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, Ø1.5, Ø2, Ø3, Ø3.1, Ø4, Ø4.1, Ø8, Ø9 Ø10.

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

Reamer Ø10 for reaming out the holes in the frame for the bearings.

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 120mm x 9mm and 120 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.

Generally speaking, 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.

In this case I used MDF for the Frames and the dials and then finished it by Painting. Unfortunately, I had no material available at the time of building the prototype out of natural timber. It did however work out reasonably well to use MDF for the non-moving parts.

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 1000mm 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 Silver Steel for all the shafts and numerous pins - 3 rods 13" Long
Ø3 Silver Steel for pins 1 rod 13" long
Ø2 Silver Steel for pins 1 rod 13" long
Ø6 mm Stainless steel threaded rod 700mm
Ø8 mm Brass Rod 150 mm for Drive Shaft
Carbon Fibre tube Ø6 x Ø4 bore x 1200mm for Pendulum.
Ball Bearing Ø6XØ10x3   MR106ZZ2 required
Ball Bearing Ø8 2 MR148ZZ required
Ball Bearing Ø4 12 MR104ZZ required
Ø6 Dome Nuts Brass 6 required
Chain Meadows and Passmore CLOCK CHAIN NO.100 Iron. I/L: 6.00mm. E/W: 4.40mm. Wire: 1.00mm. LPF: 50.5. Len: 6ft.

Ø6 Locknuts 2 required
WoodscrewsØ4.5x60mm 3 required
Clevis Pins Ø4x 20 4 required (saves you making the headed pins)
Lead 2.5kg (either Lead shot or Sash weights)

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 must move freely on the pivot,

I have used a standard winder for this clock instead of making one especially. Grandfather clocks use a special kind of winder available in many sizes, but the largest of these is most useful for our purpose. The Type 13 (5.5mm) or the Type 15(6mm) would both work, you will just need to make the end of the shaft to suit.

The weight needed to drive the clock is around 2500kg on my prototype, yours may be more or less than this. To establish what the weight should be I used 2 x 1.5 litre plastic bottle with a Ø28mm neck dia. The bottle holder (can be machined from the DXF file of all the parts) is fitted to the neck under the screw cap after filling it with water. The bottle holder has slots that allow the cord to be wrapped around it and easily removed if needed. The cord itself is wrapped around the drum one and a half times so that the bottle hangs to the left when looking at the clock from the front.
This can then be used to establish the weight needed to drive the clock by either adding or removing water from the bottle.
I have shown a typical construction for the actual weight that I use, made from plastic drainpipe, the sizes may need to be varied depending on the pipe available in your area. I use a section of lead weight inside that is normally used in sash type windows again local availability will dictate what you can use.

The Pendulum Bob needs to be fitted so that the centre of the Bob is approximately 1100mm 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 use ball bearings generally for all of the main gear shafts in the clock, the type that I have found best are the Stainless steel ones with metal shields. It is best to wash out the grease from these using white spirits, as the grease is only going to increase the drag on the shafts. The speed and the loads on these clock bearings are not so great that it will cause damage to the bearings without grease. The metal shields are preferable as they don't touch on the balls whereas plastic shields do. Part two of this article is helpful to understand this.
http://www.bocabearings.com/dropin.aspx?f=Ball-Bearings-In-Clocks.txt
An explanation of bearing numbers is explained here
http://www.engineerstudent.co.uk/bearing_numbers_explained.html

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.

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. 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.

You may have noticed a slot milled across the hole of the 10 toothed gear, the reason for this is to allow the gear to be a fairly tight fit on the shaft so that it moves with it but not that tight it is impossible to get on and off without damage. This is necessary as the 8 tooth gear is fitted after the front frame is fitted, and of course needs to be pulled off to dismantle.

The action of the remontoire is such that the gear drive train is prevented from moving for 30 seconds whilst the Escapement weight is powering the escapement. When it is released the Minute hand will move forward 30 second in one leap.

To ensure that the Drum and the brass Ø8 drive shaft move together whilst winding is taking place, it is advisable to drill a Ø2 hole through them both and fit a pin.

I used a chain for this clock purchased from Meadows and Passmore, details above in materials section. They have a technical page to help you to determine the right chain for your clock based on what Sprocket you are using. If you are going to use a different chain to the one I used, you will need to re design the sprocket and the and the channel the chain runs in. To help with this I show a modified version of their formulae to calculate the diameter of the shoulder that the chain will sit on.
Shoulder diameter =Inside Length of the link x No of Teeth on Sprocket x 2 / 3.456
In my case this is Ø=6.1 x 6 x 2 /3.456 =Ø21.2 mm
If I used an 8 tooth sprocket Ø= 6.1 x 8 x 2 / 3.456 = Ø28.24