Clock 27 FDM- Hints and Tips-1

1 Silver steel is common tool steel that is supplied as a centreless ground round bar (with tolerances similar to that of drill rod). The name comes from the highly polished appearance of the rods. The American equivalent is tools steel or Drill Rod. Typical American supplier is www.speedymetals.com/ps-3356-17-2532-rd-o-l -drill-rod.aspx. The nearest equivalent to the Ø2 mm used for this project is Ø 5/64".

The bearings used for this project are Ø2 mm x 6mm O/Dia x 3 mm. The spec used is 692ZZ 2X6X3, again the American equivalent is Ø 5/64" bore x ØI /4"O/D x 9/64" wide.

2 The screws, nuts and washers used are M4 for the Pendulum Bob. For American equivalent see this table
http://www.trfastenings.com/pages/Thread+Conversion+Tables

3 To enable you to modify the models I have supplied IGS or STP files for all of the parts which should be easier to modify than the original STL. See this web page for a list of suitable CAD programs, several of which are free http://alternativeto.net/software/freecad/

4 The Cross section drawing in the instructions shows the types of fit needed for all the moving parts in the clock, it is recommended that these fits be achieved by drilling the holes formed in the printed parts using drill sizes given in the chart below. For the metric build use ØI .9mm for tight fit and Ø2.1 for a loose fit.

5

Drill size	Diameter (in)	Diameter (mm)
#49	0.0730	1.8542
1.9 mm	0.0748	1.9000
#48	0.0760	1.9304
5/64 in	0.0781	1.9844
#47	0.0785	1.9939
2 mm	0.0787	2.0000
#46	0.0810	2.0574
#45	0.0820	2.0828
2.1 mm	0.0827	2.1000
#44	0.0860	2.1844

6 The Escapement used on this clock is the Woodenclocks Gravity escapement develop originally on Clock 22. This is a modified version adapted to be made by 3D printing. It comprises a Gravity arm, a Trigger and a lifting lever, as well as the Escape wheel. For a detailed explanation of how this works see http://brianlawswoodenclocks.blogspot.co.uk/2014/11/how-woodenclocks-gravity-escapement.html

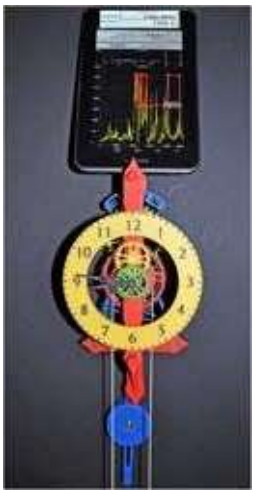
7 1 used Ø8 mm steel balls (Catapult Ammo) for the Main weight 400gms and the Counter weight 12gms, but you can of course use any heavy metal to serve this purpose. The main weight container is a little large deliberately as the running weight was unknown at the time it was modelled so you may want to make it a little smaller. An alternative would be to use a brass rod Ø25 diameter by 80mm long, with a counter weight in proportion. The pendulum Bob is filled either with smaller balls or nails so that the weight is around 30gms (1 oz.)

8 1 used ABS throughout for this model and it has worked well, I won't try to advice on the settings for your printers as this is my first use of the process and I am sure you are more experienced at this than I am.

9 The cord used is 900mm long, I used 0.5mm red fishing cord, the advantage of this cord is that it doesn't twist when loaded.

10 To bond together the plastic parts together such as the Pendulum head and rod use a liquid solvent adhesive applied with a syringe like applicator or if necessary a small brush, this latter can be a bit messy.

1 1 When the clock is first assembled, the pendulum bob is fixed at a point on the rod that is approximately 265 mm from the pendulums pivot point. This is roughly the right position for the clock to run at the correct rate. It will not be the exact position for your clocks because of all the small differences in your build of the clock, so to get it to run correctly you need to adjust the pendulums position on the rod, either move it clover to the pivot point or further away to slow it down. It will take several attempts but it should be possible to get the clock running within a minute in 24 hours.
The length of time your clock will run for will depend on how high you hang the clock on the wall, but if you position it so the centre of the dial is at eye level then it should run for about 12 hours.



I used the Clock Tuner app to set the pendulum to the correct position. Set it running and read whether your running fast or slow allow 2-3 minutes to all things to settle down and for the App to get a good sample. Stop the app and adjust the pendulum up or down depending on whether it is running slow and then repeat the measuring until you get it running to within a couple of seconds an hour.
If you do this 4 or 5 times you should get a sense of how sensitive your clock is to each adjustment, at some point you won't be able to improve it any more so best leave it at that.

1 2 The clock is fitted with a gravity ratchet comprising 4 Pawls placed around the ratchet on the drum, so that at any position two pawls will always engage.
To wind the clock simply pull down on the counterweight cord repeatedly until the main weight reaches its highest possible position.

13 Many of the parts have been split into 2 or more components to reduce the need to add supports during the printing of the part. Liquid solvent bonding is used to glue all the necessary parts together.
I printed the dial in 2 colours as the machine I was using (Zortrax) although not fitted with two printing heads allowed printing to be paused and the filament changed. If you can't do that then you will need to paint the top face of the up-standing numerals.
I have sized the parts mainly so that the small holes come out under size to allow you to drill out the part to get the correct fit. You are going to need tight and loose fits at different points in the assembly so you will need to have 01.9mm 02mm and 02.1mm drills. In the case of the bearings the holes are sized to give a press fit, so you may need to adjust that for your printer.

14 The shafts need to be just long enough to run freely in the bearings when assembled into the frames, they don’t want to be too loose or the gears can move out of line with their mating gears.
If they are too tight and are held tightly against the end frames, then the chances are the clock won’t run.

15 The gears should be positioned on the shafts so they line up with the mating gears, the dimensions given on the instructions should be used as a starting point to achieve this.

16 All the bearings should be Stainless steel and should have the grease removed before fitting into the frames. To do this let the gears sit overnight in white spirits to dissolve the grease out of them. Dry with absorbent towel or paper before fitting.

17 Clean up all the gears to make sure they are burr and swarf free. All the gears should run absolutely smoothly when assembled into the frames, check by slowly turning the first driving gear and feel for any restrictions, if you find one track it down and remove them with sharp knife blade, and continue till the all run freely.
If the clock keeps stopping in the same place or places, then there is still a restriction in there somewhere, as a last resort assemble the clock without the escapement in place, add the weight an let it run down to the floor, repeat several times and the retry running fully assembled, it will then hopefully work.

18 Things that can go wrong,
The gravity Arm should be heavy enough on its own to kick off the trigger, if it doesn't the add a m6 washer or 2.
Too much main weight can kick out the lifting lever.
Lifting Lever catching on the Escape wheel can kick it out.
Make sure the main weight Cord doesn't jump over the central divider into the Counter weight groove.

18 Read this article to understand the escapement
http://brianlawswoodenclocks.blogspot.co.uk/2014/11/how-woodenclocks-gravity-escapement.html