Christopher Whitehead Sixth Form

PHYSICS Summer Tasks

Making Most Sense of Graphs

Whenever you do an experiment, you will be looking for a relationship between two variables. Sometimes this relationship may be proportional (also called linear):

$$y \propto x$$

Sometimes inversely proportional:

$$y \propto \frac{1}{x}$$

Or proportional to some sort of power:

$$y \propto x^n$$

Or inversely proportional to some sort of power:

$$y \propto x^{-n} \quad \text{same as} \quad y \propto \frac{1}{x^n}$$

Where a relationship is known it is always possible to plot a graph which is a straight line, (of the form $y = mx + c$. This is a very useful tool for us because any graph of this sort will give us a clear gradient. The gradient may well contain information which we want.

An example:

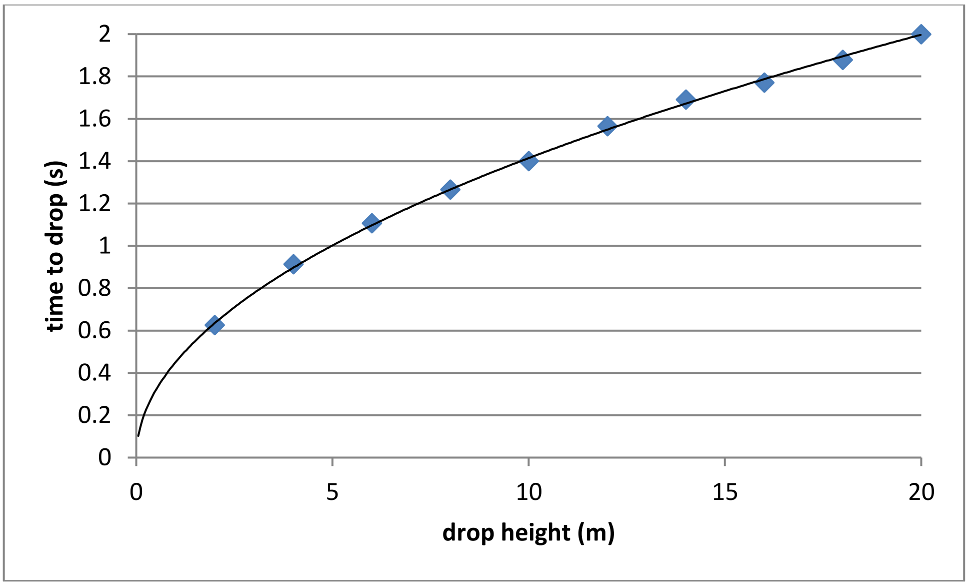
An experiment is done to try to find the acceleration due to gravity. The experimental method goes like this:

1. Drop a ball from 2.00 m and time how long it takes to hit the floor.
2. Repeat from 4.00m, 6.00 m all the way up to 20 m.
3. From your results determine the acceleration due to gravity.

Here are the results collected by a student:

Height of drop (m)	Time for drop (s)
2.00	0.63
4.00	0.91
6.00	1.12
8.00	1.26
10.00	1.40
12.00	1.56
14.00	1.69
16.00	1.77
18.00	1.88
20.00	2.00

If you were to plot this data with the distance fallen along the x axis and the time taken along the y axis you would get the following graph:



This graph, being not a straight line does not yield much in the way of useful information for us, HOWEVER, if we are cunning there is another way to present this data.

We know from the SUVAT equations that:

$$S = ut + \frac{1}{2}at^2$$

Where
S = displacement,
u = initial speed,
a = acceleration,
t = time.

As we know that acceleration = g and that the initial speed is zero we can re-write this as:

$$S = \frac{1}{2}gt^2$$

In other words, we know that in this case, the displacement (distance the ball has fallen) is not proportional to the time, but to the time squared. Thus we if we plot the displacement against time squared we should get a straight line graph of the form:

$$y = m\ x$$

Where

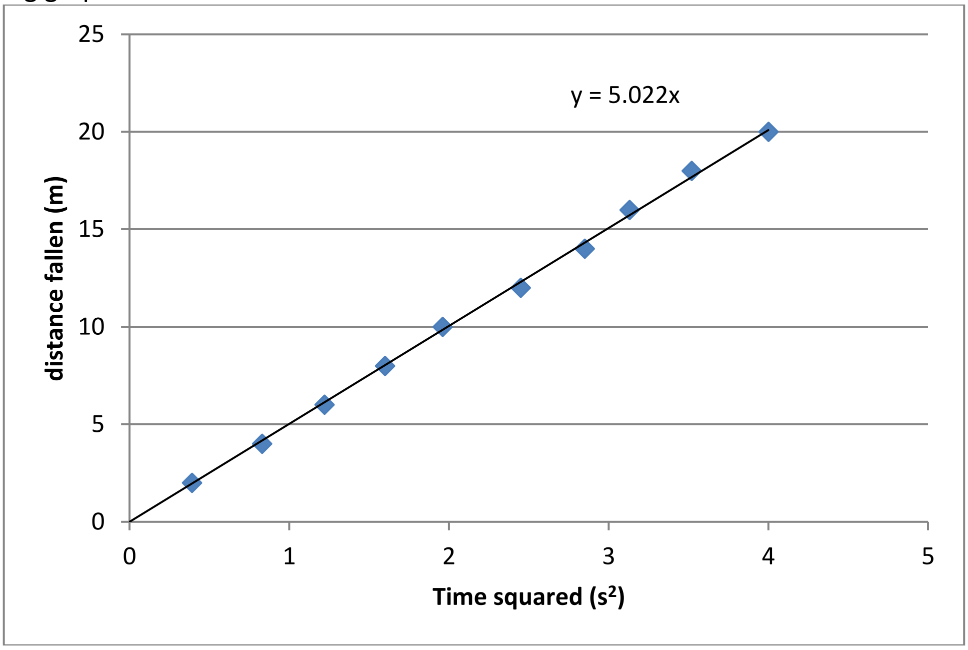
$$S = \frac{1}{2}g\ \ t^2$$

Therefore if we plot the graph with S on the x axis and t^2 on the y axis, the gradient of such a graph should be g/2.

We put these results into a new table and plot a graph which then gives us:

Height of drop (m)	Time for drop (s)	Time for drop squared (s^2)
2.00	0.63	0.39
4.00	0.91	0.83
6.00	1.12	1.22
8.00	1.26	1.60
10.00	1.40	1.96
12.00	1.56	2.45
14.00	1.69	2.85
16.00	1.77	3.13
18.00	1.88	3.52
20.00	2.00	4.00
Y axis		X axis

The resulting graph looks like this:



The gradient of this graph is 5.022 m/s^2.

However, we know that

$$gradient = \frac{g}{2}$$

Therefore

$$g = 2 \times gradient = 2 \times 5.022 = 10.044 m/s^2$$

The accepted value for g is 9.81 m/s^2. Based on this simple experiment, you can see that this is a pretty good approximation.

Questions

Braking Distance

A car undergoes a range of emergency stops at different speeds. The mass of the car is 1000 kg. The results of the car test are shown below.

Speed (m/s)	Distance (m)
8.89	6
13.33	14
17.78	24
22.22	38
26.67	54
31.11	75

On the assumption that all the kinetic energy of the car is lost as work is done by the breaks, we can assume that:

$$Initial\ KE\ of\ car = Total\ work\ done\ by\ breaks$$

Therefore

$$\frac{1}{2}mv^2 = F \times stoping\ distance$$

Or we can rewrite this is:

$$stopping\ distance = \frac{m}{2F}v^2$$

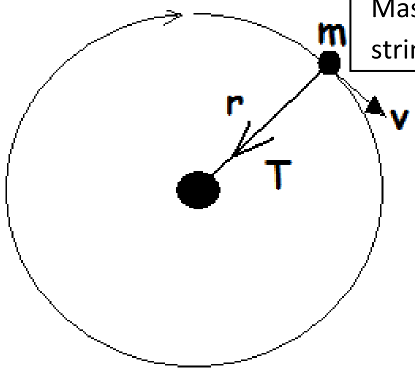
Plot a graph of speed squared against stopping distance and use the resulting graph to find the value of the braking force.

The bung on a String

An experiment was done to determine the force on a cable when it is swung in a circle with a mass on the end:

Mass of m on the end of the string, moving at a speed v.

Radius of circle r, with a tension in the cable of T to provide the centripetal force.



The mass on the end of the cable is unknown. The mass is whirled at a range of different speeds with a radius of 1.5 m, and the tension in the cable (T) is measured each time. Here are the results.

Velocity of the mass (m/s)	Tension in the cable (N)
0.5	0.83
1.0	3.33
1.5	7.5
2.0	13.3
2.5	20.83
3.0	30

It is known that the centripetal force for any object moving in a circle is given by:

$$F = \frac{mv^2}{r}$$

Plot a suitable graph to get a straight line and determine from the gradient what the mass of the object is.

A Sphere – Finding Pi

A computer program can, using laser measuring technology is able to find the diameter and volume of a ball. A range of balls are tested with this equipment. Here are the results:

Diameter (m)	Volume(m3)
0.2	0.004189
0.5	0.06545
1.1	0.69691
0.9	0.381704
1.6	2.144661
0.6	0.113097
0.8	0.268083
1.4	1.436755
1.3	1.150347
1	0.523599

Knowing that the volume of a sphere is given by the relationship:

$$V = \frac{4}{3}\pi r^3$$

Where V is the volume of the sphere and r is the radius of the sphere.

Plot a suitable graph which will give a straight line and use the gradient of the graph to find the value of pi.