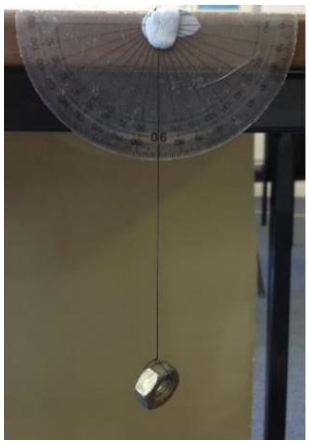
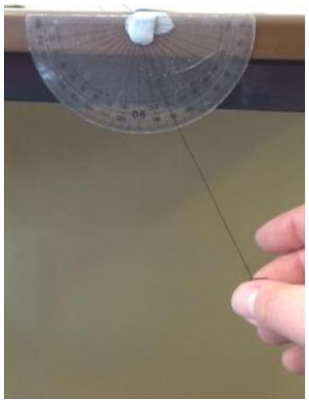
# Determining acceleration due to gravity, g, from a pendulum swing

**Method**





1. Make a pendulum by tying a small mass (such as a nut) to a piece of cotton (or thin string) that is about 1 m long.
2. Stick (Blu-tack works well) a protractor to the edge of a table and then using another piece of Blu-tack on the front of the protractor, hang the pendulum so that the thread lines up with 90° (see Fig. 1).
3. Adjust the length of the pendulum until it is 0.1 m long
4. Pull the pendulum to one side through an angle of 20° from the vertical (see Fig. 2).
5. Release the pendulum and record the time taken for it to do 10 complete swings.
6. Repeat two more times.
7. Adjust the length of the pendulum to 0.2 m and repeat steps 4-6.
8. Adjust the length of the pendulum to 0.3 m and repeat steps 4-6.
9. Adjust the length of the pendulum to 0.4 m and repeat steps 4-6.
10. Adjust the length of the pendulum to 0.5 m and repeat steps 4-6.
11. Adjust the length of the pendulum to 0.6 m and repeat steps 4-6.

**Results table**

- The independent variable (length of pendulum) must be in the first column.
- You must show all the repeats for each pendulum length.
- Calculate the average of the repeats for each pendulum length and record this in the results table.
- Determine the time for one swing (T) for each pendulum length and record this in the results table.
- Determine $T^2$ for each pendulum length and record this in the results table.

## Graph

- Plot a scatter graph of length on the $x$-axis and $T^2$ on the $y$-axis. Do not use a false origin.
- Draw the line of best fit. In this practical, the line of best is straight so must be drawn with a ruler and it goes through the origin. Remember, there must be an even spread of points each side of the line of best fit.
- Determine the gradient of the line.

## Determining acceleration due to gravity, g.

The gradient of the line = $4\pi^2/g$

Use this to determine g, acceleration due to gravity (it has the units $m/s^2$).

## The Rationale

The time it takes a pendulum to complete one swing (T) and the length of the pendulum are related by the equation:

$$T = 2\pi \sqrt{\frac{l}{g}}$$

Where:

l = the length of the pendulum
g = acceleration due to gravity.

Trying to plot graphs of equations with square roots in can be complicated so it is easier to get rid of the square root by squaring every term. This makes the above equation:

$$T^2 = 2^2\pi^2 (\sqrt{\frac{l}{g}})^2$$

This simplifies to:

$$T^2 = 4\pi^2 (\frac{l}{g})$$

Or re-organised:

$$T^2 = \frac{4\pi^2}{g} l$$

The equation of a straight line is:

$$y = mx + c$$

If we relate the above equations to each other we see that:

$$y \text{ is equivalent to } T^2$$
$$x \text{ is equivalent to } l$$
$$m \text{ is equivalent to } \frac{4\pi^2}{g}$$
$$\text{and there is no intercept, } c$$

So, if we plot $T^2$ on the y-axis and l on the x-axis, then the line will pass through the origin (no y-intercept) and the gradient, m, will be $\frac{4\pi^2}{g}$.