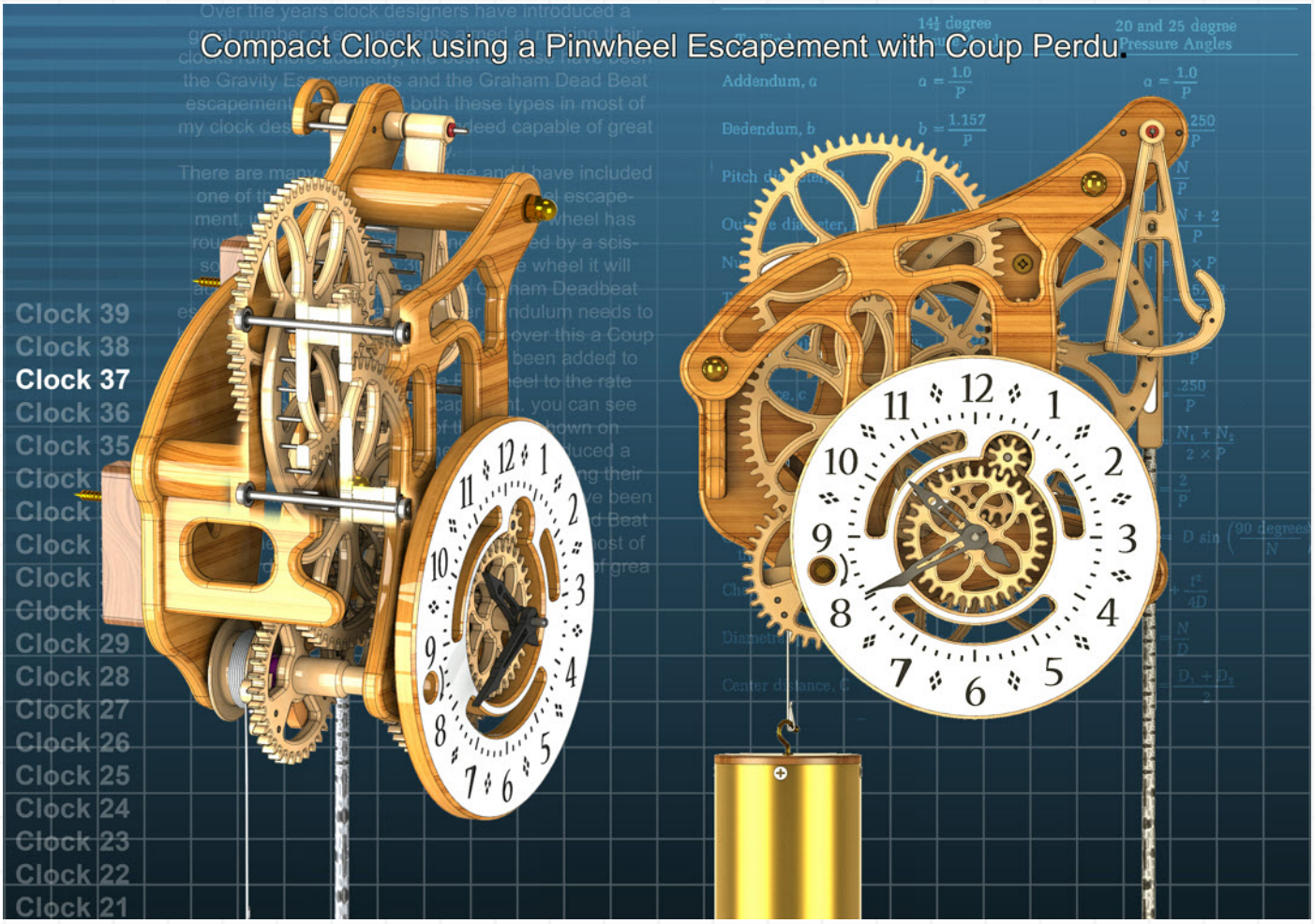
Clock 37-Compact Clock using a Pinwheel Escapement with Coup Perdu.

Construction instructions for Clock 37



Over the years clock designers have introduced a great number of escapements aimed at making their clocks run more accurately, the best of these have been the Gravity Escapements and the Graham Dead Beat escapement. I have used both these types in most of my clock designs and they are indeed capable of great accuracy. There are many other types in use and I have included one of these in this clock. It is a Pin wheel escapement, instead of using teeth, the escape wheel has round pins that are stopped and released by a scissors-like anchor. Using 30 pins on the wheel it will actually rotate twice as fast as a Graham Deadbeat escapement which means a longer pendulum needs to be used to slow the beat down. To get over this a Coup Perdue or 'Lost Beat' mechanism has been added to slow down the rotation of the Pin wheel to the rate achieved by the Graham escapement. you can see this in action in the video of the clock shown on

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Equipment

The following equipment is desirable:

CNC Router or Laser or Waterjet 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,Ø4 mm ,Ø4.1 mm, Ø6.5

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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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 a lot thicker.

You can also use Perspex with which you can create some colourful clocks (see Clock 19).

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 700 mm Long for all the shafts and numerous pins.
Ø3 mm Drill Rod or Silver Steel 250 mm Long
Ø2 mm Drill Rod or Silver Steel 700 mm Long
The 30 Ø2 x 18 mm pins used in the Pinwheel can be bought on the Internet instead of being cut individually from a longer rod. Search for 'Dowel Pins Ø2 mm
Ø24 Wooden dowel 250 mm
Ø16 Wooden dowel 75 mm
Ø12 Wooden dowel 25 mm
Ø10 Wooden dowel 20 mm
No 5 wood screw 12 mm long for constructing the weight.
Woodscrews
6 MM Threaded rod 500 mm long
Ø8 mm Brass Rod 110 mm for the Drive Shaft and Pendulum Bob Pins
1 mm, 2 mm, and 3 mm Plastic sheet for hands and pallets, ABS or HIPS

Note these are the minimums 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.

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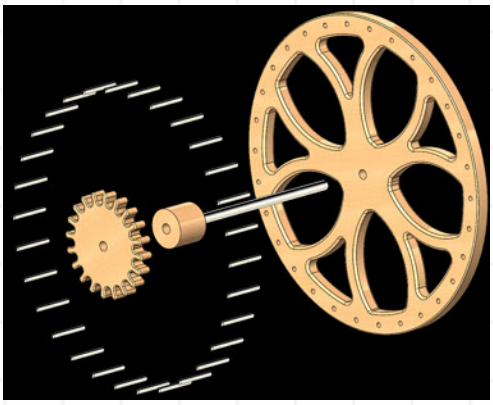
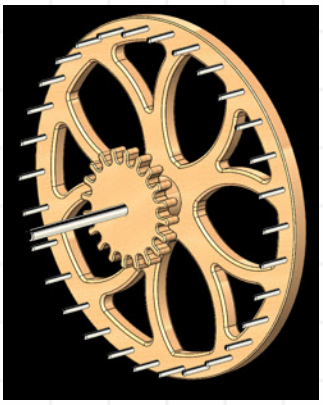
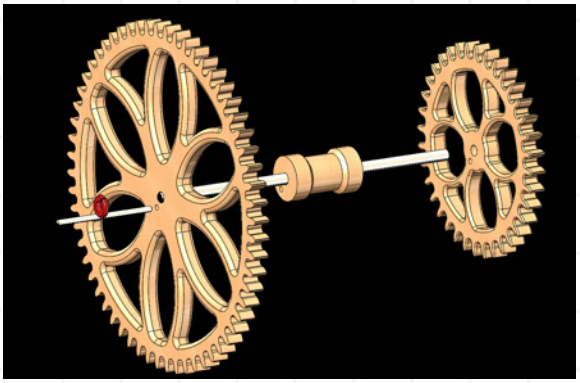
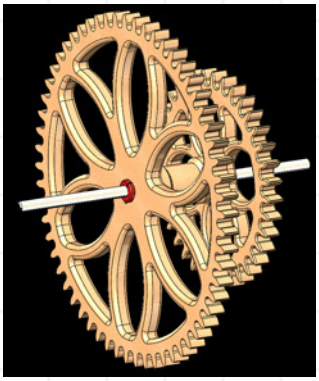


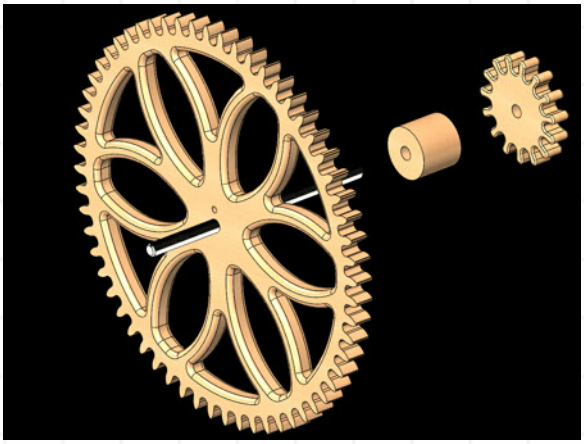


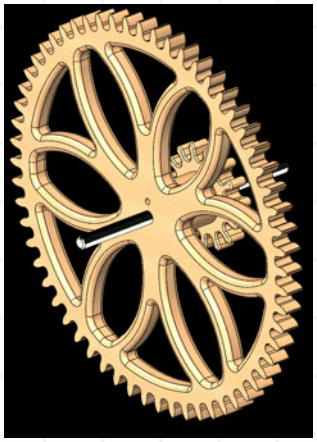
Insert the 30 pins into the Pin Wheel
Assemble the Pin wheel parts onto the shaft to the dimensions shown on the detail drawing. Both gears to be glued each side of the spacer and be a tight fit on the shaft.



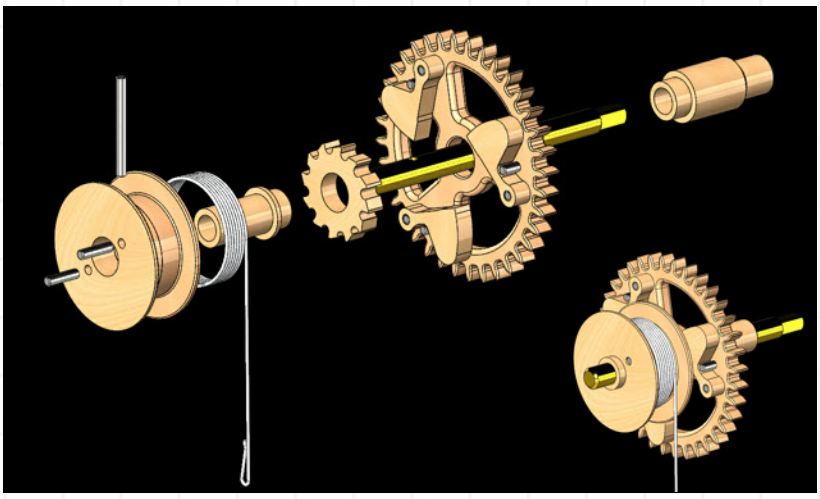


Assemble the Minute shaft parts onto the shaft to the dimensions shown on the detail drawing. Both gears to be glued each side of the spacer and be a tight fit on the shaft. Addition al pin fits through all parts to ensure no relative movement when the Weight is applied.





Assemble both sets of the Intermediate shafts parts onto their respective shafts to the dimensions shown on the detail drawings. Both gears to be glued each side of the spacer and be a tight fit on the shaft.



Assemble the Drum, Ratchet and Spacer to the sleeve then glue together and pin too shaft. Fit the Pawls and the pins to the 50 tooth gear and glue it to its sleeve and the slide on to the shaft. Ensure this part of the assembly runs freely on the shaft.

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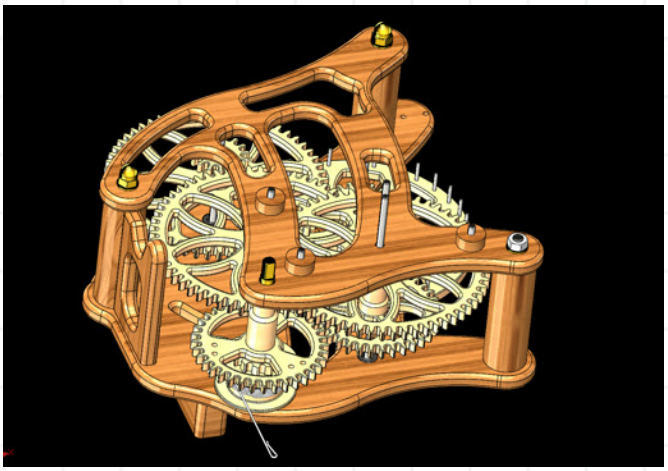

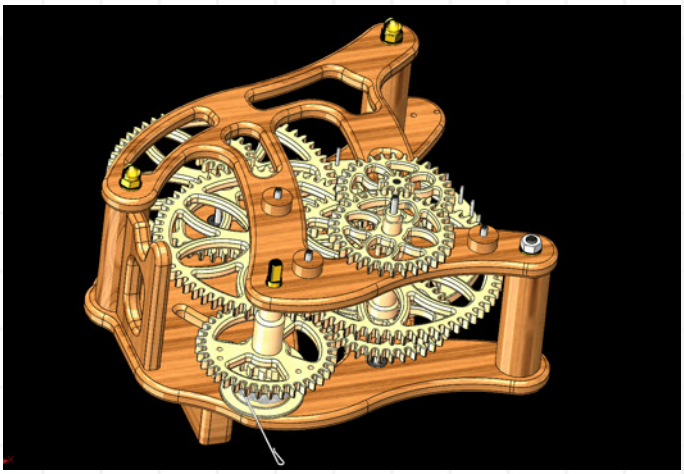

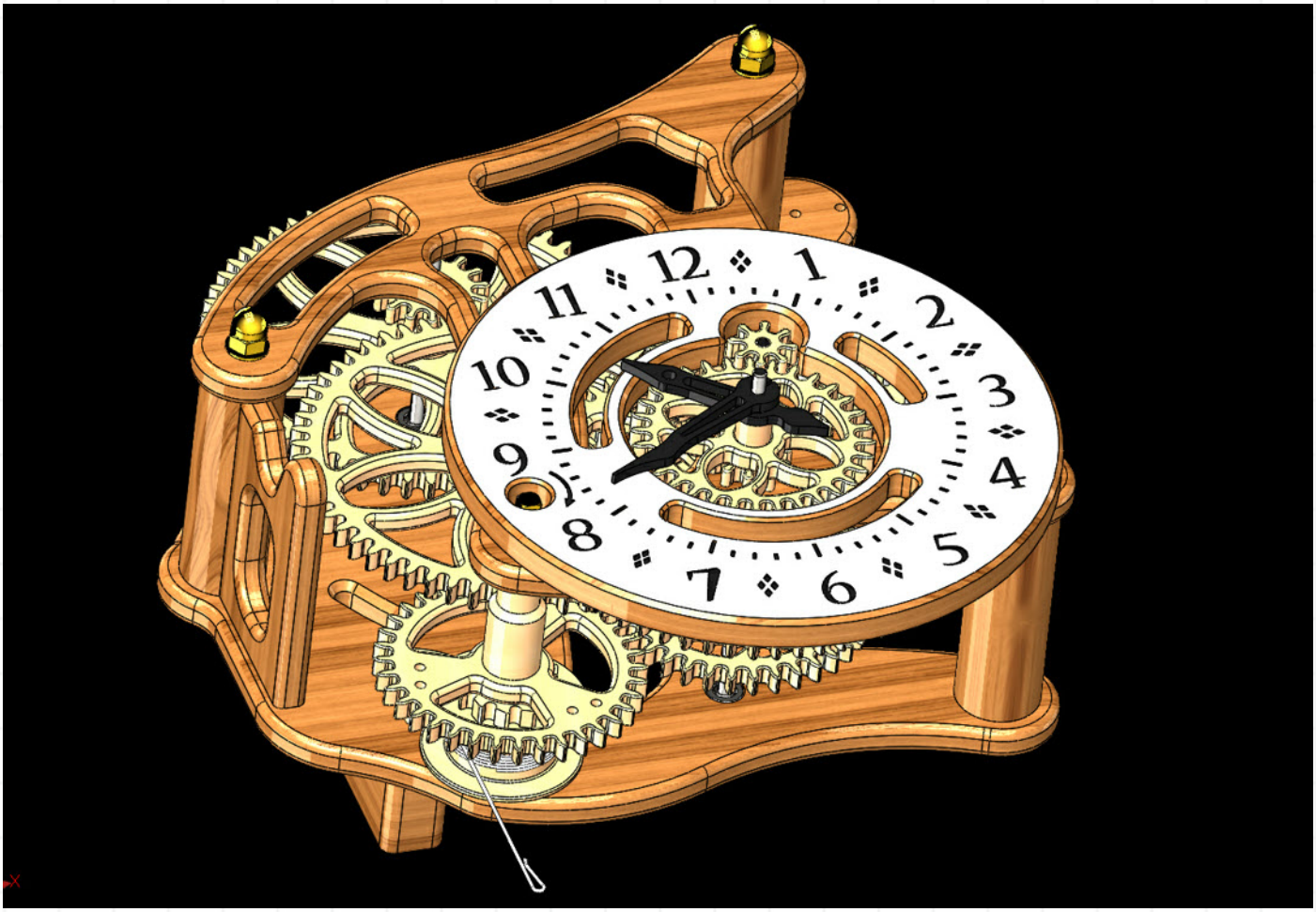

Now fit the Front frame over the Gear shafts and onto the top and bottom spacer pillars and secure with Domed nuts and washers. Fit the pins and spacers used to locate the dial and the pivot pin used by the pair of Hour gears.
Fit the Hour bush into the 32 toothed gear and glue together, then the 30 toothed gear to the 8 toothed gear and glue them together.
Now fit the 10 toothed gear onto the Minute Shaft, it should be a fairly tight fit and fit the 30t-8t pair to its adjacent shaft and finally the locate the 32 toothed gear onto the minute shaft.
Fit the dials onto their location pins and fit the hands onto their respective shafts.

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The Escape Lever is one of the most difficult parts of the clock to make, as well as the one needing to be very accurate. It is made from 4 fabricated parts and uses glue and pins to hold it altogether and the fitting of bearings to ensure smooth running of the clock.
The first step is to fit the long strip down the left side this needs to be both pinned and glued into position as shown. The Drive Catch is next, pin this in position and ensure it t can move freely and drop down against its stop under its own weight. The escapement spacer is fitted next By sliding into the large hole at the top of the Escape lever and gluing into position.
When dry fit the 2 Needle roller bearings using Loctite 603 or similar by fitting the bearings into each end of the tube and then fitting a Ø3 mm rod through both bearings to ensure they are lined up properly and the shaft can spin freely. When Loctite is dry remove the temporary rod.

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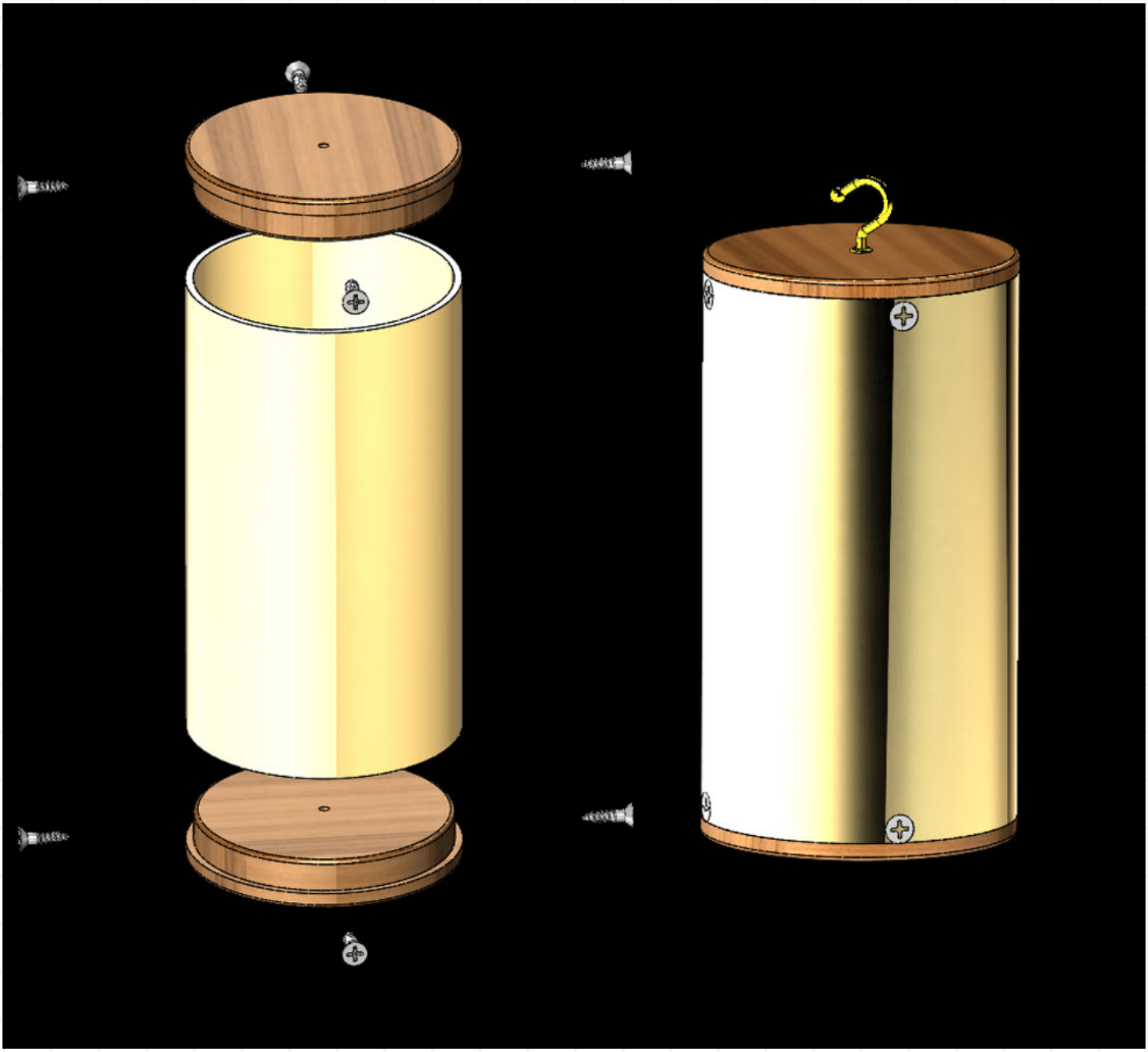

This simple weight is constructed from a suitably sizes section of plastic Drainpipe, with top and bottom endplates screwed in through the side.
It should be filled with either Lead shot or Ball bearings to a weight of around 1000 grams, that is what I used on the prototype but you may find you could get away with less.
You may want to develop your own design for this part but you should keep it around 120 mm high so as to ensure you get the 24 hour runtime when you mount the Clock on the wall with the centre of the dial 1500 mm above the floor.

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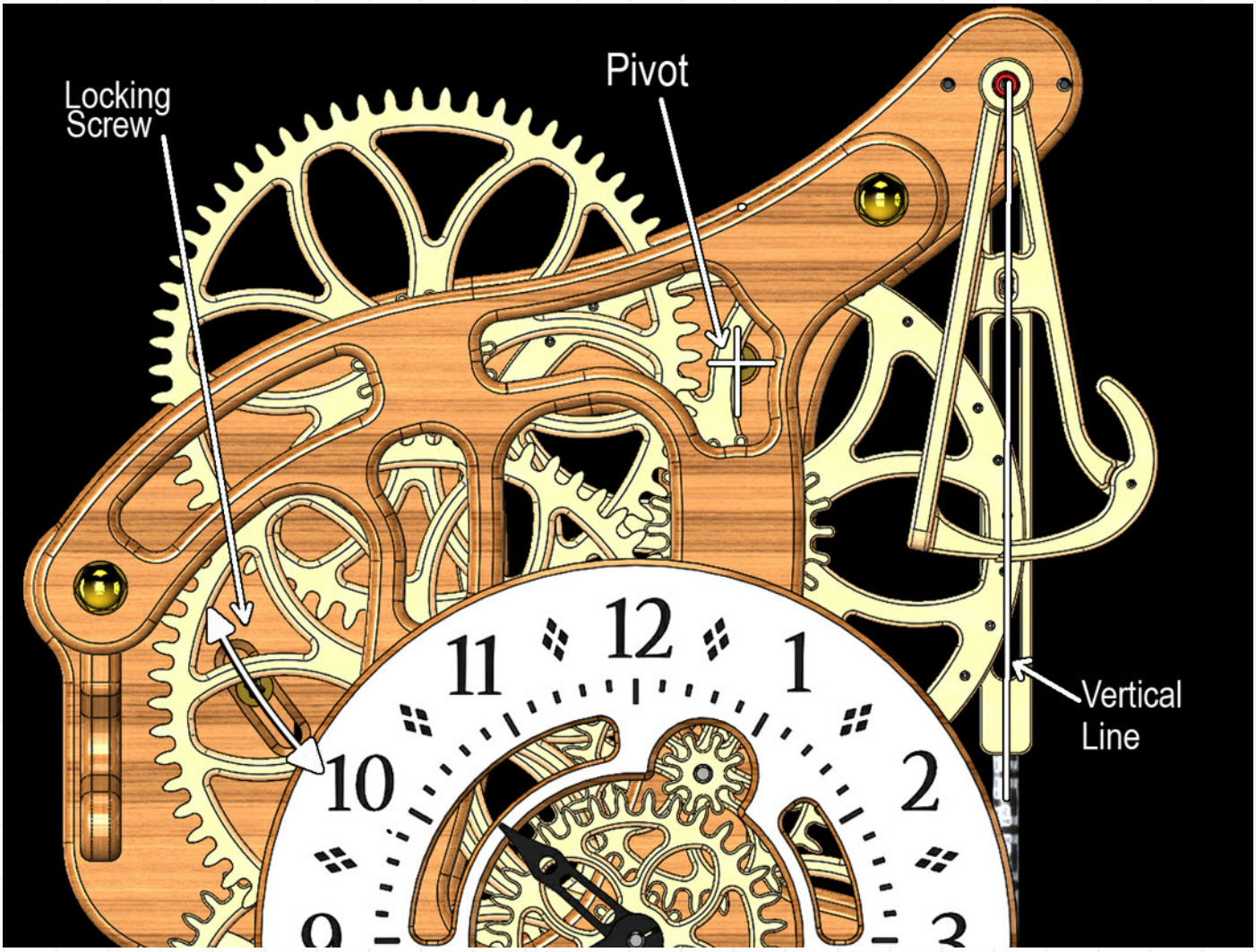

To set up the escapement you will need to mount the clock onto the wall, two woodscrews are used to attach the clock, the first is positioned where the arrow in the above diagram shows Pivot. The second is positioned where it says locking screw. Initially fit the pivot woodscrew and tighten it to nearly its full tightness, now hold the bottom of the clock by the Brace and rotate the clock until the pendulum hangs vertical with its centre line passing through the centre of the 45 degree angled face of the Pin wheel escape lever and the Escape catch. This is the position shown above, at this point position the second woodscrew in the centre of the radial slot and secure it to the wall.
When both screws are holding the clock in position attach the weight to the end of the cord hanging from the Drum and set the pendulum swinging. If the clock stops after a short time adjust the clocks angle on the wall by moving the back end either up or down after loosening the locking screw. Continue these small adjustment until the pendulum swings continuously.

When the clock is running you will need to adjust the rate at which it runs to do this move the Pendulum Bob UP if it is running too slow and push it down if it is moving too fast.

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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 used 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.
Alternatively the Pendulum / Escapement may not be running freely on the Ø3 shaft they are fitted to. The parts should be a running fit in the Ø3 mm shaft, and the Escapement-Pendulum pin in the centre lower down, should be a slightly loose fit in the slot in the Pendulum Head, if any of these fits are too loose then the parts can twist relative to each other and some impulse will be lost from the Pendulum.

- 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.

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- I needed to use Headed pins in several positions on this and other clocks to stop loose parts sliding off the ends of their shafts. The problem is they are hard to find and what few are available, like Clevis pins can be expensive. Round nails can work but they are not really accurate and can be quite rough. An alternative I have used on this clock is a small plastic End Stop Machined from Plastic with an undersized bore with a slit through it to allow it to be a tight fit on the shaft without overstraining the plastic. Another alternative is to use small Ø5 mm Rod magnets.

- 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

- The Pendulum Bob needs to be fitted so that the centre of the Bob is approximately 1010 mm from the pivot point. This should allow the pendulum to swing a complete cycle every 2 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 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.

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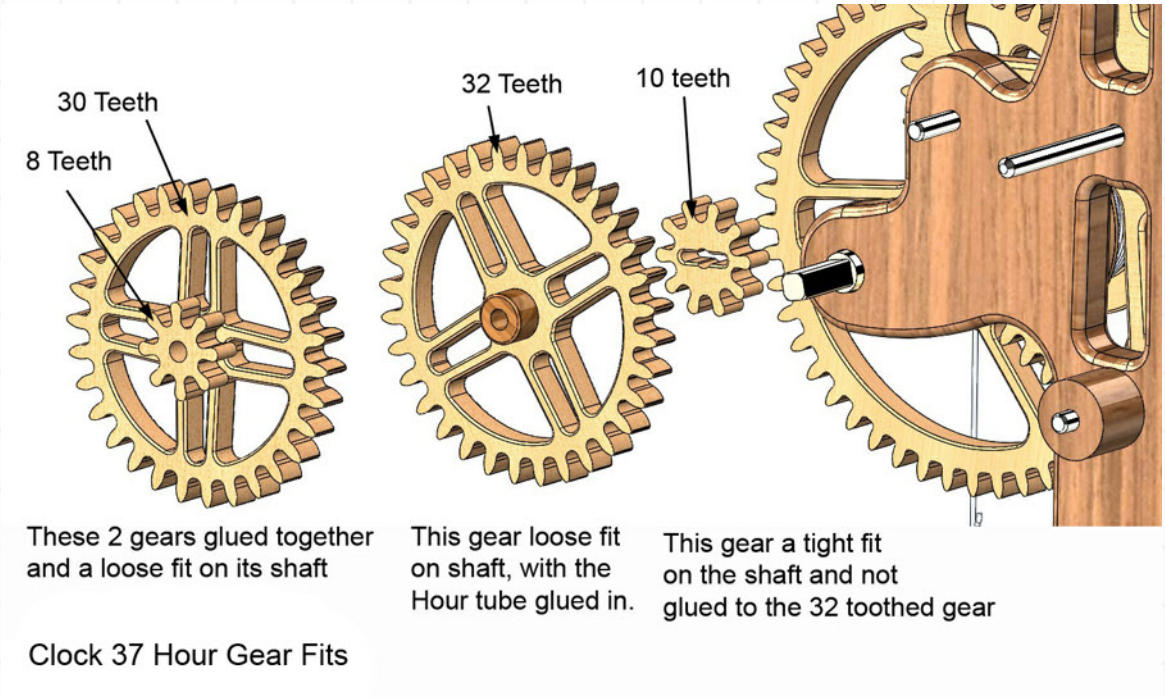
- Fits for the Hour gears



Clock 37 Hour Gear Fits