Candidate 7 evidence (Measuring g)

The accleration due to gravity

Aim

The aim of this investigation is to measure the acceleration due to gravity of a falling object.

Underlying Physics

The force of gravity pulls every object down towards the centre of the Earth. The force of gravity on an object is called the weight of the object. All falling objects accelerate the same because bigger masses have a bigger weight but greater mass to pull. The scientist Galileo proved this by dropping cannon balls of different masses from the leaning tower of Pisa in Italy. The value I use to solve problems in class is $9.8 \, m s^{-2}$.
The acceleration due to gravity can be calculated using

$$g = \frac{G M_{earth}}{d^2} \quad (1)$$

G is the universal constant of gravitation
M_{earth} is the mass of the Earth
d is the radius of the Earth

In my first experiment I will use the equation $s = ut + \frac{1}{2}at^2$ to find g. When u is zero the equation becomes $a = \frac{2s}{t^2}$ so the gradient of a graph of 2s against t^2 is equal to g.

(1) http://www.physicsclassroom.com/class/circles/Lesson-3/The-Value-of-g

Description of Experiments

Expt. 1

I released a ball (metal) from a height and it hit a timing plate. The release mechanism and the timing plate were connected to a TSA set to gap time. The TSA displayed the time for the ball to fall. The height was measured using a metre stick. I repeated the experiment five times from different heights

Expt. 2

I dropped a double mask through a light gate. The light gate was connected to a TSA set to acceleration data. I dropped the mask lots of times but had to ignore some readings because they were way off the answer. I kept the height the mask fell about the same each time.

Expt. Data.

Expt. 1

Height (cm)	Time (s)
50.4	0.326
	0.329
	0.328
	0.324
	0.325

Height (cm)	Time (s)
70.2	0.387
	0.385
	0.388
	0.389
	0.391

Height (cm)	Time (s)
81.0	0.410
	0.398
	0.411
	0.411
	0.399

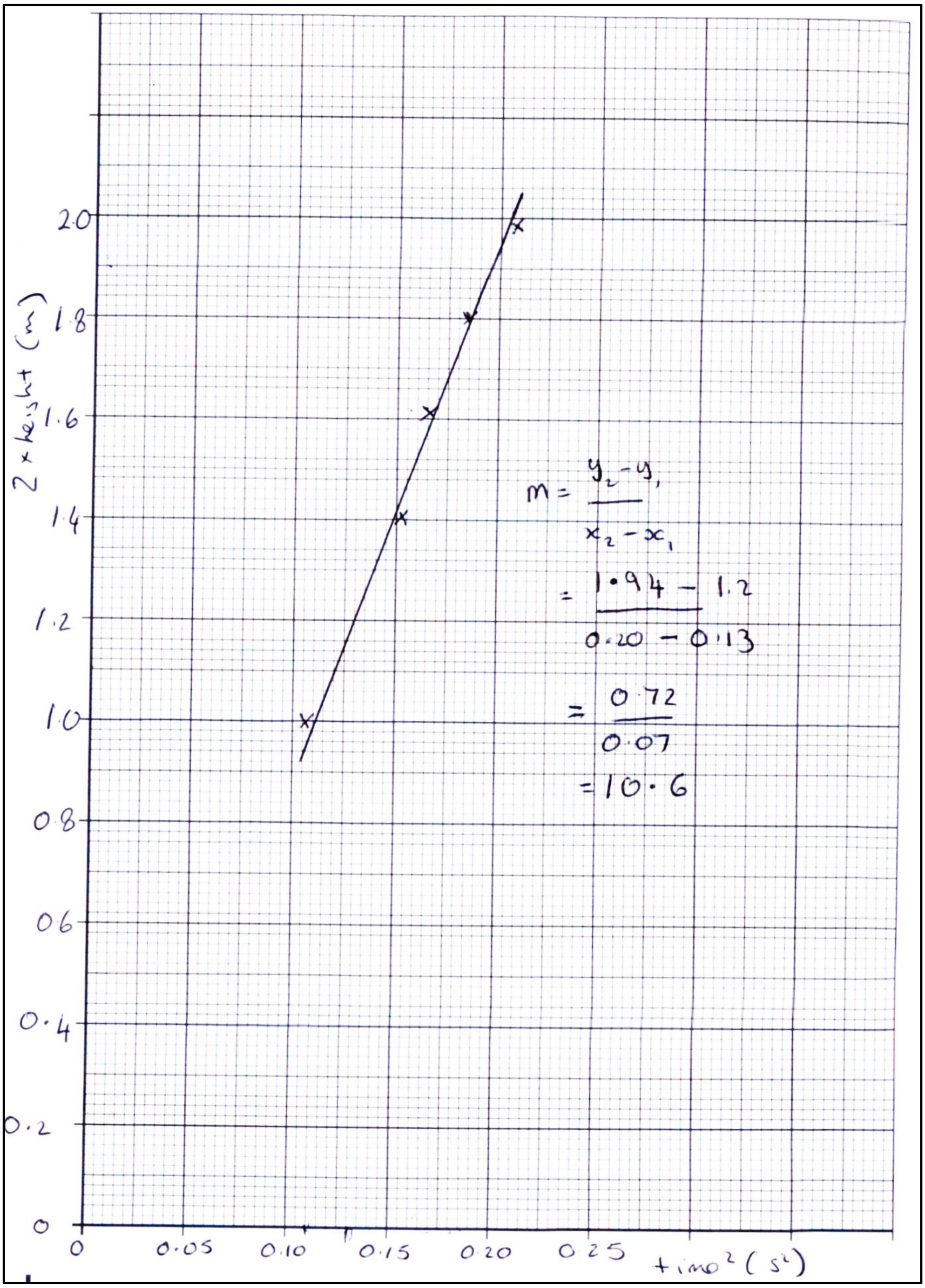
Height (cm)	Time (s)
90.3	0.428
	0.434
	0.438
	0.436
	0.436

Height (cm)	Time (s)
99.5	0.460
	0.449
	0.459
	0.454
	0.458

Height (m)	2×Height (m)	Average Time (s)	Average Time Squared (s^2)
0.504	1.008	0.326	0.106
0.702	1.404	0.388	0.151
0.810	1.62	0.406	0.165
0.903	1.806	0.434	0.188
0.995	1.99	0.456	0.208

~~readunc~~ reading uncertainty in height = ± 0.5 mm

reading uncertainty in time = ± 0.001 s


2 × height (m)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0
0.05
0.10
0.15
0.20
0.25
time² (s²)
m = y2 − y1 / x2 − x1
= 1.94 − 1.2 / 0.20 − 0.13
= 0.72 / 0.07
= 10.6

Expt. 2

Try	v_1	v_2	t	$a = \frac{v_2 - v_1}{t}$
1	1.59	2.11	0.051	10.02
2	1.53	2.04	0.052	9.81
3	1.64	2.15	0.054	9.44
4	1.49	2.05	0.057	9.822
5	1.57	2.08	0.053	9.62

average acceleration = 9.74 ms^{-2}
random uncertainty = 0.116 ms^{-2}

Analysis

The gradient of the graph from my first experiment was calculated using $m = \frac{y_2 - y_1}{x_2 - x_1}$

I selected points (0.13, 1.2) and (0.20, 1.94) on my best fit line and worked out that the gradient is 10.6. The points on my graph gave a very good straight line so I was surprised by this inaccurate value for g.

The results of my second experiment were all very different but when averaged give a better answer.

Conclusion

The first experiment gave a value of 10.6 ms^{-2} for g the acceleration due to gravity. The second experiment gave a value of 9.74 ms^{-2} for g.

Evaluation

I spent more time on the first experiment so I thought it would give a better value for g.
When I use a ruler and extend my line it does not go through the origin. If the height is zero then the time should also be zero. Maybe there was a systematic error in my experiment.
When I first attempted the second experiment I found that the mask sometimes missed the light gate or twisted as it fell. The best way to get good results was to drop the mask just above the light gate. Dropping the mask just above the light gate will reduce air resistance on the mask. It also seemed to matter which way the mask faced as it was dropped.