Clock 24 Build instructions

Jacques Favre, June 2021

Introduction

A mostly 3d printed functional mechanical clock with a runtime of well over 24 hours
Once all the parts are printed, it is basically a kitchen table kit
No shop needed for complicated post processing, no power tool needed
I personally cut the 5mm arbor with a hacksaw, and the piano wire with a good set of pliers
A dremel tool can be handy
Other than that, only a few hand tools needed
Patience, dedication and attention to details are good qualities to have

Prerequisite

3D printing

A printer with a bed that accept a 202 /202 mm part (front frame)

Printing big parts with good bed adhesion from one corner of the bed all the way to the opposite corner.
While none of the parts are challenging to print, gears and the escapement need to be of adequate quality
Knowledge on how to set up custom settings in the slicer for optimal results

Note:
I use Esun PLA+ on glass bed, at 215 C and 60 C for the bed on an Ender 3

PLA or other material can be used

Tools

While a shop is not necessary, a way to cut the arbors and piano wire to size is needed
A dremel tool with a cutting wheel can do
A few hand tools, pliers, screw driver, allen wrench, round and flat files, sand paper
A small vice is helpful

Supplies

PLA or PLA+ or other filament
5mm steel or brass rod
2mm piano wire or other brass or steel rod
1 mm piano wire
Bearings
M3 screws and nuts
Glue, epoxy or super glue
String
Weight, steel balls, steel rod or other, between 2 and 3 Kg for straight drop

Optional: brake cleaner to clean grease out of bearings, dry lube
(I do not use any lube on my clocks)

You will need a wall or post or other rigid support to install the clock

You will need some patience and dedication to get to the final result. A week or two will be needed to complete the printing, possibly another week or two for the build and tuning.

Shafts/Arbors

5mm rod
1 X 150 mm
2 X 106 mm
1 X 71 mm (lock rewind)
1 X 43 mm (anchor)
1 X 37 mm (maintain ratchet)
4 X 18 mm

2mm Rod (piano wire)
1 X 112 mm (middle gear)
1 X 93 mm (clutch to hands)
2 X 61 mm (clutch)

1 X 53 mm (escape wheel)
1 X 46 mm (anchor)
1 X 38 mm (hands)

1mm piano wire
1X 115 mm

M3 Screws and nuts

6 nuts
2 X 20 mm
3 X 15 mm
1 X 10 mm

Bearings

4 X 605 ZZ (5 x 14 x 5 mm) ZZ have a steel flange, there is very little friction with one flange removed and the grease cleaned out, 2RS have a rubber flange, better protection, but to much friction for a clock
Bare 605 bearing with no flange would work too in a low dust environement

Misc

Glue (super glue/epoxy)
String for weight
Weights, ballast, steel balls
Screw for wall fixation
10 mm rod long enough for pendulum (90 cm minimum to adjusted)

Options

Escape wheel:

There is two options for the escape wheel, the latest version uses escapeWheelNarrow, with a taper to reduce friction, I left the first verion, escapeWheel

With or without maintain power:

Parts for maintain power:
gear72_36Maintain, diskMaintain, gear12Ratchet, ratchetMaintain

Simpler version with no maintain power

gear12RatchetNoMaintain, gear12-36NoMaintain

In both case, still need 4 of the ratchet rewind parts

There is also variation of hands gear
Firts I made: gear72Hour, gearMin39
Someone mention they where to loose, so I did the following gears tighter:
minGeartightPlus2, hourGearPlus1

You will have to try and see what works best with your printer and settings

Preparation for the build

View of all the parts

Check all parts for defects, blobs of materials on teeth, excessive elephant foot, especially on the big gears, escape wheel, anchor
In most modern slicers, there is a setting to shrink the first layer to minimize elephant foot

I print all the gears, one at a time. This limits stringing, and maximize the quality of print
No support is needed for any parts

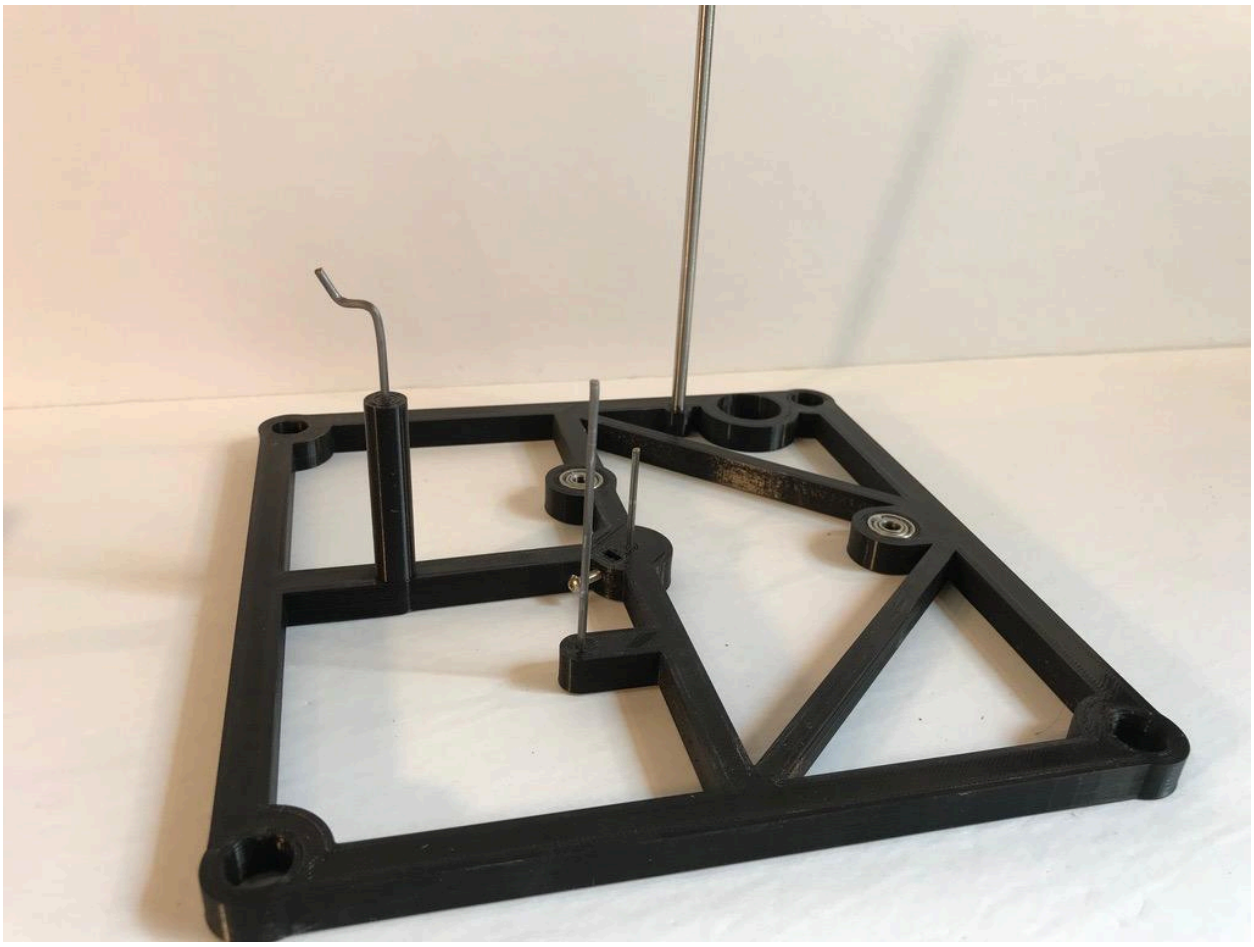
The Studs

Check the fit of the nuts on the rods
The long ones are M12, the small one is M10
Screw the nuts on and off a few times until smooth operation
If nuts are too tight or too loose, it easy enough to scale them in the slicer before printing them

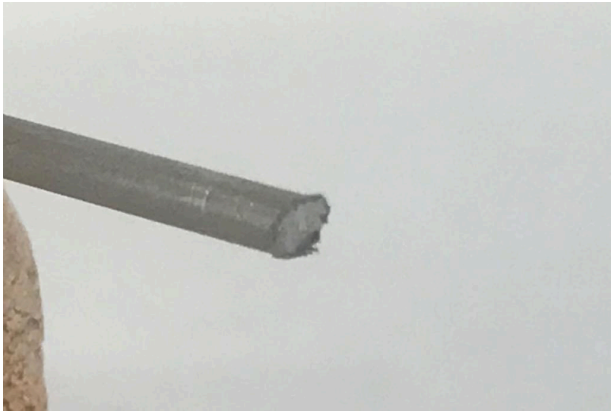
Frames and studs

Check the bores on the frames
The studs will line up the frames
The studs need to slide freely without play
The way I do it is to roll some sandpaper to clean up the bores

Arbors and Front Frames



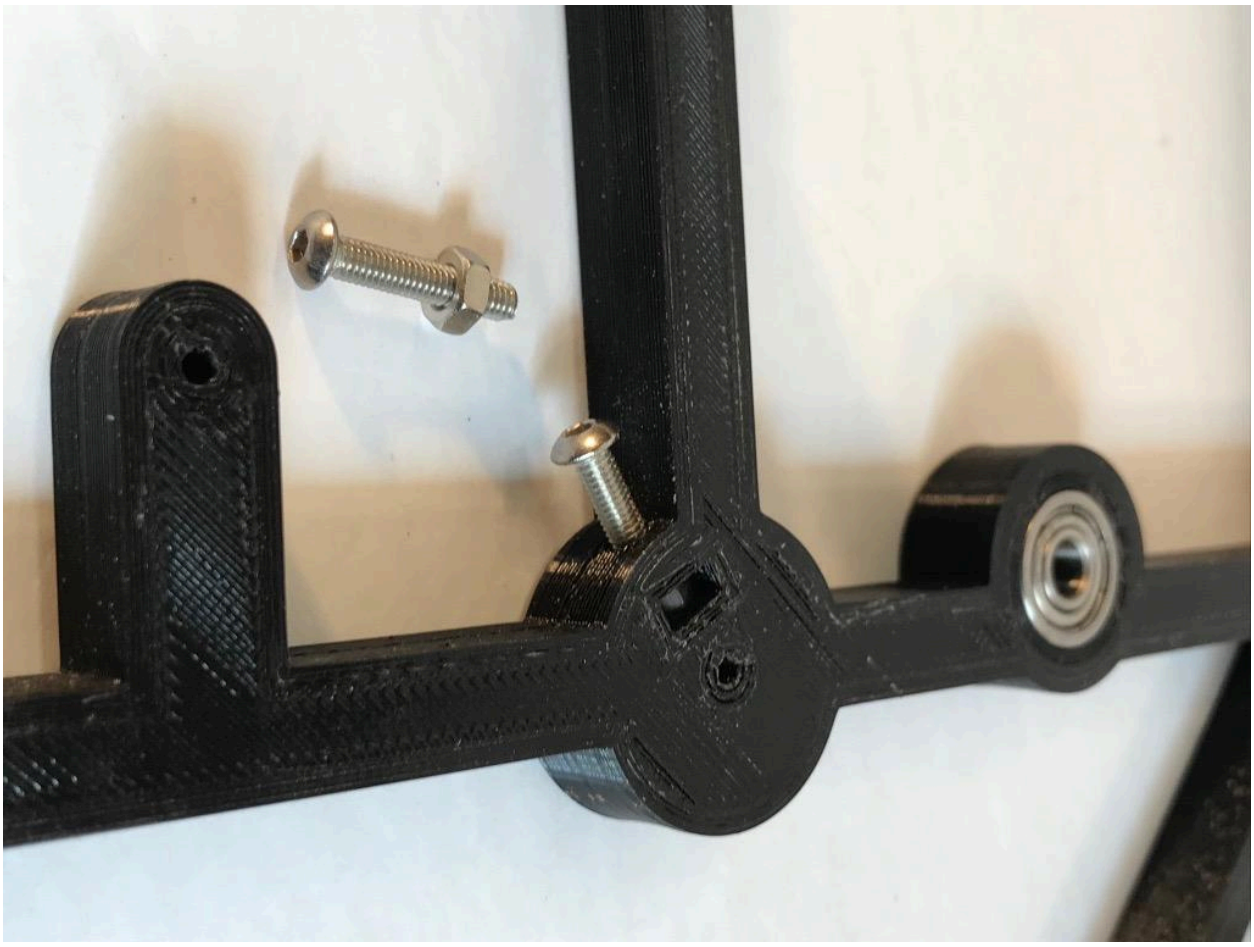
Install the bearings
Check the holes for the piano wire, best to have a loose fit to facilitate the assembly
The longer tube for the front gears need to be real loose



A piece wire with the end cut at a 30 degree angle helps in cleaning /reaming the holes

Alternatively a 2.2 mm drill bit will work, however I advised not to use a powered drill, there is a risk of going too far, too quick!

Hands lock screw



Install a M3 nut in the slot hole
Install M3x15 screw in the nut

Back Frame

Check all holes, install bearings

Middle gear

Check that the middle gear spins freely on shaft 112 mm

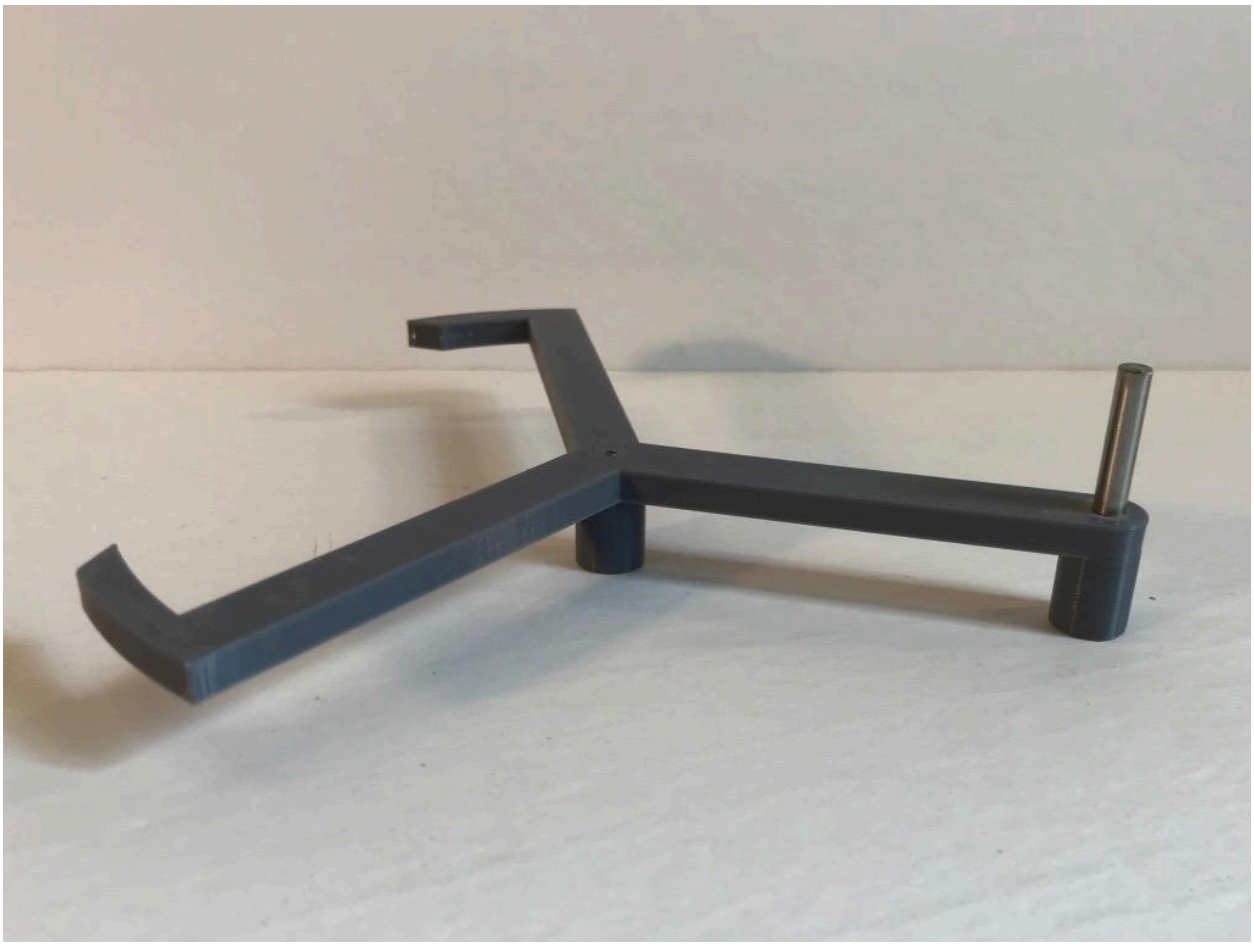
Front escapement frame

Check and clean 2mm holes, install 46 mm shaft for the anchor, and the 53 mm for the escape wheel

Back escapement frame

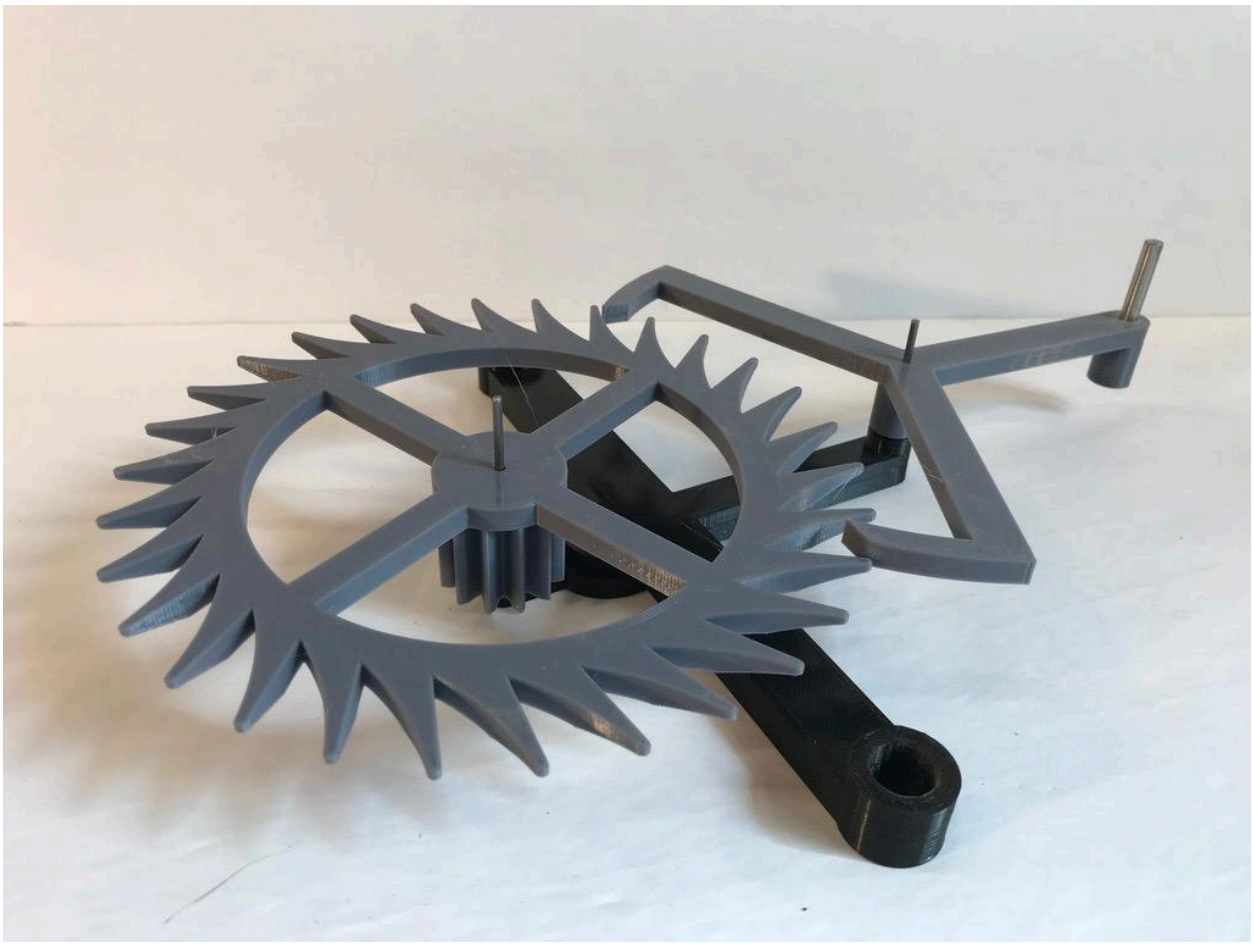
Check holes in the back frame, check both frames together with arbors

Anchor



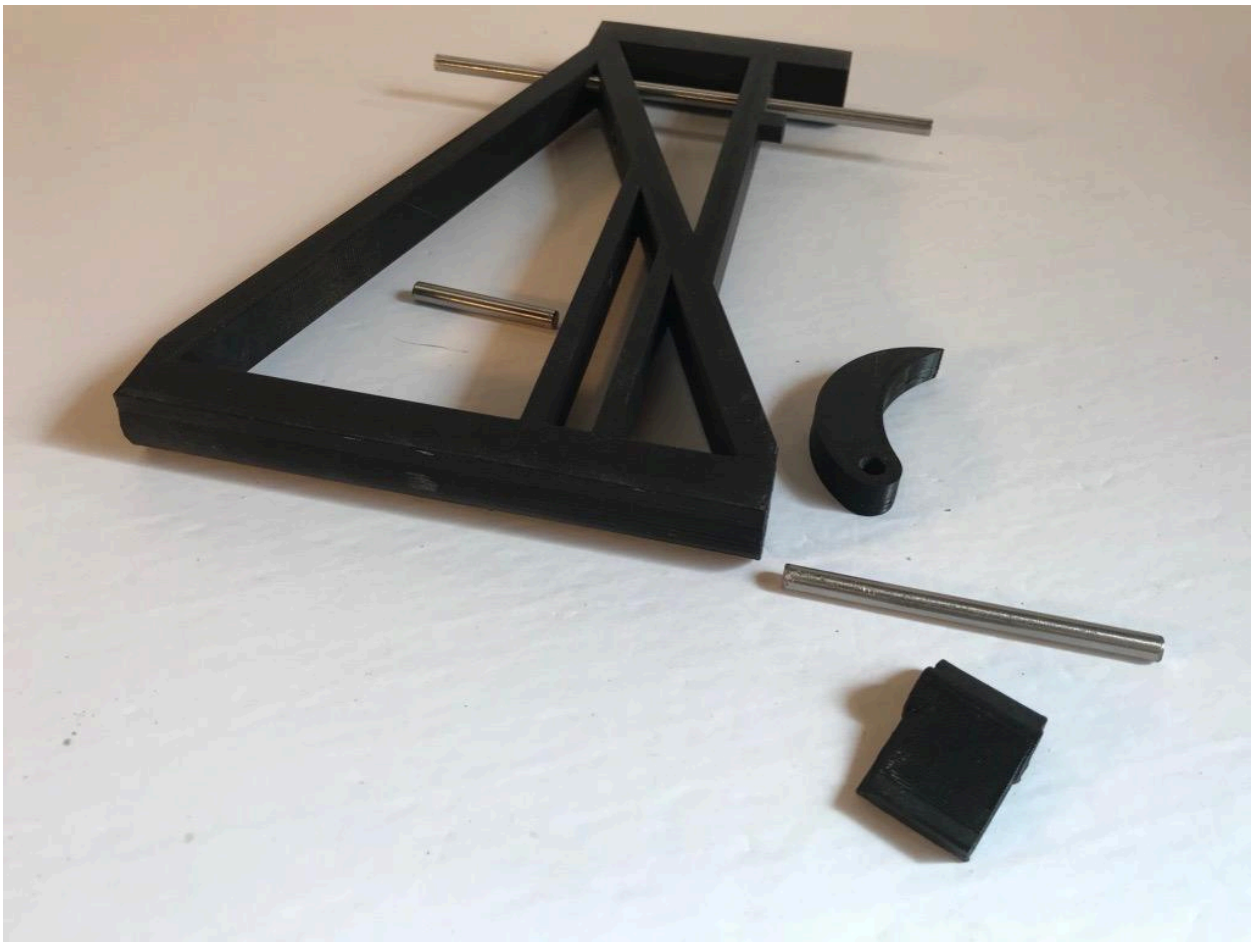
Check and clean 2 mm hole in anchor
Install 43 mm long, 5mm rod in the lower part of anchor
If too loose, glue the rod

Escapement



Check free motion of both the escape wheel and the anchor on the 2mm arbors

Left Frame



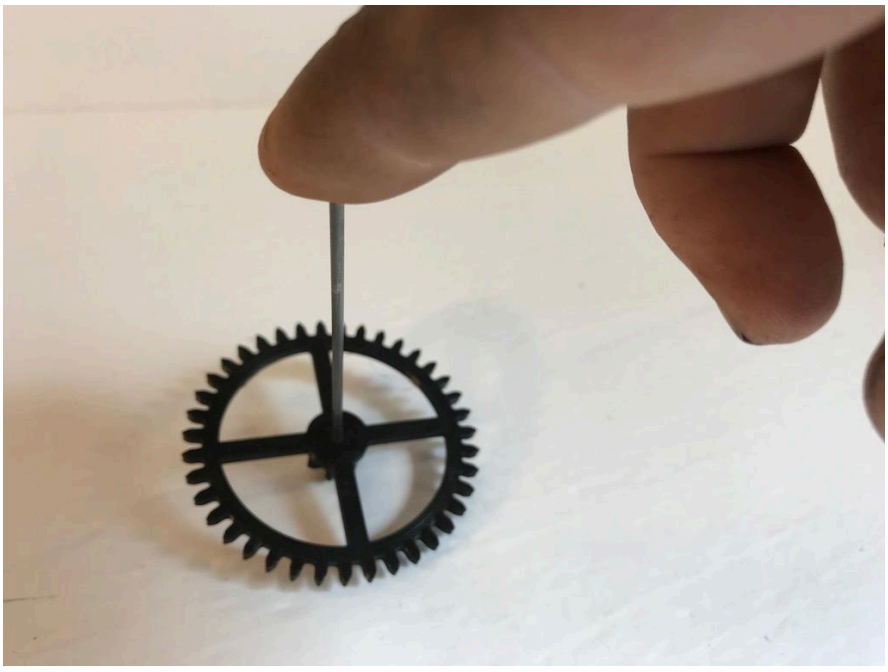
Preparation of left frame
37 mm, 5mm rod and ratchet for the maintain power
71 mm, 5mm rod and lock for the rewind
150 mm rod for the rewind gear
A drop of glue can be used if rods are to free and fall out

Left frame assembled

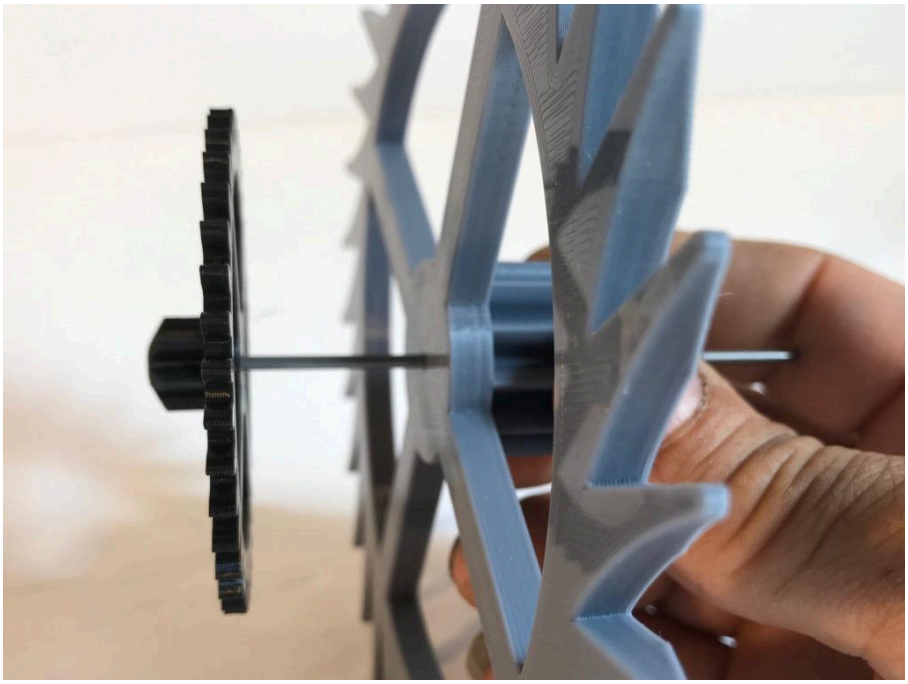
Observe the direction of placement of ratchet and lock

Hands gear

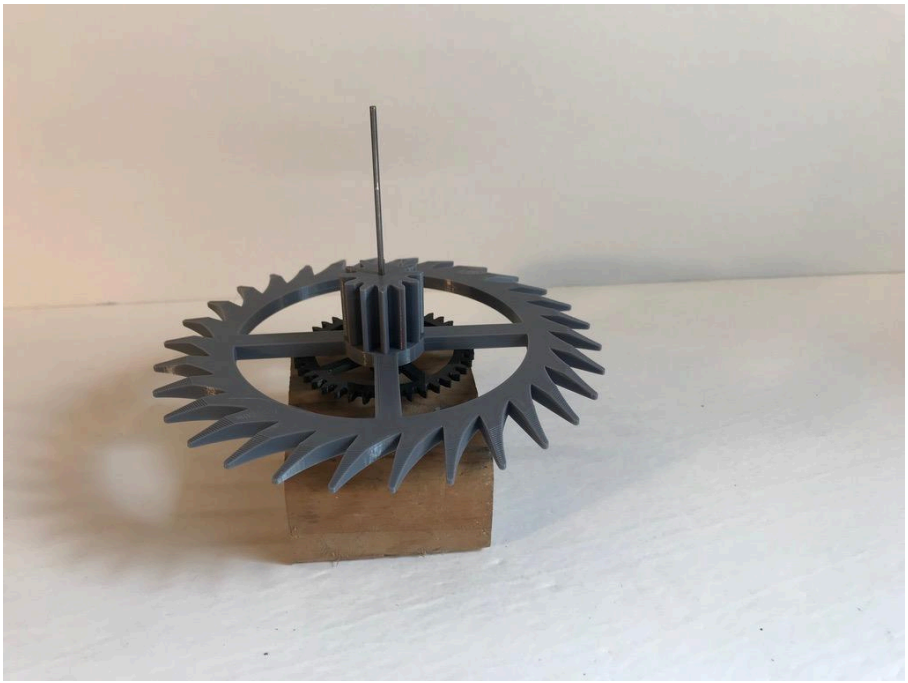
39 - 6 gear and 61 mm, 2mm rod
Here the rod will have a tight fit, glue is needed



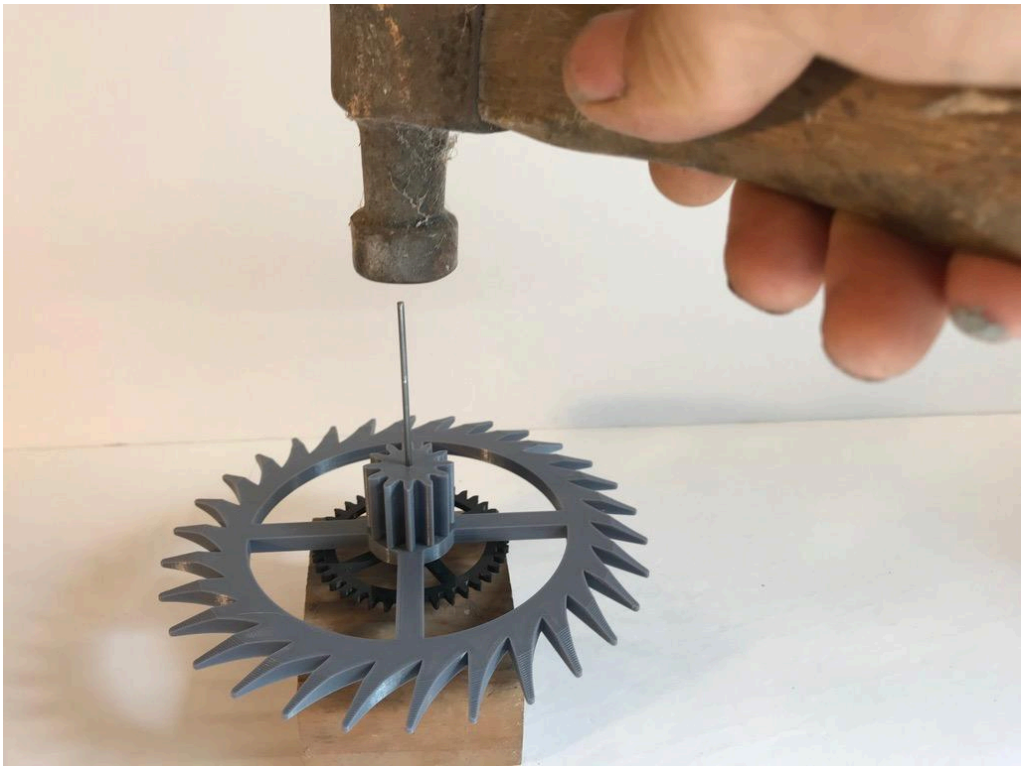
Engage the rod in the gear



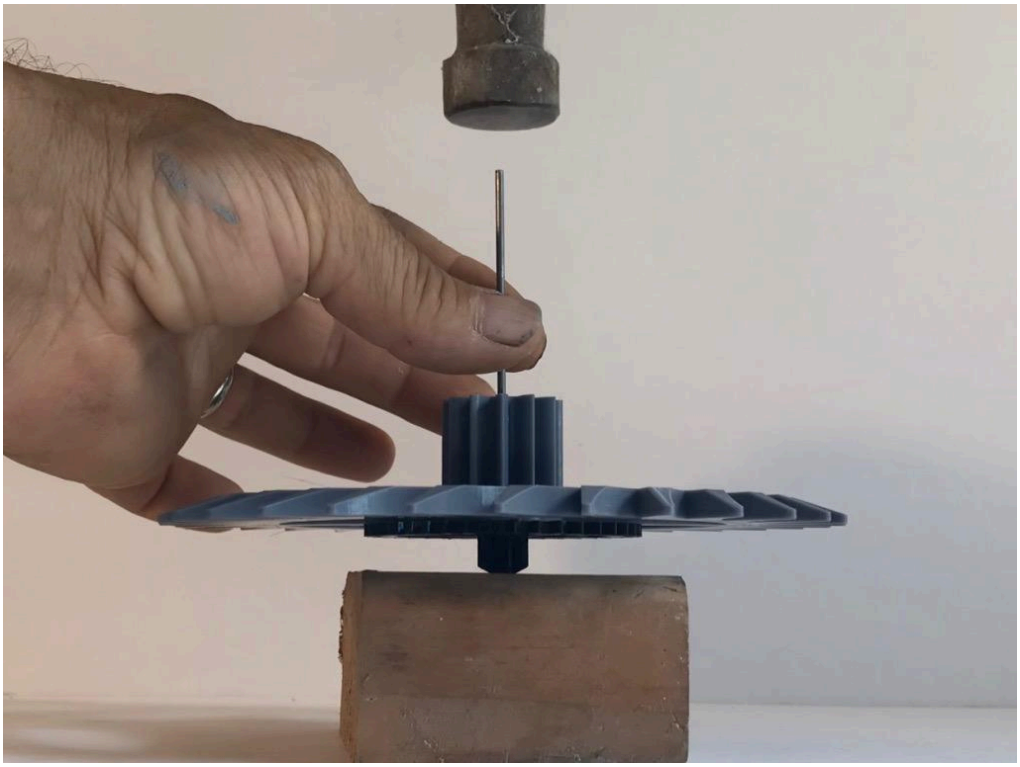
Then, I use the escape wheel as a guide for the rod
This to make sure the rod will be square with the rod



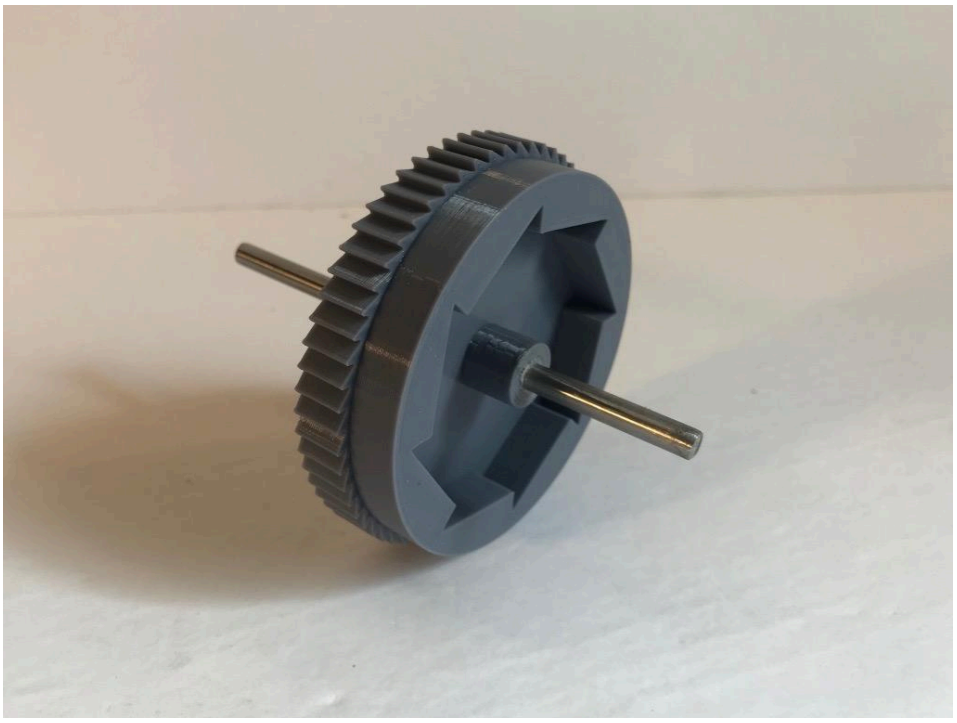
Place the gear on a block of wood



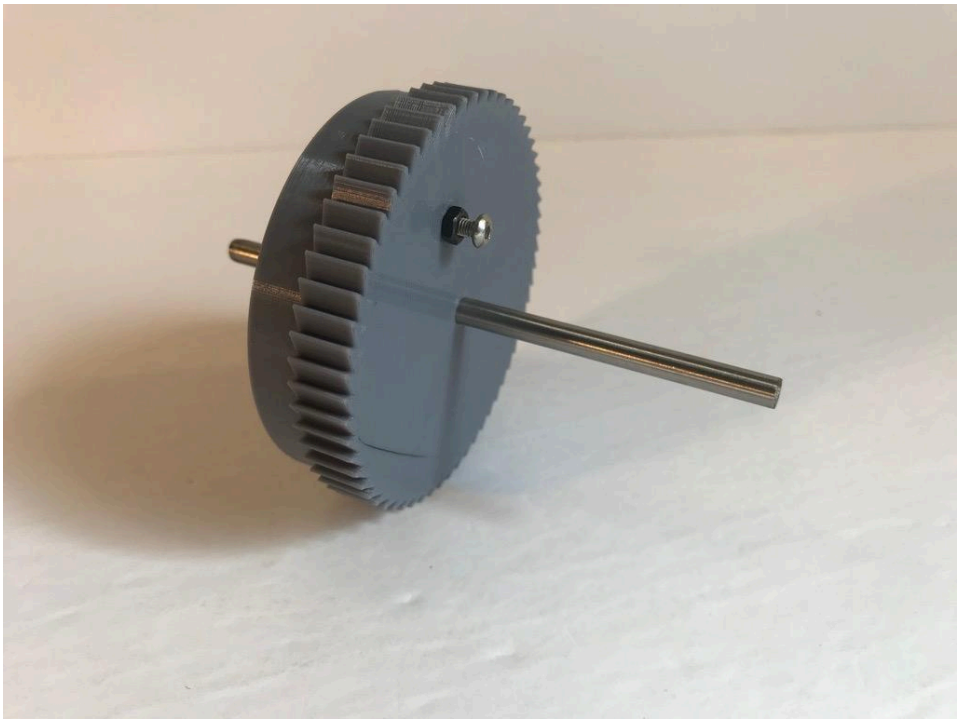
And hammer the rod in the gear until the rod is flush with the front of gear



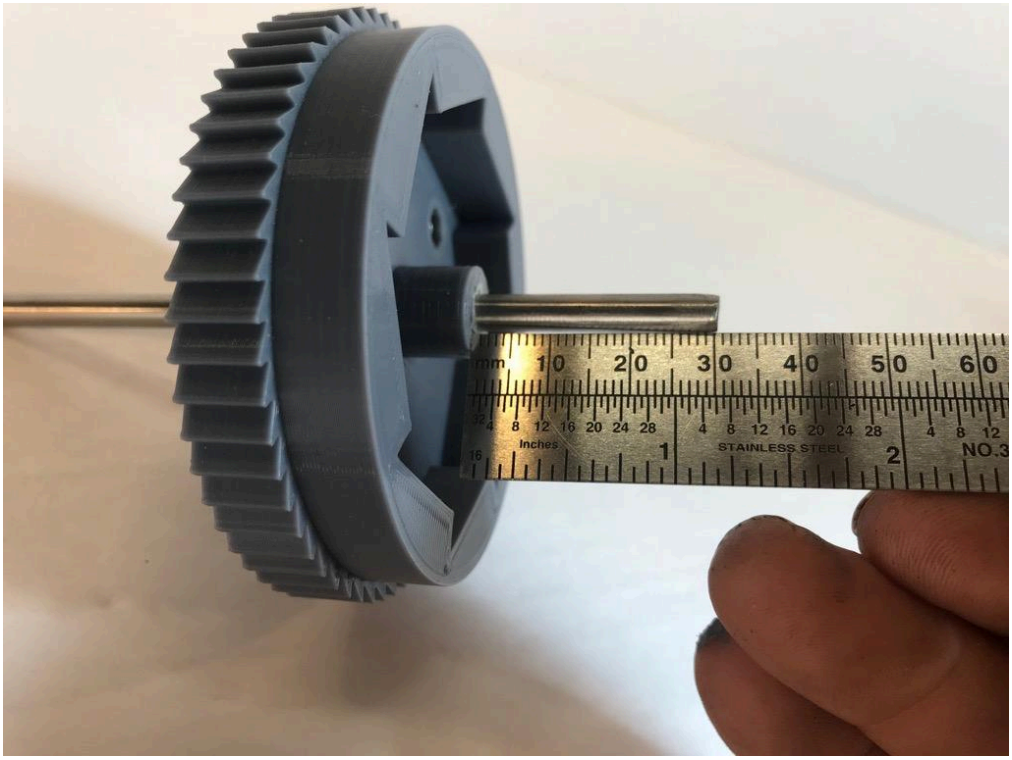
Maintain power

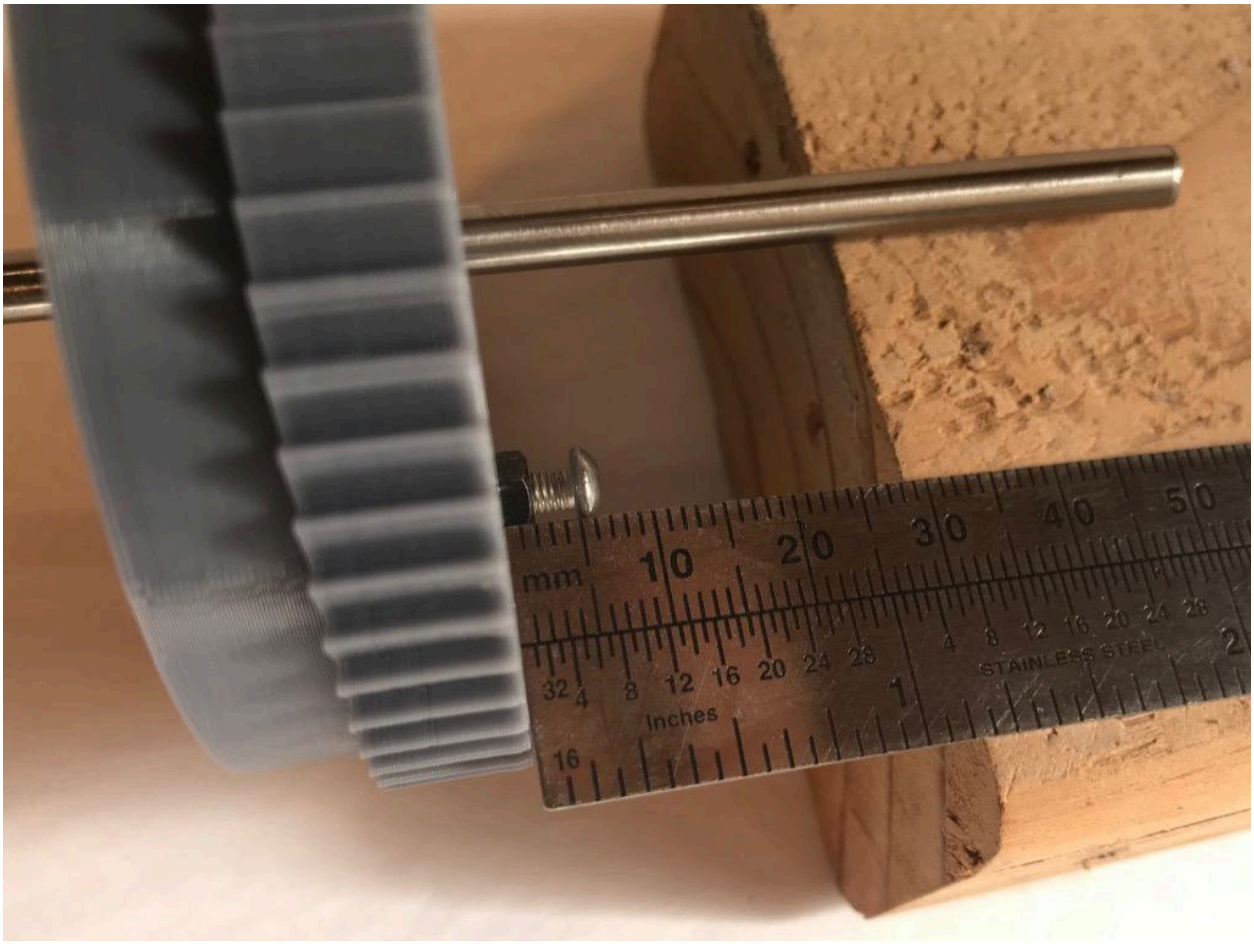


Maintain disk, 5mm rod, 106 mm long
This is planned to have a tight fit

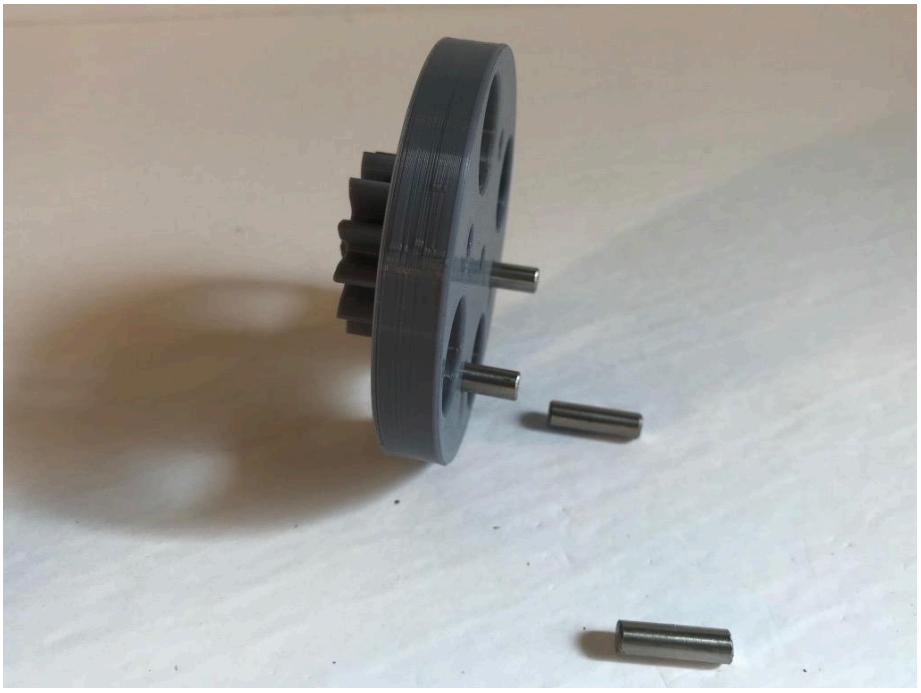


Distance to back end, above, and front, below

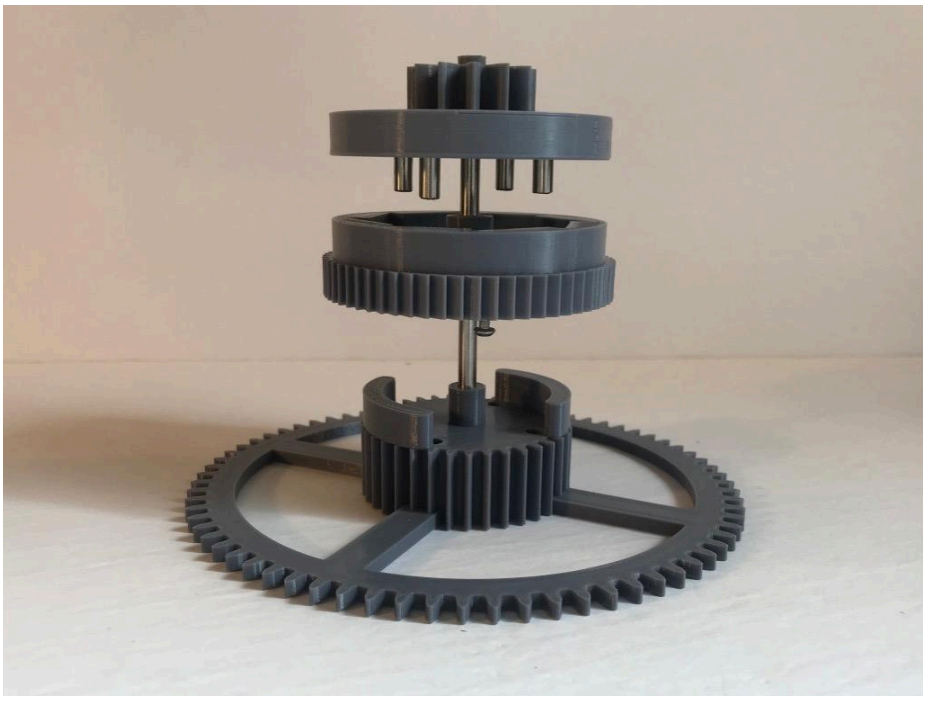




Install M3 x 12 screw with 2 nuts, one in front, one in back
Make sure the end of screw does not stick out inside the maintain disk and will not interfere with the rewinding ratchets



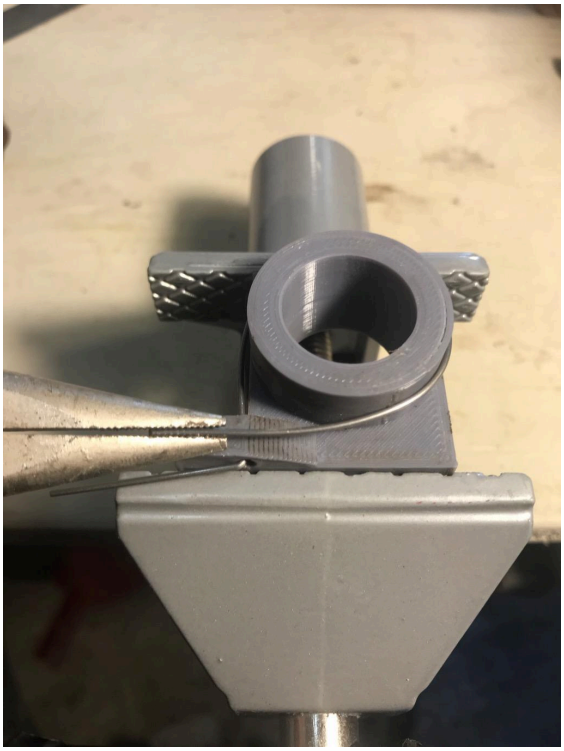
Install 4 ratchet pins on the gear 12 , 5mm x 18 mm, glue in if loose fit



Presenting all parts together
The maintain disk, in the middle is tight fit
The gears are a loose fit, they need to spin freely on shaft
Also check that the bolt in the maintain spring does not rub the cheecks

Maintain Spring

1 mm piano wire, shaping tool

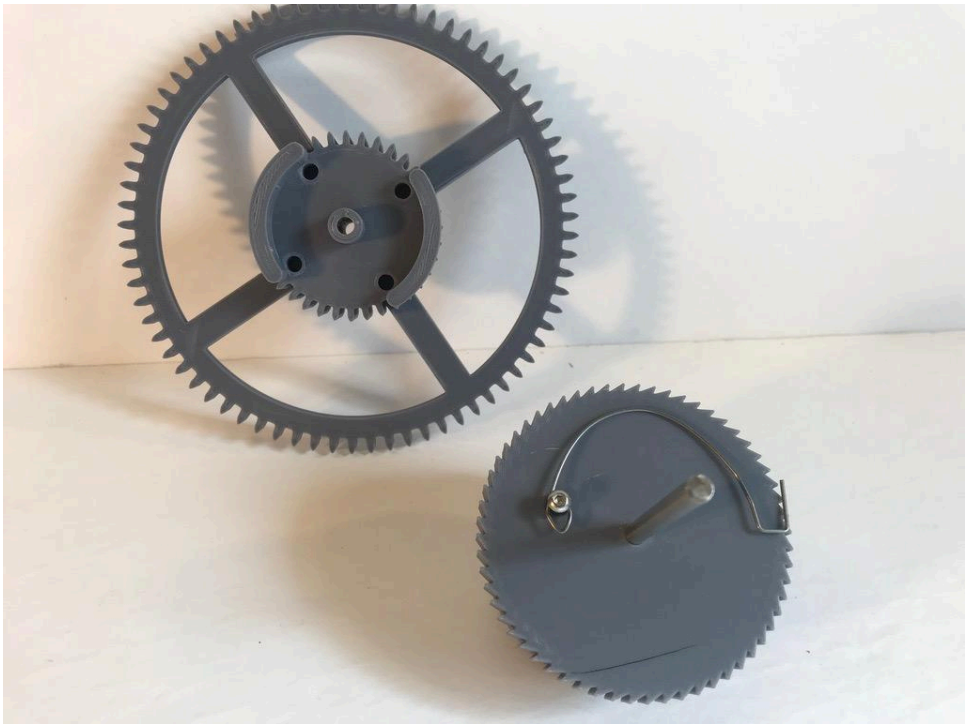


Using the tool, bend the 1mm piano wire ¾ of a loop, about 80 mm in length, then make a loop

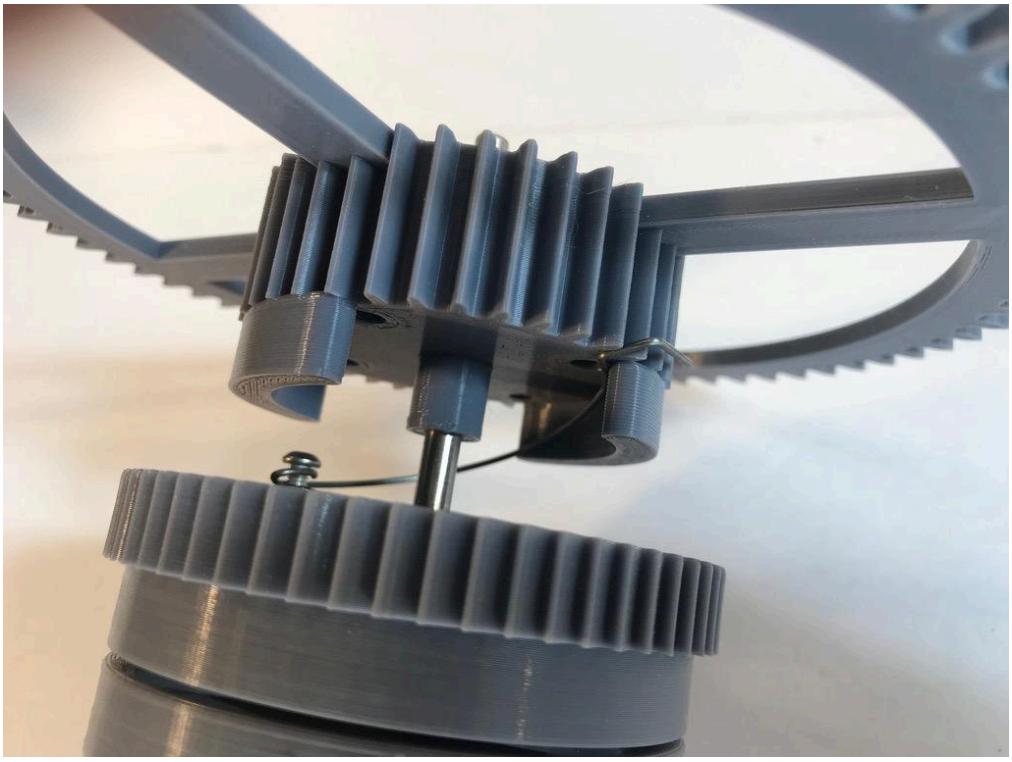
One end will have a loop that engage the bolt
It is good idea to make loop small enough, so that the spring will not fall off the bolt
The other end a hook to engage with the gear 72-30
The over bend in the spring is the result of mishandling the weight and dropping it, and as a result overwinding the spring
Still works fine, the mechanism is quite resilient

Install maintain spring

View of all parts, including the rewind ratchets and maintain spring

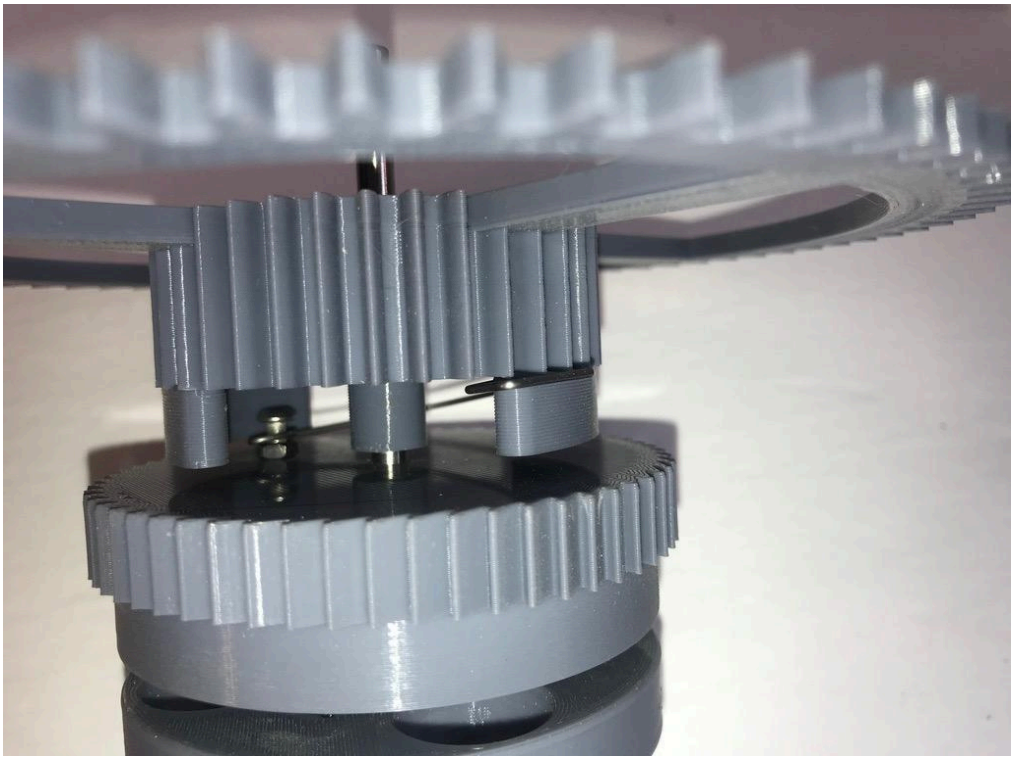


Maintain spring in place

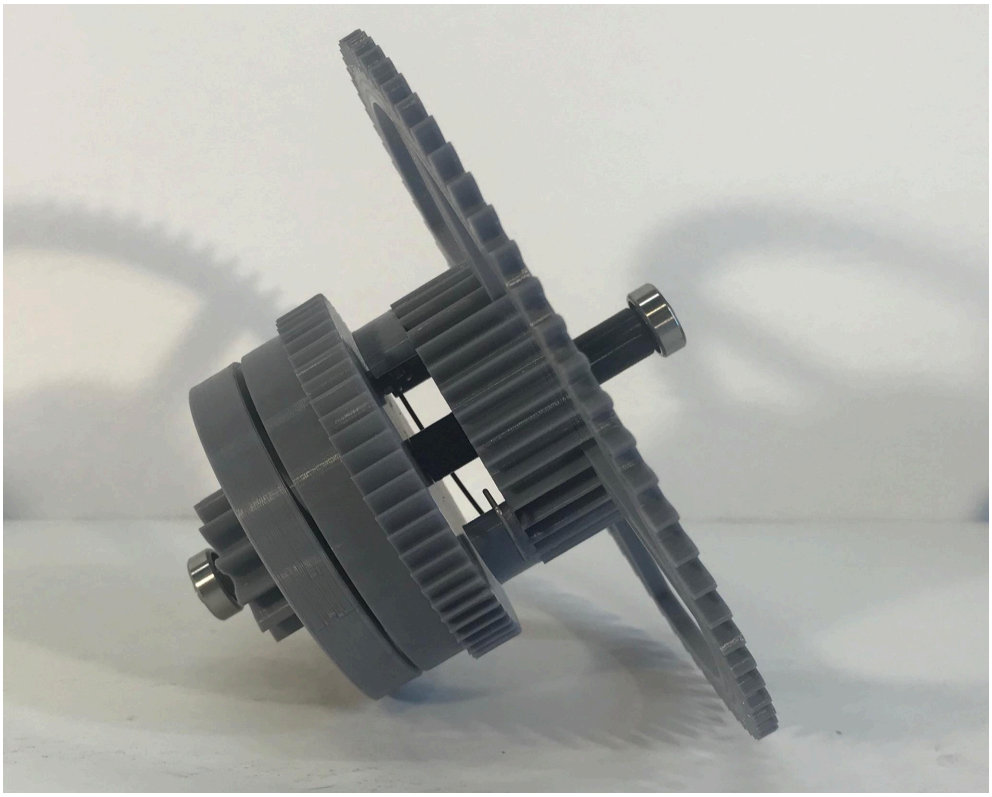


Close up view on maintain spring placement

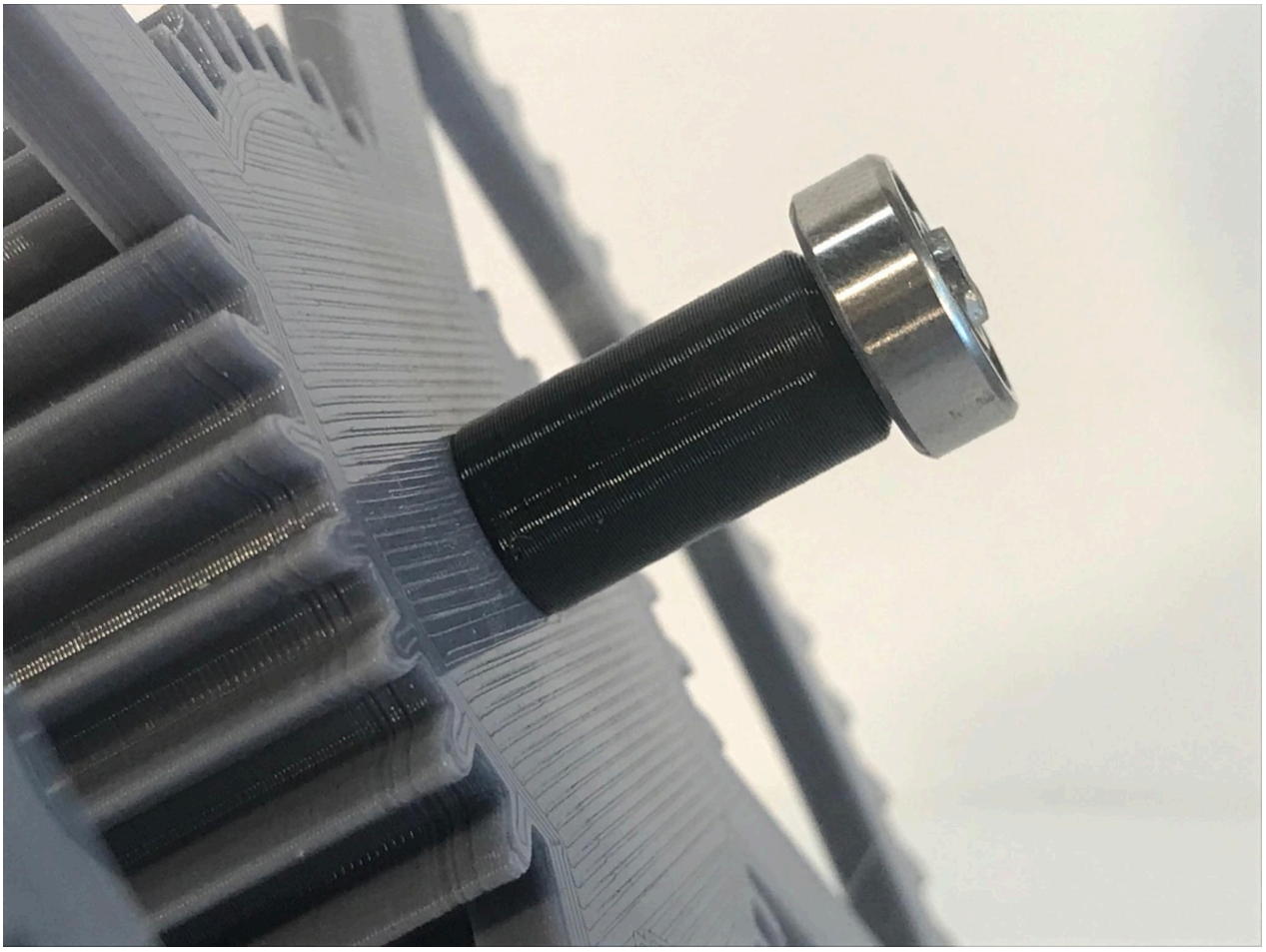
Engage the loop in the gear and slowly rotate the gear to slightly wind up the spring until it sit inside the two cheeks



Maintaining power spring close up

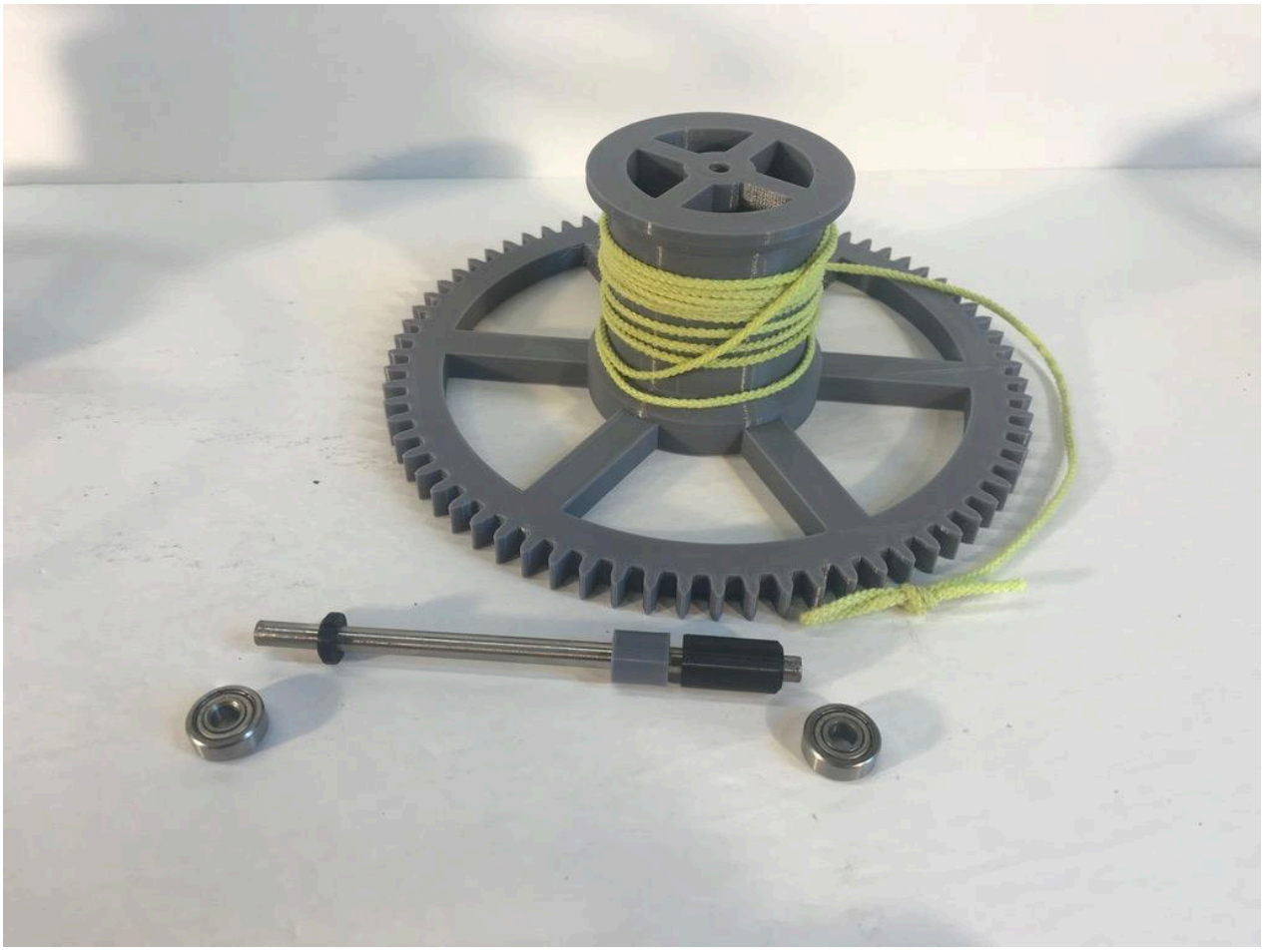


Maintaining power device ready to install with spacer 16 and bearings

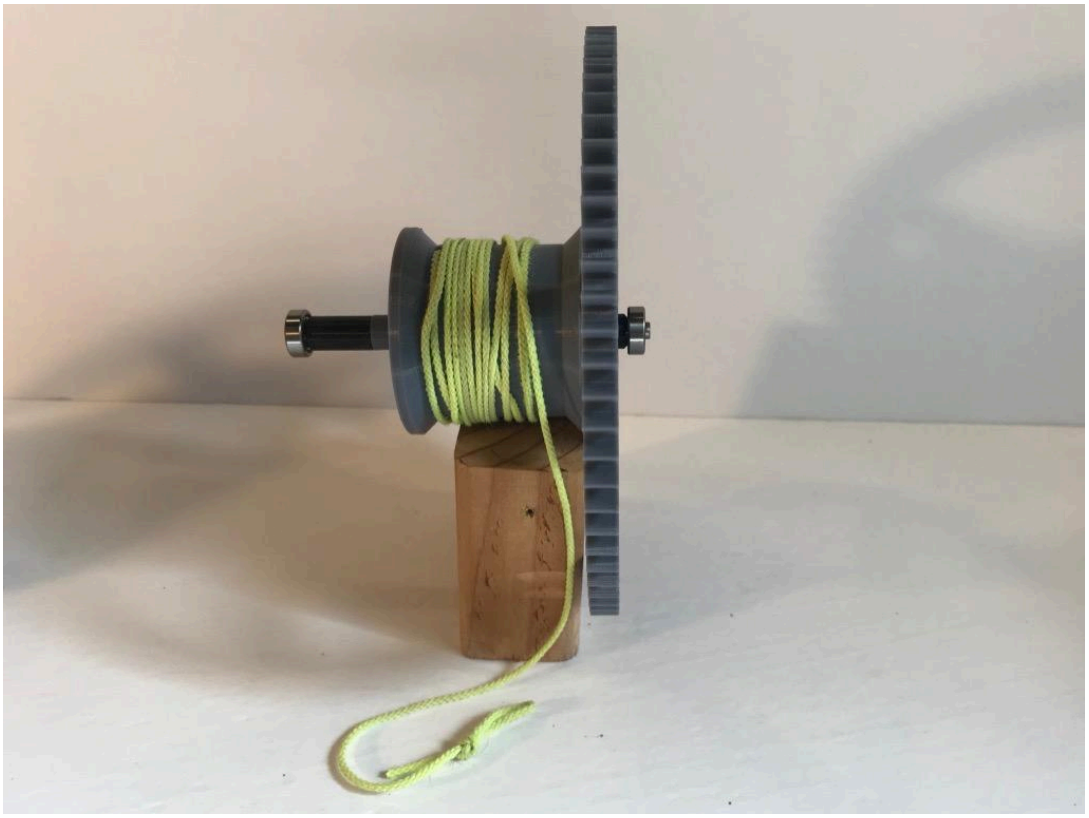


Close up on placement of spacer 16, notice tapered end toward bearing

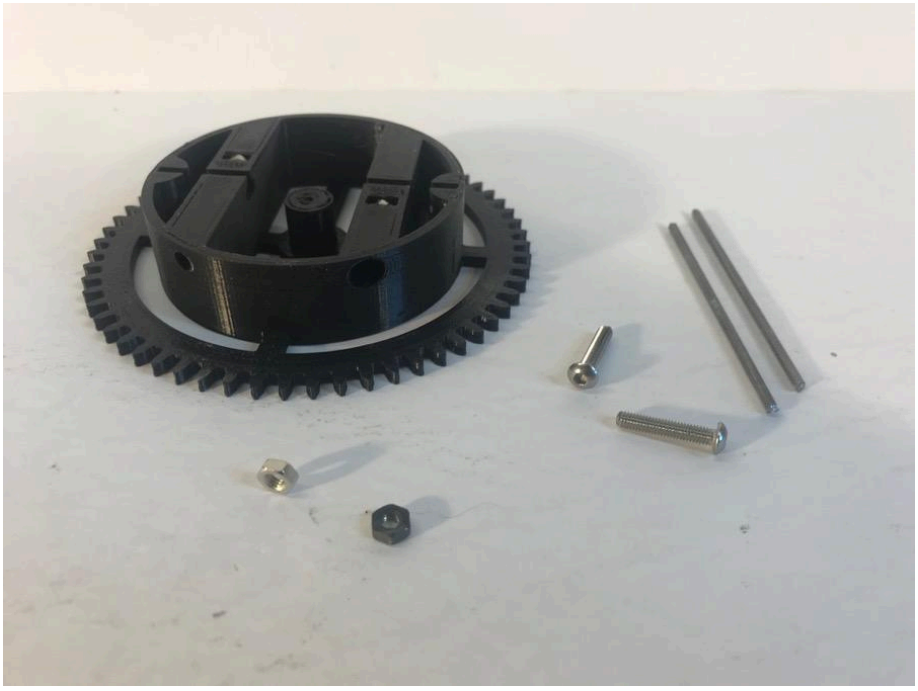
Drum gear



5 mm arbor, 106 mm long
Drum and gear
1 short bushing, 4 mm, spacer 4
1 medium bushing, 11 mm, spacer 11
1 long bushing, 16mm, spacer 16
2 bearings
1 string



Clutch

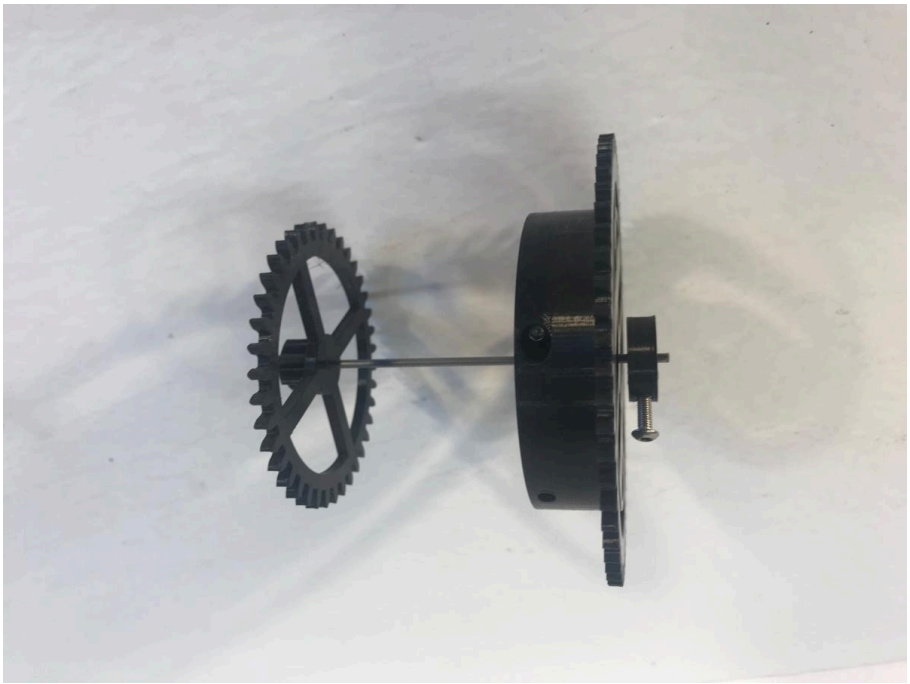


View of parts needed for the clutch
2x 2mm piano wire, 61 mm long
2x M3 x 15 screw and nuts

Installed rods and nuts, next install screws

Clutch stop ring

Ring, M3 x 12 screw and nut



Clutch complete

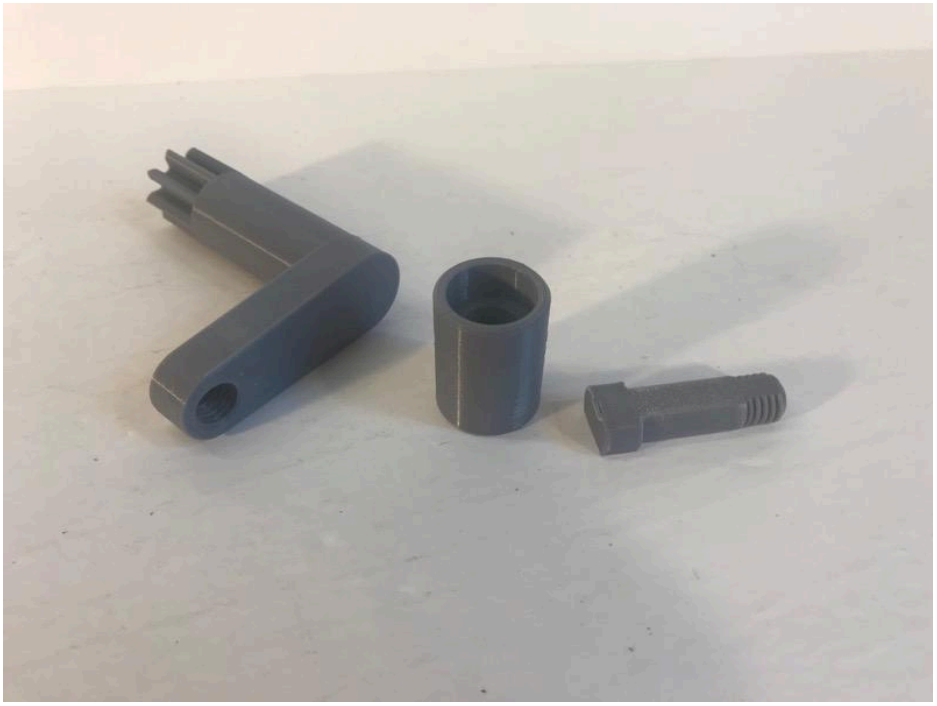
Hands

All parts, hour and minute gear and hands, 38 mm rod, knob

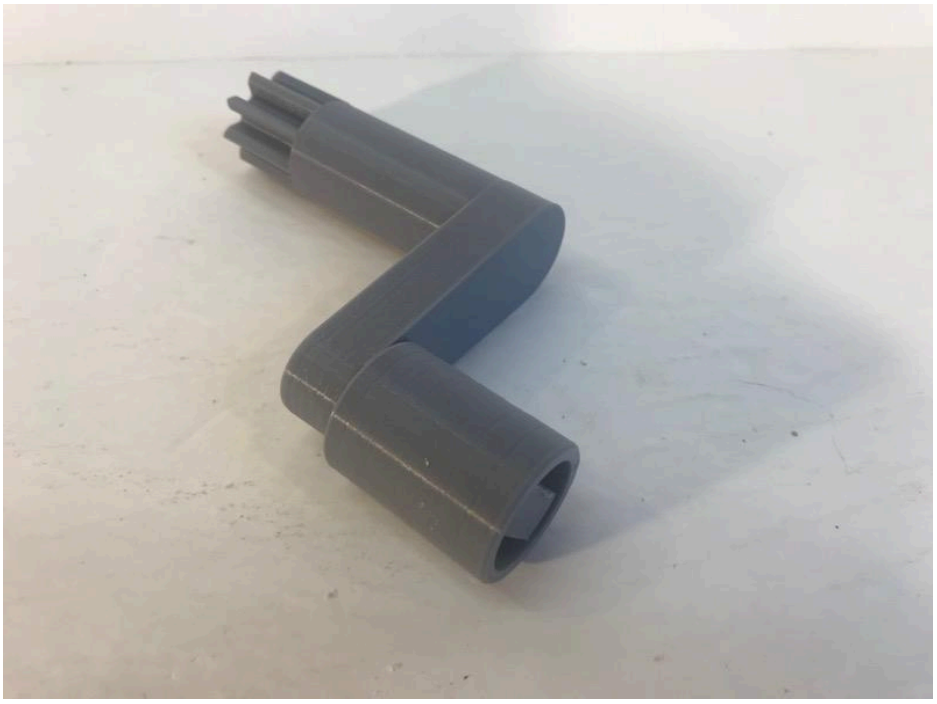
Install knob on 38 mm shaft
Test loose fit of hour gear on minute gear and shaft in minute gear

Hands assembly complete

Rewind Key



Parts of the rewind key
Gear 8 rewind
Screw
Barrel

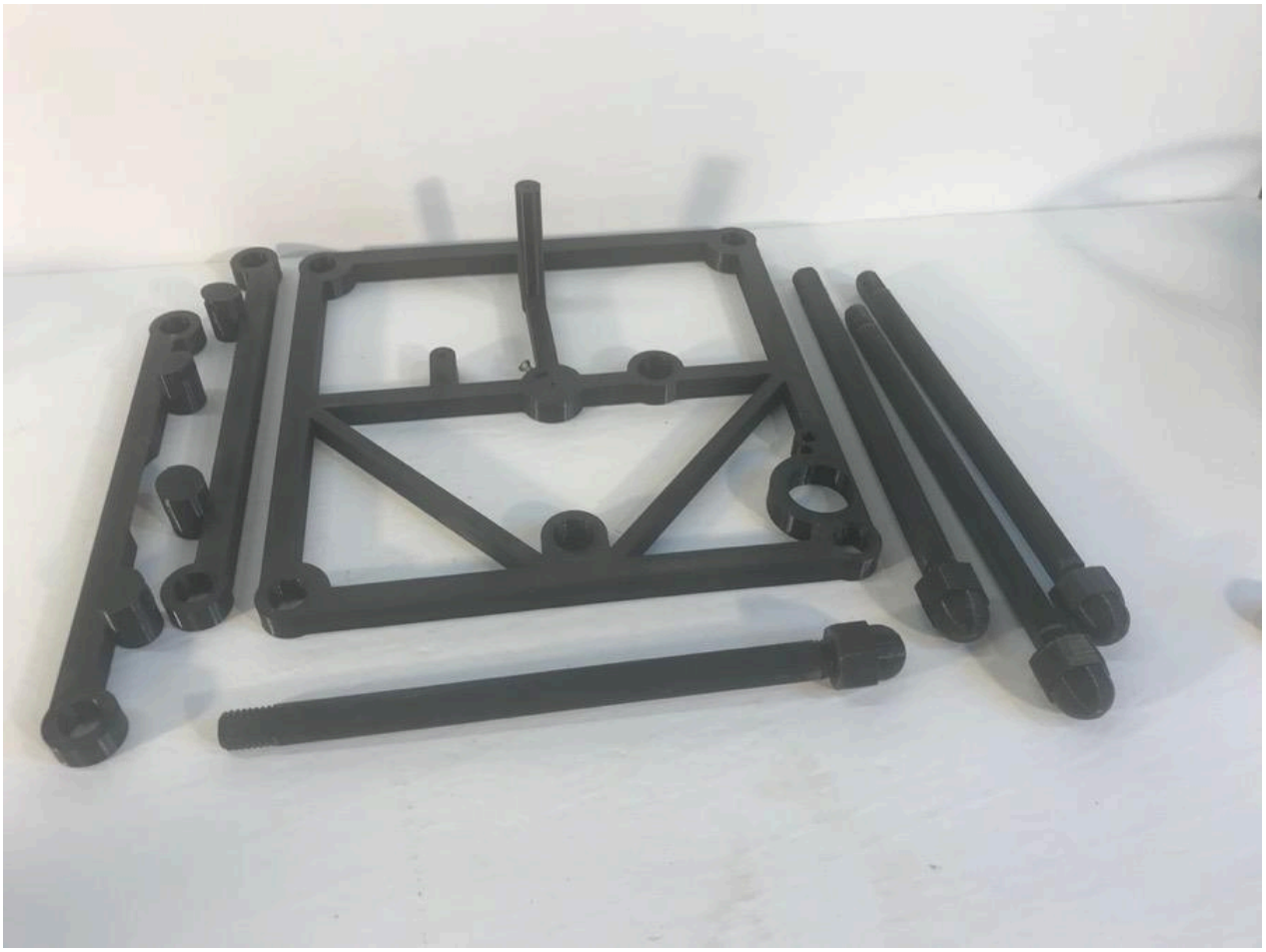


Rewind key assembled

Assembly

Powertrain and Escapement

Front Frame, Face holders, Studs



Front Frame
Studs and Acorn nuts, 4 pieces
Face holders, 2 pieces

Engage studs thru face holders then front face

Side frames

Install left frame with rewind stop and maintain power ratchet

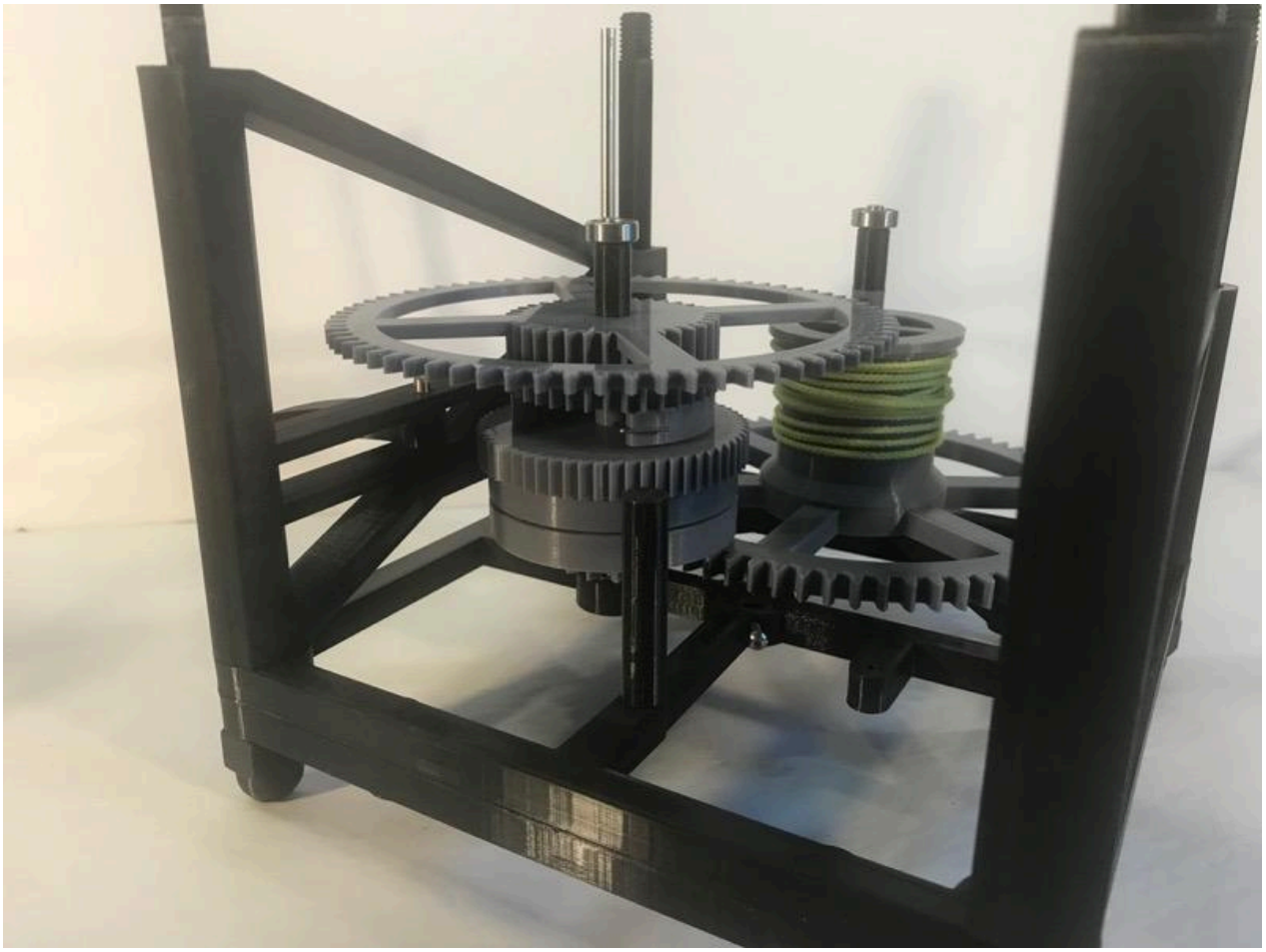
Install right frame

View on rewind stop and maintain ratchet

Drum Gear

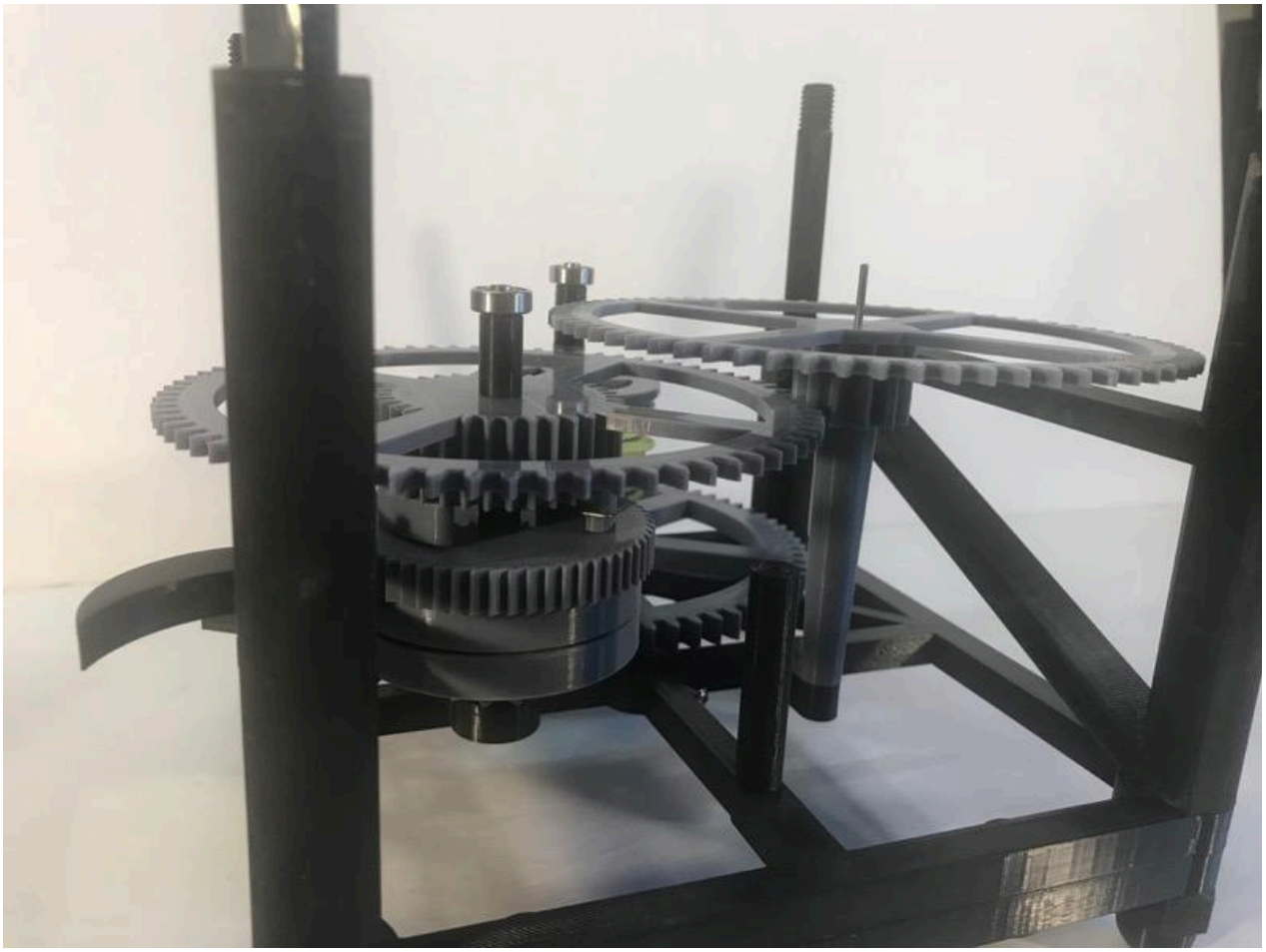
Install drum gear assembly

Maintain Power Assembly



Install maintain gear assembly

Middle Gear



Install middle gear and 2mm piano wire

Add a 2 mm washer on top of gear

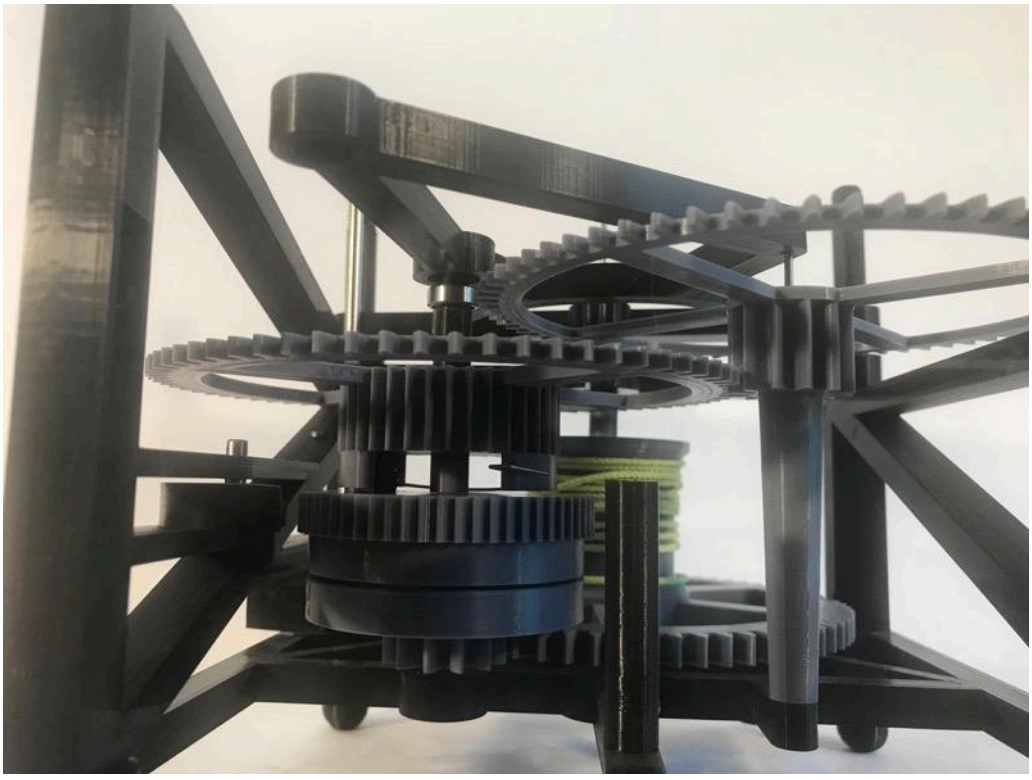
Front Escapement Frame

Front escapement frame

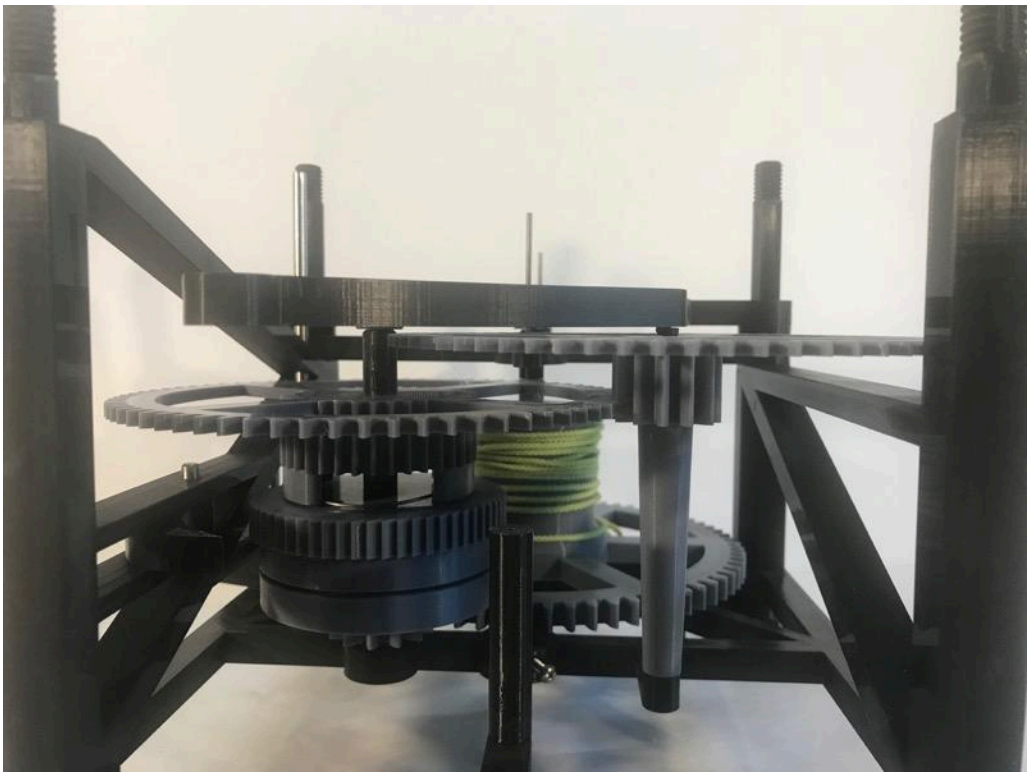
Install front escapement frame

Back frame

Install back frame



Align bearings and shaft with respective holes



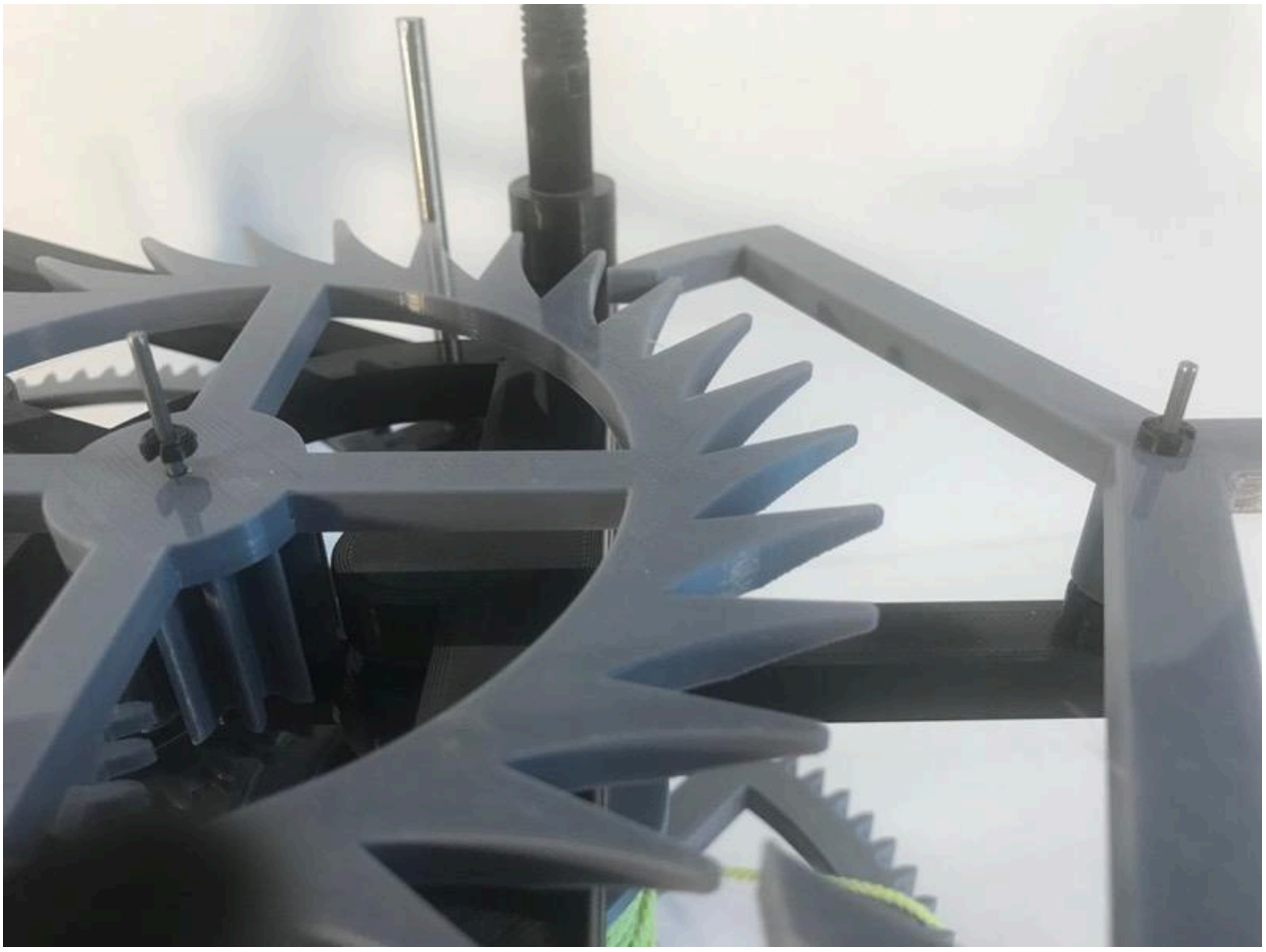
Check clearances and absence of biding

Escape wheel

Install the escape wheel with the 53 mm shaft

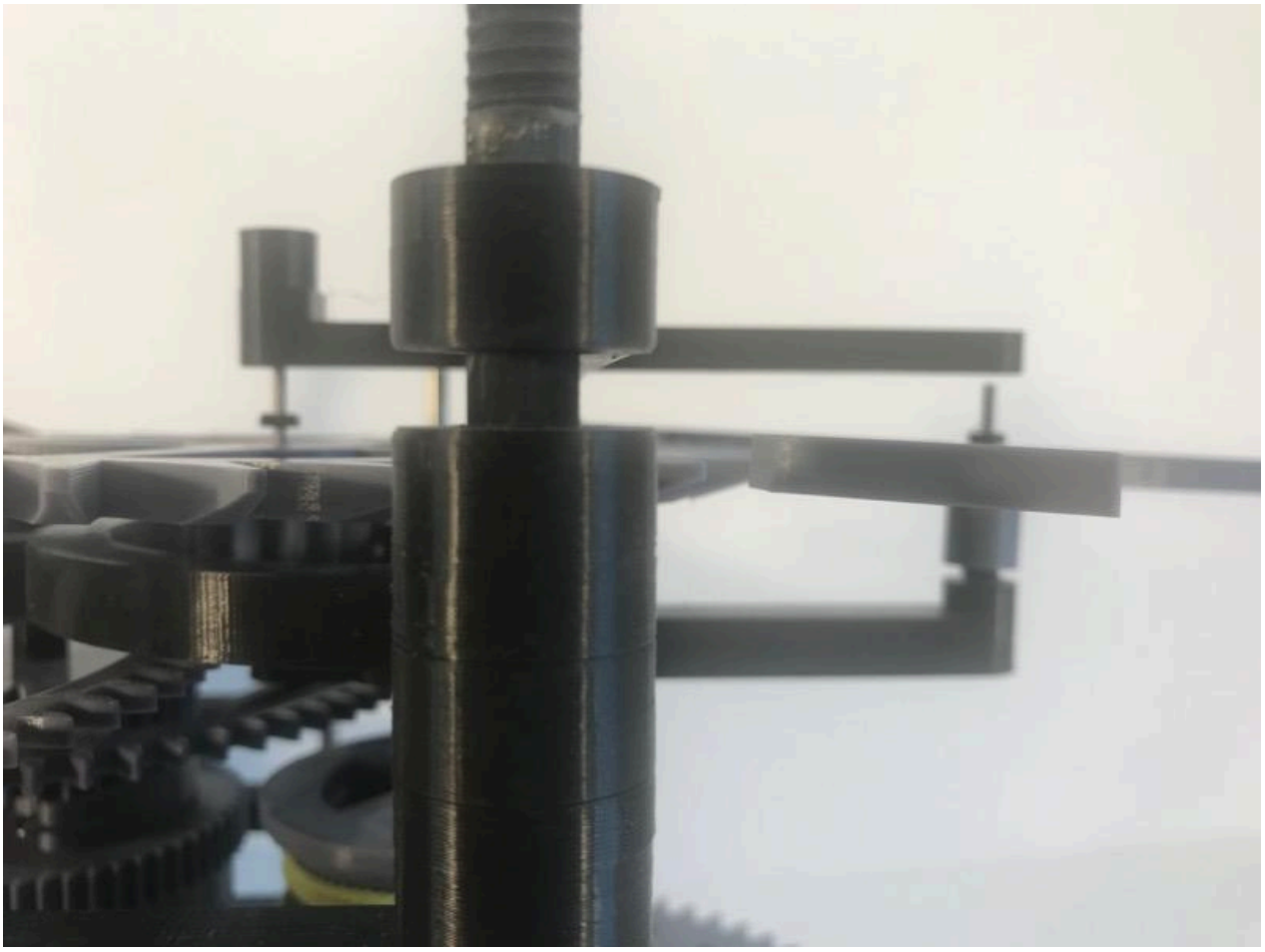
Anchor

Install the anchor on the 46 mm, 2mm rod and 2mm washer on each side

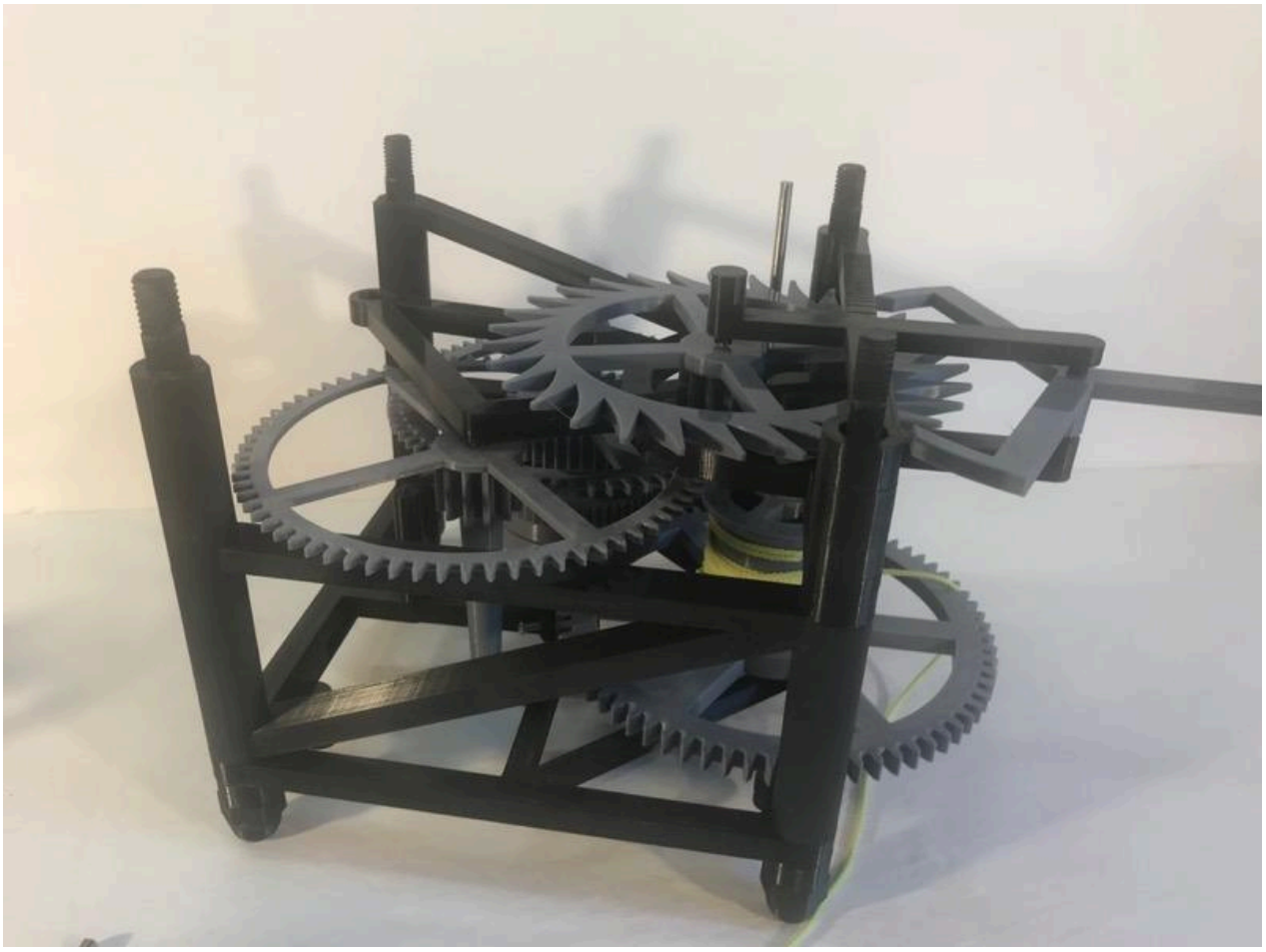


Install the anchor
Install another 2 mm washer on the back of escape wheel

Back frame escapement

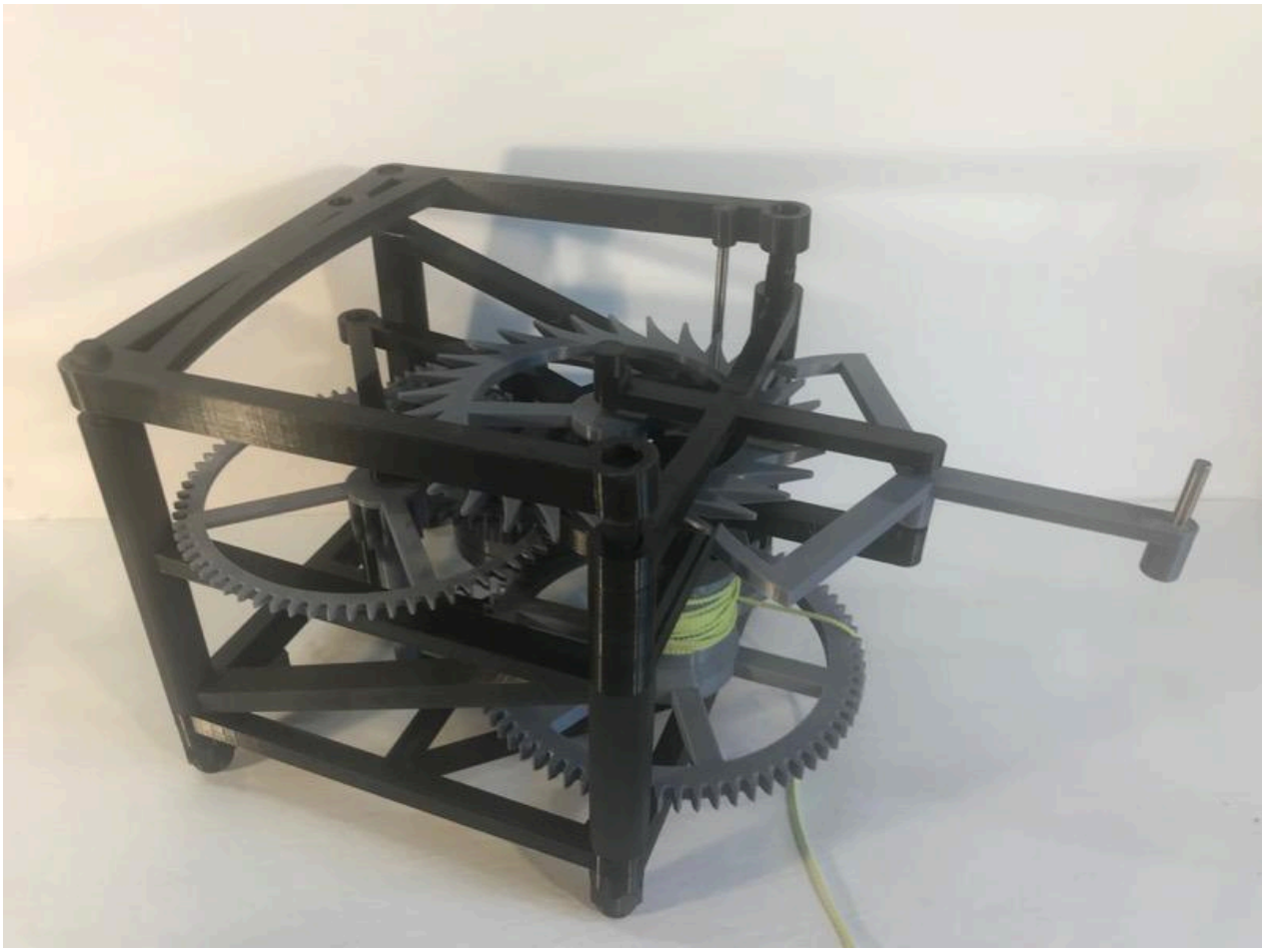


Install back escapement frame and line up the shafts

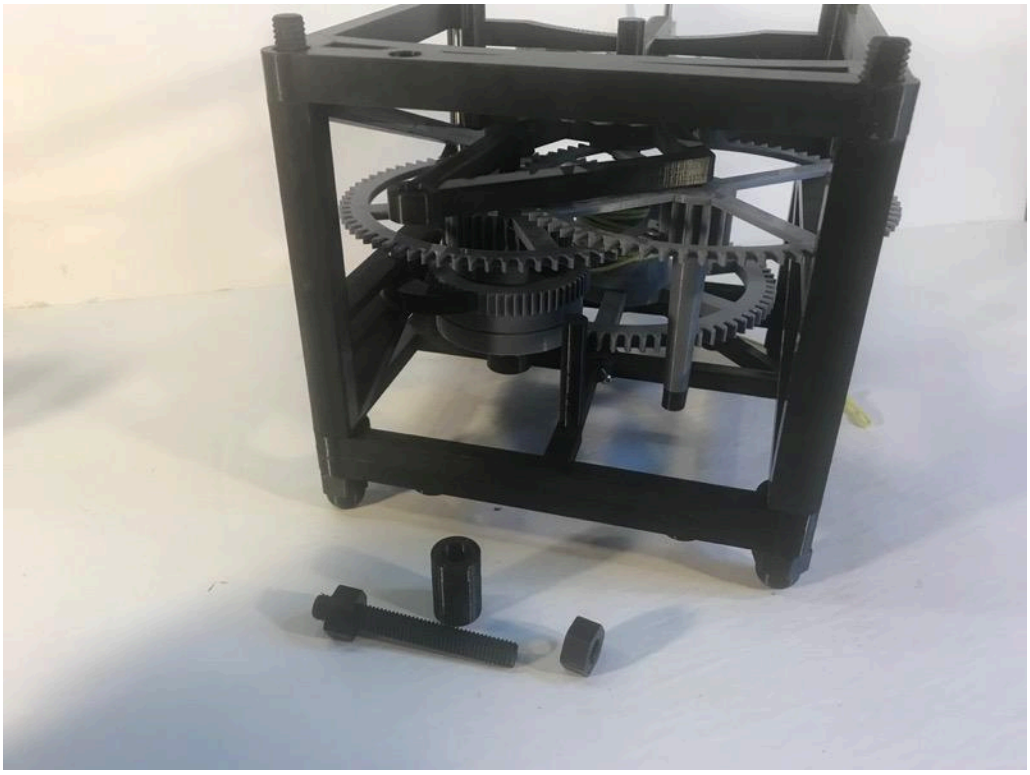


Check for no binding and test function of anchor and escape wheel

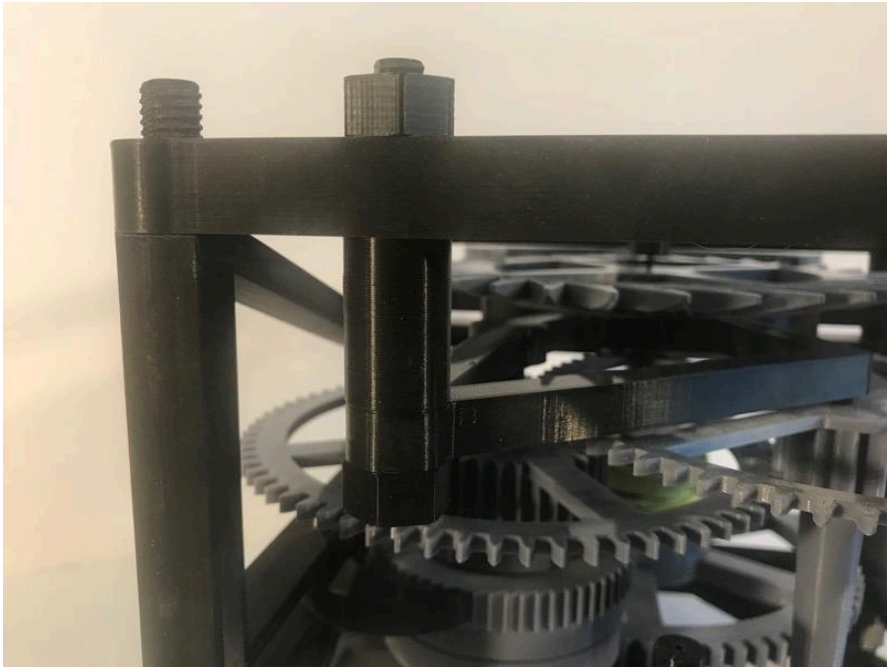
Frame support

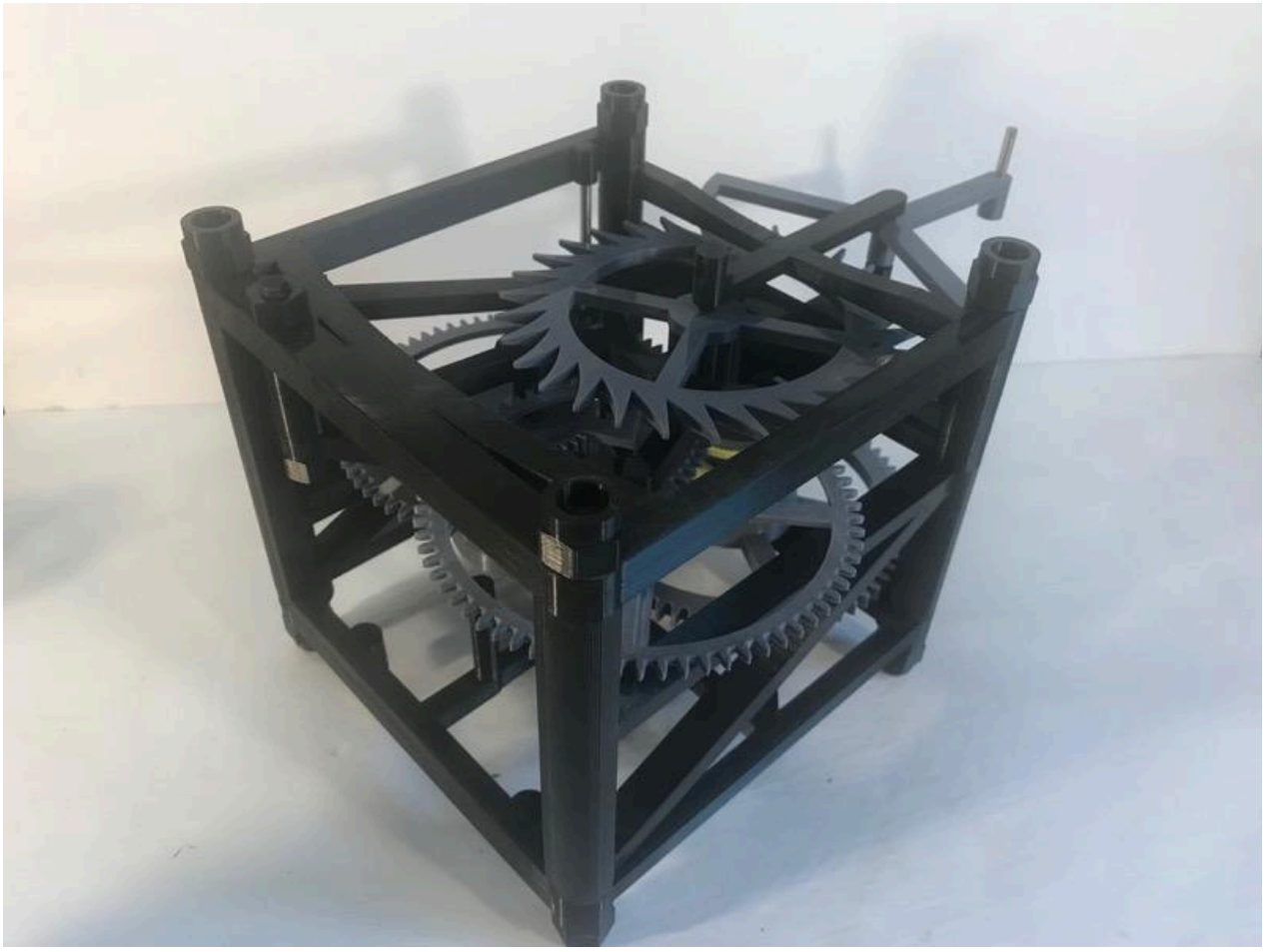


Install frame support



Install back frame to frame support rod, spacer and nut

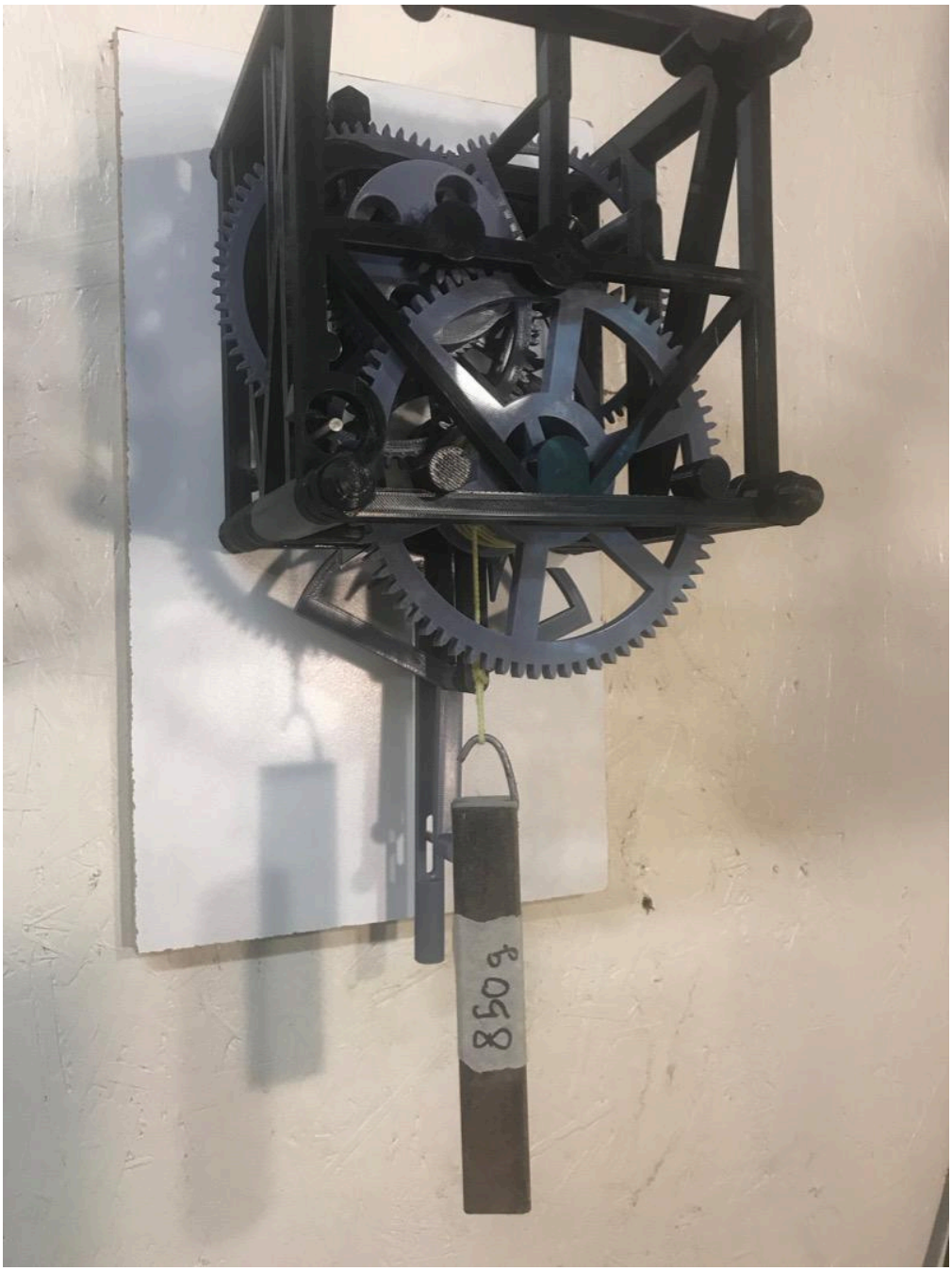




Instal nuts at all 4 corners

Check fit of pendulum crutch

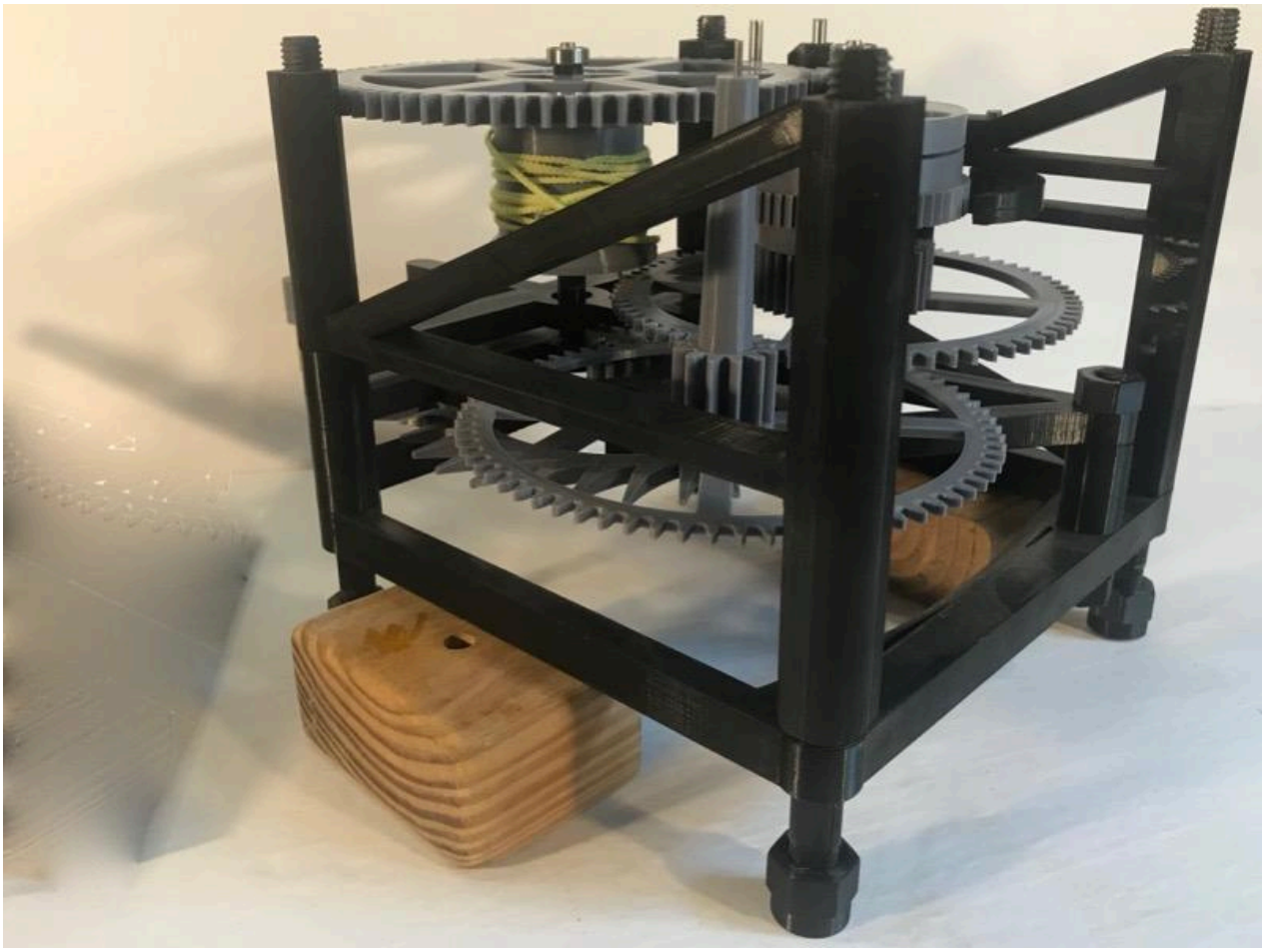
Test 1



Check function by increasing the weight
Install a temporary rod as a pendulum
I could run my clock with the weight shown
The finished clock will need more weight to be reliable

Test rewinding

Finishing the Front Frame



Disassemble the front of clock and remove the front frame
Raise back frame on blocks
Push out studs

Install gears and hands on frame

Install The gear 39-6 with a 2 mm washer between it and the frame

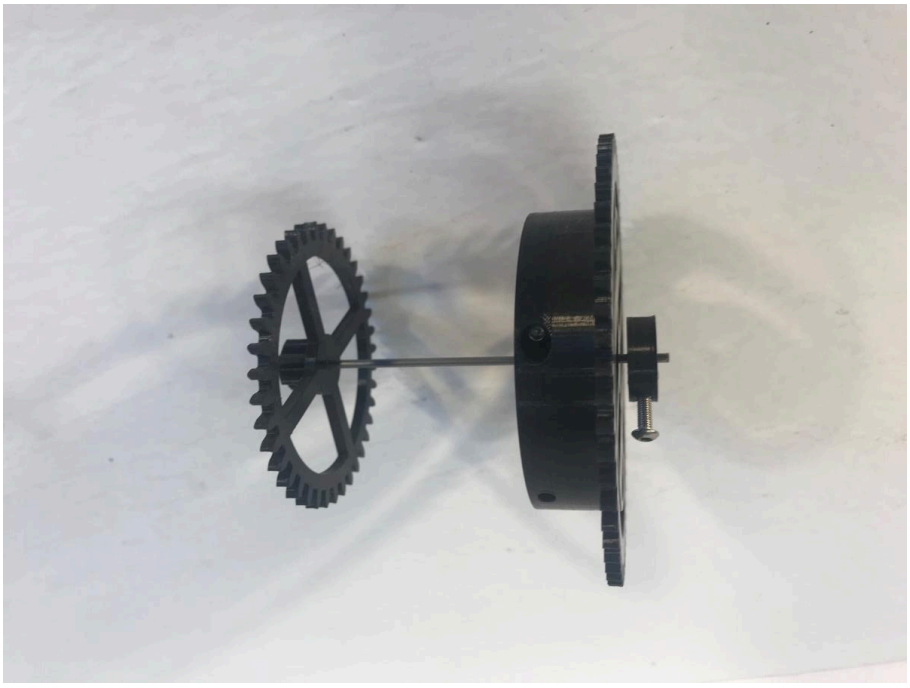
Install the hands assembly
Remember to install a 2 mm washer between frame and gears so both 39 teeth gears are aligned
Check meshing of gears

Front view

Clean out any unwanted blobs of filament

Secure hands shaft screw

Install clutch and stop ring

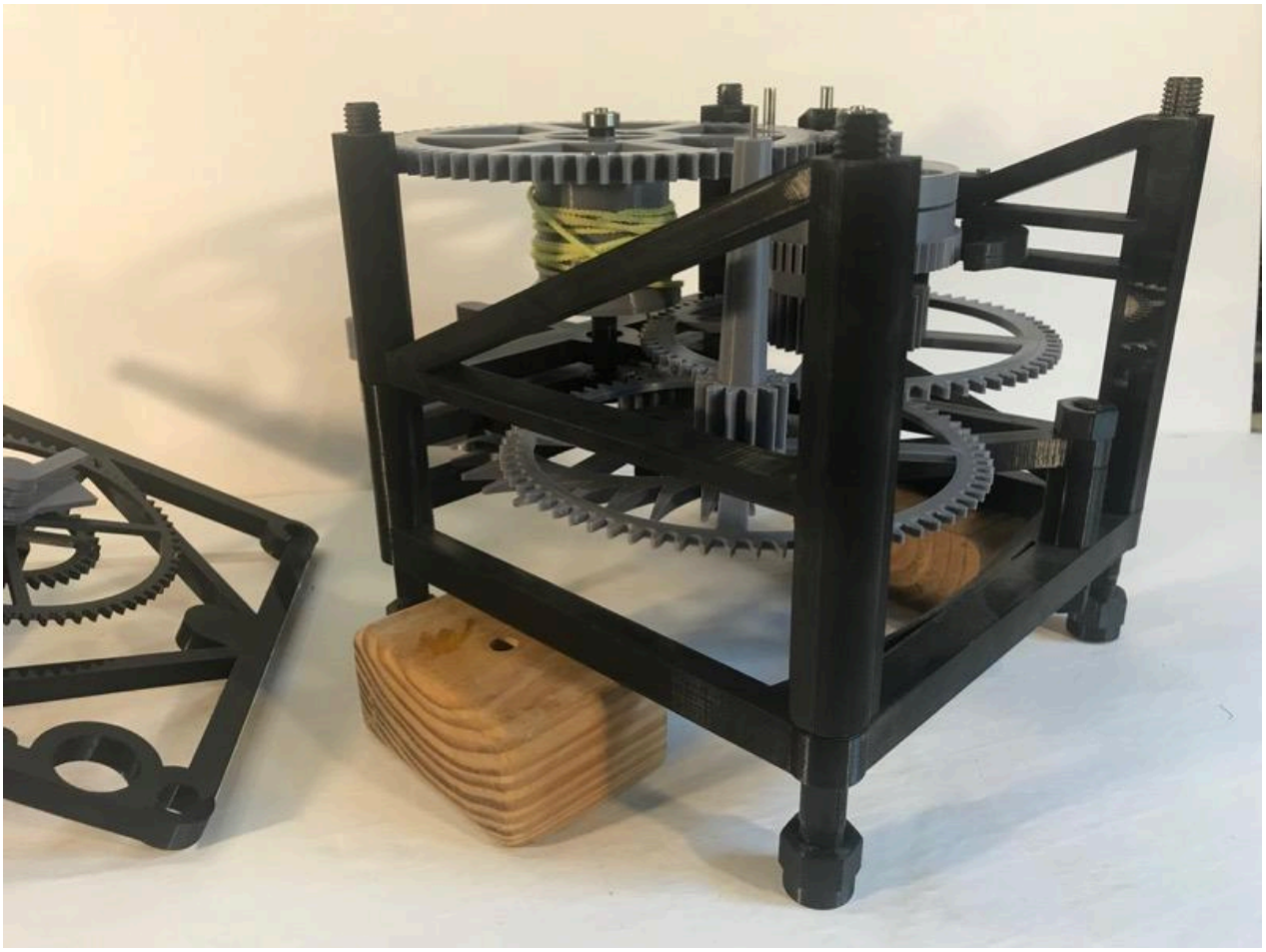


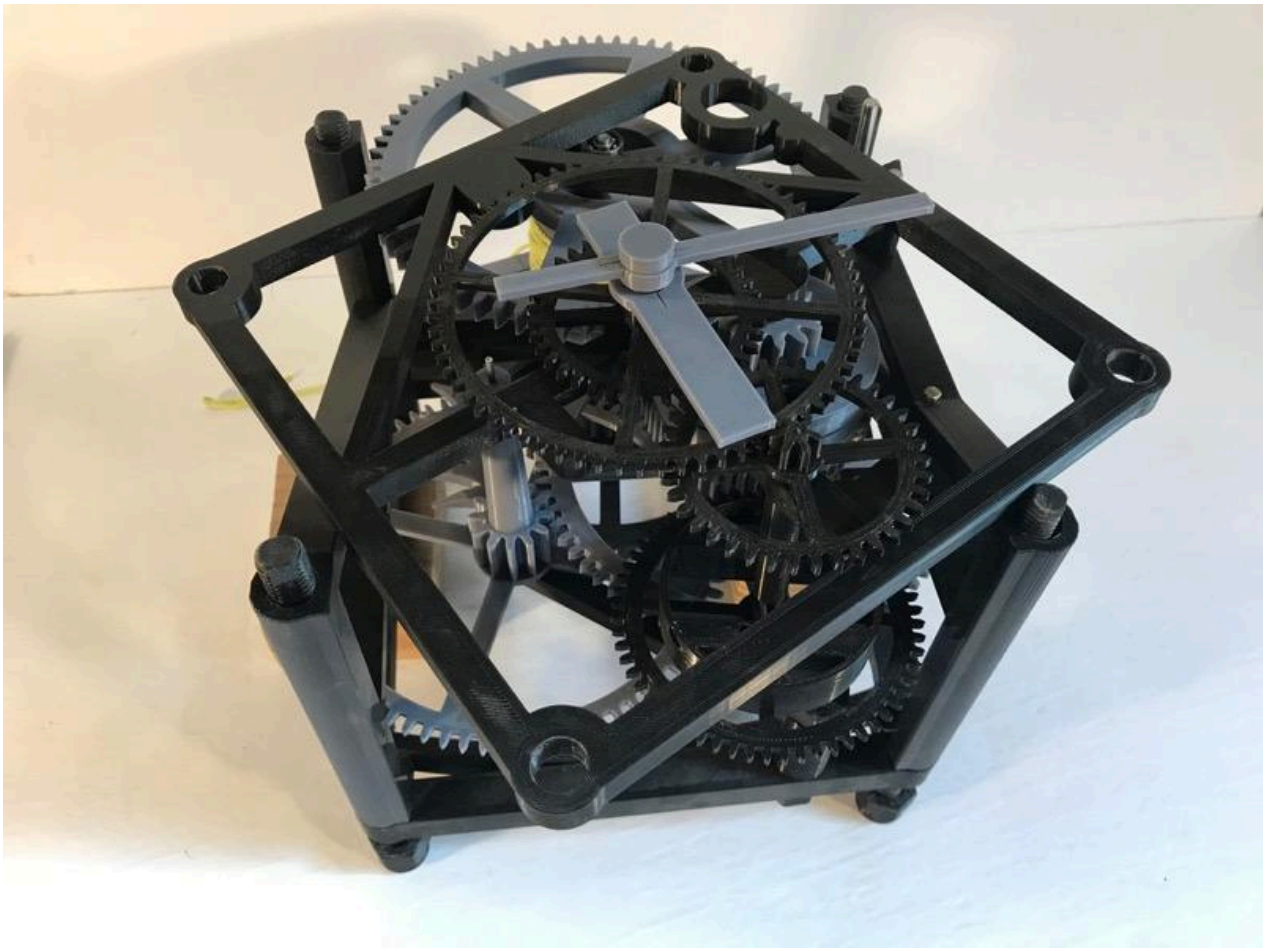
Clutch orientation shown without frame

And on frame

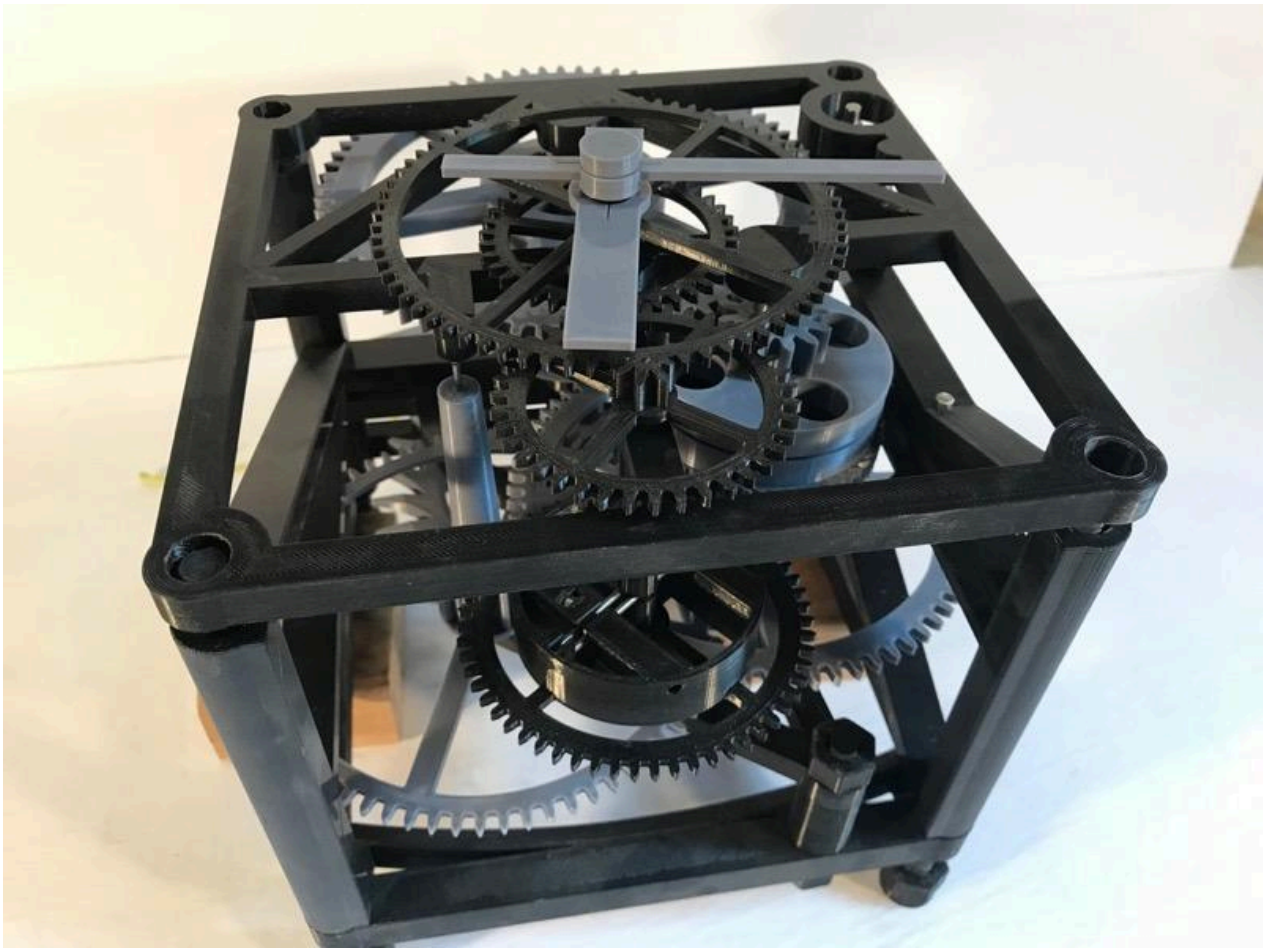
Secure stop ring

Install front frame on clock

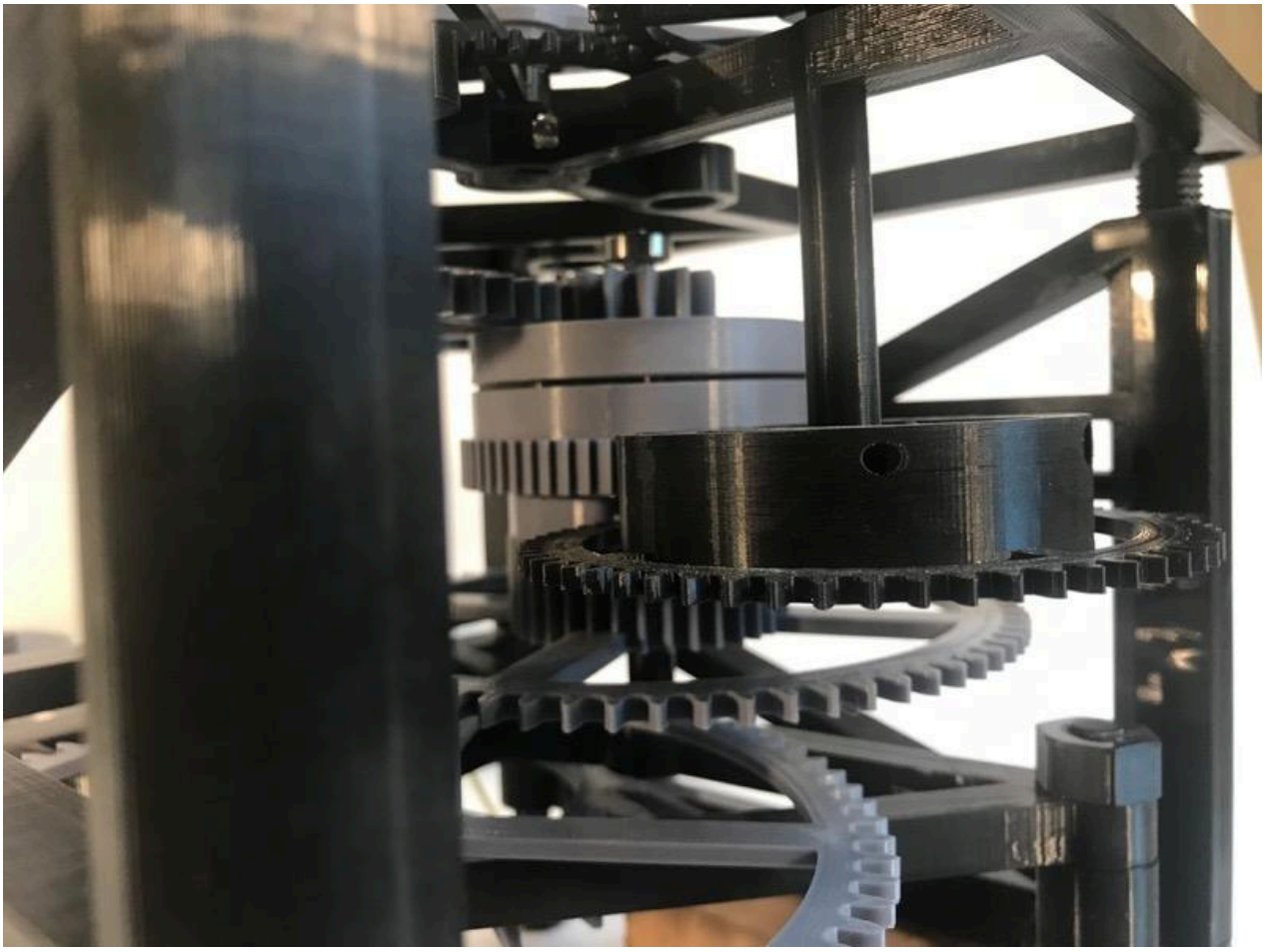


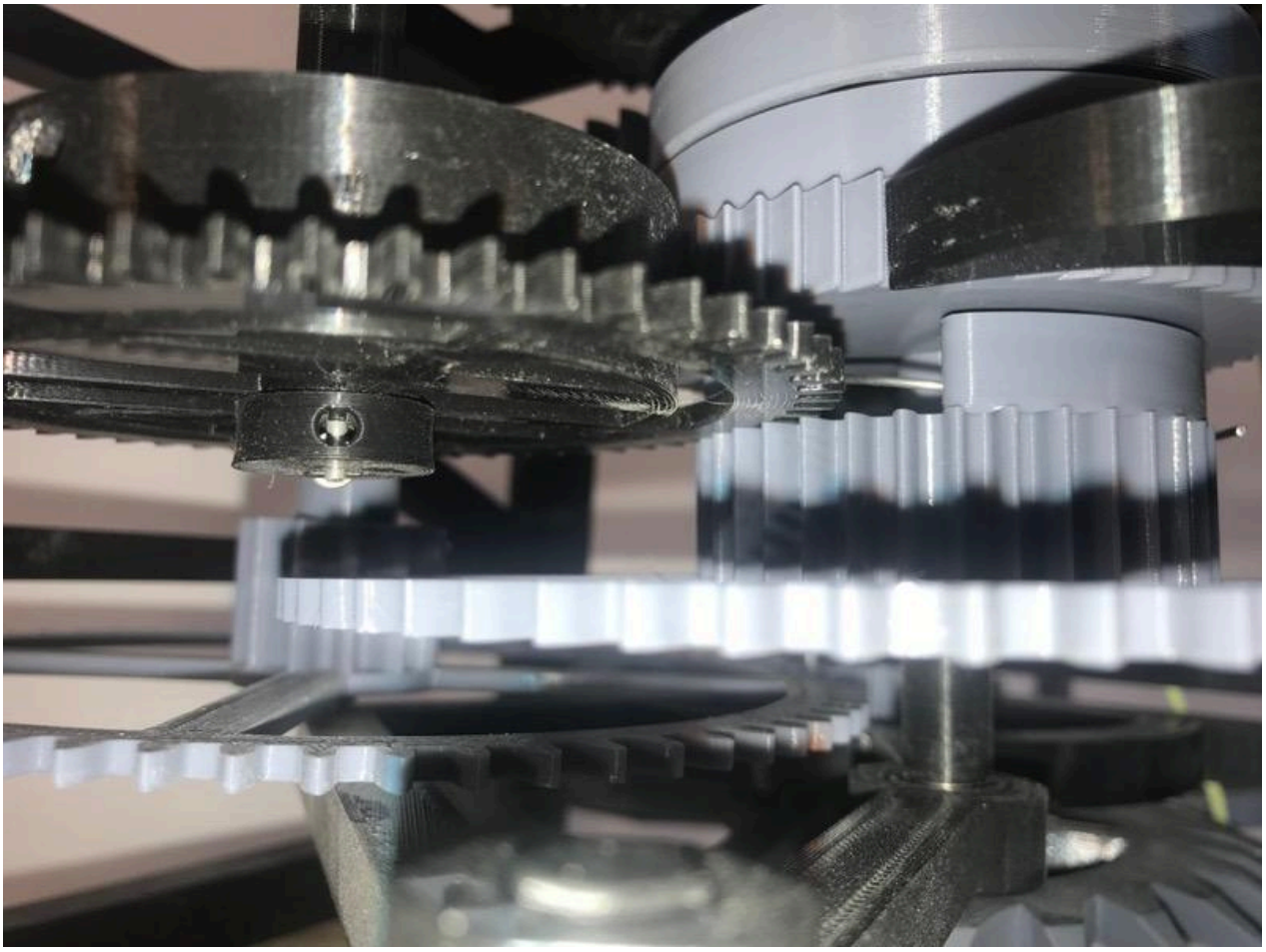


Position frame at an angle

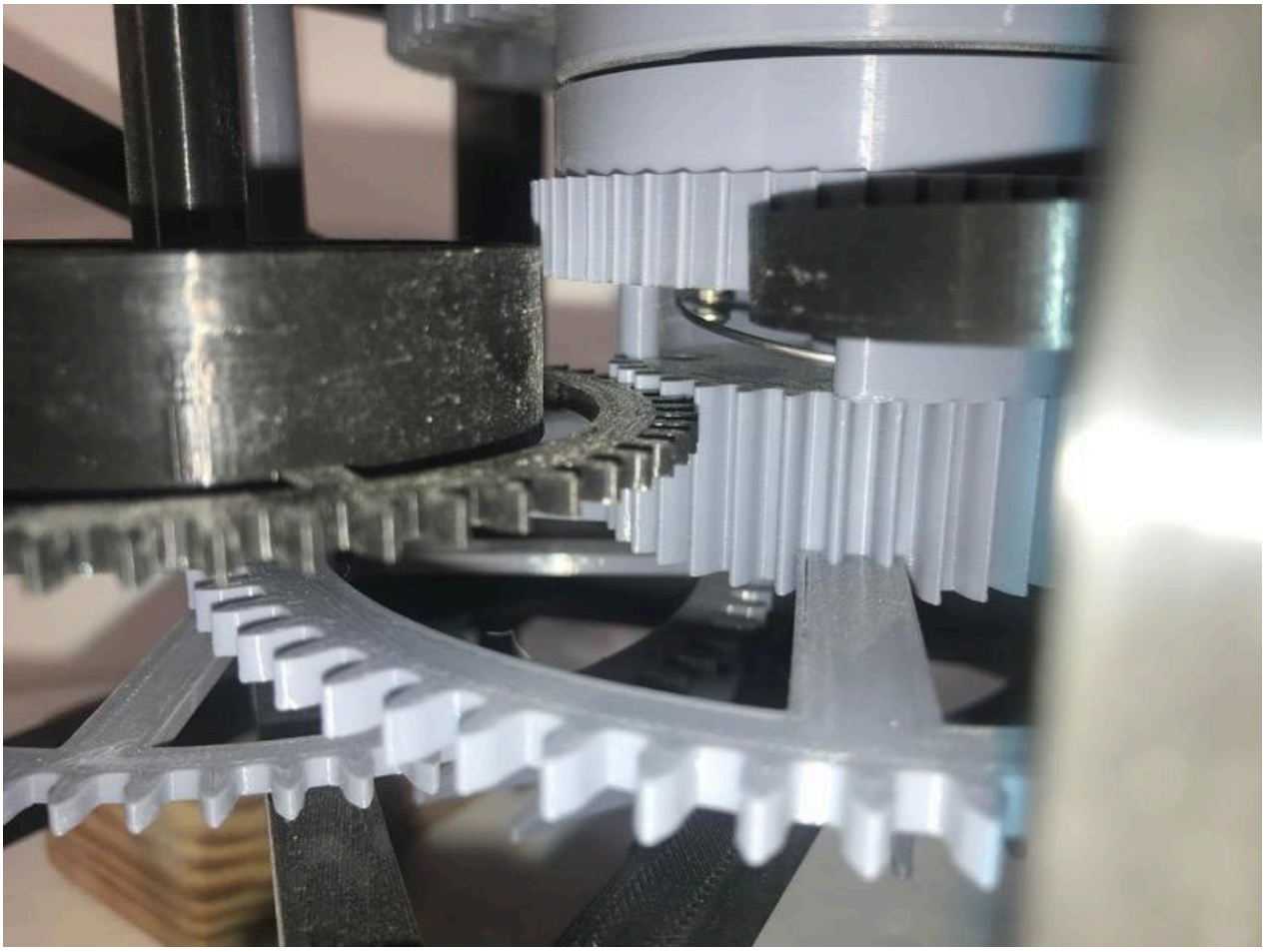


Rotate and engage clutch gear

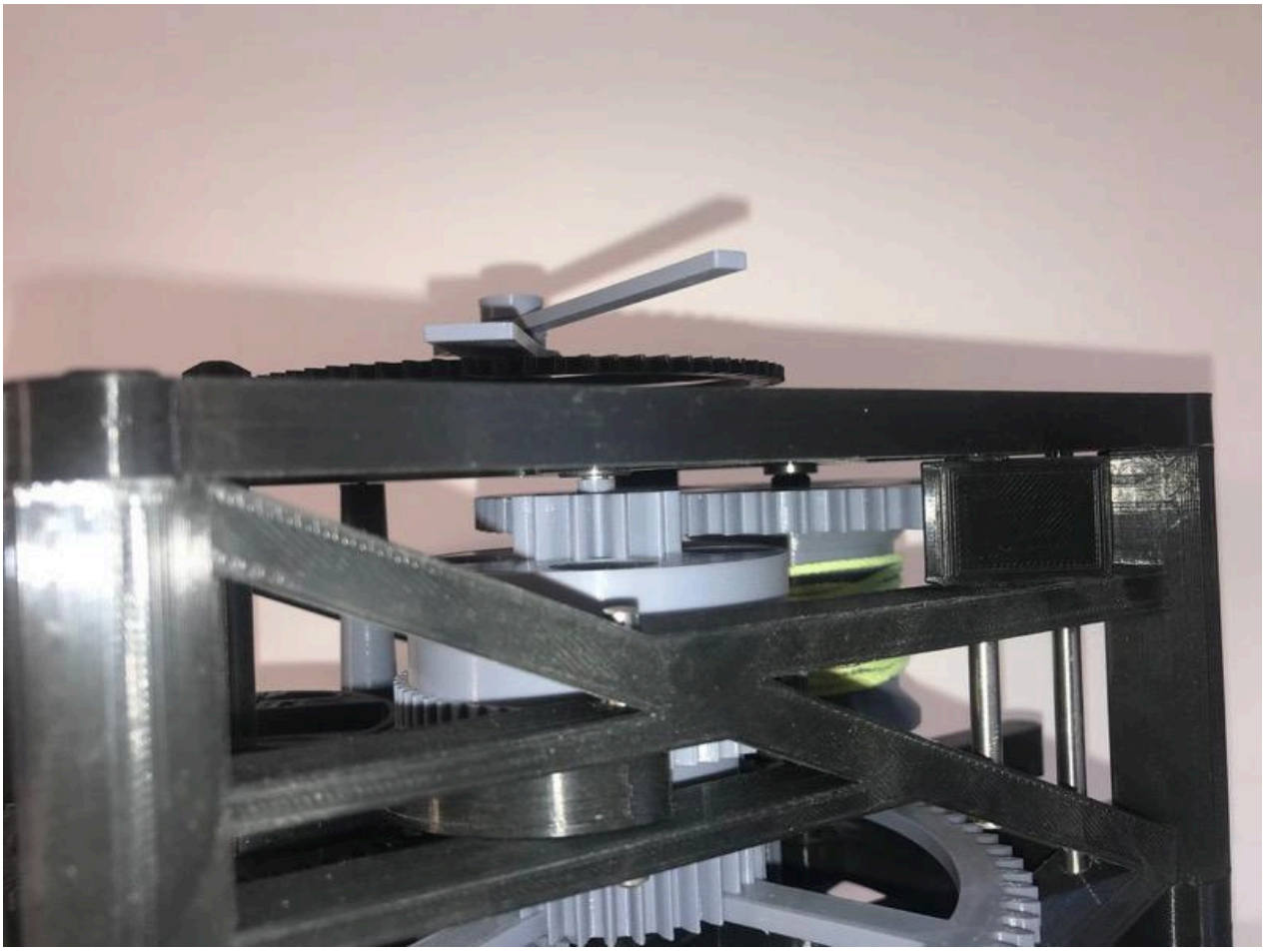




Watch the gear meshing, wiggle to engage gear



Clutch is engaged



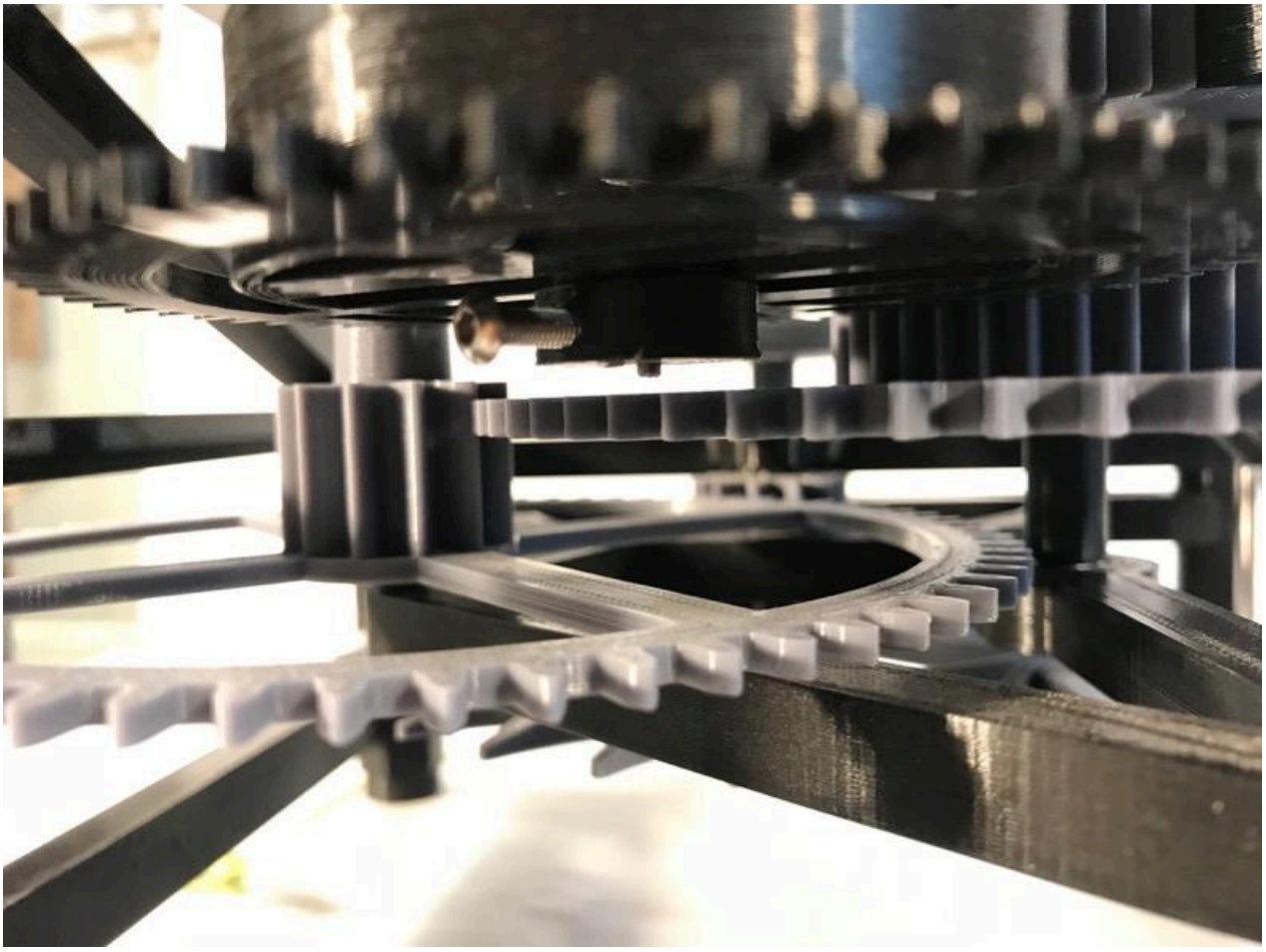
Engage bearing and middle gear shaft in front frame
Once front frame is well installed
Check all shafts for a small amount of lateral play and no binding
Push one by one the threaded rod all the way in toward the front
Remove blocks under back frame

Install one face holder as well as the face

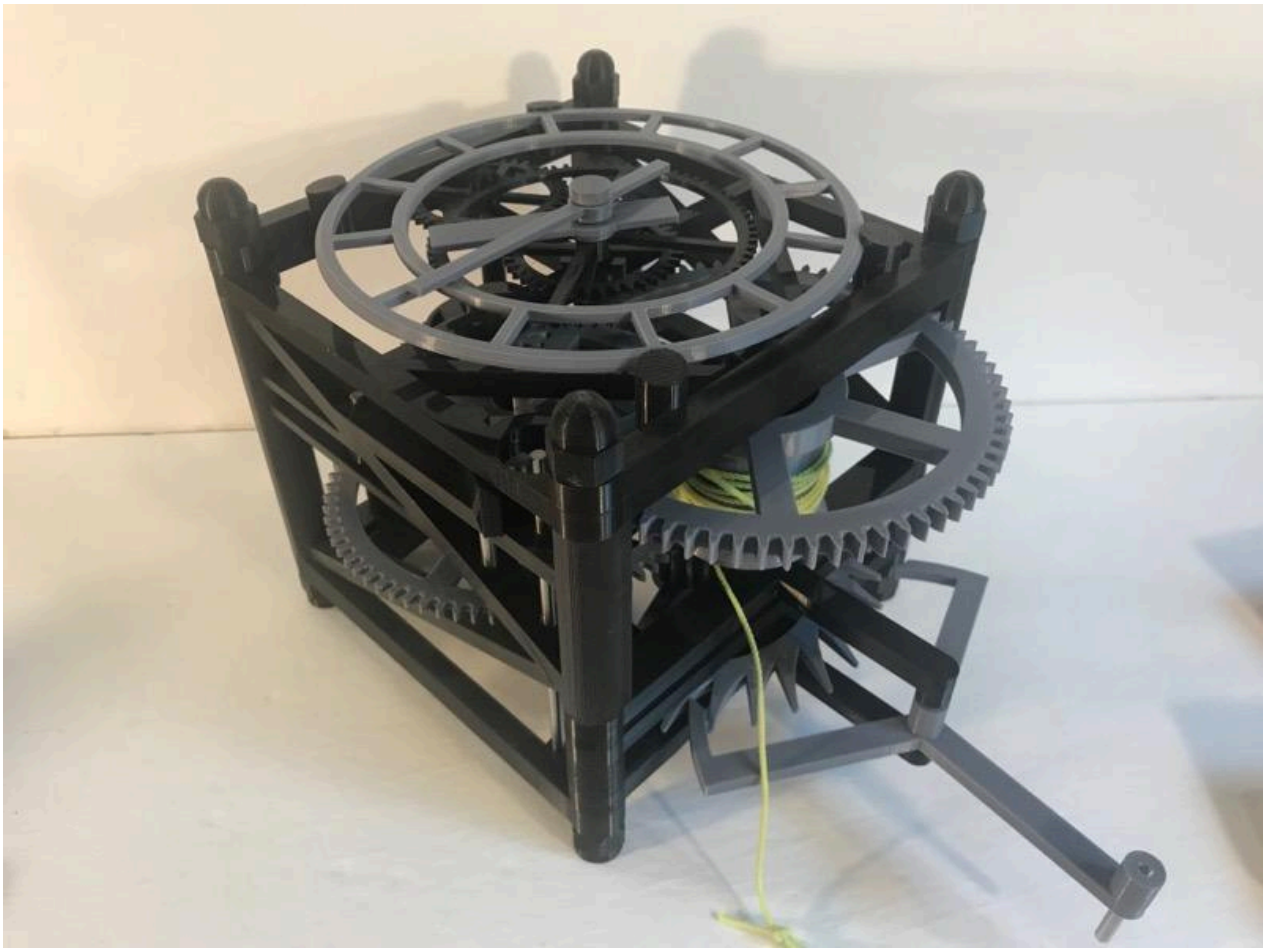
Install second face holder

Engage face in notches
Install all 4 Acorn nuts and hand tight

Double check that the hands arbor does not interfere with the drum gear



Check that the clutch arbor has room to clear the gear 72-30

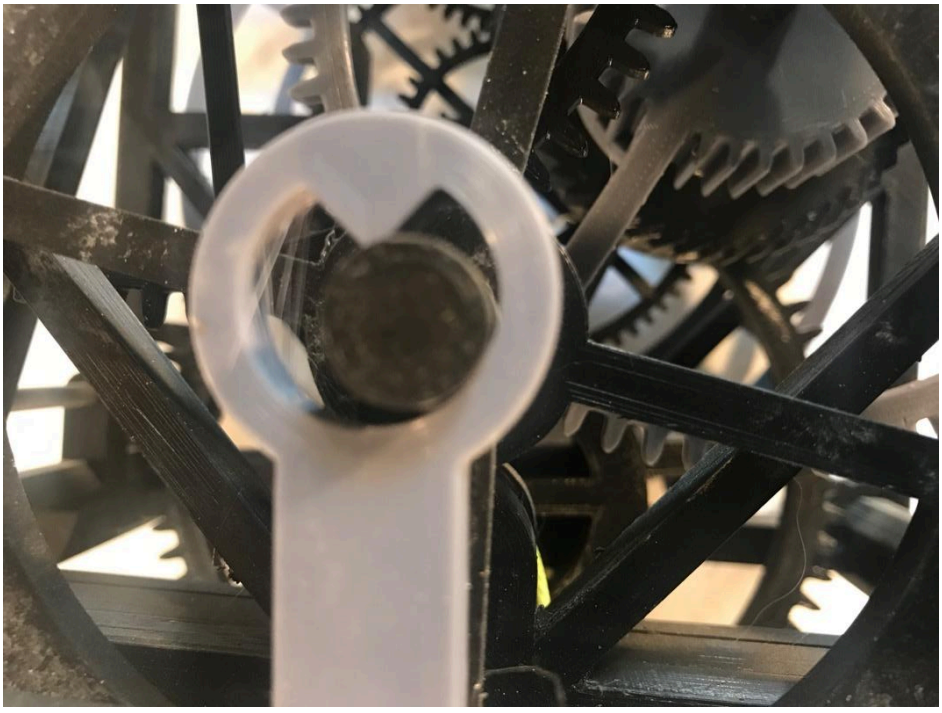


The clock assembly is done
Time to get it ticking and on time

Start the clock

Hanging the pendulum right

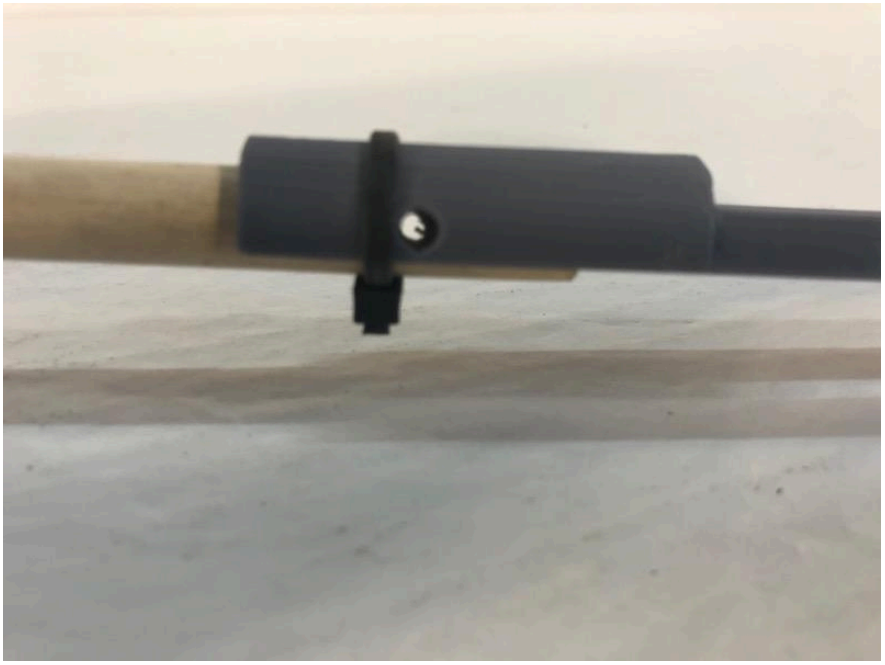
When hanging the pendulum, make sure it sits well in the grove



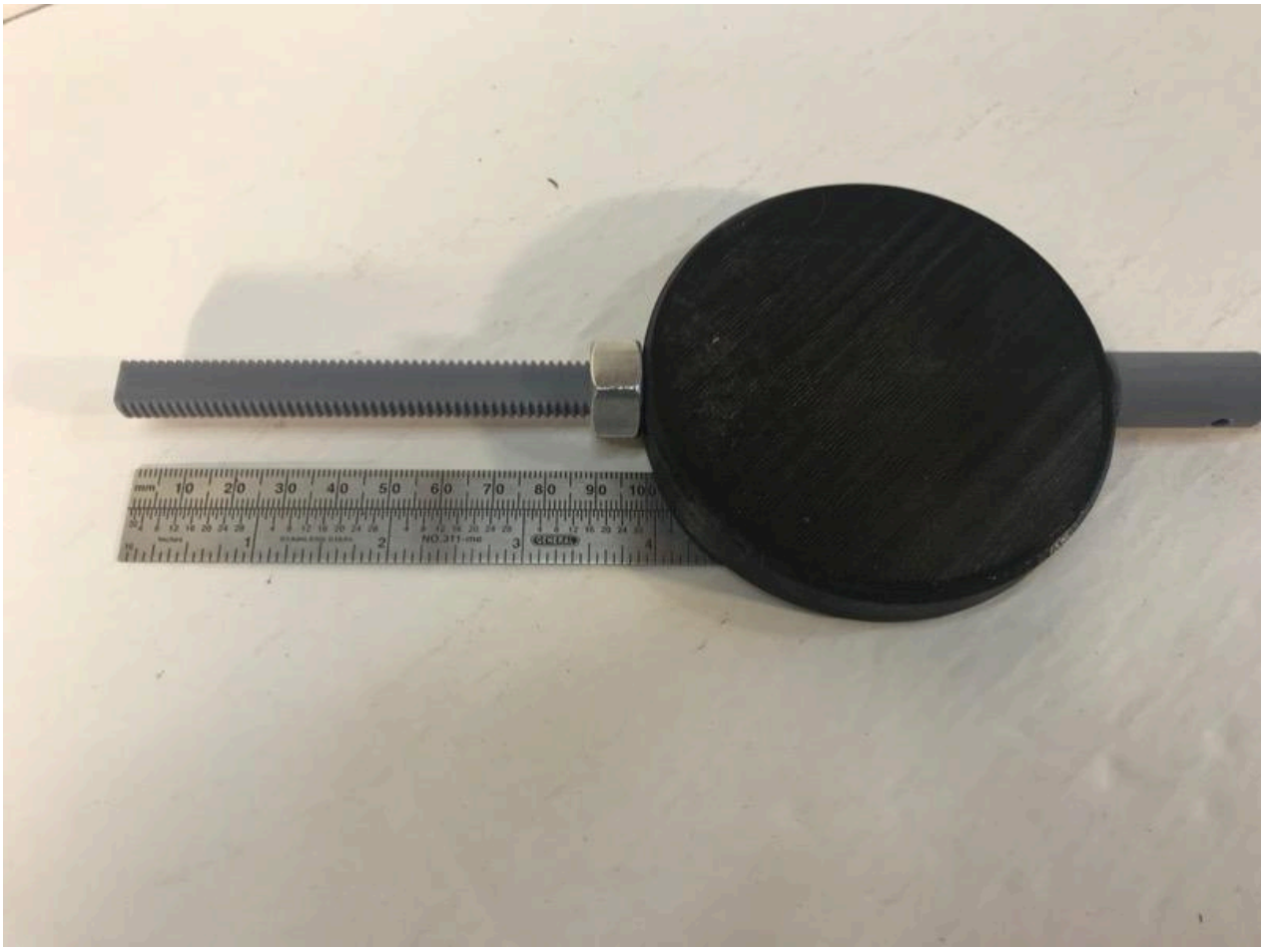
Not like this, clock might work for a while then stop

Assembling the pendulum

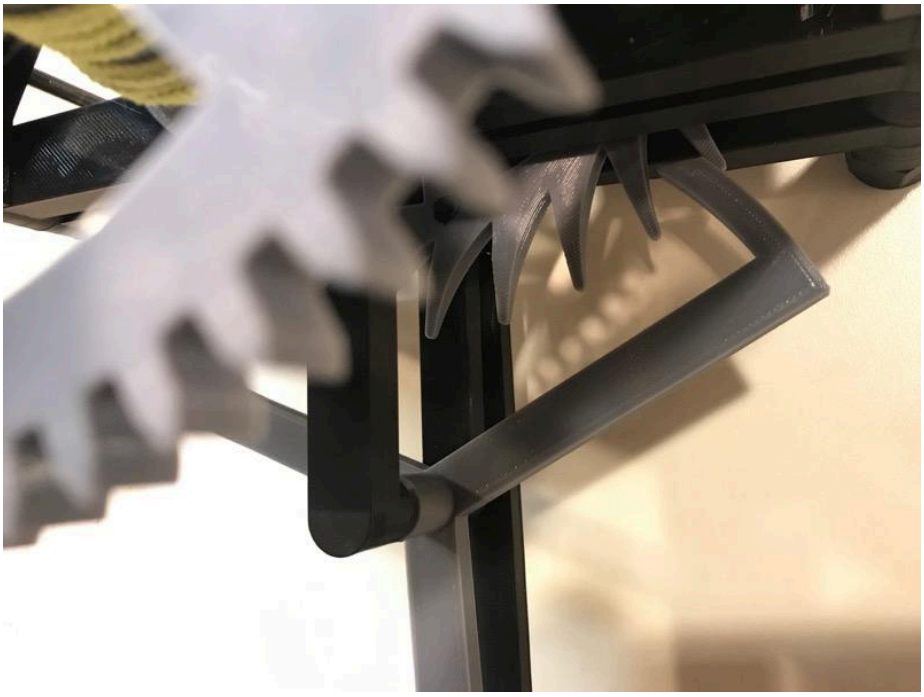
Rod can be glued in
Attached with a screw
Or simply secured with a zip tie as a temporary set up



Adjusting the length of the pendulum



In theory a 1 m long pendulum should give close to the correct time
In reality, the weight of the rod, the anchor and other oscillating parts is interfering with a pure pendulum
I usually start with as long I can get of a pendulum, position the bob all way up, and give it a try
Time how long it takes for one rotation of the escape wheel
The clock should be too slow, I can cut the rod, probably 8 cm at the time in this situation and time it again



Level the clock, so the motion of the anchor is even right and left

I make a mark on the escape wheel and time how long it takes for a full rotation

Once the rod is at the right length, it should look like this
The range of motion allows almost +/- 1 second per minute
Go for a couple hours or even 24 hours and adjust accordingly
After a few days, it should run with a minute or two per day

Weight:

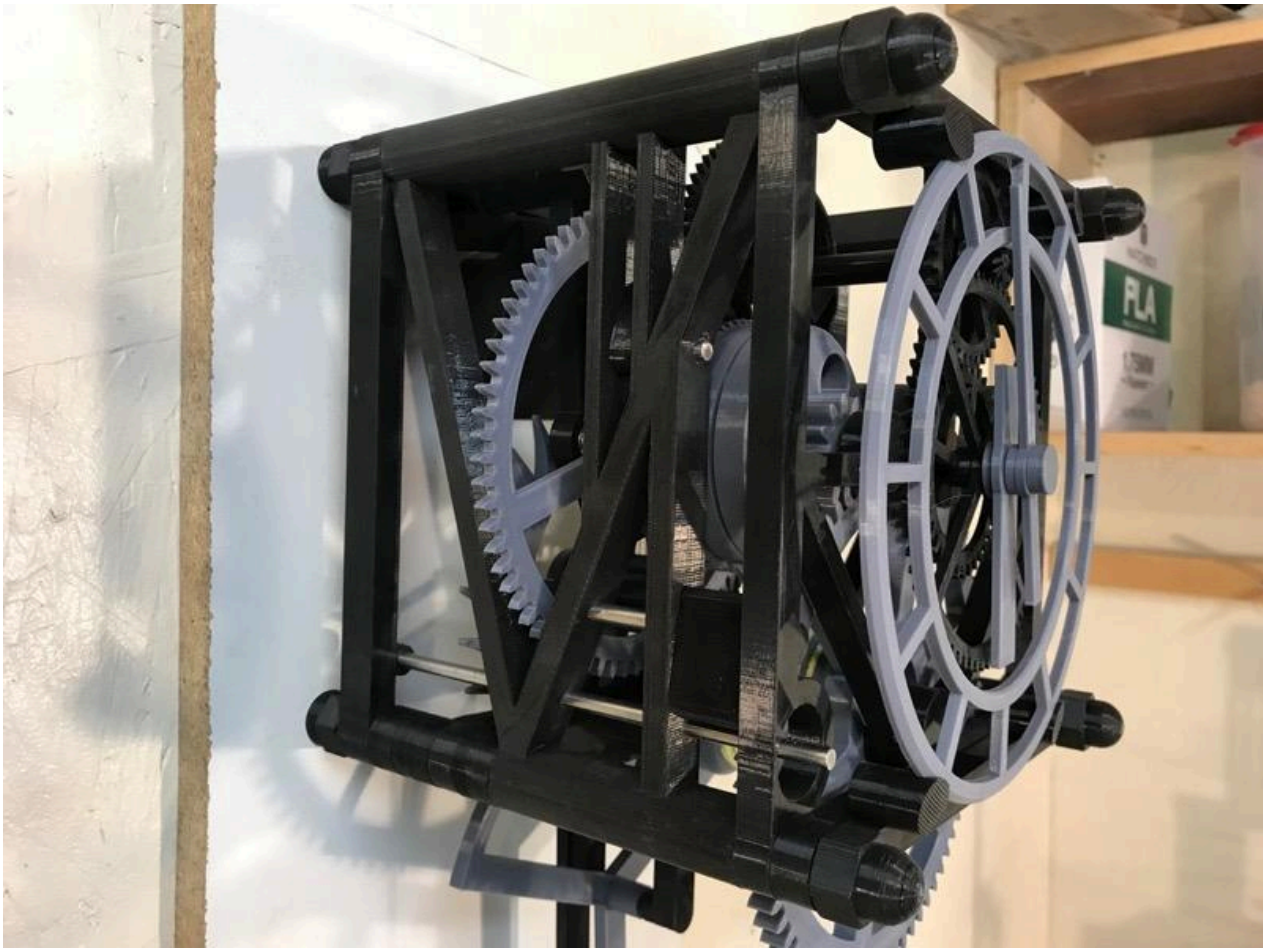
Also start with as little weight as needed, then increase until there is a good engagement of the anchor with the escape wheel, 2 or 3 mm on the round part of the anchor is good starting point
Also check that the clock is level, that the engagement of the anchor is the same right and left
You will realize that there is too much weight when the anchor will bottom in all way in the escape wheel

As an idea, I run my clock with 2 kilo

Caution:
When hanging the weight, allow the string to pick up the tension slowly, that ways the maintain power spring does not get over stretched

Troubleshooting:

If the clock stops after a while?
Check that the knife edge of the pendulum is well engaged in the notch
Check that the clock is level
Check if there is binding between the anchor and the escape wheel
Check the power train, starting at the escape wheel, can you wiggle and feel free motion between all gears?
Is there any binding? Could be a blob of filament, excessive elephant foot
Move up one set of gears at the time
Check if enough weight is powering the clock, would the clock run when adding pull on the string


PLA