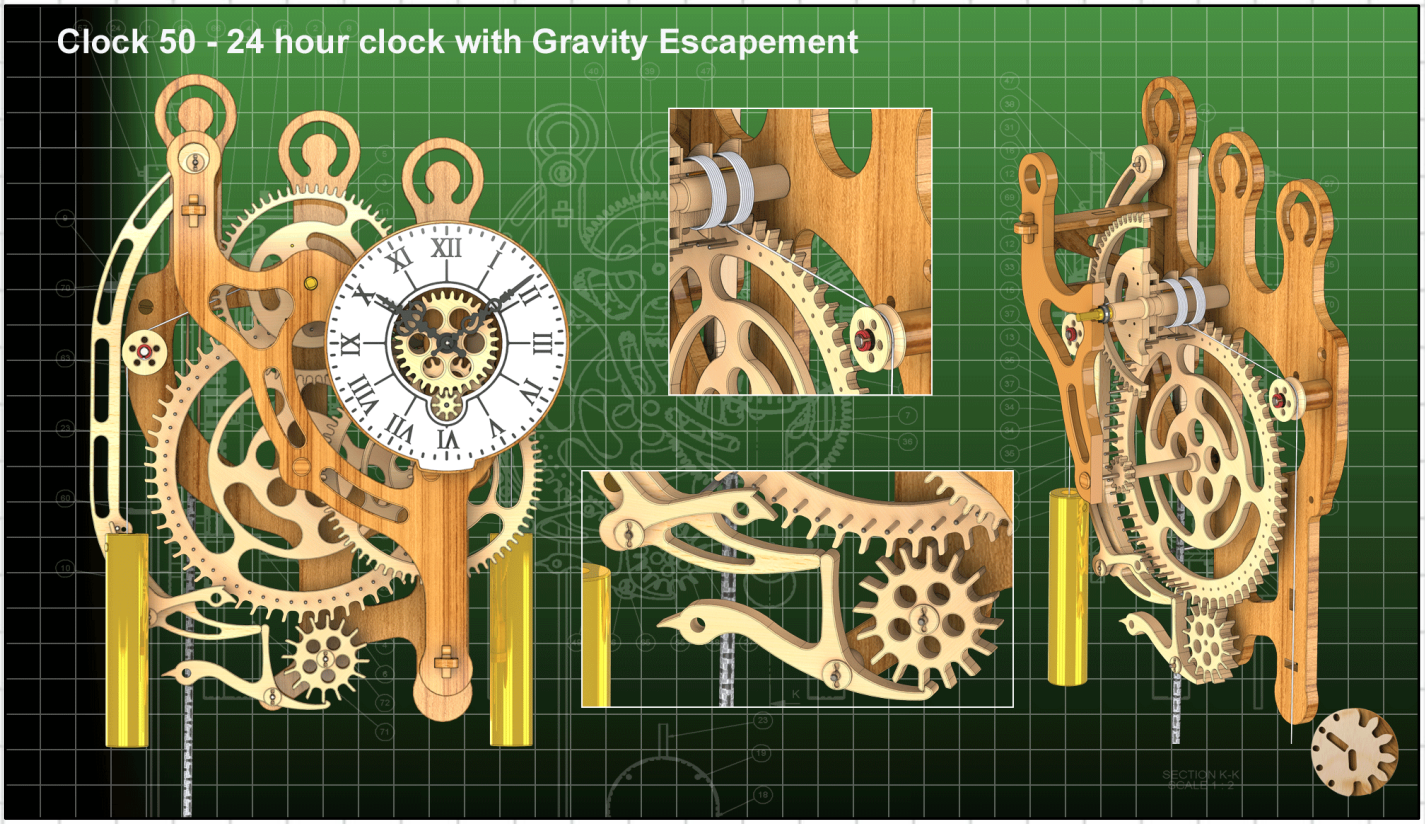
Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50



The prototype for Clock 50 is now completed and running really well, it uses the woodenclocks Gravity escapement and runs for 27 hours on a wind.It has 2 driving weights 750 gram each and the reason for splitting the weight like this is to remove the load from the Front frame and stop Parallelogram distortion. It does add to the complexity of the clock but the benefits in terms of reducing structural load are worth it.

It is one of the largest clocks on the site with a with a Geartrain and Escapement largely exposed so that the novel Gravity Escapement mechanism is properly visible from the front and side.

I have used Needle Roller bearings for most of the shafts as they are more easily cleaned and kept lubricated with a light oil. The exception was the Drive assembly uses Flanged Ball Bearings as these are carrying the highest loads.

I have used 2mm diameter pins on the Escape wheel as they interact with the wooden Catch it offers the smallest amount of friction to the system, unfortunately it means fitting 60 small pins equally spaced to ensure clean and accurate action on every swing of the Pendulum.

This has turned out to be an accurate and reliable clock and perhaps a favourite that I will keep running.

The birds on the Latch and the Catch appeared by accident when I added the Eye Hole to carry a small brass weight if it was found to be needed.

Equipment

The following equipment is desirable:

CNC Router or Laser or Waterjet and if not one of these then a Scroll-saw or a Bandsaw.

Pedestal Drill or simple drill stand 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,Ø2 mm Ø2.9mm, Ø3 mm, Ø3.1 mm, Ø3.2, Ø6 mm

Router Cutters Ø 2mm, Ø3 mm and possibly Ø6 mm 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 just 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.

Materials

For all the wooden Parts

The choice of material to build the clocks from is a very personal one and is 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 125mm x 6mm, and 125mm X 10mm, 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 lay out 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 a lot quicker. However, on this particular clock, I would advise against using Plywood for anything other than the frame parts as greater accuracy is needed for the gears and the Escapement parts.
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 48” 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:-

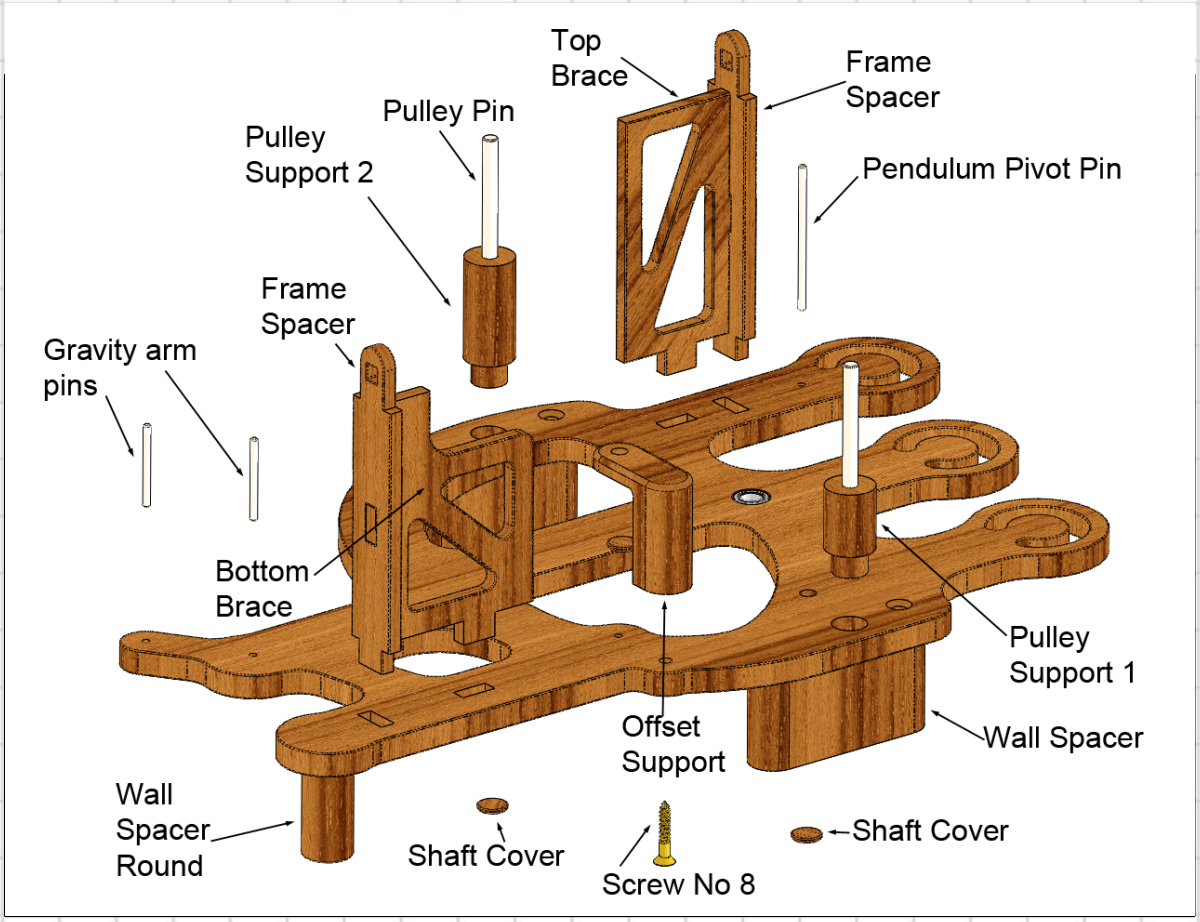
Ø3mm Drill Rod or Silver Steel 450mm Long for all the shafts and numerous pins.
No 8 or 10 wood screws 63 mm long for wall fixing 4 required
No 8 or 10 wood screws 25 mm long for Pivot support 1 required
Ø28.5 Brass Rod 155 mm long for the weight (2X 750 Grams)
Ø6 Brass Rod 100 mm long for the weight hanger and Gravity Arm weights.
Ø8 Brass Rod 150 mm long for the Drive Shaft
3 mm thick Plastic sheet for hands and Endstops, ABS or HIPS

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 buy 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.

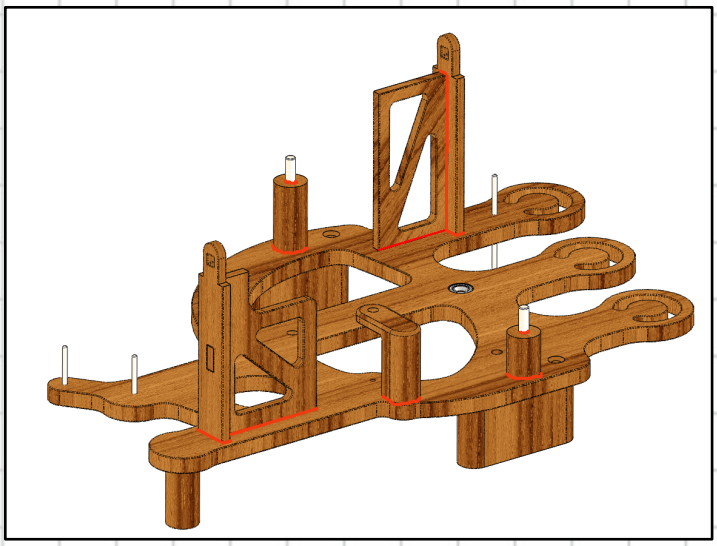
Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

Step 1 Preparation of the Frames

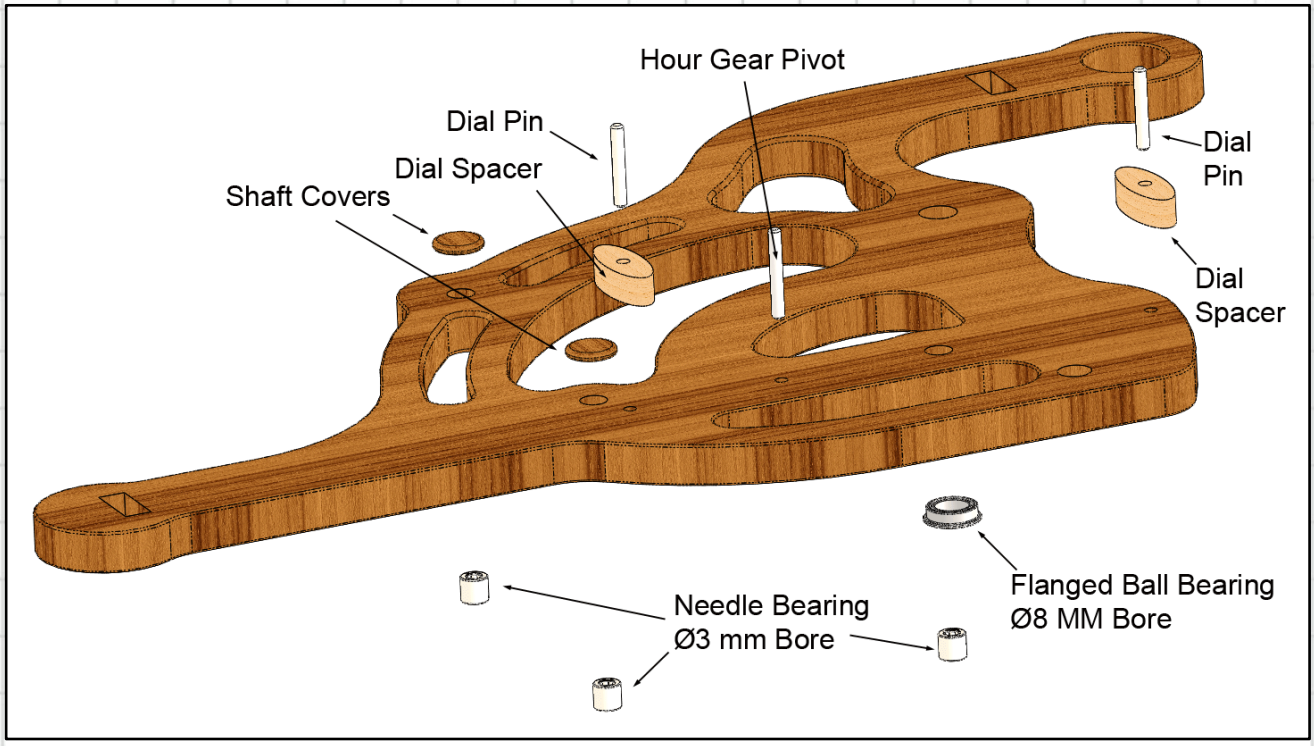


Fit and glue the 2 Pulley supports in Frame the longest into the large hole on the LH side as shown, then fit the Pulley Pins into the supports, tight fit, glue if necessary. Gravity Arm Pins and Pendulum Pivot next to be fitted followed by inserting all the bearings into their pockets. Frame Spacers and Braces go in next and are glued in place followed by the Wall spacers glued into the back of the Back Frame. Now loosely fit the Front frame and fit a long 3 mm diameter rod through both frames and the Offset Support to guide it into position before the No 8 wood screw is used to glue and hold it in position. Remove the Rod just used for guide purposes and fit the 2 shaft covers over the bearing holes in the rear.

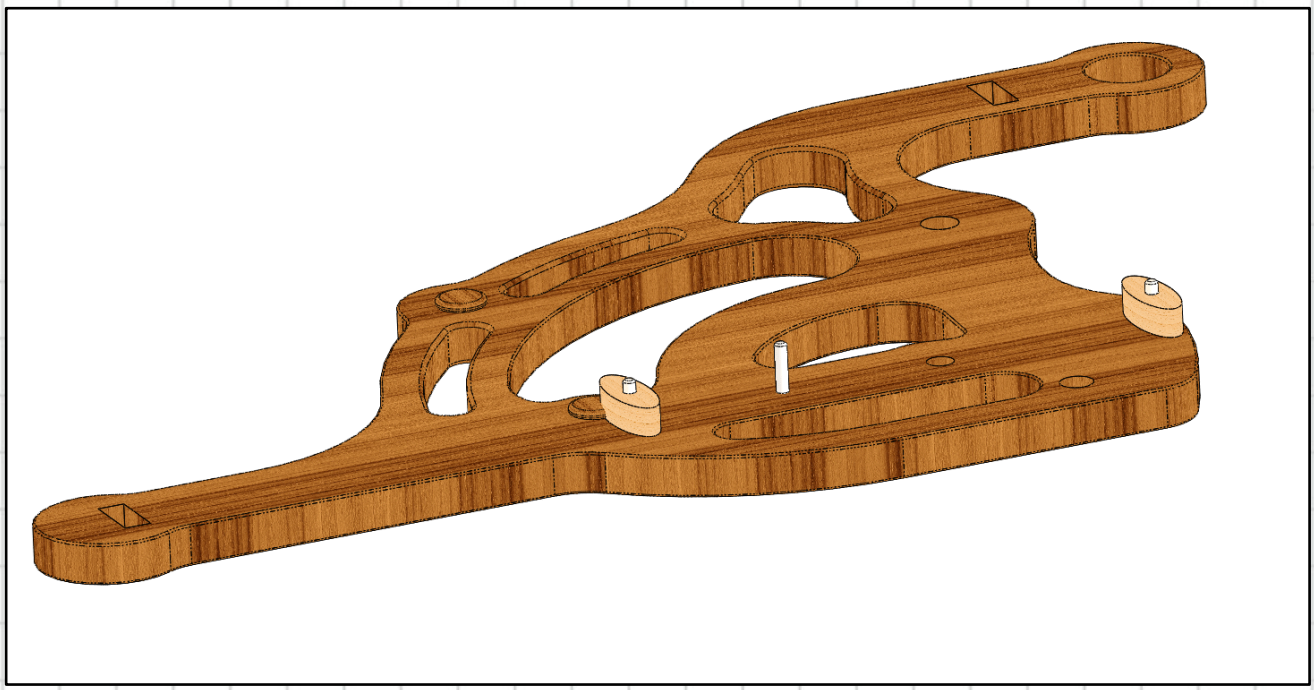


Clock 49 - 24 Hour Clock with Gravity Escapement
Construction instructions for Clock 50

Step 1 Preparation of the Frames



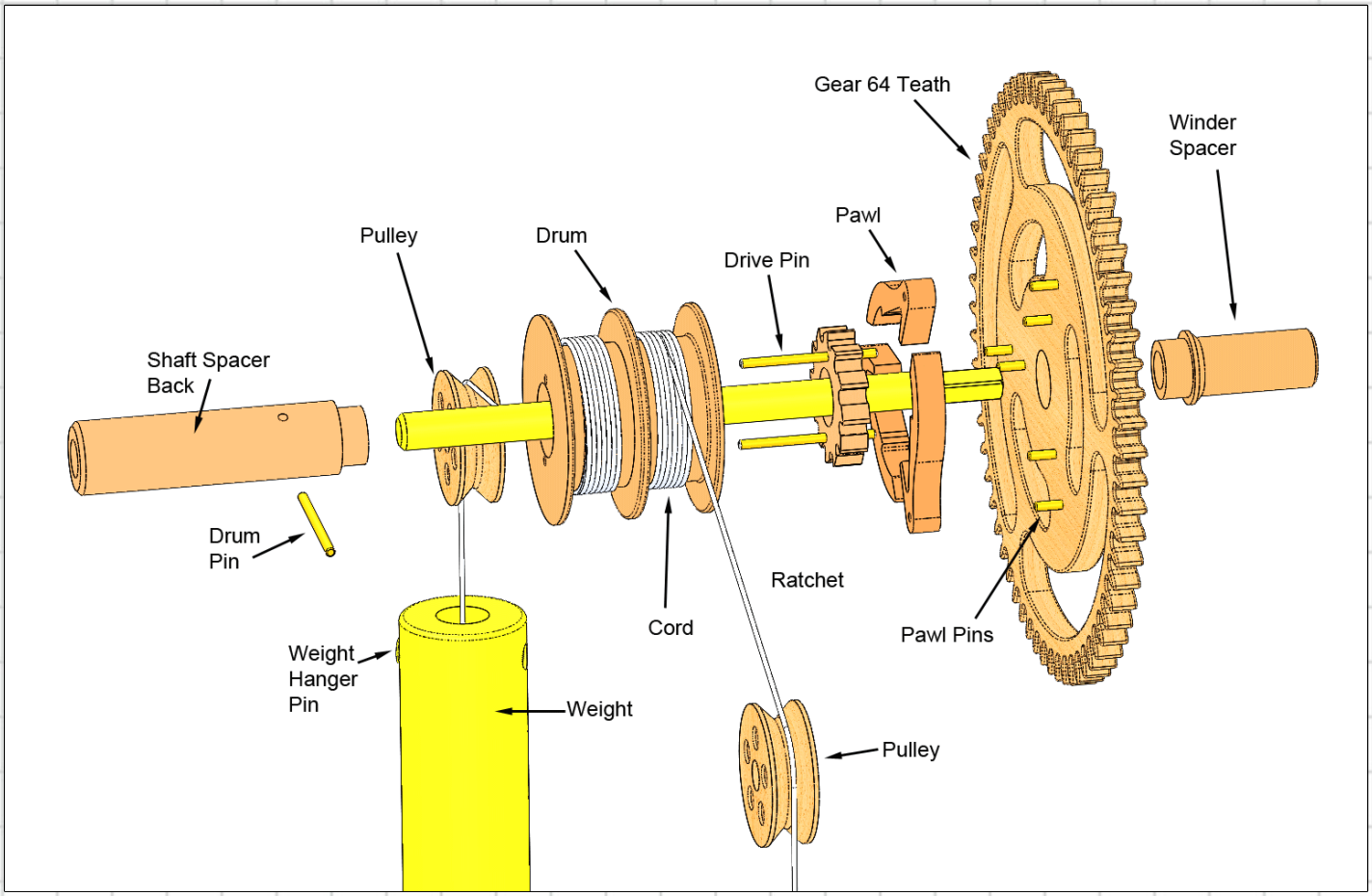
Start by fitting the 3 Needle Roller bearings into their respective holes and then Flanged 8 mm diameter Bearing into its hole into the underside face of the frame. Now fit the 3 pins shown into the Front Frame.
The Shaft cover for the hole next to the Dial Pin needs to be trimmed so the Dial spacer can be fitted flush to the frame, so do that next before gluing both shaft covers over their respective holes.



Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

Step 2 Preparation of the Drive assembly



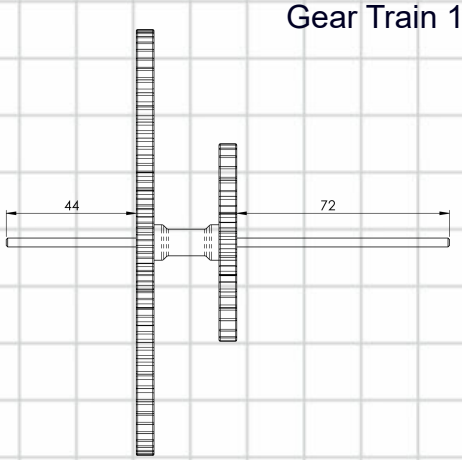
You will need to study the detail drawings to see a description of all of the parts in this sub assembly, it is the most complicated of the sub assemblies used on the clock, Take a special note about the fitting of the Pawl and the orientation of the ratchet.
The cords used to support the main weights are wrapped clockwise around the drum sections when viewed from the front of the clock.
The Pawl pins are a tight fit in the 64 toothed gear and the Pawls that are mounted on them are a loose fit. The drive pins that lock the Drum and the Ratchet together are a tight fit.
The Drum is secured to the Brass central Drive shaft and the Shaft Spacer with the Drum pin, the hole for that is drilled on assembly to ensure proper alignment of the parts.
Finally the winder Spacer is a loose fit on the Brass central Drive shaft and plugs into the 60 toothed gear and is glued in place.

Clock 49 - 24 Hour Clock

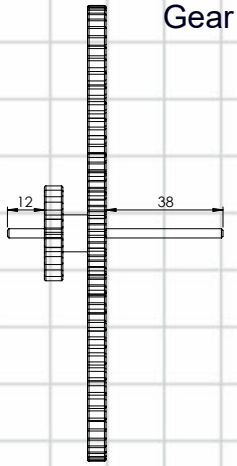
Construction instructions for Clock 50

Step 3 Preparation of the Drive train sub assemblies

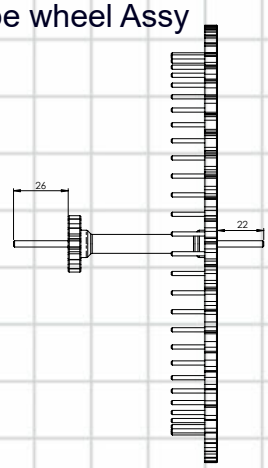
Gear Train 1



Gear Train 2

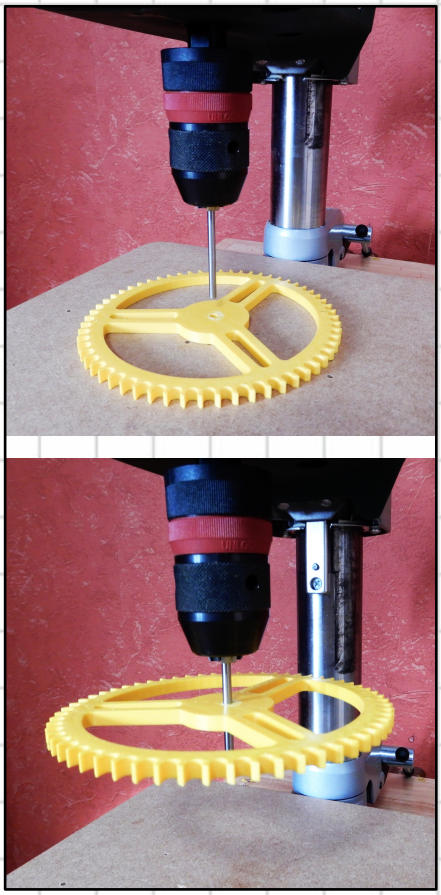


Escape wheel Assy

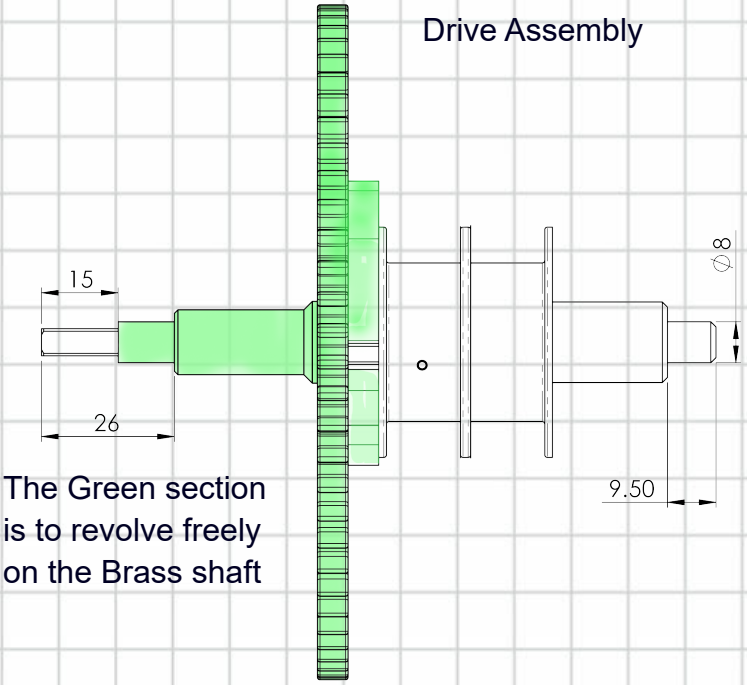


The Gear train sub assemblies shown here are all very similar and require to be assembled in the same manner. I recommend you use a drill press to do this as I have done, as it ensures that the gears are all mounted square to the shaft.

All but the Drive Assembly should be a **fixed** on the shaft. Make sure to glue all gears and spacers together so there is no relative movement between the parts.



Drive Assembly

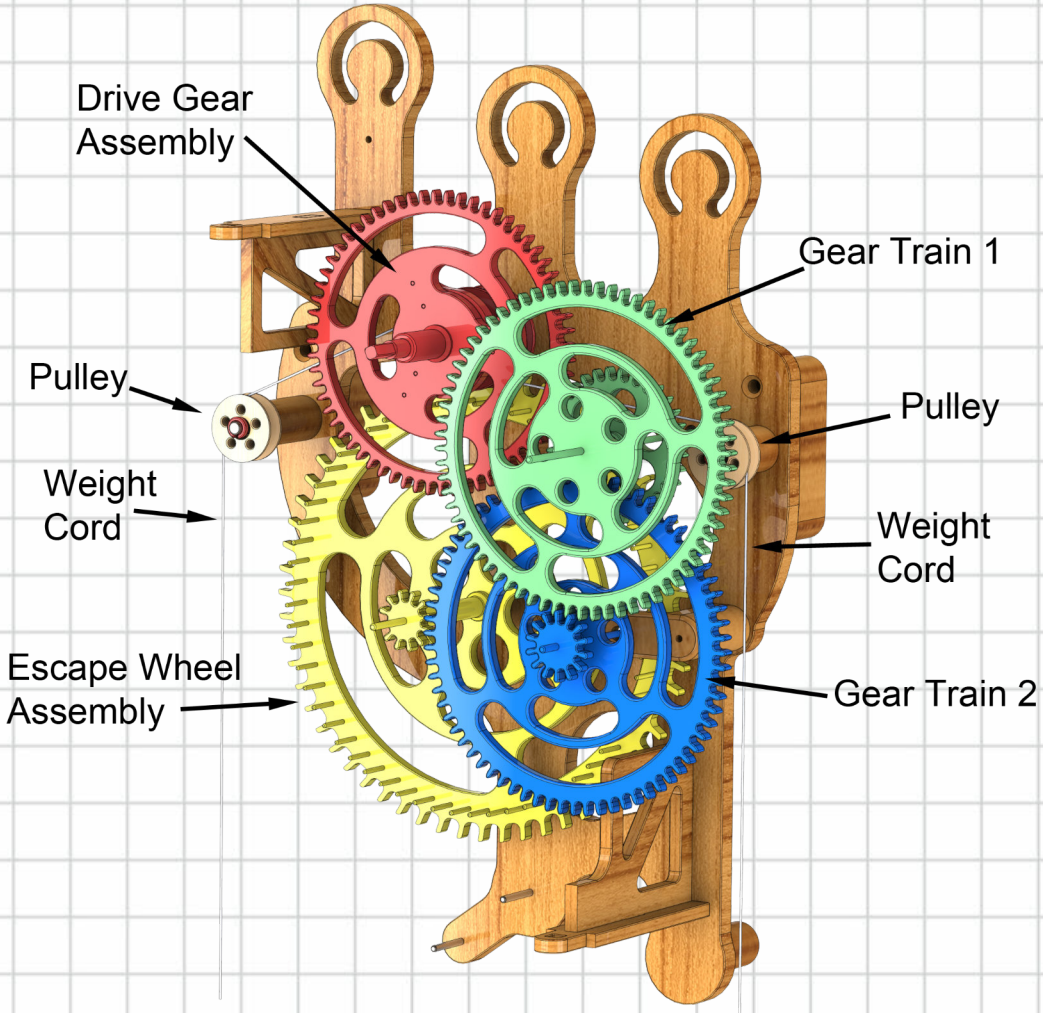


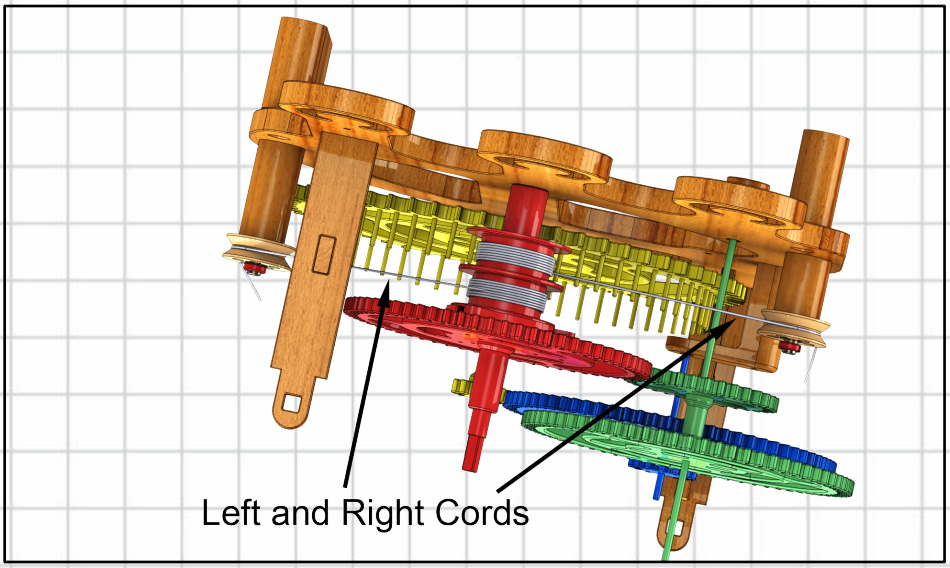
The Green section is to revolve freely on the Brass shaft

Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

Step 5 Fitting the Gear trains



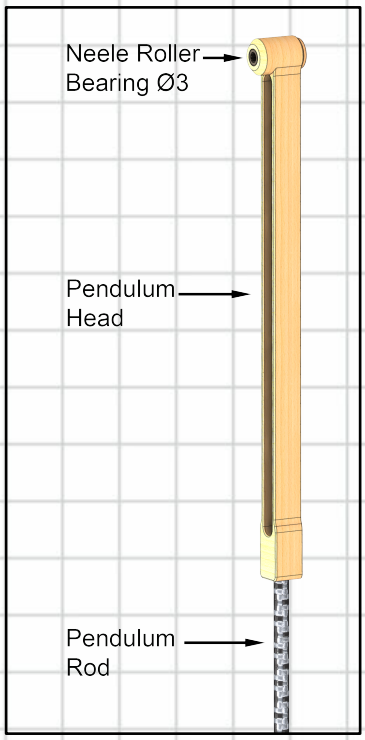


Load each of the Gear and Escape Wheel sub assemblies into the Back frame in the sequence, it is best to do this with the clock laying down on its back. Fit the Escape wheel first using the shaft to hold it in place. Next place Gear train2, followed straight the way with the Drive Gear Assembly and finally Gear train 1. Now load the cords onto the 2 sections of the Drum Winding clockwise when viewed from the front of the clock, laying the cords over the Pulleys to finish.

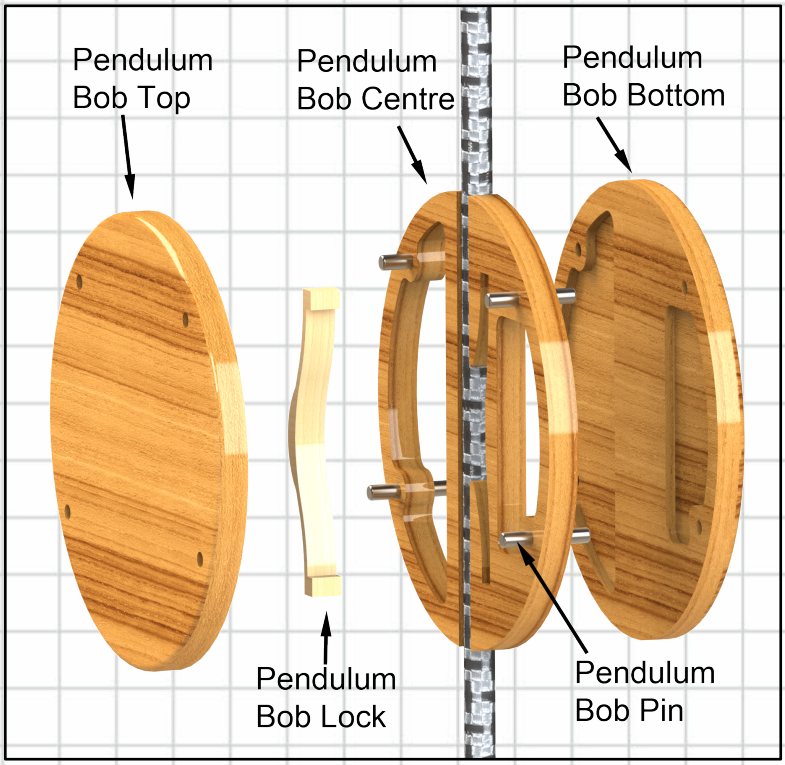
Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

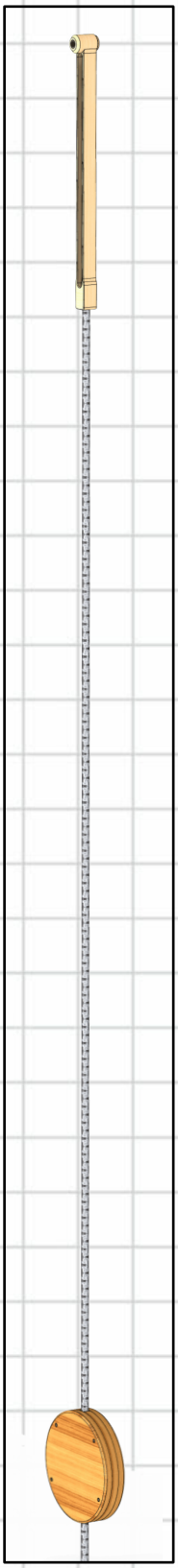
Step 6 Preparation of the Pendulum sub assembly



First fit the 2 Needle roller bearings into the hole at the top, one in each side.
Now Slide the Pendulum Rod into the hole in the underside and glue into position if it is not a tight fit.



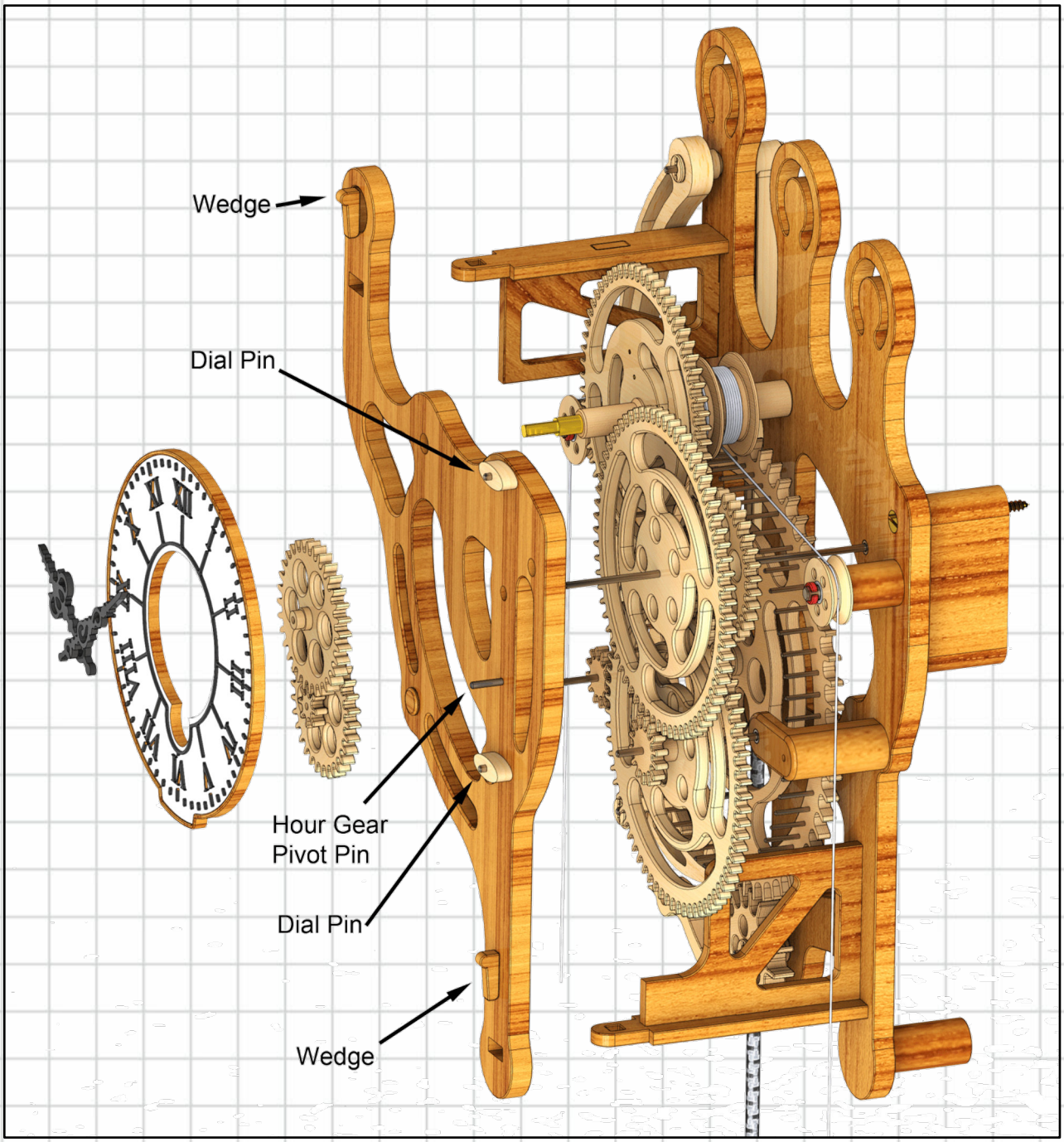
Fix the Top and the Centre parts together using the 4 pins, then lay the Ball bearings into the pockets to get total weight around 150 grams. Fit the lock in position and fit the top part, then slide onto the pendulum Rod.
(Note! The Ball bearings are not shown, any size can be used that fits)



Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

Step 7 Fit the Front Frame

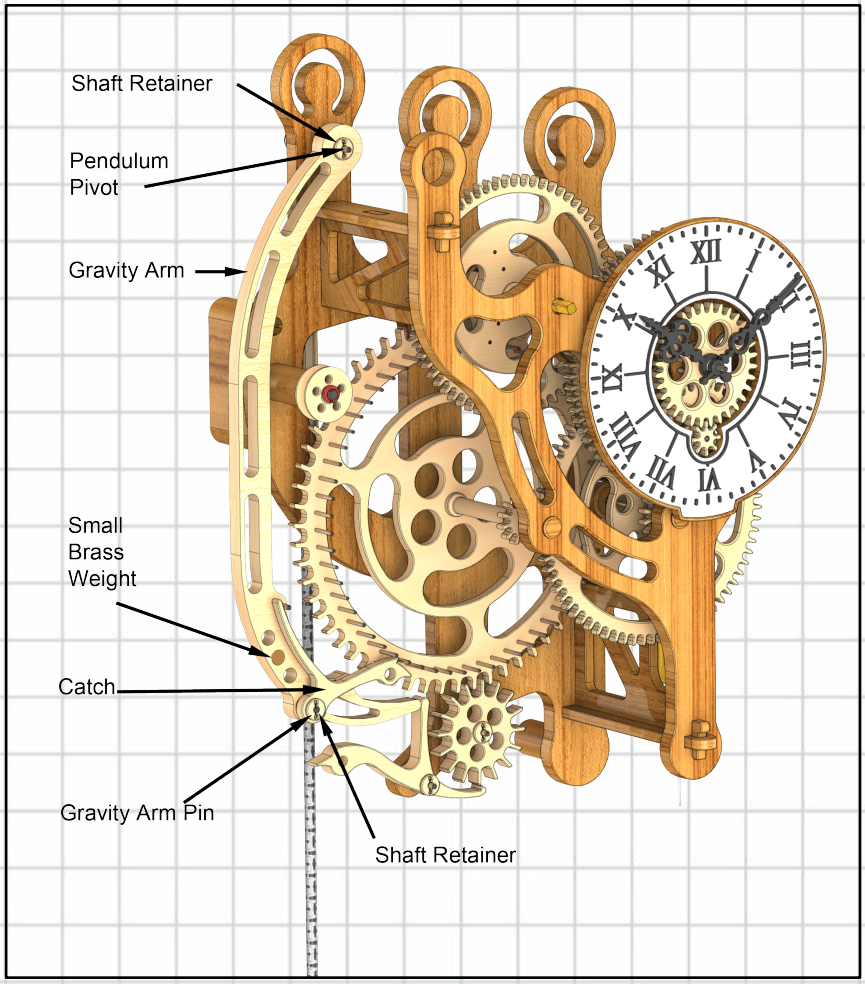


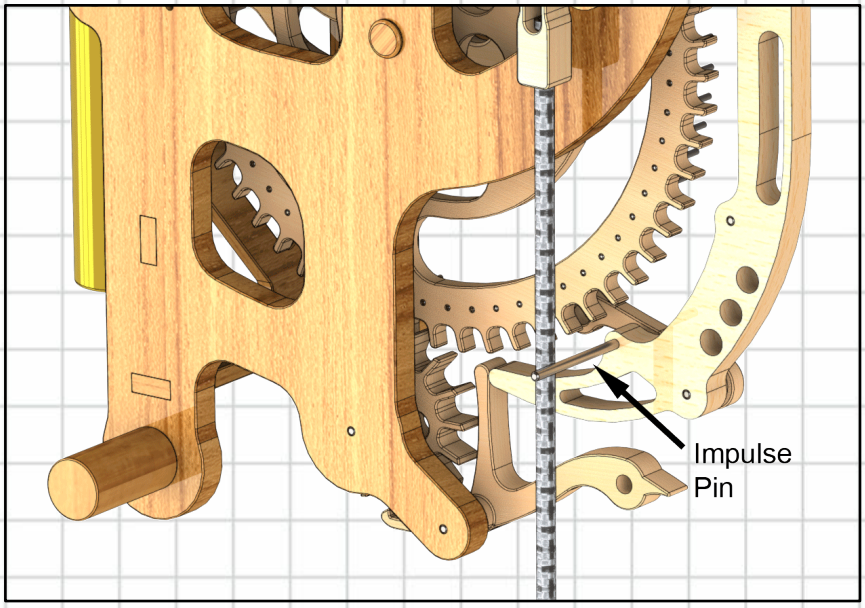
Fit the front frame by fitting over the 2 protruding Frame Spacers and engaging the the protruding gear shafts. Secure in position with the 2 Wedges.
To fit the Hour gears push the 10 toothed gear onto the minute shaft, this should be a tight fit so it can transmit the drive through to the next gear in the chain. The slot cut across the hole is to give it some flexibility so you can push it on and Pull it off if needed. Now glue the 8 tooth and the 30 toothed gears together and fit on the Hour Gear Pivot Pin below the Minute shaft. Should be free to run.
Now fit and glue the Hour tube into the 32 toothed gear and make sure it can can run freely on the Minute shaft.Now fit the Hands and the Dial to its protruding pins.

Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

Step8 Fit the Gravity Arm Assembly





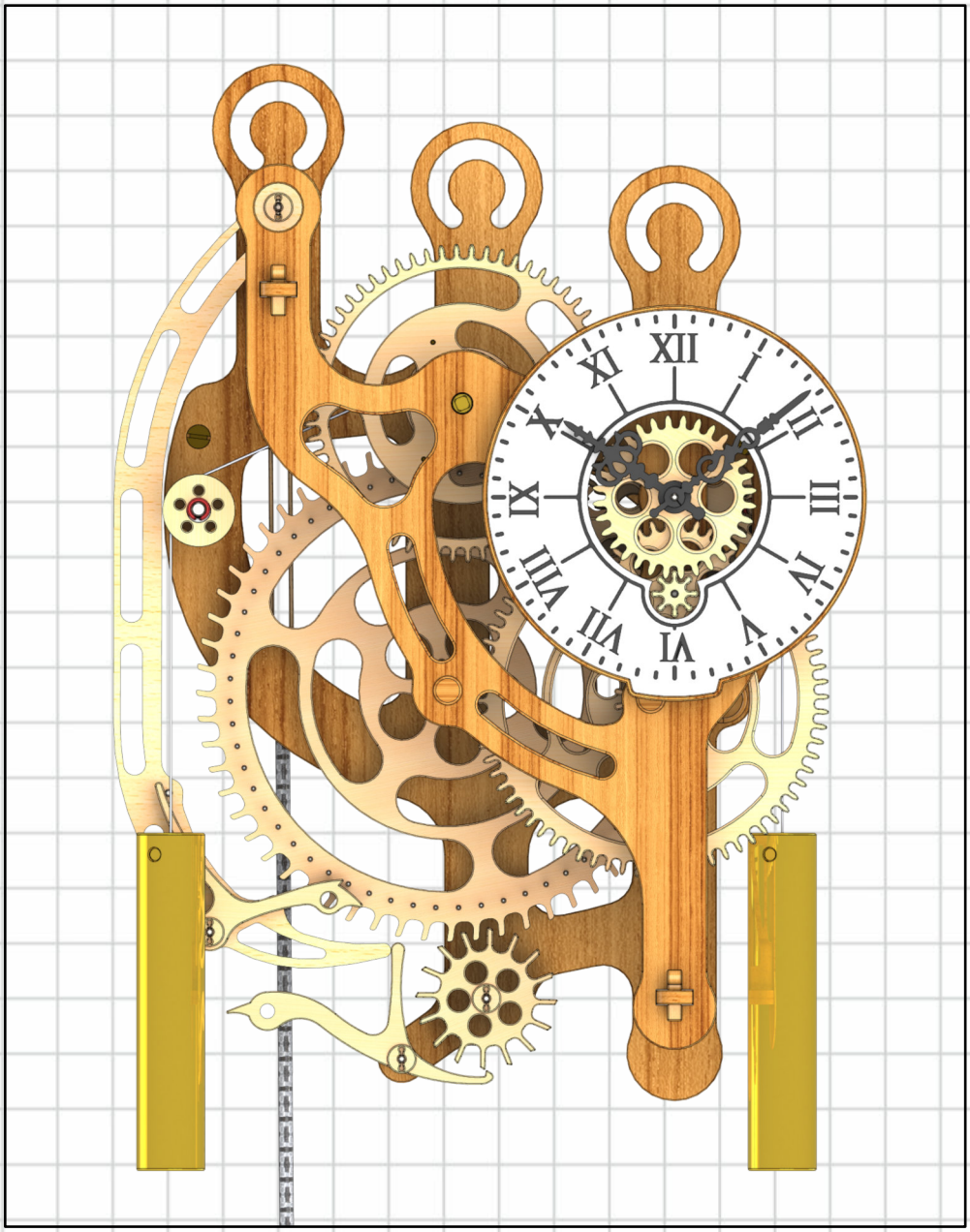
Glue the pair of Needle Roller Bearings into the top hole on the Gravity Arm, and fit the Gravity Arm Pin into the Gravity Arm at the bottom. Now fit the Catch onto that Pin and hold in place with a Shaft Retainer.
Now fit the Impulse Pin into the bottom of the Gravity Arm as shown in the view below.

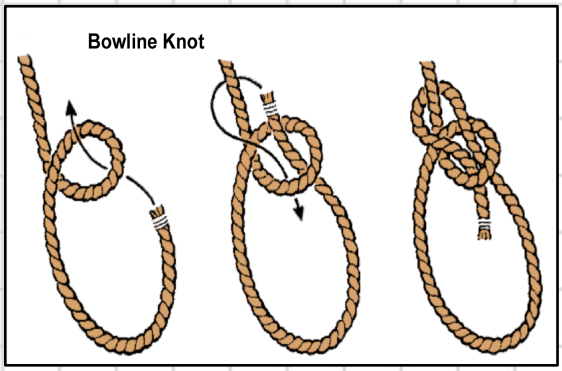
The Pendulum can either be fitted onto its Pivot Pin now or later after the Front Frame and its fittings are attached, either way ensure that the Pendulum hangs inside the Impulse pin as shown

Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

Step 8 Setting up the Weight and Cord and getting it running



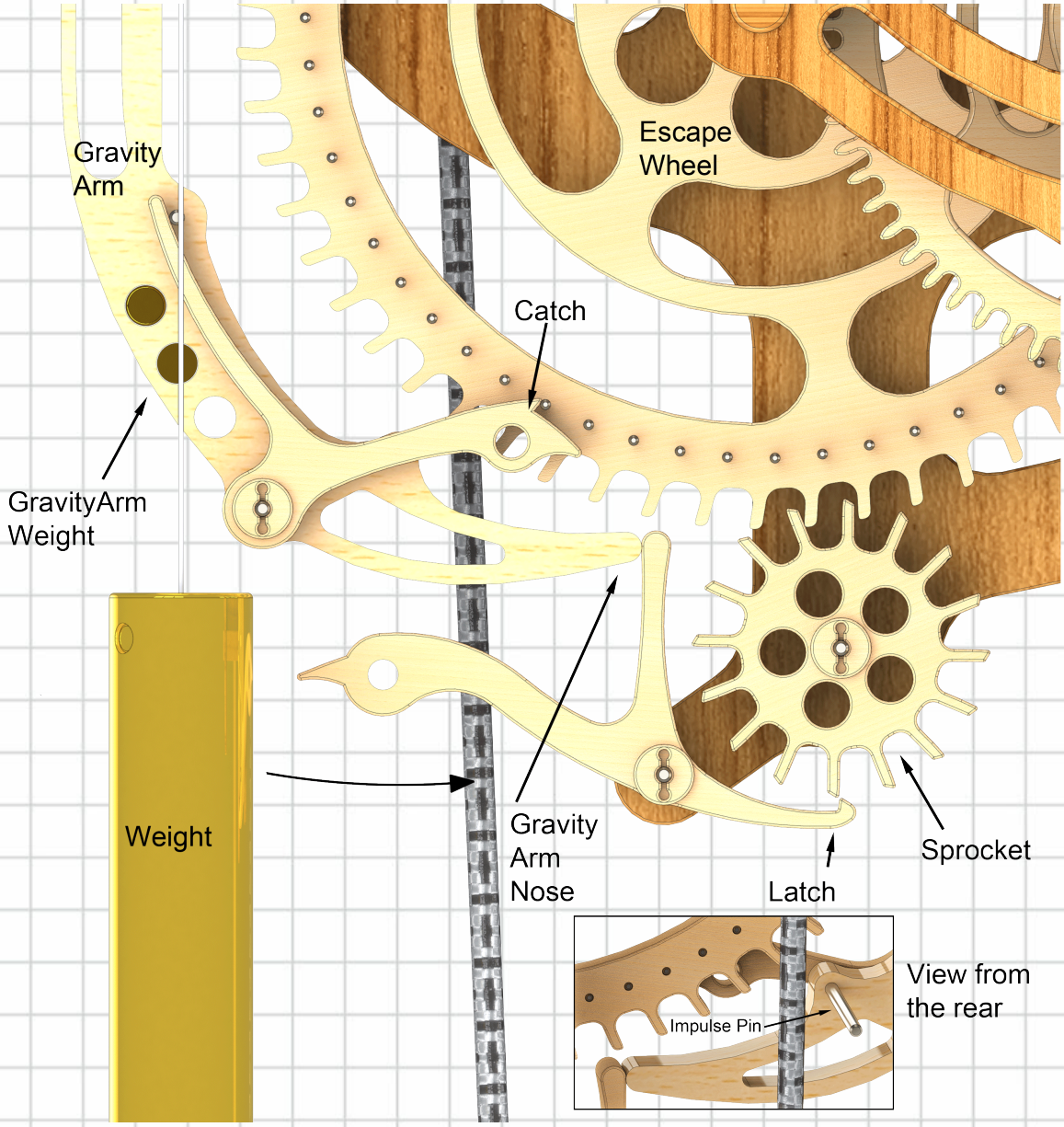


Mount the clock vertically on the wall with the 2 long woodscrews using a spirit level against one of the vertical surfaces, with the centre of the Dial 1600mm above the floor. With the Cords Wrapped around the drum in a counter clockwise manner you now need to ensure that the ends of the cords are level before tying a loop in the end of each cord using a Bowline Knot or similar, still maintaining the loops level. Now attach the two weights by pushing the Loops into the holes in the top and securing by sliding the weight hanging pin through the holes in the side at the top.

Clock 50 - 24 Hour Clock with Gravity Escapement

Construction instructions for Clock 50

Step 9 Setting up the Gravity Escapement



It is the weight that drives the clock but it is the escapement that controls the rate at which it runs. In this case the clock is controlled by the mechanism shown above at the exact moment illustrated here, the Sprocket has just been released by the latch and it is free to move which in turn allows the Escapement wheel to turn in a clockwise motion and then get caught by Catch mounted on the Gravity Arm. This in turn pushes on the Catch and forces the gravity arm backwards until the Latch rocks back to re-engage the Escape wheel and stops It rotating. It stays that way until the Pendulum returns and touches on the impulse pin pushing the gravity Arm back a little releasing the Catch again.
This I think is best understood by watching the Video

HINTS AND TIPS

- The Pendulum Bob needs to be fitted so that the centre of the Bob is about 110cm from the pivot point. This should allow the pendulum to swing a complete cycle every two seconds. The pendulum swing can be adjusted to make the clock run faster or slower by moving the Bob up to speed it up and down to make it run slower. I have found over the years that a slightly heavier Pendulum Bob is an advantage as it seems to overcome any momentary fluctuations caused by a sticking gear train, to achieve this on this clock I have added 9 mm diameter steel ball bearings to the pocket inside the Pendulum Bob, making the overall weight around 150 grams.

- Establishing the actual weight to use for the main clock weights, 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 large 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 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.
  There are many styles of weight that can be used and I have shown several of these in a separate article that can be seen here
  https://brianlawswoodenclocks.blogspot.com/2021/05/the-woodenclocks-weight-drive.html

- If you intend to print out the clock profiles for use in conjunction with a Scrollsaw the this article from my Blog should help https://brianlawswoodenclocks.blogspot.com/2014/09/printing-clock-plans-using-pdf-and-dxf.html
  I would also recommend printing the parts using Foxit Reader as it seems to give a better solid black print out than Adobe Acrobat,

- Before assembling any gears onto their shafts cut all the shafts to length and then try them between the front and Back assembled frames, they should be free to rotate and slide forwards and backwards a small amount all quite freely.

HINTS AND TIPS - continued

- Main Weight between 1500 grams total for the two weights
- Distance from pivot to centre of Pendulum Bob 110cms
- Run time 27 hrs when dial is set at 1600 mm above the floor.

- 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 a little without rubbing on the frames.

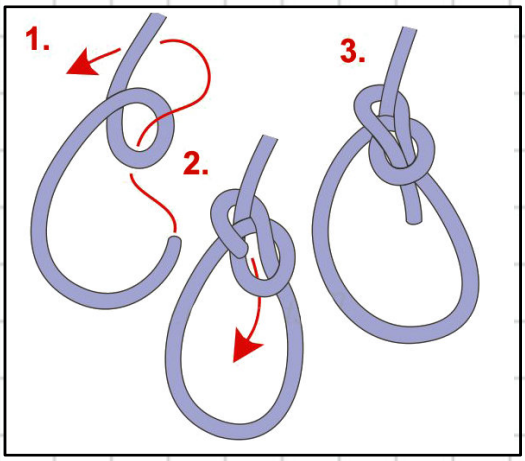
- For the dial on this clock you could use a V bit cutter to cut out the numerals and minutes ring. I use Artcam Express which gives a good clean-cut edge and very fine detail without having to use extremely small diameter cutter. A free alternative to Artcam is a program called F-Engrave, There are many ways to construct the dial some can be found here in a two part article from my Blog https://brianlawswoodenclocks.blogspot.com/2014/11/clock-dials.html https://brianlawswoodenclocks.blogspot.com/2014/11/clock-dials-part-2.html

- 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.
- Alternatively the Pendulum / Escapement may not be running freely on the 3 mm diameter shaft they are fitted to. The parts should be a running fit in the 3 mm diameter shaft.

- The DXF files supplied include all the parts that can be cut using the CNC router, they do not include 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 6 separate layers , these being ‘Outside Cuts’ ‘Inside Cuts’ ‘Pockets ’ ‘Non Cutting Profiles’ and ‘V cuts’ and ‘Chambers’. The layers are colour coordinated as shown.

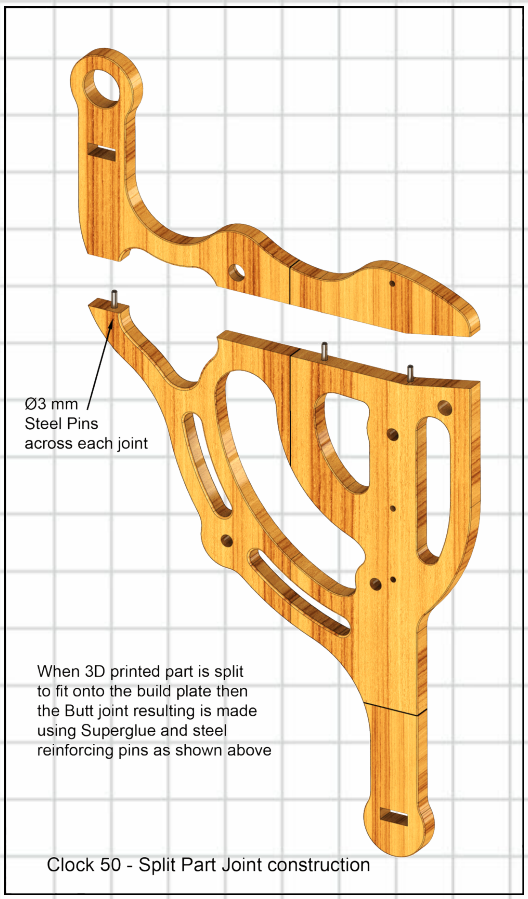
HINTS AND TIPS - continued



I always use a Bow Line Knot on the end of the cord holding the driving weight of a clock, it is one of the most useful knots you can know. The Bowline forms a secure loop that will not jam and is easy to tie and untie. The Bowline is most commonly used for forming a fixed loop, large or small at the end of a line. Tried and tested over centuries, this knot is reliable, strong and stable. Even after severe tension is applied it is easy to untie.

There are of course many alternatives and you can find illustrations of them here,

https://www.animatedknots.com/end-loop-knots



Clock 50 - Split Part Joint construction

When the parts of the clock are just to big to be printed on the Build plate then the part must be split into separate pieces. This is illustrated opposite where the front panel of the clock has been split into 5 pieces . The parts are printed with 3mm diameter holes into the faces of the splits so that steel pins can be inserted when the parts are assembled back into a whole part. I normally use a thin superglue for this purpose if printing with PLA, but I use a solvent bond technique with Acetone if printing with ABS.

On this clock I have supplied the STL files for all of the parts as well as a separate set of split parts for the front and Back panels along with a split set for the Gravity arm.