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 absolutely essential but it would make making the clock a lot easier for all of the round parts that are needed.

Pedestal Drill with work holding vice. There are 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, Ø2.0mm, Ø2.3mm, Ø3mm

Router Cutters Ø2 mm, 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 nice to have.

Consumables
Sand paper in various grades from rough to fine
Danish oil for finishing.
Low Viscosity Superglue
Gorilla Glue
PVA
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 really down to you to decide. I personally 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 120 mm x 12mm and 120 mm x 6 mm, and these are fabricated into blanks for the larger components by gluing two strips together. In this project, I actually used the wood salvaged from a Pallet as an exercise to see if it was practical to use softwood such as Pine, it did actually work out but it would not be the way I would do it again, as the finish is really compromised by the defects in the wood and the splintering at some crucial places.

You can however use a quality grade of plywood (Marine Ply) 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.

I wouldn't recommend MDF unless you are laser cutting, as the parts can be easily damaged. If you use a laser however the burnt finish is actually carbon and will act as a lubricant.

You can also use Perspex with which you can create some quite colourful clocks (see clock 19). Also you can of course use Brass or Steel or even Aluminium but this latter would need some post treatment to stop the wear that can happen between two aluminium parts in rubbing contact.

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 40 inches' 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

Ø2 mm Drill Rod or Silver Steel for all the Pivots and numerous pins, and Ø3 mm Brass or Silver Steel for the rods used in the shafts.
Carbon Fibre tube Ø6 mm x 1.0 meters for Pendulum.
Ø 4 mm Nuts, Bolts and washers for holding the Pallets into the Escapement
Woodscrews 3 required
Ø9 24 Ball bearings or 'Catapult Ammo' for the weight inside the pendulum. Nails are also a good alternative for this as they stack fairy well.

Note these are the minimum amounts 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.

HINTS AND TIPS

- 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.

- The Pendulum and the Escapement both hang from the same pivot. The Escapement and the Pendulum can be a tight fit on the pivot pin, but the Pivot pin must be free to move in the two Hanger parts that support it, this fit should not be too loose so a Ø2.3 hole should be used as a maximum. Where it passes through the Back frame a Ø3 should be used.

- The Pendulum Bob needs to be fitted so that the centre of the Bob is approximately 1040 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. The hollowed out Pendulum should be filled with either Ball bearings or Nails before gluing the two halves together, to give a total weight of 170 grams.

- The dial used on the prototype had a blank dial with a recess cut into the front face so that a printed Chapter Ring could be glued into it. This would be the preferred method if you don't have the software to cut the dial numerals directly with a Vee Bit. Alternatively, you could paint the front face of the dial blank with white emulsion and a coat of Danish oil before cutting. The numerals are then cut using a 'V' bit cutter using Artcam Express software or similar which gives a good clean cut edge and very fine detail without having to use extremely small diameter cutter. The letters were then painted in the darker colour and any over painting easily rubbed off due to the earlier application of Danish oil. The chamfer around the outer and inner edges were done with the same 'V' bit cutter following along the inner and outer profiles 2 mm deep.

- All the gear shaft should be constructed in accordance with the instructions provided. You should ensure that the all the gears and spacers are sanded flat on their mating faces so that when they are pressed together of the 4 Rods then they are actually square to those rods as otherwise the gears will wobble when the shafts are rotated. Gear trains 2 and 3, along with the Drive train all have an 18mm spacing from the end of the rods. A simple spacer such as that shown below helps you to position the gears and the Drum accurately.

Use 18mm thick Spacers either side of the shaft, and then push the 60 Tooth gear down until it touchs square on the spacer.

- The slots to hold the mating parts in the Frame are all drawn with a gap of 0.1 mm clearance all round, this generally speaking will give the correct tight fit needed for assembly. You will still need to have a small file to hand so that you can adjust any parts that won't fit. If the wood that you are using is undersize in its thickness, unless this is excessive then it should not be a problem, and any parts that are excessively loose can be glued.

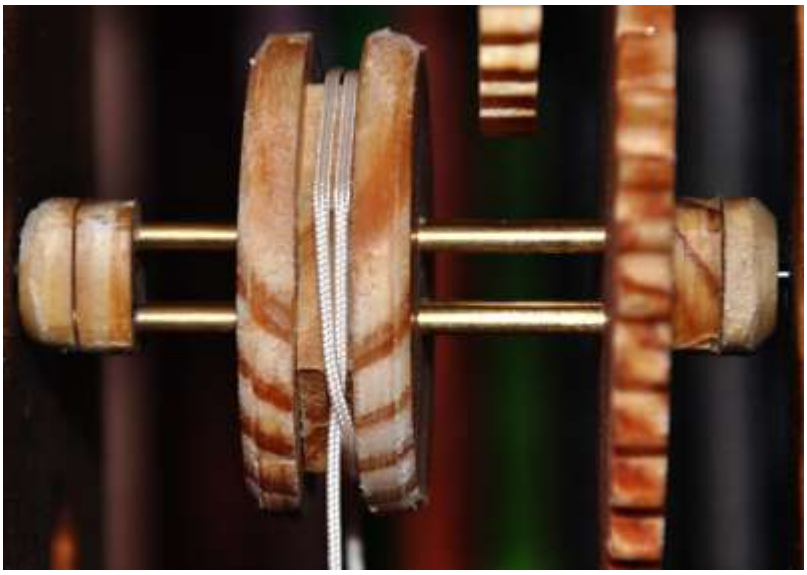
- I don't drill the 2 holes in the back of the Dial on the CNC, instead I temporally fix the Dial to the Front Frame with clamps or double sided tape. After measuring and adjusting its position relative to the Shaft 1 centre hole, and then drill with a hand drill from the back through the pivot holes, being careful not to drill right through the Dial. If you are going to use a Chapter ring printed on card and stuck in the recess the you can simply drill the holes when routing the profile.

- Any variation in the thickness of the 6 and 12 mm material used, may make the Wedges a loose fit, in this case you will have to make slightly thicker ones, the ones I have drawn are slightly thick so as to account for a small amount of variation in material thickness and may need to be filed or linished to make them a correct tight fit.

- To increase the Hardness of the gear faces and so reduce the wear that will occur over the clocks life, you can coat the faces with a Low Viscosity Super Glue before finally sanding the faces with a fine grit sand paper.

- Finishing the wooden gears, I use a 50/50 solution of Danish oil and white spirits, a single coat with sanding of the teeth with fin grit sand paper before and after.

- To attach the weight to the Drum the cord is wrapped around the Drum 1.5 times with the weight hanging to the left when you are stood in front of the clock. The cord should overlap itself as shown in the photo to ensure there is sufficient grip to stop the bottle slipping.



- The simplest way to provide a weight to run the clock is to use a 500 ml Coke bottle or similar. This can be supported using the Bottle Hanger part shown on the Profile cuts sheet, along with a cord tied with a Bowline knot, as shown below. This simple arrangement allows the weight to be adjusted easily by adding or removing liquid. If you require more weight you can always add Stainless Steel bolts to increase the weight. The prototype I built used a 500gram main weight and a 28gram counterweight.

- The two main areas where you may experience problems when you assemble and run the clock for the first time are usually as follows
  The Pendulum and the Escapement arm are linked together with two Ø3 pins set either side of the main Pivot pin in the centre. These should be a fairly tight fit so there is no movement between the two of them. The pivot pin itself should also be a tight fit on the two parts but be a running fit in the two Pendulum Hangers, but they should not be too loose as this will cause loss of impulse to the pendulum, Ø2.3 should be the maximum diameter used.
  The gears in the gear train should all mesh freely together and should be tested in pairs to check for any stiffness between the meshing gears. To do this mount each meshing pair into the front and Back frames without any other gears present and then turn them slowly by hand to check that there is no catching or stiffness. If there is then mark the teeth involved and carry on until the largest gear has turned one complete revolution. Then take the gears out of the frame and gently sand away the discrepancies on the teeth concerned. Repeat this until all the gear pairings have been tested and the whole gear train is running freely.