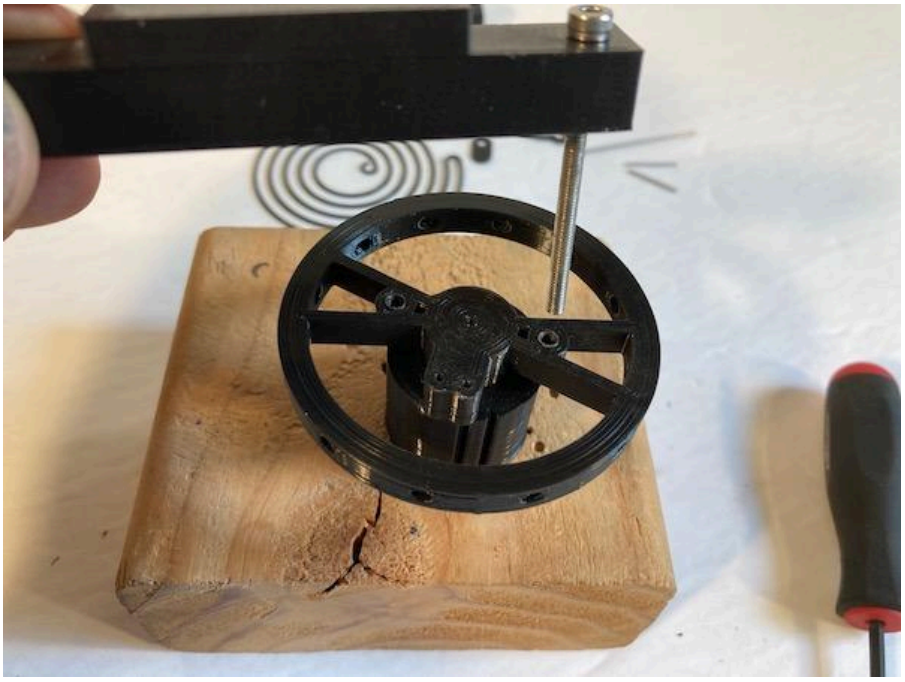


Work the tread on the balance wheel, use the balance tool for stability



Ream the center hole with the 1 mm tool

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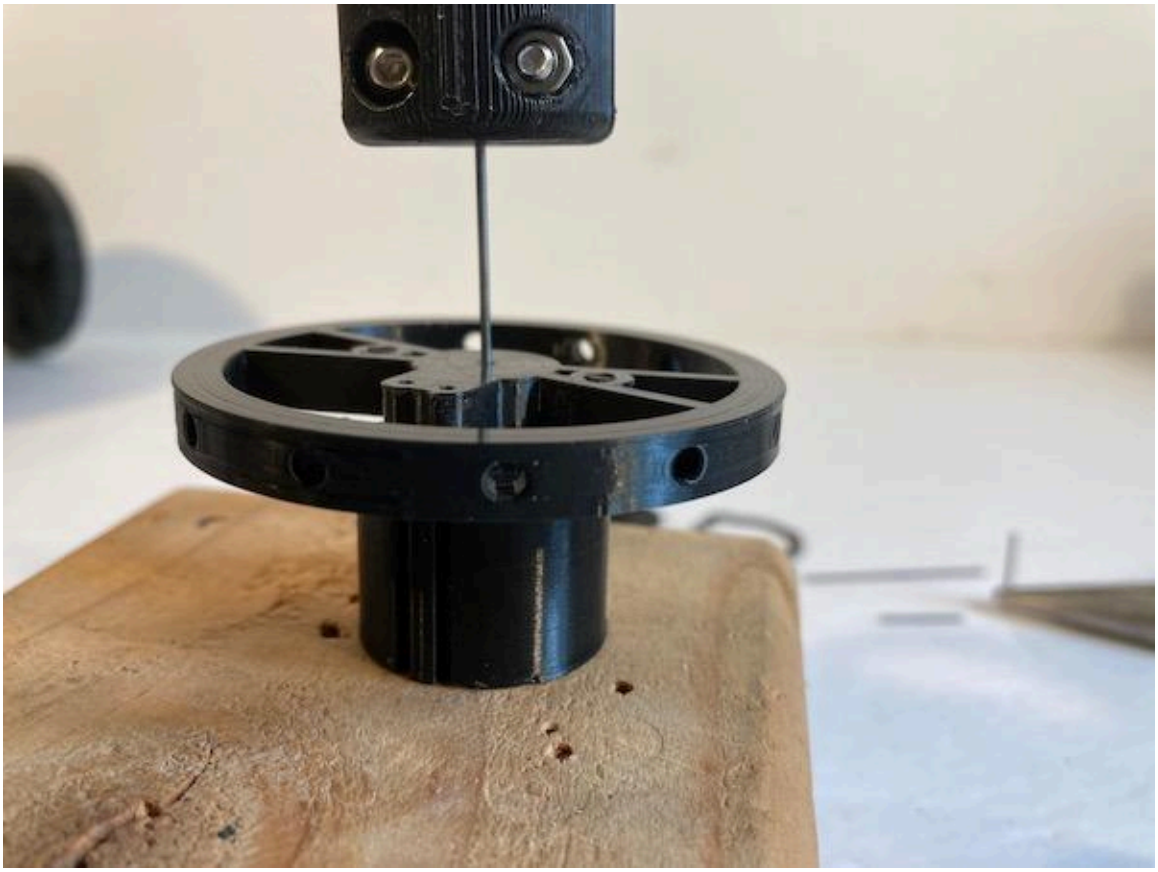

Insert and press 16 mm pins in the balance wheel

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Hammer in till flush to top

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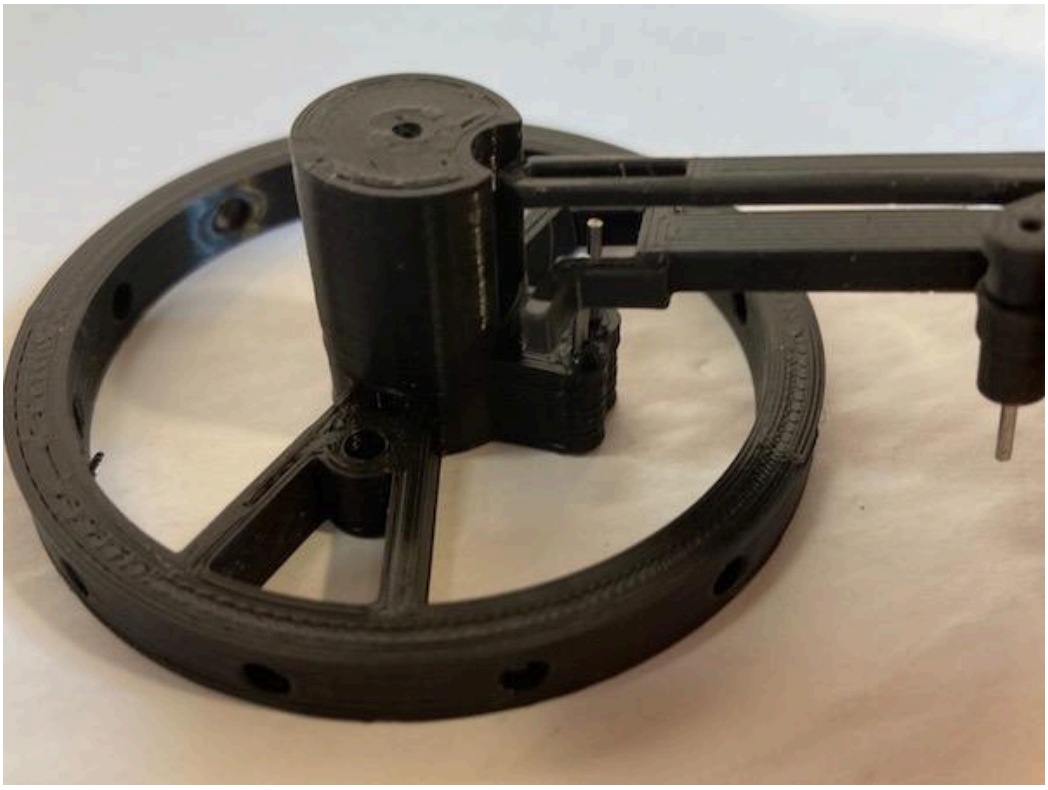
Check for some play with the anchor



Thread on collet palte

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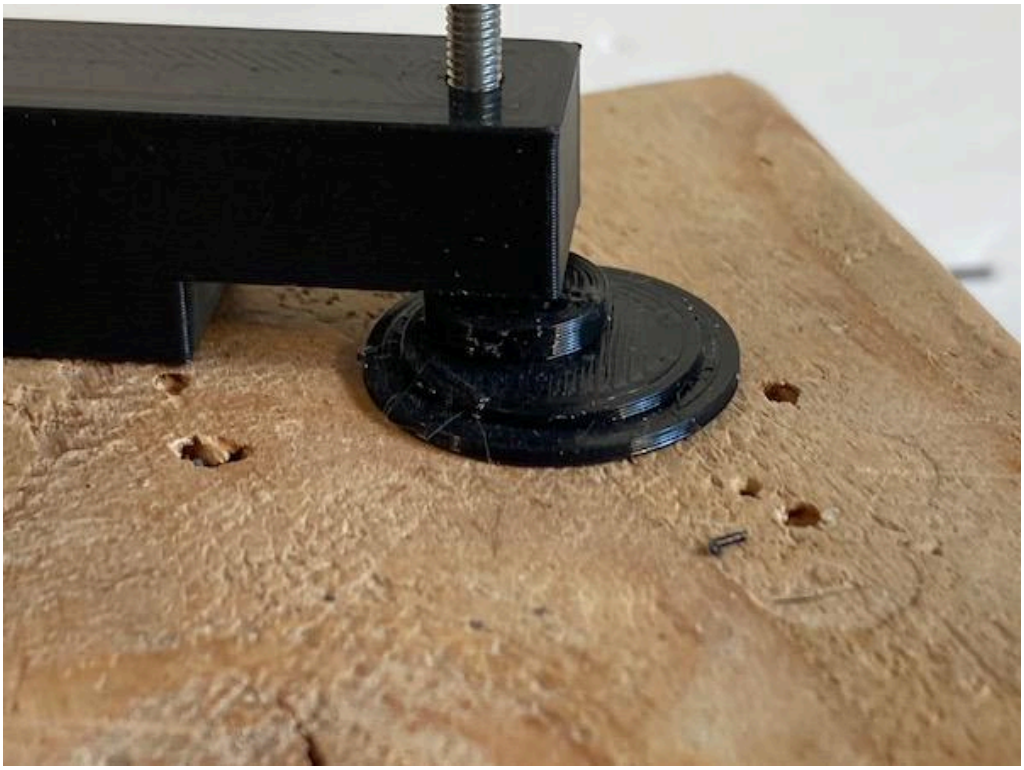
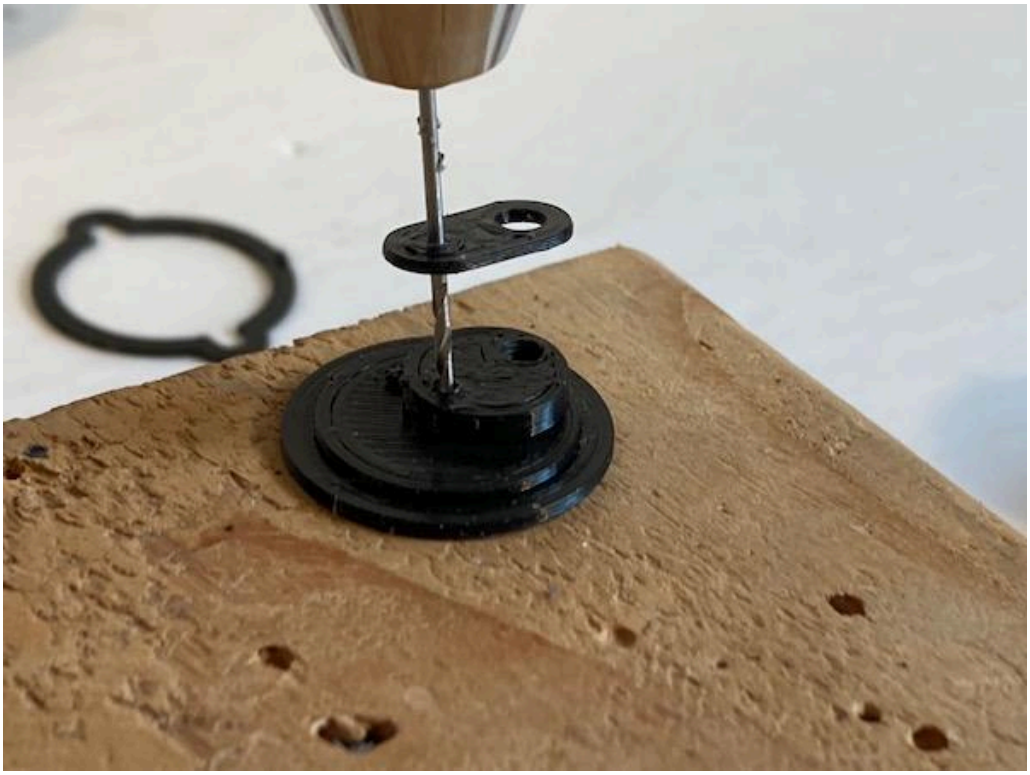


I drilled the center hole to 1 mm



Install M3 x 6 screw for collet ring

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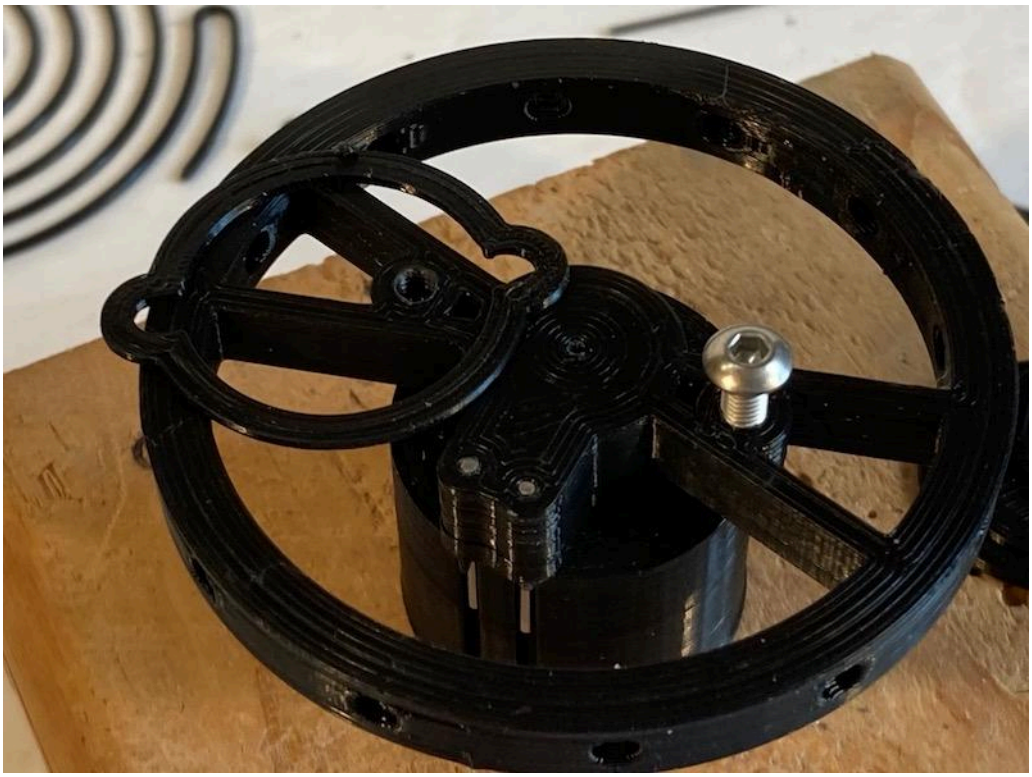

Check fitment of collet and ring with a M3 x 5 screw

Install second M 3 x 6 screw

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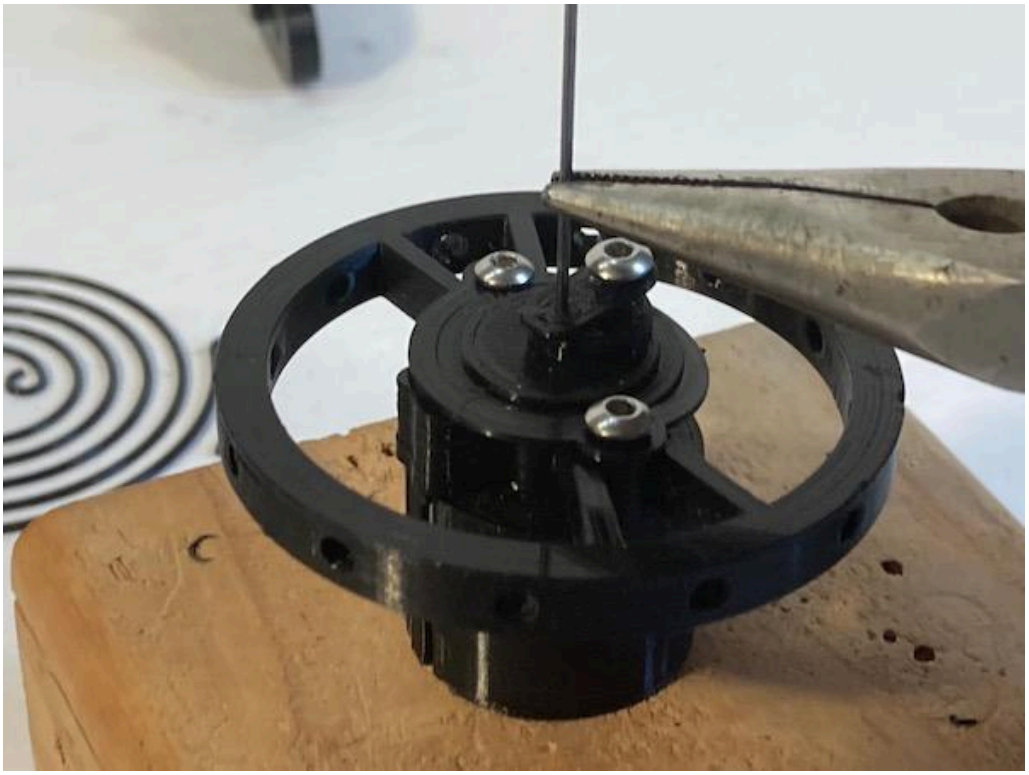
Press in the arbor



Check engagement of pins and anchor

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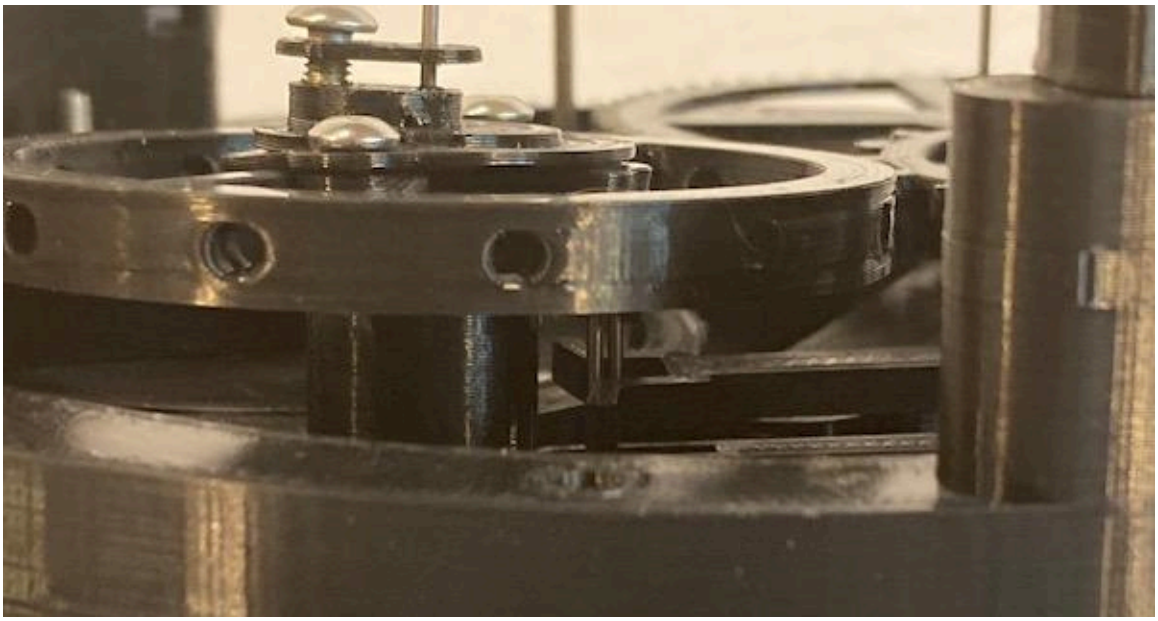

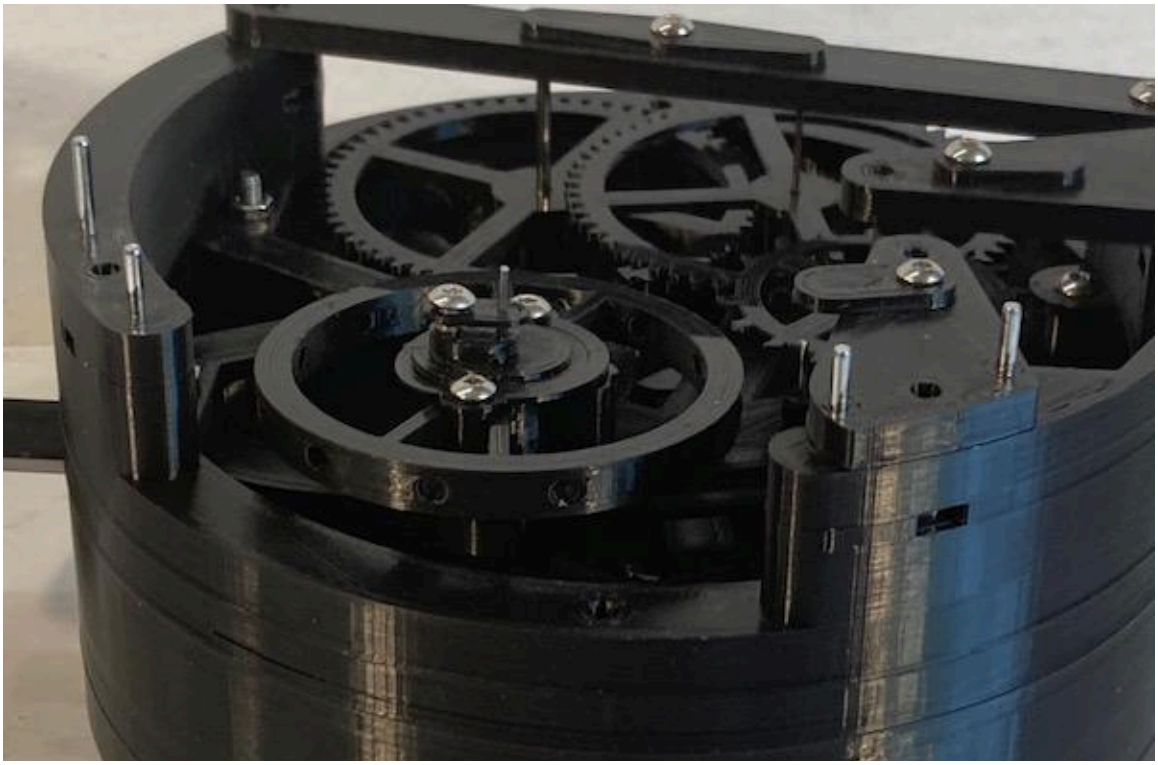

Install balance bridge and check interaction of anchor with balance wheel

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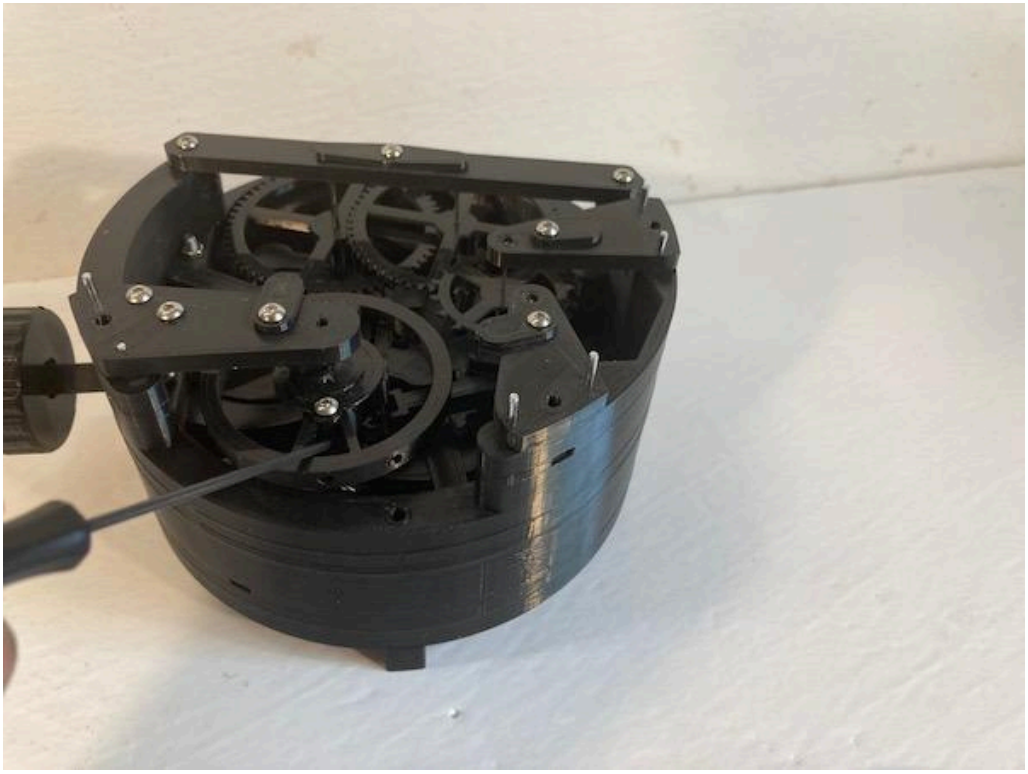
With a little tension on the mainspring, the anchor should be ticking when moving the balance back and forth



Remove the balance wheel and install the spiral spring

The top plate will allow to tighten the screw without the spiral moving

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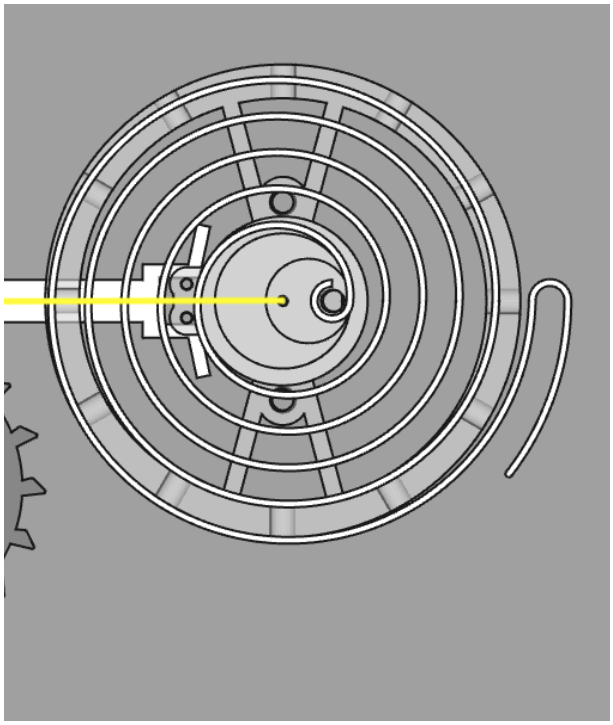
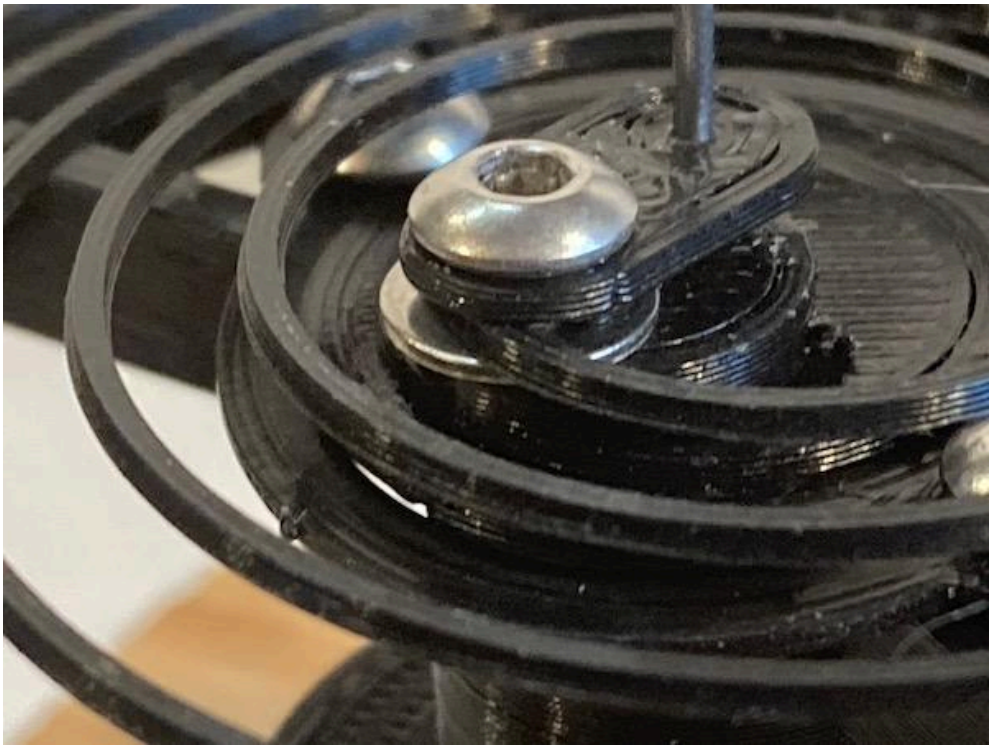
Center the spiral with the balance wheel
Position the spiral screw opposite to the pins



I added an washer under the spiral to be more level and prevent the screw sticking out of the collet



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The outer end of spiral will come around the right screw

Just like that

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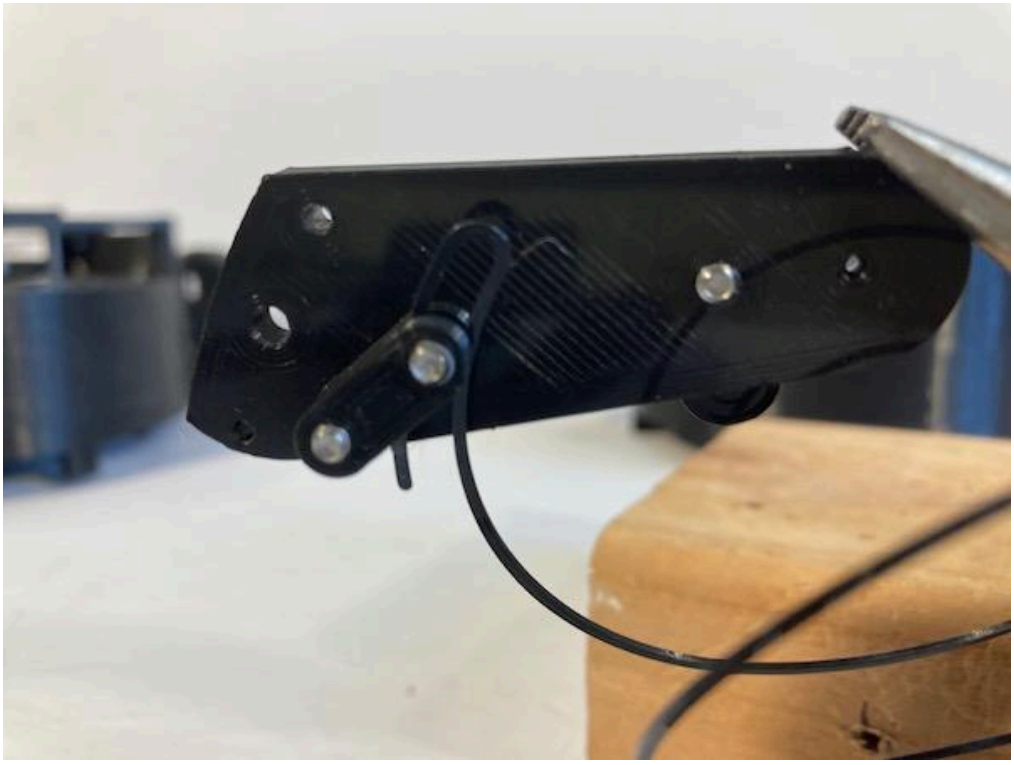
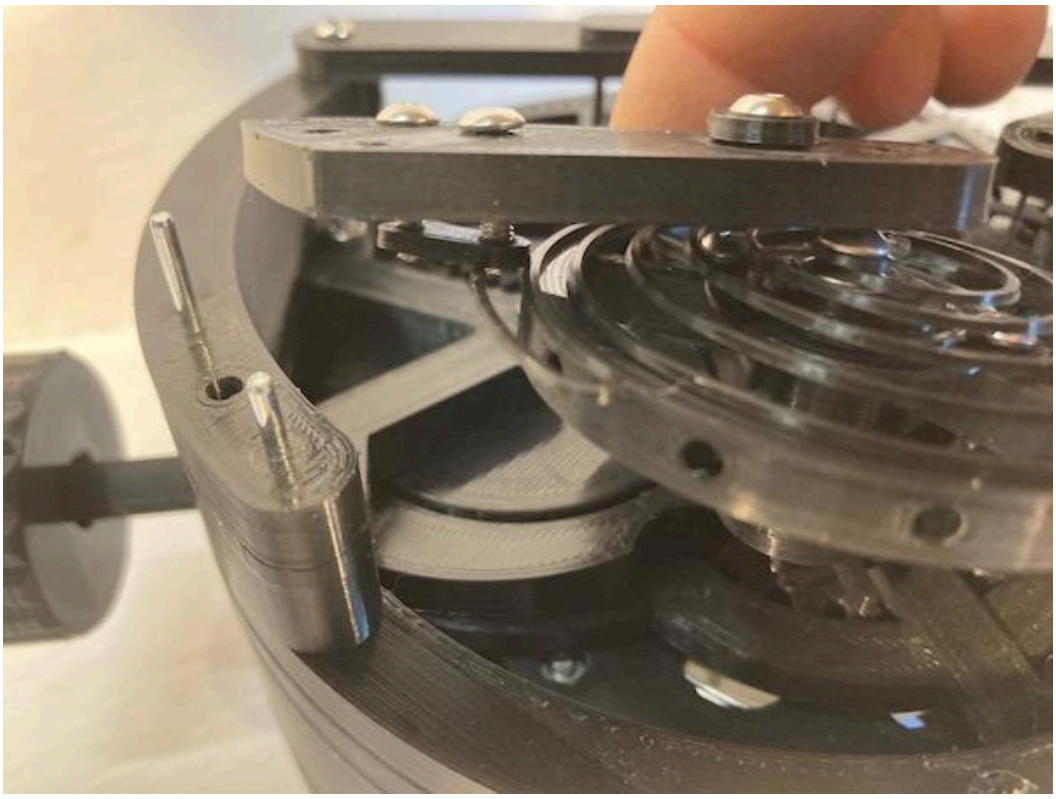


Install the balance wheel



Install the balance bridge

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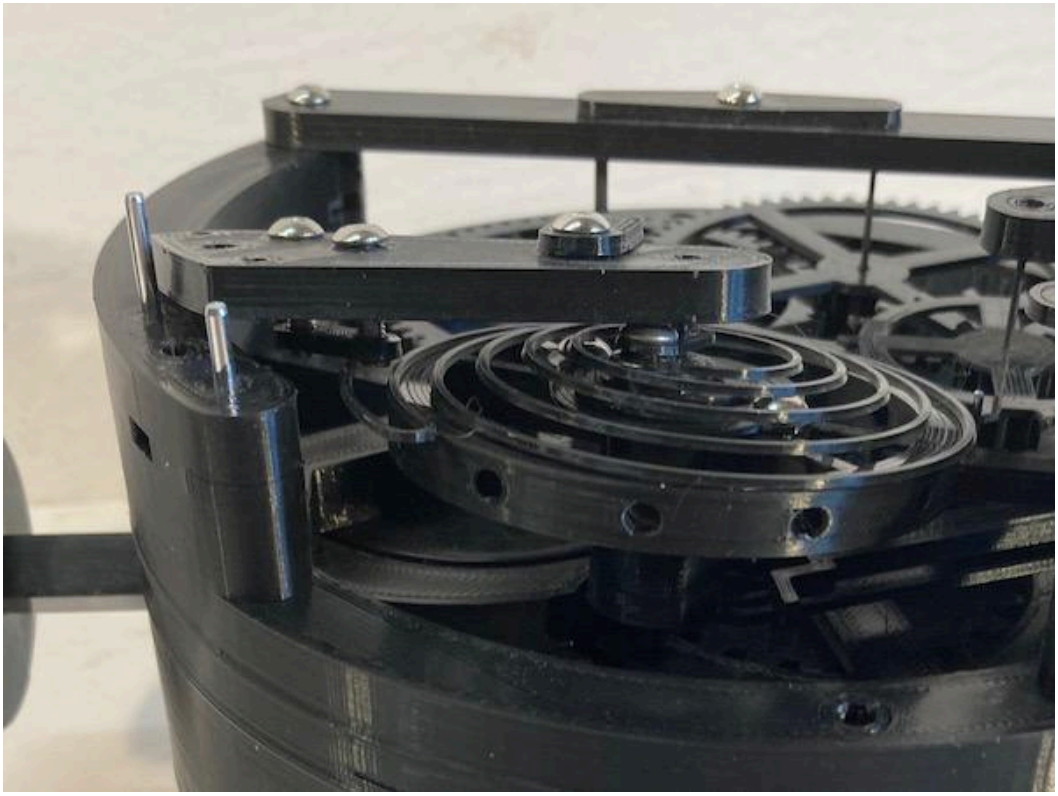

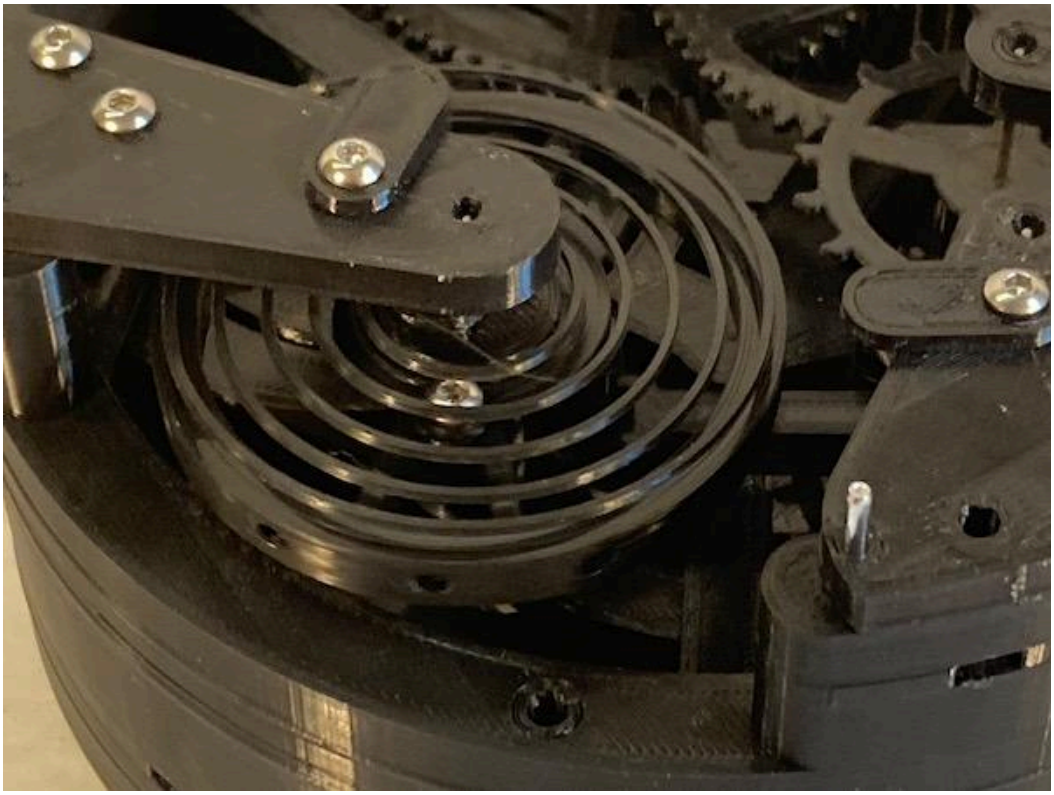

Check and adjust the alignment of balance wheel and anchor

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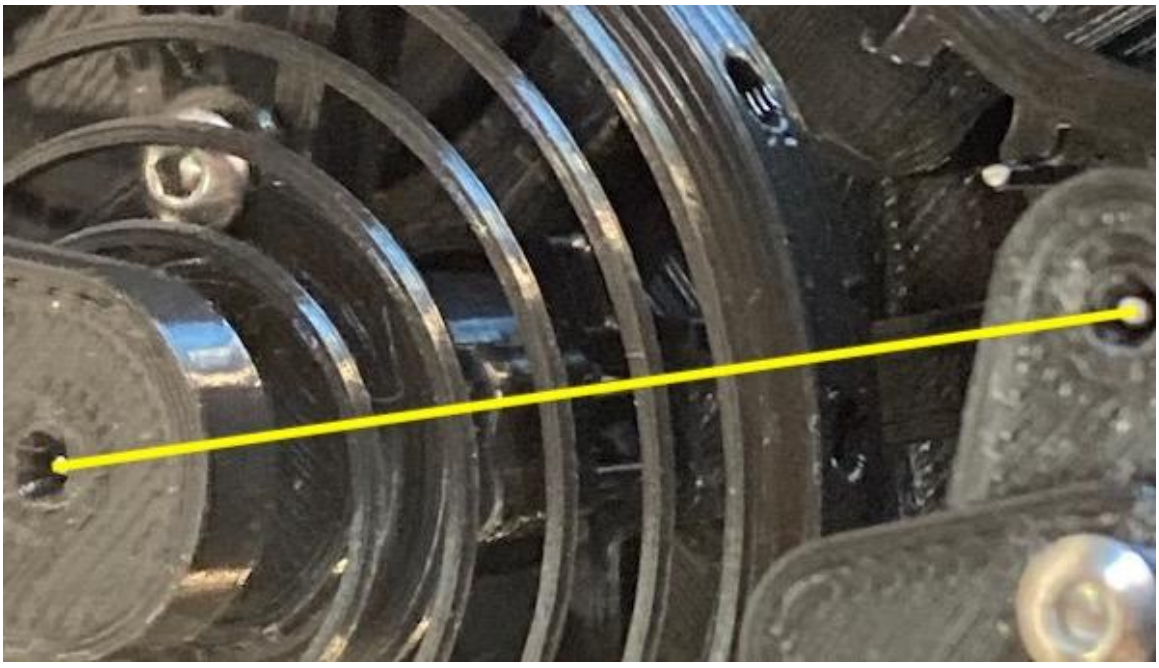
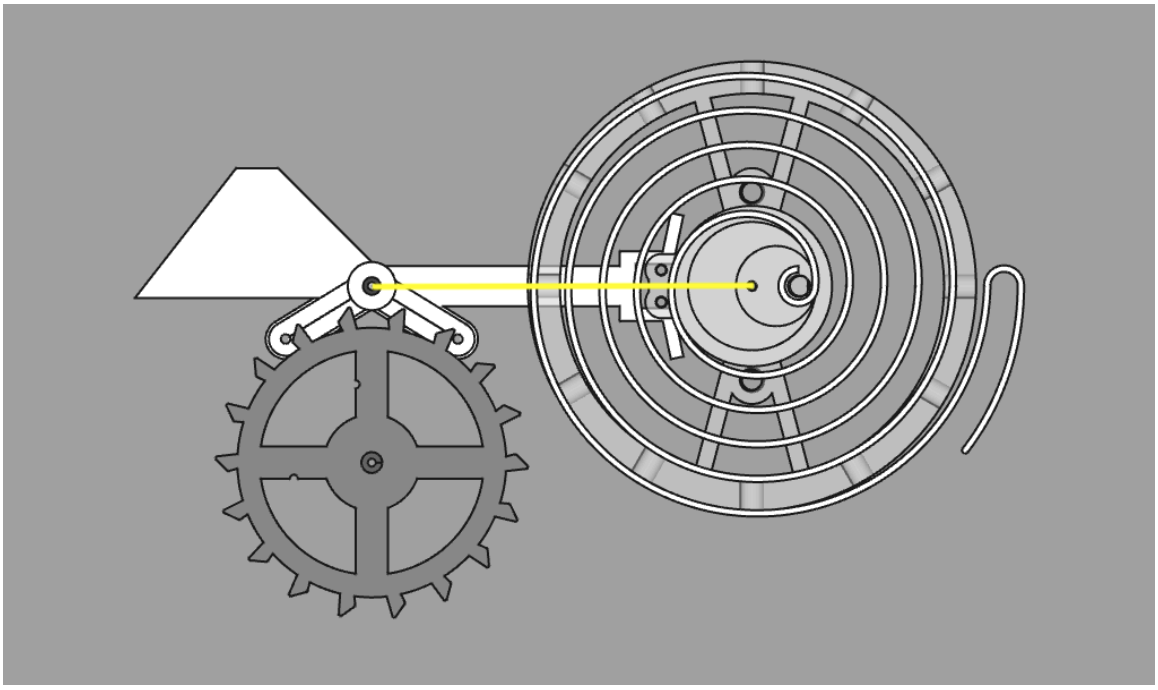
Rotate the spiral spring to adjust
The goal is to have even motion both sides





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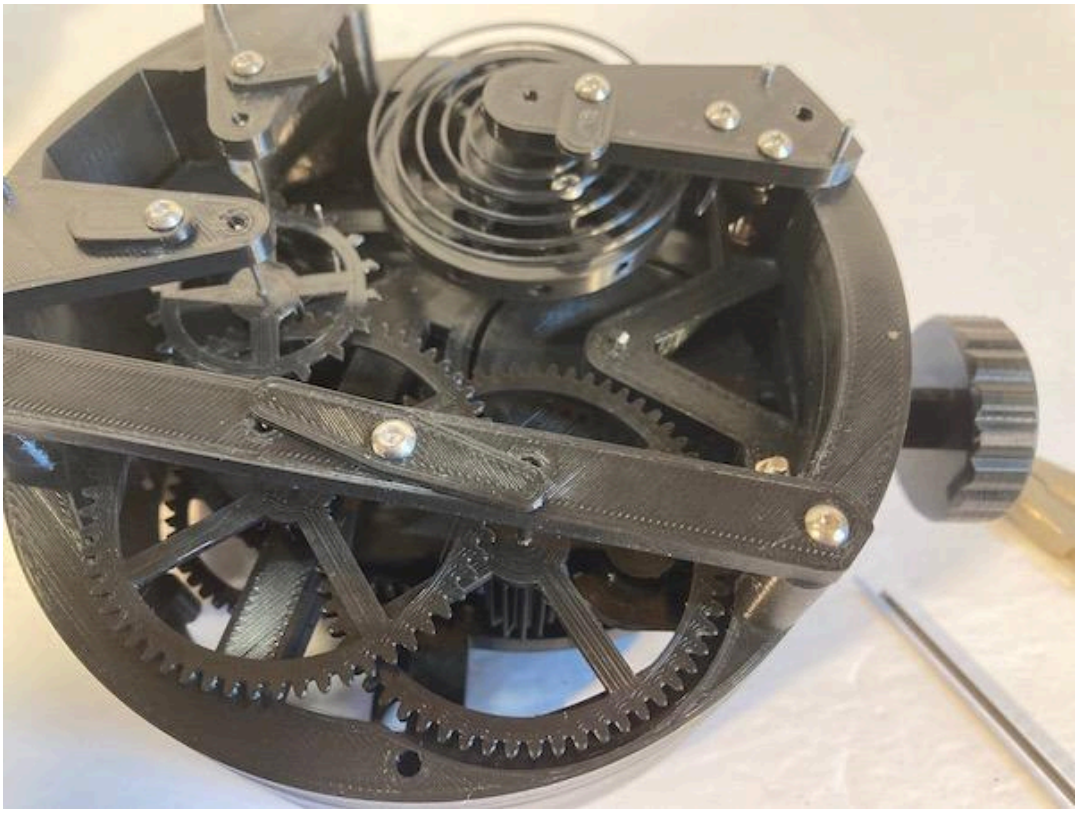
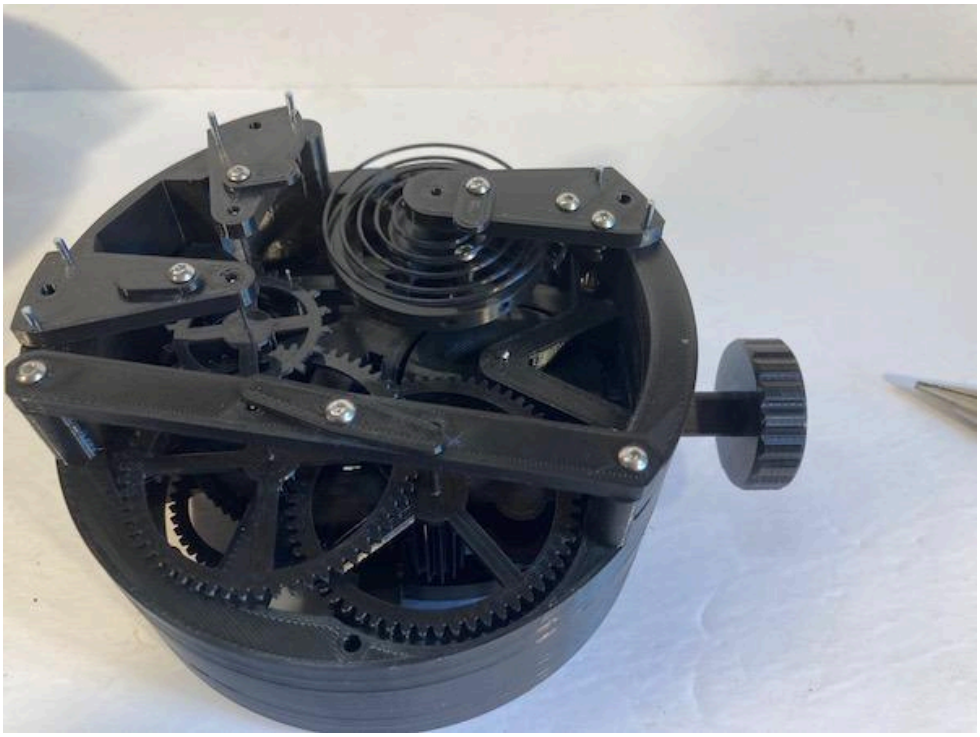
Final adjustment can be done on outer end of spiral



Wind up the main spring
If all was done right, the watch should start ticking



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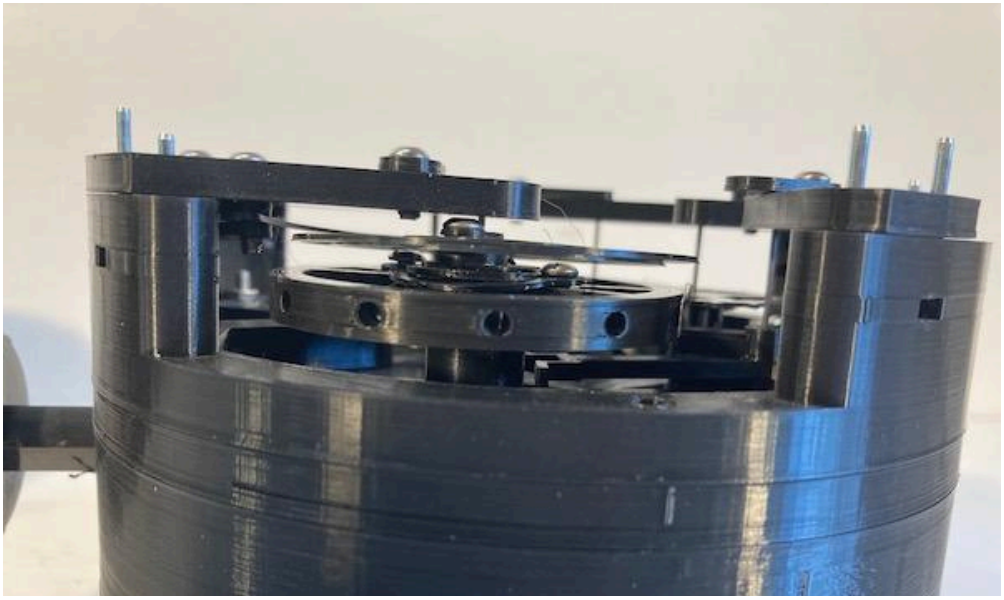
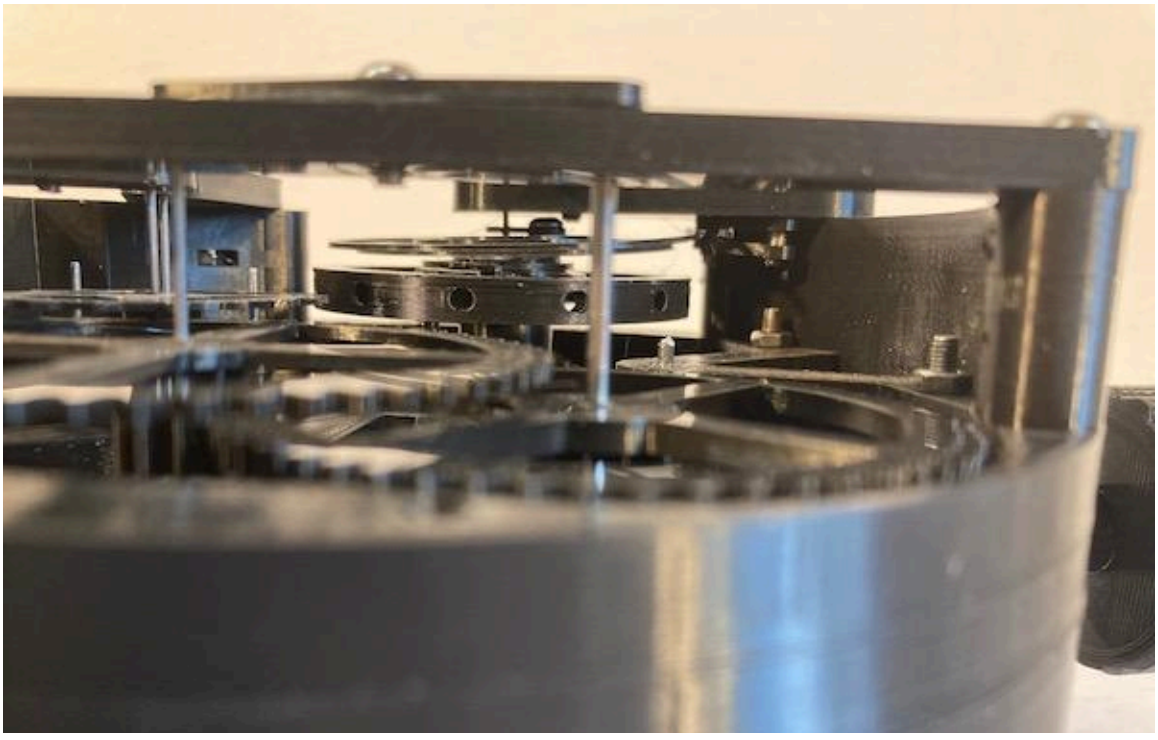
If needed, give a little push on the balance





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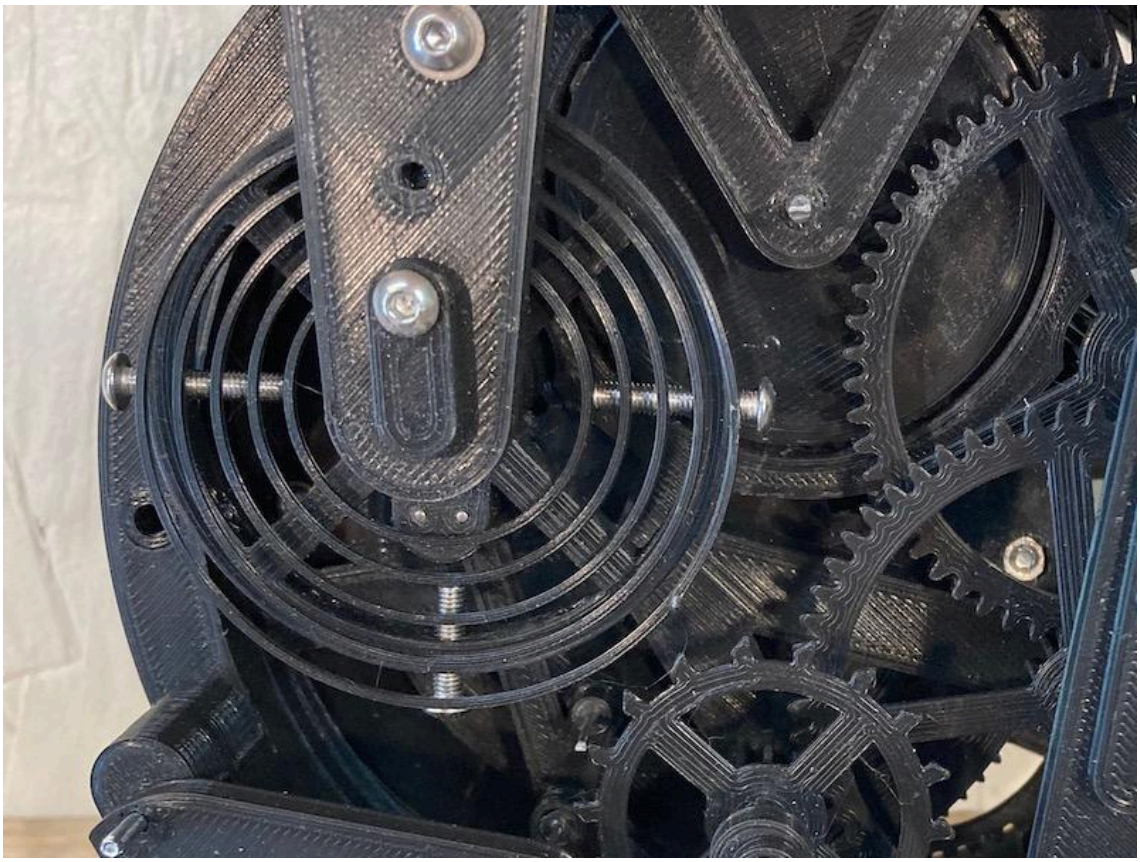
To check the timming, I used a timing App that run on smartphone
I used this App that works nicely on my Iphone and I pad
https://apps.apple.com/us/app/cuckoo-clock-calibration/id1171487289
There are plenty of others for android and computers

The watch should tick every 0.4 sec to have correct time keeping
Ad screws around the balance wheel to slow the frequency
It is a combination of the weight of balance and the stiffness of spring
Keep in mind that timing might vary depending on the position of the watch and on how much the mainspring is wound
As is, the spiral spring is not isochronous, maybe one day I will improve on that

For this earlier version of a 3D printed spring in PLA I got reasonable timing with
4x M3 x 16 screws almost all the way in
Also check out the balance of the wheel using the balance tool
I got 30 ms difference between the vertical position and horizontal position



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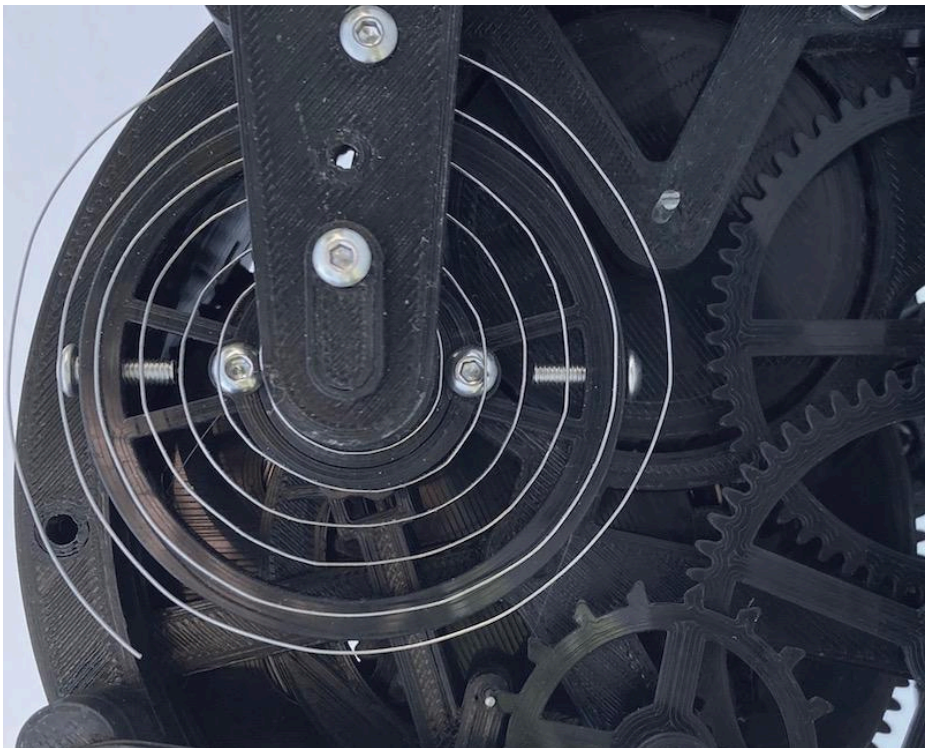
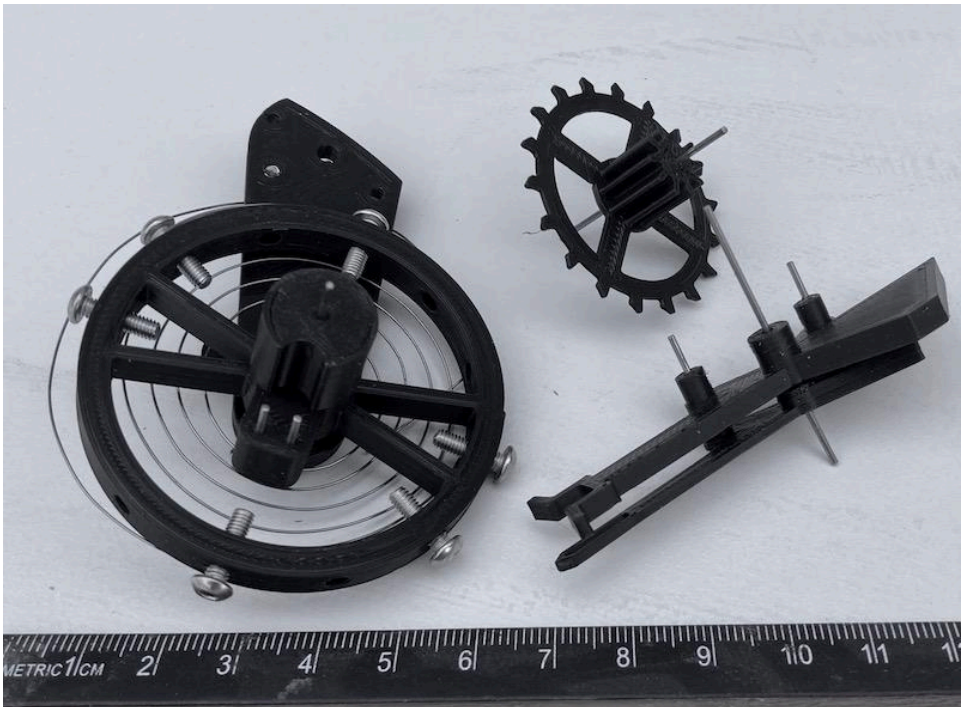
This 0,4 mm piano wire only use 2x M3 x 12 screws



This earlier 0.5 mm piano wire needed 6x M3x12 screw to get correct timing
This video explore the timing of this spring
https://youtu.be/Dz45cnH7POQ



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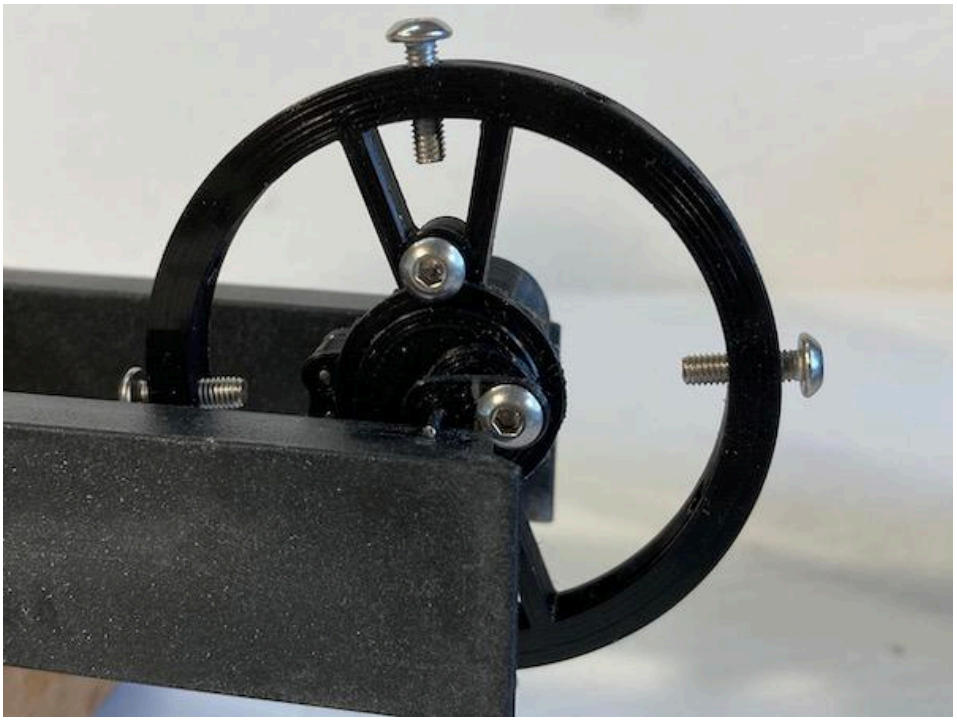
Naturally, it is also a good idea tocheck the balance of the balance wheel



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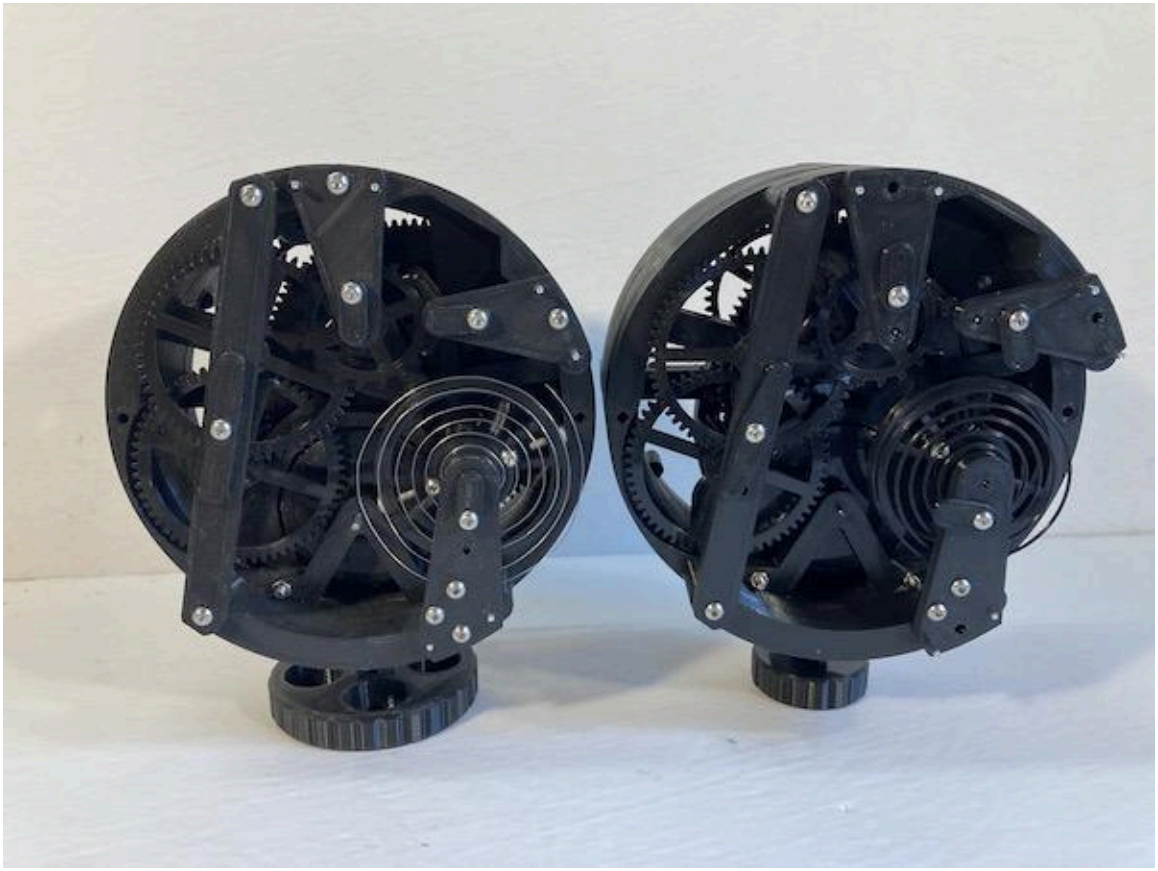
Taking it further

Make a spring steel spiral
Using a 0.4 mm piano wire
I found this book that explain how spiral springs used to be made by hand
This site has a lot of interesting books, all public domain
http://www.watkinsr.id.au/blakey.html
I used this video to understand how to do
https://youtu.be/98wI6IA4TH0
I gave it a try here in a previous project:
https://youtu.be/612ysL7achE



Improving all position timing
Minimize friction, dry lube on arbors, Not the gears!

More ideas to explore:
Testing lube on mainspring
Swap the mainspring to get more power, and or more run time
Make a 3D printed mainspring (Run time might be limited)
Re-make the project half the size with a 0.2 mm nozzle

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