Measuring the acceleration due to gravity from a pendulum swing

Apparatus

A wireless motion sensor.

Retort stand and clamp.

Small clip (crocodile clip or binder clip).

Pendulum mass (tennis ball, punctured)

String

Ruler

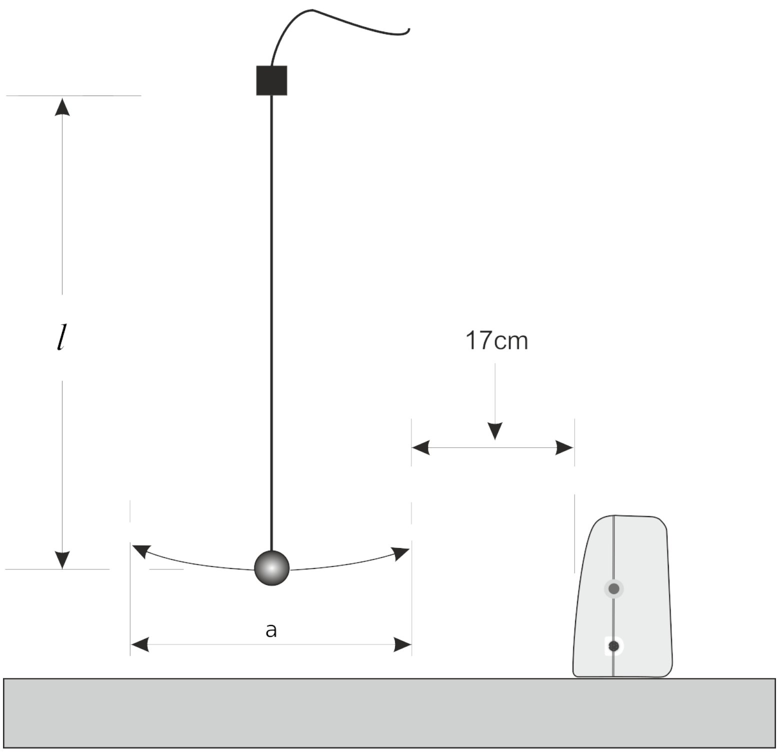
Data recording setup.

Select Start to begin, stop after duration.

Intersample to 10ms

Sensor range set to 1.5m

After initial set up use a trigger to start recording when distance rises above (static distance + 10cm)



The relationship between pendulum period and the length of the pendulum is described by the equation. Where T is

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

the period of the pendulum oscillation and "l" is the length of the pendulum.

The force driving the motion of the pendulum is gravity.

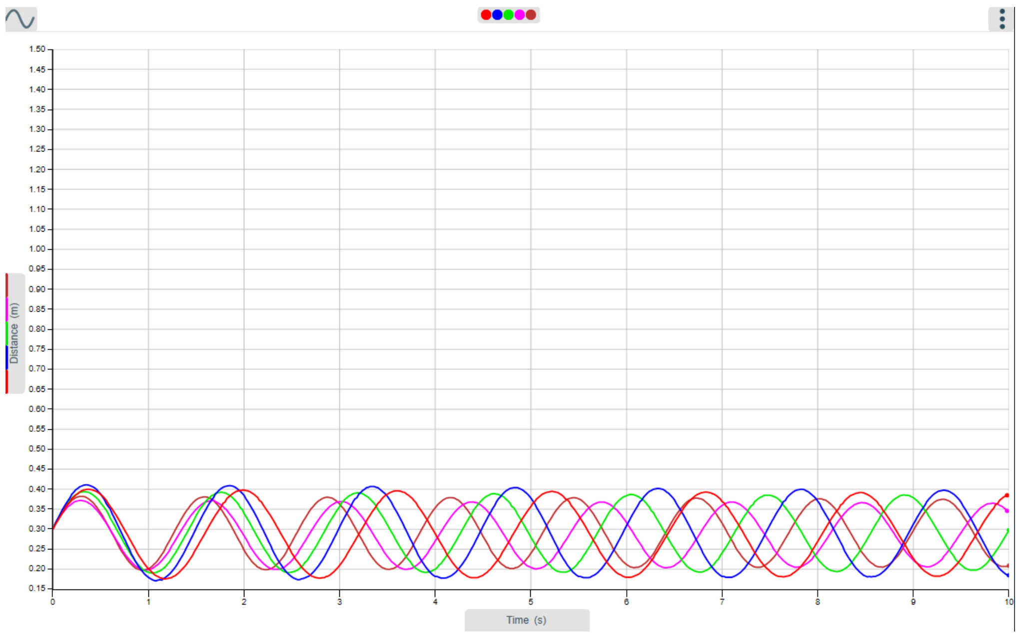
The practical gives an opportunity for you to calculate an etimated value for g, and use the result to consider how the apparatus or practical can be improved to improve the accuracy of the estimation

Method.

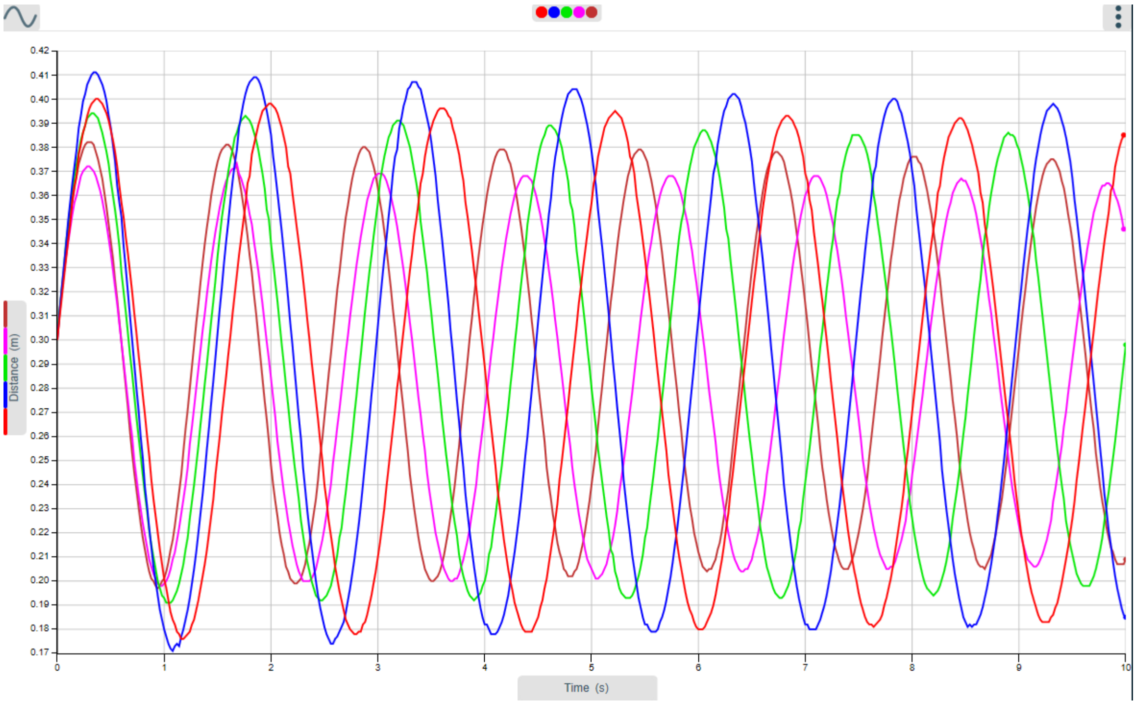
1. Assemble the apparatus as shown. Make sure the pendulum can swing freely and check the path of the pendulum is fully in the motion sensors detection range. The pendulum should not get closer to the detecting capsule than 17cm and should (at rest) not lower than the base of the detecting capsule. To start with place the pendulum bob at least 0.5m from the motion sensor at rest and have the mid line of the pendulum bob at the half height position of the detection capsule.
2. Link the sensor to the software and set the range to the lowest distance range available.
3. Use a starting length “l” of about 0.9m (this is normally to the centre of the pendulum mass, but you may find it easier to use the base of the pendulum bob). Record the length you have set the pendulum to in the results table.
4. Use settings to enter the recording parameters (the default sample period is 50ms between samples but this will be too slow, set it to 20 or 10 ms between samples.
5. Pull the pendulum back by 15cm and release. After two or three swings select the start button and record 11 swings of the pendulum. Check the recording gives nice sine wave type graph. If there are flat spots in the data check for the pendulum bob swinging below the detection range of the sensor and it is not getting to closer than 17 cm from the front of the motion sensor.
6. Use the data from this first run to refine the position of the pendulum and motion sensor.
7. Change the length of the pendulum and repeat. Use the runs tool to make data visible or invisible in the graphing area. You can also use runs to delete and bad sets of data.
8. Repeat to get at least 5 pendulum lengths.
9. Save the data after each run.

You can use a trigger and overlay to get all the data on one graph. Use settings to change the start condition to a triggered one. Use a start condition of rises above (the distance from the motion sensor to the bob at rest +10cm). This will trigger the recording as the pendulum bob moves away from the sensor.

Data should be collected from at least 5 different lengths.



Example of data as collected with 5 different pendulum lengths, data in this example collected with a trigger and overlay in place



Sample data after re-scaling. The difference in the period due to pendulum length is quite clear.

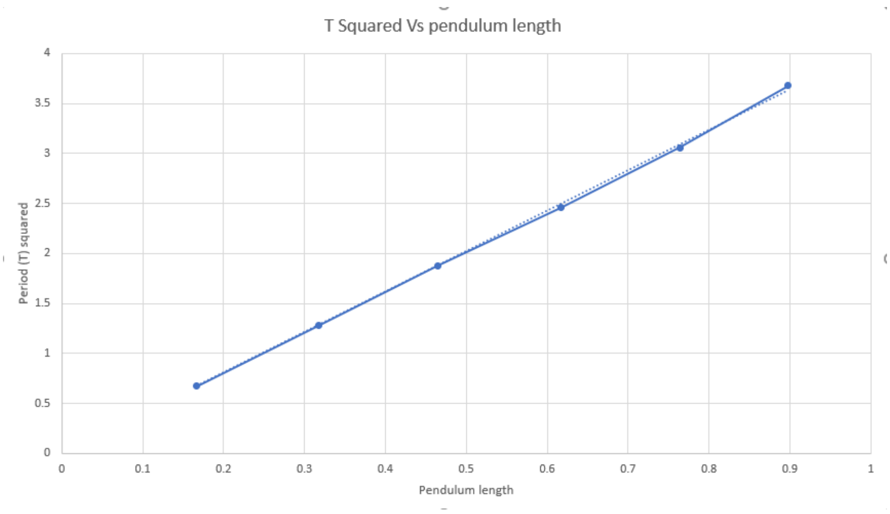
Use the coloured dots at the top of the graph to turn on and off runs of data and use the difference tool to work out the period of each pendulum length.

Tabulate the pendulum length, time for 10 oscillations (and hence the period T), T^2.

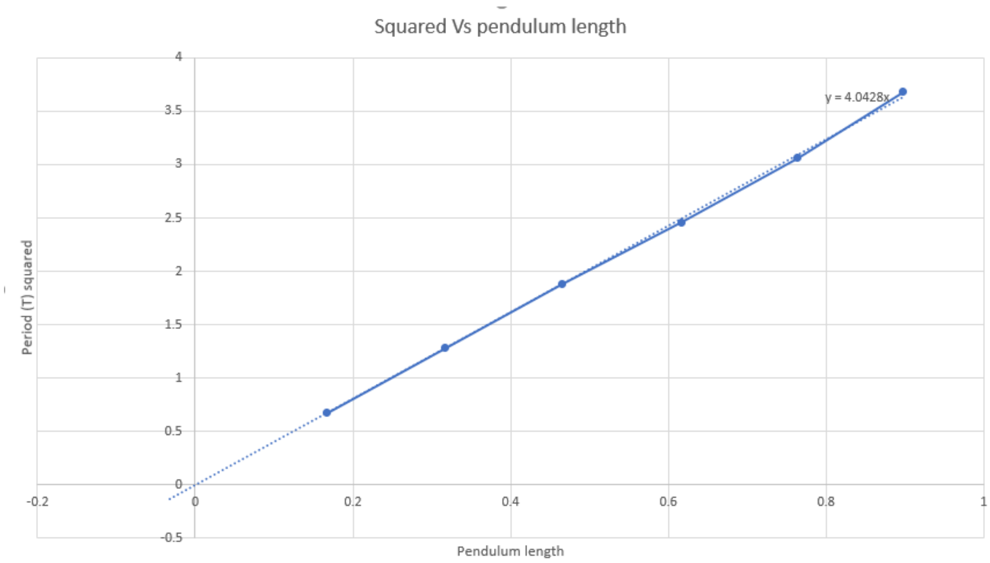
Produce a graph plot of T^2 vs. L

Results T vs. l			
Pendulum length (T) (m)	Time for 10 oscillations	Period T (s)	T^2

You can add an additional column for T^2/l



Example Plot of period (T^2) vs. pendulum length (l)



Example data with best fit imposed. In this case by Excel's trendline tool.

Why is it acceptable with this data to draw the best fit line through the origin (0/0)?

You can do a quick check of the data, the gradient of the line should be equal to,

$4\pi^2/g$ (4.023)

How far from the theoretical value is you data? Express this as a % error.

The gradient can be calculated as a set of spot values and averaged (any pair of T^2 and l values can be used), or more conventionally over the whole graph line.

$$gradient = \frac{T^2}{l}$$

The equation for the period of a simple pendulum is,

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

Squaring the equation to remove the root, we get,

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

From the practical we know T2, l and we know the constant 4pi, so we can re-arrange for g. Plug in our values from the practical and get an estimate for g.

Make g the subject of the equation

If we consider the accepted value for g as 9.81,

1. Find the % difference.
2. Analyse the data and practical to look for improvements.
3. Test the improvements by experimentation.