<u>Guide to building an improved crank mechanism   John Dingley 28.06.22   Version 1</u>

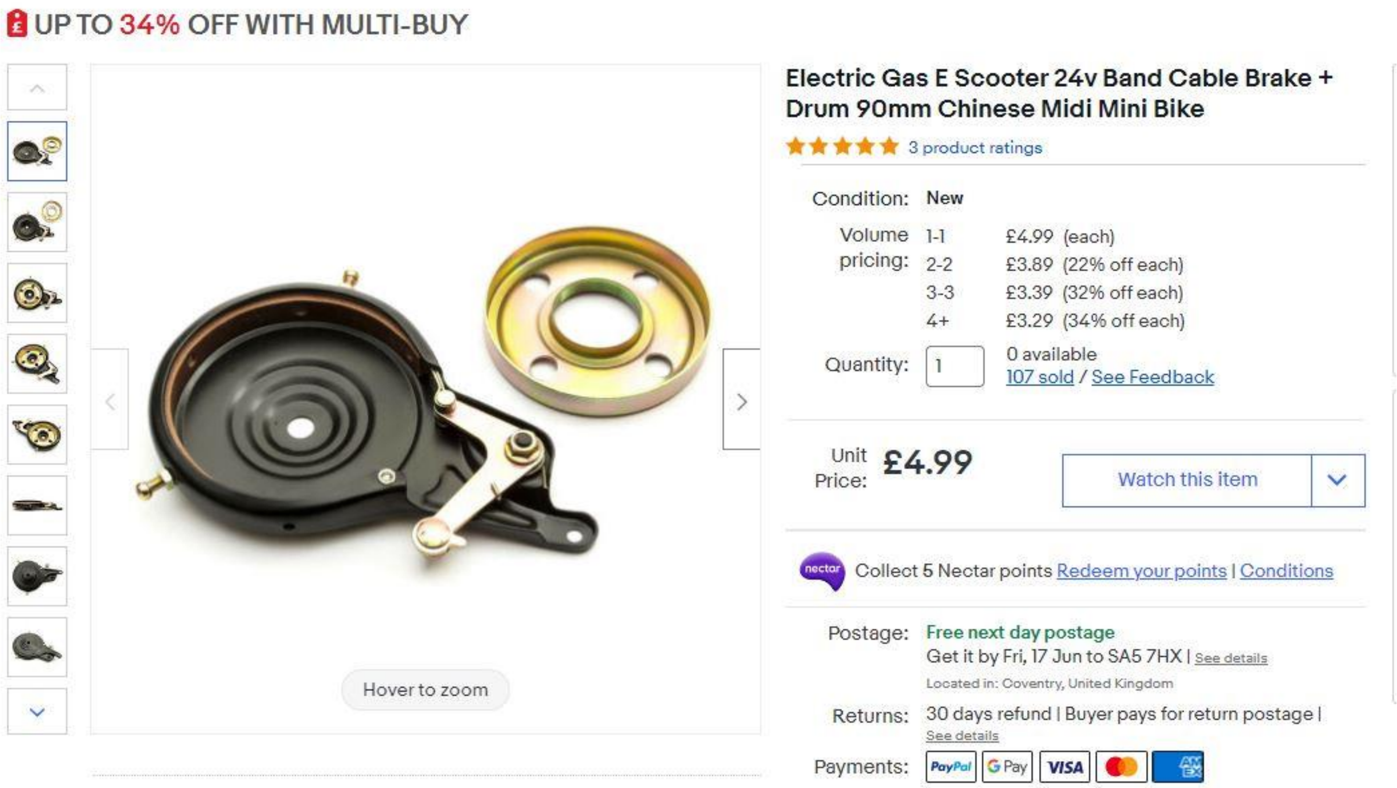
The general principle of operation is in 2 parts.

Firstly, the drum brake mechanism from a small toy electric scooter is used to create the correct amount of friction as you turn, to simulate the friction of the strings rubbing on a wheel.

Secondly, an optical chopper wheel is used to measure the speed of rotation. This reading has to be updated very frequently in order to detect when the cranking speed suddenly increases in order to create the buzz sound without any delay or lag. I initially tried a magnetometer compass module and a rotating magnet, this worked really well as a crank position sensor but it was not possible to read values from it frequently enough to create the buzz sound without a lag.

The build

The drum brake mechanism is of this type:

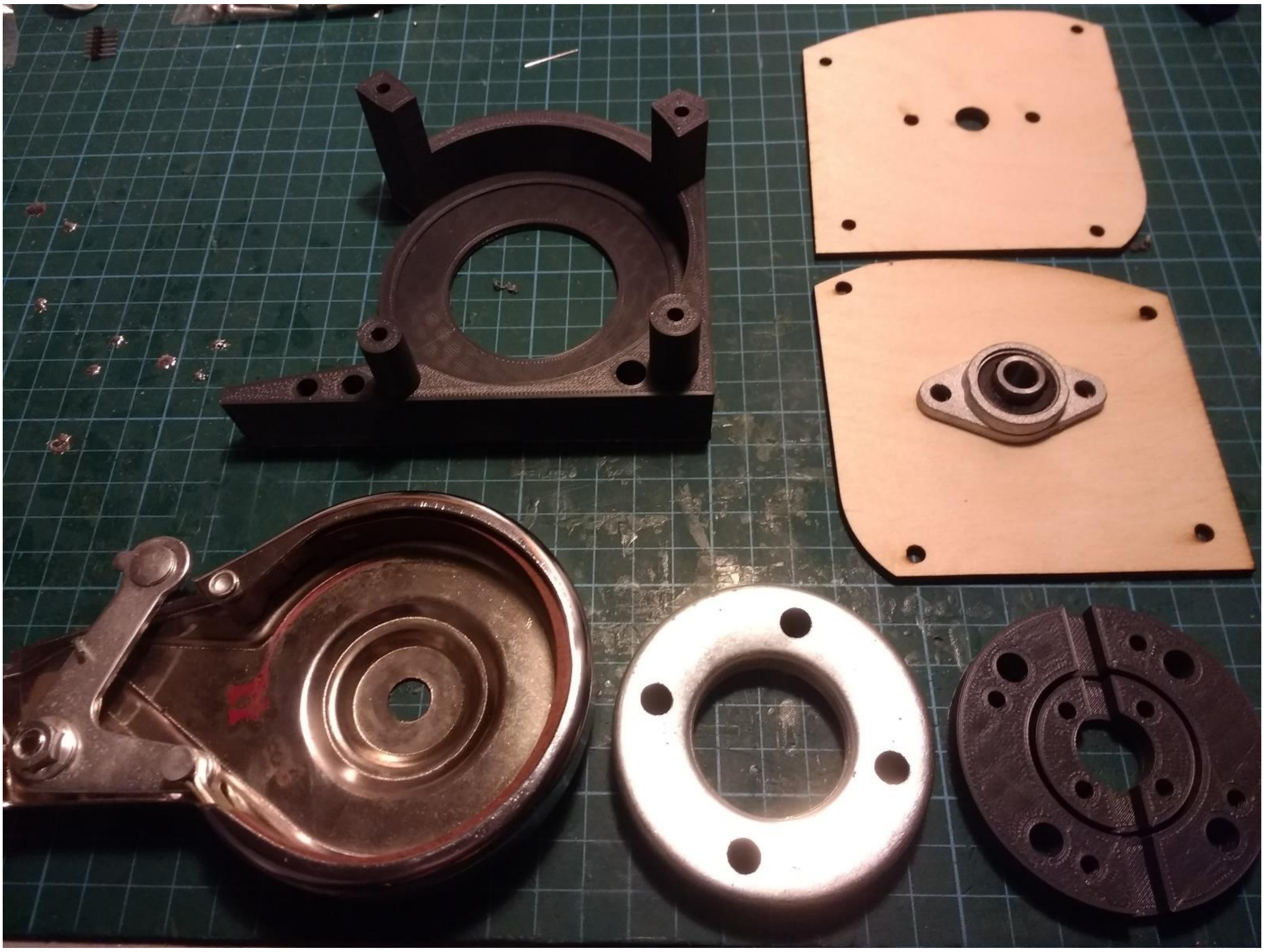


Note that the drum is 90mm in diameter. Larger ones exist which look almost identical on webstores so be careful to order the correct version.

The nut here is cheaply made and a little loose so once replaced, a dab of glue or threadlock on the threads may be useful to stop it working loose.

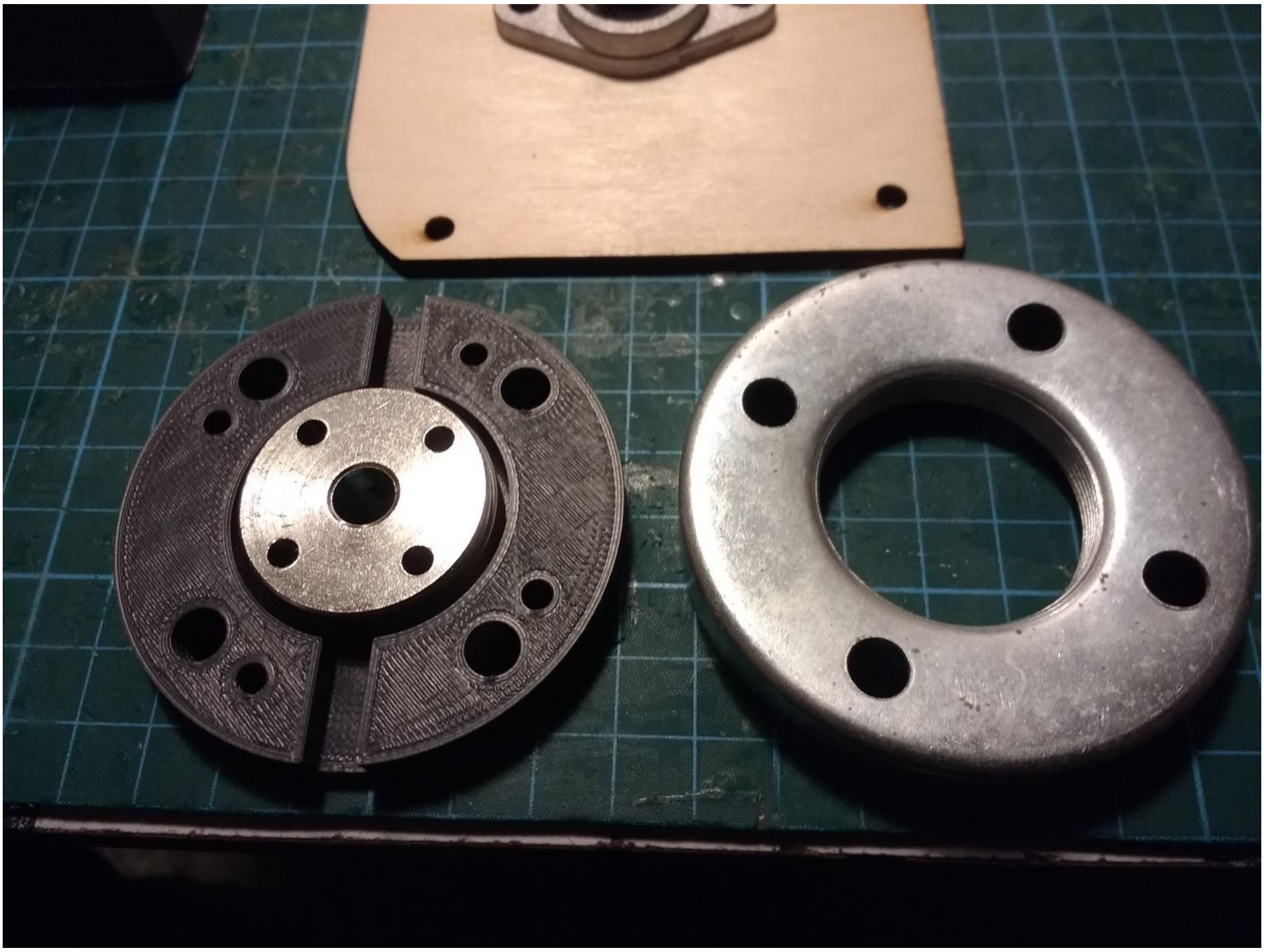
You will also see here that the brake assembly housing has been glued into a 3D printed part as it has an unusual shape. The 3D print has stand-offs so you can bolt a thin panel to the rear of the 3D print and also a panel of the exact same design to the front of the 3D print. These 2 panels will hold the bearings for the main crank shaft.

First though we have to prepare the drum mechanism inside it.

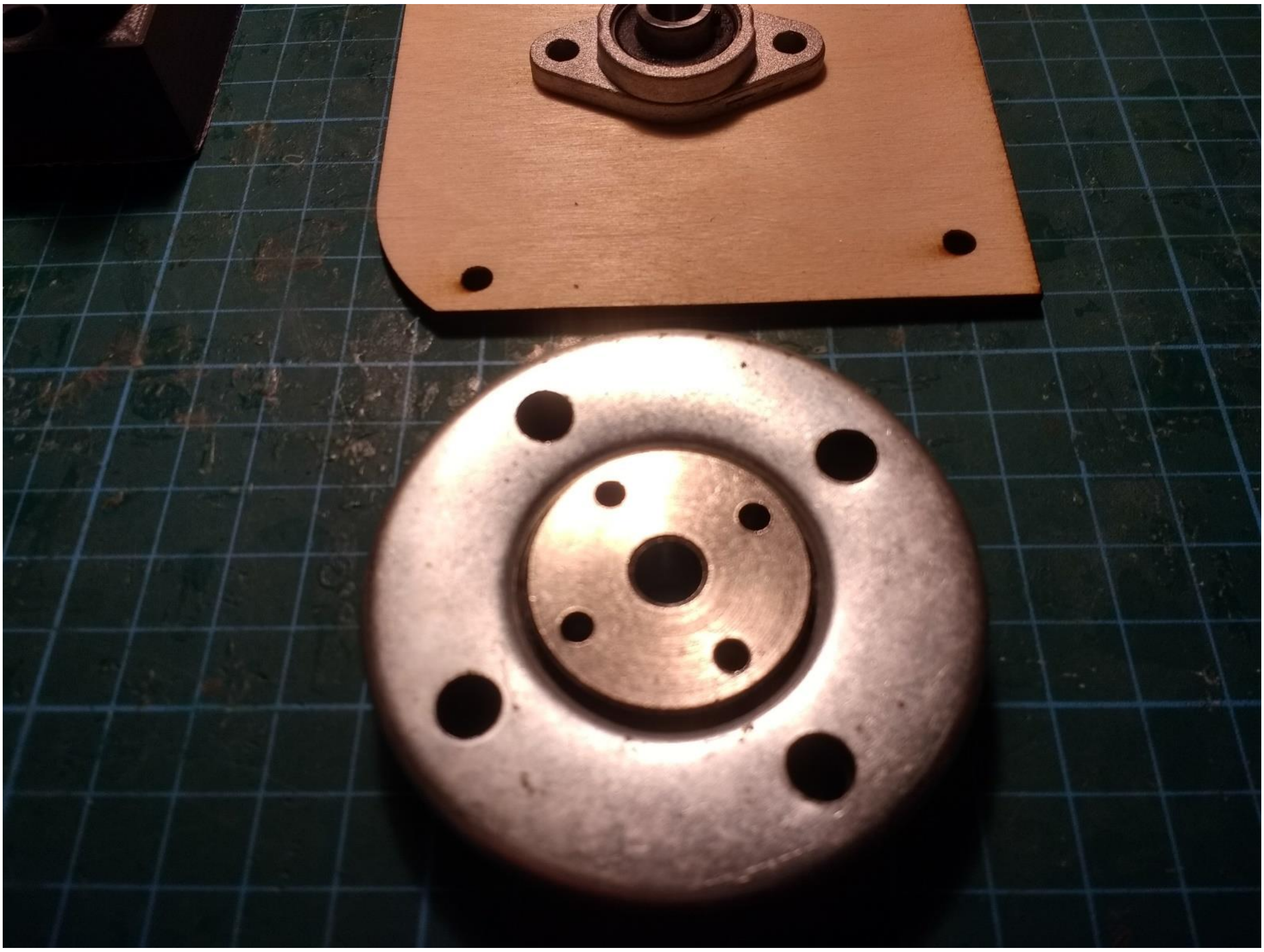


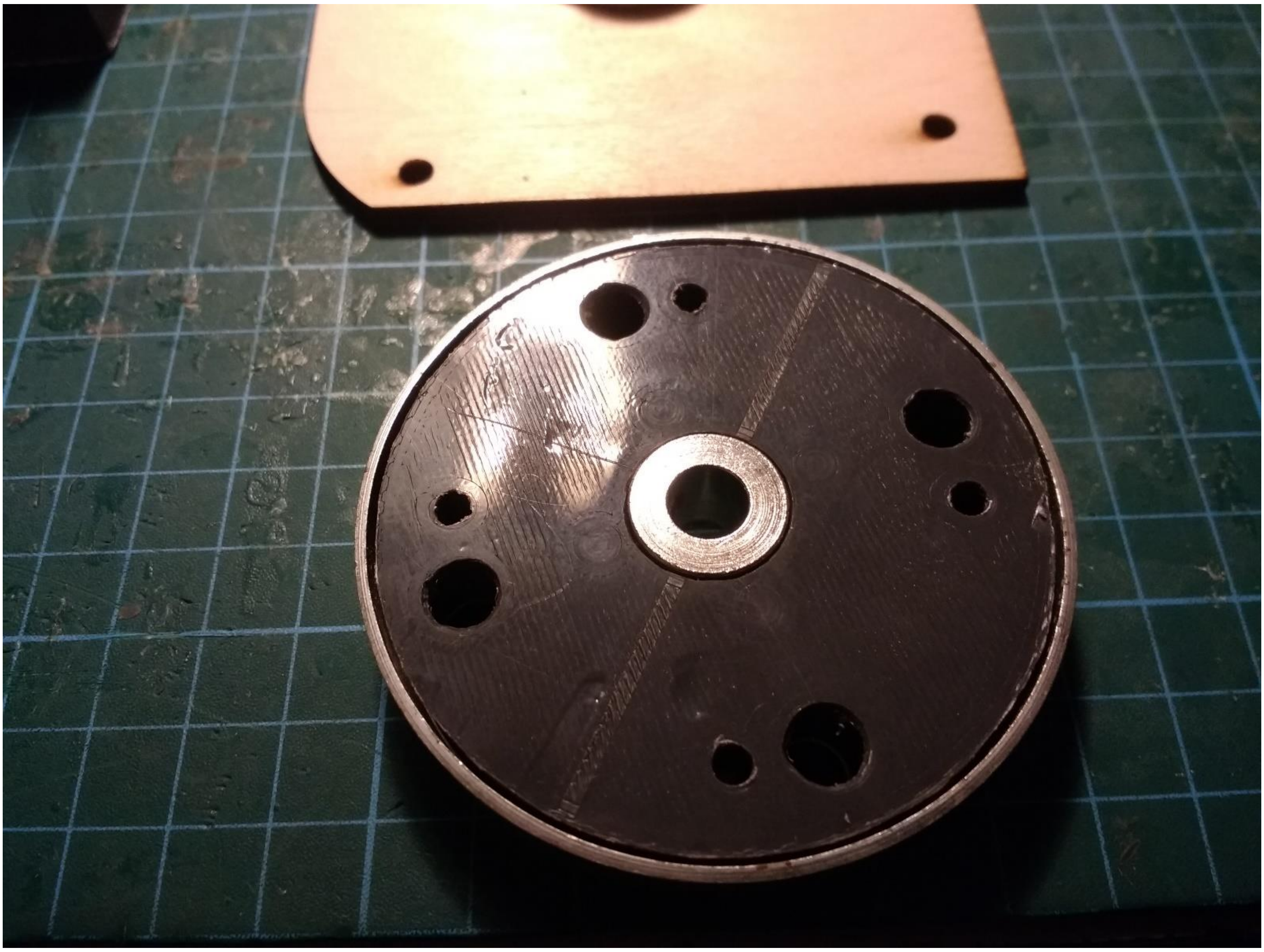
There is a drum supplied with the brake kit. A band of friction material is pulled tight around it when the lever on the left in this photos is pulled outwards. However, first we have to find a way to make the drum fit onto the thin steel shaft we want to use as our crank shaft. To do this I have designed a 3D printed adapter (bottom right in this picture) that allows the drum to be fixed to a metal flange, this flange part has a hole in its centre 8mm in diameter and this allows it to be fixed to an 8mm diameter shaft.

Here is an example of the flange I used. It has two tiny metric Allen hexagonal socket screws (known as grub screws) in its side that allow it to be clamped rigidly onto an 8mm diameter steel rod.

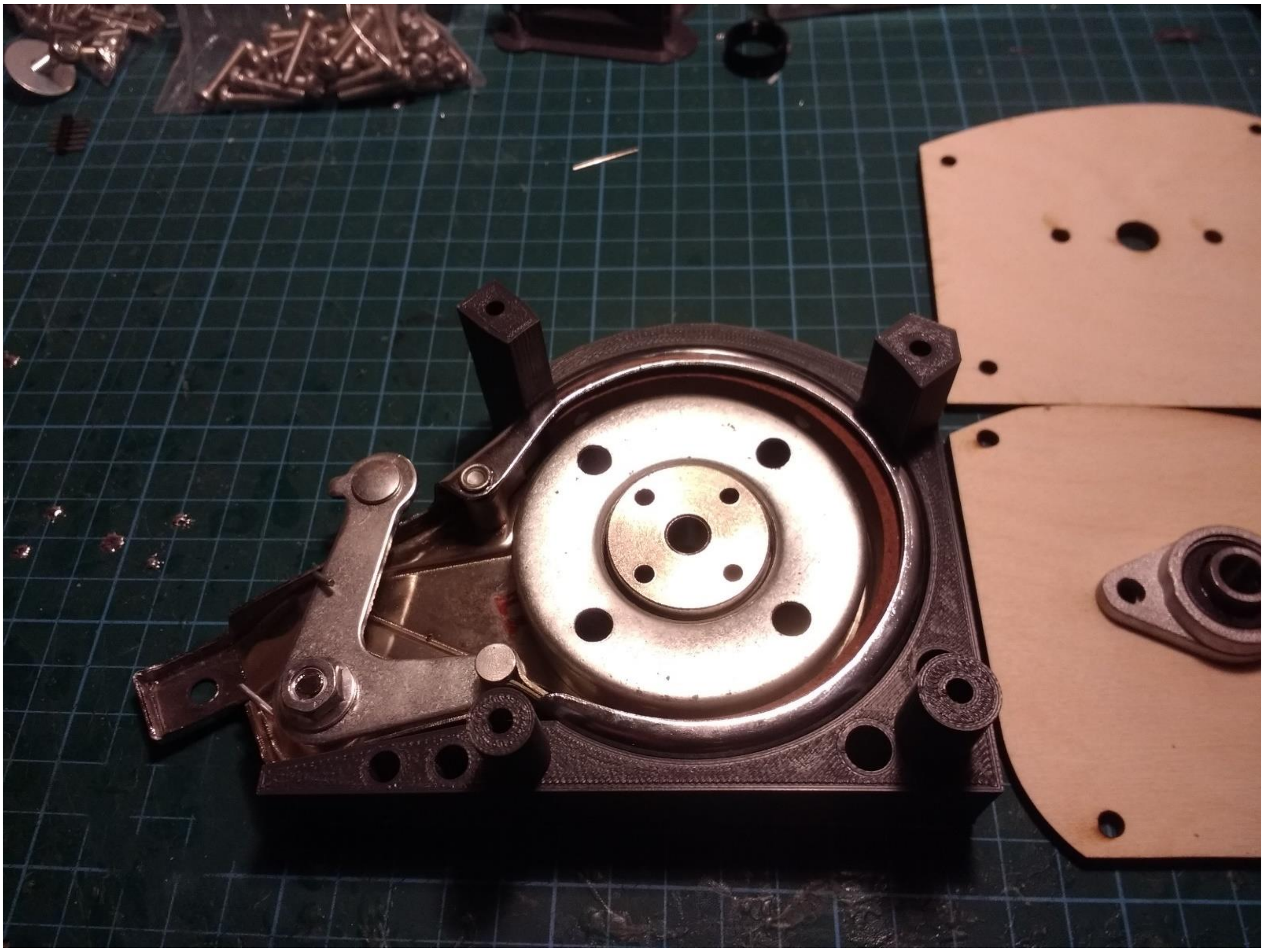


The flange is shown above fitted to the 3D printed adapter. The small holes in the 3D print are sized exactly so that a 3mm diameter bolt (also called M3) can be screwed directly into them and the bolts will grip, cutting their own threads. 3 small bolts will be used to fix it to the flange.



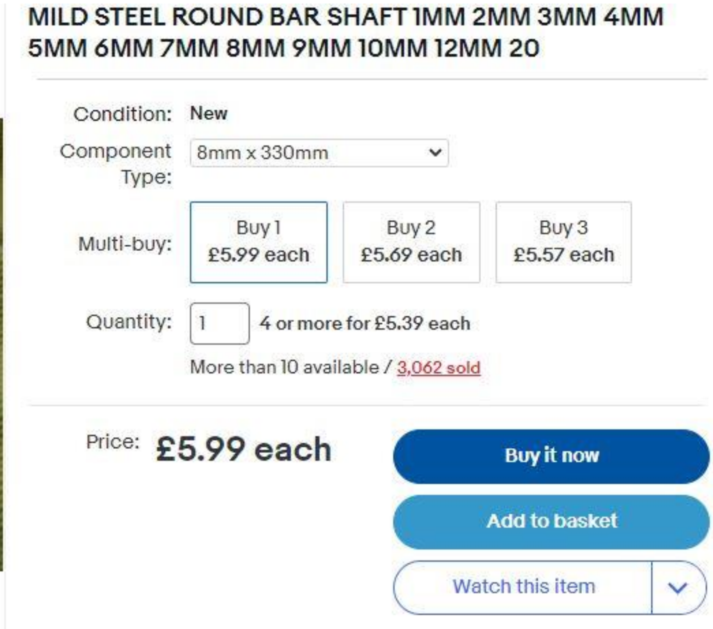


In the above two images the flange has been fitted to the 3D printed adapter and the adapter fitted into the drum of the drum brake. The drum brake can now be fixed to an 8mm diameter metal shaft.

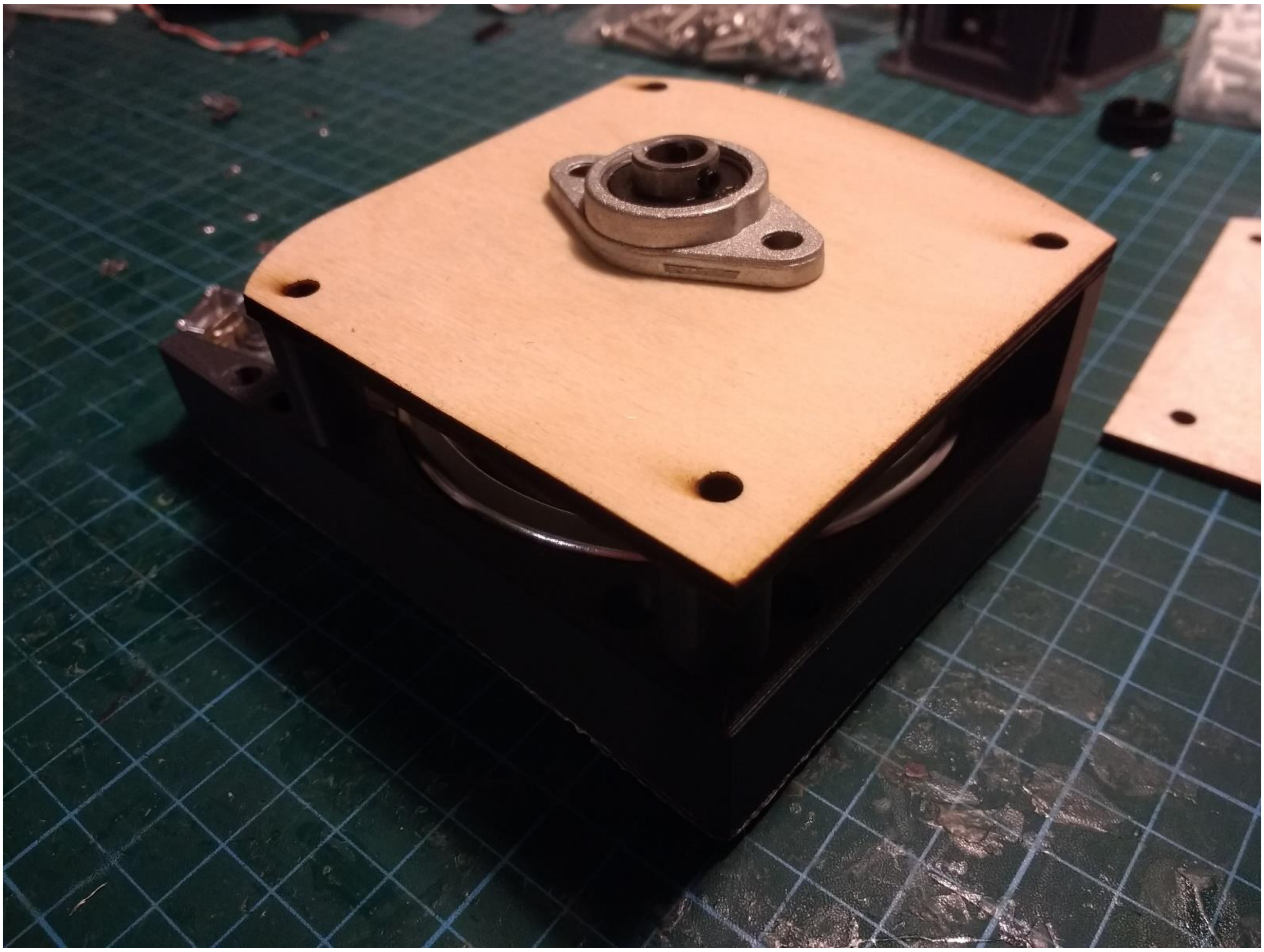


You can see here it mocked up in place. A bearing is fitted to each of the two panels, one of which is shown on the right. These bearings also have small screws in their sides allowing the shaft to be clamped into the bearing so the shaft cannot slide in and out once it is all assembled.

Here is an example of the bearing I used, 8mm internal diameter. Two are required.

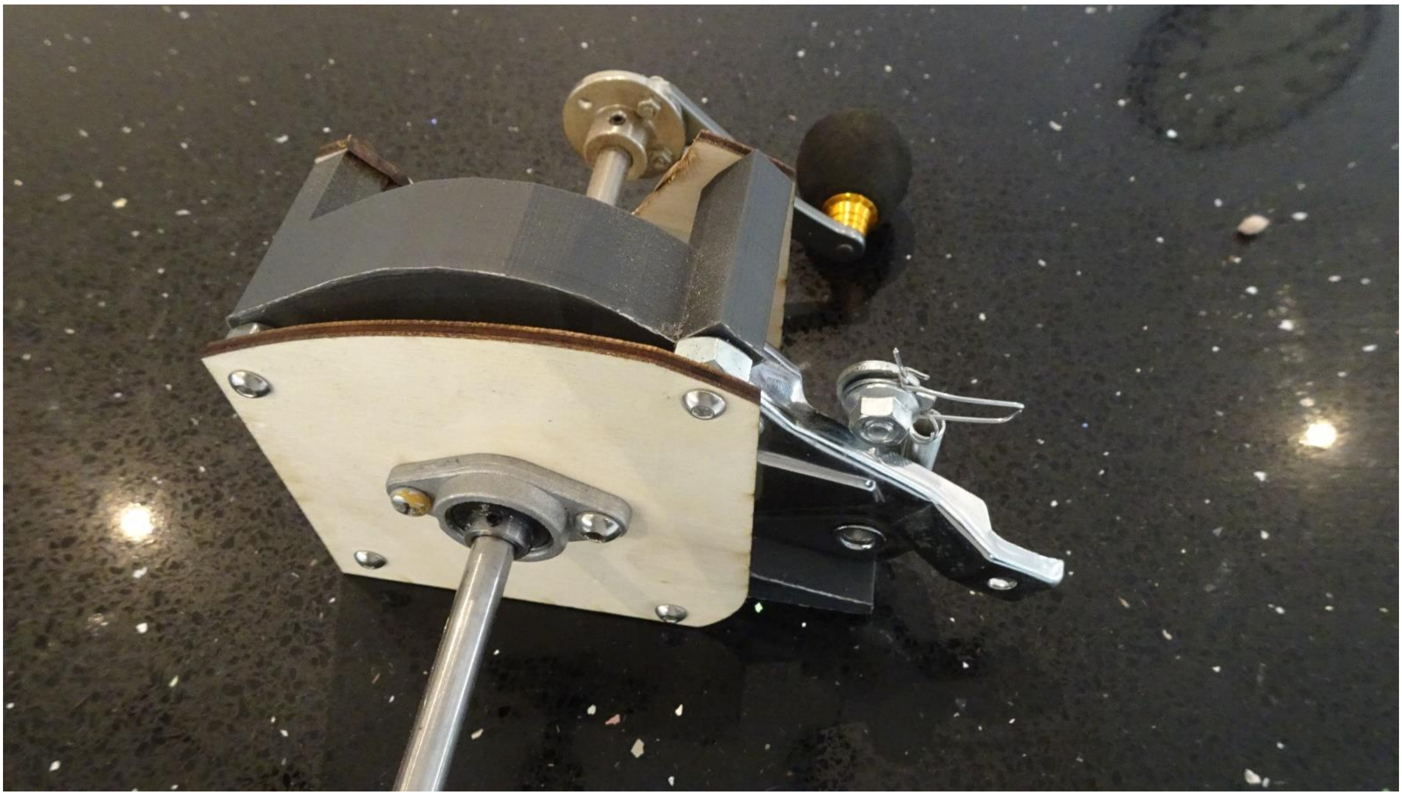


Here is an example of the metal rod I used. Note that if you buy this in a DIY store it will probably be ABOUT 8mm and may not fit into the bearings. If you buy precision round bar, a little more expensive, it will actually be 8mm diameter so I recommend you do this. A short length is all you need.



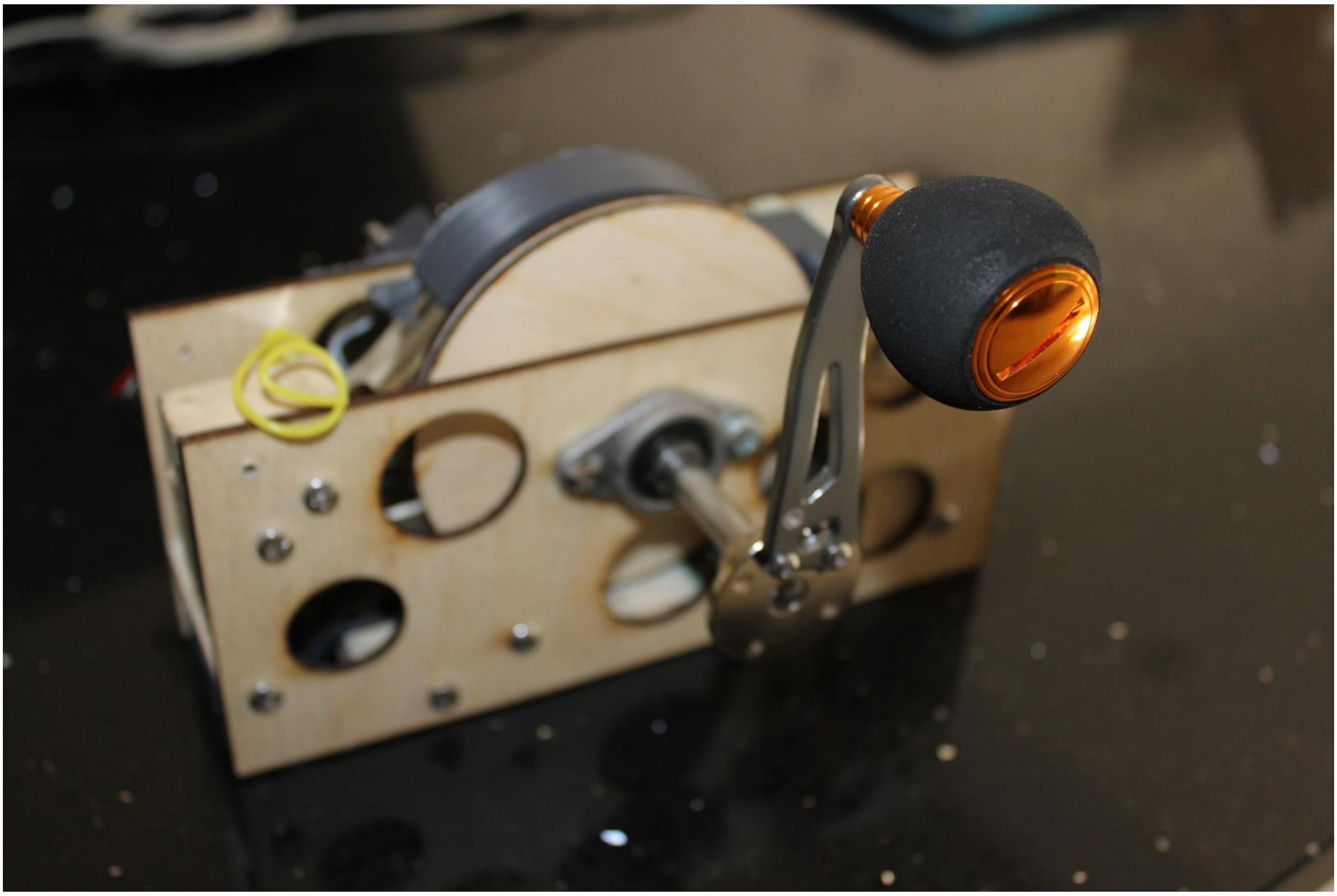
Bolt a bearing into centre of the front and rear panels. Mine are laser cut but you can do them by hand. Make sure the centre of the bearing is lined up perfectly withy centre of the hole on drum brake housing, i.e. the drum needs to be central in the mechanism that then clamps the friction material around it.

If you use M4 (4mm diameter) bolts (not M3) they should screw directly into the 3D print, one roughly in each corner, holding these panels on front and rear.

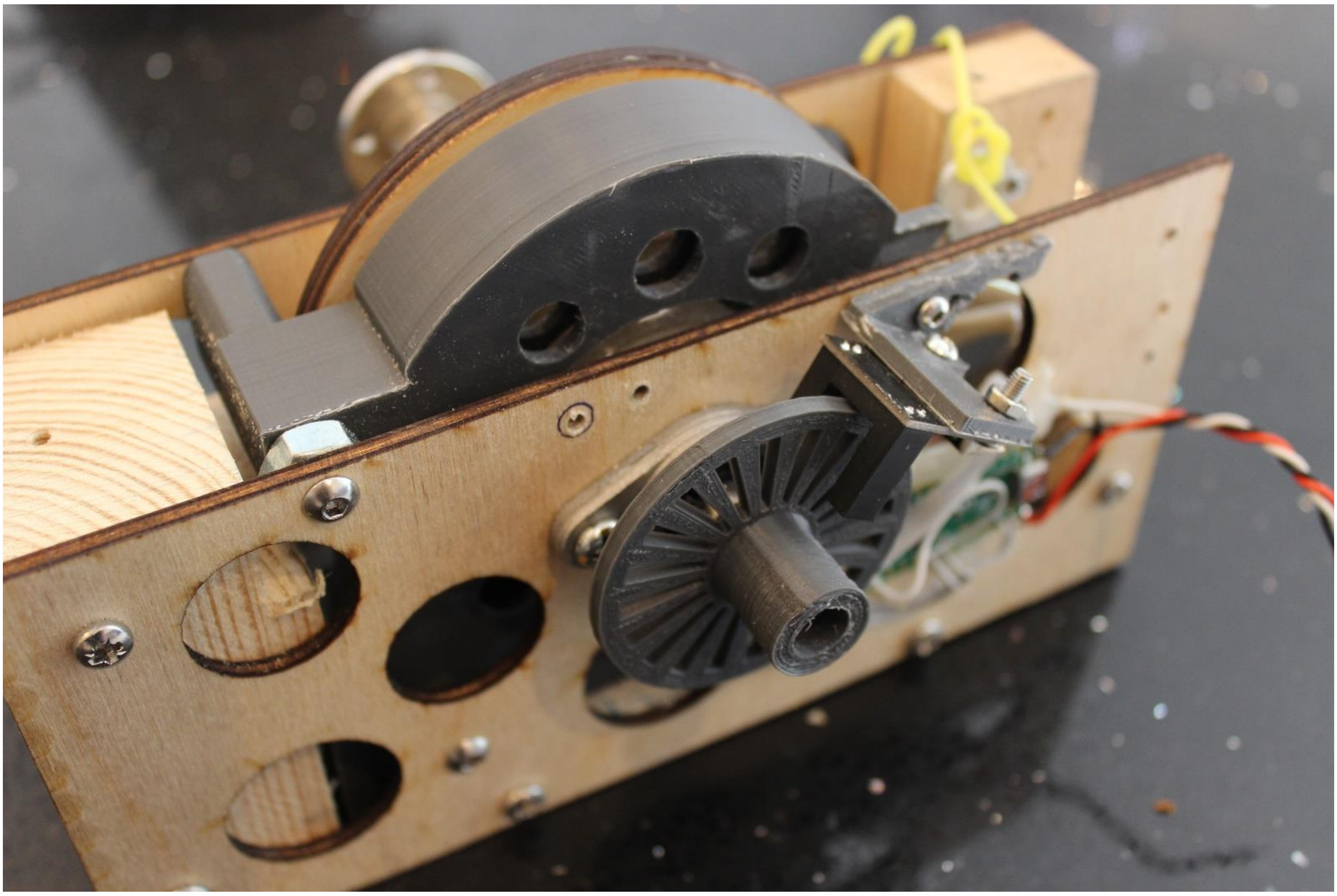


You can see here that for the rear panel I have used 4 big nuts as spacers to space the rear panel off the 3D print by about 8mm.

If you arrange everything correctly and do up the little clamping (grub) screws in the sides of the drum-flange and bearings all correctly, then it will spin freely and the drum part will sit within the friction band located around it. If you pull on the lever, in the image above the thing with a paper clip attached to it, outwards, the friction band will grip the spinning drum applying a friction braking effect to it.



In this version above I have cut the front and rear panels so they exactly fit into the right hand end of a Jaap Brand Nerdy Gurdy design – the versions with the flat right hand end of the soundbox. I also used a second flange as a means of bolting my crank handle to the end of the shaft.



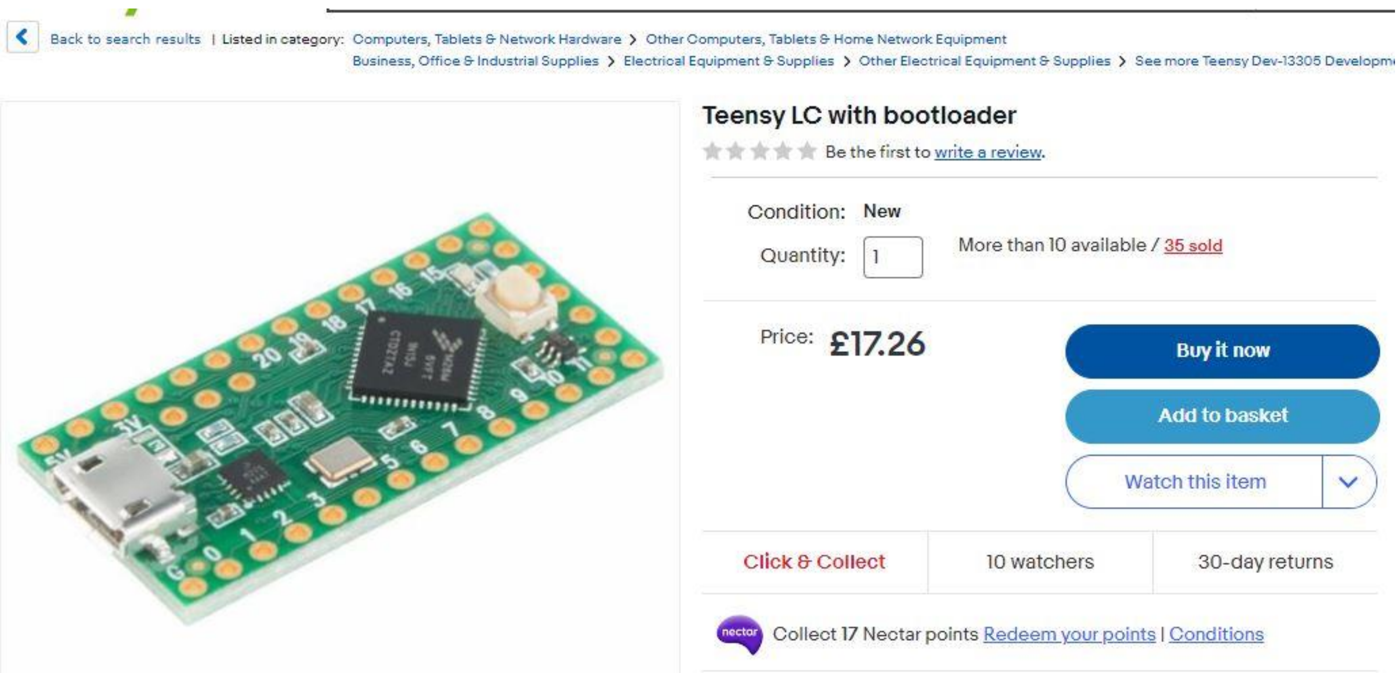
You can see here that I simply used blocks of wood of the correct thickness as spacers to join the front and rear wooden panels, not just relying on the spacing effect of the 3D printed frame alone. These blocks allow screws to be inserted through the soundbox panels into them, to hold this whole assembly rigid in the end of the soundbox. Also I have tied a length of thin strimmer line (any nylon string will do, badminton racket string etc), to the hole in the end of the brake actuation lever for use later on as we will need to create a mechanism to apply tension to this string to vary the braking effect.

Also here for the first time you see the optical chopper wheel.

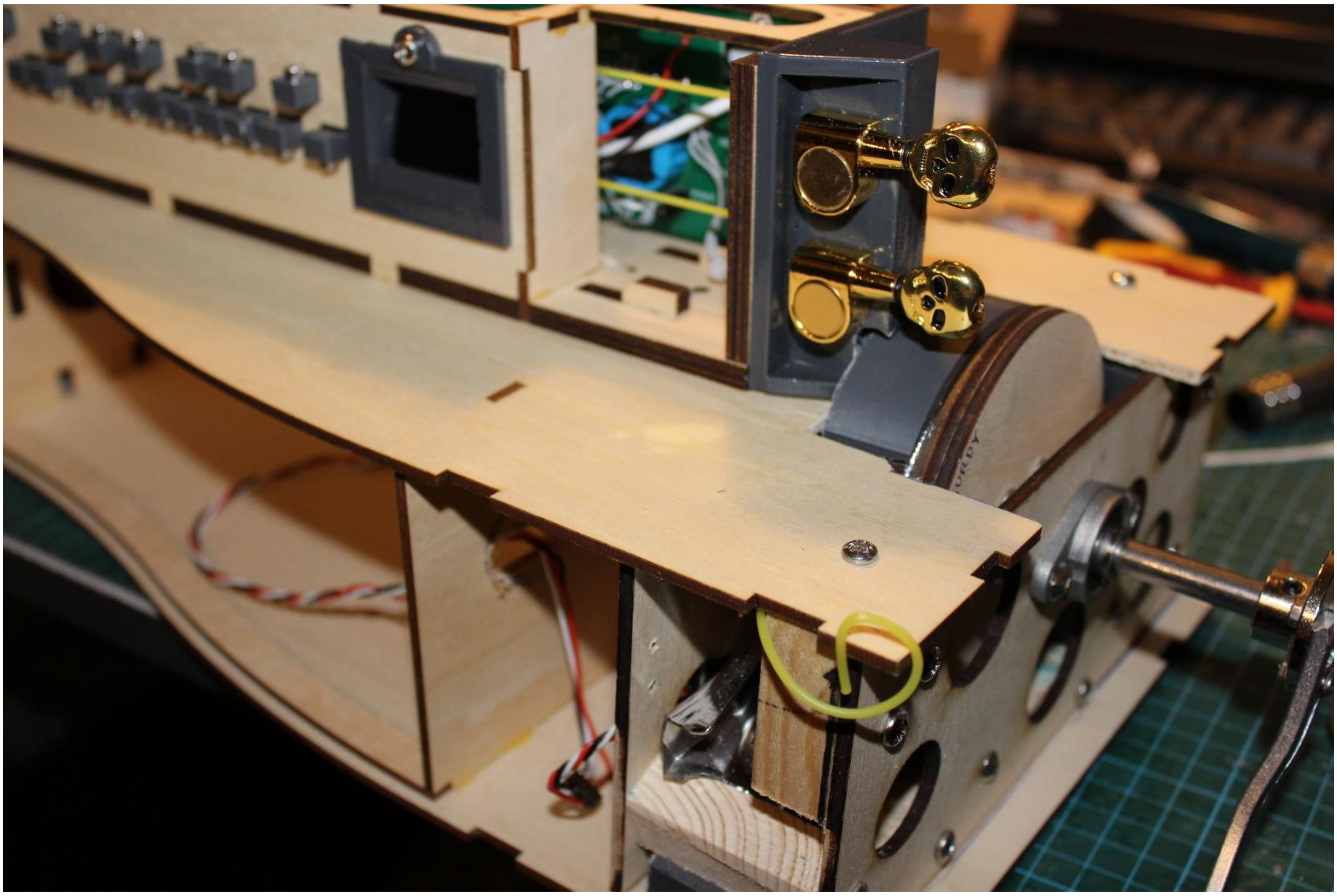
The chopper wheel has about 20 slots (holes) in it and my code that reads it is set up for that number of slots. The black thing each side of this wheel is the optical sensor. It shines a beam from one side to the other, through the slots, and it outputs pulses as the slots pass by when the wheel is rotating.
This sensor sends data to a small microcontroller called a Teensy LC (low cost) board. As well as being small and low cost, it has an analog output port that puts out a genuine steady analog variable voltage. My software reads the speed of the wheel rotation and varies the output voltage in direct proportion to this.
This means it behaves in a manner very similar to the gearmotor I previously used, which was acting as a dynamo when the shaft rotated, putting out a variable voltage.
This means this whole assembly can be used as a direct replacement for the gearmotor AND *the main software running on the main microcontroller (a small computer) inside the main digigurdy does not have to be adjusted in any way.*

The chopper wheel is 3D printed.

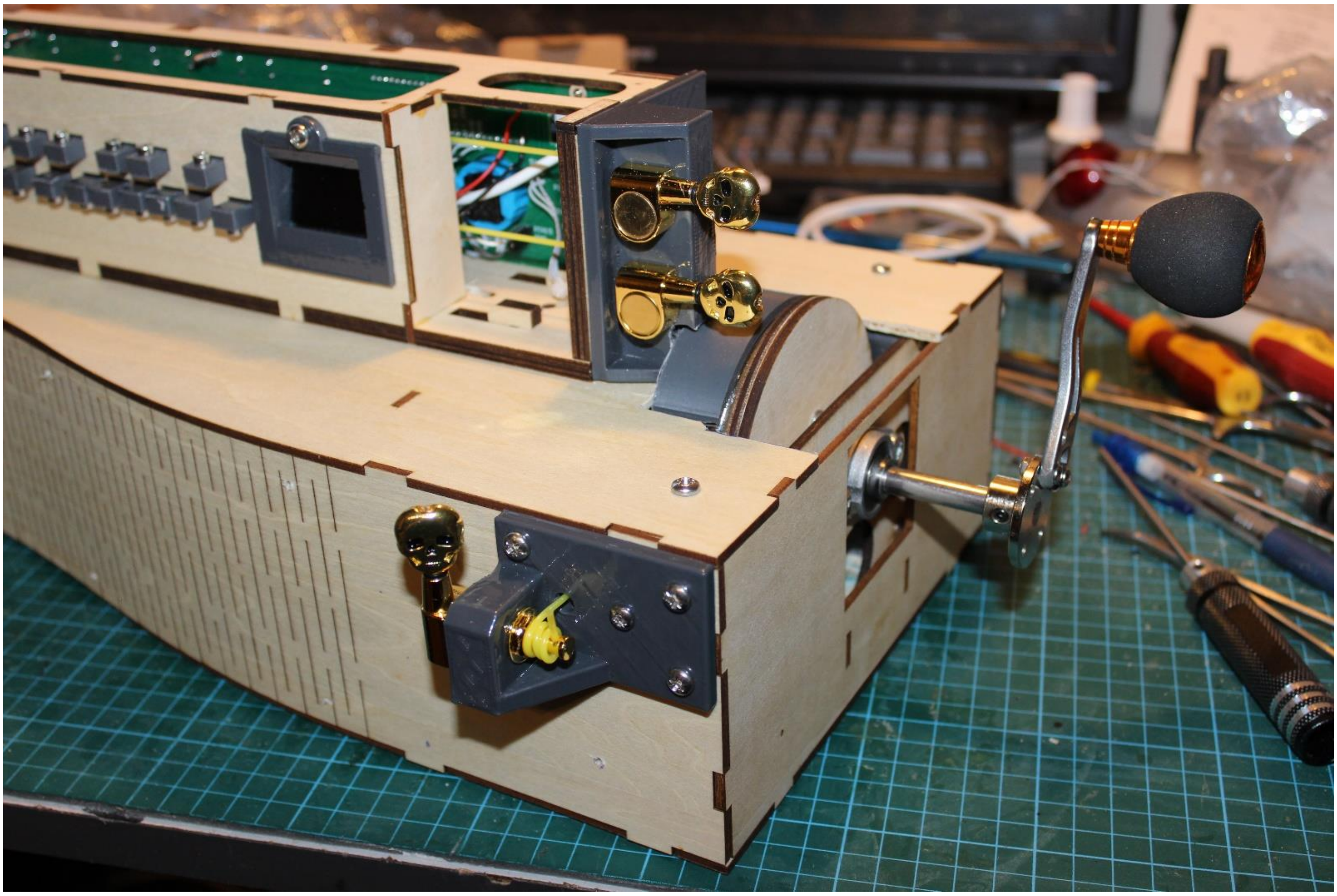
Here is an example of the optical sensor. NOTE: They are usually narrower, i.e. a narrower gap between each side of the sensor than this one. This wider one is good as it allows more error when positioning it relative to the chopper wheel!



Example of the Teensy LC. Not so low-cost as a couple of years ago due to ongoing chip shortages……….



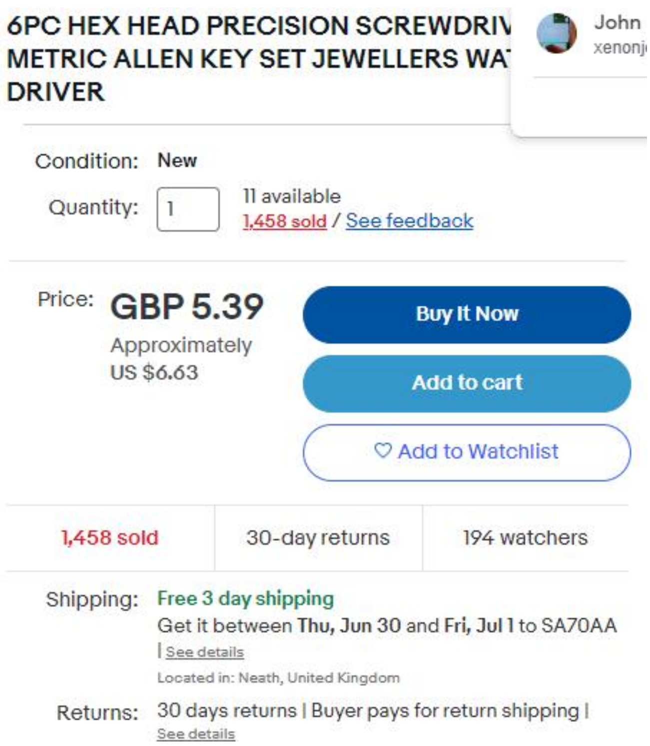
Here you can see the whole assembly has been screwed into place through the upper and lower surfaces of the soundbox. The nylon line will emerge through the side of the soundbox where we will fit a tensioning tuning peg. Here I have also bolted a wooden mock-wheel to the rotating drum to simulate visually the rotating wheel of a real gurdy. The steel shaft needs shortening later on as my crank handle projects a little too much in this photo.



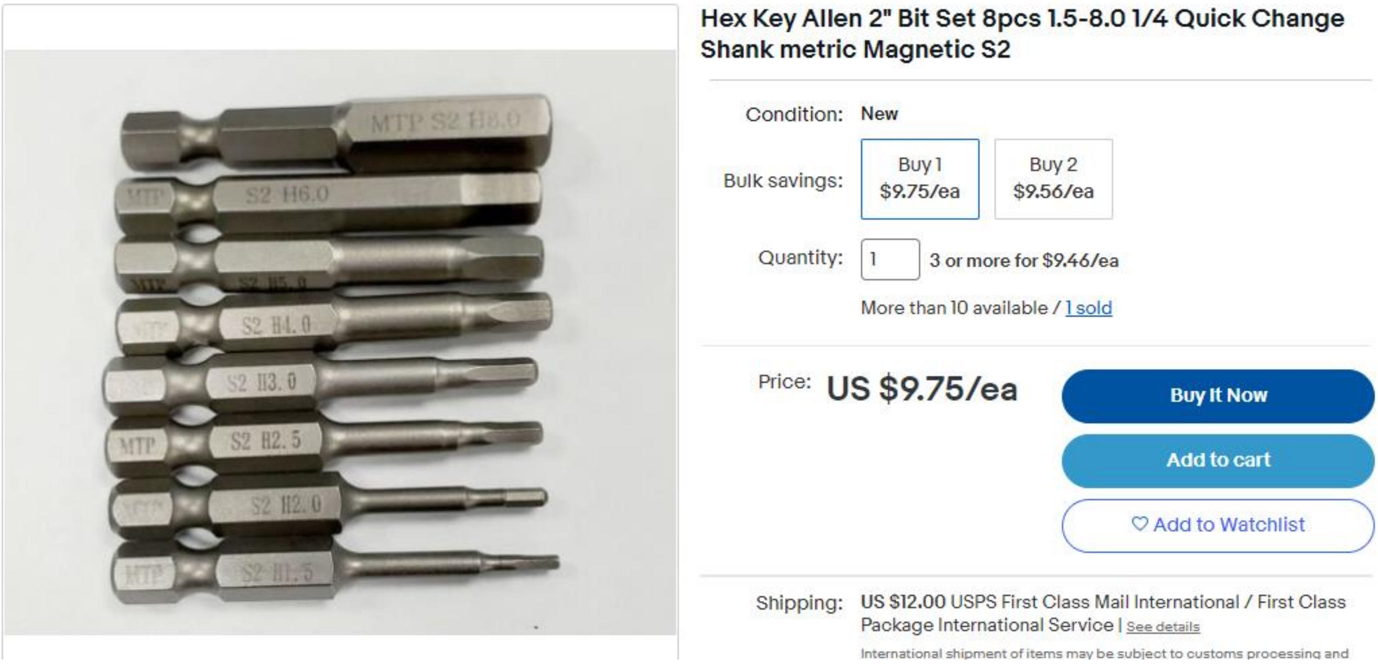
Here I have fitted the side panel of the soundbox. As this is a prototype the side panel is held in with 10 small screws along both long edges of the side panel, it allows me to get inside in the future to adjust things.
The guitar tuner on the side is mounted in the 3D printed mount. This does not have to be very strong as the tension required to get the brake band to just start to rub around the rotating drum is actually quite small (compared to what would be required to stop an electric scooter with a human standing on it).

Practical aspects of construction:
I am in the US, where do I get all this metric stuff from ?
Your local DIY store may not have it but M3 bolts with cup heads are available on ebay just as in the UK I can obtain bothy metric and imperial fasteners online (our old classic cars are imperial for example on account of having an empire back then).

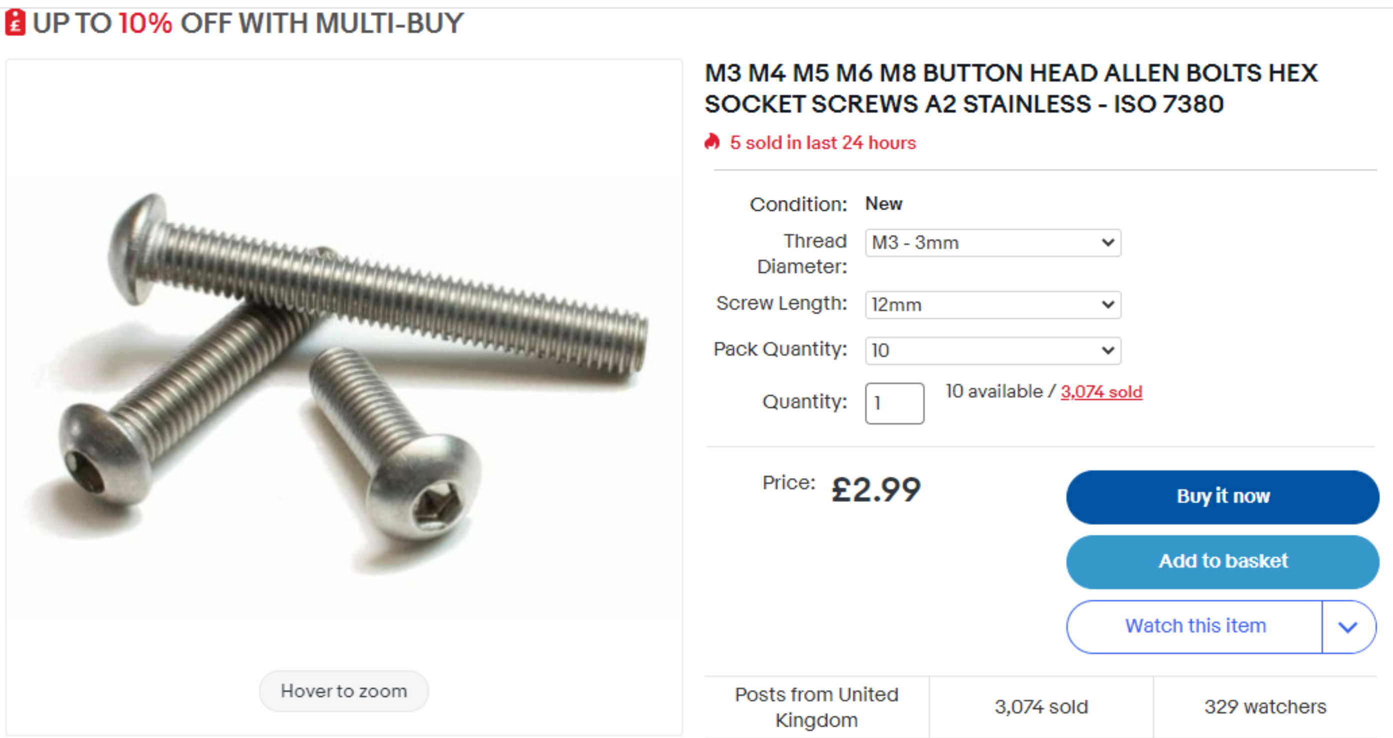
You can also use those L shaped hex (Allen) keys to screw them in but it is much nicer to buy a cheap set of metric (Allen) head screwdrivers. They come as a set of 4 quite often. If you use M3 and M4 bolts for screwing things directly into my 3D prints, apart from that you can always use maybe a ¼ inch diameter metal shaft and buy ¼ inch flanges and bearings if you find they are easier to get hold of.



Example. These go from very small up to M4 (4mm).



The other way to do this is to buy a set of metric Allen bits as above.

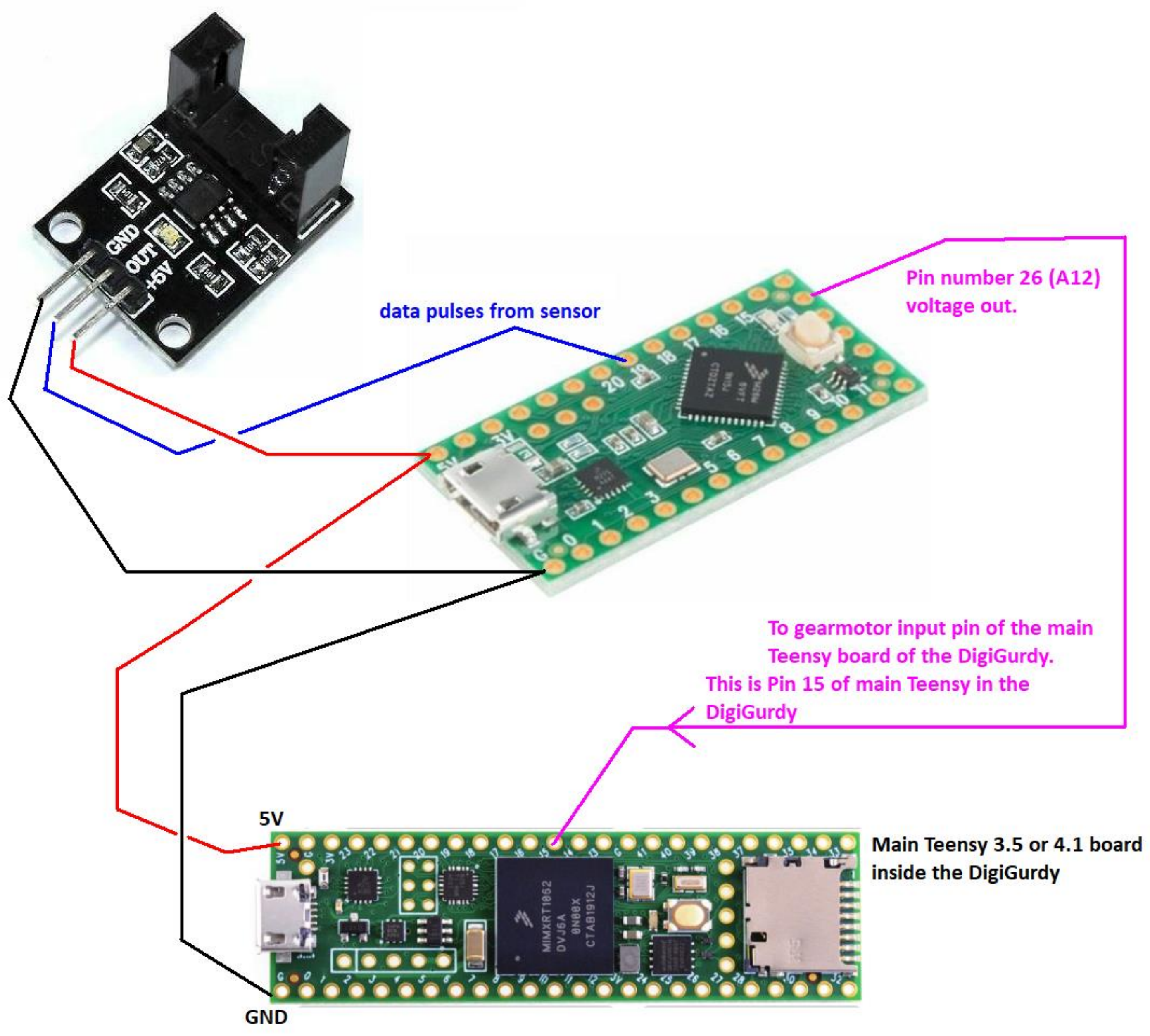


Example of the M3 bolts I used. I use button-head as the heads have a low profile. My M4 bolts were from the same webstore.

Wiring diagram:

Basically there are 3 wires (5V, GND and the output) between the sensor and the Teensy LC. There are power (5V and GND) from the 5V and GND pins on the end of the main Teensy board in the DigiGurdy to power the Teensy LC and there is a third wire from Pin 26 of the Teensy LC (variable output voltage signal) to the pin on the main Teensy board that formerly read the voltage from the gearmotor crank, this is Pin 15 on the main teensy board inside the DigiGurdy.

NOTE: If I programmed the LC to output the maximum voltage (5V) on Pin 26, it could damage the main Teensy inside the DigiGurdy as that is only capable of accepting 3.3V maximum, however my software for the Teensy LC that reads the chopper wheel is set up to never output this high a voltage.



So, there are 3 wires between the Teensy inside the digigurdy keybox and the new crank assembly in the end of the soundbox.

Finally:

I am experimenting with replacing the dummy wooden wheel with a disc of thick steel. These can be bought online ready cut. Having recently tried a very expensive real gurdy I realised that it had a large heavy solid wood wheel. This gives it a certain quality feel when cranking that is absent from a smaller gurdy with a lightweight wheel so I thought I would experiment with increasing the rotating mass of my wheel. As my dummy wheel is smaller in diameter than that of a real gurdy I will compensate by using a smaller diameter but quite heavy steel disc some 6mm thick. This is an experiment I have not done yet but will try soon.