

# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38



I have been experimenting with various types of escapement used in earlier clocks and have by now incorporated quite a few of them in my wooden clock designs. There is however been one design that I have never gotten around to, and that is the escapement designed by Galileo, used in a clock design he developed from his pioneering work on the pendulum. He described the design to his son who produced a drawing of it, unfortunately, they had both died before they could see the clock completed. This is my tribute to that design, I have tried to stay close to the original by retaining the teeth, Pin and finger arrangement shown in the original, but included more teeth to keep the gear ratios manageable. This is not as accurate an escapement as the Graham escapement nor as efficient as it only picks up the impulse on one side of the pendulum swing, but it is non the less an interesting designed carried entirely on the front face of the back panel so the whole of the mechanism is completely visible.

It is quite a compact design and can be made either by hand on a scroll saw or using a CNC router or even 3D printing.

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### Equipment

The following equipment is desirable:

**CNC Router** or Laser and if not one of these then a Scrollsaw or a Bandsaw. Small Lathe, this is not essential but it would make making the clock a lot easier for all the round parts that are needed.

**Small Milling** machine or **Pedestal Drill** with work holding vice. There is a lot of holes to be drilled and cleaned up after CNC machining and fabrication so the drill is pretty much essential. It may be possible to get away with an ordinary electric drill in a stand but a work holding vice is still necessary.

**Drill Bits** in the following sizes, Ø1.9, Ø2 mm, Ø2.1, Ø2.9, Ø3mm, Ø3.1, Ø3.9, Ø4 mm, Ø4.1 mm, Ø8.5

**Router Cutters** Ø 2, Ø3 and possibly Ø6 for cutting out the larger frames.

**Hand tools;** all the normal things that are used in the workshop, Files, screwdrivers, hammer, pliers etc.

If you want to save a lot of time, then look at a **Sanding disk** and a **Drum sander** but these are really nice to have.

#### Consumables

Sandpaper in various grades from rough to fine

Danish oil for finishing.

Gorilla Glue

PVA wood glue

Dry Film Lubricant in a spray can for the gears after everything is finished.

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## Construction instructions for Clock 38

### Materials

#### For all the wooden Parts

The choice of material to build the clocks from is a very personal one and is really down to you to decide. I prefer to use actual timber, Cherry for the frames and Maple for the gears and other parts. I use timber machined to a standard size of 125 mm x 6 mm and 125 x 9 mm and these are fabricated into blanks for the larger components by gluing two strips together.

You can, however, use a high quality grade of plywood (Marine Ply) or MDF this route is a lot quicker as you can layout multiple parts on a sheet and have the whole thing cut out in a day, still need to put in the time cleaning up the parts and making all the other bits, but generally speaking the whole thing can be done more quickly. You can also use Perspex with which you can create some colourful clocks

Whatever you use, the flat 2D parts are all laid out for you on the Profile cuts sheet, this comes as a DXF file that is 1200 mm square, you can manipulate this in your own CAD program, which you will probably need to do, to be able to feed the files into your CAM program.

#### For all the other parts

Ø4 mm Drill Rod or Silver Steel 800 mm Long for all the shafts and numerous pins.

Ø2 mm Drill Rod or Silver Steel 200 mm Long

Ø20 Wooden dowel 200 mm long

Ø25 Wooden dowel 200 mm long

No 8 wood screw 65 mm long for Mounting Clock to the wall

6 MM Threaded rod 500 mm long

Ø8 mm Brass Rod 110 mm for the Drive Shaft

2 mm Plastic sheet for hands, ABS or HIPS

Carbon Fibre rod Ø6 x Ø4 x 750 mm source from Kite maker supplies

Ø1 mm Braided cord to hang the weight .

M6 Cap or Domed nuts 6 required

M4 and M6 Washers

Flanged Bearings and needle roller bearings see the BOM (Bill of Material) on the drawings sheet.

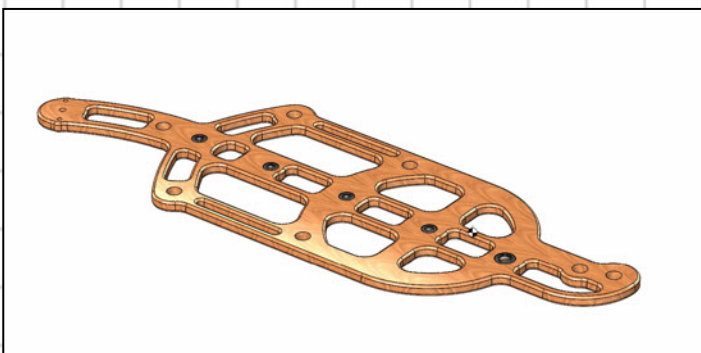
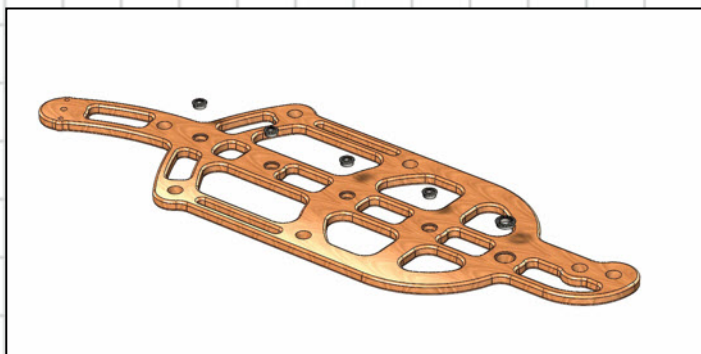
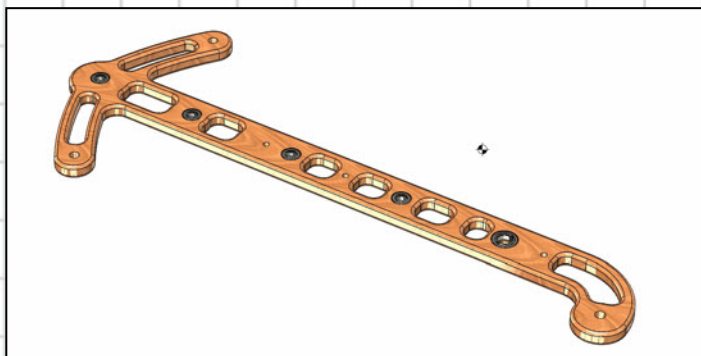
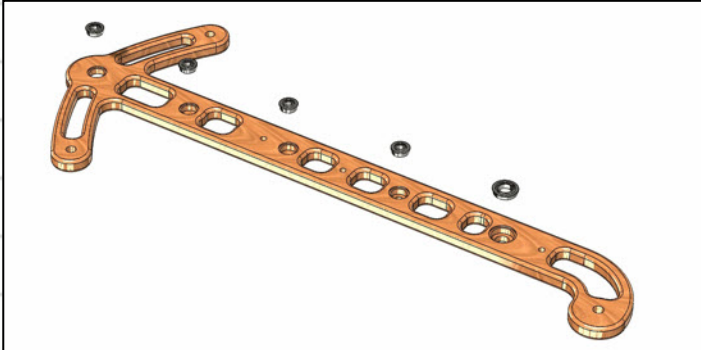
Note these are the minimum amount of material necessary to build the clock I used more in the prototype and you may well be advised to by extra to cover those accidental losses that occur. If I have missed anything here, you will find them in the parts list for the clock anyway.



# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38

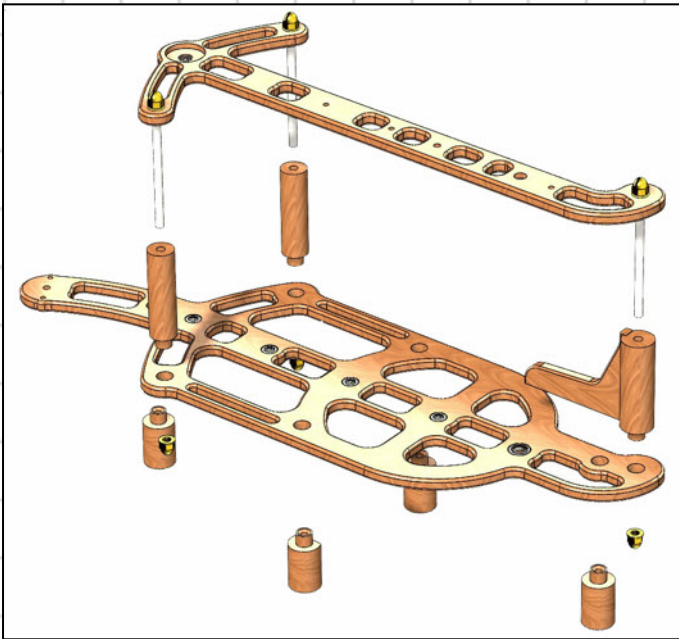
### Step 1 Preparation of the Frames



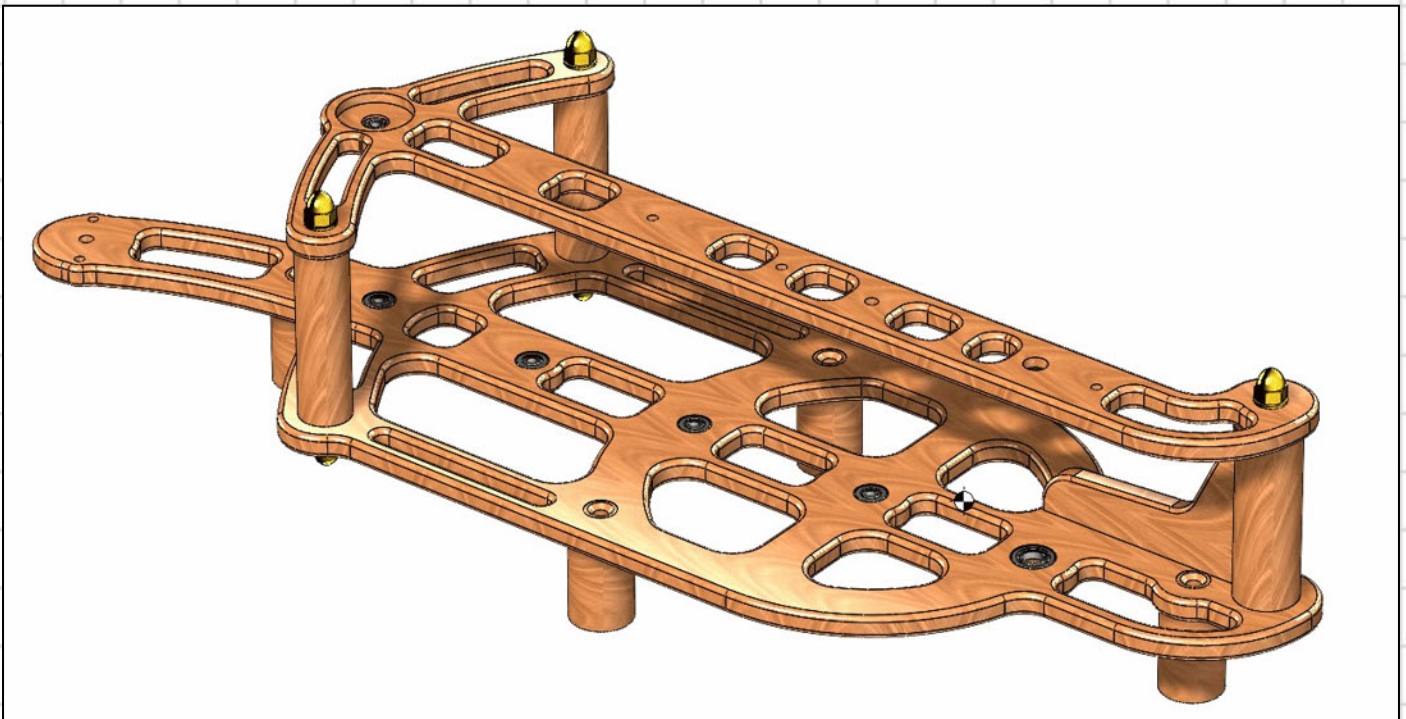
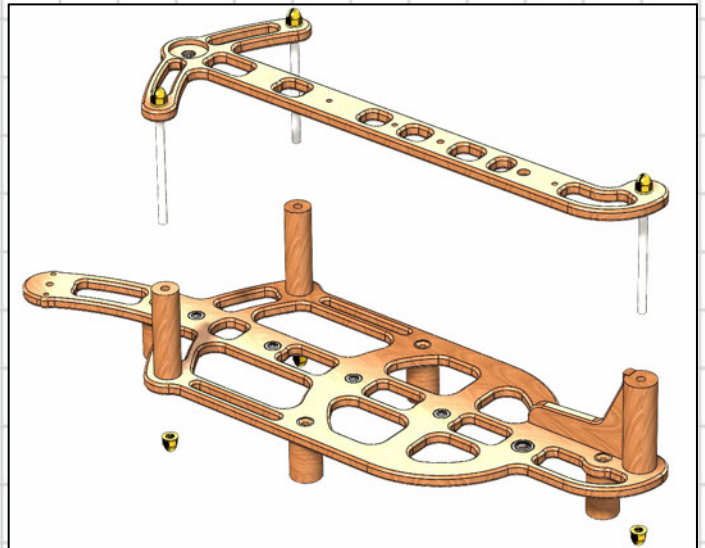
### Fit Bearings into the Front and Back frames

# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38



Fit the Wall Spacers into the back of the Back Frame and glue in position

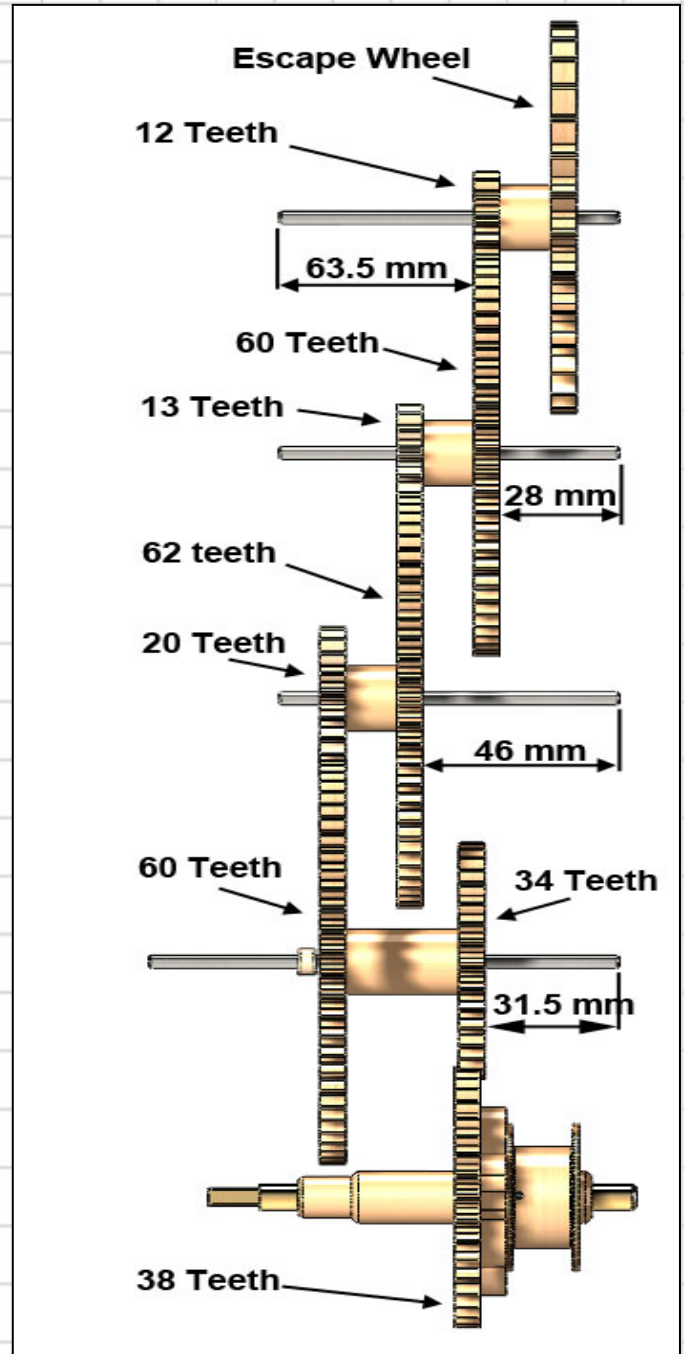
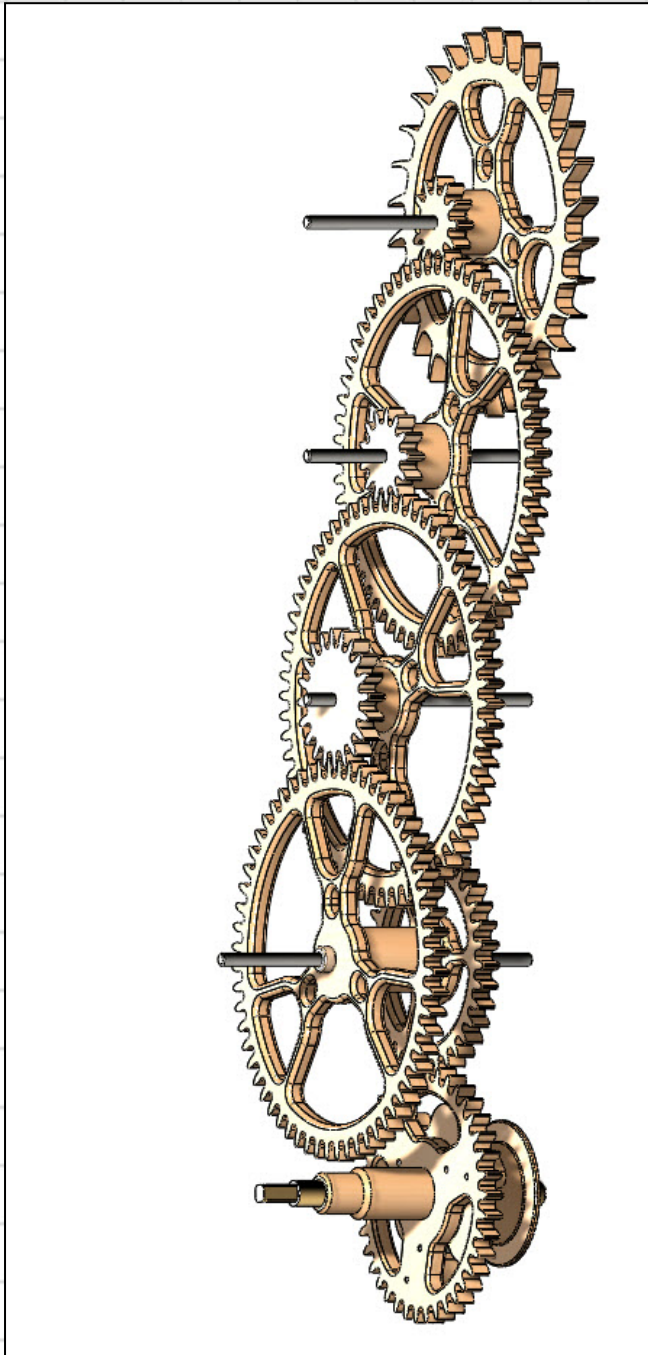


Glue the Frame spacers, and Brace to the front side of the Back frame and clamp both the Front and Back frames together using the Threaded rods and the M6 Nuts and Bolts to hold the frames accurately together as the glue dry's.

# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38

### Step 2 Assemble the Gear train Parts



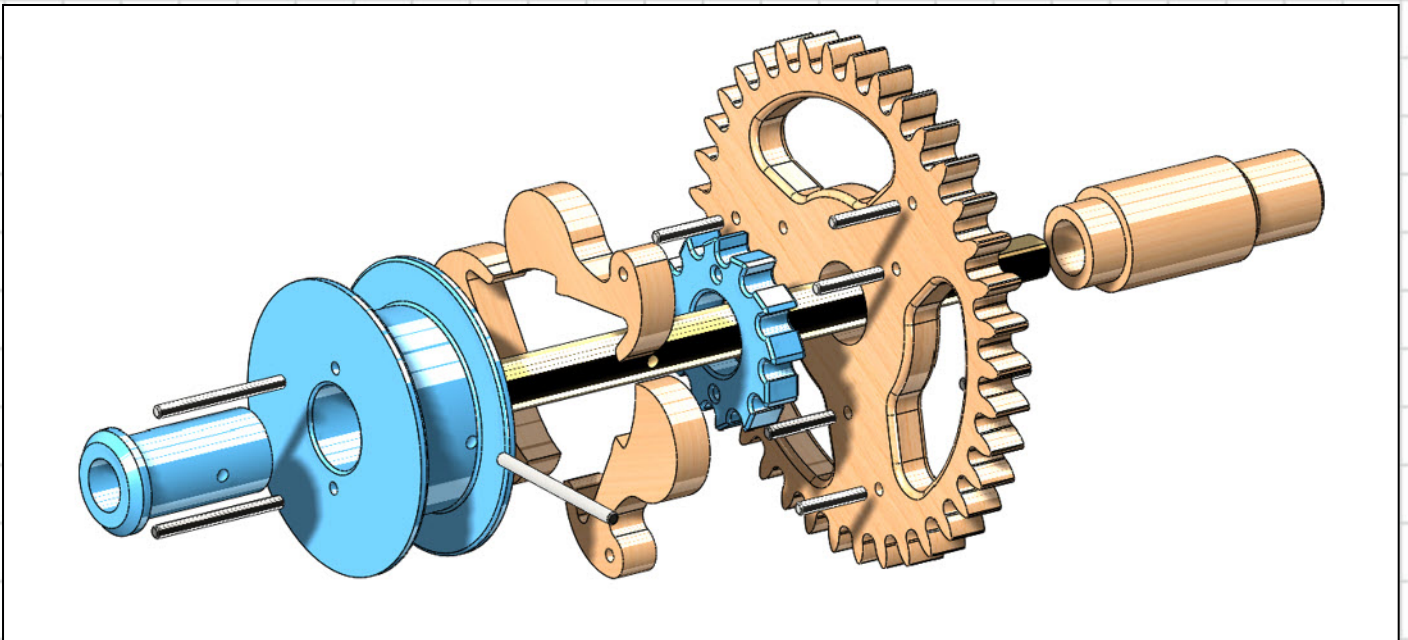
Assemble each gear train sub assembly in turn by driving the shaft through the centre holes in the spacers and gears. This should be done on a Drill press or similar setup to ensure the the shaft is fitted square to the gears. All gears should be a tight fit on the shaft and the gears and spacers should be glued together to ensure that there is no movement between the gears when a load is applied.



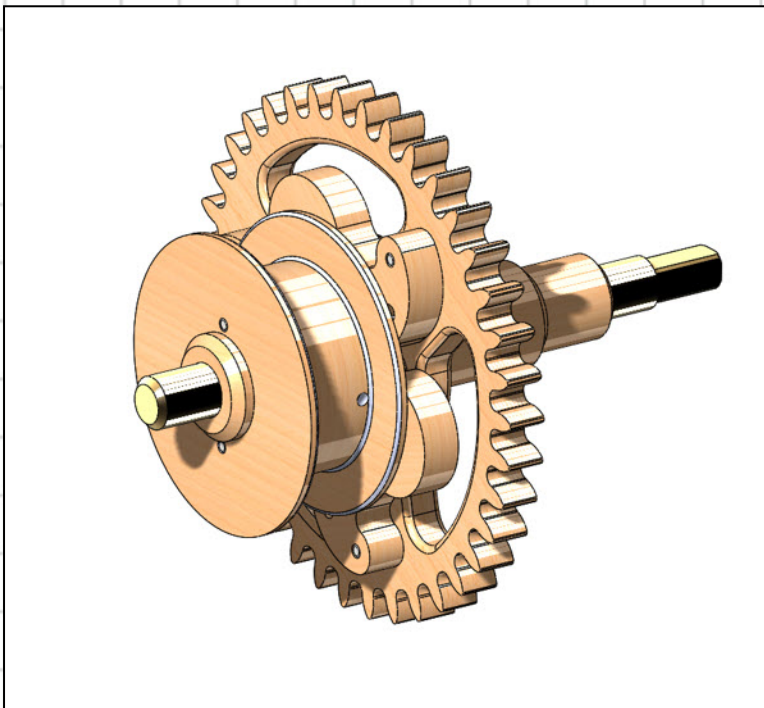
# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38

### Step 3 Assemble the Drive Parts



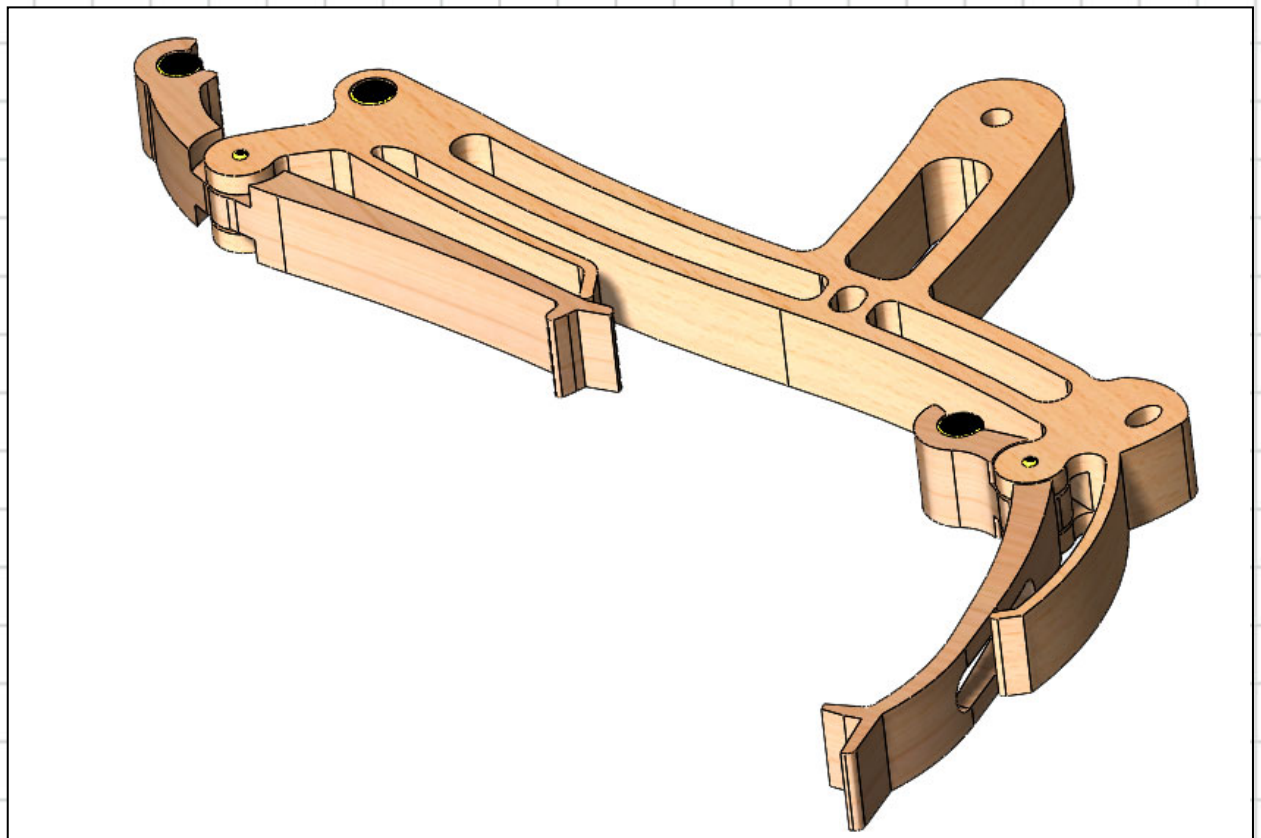
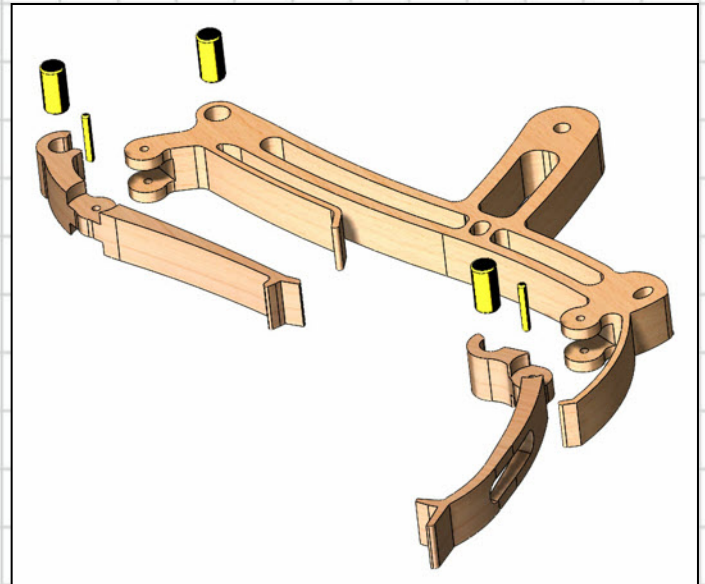
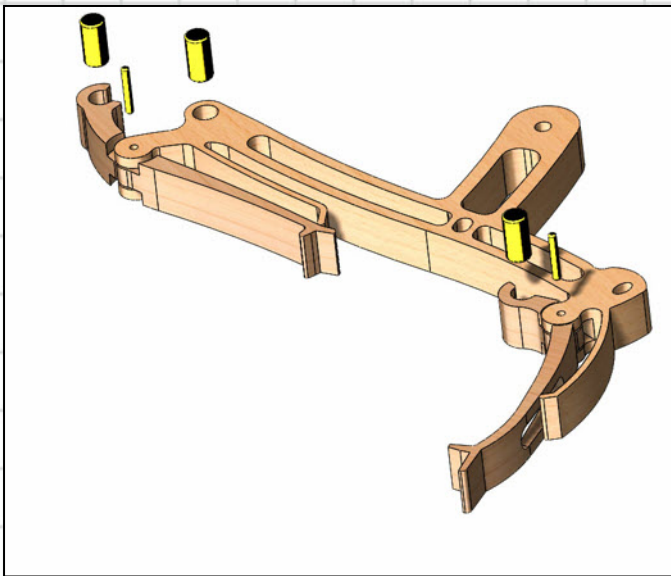
All the Blue parts should be glued together and then pinned to the Brass Drive shaft. The Pawl pins should be fitted to the holes in the 38 toothed gear. The drive gear spindle should be glued into the 38 toothed gear and be a loose fit on the Brass drive shaft. The Pawls are assembled onto the pins in the 38 toothed gear and gear and its parts slid onto the Brass Drive Shaft. Important Make sure that the ratchet and the Pawls are assembled exactly as shown above.



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Step 4 Assemble the Escapement parts.

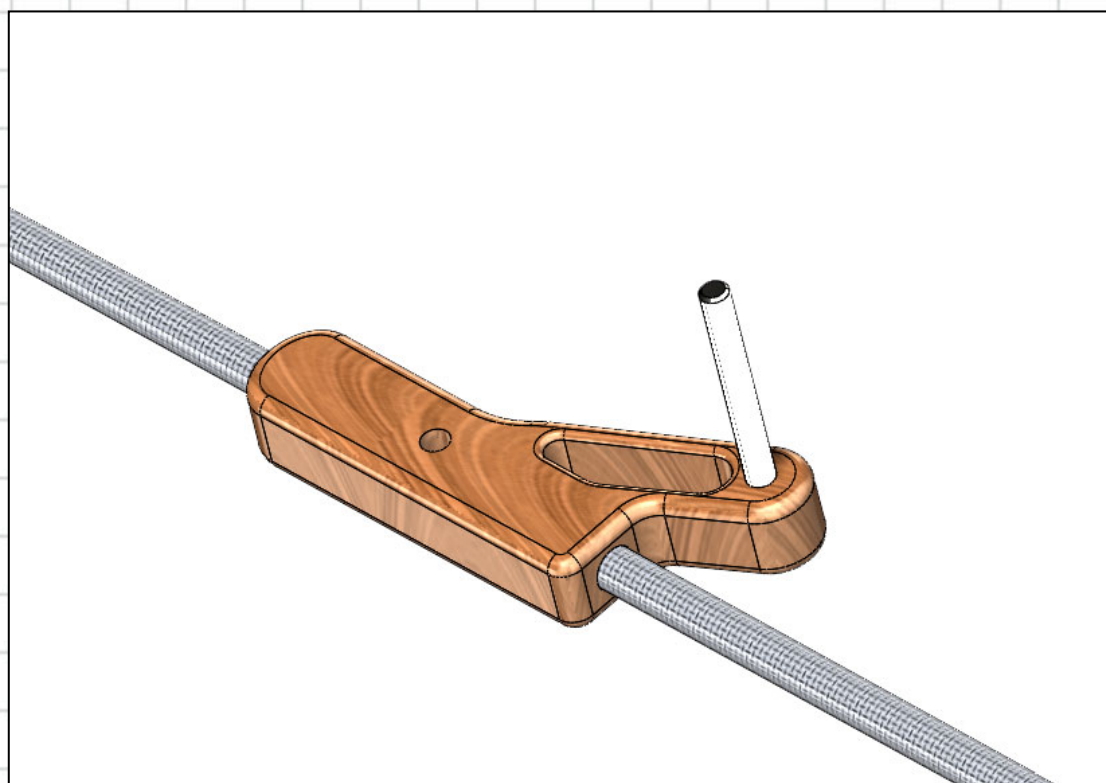
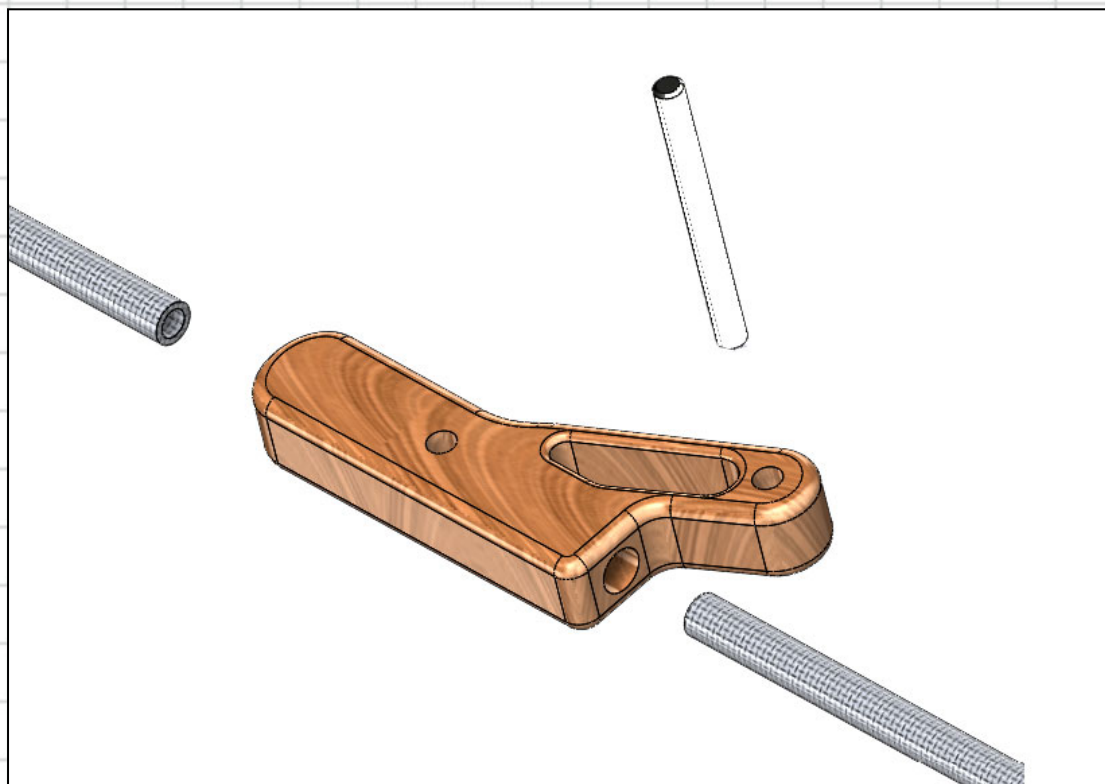




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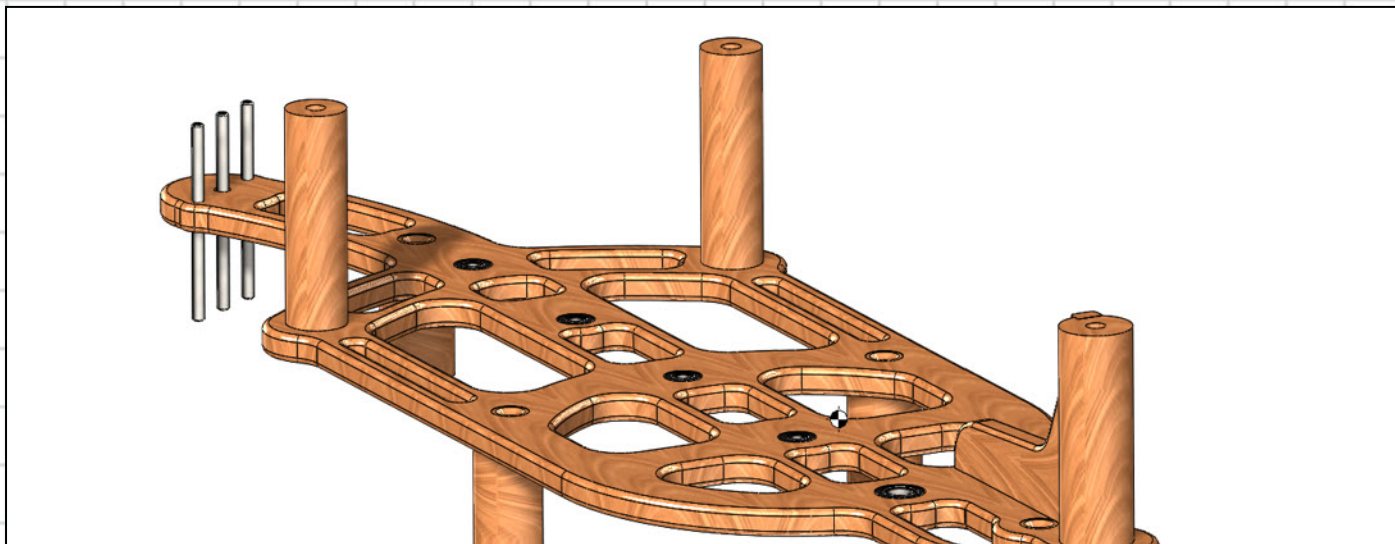
Step 5 Assemble the Compound Pendulum Parts.



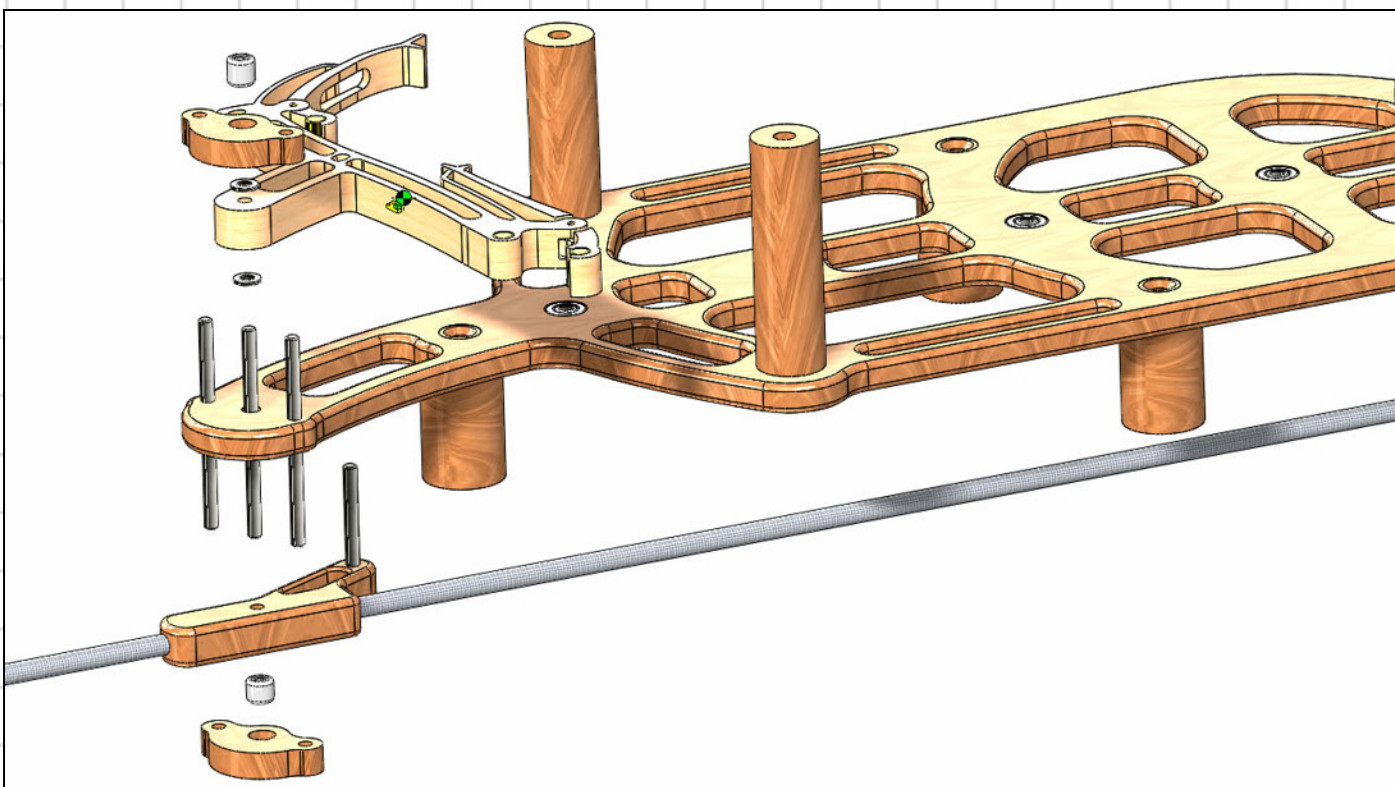
# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38

### Step 6 Assemble the Compound Pendulum and Escapement to Bottom Frame



Fit the 3 Stretcher pins into the Upper section of the Back Frame as shown above.

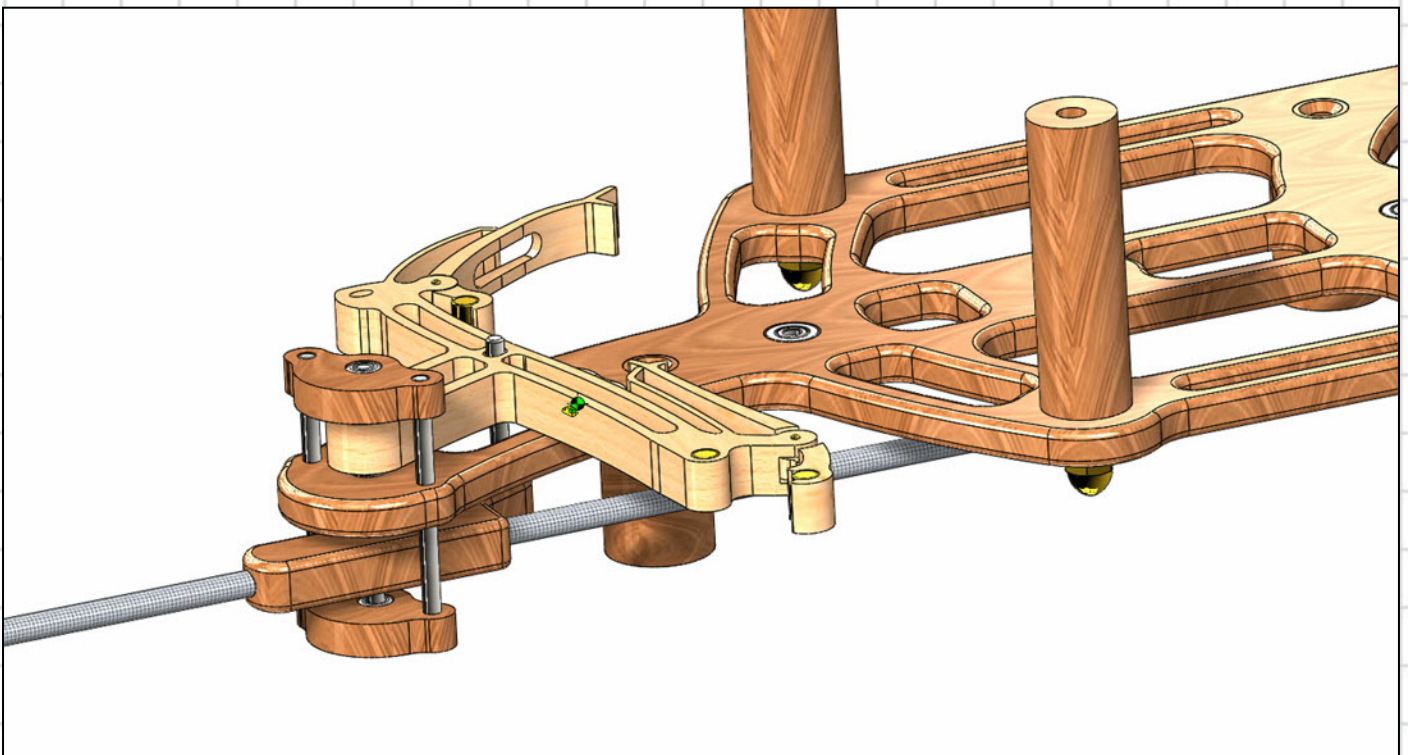
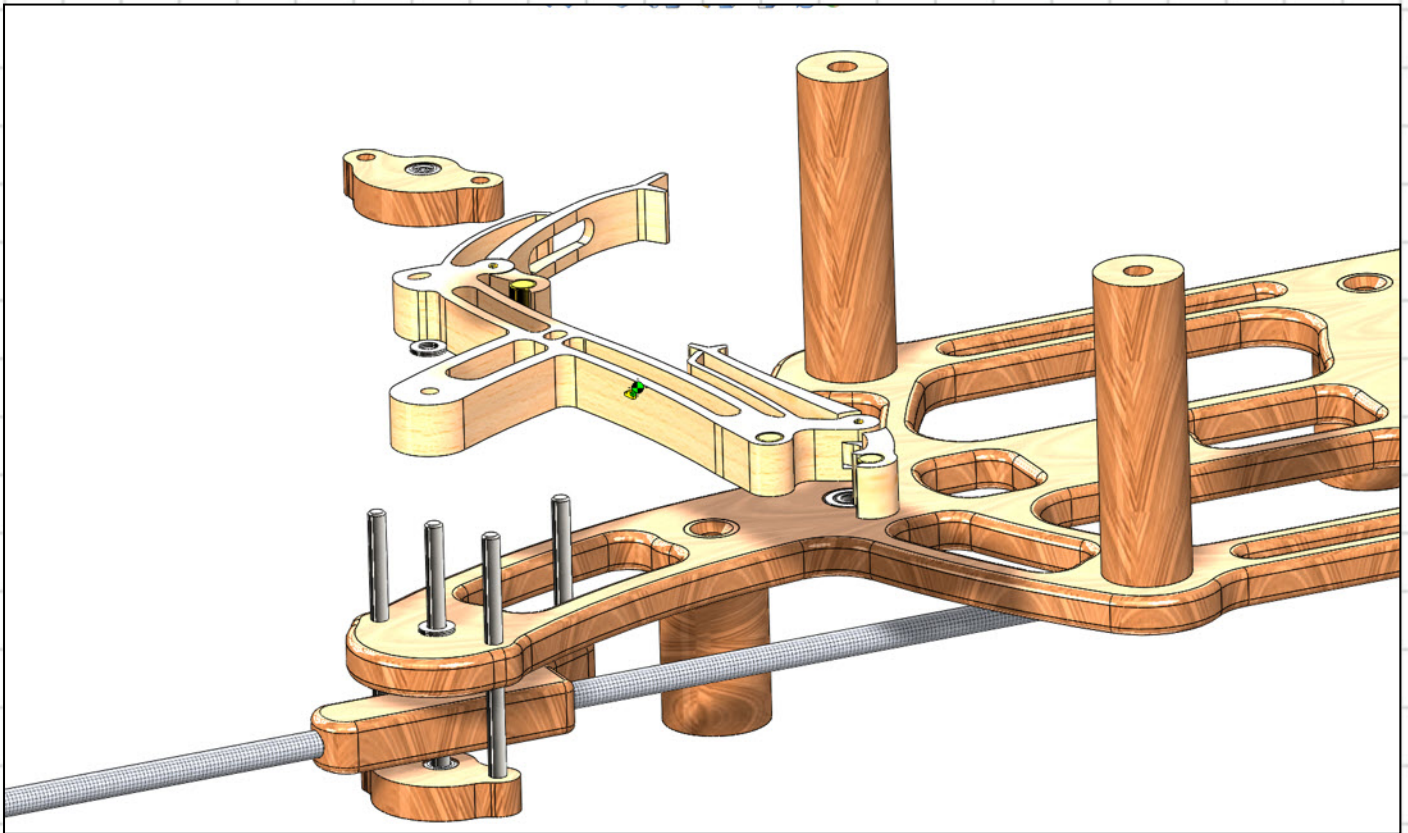


Fit the Needle roller bearings into the Stretcher parts and assemble the rest of the Escapement and Pendulum parts onto the Stretcher Pins

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### Step 6 Assemble the Compound Pendulum and Escapement to Bottom Frame

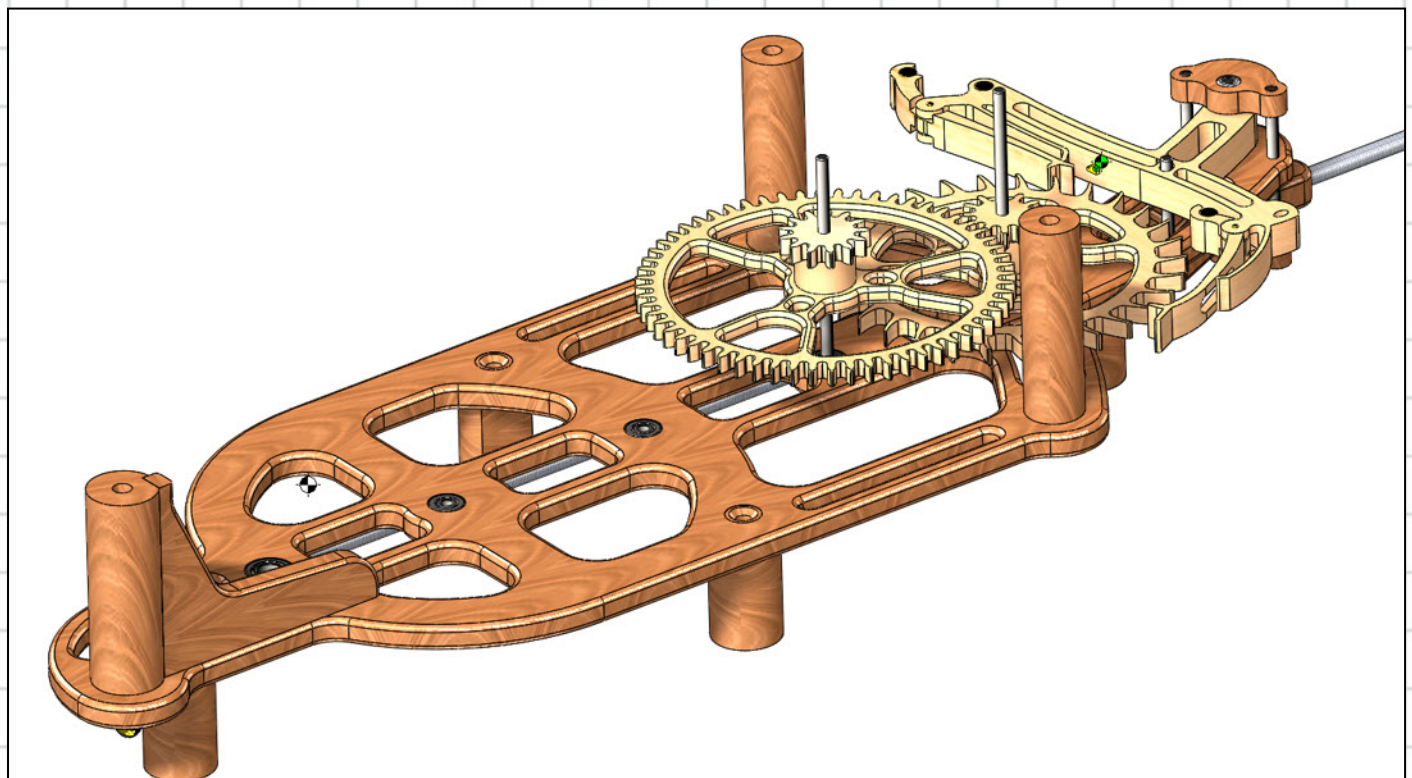
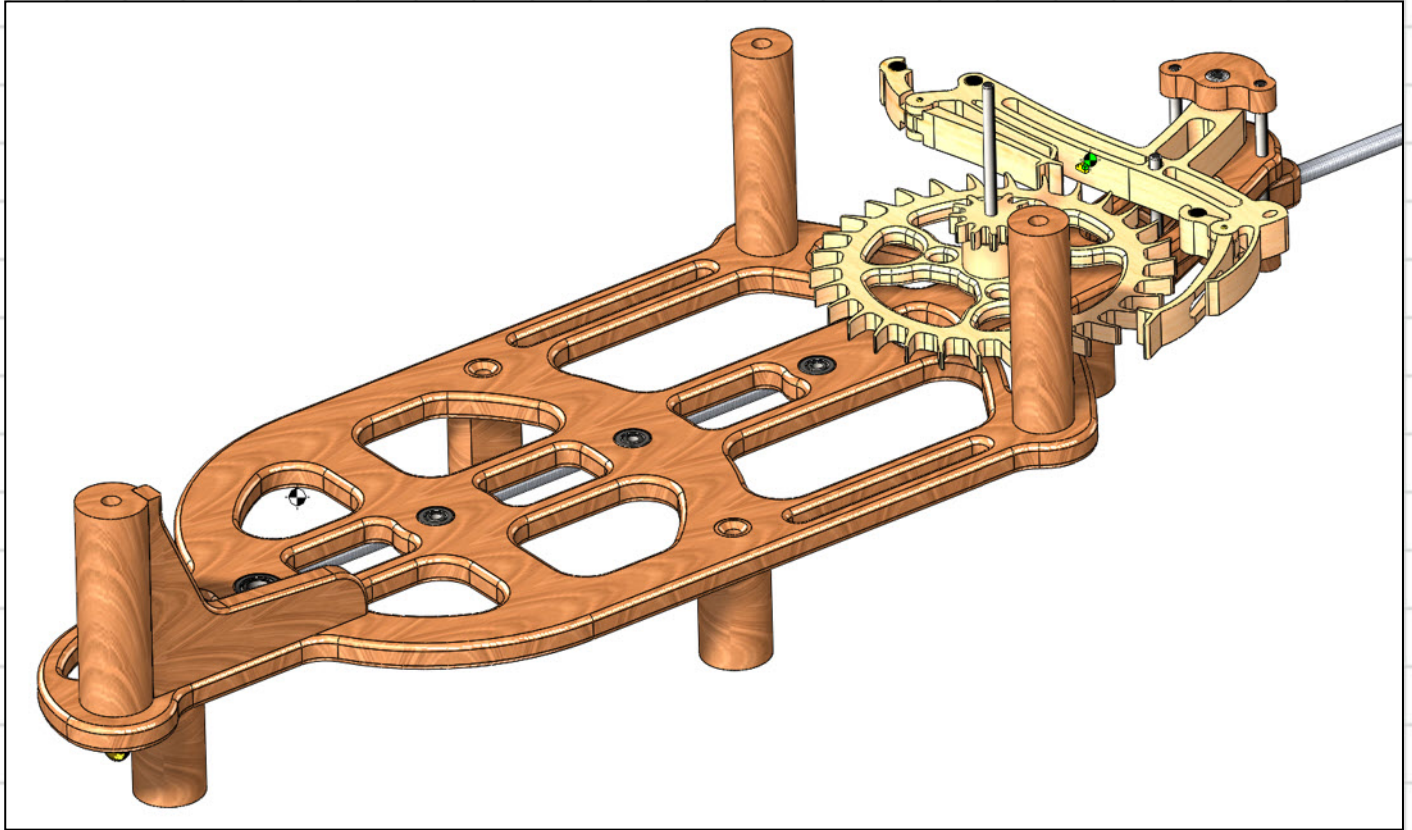




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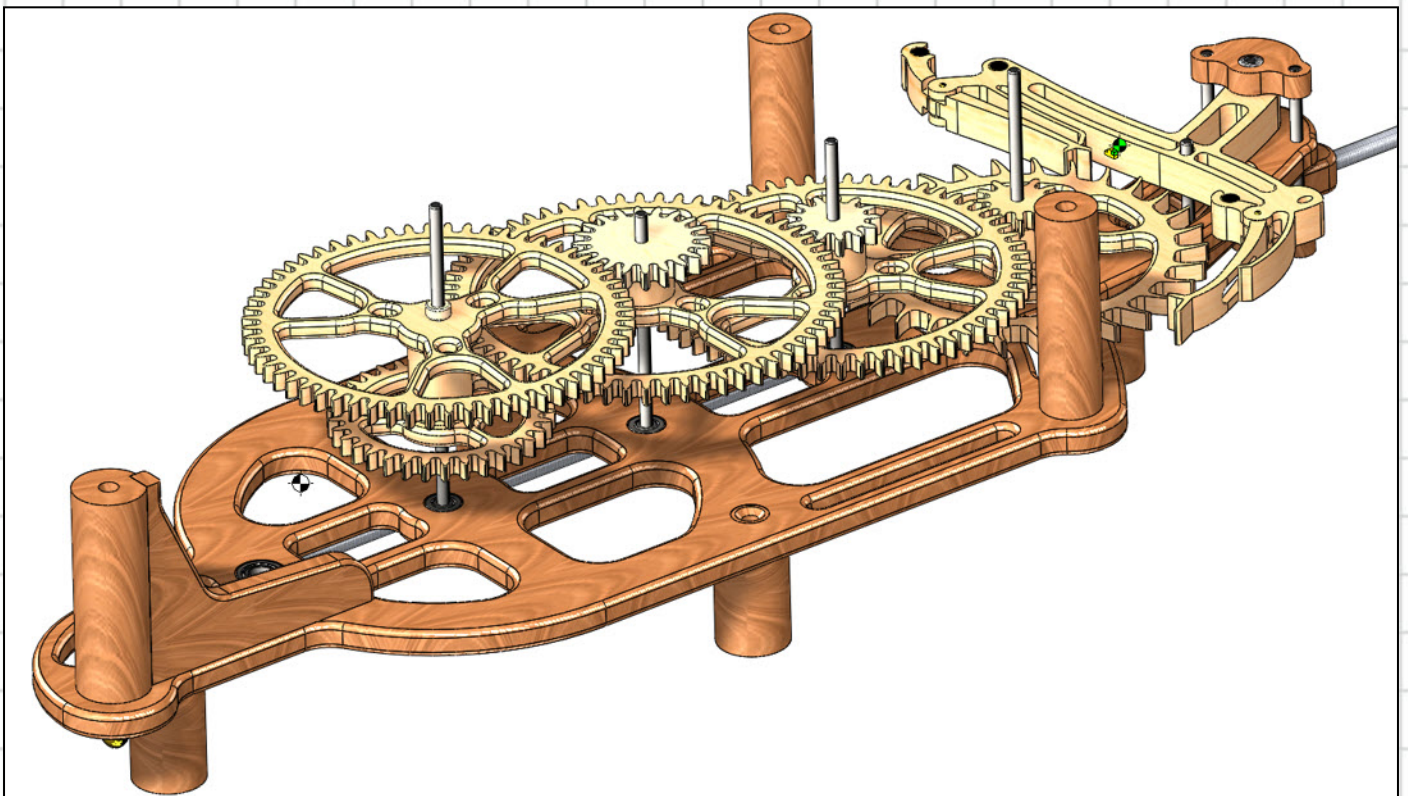
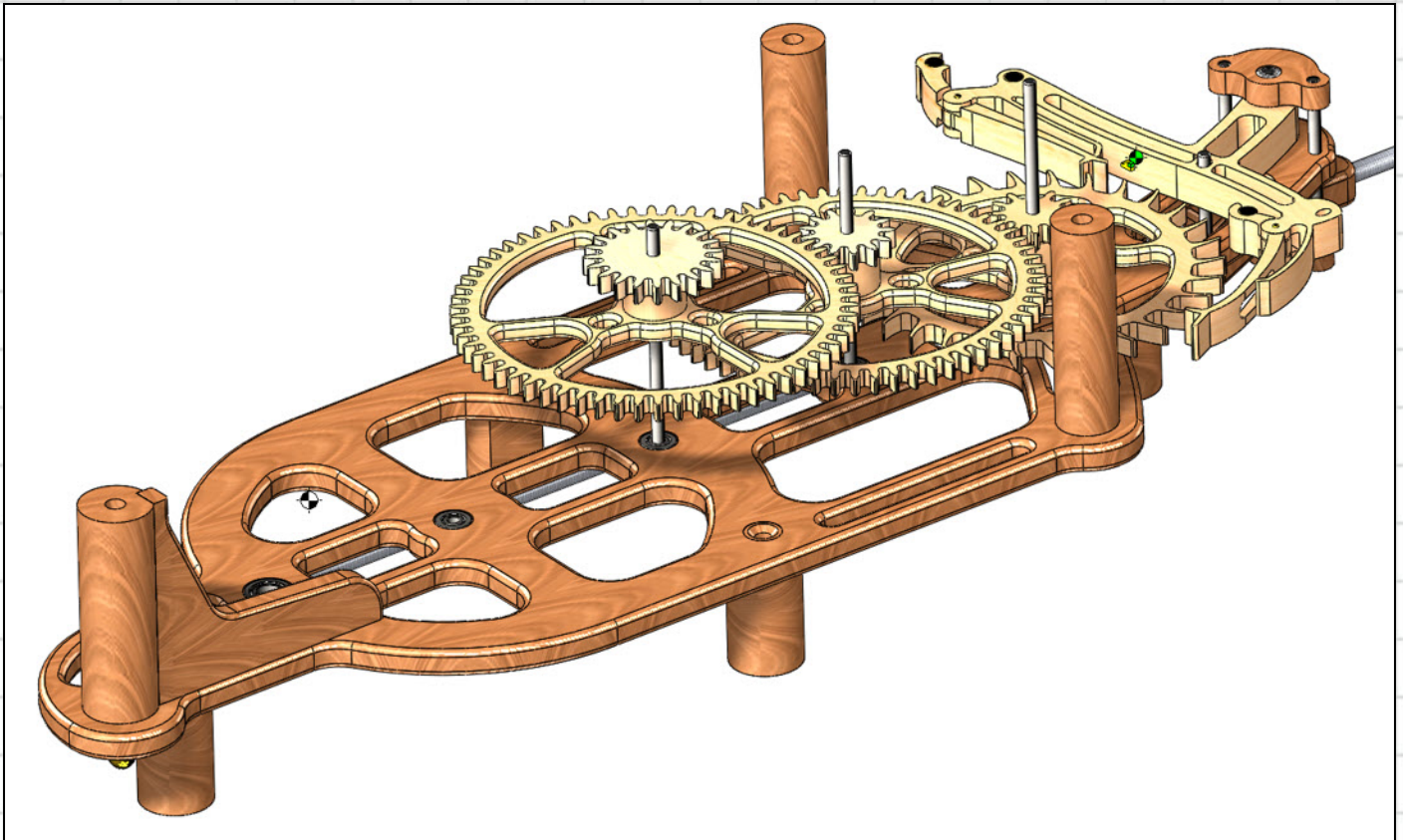
Step 7 Assemble the Gear train into the Back frame.



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## Construction instructions for Clock 38

Step 7 Assemble the Gear train into the Back frame.

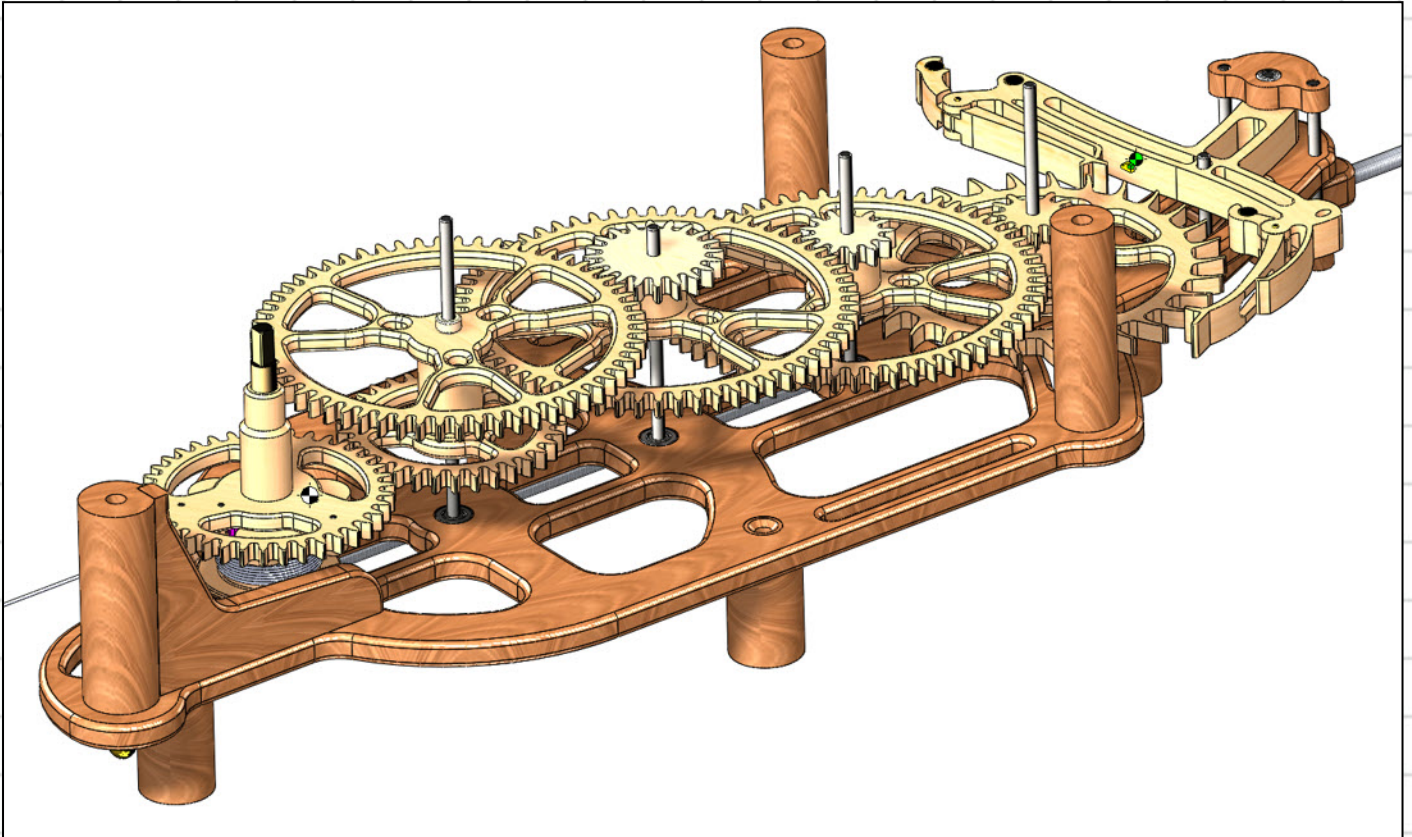




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## Construction instructions for Clock 38

Step 7 Assemble the Gear train into the Back frame.

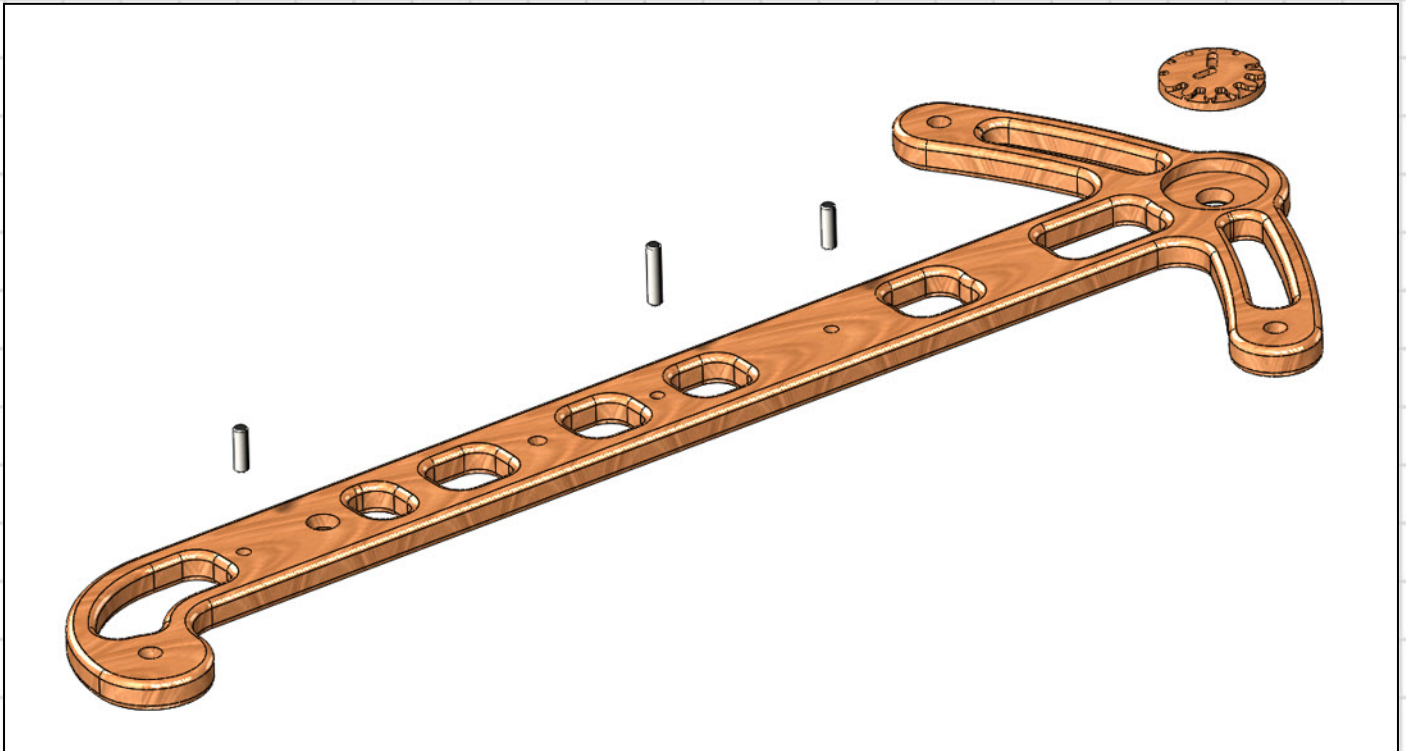




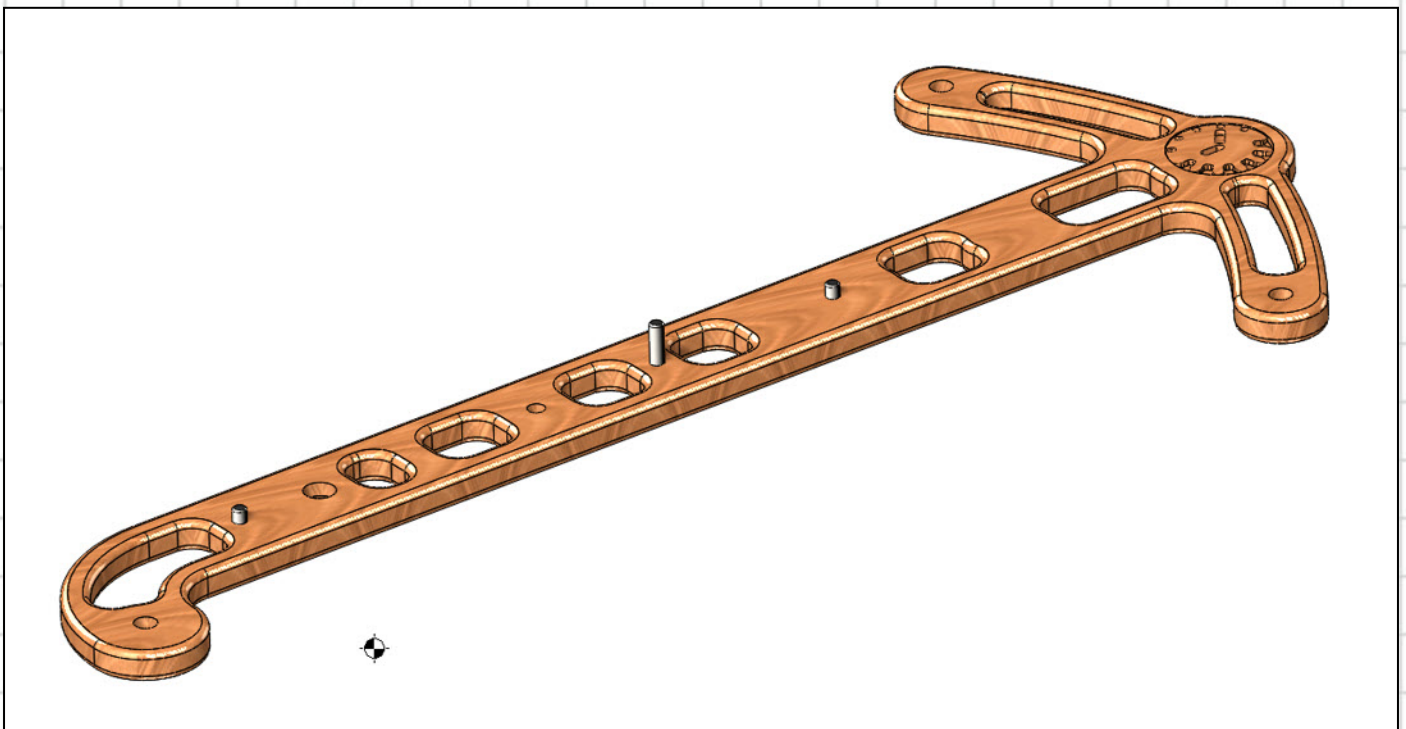
# Clock 38-Clock with Grasshopper Escapement

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### Step 8 Assemble parts to the Front Frame



Fit the Dial Pins and woodenclocks Logo, along with the Hour Gear Pivot pin to the front face of the Front frame.

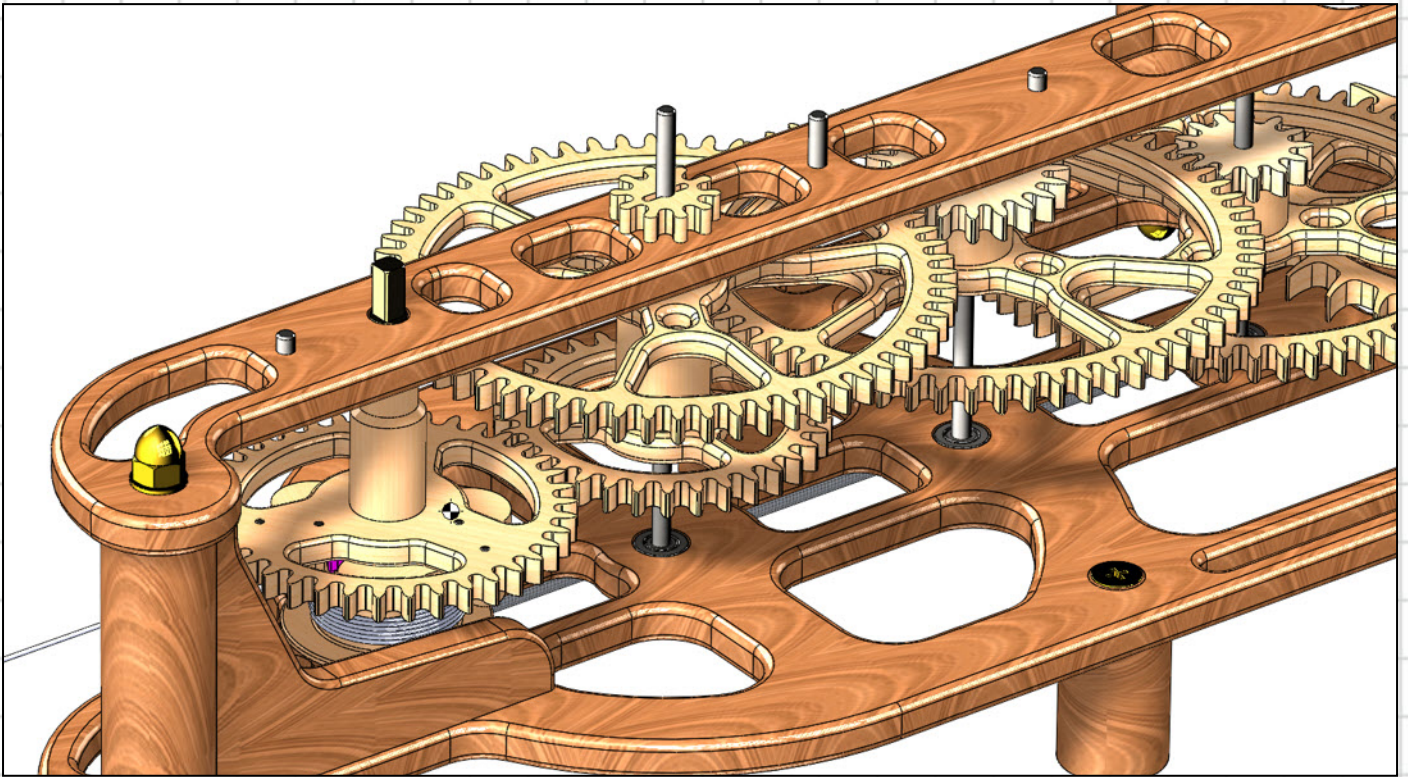




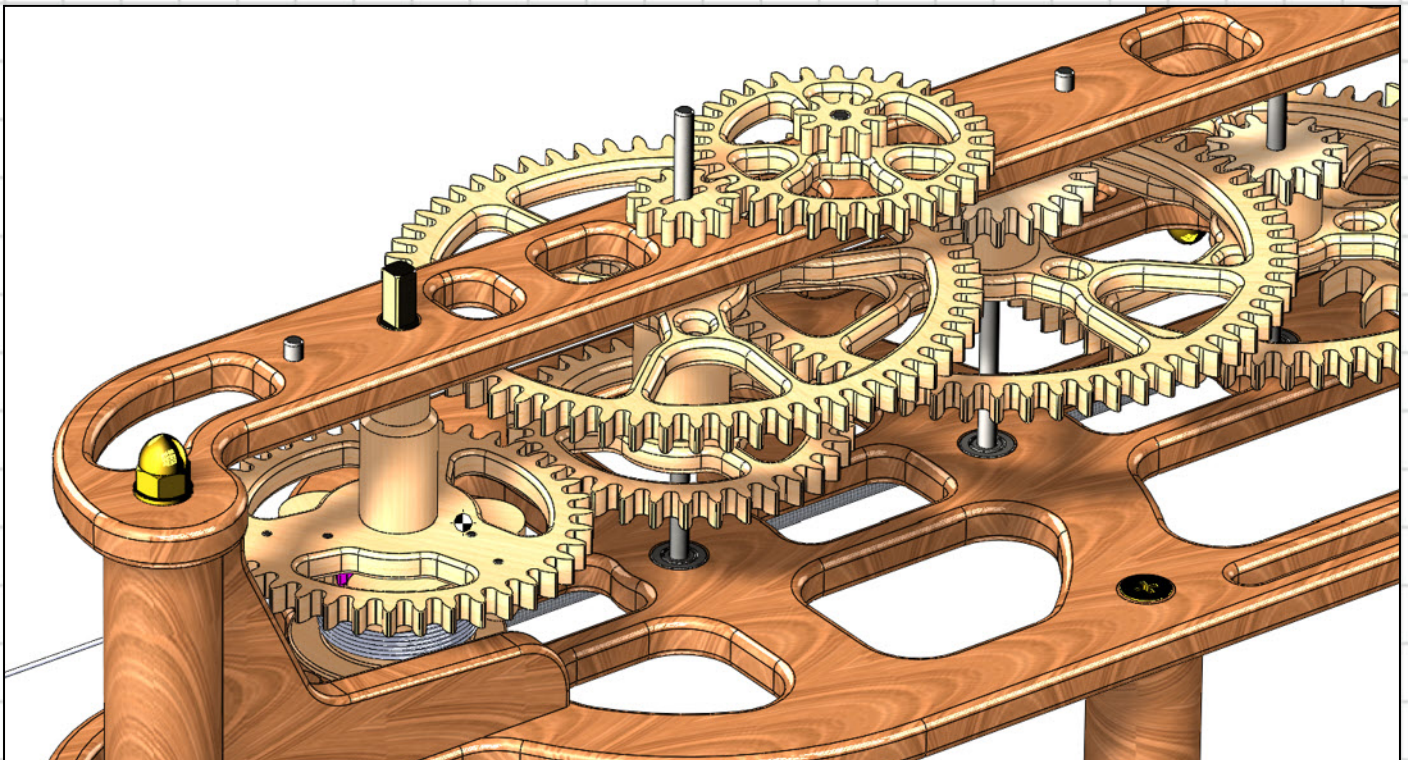
# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38

Step 9 Assemble Front Frame to the Spacers and secure with Cap nuts.



Fit the Front frame and secure with M6 Nuts and Bolts and Threaded rod. Fit the 10 toothed gear to the Minute Shaft

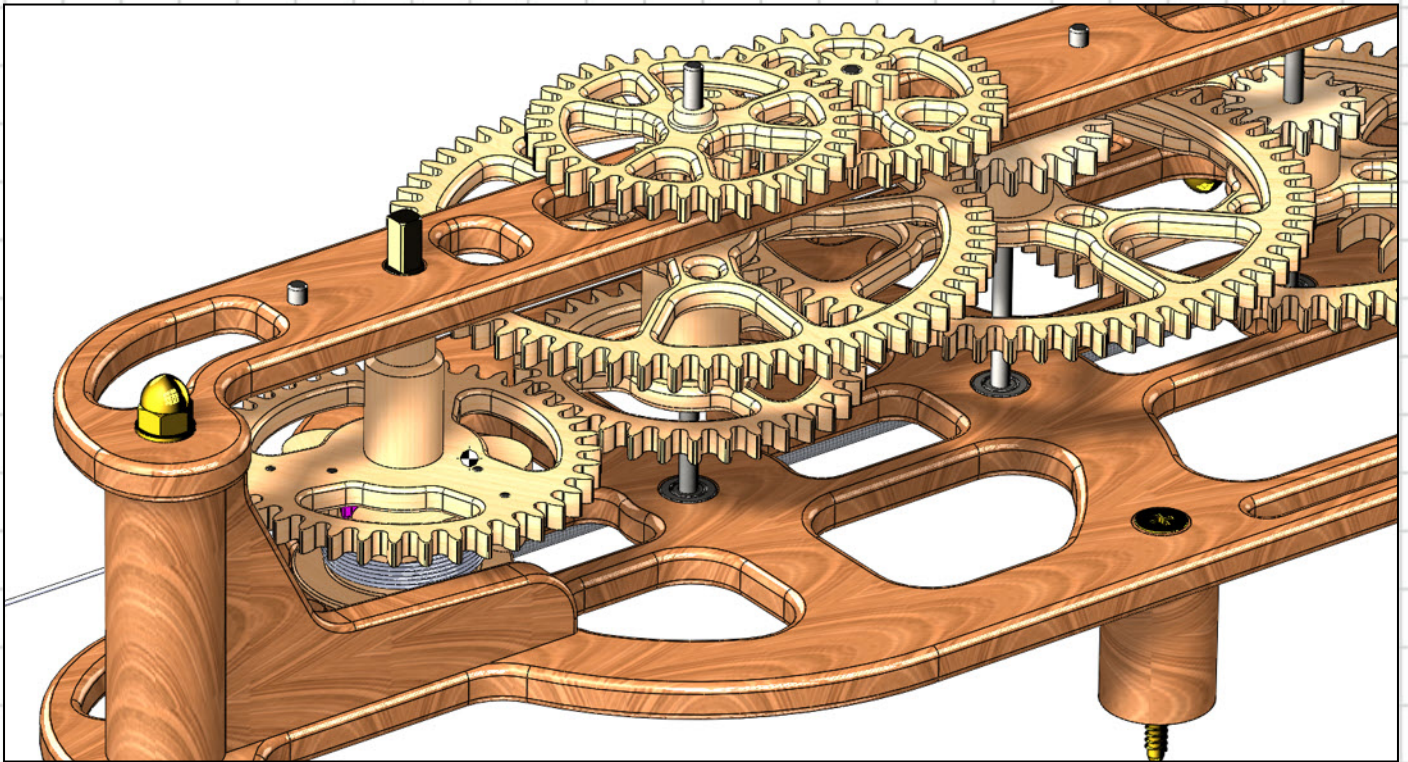


Fit the 30 toothed gear with the 8 toothed gear glued to it onto its small shaft.

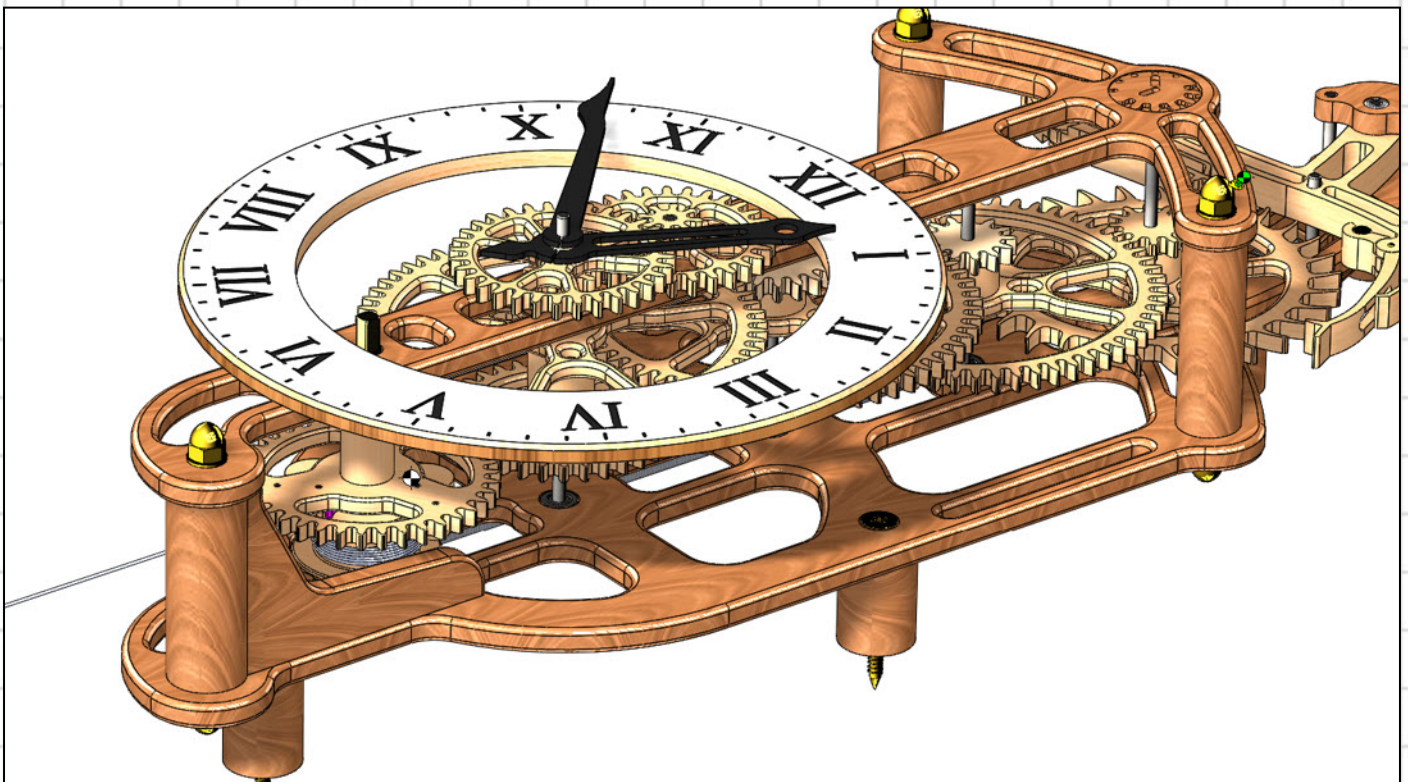


# Clock 38-Clock with Grasshopper Escapement

## Construction instructions for Clock 38



Glue the hour tube into the 32 tooth gear and fit to the Minute Shaft

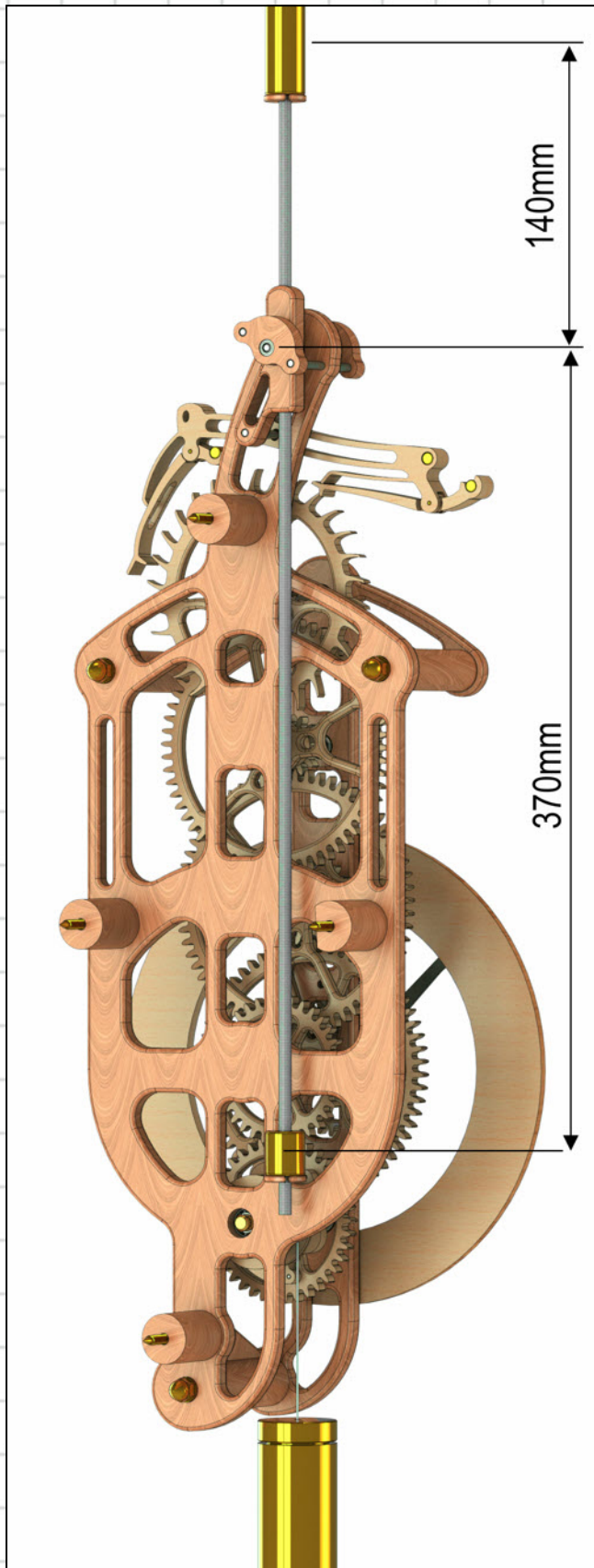


Fit the dial onto the dial pins and secure in place with double sided tape. Fit the two Hands.



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### Adding the pendulum weights

To start the clock set up before running for the first time you will need to attach the large and the small weights to the compound pendulum in the positions shown the weights are held in position with the Locking ring which are designed to be a tight but moveable fit on the Carbon Fibre pendulum Tubes. The weights are adjusted by sliding up or down. To slow the clock either weight can be moved upwards the top weight being moved for course adjustment and the smaller weight for fine adjustment. To speed the clock up move either weight down.

### Adding the Main weight

Once the clock is mounted on the wall You will need to establish the weight required to get the clock to run continuously, I would suggest you do this using a 2 litre Soda bottle half filled with water and the adjust the weight by adding or removing water. When the weight is established you can construct your weight.

I used 1200 grams.

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### HINTS AND TIPS

- The DXF files are on a single sheet, with the inside and outside cuts set on separate layers. Pockets are also included on yet another layer so 2.5 D cuts can be made.
- When fitting the gear sub-assemblies into the frame make sure the mating gears engage and run smoothly. The faces of mating gears should be aligned so they fully engage with each other, i.e. the front faces of the gears are lined up. There is some clearance built into the design so that when the gears are enclosed between Front and Back frames they are free to move without rubbing on the frames.
- For the dial on this clock you could use a V bit cutter to cut out the numerals and minutes ring. I use Artcam Express which gives a good clean-cut edge and very fine detail without having to use extremely small diameter cutter. A free alternative to Artcam is a program called [F-Engrave](#).
- If you have problems getting the clock running initially it could be that the problem is in the gear train itself, one or more of the gears may not be meshing correctly, You need to test each pair of gears in turn, by mounting each meshing pair in the frames on their own and turning them by hand very slowly with little pressure. If any pair sticks or interferes with the other you should mark the teeth that are affected and carry on until you have turned the large gear around completely, then strip down and dress the teeth you have marked until they work together smoothly. Repeat this process for all the meshing pairs of gears are running freely. It is not sufficient to test them when the gears are mounted in the clock and then left to run continuously unrestricted, as the free running gears will easily override any slight interference, whereas when the gears are running in the clock with the escapement in place they never run fast and so easily feel the effects of interference.
- The DXF files supplied include all the parts that can be cut using the CNC router, they do not include those round items such as the turned parts cut from Doweling nor any pins or nuts and bolts, information on these parts are included in the Detail drawings supplied in PDF format. The parts shown laid out in a single DXF files ready for you to extract and use in your CAM software. The profiles are shown on 4 separate layers, these being 'Outside Cuts' 'Inside Cuts' 'Pockets' and 'Non Cutting Profiles' The layers are colour coordinated as shown below.

	Outside Cuts
	Inside Cuts
	Pockets
	Non Cutting Layers

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## Construction instructions for Clock 38

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- carbon steel ground pins for the shafts, and then fit a larger diameter Rod type magnet to cap the end and prevent any parts falling off. Best not to use these close to any ball bearings as it can apply a drag to the rotating balls
- I don't drill the 2 holes in the back of the Dial on the CNC, instead I temporally fix the Dial to the Front Frame with clamps or double sided tape. After measuring and adjusting its position relative to the Shaft 1 centre hole, and then drill with a hand drill from the back through the pivot holes, being careful not to drill right through the Dial.
- For winding the clock I would suggest you use a off the shelf Winder, the Grandfather clock Key number 13 is ideal.
- Establishing the actual weight to use for the main clock weight, is done initially by trial and error. Each clock build is different and that has an effect on the size of weight to use. I normally use a 2 litre Coke bottle partly filled with water to start and add or remove water to get the clock running continuously.  
You would do this finally after setting assembling the clock and making sure everything is running freely and the escapement is set up correctly. Usually, a bit of back and forth here to adjust the escapement then adjust the weight.

