Force meter.

This device is made cheaply from readily available parts and will measure up to 5N and has a large scale.
The range can be changed by using a different spring.
The equipment listed below was used for the prototype, but can be readily modified so that materials already available can be used.

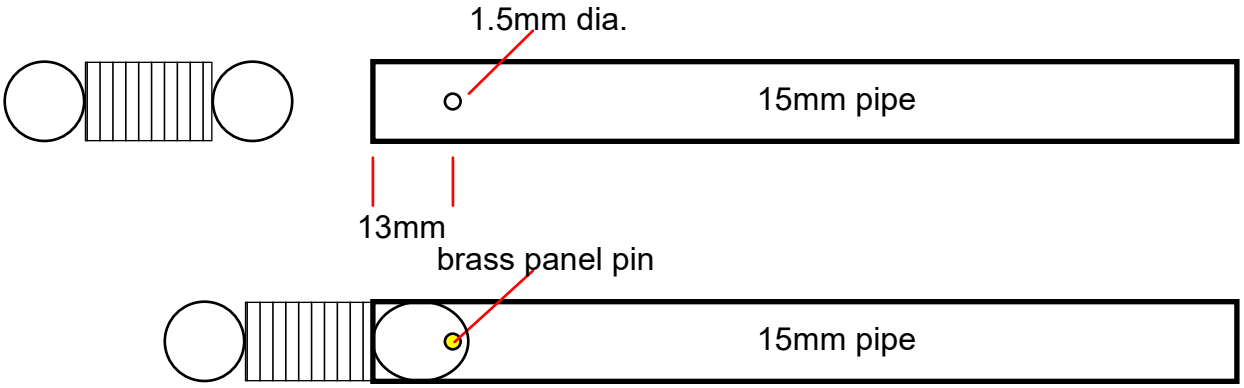
Equipment.

1 x 30cm of 21.5mm diameter plastic overflow pipe (Screwfix 68593)
1 x 27cm of 15mm diameter plastic (Screwfix 96983)
1 x expendable spring (50mm x 15mm diameter) (Rapid Electronics 37-0416)
(Force constant 0.0244N/mm)
1 x brass panel pin 25.4mm by 1.5mm diameter.
1 x M4 bolt, 30mm long plus M4 nut and washer.
10cm of 1.6mm diameter wire (e.g. extracted from off cut of 2.5mm^2 twin and earth main cable).
10cm of 3mm diameter wire (e.g. from a wire coat hanger).
2 x M4 solder tags.

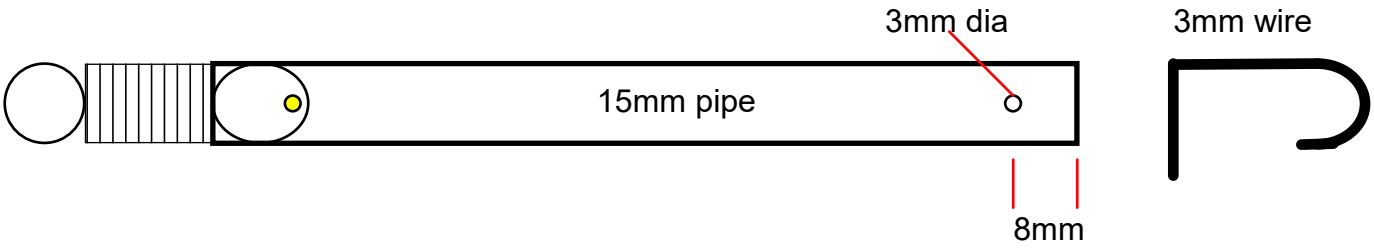
Construction

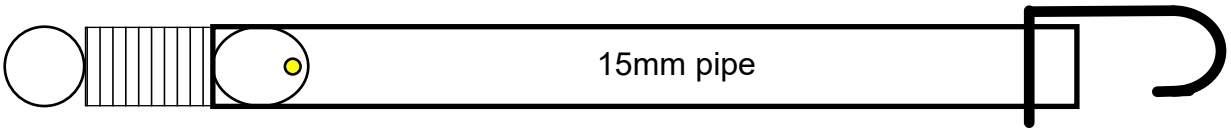
The plastic pipes can be cut wither with a fine blade hacksaw of a wheel pipe cutter.
If a wheel pipe cutter is used, then it is worth putting packing into the tube to stop the tube being squashed.

1). Remove any burr from the ends of the plastic pipes.
2). Drill a 1.5mm diameter hole through the diameter of the 15mm pipe, 13mm from the one end.
3). Gently squash the loop on the one end of the expendable spring with pliers and push it into the drilled end of the 15mm pipe.
4). Push the brass panel pin through the drilled hole to pass through the loop of the spring, so fixing the spring to the end of the 15mm tube.
5). Cut off the excess panel pin and file to be almost flush with the plastic tube.

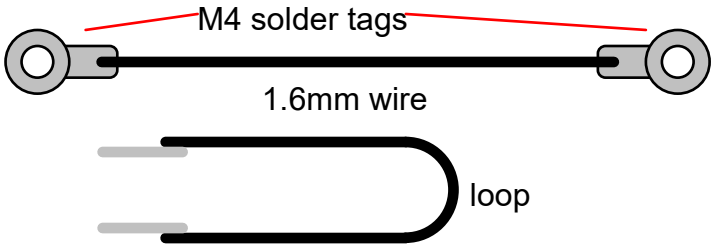


6). Drill a 3mm diameter hole through the diameter of the 15mm pipe, 8mm from the other end.
Use pliers to bend the 3mm wire to form a hook and pass through the 3mm hole.

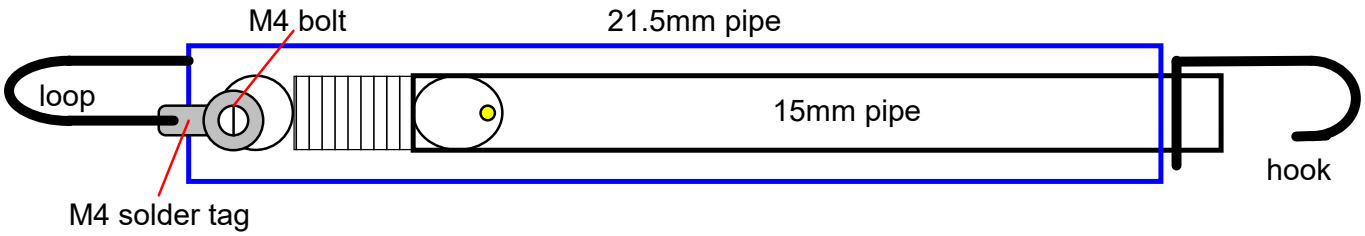




7). Solder the M4 solder tags onto the ends of the 1.6mm wire and bend to form a loop.
This will be the hook used to hold the force meter.



8). Drill a 4mm diameter hole through the diameter of the 21.5mm pipe, 1cm from the one end.
9). Put the 15mm pipe into the 21.5mm pipe, with the free loop of the spring near to the 4mm hole.
10). Pass the M4 bolt through one of the solder tags, then through one of the 4mm holes in the pipe, then through the loop of the spring, then through the other 4mm hole and finally through the other solder tag.
Fix in place with the M4 washer and nut.



When hung vertically by the loop, the 15mm pipe and hook should stretch the spring a little so that the wire from the hook is a few mm below the bottom of the 21.5mm pipe.

Calibration and Scale.

The force meter should be calibrated when held vertically because this is likely to be how it is normally used (to 'weigh' an object).
In this position the inner pipe will be hanging freely with its weight also stretching the spring downwards.
The most accurate way to calibrate the force meter is to apply a known force to the force meter and mark the inner pipe to show this force.
The original was calibrated in this way by hanging 100g masses to the hook of the force meter.
The extension of the spring should be proportional to the force applied (up to about 7N) (Hooke's Law) and so the force needed to stretch the spring by 1mm can be calculated.
For the original, 0.5kg stretched the spring by 213mm.
With the gravitational field strength being $9.81 N.kg^{-1}$,
=> 4.905N caused an extension of 213mm
=> 0.0230N gives an extension of 1mm
This is in reasonable agreement with the manufacturers value of $0.0244 N.mm^{-1}$.

Calibration scale using a force constant of $0.024 N.mm^{-1}$.

Force (N)	Extension (mm)
0	0
0.5	21
1.0	42
1.5	63
2.0	83
2.5	104
3.0	125
3.5	146
4.0	167
4.5	188
5.0	208

The scale should be 22cm long when printed. The printed scale should be stuck onto the inner tube, with the start being positioned at the opening to the outer tube when there is no extra force on the force meter.

Using this scale, measurements should be within ±10%