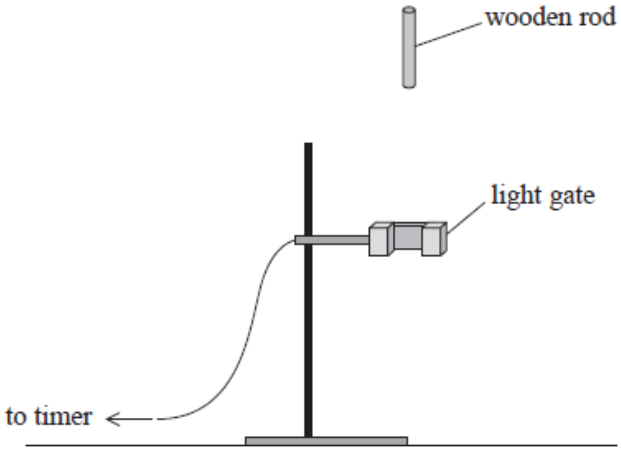
Questions

Q1.

A student carries out an experiment to determine a value for g, the acceleration of free fall. A short wooden rod is released above a light gate. A timer connected to the light gate is used to measure the time taken for the wooden rod to pass through the light gate.

The experimental arrangement is shown.



The student uses the equation $v^2 = u^2 + 2as$, where $u = 0$, and a graphical method to determine a value for g.

(a) State the additional measurements the student should take.

(2)

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(b) Describe how the velocity v of the wooden rod as it passes through the light gate can be determined accurately.

(2)

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(c) Describe how the student can determine a value for *g* using a graphical method.

(3)

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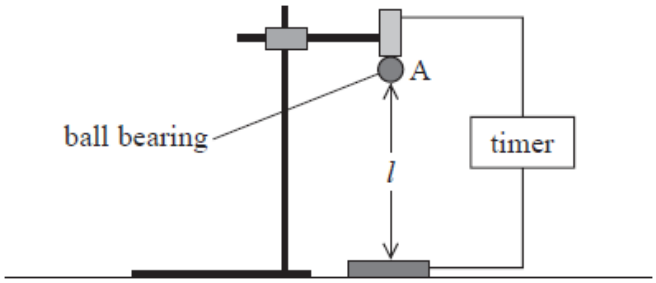
(Total for question = 7 marks)

Q2.

A student carried out an experiment to measure the acceleration of free-fall *g*.

A ball bearing was released from position A. The time *t* for the ball bearing to fall a distance *l* was measured. This was repeated for decreasing values of *l*.



Explain how the measurements obtained can be used to determine a value for *g* in m s^{-2}. Your answer should include a sketch on the axes below of the graph that the student would expect to obtain.

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(Total for question = 5 marks)

3)

Answer ALL questions in the spaces provided.

1 A student is carrying out an experiment to determine a value for the acceleration due to gravity g. He drops a ball from various heights, which he measured with a metre rule. The ball has a built in timer which starts when the ball is released and stops when the ball hits the ground.

The student starts by releasing the ball from a height of 1.00 m and measures the time taken for the ball to fall. He repeats this twice.

t_1 /s	t_2 /s	t_3 /s
0.45	0.51	0.43

(a) Use the student's data to calculate a value for g.

(3)

g = ...

(b) Estimate the percentage uncertainty in your value for g.

(3)

Percentage uncertainty = ...

(c) The student then measured the time interval for the ball to fall from a 3.00 m height. Explain how this would improve the value obtained for g.

(2)

(Total for Question 8 marks)

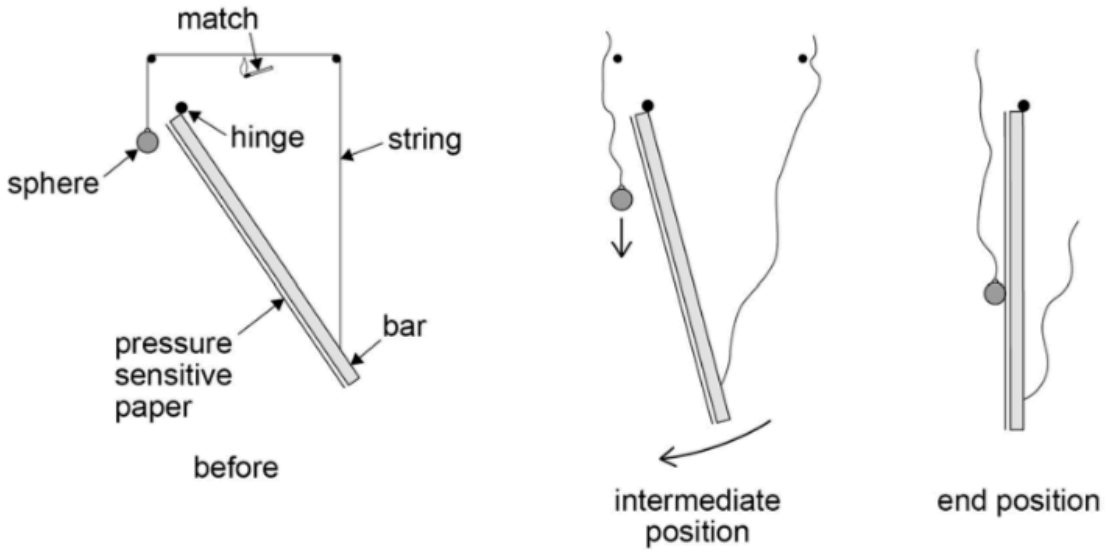
4)

This question is about measuring the acceleration of free fall g.

A student undertakes an experiment to measure the acceleration of free fall.

Figure 1 shows a steel sphere attached by a string to a steel bar. The bar is hinged at the top and acts as a pendulum. When the string is burnt through with a match, the sphere falls vertically from rest and the bar swings clockwise. As the bar reaches the vertical position, the sphere hits it and makes a mark on a sheet of pressure-sensitive paper that is attached to the bar.

Figure 1



The student needs to measure the distance d fallen by the sphere in the time t taken for the bar to reach the vertical position.

To measure d the student marks the initial position of the sphere on the paper. The student then measures the distance between the initial mark and the mark made by the sphere after falling.

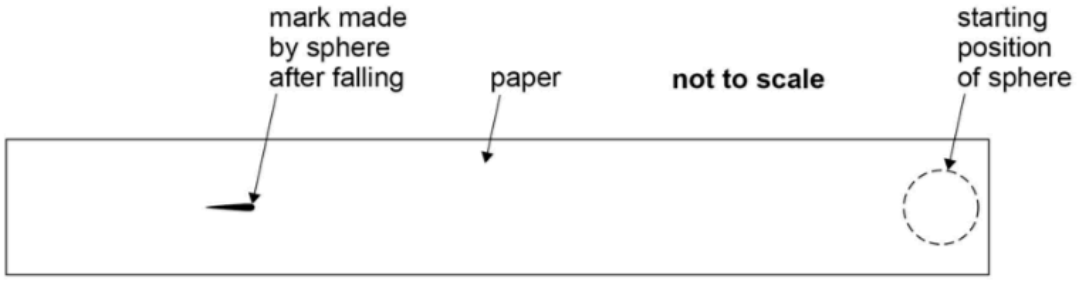
To measure t the student sets the bar swinging without the string attached and determines the time for the bar to swing through 10 small-angle oscillations.

1 **Figure 2** shows the strip of paper after it has been removed from the bar. The initial position of the sphere and the final mark are shown.

Mark on **Figure 2** the distance that the student should measure in order to determine d.

[1 mark]

Figure 2



2 The student repeats the procedure several times.

Data for the experiment is shown in **Table 1**.

Table 1

d / m
0.752
0.758
0.746
0.701
0.772
0.769

Time for bar to swing through 10 oscillations as measured by a stop clock = 15.7 s

Calculate the time for one oscillation and hence the time t for the bar to reach the vertical position.

[1 mark]

time _____ s

. **3** Determine the percentage uncertainty in the time t suggested by the precision of the recorded data.

[2 marks]

uncertainty = _____ %

. **4** Use the data from **Table 1** to calculate a value for d.

[2 marks]

d = _____ m

. **5** Calculate the absolute uncertainty in your value of d.

[1 mark]

uncertainty = _____ m

. **6** Determine a value for g and the absolute uncertainty in g.

[3 marks]

g = _____ m s^{-2}

uncertainty = _____ m s^{-2}

. 7 Discuss **one** change that could be made to reduce the uncertainty in the experiment.

[2 marks]

. 8 The student modifies the experiment by progressively shortening the bar so that the time for an oscillation becomes shorter. The student collects data of distance fallen s and corresponding times t over a range of times.

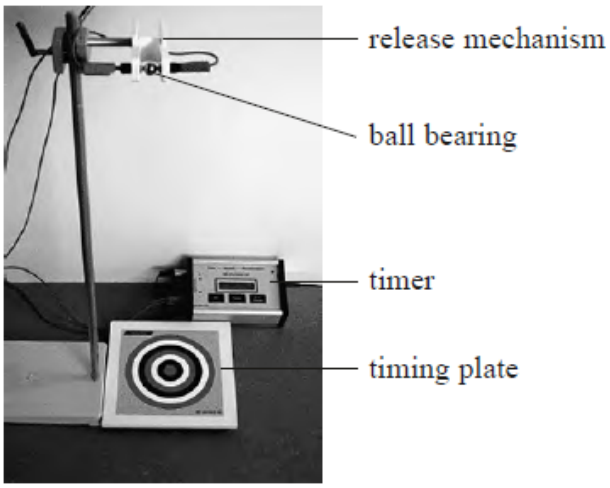
Suggest, giving a clear explanation, how these data should be analysed to obtain a value for g.

[3 marks]

Q5.

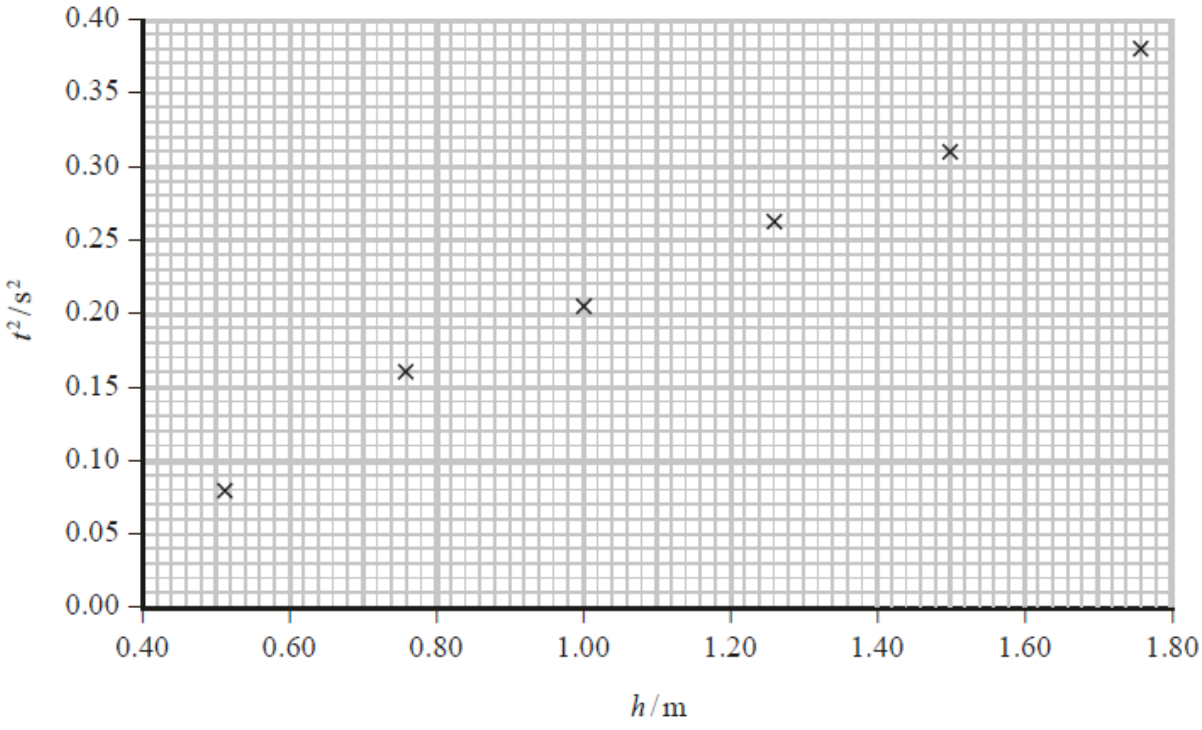
A student carried out an experiment to determine the acceleration of free-fall *g* using the apparatus shown in the photograph.

A ball bearing was released from a measured height *h* and a timer automatically started. On hitting a timing plate, the ball bearing stopped the timer and the time *t* was displayed on the timer. This was repeated for different values of *h*.



The uncertainty in *t* was ± 3%. The uncertainty in *h* was ± 1%.

The student plotted a graph of t^2 against *h* and used it to determine a value for *g*.



The student concluded that her value for *g* was consistent with the accepted value.

Comment on the student's conclusion. Your answer should include a calculation of g from the student's data.

You may assume that the percentage uncertainty in your value of g is the same as if the value were calculated from just one pair of readings.

(5)

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(Total for question = 5 marks)

6 This question is about the article *Measuring g by freefall*.

A student carries out an experiment to measure *g* in the classroom using the equipment described in the article and shown in Fig. 13.1.

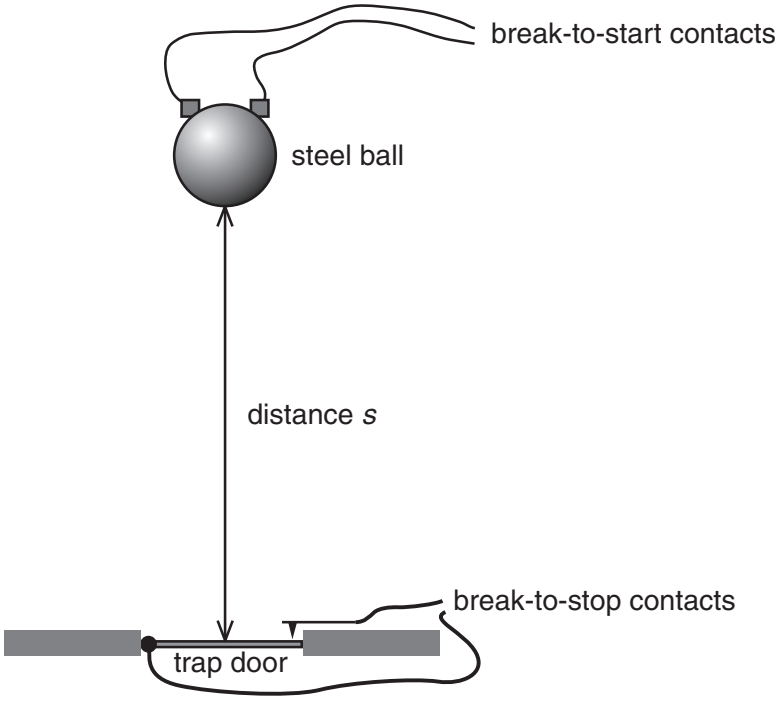


Fig. 13.1

She sets up the equipment and judges the uncertainty in the two measurements. The timing device measures to within 0.01 s and the distance *s* is measured to within 0.01 m.

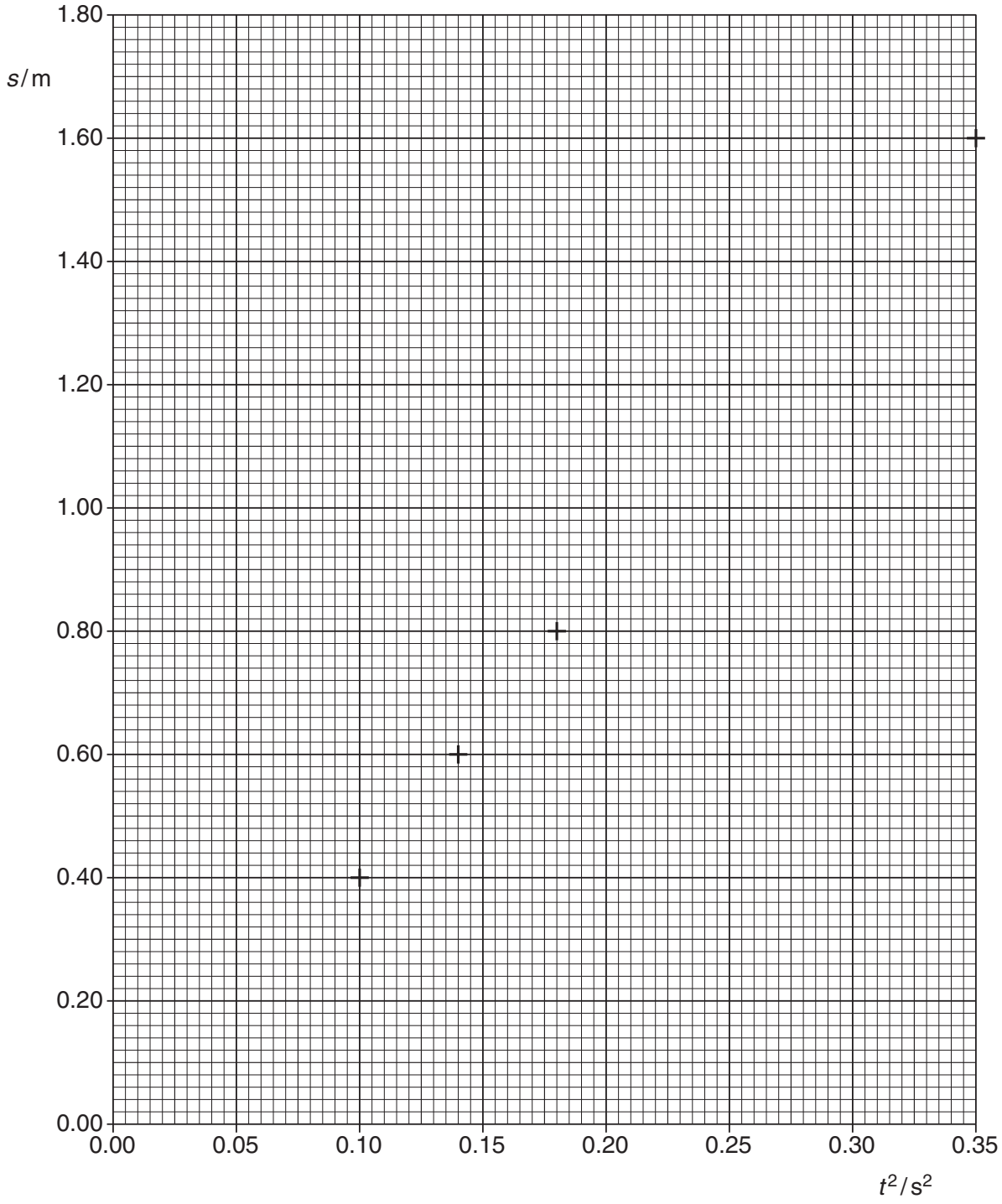
(a) The student records the following data for a range of distances, averaging the time *t* at each distance *s* over several drops. She intends to plot a graph of *s* against t^2.

(i) Complete the table.

***s*/m**	**mean *t*/s**	**t^2/s^2**
0.40	0.31	0.10
0.60	0.38	0.14
0.80	0.42	0.18
1.00	0.47	
1.20	0.51	
1.40	0.55	
1.60	0.59	0.35

[2]

(ii) Using your values from the table, complete the graph of *s* against t^2 opposite and draw a straight line of best fit.



[3]

(b) (i) Explain why the equation $s = ut + \frac{1}{2}at^2$ would lead you to expect the graph to go through the origin.

[2]

(ii) Calculate the gradient of the graph.
Show your working clearly on the graph or in this space.

gradient = ... **[2]**

(iii) Use your answer to **(ii)** to obtain a value for the acceleration due to gravity, *g*.

g = ... unit .....**[2]**

(c) (i) The graph does not pass through the origin. Suggest one way in which this may have come about, and what effect it would have on the recorded values.

[2]

(ii) Explain whether this source of systematic error would affect the value of *g* obtained as in **(b)(iii)**.

[2]

[Total: 15]

7 A student performs an experiment to find the acceleration due to gravity. The student measures the time t for a spherical object to fall freely through measured vertical distances s. The time is measured electronically. The results are shown in the table below.

s/m	t_1/s	t_2/s	t_3/s	**mean time** t_m/s	t_m^2/s^2
0.300	0.245	0.246	0.244	0.245	0.0600
0.400	0.285	0.286	0.286	0.286	0.0818
0.500	0.319	0.321	0.318	0.319	0.102
0.600	0.349	0.351	0.348	0.349	0.122
0.700	0.378	0.380	0.378	0.379	0.144
0.800	0.403	0.406	0.404		
0.900	0.428	0.428	0.430		

(a) Complete the table by entering the missing values for t_m and t_m^2

(1)

(b) Complete the graph below by plotting the remaining two points and draw a line of best fit.

(2)

(c) Determine the gradient of the graph.

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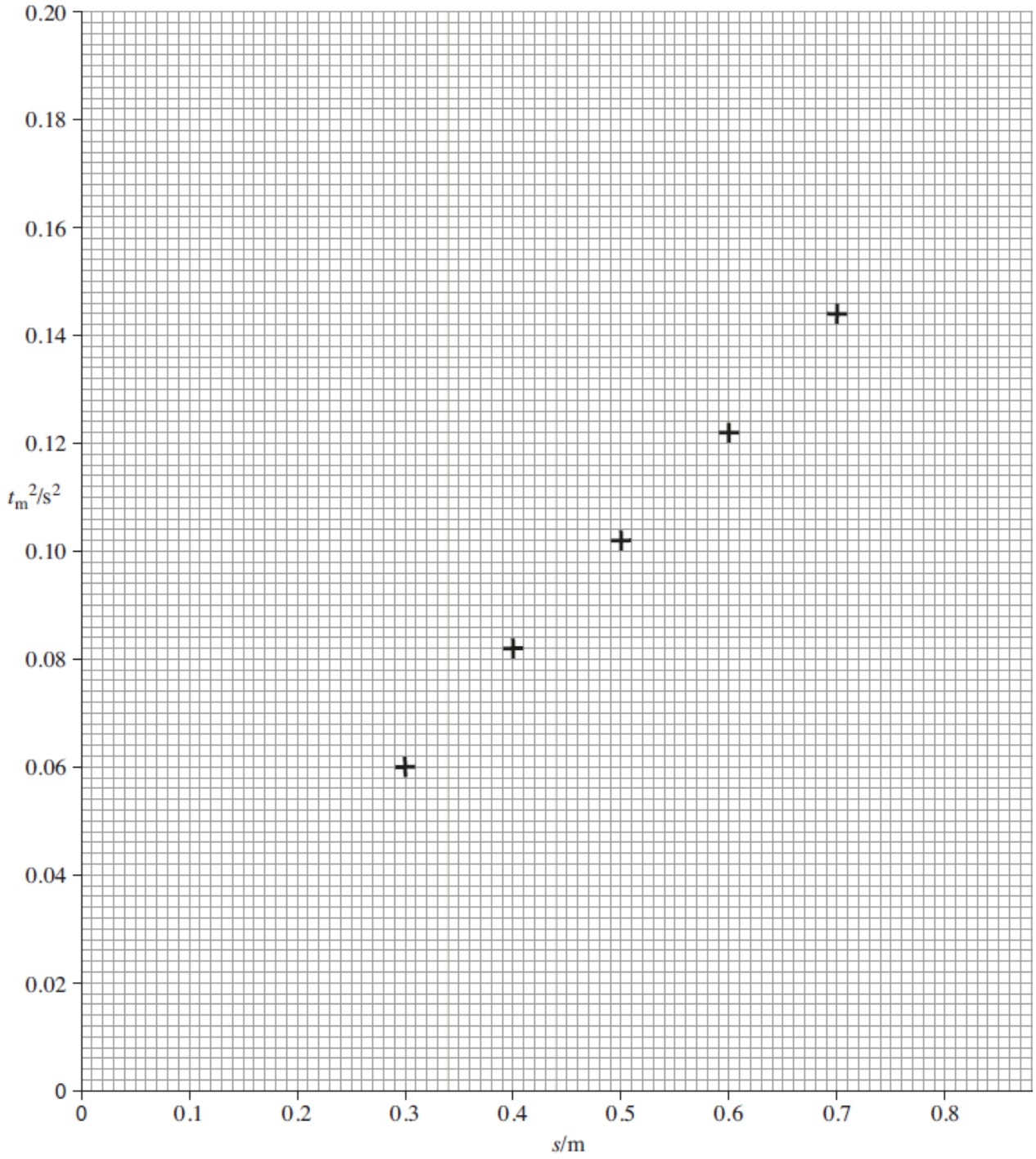
(3)


0.20
0.18
0.16
0.14
0.12
t_m^2/s^2
0.10
0.08
0.06
0.04
0.02
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
s/m

(d) Theory suggests that the equation for the line is $t^2 = \frac{2s}{g}$ where g is the acceleration due to gravity.

Calculate a value for g using the above equation and the gradient of your graph above.

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(1)

(e) Calculate the percentage difference between your value for g and the accepted value of 9.81 m s $^{-2}$.

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(1)

(f) Calculate the uncertainty in the smallest value of t_m.

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(1)

(g) Calculate the value of g which would be given from the smallest value of t_m and the corresponding value of s.

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(3)

(h) The uncertainty in each value of s is ± 0.001 m.

Calculate the uncertainty in the value of g you calculated in part **(g)**.

You will need to use the uncertainty for t_m you calculated in part **(f)**.

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(3)

(i) A student wishes to investigate the effect of changing the mass of the spherical object on the acceleration of free fall.

Explain how you would modify the experiment seen at the start of this question.

(3)

(Total 18 marks)

8

An experiment is carried out to investigate how the time *t* for a steel ball to fall through air varies with the height *h* through which it falls.

The equipment is set up as shown in Fig. 2.1.

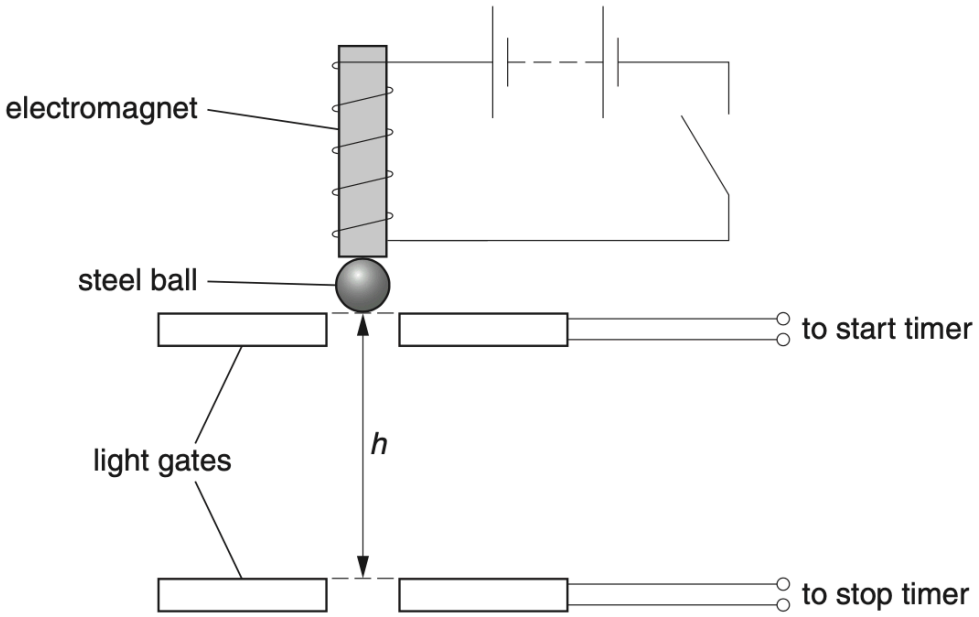


Fig. 2.1

An electromagnet is used to release the ball. As soon as the ball is released, it passes a light gate, which starts a timer. As the ball passes the lower light gate, the timer is stopped.

It is suggested that t and h are related by the equation

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

where g is the acceleration of free fall.

(a) A graph is plotted with t^2 on the y-axis and h on the x-axis. Express the gradient in terms of g.

gradient = ... [1]

(b) Values of h and t are given in Fig. 2.2.

h/m	t/s	
0.60	0.35 ± 0.01	
0.75	0.39 ± 0.01	
0.90	0.43 ± 0.01	
1.00	0.45 ± 0.01	
1.15	0.49 ± 0.01	
1.30	0.52 ± 0.01	

Fig. 2.2

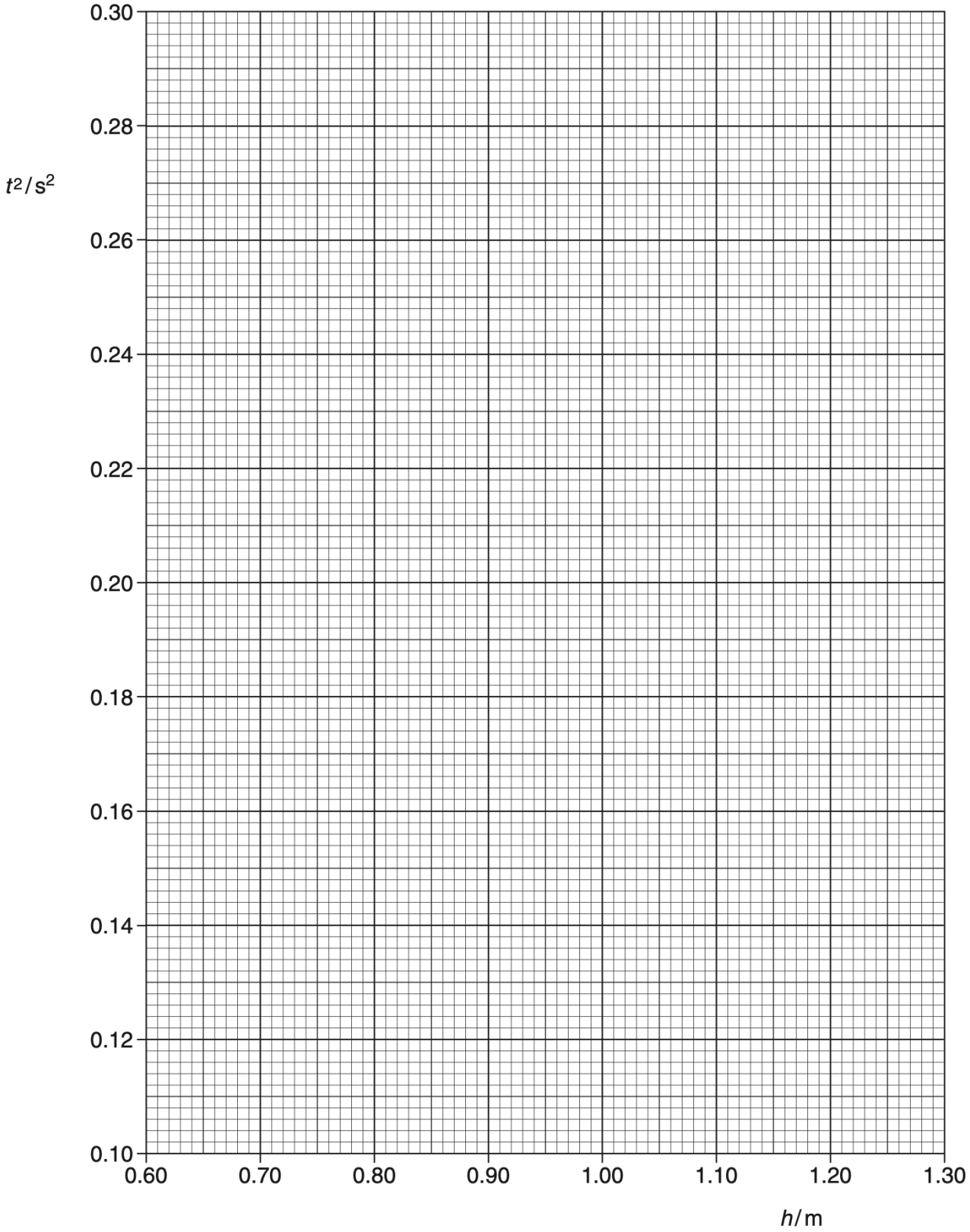
Calculate and record values of t^2 in Fig. 2.2. Include the absolute uncertainties. [3]

(c) **(i)** Plot a graph of t^2/s^2 against h/m. Include error bars for t^2. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient = ... [2]


0.30
0.28
t^2/s^2
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
h/m

(d) Using your answer to **(c)(iii)**, determine the value of g. Include the absolute uncertainty in your value and an appropriate unit.

g = ... [3]

(e) The experiment is repeated from the top of a building.

(i) The time taken for the steel ball to fall is 2.21 ± 0.01 s. Using your value of g, calculate the height b of the building.

b = ... m [1]

(ii) Determine the percentage uncertainty in b.

percentage uncertainty = ... % [1]