9 A student used a falling sphere to determine the acceleration of free fall.

A camera produced images of the sphere at constant time intervals as it fell.

The positions of the sphere in the first two images are shown. Image 1 shows the sphere's position at the instant it was released.

○ Image 1

○ Image 2

○ P

○ Q

○ R

○ S

Which of the positions P, Q, R or S will the sphere be at in Image 3?

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(Total for Question 9 = 1 mark)

2 A coin and a feather are dropped from the same height, through air.

Which row of the table is correct as the coin and feather fall to the ground?

		Initial acceleration	Time taken to reach the ground
☒	**A**	Greater for coin	Less for coin
☒	**B**	Greater for coin	Same for coin and feather
☒	**C**	Same for coin and feather	Less for coin
☒	**D**	Same for coin and feather	Same for coin and feather

(Total for Question 2 = 1 mark)

4 A ball rolls off a table with a horizontal velocity of $1.2\,\text{m s}^{-1}$. The ball takes $0.9\,\text{s}$ to reach the ground and lands a distance s from the table as shown.
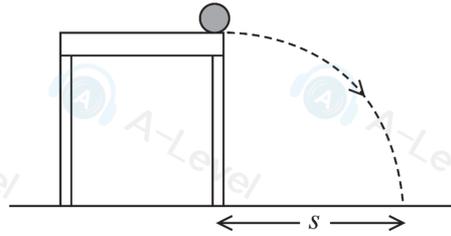
Which of the following expressions could be used to determine the value of s in metres?

☒ **A** $\dfrac{1.2^2}{2 \times 9.81}$

☒ **B** 1.2×0.9

☒ **C** $\tfrac{1}{2} \times 9.81 \times 0.9^2$

☒ **D** $(1.2 \times 0.9) + (\tfrac{1}{2} \times 9.81 \times 0.9^2)$

(Total for Question 4 = 1 mark)

7 A ball bearing falls vertically from rest through a distance of $50\,\text{cm}$ in a time of $0.32\,\text{s}$.

Which expression gives the acceleration of the ball bearing in m s^{-2}?

☒ **A** $1 \div 0.32^2$

☒ **B** $0.5 \div 0.32$

☒ **C** $100 \div 0.32^2$

☒ **D** $50 \div 0.32$

(Total for Question 7 = 1 mark)

6 The path of a projectile is shown.
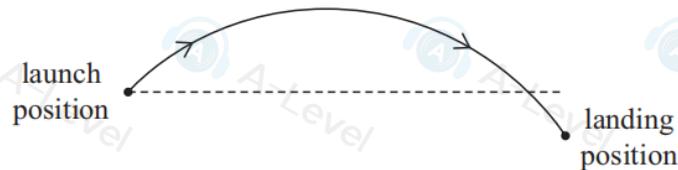
The projectile landed at a height lower than the height from which it was launched.

Assuming there is no air resistance acting on the projectile, which of the following is a correct statement?

A At the maximum height, the horizontal velocity is a minimum.

B At the maximum height, the vertical velocity is a maximum.

C The initial horizontal velocity is equal to the final horizontal velocity.

D The initial vertical velocity is equal to the final vertical velocity.

(Total for Question 6 = 1 mark)

4 A student measures the time t taken for a ball bearing to fall different measured distances s from rest. The student uses his measurements to plot a graph with a gradient equal to the acceleration due to gravity g.

Which row of the table shows a graph with a gradient equal to g?

	y-axis	x-axis
☒ A	s	t^2
☒ B	$2s$	t^2
☒ C	t^2	s
☒ D	t^2	$2s$

(Total for Question 4 = 1 mark)

13 The photograph shows an area of land where golfers can practise their golf shots. Distances are marked out along the land in front of where the golfer stands, to measure the distance travelled by the ball.

Two levels are available. If the lower level is used, the ball lands at the same height from which it was hit. If the higher level is used, this enables the ball to be hit further.

Source: www.golfnews.co.uk

(a) A ball is given an initial velocity of $33\,\mathrm{m\,s^{-1}}$ at an angle of $28°$ to the horizontal.

When hit from the lower level, this ball travels a horizontal distance of $92\,\mathrm{m}$ before landing. Use of the higher level increases the horizontal distance travelled before landing by $10\,\mathrm{m}$.

Deduce whether an upper level at a height of $4.5\,\mathrm{m}$ would be sufficient to produce this increase. You should ignore air resistance.

(5)

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*(b) Your answer to part (a) did not consider the effect of air resistance.

The trajectories of the motion of the golf ball with air resistance and without air resistance are shown.

Trajectory without air resistance ----------

Trajectory with air resistance _____

Explain the differences between the two paths.

(6)

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(Total for Question 13 = 11 marks)

15 Two projectiles, A and B, are launched from position O at the same time. At time t, both projectiles have travelled a horizontal distance OP as shown.

Diagram not to scale
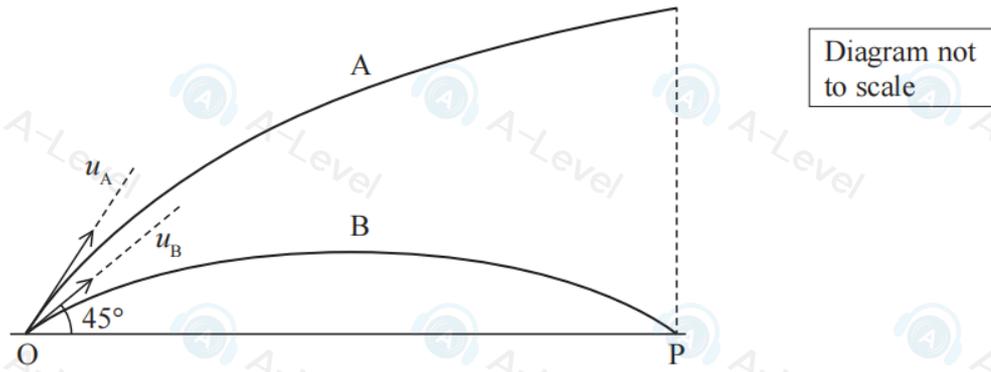
Projectile A is launched with a velocity u_A at an angle of θ to the horizontal and projectile B is launched with a velocity u_B at 45° to the horizontal.

(a) (i) Show that u_A may be expressed in terms of u_B as

$$u_A = \frac{0.707u_B}{\cos\theta}$$

(3)

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(ii) Explain why, for the paths of the two projectiles to be as shown, $u_A > u_B$.

(2)

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(b) On the axes below sketch labelled graphs for the vertical component of velocity against time for the motion of projectile A and projectile B between O and P.

You may ignore the effects of air resistance.

(4)

(Total for Question 15 = 9 marks)

19 In the sport of shot put, a person launches a heavy ball called a 'shot' into the air.

The photograph shows a person about to launch a shot.

shot

(a) The shot is very dense and has a large mass.

Explain why the equations of motion can be used to give an accurate prediction for the path of the shot.

(2)

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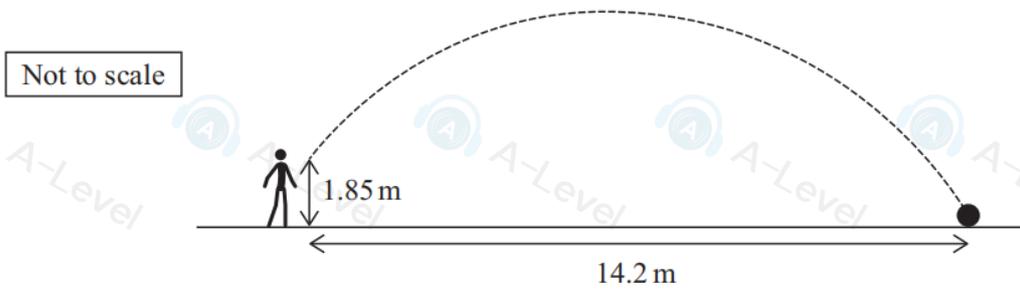..

(b) The shot was released from a height of 1.85 m above the ground. The shot travelled a horizontal distance of 14.2 m before landing on the ground, as shown.

Not to scale

1.85 m

14.2 m

The shot moved through the air for a time of 1.61 s.

(i) Show that the horizontal speed of the shot was about $8.8\,\mathrm{m\,s^{-1}}$.

(2)

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(ii) Determine the velocity of the shot at the point it was released.

(5)

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Magnitude of velocity = ...

Angle to horizontal = ...

(Total for Question 19 = 9 marks)

14 A firework is launched into the air and explodes once it reaches a maximum height.

(a) The firework is designed to explode at a maximum height of 350 m.

   (i) Show that the vertical component of the velocity at launch is about $80 \, \text{m s}^{-1}$.

   (2)

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   (ii) The vertical component of the velocity at launch depends on both the initial velocity of the firework and θ, the angle between the initial velocity and the horizontal.

   Sketch a graph showing how the initial velocity required for the firework to reach the maximum height of 350 m varies with θ for the firework.

   (4)
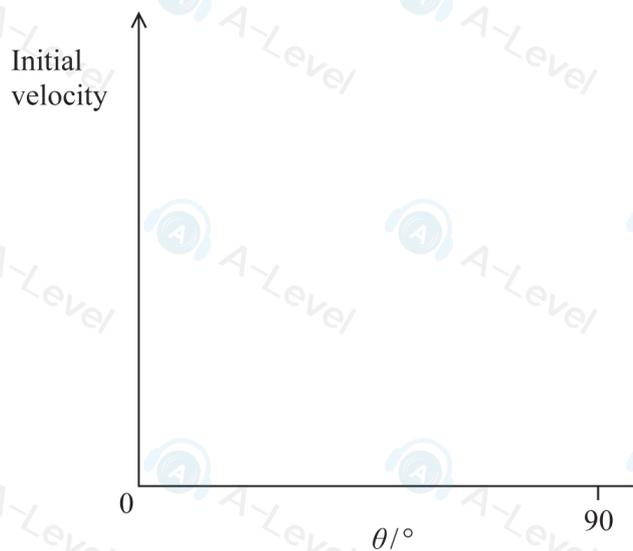
17 The photograph shows a cyclist performing a jump. To produce the photograph, the camera shutter is opened at regular time intervals.

*(a) With reference to the photograph, describe the motion of the cyclist as he performs the jump.

(4)

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(b) The path of the cyclist is shown. The cyclist takes off with a velocity of $9.5\,\mathrm{m\,s^{-1}}$ at an angle of $10°$ to the horizontal. The total time taken for the jump is $1.8\,\mathrm{s}$.
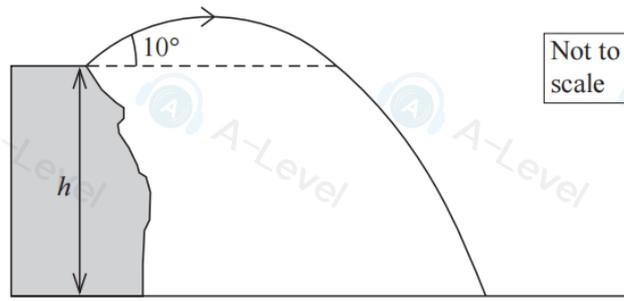
(i) Calculate the vertical height h.

(3)

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$h = $ ....

(ii) Calculate the horizontal distance jumped by the cyclist.

(3)

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Horizontal distance jumped = ...

(c) The cyclist briefly has a feeling of 'weightlessness' during his jump.

Explain why.

(2)

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(Total for Question 17 = 12 marks)