Chapter 8 Past Paper Question Booklet Three (H157)

8.1 Graphs of Motion
8.2 Vectors
8.3 Modelling Motion
8.4 Kinematic Equations

Describe and explain:
(i) the use of vectors to represent displacement, velocity and acceleration
(ii) measurement of displacement, velocity and acceleration

Make appropriate use of:
(i) the terms: displacement, speed, velocity, acceleration, vector, scalar

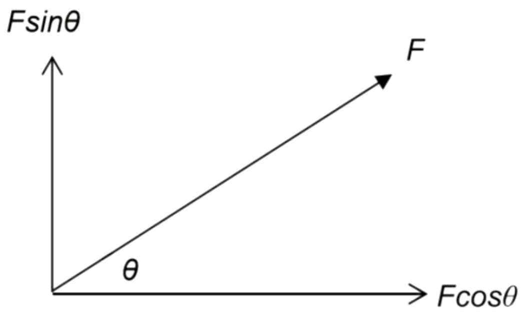
by sketching and interpreting:
(ii) graphs of accelerated motion; slope of s-t and v-t graphs, area underneath the line of a v-t graph
(iii) graphical representation of addition of vectors and changes in vector magnitude and direction

Make calculations and estimates involving:
(i) the resolution of a vector into two components at right angles to each other
(ii) the addition of two vectors, graphically and algebraically (two perpendicular vectors only)
(iii) the equations for constant acceleration derivable from: a = (v-u)/t and average velocity = (v+u)/2

$$v = u + at \qquad s = ut + ½at^2 \qquad v^2 = u^2 + 2as$$

(iv) modelling changes of displacement and velocity in small discrete time steps, using a computational model or graphical representation of displacement and velocity vectors. (constant force only).

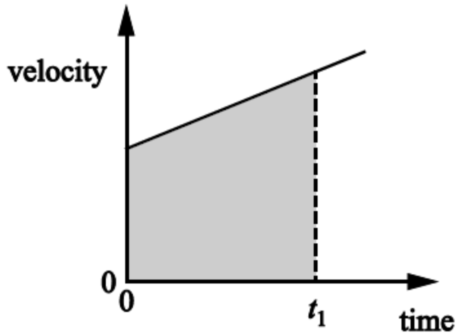
components of a vector in two perpendicular directions



equations for uniformly accelerated motion

$$s = ut + \tfrac{1}{2}at^2$$
$$v = u + at$$
$$v^2 = u^2 + 2as$$

15 Here is a velocity–time graph.



Which statement/s about the graph is/are correct?

1 The gradient represents acceleration.

2 The shaded area represents the change of displacement from time = 0 to time = t_1.

3 The graph shows that velocity is proportional to distance.

A 1, 2 and 3

B Only 1 and 2

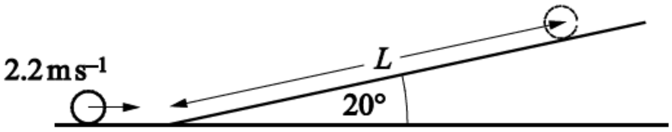
C Only 2 and 3

D Only 1

Your answer ☐

[1]

16 A ball rolls up a ramp which is at angle of 20° to the horizontal. The speed of the ball at the bottom of the ramp is 2.2 m s^{-1}. L is the distance the ball moves along the ramp before coming to rest.



What is distance L? Ignore the effects of friction and rotation in your answer.

A 0.25 m

B 0.26 m

C 0.68 m

D 0.72 m

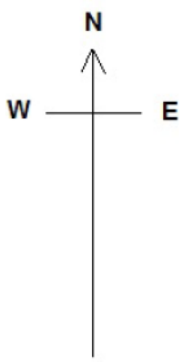
Your answer ☐

[1]

21 In still air an aircraft flies at 200 m s^{-1}. The aircraft is heading due north in still air when it flies into a steady wind of 50 m s^{-1} blowing from the west.

(a) Calculate the magnitude and direction of the resultant velocity by sketching a vector diagram to show the new resultant velocity of the aircraft by the addition of vectors.

Label the resultant velocity clearly.



magnitude = ………………….. m s^{-1} direction = ……………….. ° **[3]**

(b) The pilot now heads slightly to the west of north with the same speed setting of 200 m s^{-1} in order to regain his original northerly direction.

Calculate the magnitude of his new northerly velocity.

magnitude = ……………….. m s^{-1} **[1]**

1 A teacher uses strobe photography to demonstrate the motion of a tennis ball thrown under gravity. She opens the camera shutter in a darkened room and throws the tennis ball in front of the lens as the strobe flashes at 20 ± 2 Hz. **Fig. 1** shows the result, superimposed on a metric grid.

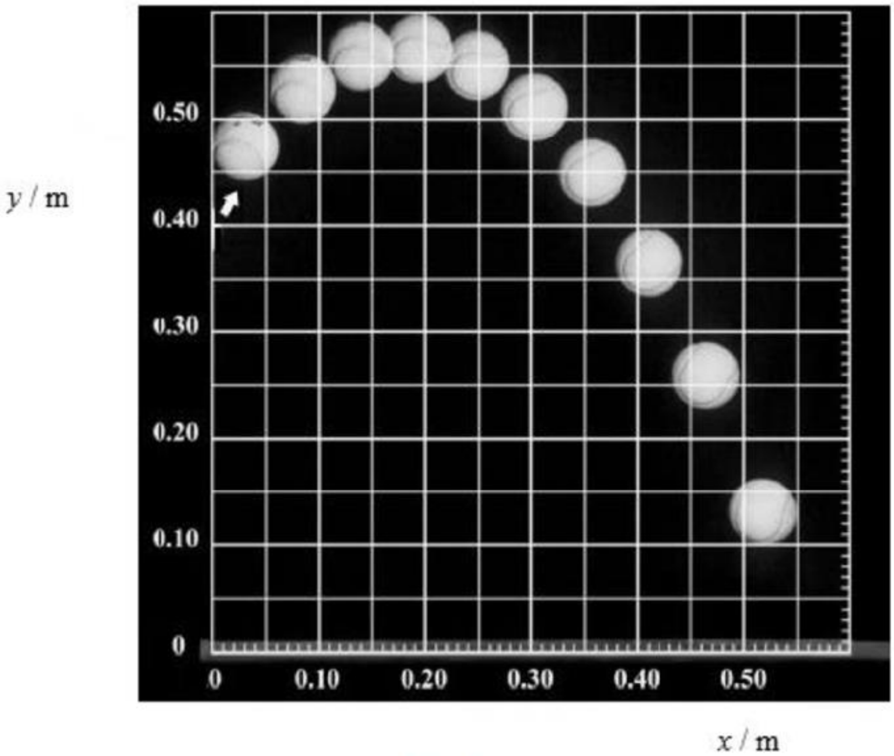


Fig. 1

A student takes measurements of the *y* position from **Fig. 1**, starting from the image centred on $x = 0.20$ m. He measures the *y* positions from the bottom of the ball and performs calculations; some are recorded in the table below. He concludes that *g*, the acceleration of gravity, is 9.2 ± 0.4 m s^{-2}.

t / s ± 10%	y / m ± 0.005 m	Δy / m	$\Delta y/\Delta t$ / m s^{-1}	Δv / m s^{-1}	$\Delta v/\Delta t$ / m s^{-2}
0	0.54				
0.05	0.52	0.02	0.40		
0.10	0.48	0.04	0.80	0.40	
0.15	0.42	0.06	1.20	0.40	
0.20	0.33	0.09	1.80		
0.25	0.22	0.11	2.20		
0.30	0.10	0.12	2.40		

(a) **(i)** Record further values in the spaces provided to complete the data in the table.

[2]

(ii) Complete your own analysis of the data by calculating the mean value for *g* with an estimate of its uncertainty.

g = …………….. ± …………….. m s^{-2} **[2]**

(iii) You are planning to improve the accuracy of this experiment to estimate *g*. Suggest and explain which of the measured quantities is most worth improving to achieve this.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………………………………………… **[2]**

(b) **(i)*** It is suggested that the horizontal velocity component of the motion is constant at 1.0 m s^{-1}.
Test this hypothesis, making your method clear. Explain your judgement and conclusion.

You may wish to use the table provided to record values taken from **Fig. 1**.

[6]

(ii) The teacher states that the vertical and horizontal components of the motion shown illustrate Newton's first two laws of motion.

Explain how the two components of the motion could illustrate these laws of motion.

....

....

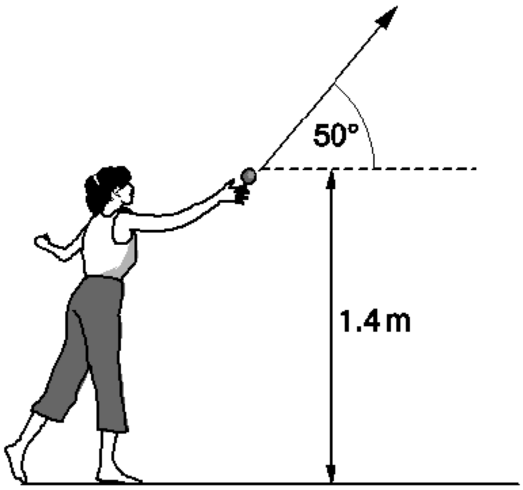
....

....

....

.... **[2]**

19 A ball is thrown at an angle of 50° from a height of 1.4 m with an initial velocity of 15 m s^{-1}.
What is the maximum height reached by the ball?



A 3.3 m

B 4.7 m

C 6.7 m

D 8.1 m

Your answer ☐

[1]

23 A car accelerates from rest to a speed of 20 m s^{-1} as shown in Fig. 23.

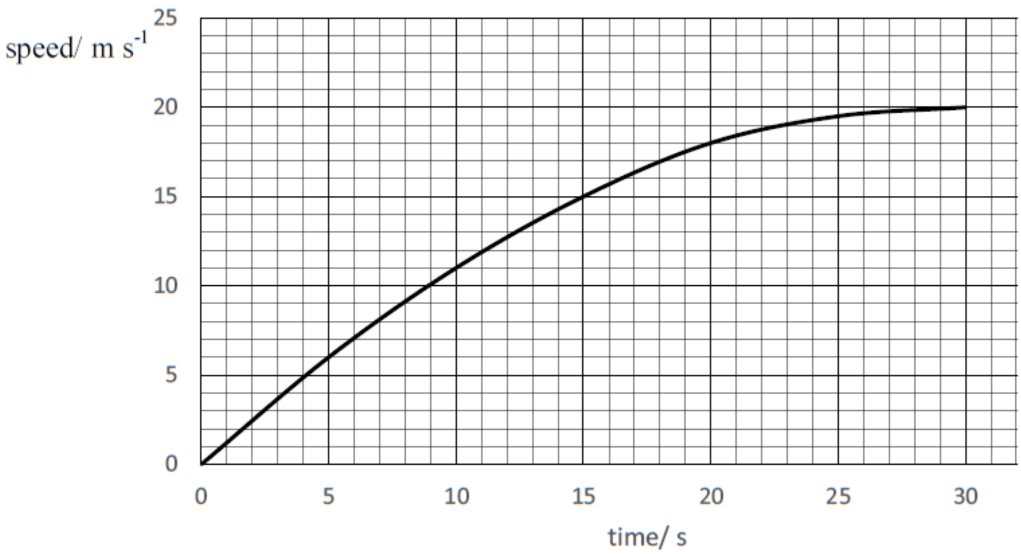


Fig. 23

(a) Calculate the average acceleration of the car in the first 30 s of the journey.

acceleration = ... m s^{-2} **[2]**

(b) Use the graph to find the distance travelled by the car in the first 30 s of the journey. Make your method clear.

distance travelled = ...m **[2]**

29 This question is about measuring the acceleration of a ball rolling down a ramp.

Fig. 29.1 shows the experimental arrangement.

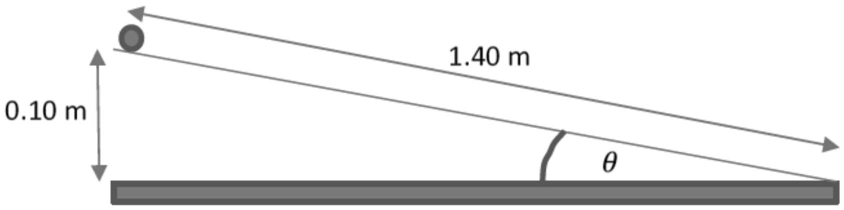


Fig. 29.1 (not to scale)

(a) Show that the angle θ is about 4°.

[1]

(b) Students film the ball rolling down the ramp from rest and obtain the results shown on the graph in Fig. 29.2.

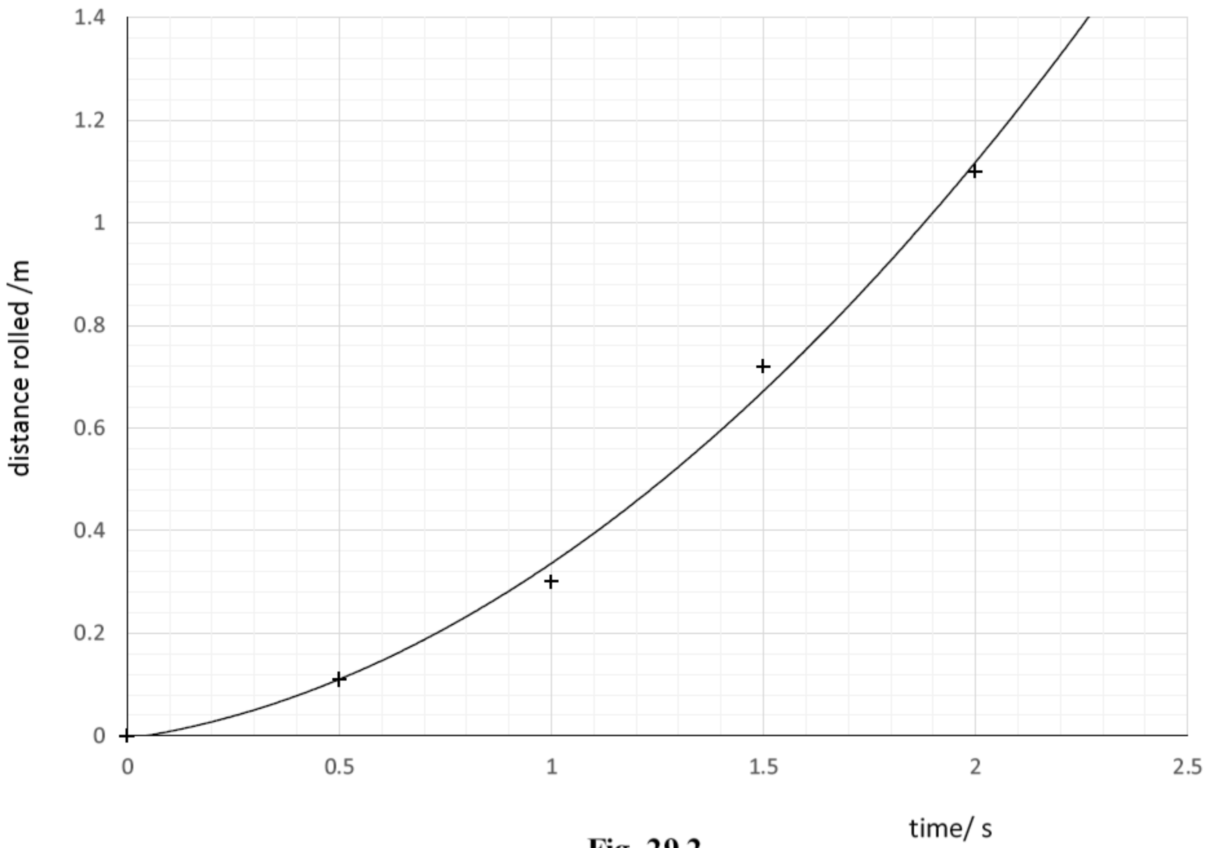


Fig. 29.2

From the graph find the velocity of the ball at 1.0 s and 2.0 s. Show your method clearly.
Use these results to calculate the acceleration of the ball.

velocity at 1.0 s = ………………….. m s^{-1}

velocity at 2.0 s = …………………… m s^{-1}

acceleration = …………………… m s^{-2}

[4]

(c) (i) Show that the component of the gravitational field strength, *g,* acting parallel to the slope, is about 0. 7 N kg^{-1}.

[2]

(ii) Use this value to calculate the time taken for the ball to roll 1.4 m down the slope from rest.

time = …………………………… s

[2]

2 A teacher sets up a demonstration represented in Fig.2. A ball-bearing is released from rest at the top of the curved track. After leaving the track it accelerates under gravity until striking the ground at horizontal distance *s* from the end of the track.

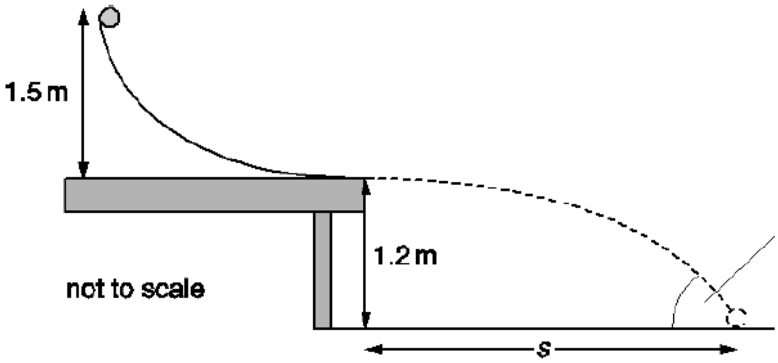


Fig. 2

(a) Show that the horizontal velocity of the ball-bearing as it leaves the track is about 5 m s^{-1}.
Assume that all the gravitational potential energy at the top of the track is transferred to translational kinetic energy at the bottom of the track.

[2]

(b) **(i)** Calculate the time the ball is in the air.

time = ……………… s **[2]**

(ii) Use your answer to **(i)** to calculate the horizontal distance, *s*, the ball travels before hitting the ground.

distance = …………………… m **[1]**

(c) The vertical velocity of the ball when it strikes the ground is 4.8 m s^{-1}. By considering the horizontal and vertical components, calculate the velocity at which the ball strikes the ground.

magnitude of velocity = ………………..m s^{-1}

angle to horizontal θ = …………………..°

[3]

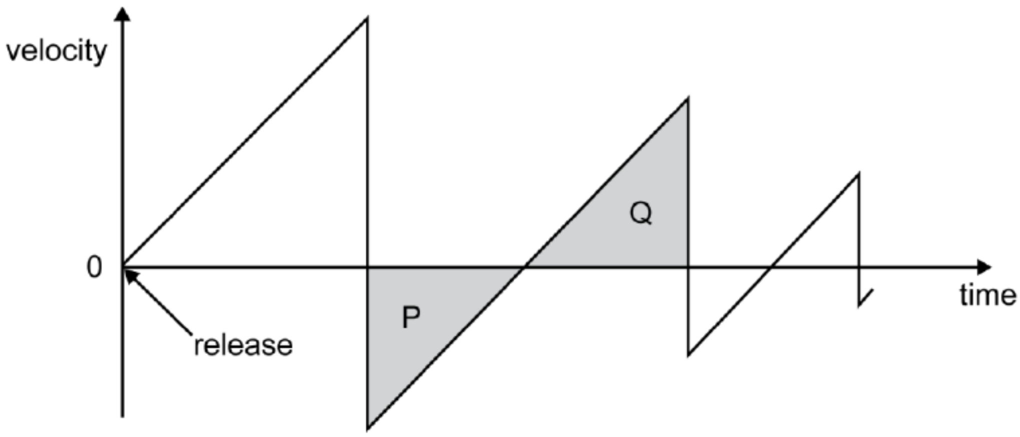
1 Which pair contains one vector and one scalar quantity?

A	velocity	acceleration
B	distance	force
C	kinetic energy	power
D	momentum	displacement

Your answer ☐

[1]

17 A ball is released from rest above a horizontal surface and bounces.
The graph shows how the velocity of the ball varies with time.



Which statement best explains why areas **P** and **Q** equal?

A The ball's acceleration is constant between bounces.

B At each bounce the ball loses a fraction of its kinetic energy.

C The ball rises and falls through the same distance between bounces.

D After a bounce the ball leaves the surface with the same speed at which it hits the surface for the next bounce.

Your answer ☐

[1]

35 In still water a boat can travel at 6.0 m s^{-1}. A river flows steadily at 2.0 m s^{-1}.
The boat must cross the river perpendicular to the banks as shown in **Fig. 35.1**.

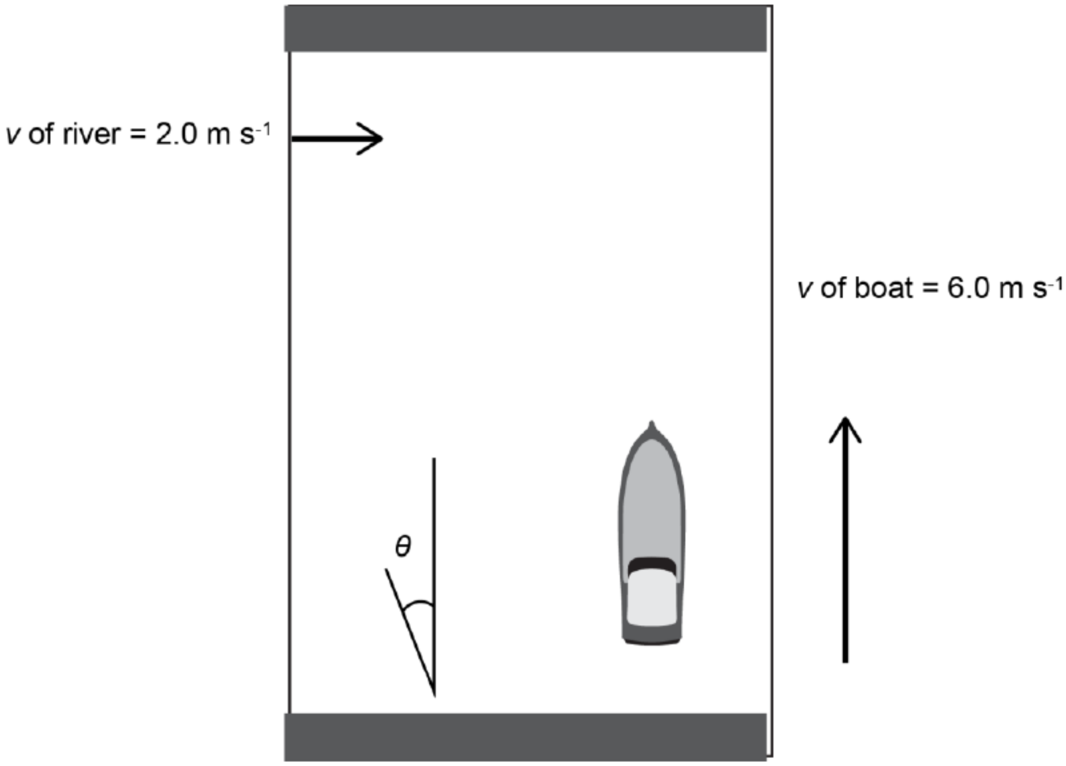


Fig 35.1

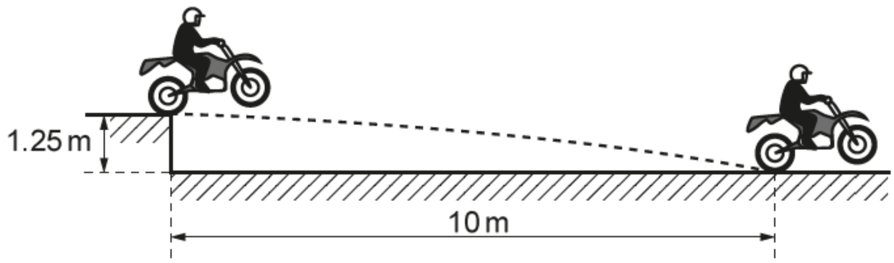
(a) Calculate the angle θ at which the boat should be steered to cross perpendicular to the banks.
Make your method clear.

θ = ... ° **[2]**

(b) Calculate the magnitude of the velocity perpendicular to the banks.

magnitude of perpendicular velocity = ... m s^{-1} **[1]**

11 A motorbike launches horizontally from a point 1.25 m above ground, and lands 10 m away as shown.



What was the speed at launch?

A $5\,m\,s^{-1}$

B $10\,m\,s^{-1}$

C $15\,m\,s^{-1}$

D $20\,m\,s^{-1}$

Your answer

[1]

12 A motorist travelling at $10\,m\,s^{-1}$ brings her car to rest in a braking distance of 10 m.

In what braking distance could she bring the car to rest from an initial speed of $40\,m\,s^{-1}$ using the same braking force under the same road conditions?

A 20 m

B 40 m

C 80 m

D 160 m

Your answer

[1]

5 Fig. 5.1 shows an experimental set-up which can be used to determine *g*.

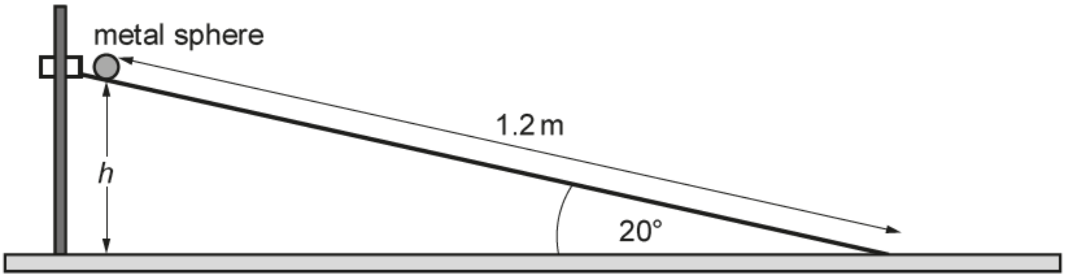


Fig. 5.1

(a)* The metal ball was filmed as it was released and travelled down the slope. The time for the ball to travel down the slope was found using stop-frame analysis.

The time was recorded as 1.1 s +/− 0.05 s.

Calculate the acceleration of the ball. Use the data given in the diagram to help explain why a student expected the journey time to be 0.85 s and suggest why the measured time was considerably longer.

[6]

(b) Fig. 5.2 shows a slope of the same length and starting height *h*. The initial gradient of the slope is greater than in the first case.

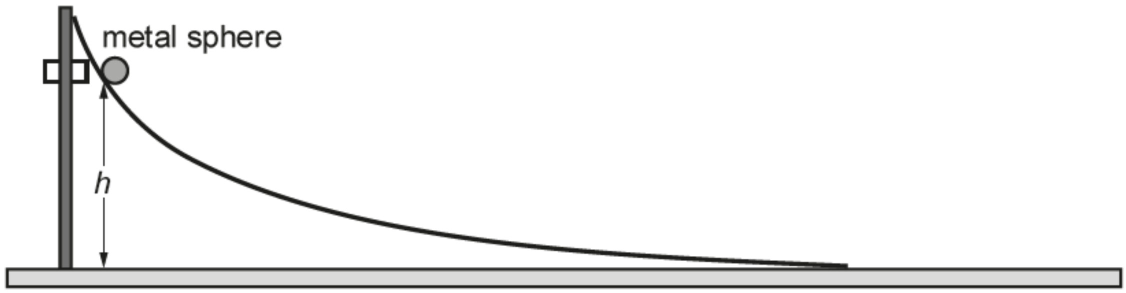


Fig. 5.2

A student says that she expects the ball to reach the end of the slope in less time **and** with greater final speed. Do you agree? Explain your reasoning and state any assumptions you have made.

....

....

....

....

....

....

....

....

....

....

.... **[5]**

2 This question is about investigating the terminal velocity of paper cupcake cases.

A paper cupcake case is dropped from a height of 2.0 m and the time taken t to fall to the ground is recorded using a stopwatch.

Fig. 2.1 shows a dot-plot recording the values obtained for t.

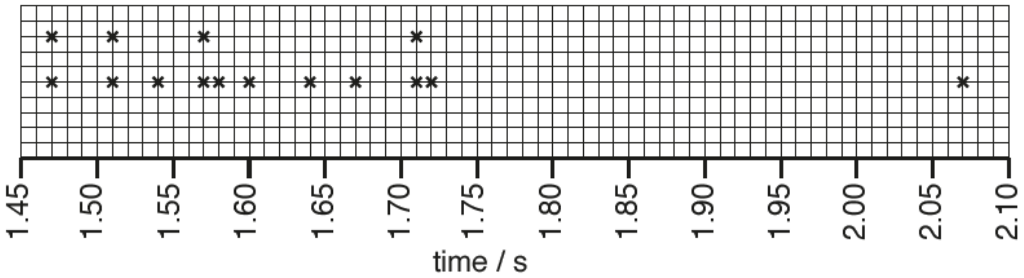


Fig. 2.1

(a) Suggest a practical reason for the outlying result of 2.07 s.

....

....

....

.... **[1]**

(b) Fig. 2.2 shows a sketch graph of velocity against time for the cupcake case.

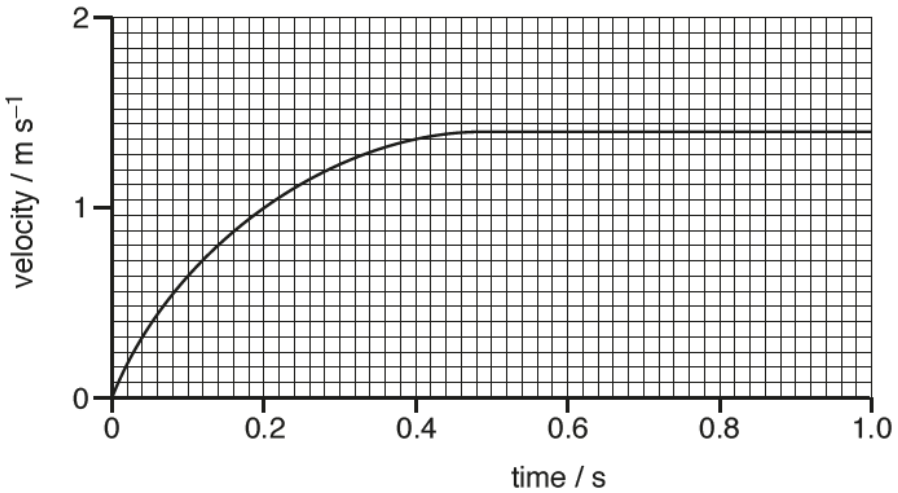


Fig. 2.2

(i) Explain the shape of the graph. Refer to the forces acting on the cupcake case in your answer.

....

....

....

....

....

....

....

....

....

....

.... **[4]**

(ii) The mass of the cupcake case is changed by inserting a second case inside the first. Draw a second graph on Fig. 2.2 showing how the velocity of the cupcake cases changes with time. **[2]**

(iii)* A student wishes to investigate how the mass of the cupcake case affects the size of the terminal velocity reached. Describe practical **methods** to find the terminal velocity reached by the cupcake case using standard school laboratory equipment. Include the measurements taken and the calculations required to determine the terminal velocity as well as ways to reduce any sources of uncertainty.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

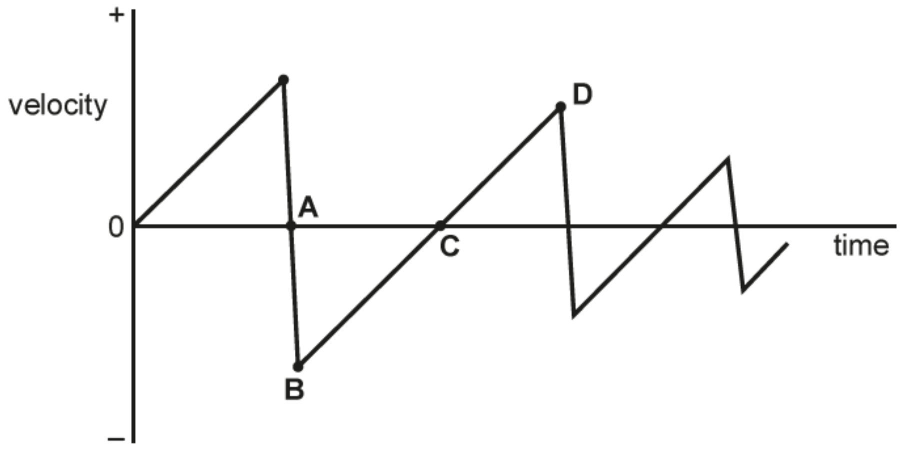
....

....

.... **[6]**

10 A golf ball is dropped from rest onto a hard floor.
The graph shows how the velocity of the ball varies with time as it bounces, from the time of release.

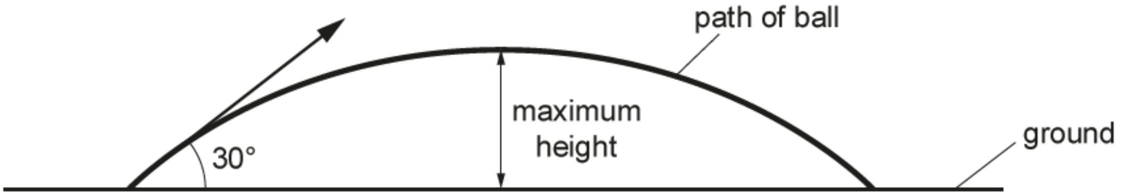
At which point does the ball reach its maximum height after the first bounce?



Your answer ☐

[1]

11 A ball is thrown at an angle of 30° to the horizontal. The initial kinetic energy of the ball is K.
Air resistance has negligible effect on the motion of the ball.



What is the kinetic energy of the ball at the maximum height?

A 0

B $0.25\,K$

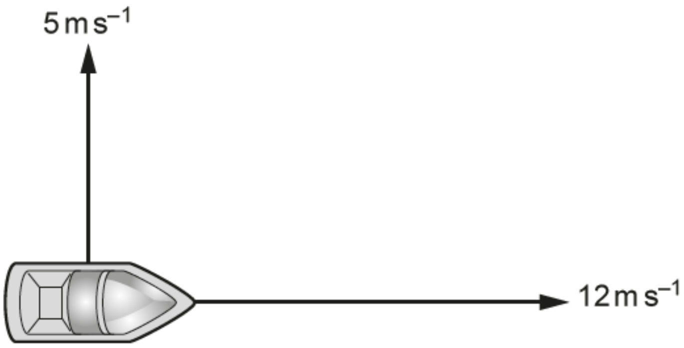
C $0.75\,K$

D $0.87\,K$

Your answer ☐

[1]

13 A boat is travelling eastwards across the sea with a velocity of $12\,m\,s^{-1}$. A wind from the south pushes the boat northwards at a velocity of $5\,m\,s^{-1}$.



What is the magnitude of the resultant velocity of the boat as it travels across the sea?

A $7\,m\,s^{-1}$

B $13\,m\,s^{-1}$

C $17\,m\,s^{-1}$

D $169\,m\,s^{-1}$

Your answer ☐

[1]

29 This question is about an experiment to find the terminal velocity of a large paper cake case, as shown in Fig. 29.1, falling in air.

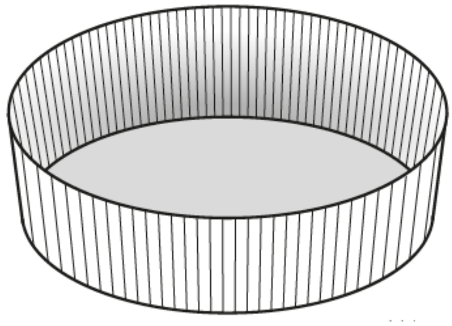


Fig. 29.1

(a) The paper case is dropped from rest and falls a vertical distance of 1.85 m.
13 students use ± 0.1 s stop clocks to time the fall. Fig. 29.2 shows a dot plot of the data obtained.

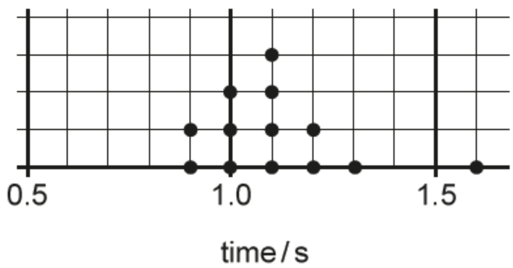


Fig. 29.2

(i) The single 1.6 s reading was treated as an outlier.

Calculate the mean time of drop for the remaining data and estimate the uncertainty.

mean time of drop = ... ± .... s **[2]**

(ii) Explain why the 1.6 s reading was treated as an outlier.

....

.... **[1]**

(iii) The vertical distance is measured as 1.85 ± 0.02 m due to the uncertainty in the release position.

Calculate your best estimate for the terminal velocity of the paper case and the uncertainty, using the data.

Make your method clear and justify how you estimated the uncertainty.

terminal velocity = ... ± .... $m\,s^{-1}$ **[3]**

(iv) Suggest **one** systematic error that exists in this method of finding the terminal velocity, and how it affects the estimate.

....

....

....

.... **[2]**

(b) An improved method for finding the terminal velocity for the same falling paper case gives the data table and distance fallen against time graph shown in Fig. 29.3.

time / s	distance fallen / s	
0	0.43	
0.1	0.43	
0.2	0.43	
0.3	0.43	
0.4	0.44	
0.5	0.49	
0.6	0.60	
0.7	0.72	
0.8	0.94	
0.9	1.17	
1.0	1.38	
1.1	1.61	
1.2	1.84	
1.3	2.08	
1.4	2.28	
1.5	2.28	
1.6	2.28	

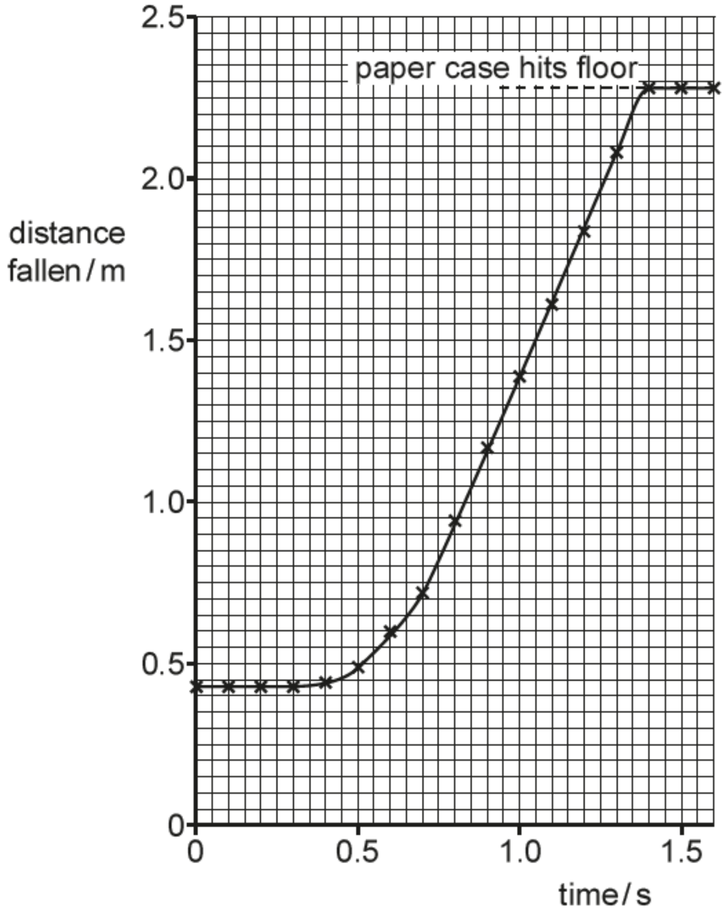


Fig. 29.3

(i) Use the data from the table or the graph to make a new estimate for the terminal velocity. The table has a blank column for you to use, if required.
Make your method clear.

terminal velocity = ... m s^{-1} **[2]**

(ii) Describe an experiment that could give the data in Fig. 29.3 and justify **one** way in which this method is better than that in **(a)**.

[3]

6 This question is about an experiment performed in AS physics to determine the acceleration due to gravity, *g*. Two students have chosen to do this experiment in different ways.
Anna is using a pair of light gates, each of which can time an object passing through it. Her set-up is shown in Fig. 6.1.

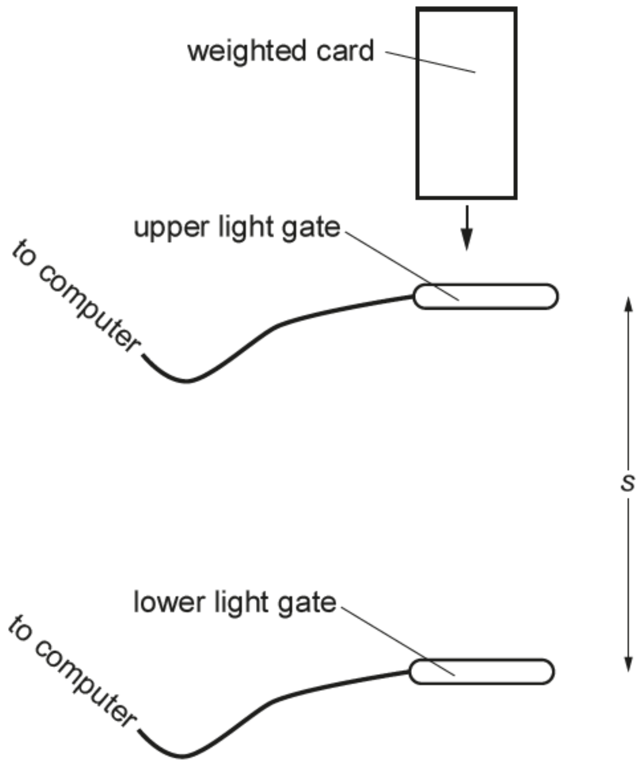


Fig. 6.1

As the weighted card falls, it interrupts the beam in each light gate. The computer records the time for which each beam has been interrupted and uses these times to calculate the mean speed of the card passing through each beam.
Anna drops the card from the same position each time.
She repeats this five times for a value of s = 0.24 m, and gets the results shown in Table 6.2.

Trial number	**1**	**2**	**3**	**4**	**5**
speed at upper light gate, u/m s^{-1}	1.40	1.44	1.36	1.41	1.38
speed at lower light gate, v/m s^{-1}	2.61	2.64	2.58	2.62	2.60

Table 6.2

(a) Anna correctly records the values of u and v and their uncertainties for s = 0.24 m as follows.

s/m	u/m s^{-1}	v/m s^{-1}
0.24	1.40 ± 0.04	2.61 ± 0.03

Table 6.3

Explain how Anna obtained the values for u and its uncertainty, and how she decided on the number of significant figures to use.

....

....

....

....

....

.... **[3]**

(b) Anna repeats the experiment for different values of s. She intends to plot a graph of $v^2 - u^2$ (y-axis) against s (x-axis).

Explain why this should result in a straight line through the origin with gradient $2g$.

....

....

.... **[2]**

(c) When $s = 0.24\,\text{m}$, the mean value of $v^2 - u^2 = 4.9\,\text{m}^2\,\text{s}^{-2}$.

(i) Use the data from **Table 6.3** to show that the uncertainty in $v^2 - u^2$ is $0.3\,\text{m}^2\,\text{s}^{-2}$ when $s = 0.24\,\text{m}$.

[2]

(ii) Anna decides to use this value of uncertainty for each uncertainty bar in her graph of $v^2 - u^2$ against s.

Suggest why this may not be accurate when s is much greater than 0.24 m.

....

....

....

.... **[2]**

(d) Anna repeats her measurements for five further values of s and plots the graph of Fig. 6.4. Draw suitable lines on the graph and use them to determine the value for g, the acceleration due to gravity, including its uncertainty.

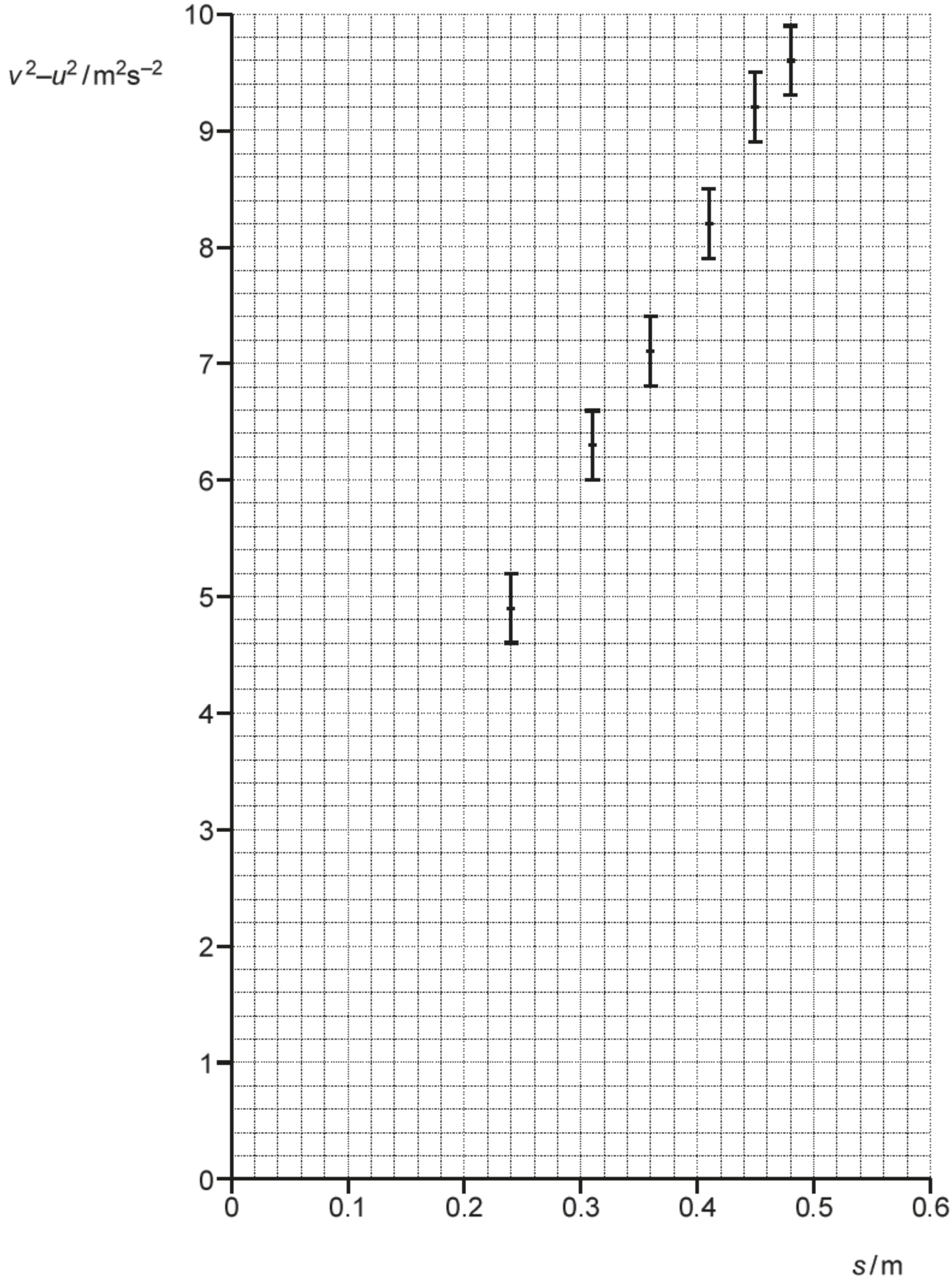


Fig. 6.4

g = ... ± .... m s^{-2} **[3]**

(e)* Simon chose to find the acceleration due to gravity by using a tablet computer to record a video of a golf ball falling against a dark background. The dark background had parallel horizontal white lines 0.10 m apart marked on it. The computer produced the time-lapse image shown in Fig. 6.5. Images of the falling ball were recorded 30 times per second, and are superimposed on the same image.

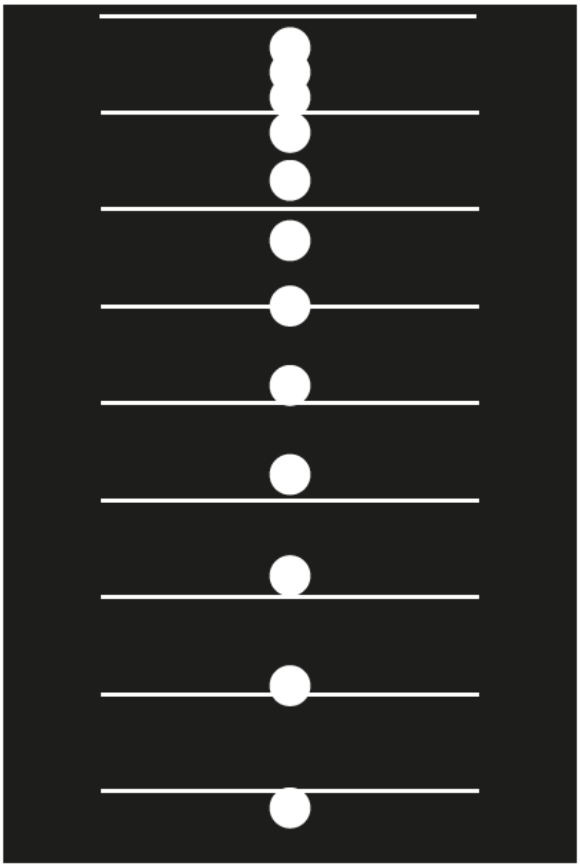


Fig. 6.5

Explain how Simon could use the image to obtain a value for *g* and discuss how you would expect it to compare with Anna's method. You are not expected to do any calculations based on measurements from Fig. 6.5. **[6]**