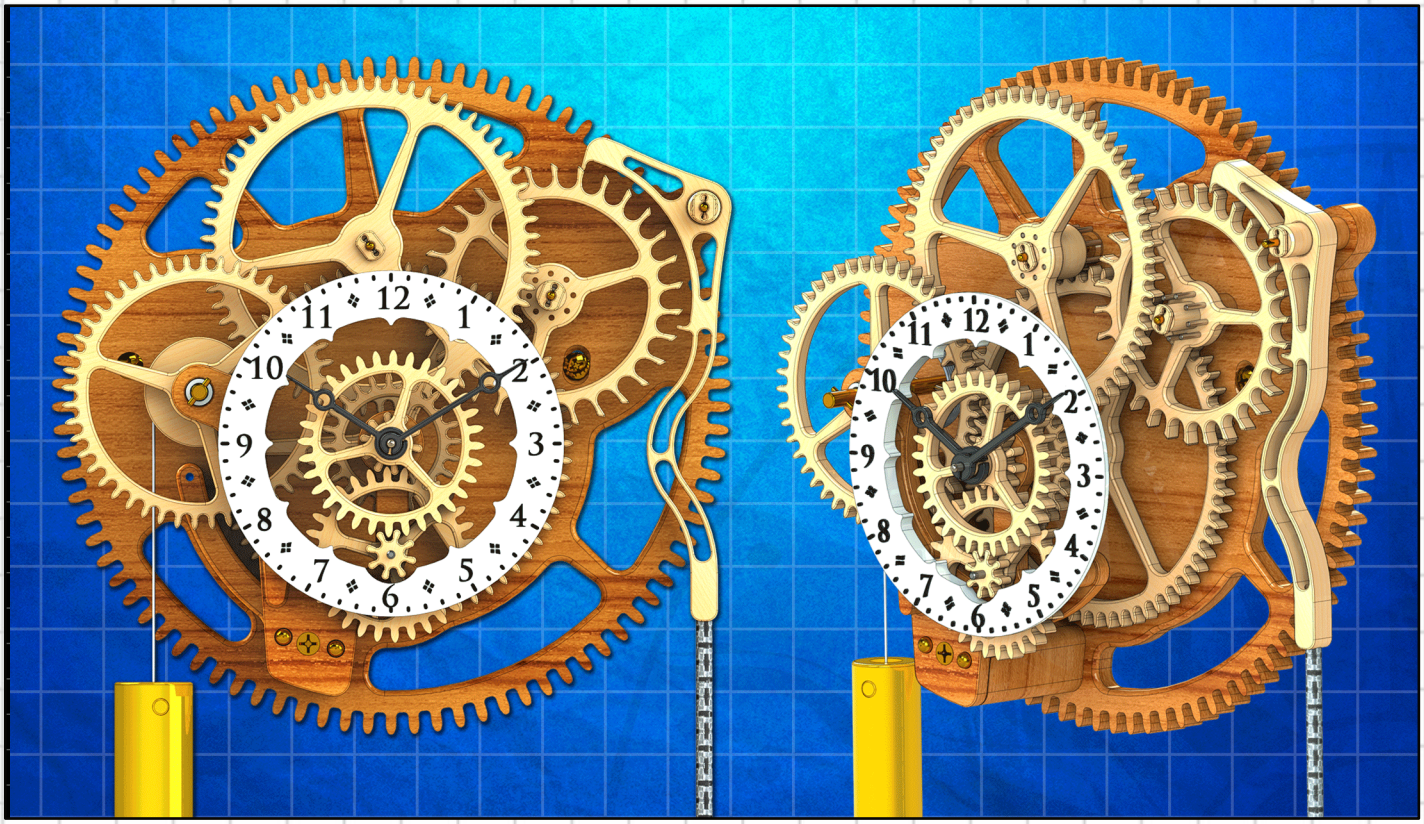
Clock 51 - 24 Hour Skeleton Clock

Construction instructions for Clock 51



I have called this one a Skeleton clock as it removes most of the Front Frame that is used to support the outermost ends of the Gear Shafts. In this way, most of the distortion of the gear shafts is eliminated reducing a lot of the friction caused by the misalignment due to the hanging weight. This means that more of the gearing is on display and as a bonus, the weight itself can be reduced considerably. All of the mechanism is mounted on the front of the back frame so it can be screwed directly to the wall and as a bonus, the Pendulum and the Escapement Arm are combined. The clock has fewer parts than most of the other clocks here and in some respects, it is easier and quicker to build.

The clock will run for 26 hours on a single winding if the centre of the clock is hung with the dial 1.6 meters above the floor. I have had the prototype running for a couple of months now with a weight of 500 grams, but earlier experiments show that it can run with significantly smaller weights around 250 grams. All of the parts can be either CNC machined, cut out by hand or 3D printed using the files provided. I must add though that many of the round parts would be more easily made on a lathe.

STP files are also available for you to use in a suitable STP file reader so you can more easily understand how all the parts fit together, also so you can alter the design of any of the parts to suit your own ideas of what the finished clock should look like.

I have used Needle Roller bearings for the gears to run on as they are more easily cleaned and kept lubricated with a light oil. The exception was the Drive assembly uses a clutch version of the Needle Roller type as this removes the need to add the Pawl and Ratchet normally included.

Construction instructions for Clock 51

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.

3D Printer can also be used with the STL files supplied with this clock.

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, Ø6.5, Ø10 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.

Clock 51 - 24 Hour Skeleton Clock

Construction instructions for Clock 51

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 30 mm long for wall fixing 2 required
No 8 or 10 wood screws 25 mm long for Pivot support 1 required
Ø25 Brass Rod 130 mm long for the weight (500 Grams)
Ø6 Brass Rod 100 mm long for the weight hanger and Drive shaft

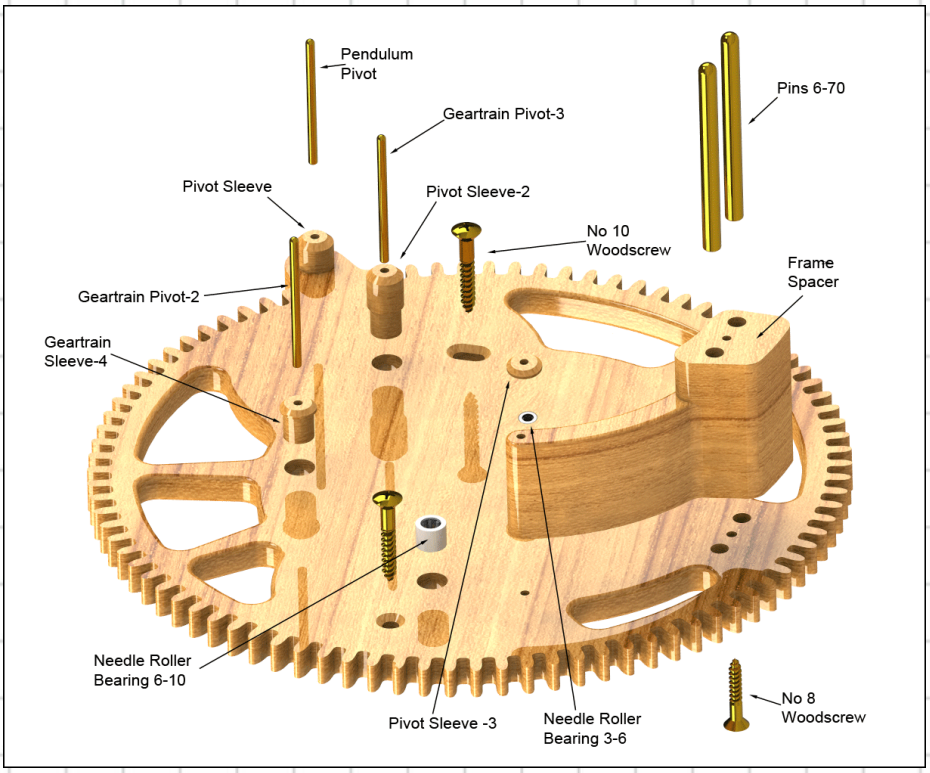
3 mm thick Plastic sheet for hands and Endstops, ABS or HIPS

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.

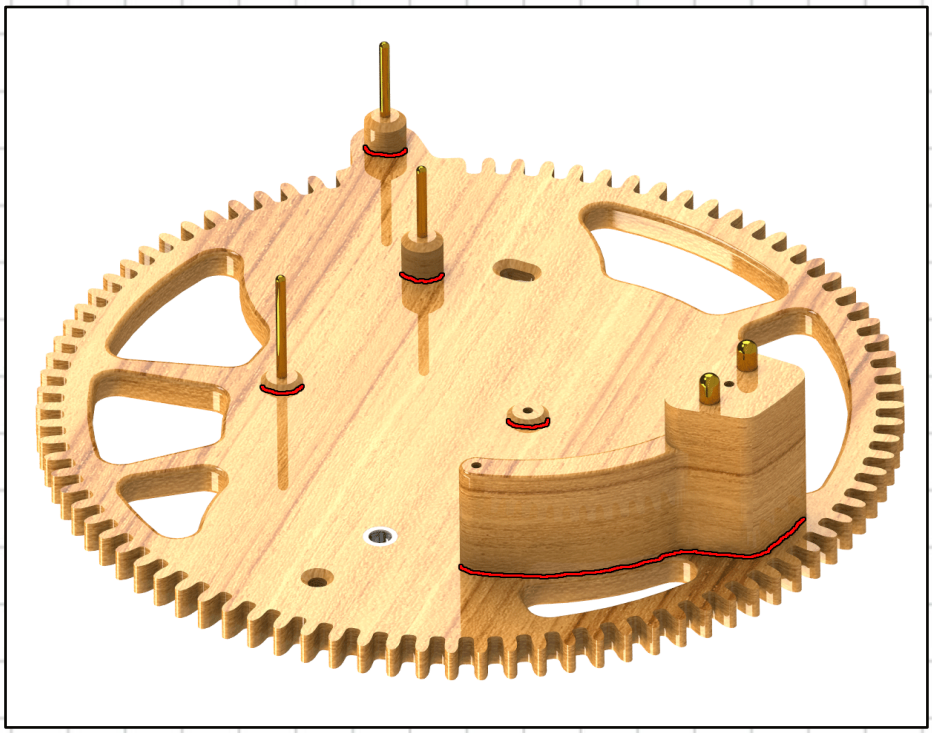
Clock 51 - 24 Hour Skeleton Clock

Construction instructions for Clock 51

Step 1 Preparation of the Frames



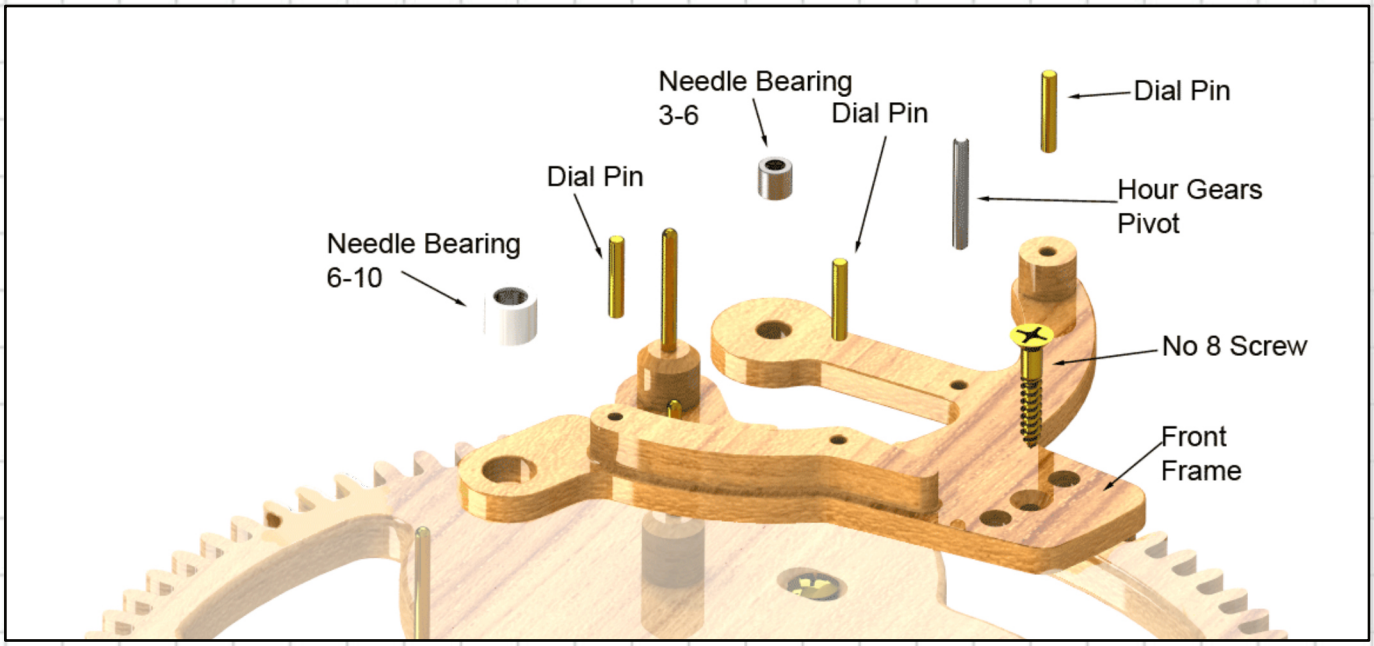
First we need to fit the 4 Sleeves into Back Frame, if they are a tight fit they need not be Glued, if not it is probably better to do so. The 3 Pivots are fitted next and these should be a tight fit in the sleeves. Now fit the two Needle roller bearings, this is best done on a Drill press using a stepped pin to ensure the the bearing is pushed in perfectly square to the base. The two 6 mm diameter pins are fitted next again using the drill press, an the the Frame spacer is fitted over these pins and pushed down to the Back Frame with a layer of glue between them.The No 8 screw is used to firmly secure it in place. The two No 10 woodscrews are not needed at this stage but are shown so that you know where they are fitted when mounting the clock to the wall.

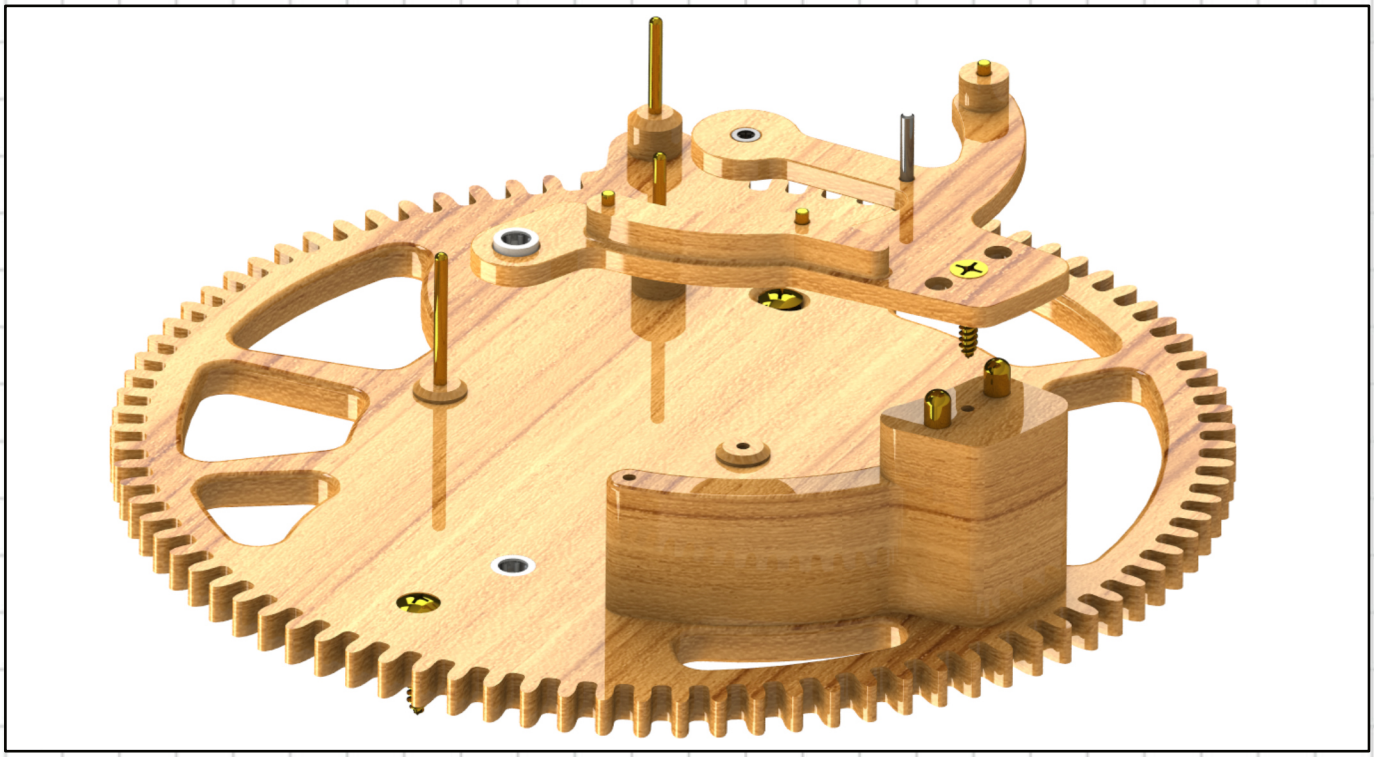


Clock 51 - 24 Hour Skeleton Clock

Construction instructions for Clock 51

Step 1 Preparation of the Frames



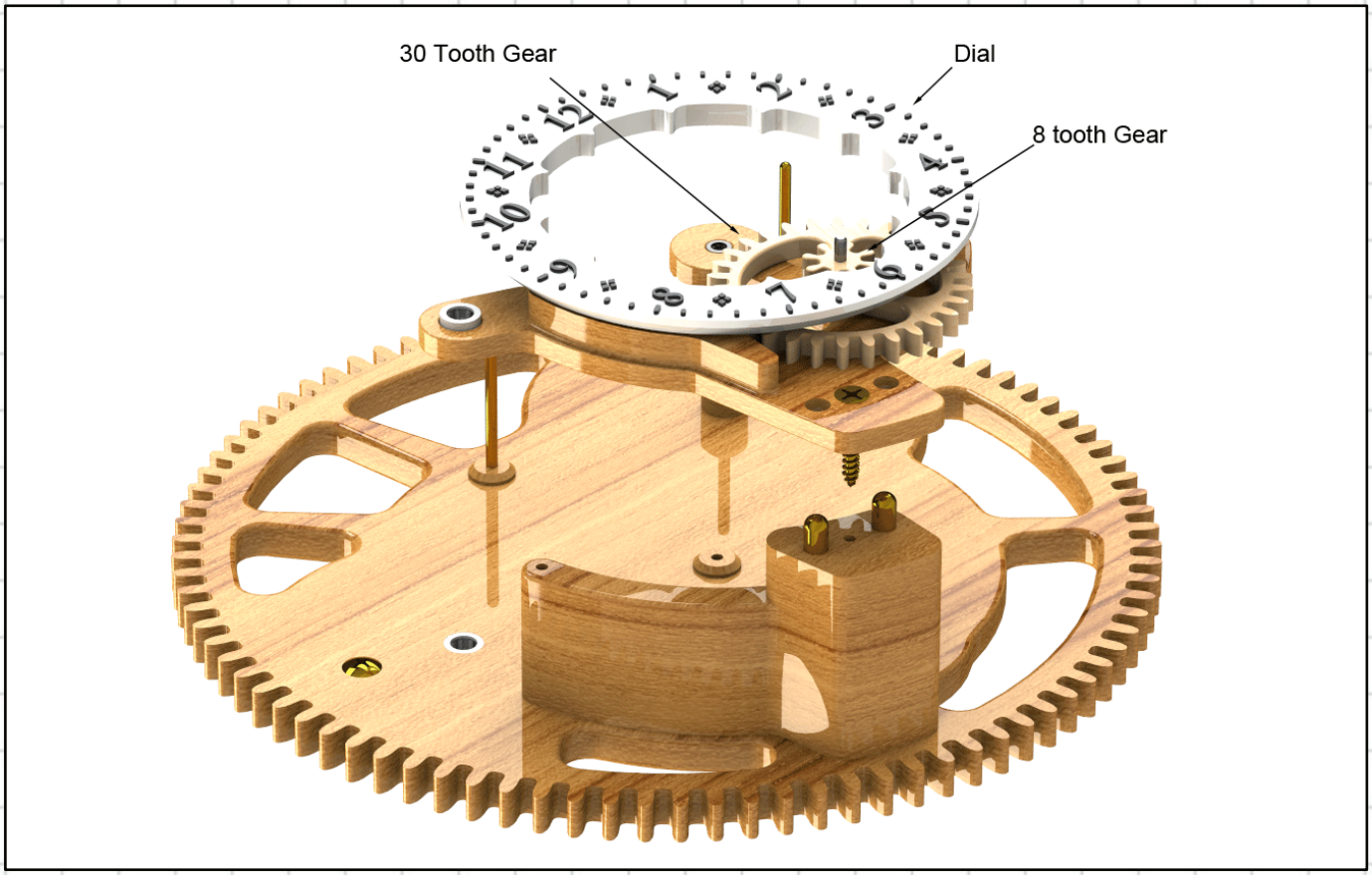


Start by fitting the 2 Needle Roller bearings into their respective holes ,note that the Larger bearing sticks out 3 mm either side of the front frame Now fit the 3 Dial pins shown into the Front Frame, along with the Hour Gears Pivot pin.
The No 8 screw is shown for reference at this stage as it will only be used to connect the Front Frame to the Frame spacer after the gears are fitted.

Clock 51 - 24 Hour Skeleton Clock

Construction instructions for Clock 51

Step 1 Preparation of the Frames

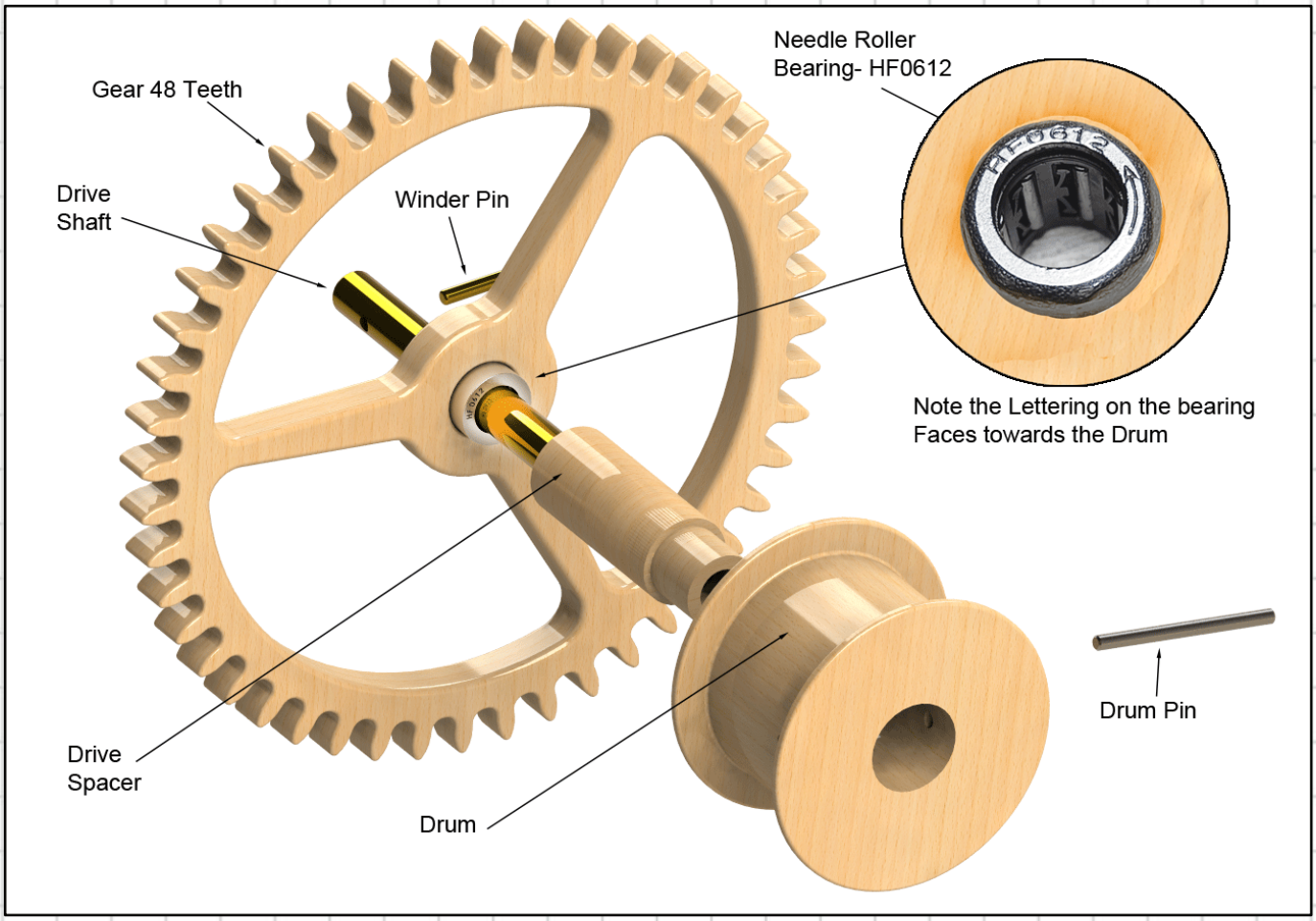


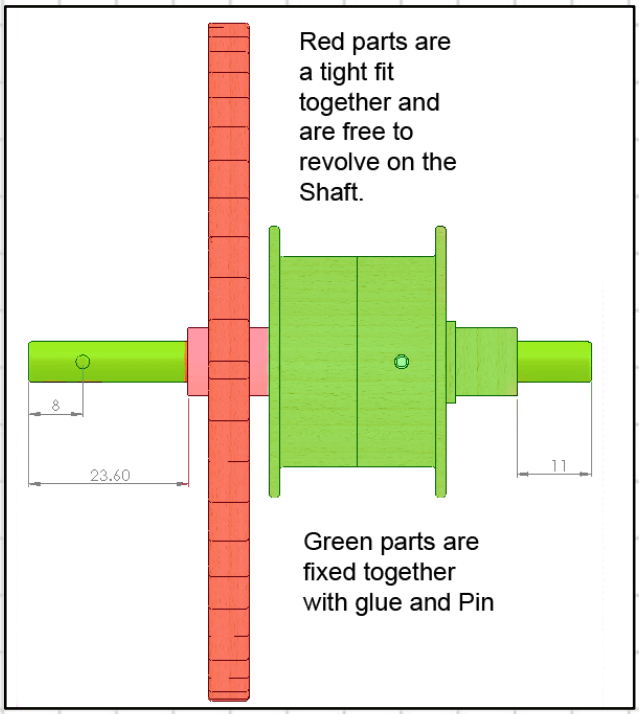
Finally for this stage glue the 8 toothed gear to the top of the 30 Toothed gear and ensure the centre holes are lined up before it dries, Drill out afterwards to ensure the pair of gears run freely on the Pivot.

With the gears in place fit the dial onto the three short Dial pins protruding from the Front Frame.

That's it for now with the Front Frame, assembling each of the gear sub assembly's comes next.

Step 2 Preparation of the Drive assembly





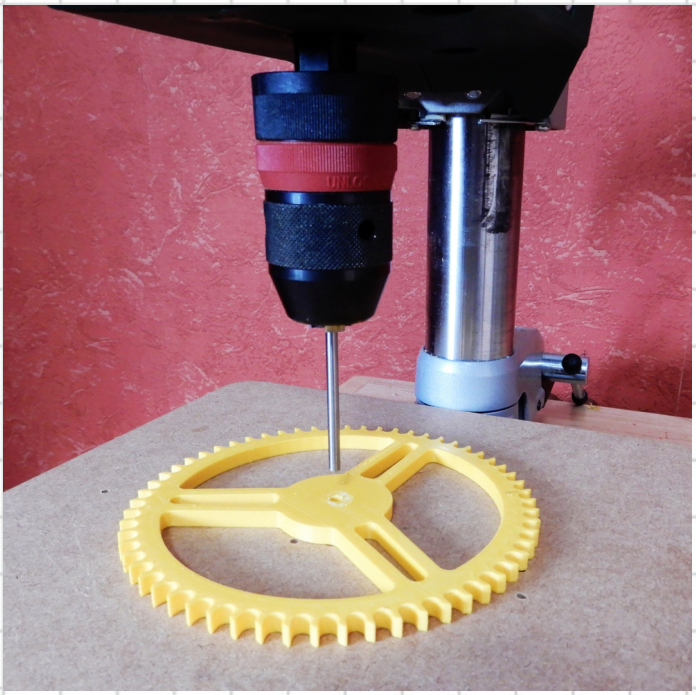
The drum is the first to be fitted and glued to the Drive Spacer and then fitted to the drive shaft by drilling and pinning with the Drive Pin in the position shown on the left here.
The 48 Toothed Gear now has the Needle roller Clutch press fitted into it and it should protrude either side of the gear 3 mm. This is then slid onto the drive shaft and pushed up against the Drum. The Winder pin needs to be fitted after this Sub assembly is mounted into the the clock itself other wise it prevents the Front frame being fitted.

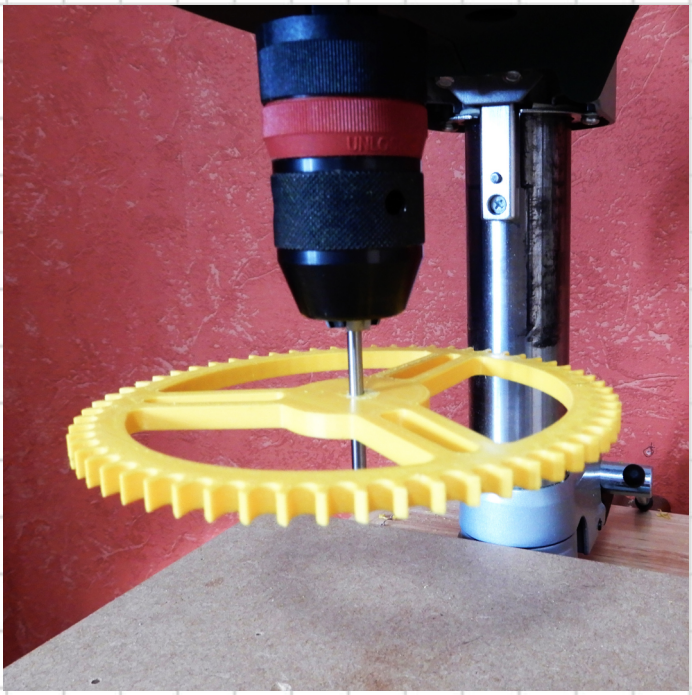
Clock 51 - 24 Hour Skeleton Clock

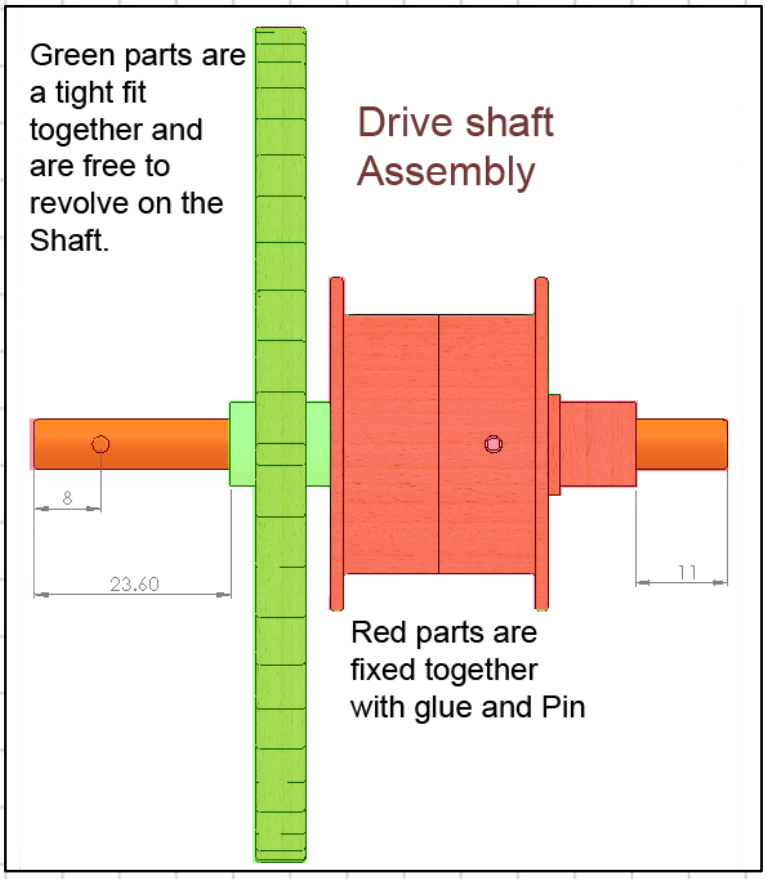
Construction instructions for Clock 51

Step 3 Preparation of the Drive train sub assemblies

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.







The Drum and the Spacer need to be drilled on assembly and the fitted with the Pin to lock the Drum securely to the shaft.

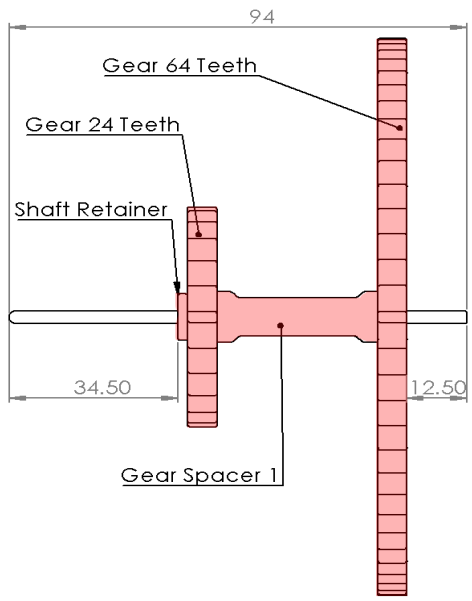
Care should be taken to maintain the 11 mm dimension of the drum to the end of the shaft.

He Winder Pin at the other end can only be fitted after this assembly has the Front Frame fitted to it, That can be done now or later.

Clock 51 - 24 Hour Skeleton Clock

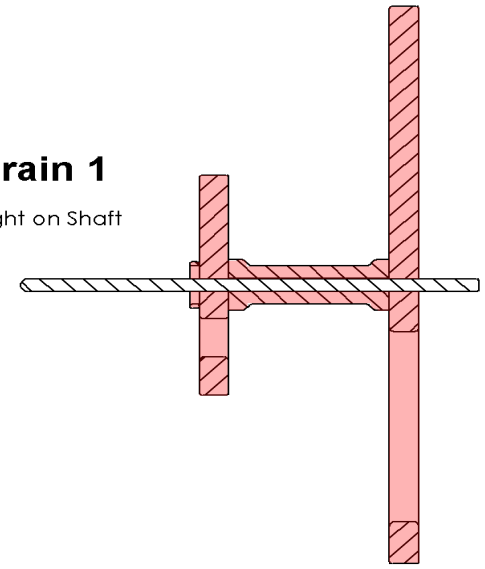
Construction instructions for Clock 51

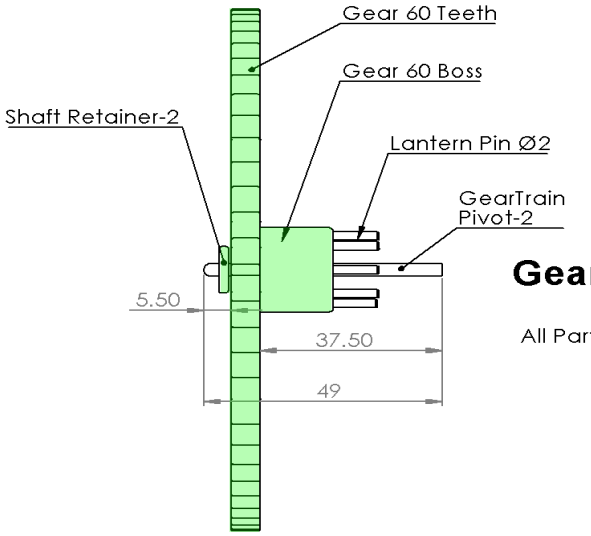
Step 3 Preparation of the Drive train sub assemblies



Geartrain 1

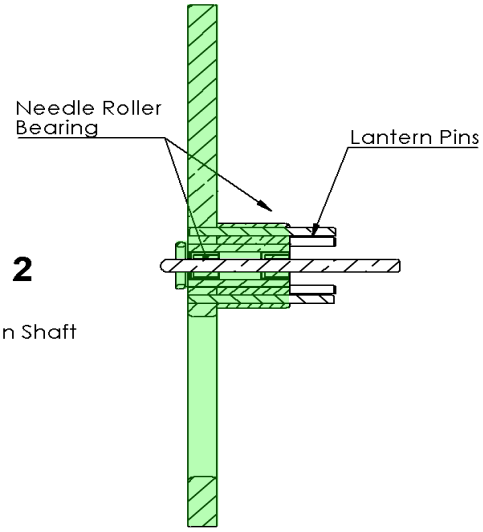
All Parts tight on Shaft

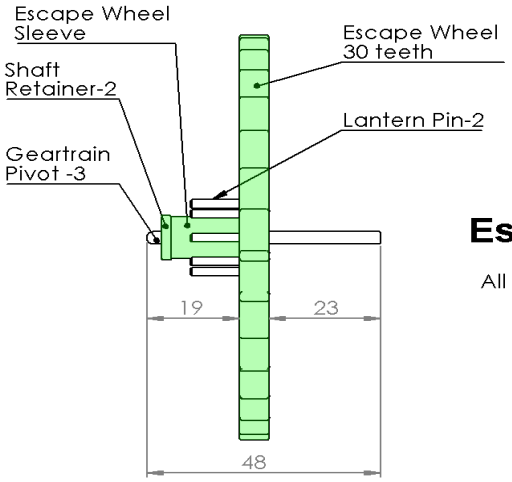




Geartrain 2

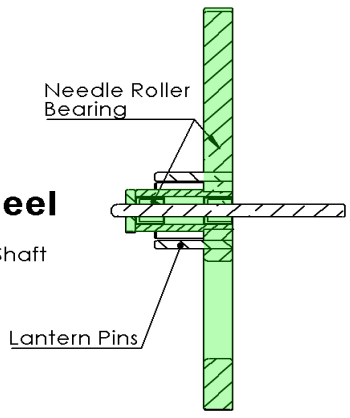
All Parts loose on Shaft





Escape Wheel

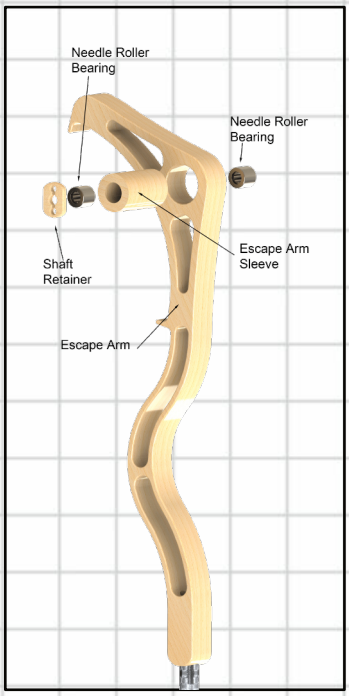
All Parts loose on Shaft

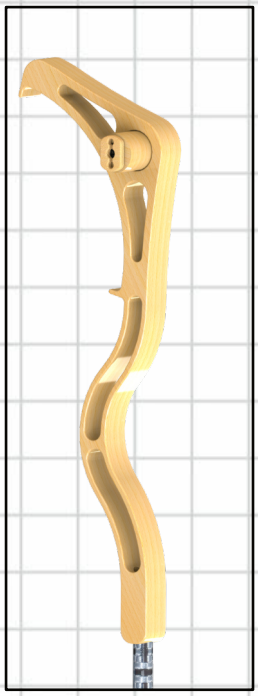


Clock 51 - 24 Hour Skeleton Clock

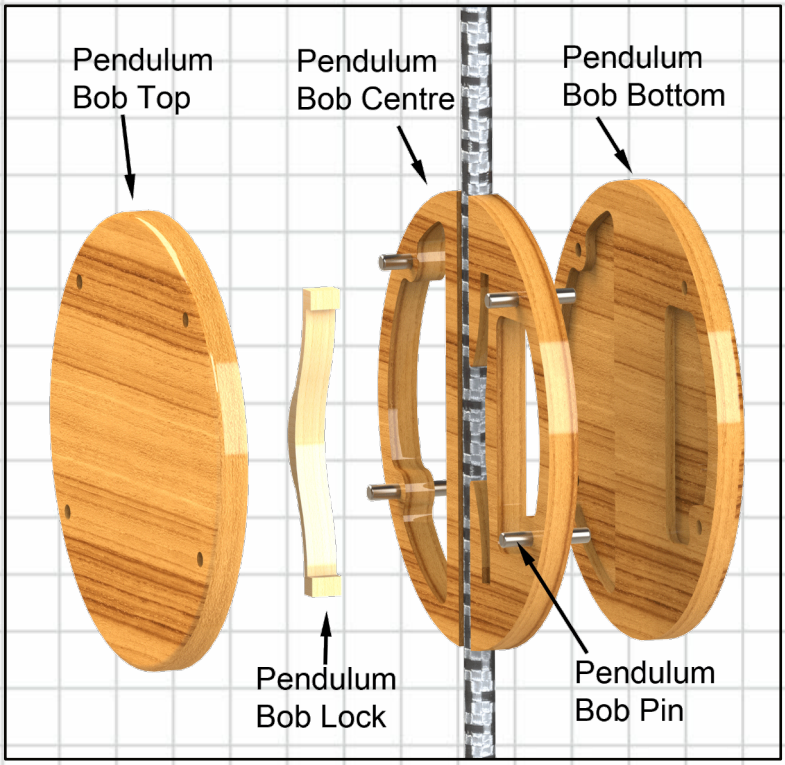
Construction instructions for Clock 51

Step 4 Preparation of the Pendulum sub assembly

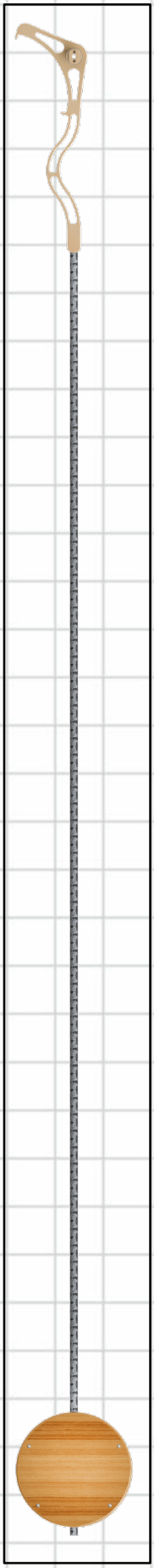




First fit the 2 Needle roller bearings into the Sleeve, one in each side. Then fit the sleeve into the top of the Escapement Arm, gluing in place. Now Slide the Pendulum Rod into the hole in the underside and glue into position if it is not a tight fit.



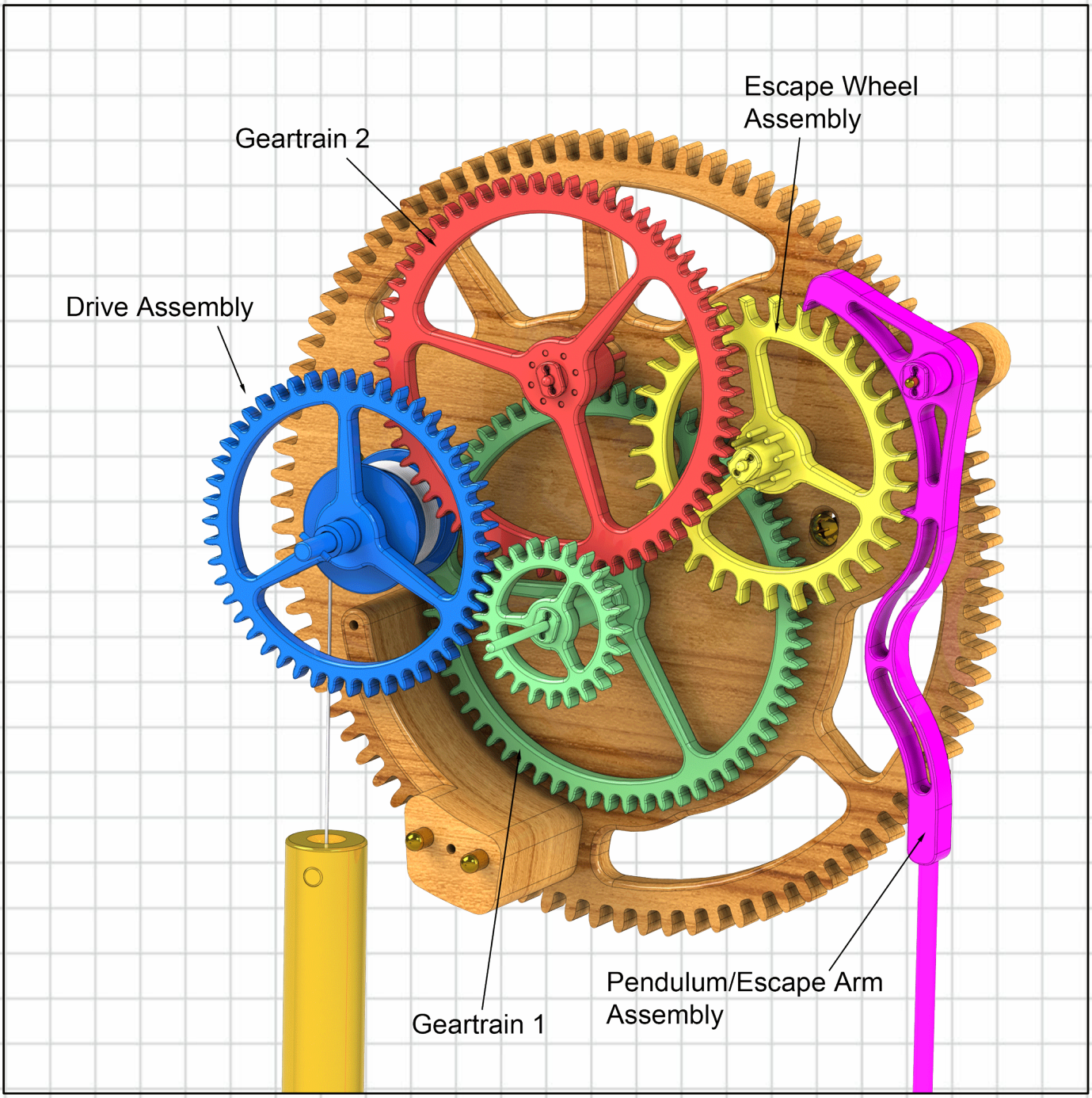
To assemble the Pendulum Bob First fix the Top and the Centre parts together using the 4 pins, then lay the Ball bearings into the pockets to get total weight around 150 grams. Fit the lock in position and fit the top part, then slide onto the pendulum Rod. (Note! The Ball bearings are not shown, any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



Clock 51 - 24 Hour Skeleton Clock

Construction instructions for Clock 51

Step 5 Fitting the Gear trains

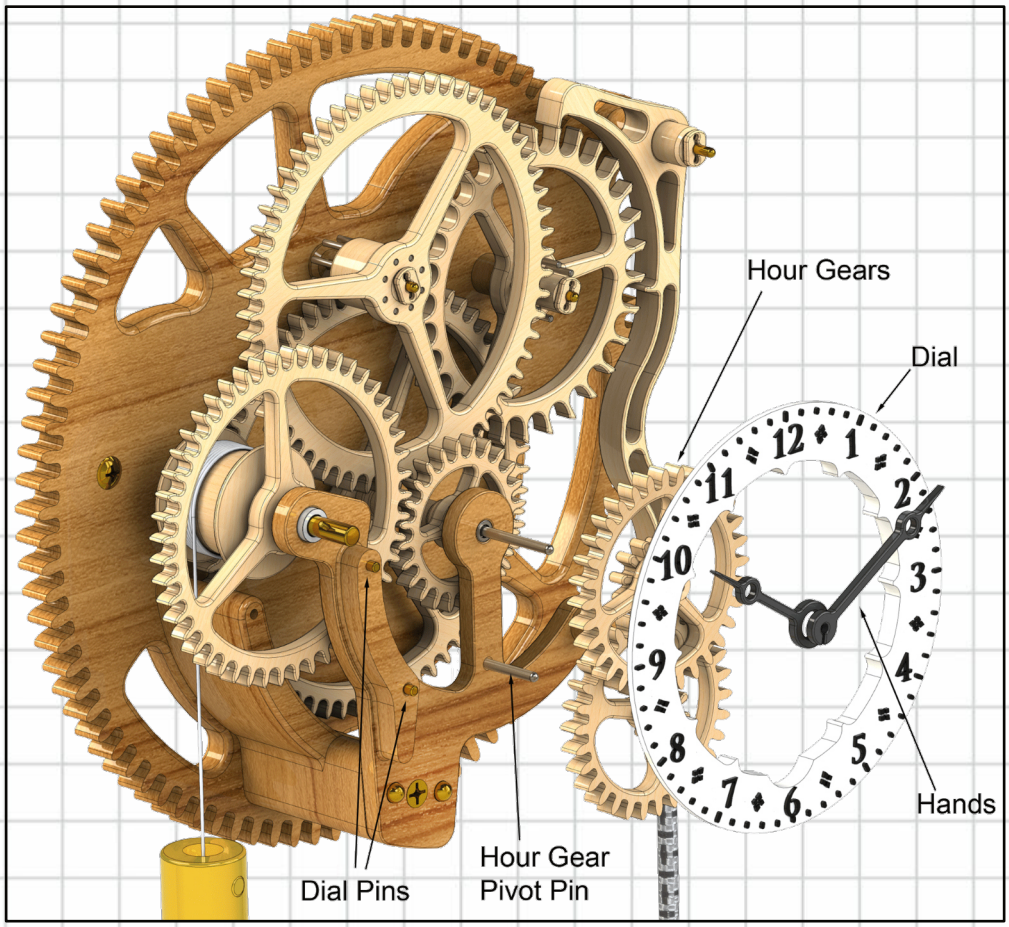


Load each of the Gear and Escape Wheel sub assemblies into the Back frame in the sequence, it is best to do this with the clock laying down on its back. Fit the Geartrain 1 first, next place Escape Wheel, followed straight the way with the Gear train 2 and finally Drive Assembly. Now load the Pendulum assembly.finally wind the cord onto the Drum, Winding clockwise when viewed from the front of the clock.

Clock 51 - 24 Hour Skeleton Clock

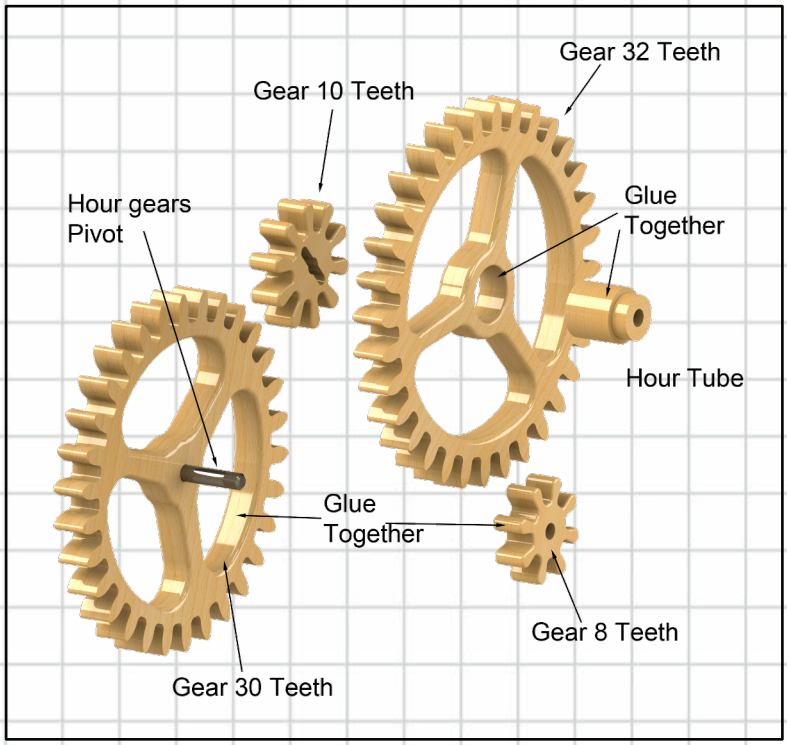
Construction instructions for Clock 51

Step 6 Fit the Front Frame and Hour Gears



Fit the front frame by fitting over the 2 protruding 6 mm diameter pins and engaging the the 2 protruding gear shafts.

Secure in position with the No 8 screw.

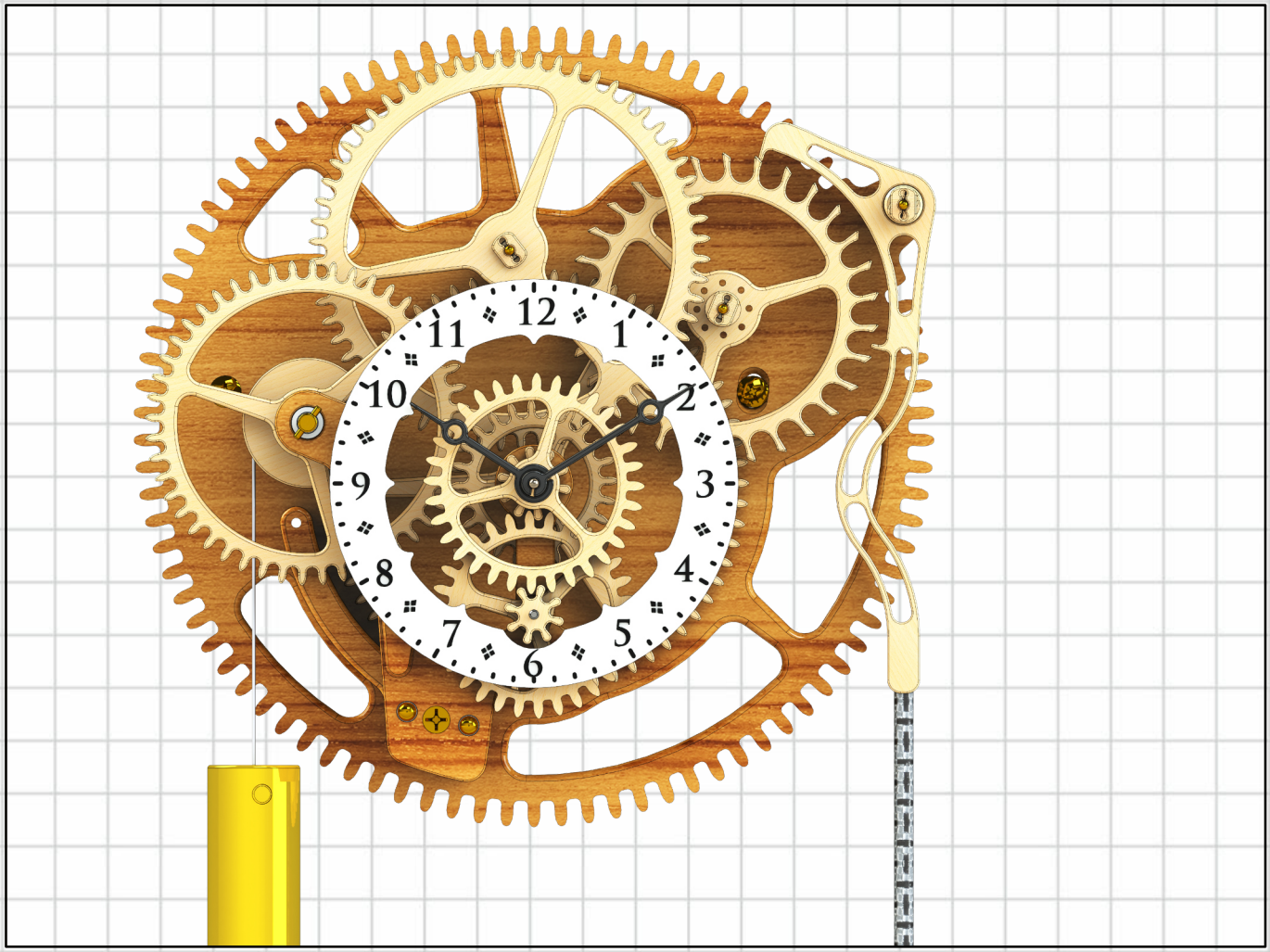


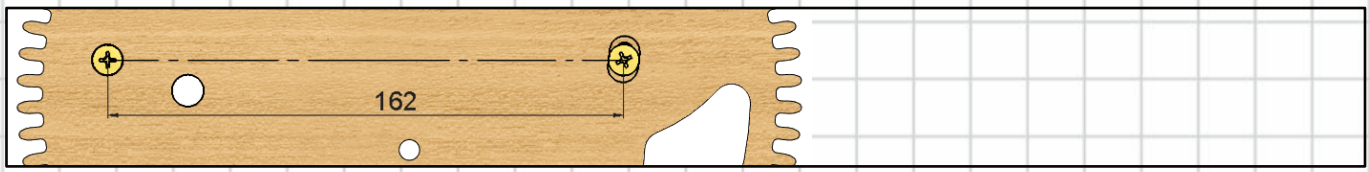
To fit the Hour gears push the 10 toothed gear onto the minute shaft, this should be a tight fit so it can transmit the drive through to the next gear in the chain. The slot cut across the hole is to give it some flexibility so you can push it on and Pull it off if needed. Now glue the 8 tooth and the 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 pinsAnd screw in place. Finally fit the pendulum and secure in position with a Shaft Retainer , make sure it is free to swing.

Clock 51 - 24 Hour Skeleton Clock

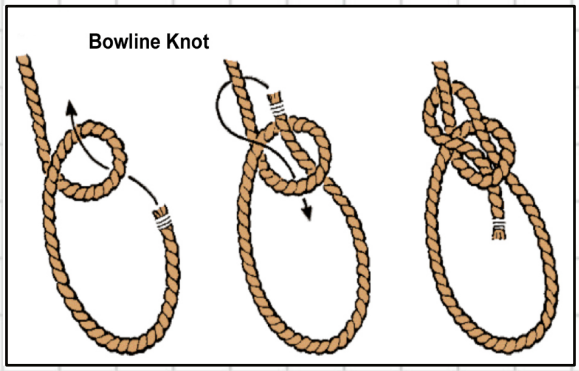
Construction instructions for Clock 51

Step 7 Setting up the Weight and Cord and getting it running





Mount the clock vertically on the wall with the 2 long woodscrews Drill the left hand hole first with the centre of the Dial 1600mm above the floor.Then with a spirit level and ruler mark and drill the second hole 162 mm to the right. Now fit the clock to the wall with the LH screw and lightly with the RH screw. Now set the clock running by gently swinging the Pendulum and lifting and lowering the RH side of the clock until it tic's evenly



With the Cord hanging down to the left of the drum tie a loop in the end of the cord using a Bowline Knot or similar. Now attach the weight by pushing the Loops into the hole in the top and securing by sliding the weight hanging pin through the holes in the side at the top. The clock should now start running.

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.

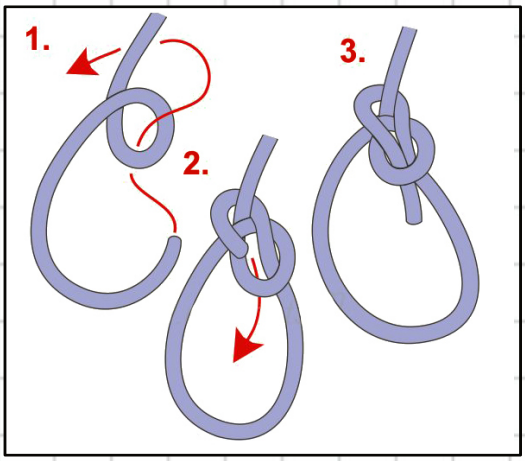
- For the dial on this clock you could use a V bit cutter to cut out the numerals and minutes ring. I use Artcam Express which gives a good clean-cut edge and very fine detail without having to use extremely small diameter cutter. A free alternative to Artcam is a program called F-Engrave, There are 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.

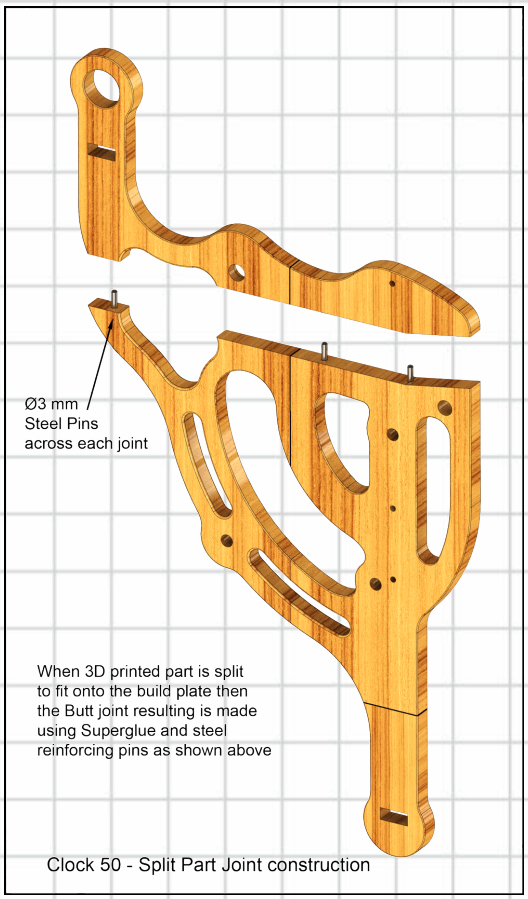
HINTS AND TIPS - continued



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.