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.

Small Milling machine or **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, Ø4mm, Ø3mm, Ø3.3, Ø4.1, Ø6.1

Router Cutters Ø2, Ø3 and possibly Ø6 for cutting out the larger frames and pockets.

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.
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 125mm x 9 mm and 125 x 12mm and these are fabricated into blanks for the larger components by gluing two strips together.

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 1200mm 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 Drill Rod or Silver Steel 1000 mm Long for all the shafts and numerous pins.
Ø3 mm Rod or Silver Steel 150 mm Long
Ø8 Brass Rod 150mm long
Ø19 Brass Rod 150mm long
2mm Thick Plastic Sheet for the hands
Carbon Fibre tube 400mm
Ø4mm" Nuts, Bolts and washers for holding the Pallets into the Escapement
M6 nuts 2 required for the weight
Ø6 Threaded rod 120 mm long for the weight
Woodscrews 2 required
Ball Bearings – See Bill of materials on sheet 1 of drawings

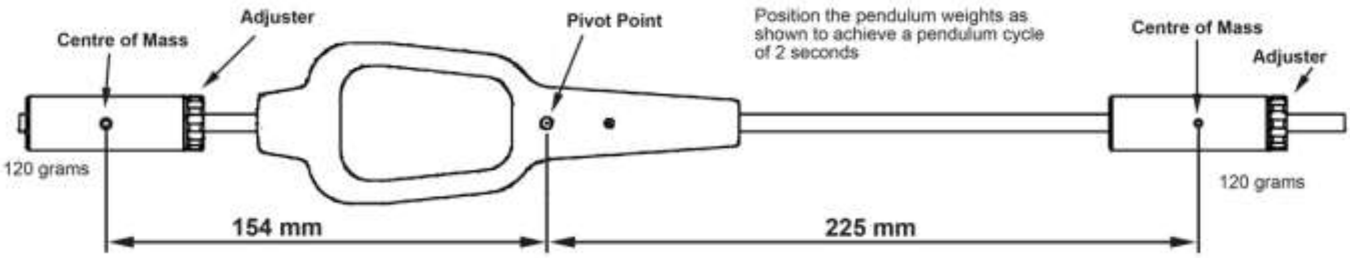
Note these are the minimum amounts of material necessary to build the clock I used more in the prototype and you may well be advised to by extra to cover those accidental losses that occur.
If I have missed anything here, you will find them in the parts list for the clock anyway.

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.

- I have constructed the Compound Pendulum with a centre wooden Pivot with Carbon Fibre rods extending above and below, the Pendulum Bobs are supported on Friction Rings that can be moved up and down to adjust the rate.
  This arrangement using light weight parts enables the Brass Pendulum Bobs to be fitted at the calculated positions leaving only small adjustment to be made to have the clock running accurately. An alternate solution would replace the Carbon Fibre Rods with Threaded Rod and have the Brass Pendulum Bobs threaded so more precise adjustments can be made.
  I used a spread sheet to calculate the size and position of the pendulum bobs, which you can download here

  For more information on the calculations see this article

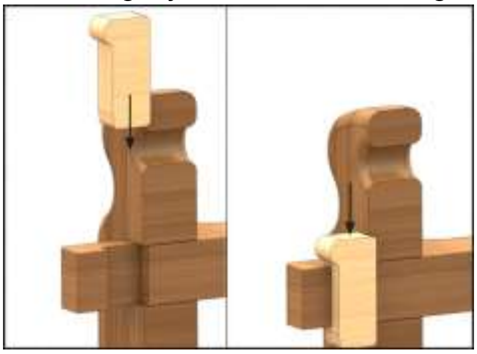


Compound Pendulum - setting dimensions 1

- The Key needed to wind the clock is a standard Grandfather clock winder Size 16

- The Drum parts on the Drive shaft need to be glued together and pinned to the Ø8 Brass shaft.

- The front and Back Frames are held together with two simple Wedges The wedges are fitted as shown, with one at the top and one at the bottom. The wedges are designed so that when cut they will be slightly too thick, this is to give you some material to sand of to get a proper tight fit.



- The dial on this clock was painted with white emulsion and a coat of Danish oil before cutting. The numerals were cut using a 'V' bit cutter in 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, 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 was done with the same V bit cutter following along the profiles 2 mm deep.

- 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.

- The weight needed to drive the clock was around 600 grams for my prototype, and I used a simple Soda Can with a 3D printed cap to attach it to the cord

- 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.

- You can make the weight from whatever you like, ideally, it should complement the aesthetic of the clock and not look bizarre or incongruous. I favour the brass weight but this is not always practical and can be quite expensive. I have used a granite block in the past on one of mine and more recently bottles of Coke or other drinks bottle.
  It is often difficult to achieve the weight that you need in a size envelope that works with the overall design. One solution to this is to construct the weight in two parts using an outer sleeve filled with lead shot. This is a really handy method for achieving the look that you want. You can find suppliers of lead shot on the Internet, the current clock uses this method

- 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.

- If you have problems getting the clock running initially it could be that the problem lies in a couple of places, the first 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 stick or interfere 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 with the weight in place, 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 second place is in the setup of the Pallets and how they interact with the Escape Wheel. I have provided a diagram to show the initial set up position for the Pallets, and this should be your starting point, If the clock doesn't tick evenly, you will need to adjust one or other of the pallets slightly until an even tick-tock is achieved. If that doesn't work then look for any stiffness oe interference to the free swing of the Pendulum.