

1. Question part 1/2 | 9702 Feb-March 2016 P2 V2 Q2

2 (a) Define *acceleration*.

.....
..... [1]

(b) A ball is kicked from horizontal ground towards the top of a vertical wall, as shown in Fig. 2.1.

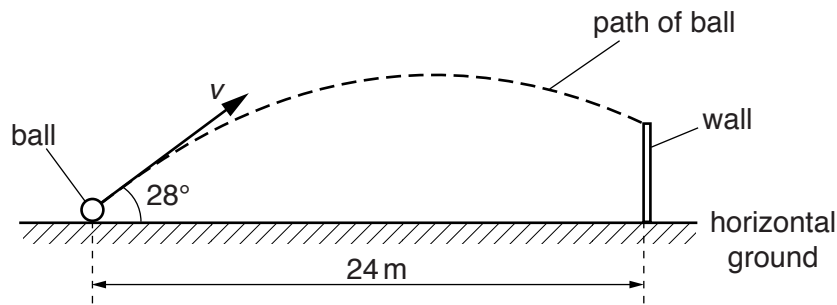


Fig. 2.1 (not to scale)

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball hits the top of the wall after a time of 1.5 s. Air resistance may be assumed to be negligible.

(i) Calculate the initial horizontal component v_x of the velocity of the ball.

$v_x = \dots\dots\dots \text{ms}^{-1}$ [1]

(ii) Show that the initial vertical component v_y of the velocity of the ball is 8.5 ms^{-1} .

[2]

(iii) Calculate the time taken for the ball to reach its maximum height above the ground.

time = $\dots\dots\dots$ s [2]

1. Question part 2/2 | 9702 Feb-March 2016 P2 V2 Q2

- (iv) The ball is kicked at time $t = 0$. On Fig. 2.2, sketch the variation with time t of the vertical component v_y of the velocity of the ball until it hits the wall. It may be assumed that velocity is positive when in the upwards direction.

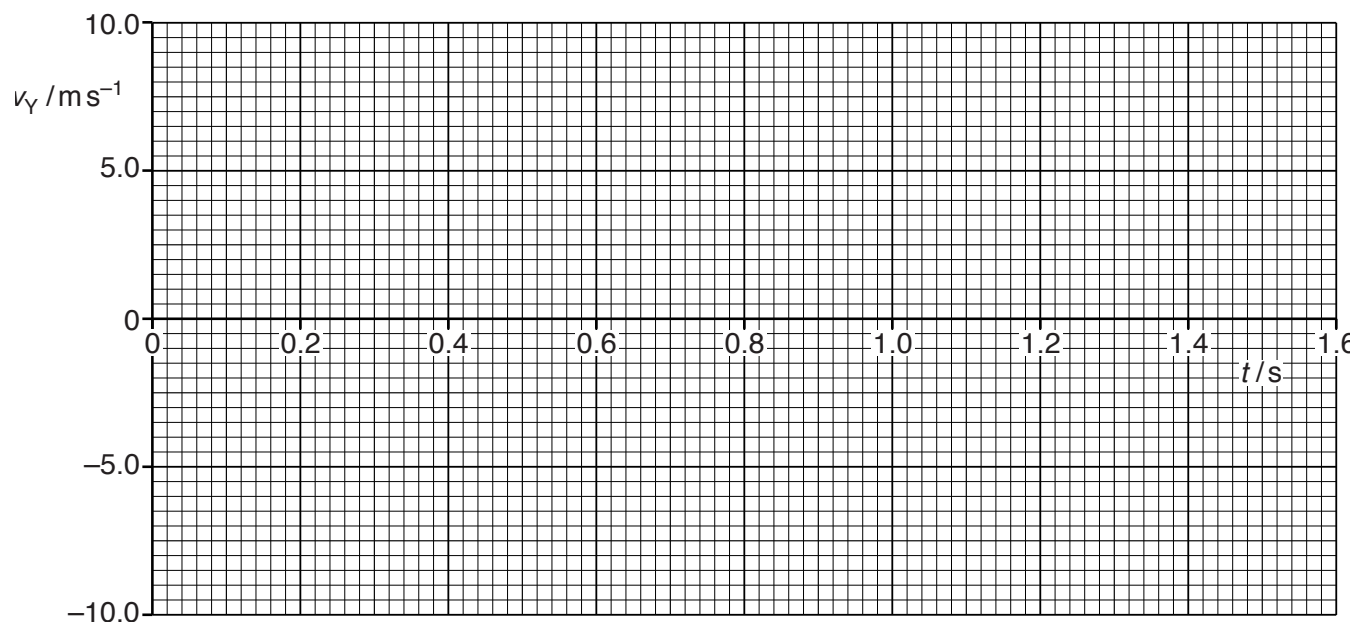


Fig. 2.2

[2]

- (c) (i) Use the information in (b) to determine the maximum height of the ball above the ground.

maximum height = ... m [2]

- (ii) The maximum gravitational potential energy of the ball above the ground is 22 J. Calculate the mass of the ball.

mass = ... kg [2]

- (d) A ball of greater mass is kicked with the same velocity as the ball in (b). State and explain the effect, if any, of the increased mass on the maximum height reached by the ball. Air resistance is still assumed to be negligible.

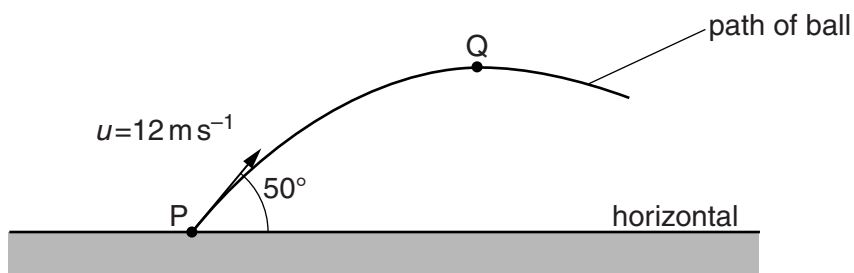
.....

..... [1]

[Total: 13]

2. Question | 9702 May-June 2016 P2 V1 Q2

- 2** A ball is thrown from a point P with an initial velocity u of 12 ms^{-1} at 50° to the horizontal, as illustrated in Fig. 2.1.

**Fig. 2.1**

The ball reaches maximum height at Q.

Air resistance is negligible.

(a) Calculate

- (i)** the horizontal component of u ,

horizontal component = ... ms^{-1} [1]

- (ii)** the vertical component of u .

vertical component = ... ms^{-1} [1]

- (b)** Show that the maximum height reached by the ball is 4.3m.

[2]

- (c)** Determine the magnitude of the displacement PQ.

displacement = ... m [4]

[Total: 8]

3. Question part 1/2 | 9702 May-June 2016 P2 V2 Q1

1 (a) Define *acceleration*.

.....
.....[1]

(b) A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.

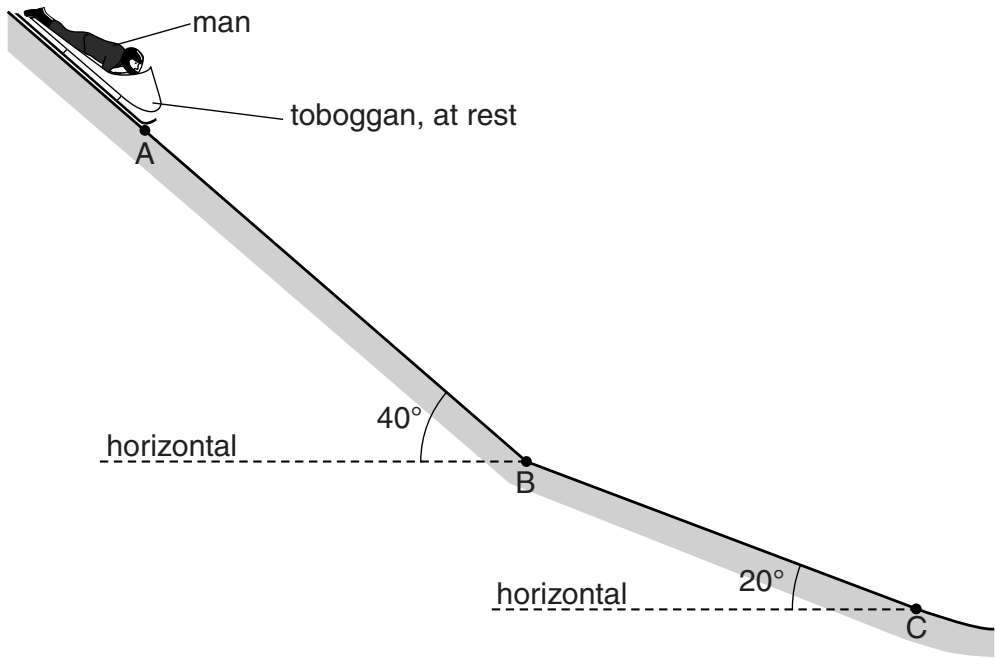


Fig. 1.1 (not to scale)

The slope AB makes an angle of 40° with the horizontal and the slope BC makes an angle of 20° with the horizontal. Friction is not negligible.

The man and toboggan have a combined mass of 95 kg.

The man starts from rest at A and has constant acceleration between A and B. The man takes 19s to reach B. His speed is 36 ms⁻¹ at B.

(i) Calculate the acceleration from A to B.

acceleration = ... ms⁻² [2]

(ii) Show that the distance moved from A to B is 340 m.

(iii) For the man and toboggan moving from A to B, calculate

1. the change in kinetic energy,

change in kinetic energy = ... J [2]

2. the change in potential energy.

change in potential energy = ... J [2]

(iv) Use your answers in **(iii)** to determine the average frictional force that acts on the toboggan between A and B.

frictional force = ... N [2]

(v) A parachute opens on the toboggan as it passes point B. There is a constant deceleration of 3.0 m s^{-2} from B to C.

Calculate the frictional force that produces this deceleration between B and C.

frictional force = ... N [2]

[Total: 12]

2 (a) Define *velocity*.

.....
.....[1]

(b) A ball of mass 0.45 kg leaves the edge of a table with a horizontal velocity v , as shown in Fig. 2.1.

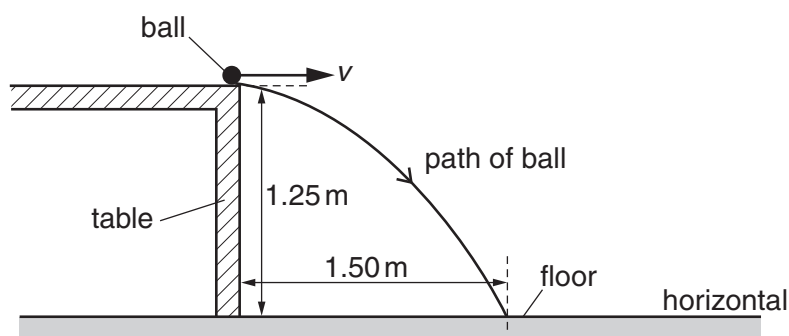


Fig. 2.1

The height of the table is 1.25 m. The ball travels a distance of 1.50 m horizontally before hitting the floor.

Air resistance is negligible.

Calculate, for the ball,

(i) the horizontal velocity v as it leaves the table,

$v = \dots\dots\dots \text{ms}^{-1}$ [3]

9702 Physics Paper 2 - Kinematics

Topical questions | 38 questions

4. Question part 2/2 | 9702 May-June 2017 P2 V2 Q2

(ii) the velocity just as it hits the floor,

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

angle to the horizontal = ... $^{\circ}$
[4]

(iii) the kinetic energy just as it hits the floor,

kinetic energy = ... J [2]

(iv) the loss in gravitational potential energy as it falls from the table to the floor.

loss in potential energy = ... J [2]

(c) Explain why the kinetic energy of the ball in **(b)(iii)** does not equal the loss of gravitational potential energy in **(b)(iv)**.

.....
..... [1]

[Total: 13]

5. Question part 1/2 | 9702 Oct-Nov 2017 P2 V1 Q2

2 The variation with time t of the velocity v of two cars P and Q is shown in Fig. 2.1.

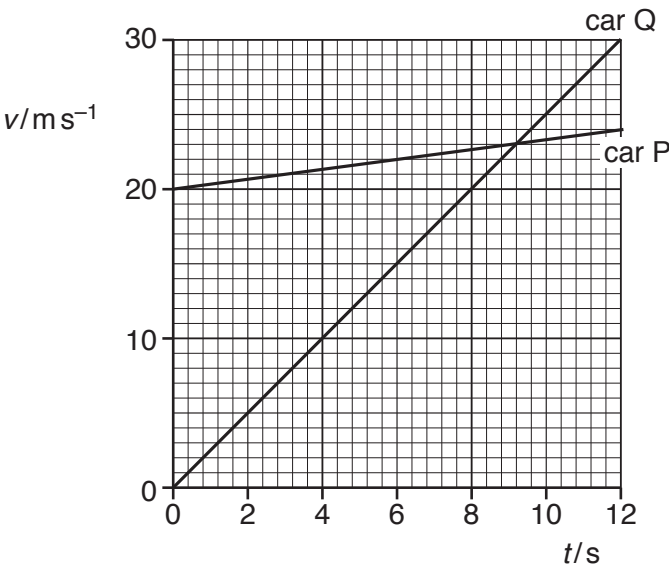


Fig. 2.1

The cars travel in the same direction along a straight road.
Car P passes car Q at time $t = 0$.

(a) The speed limit for cars on the road is 100 km h^{-1} . State and explain whether car Q exceeds the speed limit.

.....[1]

(b) Calculate the acceleration of car P.

acceleration = ... ms^{-2} [2]

9702 Physics Paper 2 - Kinematics

Topical questions | 38 questions

5. Question part 2/2 | 9702 Oct-Nov 2017 P2 V1 Q2

(c) Determine the distance between the two cars at time $t = 12\text{ s}$.

distance = ... m [3]

(d) From time $t = 12\text{ s}$, the velocity of each car remains constant at its value at $t = 12\text{ s}$.

Determine the time t at which car Q passes car P.

$t =$ s [2]

[Total: 8]

6. Question part 1/2 | 9702 Feb-March 2018 P2 V2 Q1

1 (a) Complete Fig. 1.1 to indicate whether each of the quantities is a vector or a scalar.

quantity	vector or scalar
acceleration	
speed	
power	

Fig. 1.1

[2]

(b) A ball is projected with a horizontal velocity of 1.1 m s^{-1} from point A at the edge of a table, as shown in Fig. 1.2.

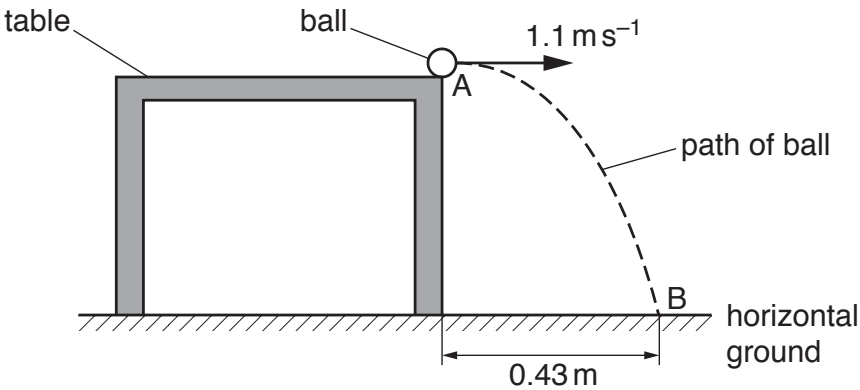


Fig. 1.2

The ball lands on horizontal ground at point B which is a distance of 0.43 m from the base of the table. Air resistance is negligible.

(i) Calculate the time taken for the ball to fall from A to B.

time = ... s [1]

(ii) Use your answer in (b)(i) to determine the height of the table.

height = ... m [2]

(iii) The ball leaves the table at time $t = 0$.

For the motion of the ball between A and B, sketch graphs on Fig. 1.3 to show the variation with time t of

- 1. the acceleration a of the ball,
- 2. the vertical component s_v of the displacement of the ball from A.

Numerical values are not required.

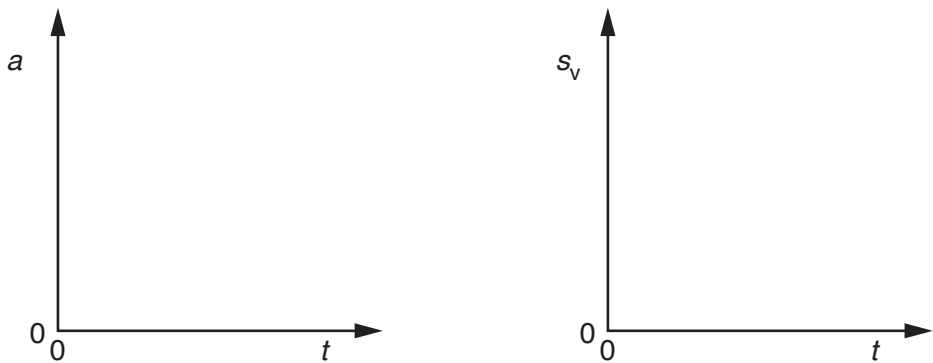


Fig. 1.3

[2]

(c) A ball of greater mass is projected from the table with the same velocity as the ball in (b). Air resistance is still negligible.

State and explain the effect, if any, of the increased mass on the time taken for the ball to fall to the ground.

.....
.....[1]

[Total: 8]

- 3 A child on a sledge slides down a steep hill and then travels in a straight line up an ice-covered slope, as illustrated in Fig. 3.1.

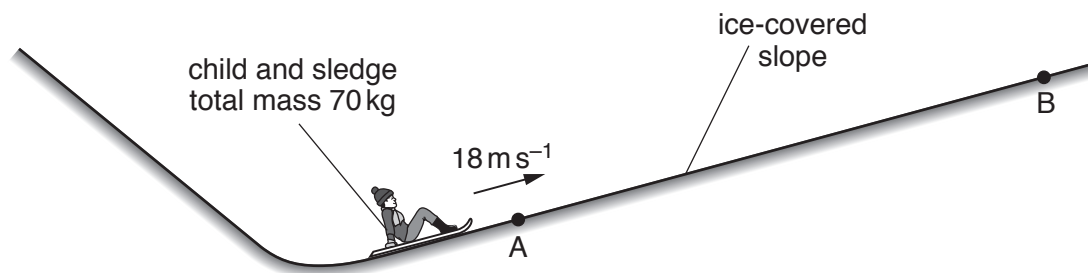


Fig. 3.1 (not to scale)

The sledge passes point A with speed 18 m s^{-1} at time $t = 0$ and then comes to rest at point B. The child applies a brake to the sledge at point B. The brake does not keep the sledge stationary and it immediately slides back down the slope towards A.

The variation with time t of the velocity v of the sledge from $t = 0$ to $t = 24 \text{ s}$ is shown in Fig. 3.2.

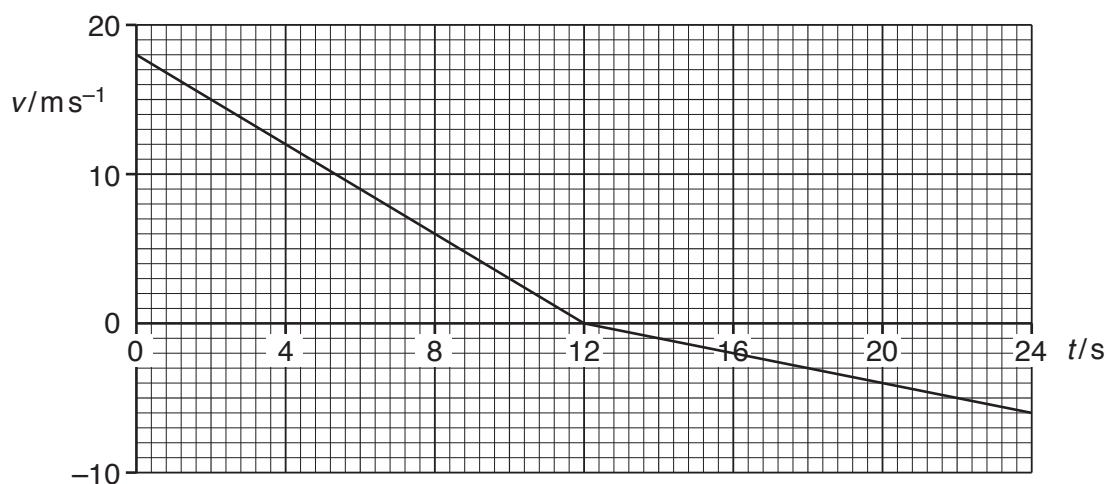


Fig. 3.2

- (a) State the time taken for the sledge to travel from A to B.

time = ... s [1]

- (b)** Determine the displacement of the sledge up the slope from point A at time $t = 24$ s.

displacement = ...m [3]

- (c)** Show that the acceleration of the sledge as it moves from B back towards A is 0.50 m s^{-2} .

[2]

- (d)** The child and sledge have a total mass of 70 kg. The component of the total weight of the child and sledge that acts down the slope is 80 N.

Determine

- (i)** the frictional force on the sledge as it moves from B towards A,

frictional force = ... N [2]

- (ii)** the angle θ of the slope to the horizontal.

$\theta = \dots\dots\dots^\circ$ [2]

- (e) The child on the sledge blows a whistle between $t = 4.0\text{ s}$ and $t = 8.0\text{ s}$. The whistle emits sound of frequency 900 Hz . The speed of the sound in the air is 340 m s^{-1} . A man standing at point A hears the sound.

Use Fig. 3.2 to

- (i) determine the initial frequency of the sound heard by the man,

initial frequency = ... Hz [2]

- (ii) describe and explain qualitatively the variation, if any, in the frequency of the sound heard by the man.

.....

.....[1]

[Total: 13]

- 3 A ball is thrown vertically upwards towards a ceiling and then rebounds, as illustrated in Fig. 3.1.

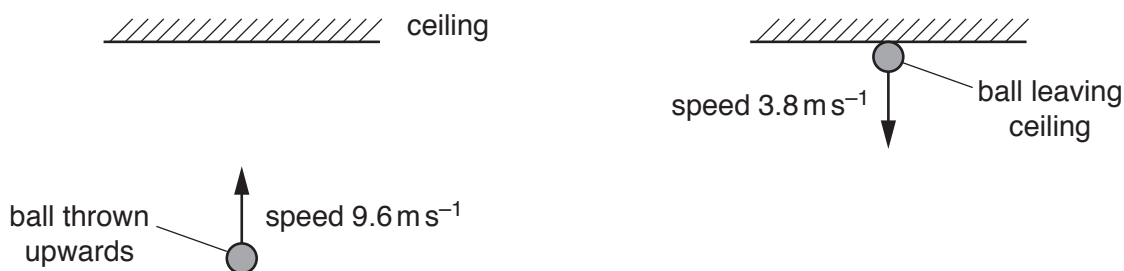


Fig. 3.1

The ball is thrown with speed 9.6 m s^{-1} and takes a time of 0.37 s to reach the ceiling. The ball is then in contact with the ceiling for a further time of 0.085 s until leaving it with a speed of 3.8 m s^{-1} . The mass of the ball is 0.056 kg . Assume that air resistance is negligible.

- (a) Show that the ball reaches the ceiling with a speed of 6.0 m s^{-1} .

[1]

- (b) Calculate the height of the ceiling above the point from which the ball was thrown.

height = ... m [2]

- (c) Calculate

- (i) the increase in gravitational potential energy of the ball for its movement from its initial position to the ceiling,

increase in gravitational potential energy = ... J [2]

- (ii) the decrease in kinetic energy of the ball while it is in contact with the ceiling.

decrease in kinetic energy = ... J [2]

- (d) State how Newton's third law applies to the collision between the ball and the ceiling.

.....
.....
.....
.....[2]

- (e) Calculate the change in momentum of the ball during the collision.

change in momentum = ... N s [2]

- (f) Determine the magnitude of the average force exerted by the ceiling on the ball during the collision.

average force = ... N [2]

[Total: 13]

1 (a) Define

(i) *displacement*,

.....
..... [1]

(ii) *acceleration*.

.....
..... [1]

(b) A remote-controlled toy car moves up a ramp and travels across a gap to land on another ramp, as illustrated in Fig. 1.1.

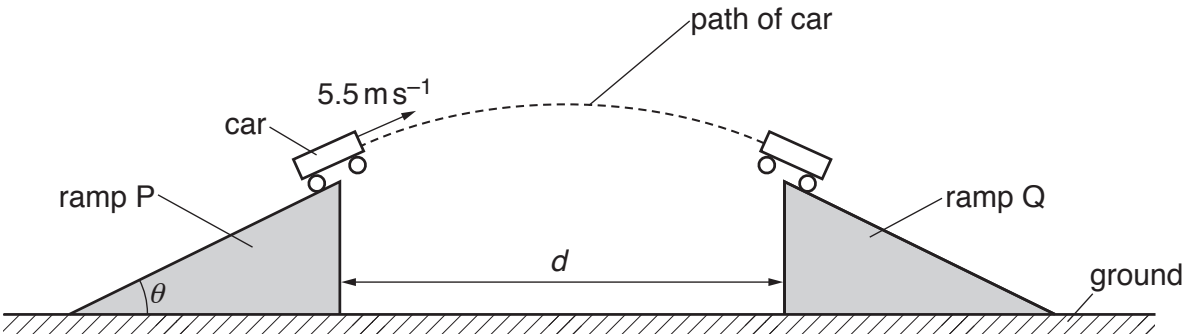


Fig. 1.1

The car leaves ramp P with a velocity of 5.5 ms^{-1} at an angle θ to the horizontal. The horizontal component of the car's velocity as it leaves the ramp is 4.6 ms^{-1} . The car lands at the top of ramp Q. The tops of both ramps are at the same height and are distance d apart. Air resistance is negligible.

(i) Show that the car leaves ramp P with a vertical component of velocity of 3.0 ms^{-1} .

[1]

(ii) Determine the time taken for the car to travel between the ramps.

time taken = ... s [2]

- (iii) Calculate the horizontal distance d between the tops of the ramps.

$d = \dots\dots\dots$ m [1]

- (iv) Calculate the ratio

$$\frac{\text{kinetic energy of the car at its maximum height}}{\text{kinetic energy of the car as it leaves ramp P}}.$$

ratio = $\dots\dots\dots$ [3]

- (c) Ramp Q is removed. The car again leaves ramp P as in (b) and now lands directly on the ground. The car leaves ramp P at time $t = 0$ and lands on the ground at time $t = T$.

On Fig. 1.2, sketch the variation with time t of the vertical component v_y of the car's velocity from $t = 0$ to $t = T$. Numerical values of v_y and t are not required.

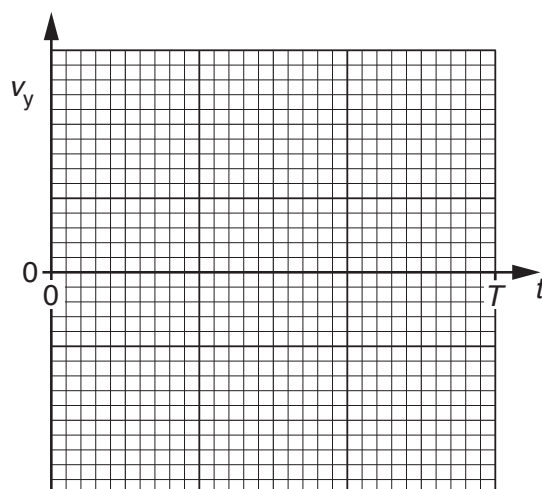


Fig. 1.2

[2]

[Total: 11]

9702 Physics Paper 2 - Kinematics

Topical questions | 38 questions

9. Question part 3/3 | 9702 Oct-Nov 2018 P2 V1 Q1

BLANK PAGE

10. Question part 1/3 | 9702 Oct-Nov 2018 P2 V2 Q1

- 1 A golfer strikes a ball so that it leaves horizontal ground with a velocity of 6.0 m s^{-1} at an angle θ to the horizontal, as illustrated in Fig. 1.1.

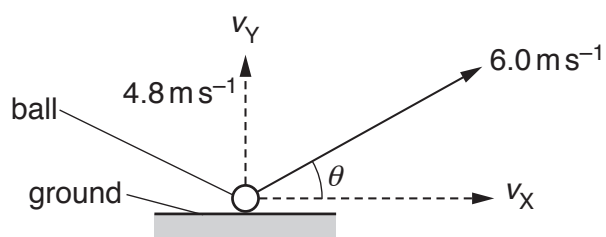


Fig. 1.1 (not to scale)

The magnitude of the initial vertical component v_y of the velocity is 4.8 m s^{-1} . Assume that air resistance is negligible.

- (a) Show that the magnitude of the initial horizontal component v_x of the velocity is 3.6 m s^{-1} .

[1]

- (b)** The ball leaves the ground at time $t = 0$ and reaches its maximum height at $t = 0.49$ s.

On Fig. 1.2, sketch separate lines to show the variation with time t , until the ball returns to the ground, of

- (i) the vertical component v_y of the velocity (label this line Y), [2]
 (ii) the horizontal component v_x of the velocity (label this line X). [2]

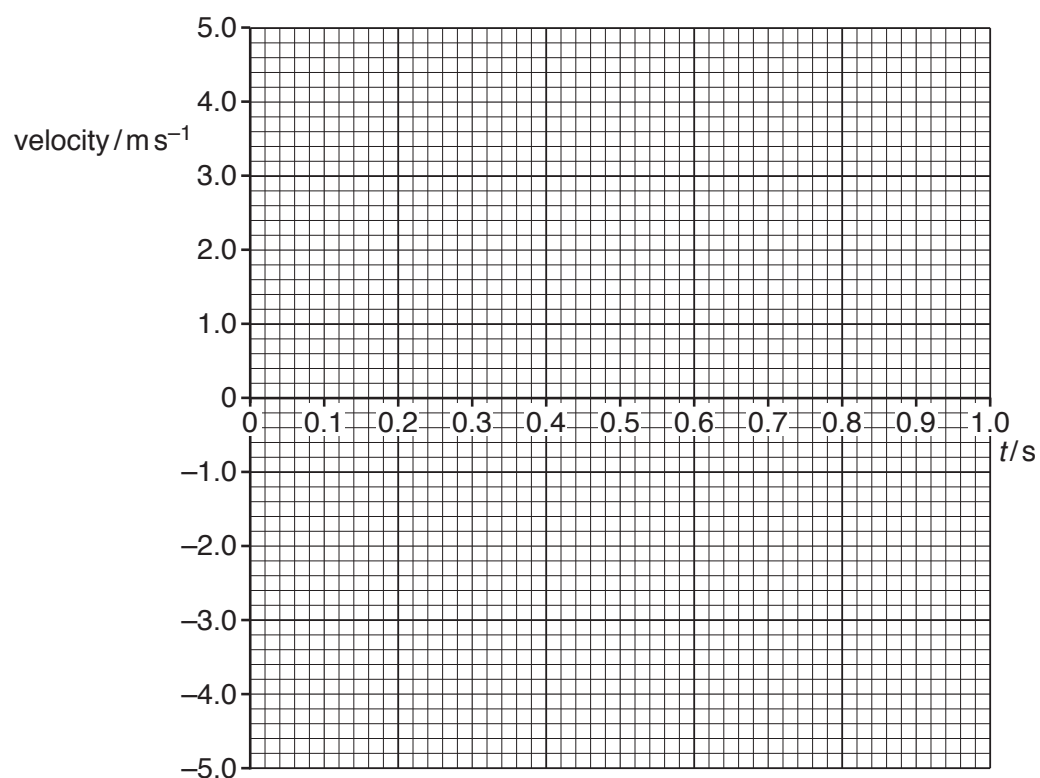


Fig. 1.2

- (c)** Calculate the maximum height reached by the ball.

maximum height = ... m [2]

(d) For the movement of the ball from the ground to its maximum height, determine the ratio $\frac{\text{kinetic energy at maximum height}}{\text{change in gravitational potential energy}}$.

ratio = ...[4]

(e) In practice, significant air resistance acts on the ball. Explain why the actual time taken for the ball to reach maximum height is less than the time calculated when air resistance is assumed to be negligible.

.....
.....
.....[1]

[Total: 12]

2 (a) Define *acceleration*.

..... [1]

(b) A steel ball of diameter 0.080 m is released from rest and falls vertically in air, as illustrated in Fig. 2.1.

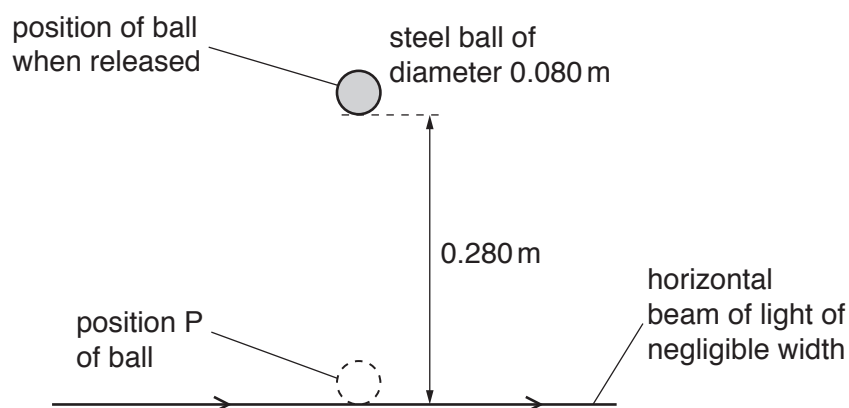


Fig. 2.1 (not to scale)

A horizontal beam of light of negligible width is a vertical distance of 0.280 m below the bottom of the ball when it is released. The ball falls through and breaks the beam of light.

(i) Explain why the force due to air resistance acting on the ball may be neglected when calculating the time taken for the ball to reach the beam of light.

.....

..... [1]

(ii) Calculate the time taken for the ball to fall from rest to position P where the bottom of the ball touches the beam of light.

time taken = ... s [2]

(iii) Determine the time interval during which the beam of light is broken by the ball.

time interval = ... s [2]

(c) A different ball is released from the same position as the steel ball in (b). This ball has the same diameter but a much lower density. For this ball, the force due to air resistance cannot be neglected as the ball falls.

State and explain the change, if any, to the time interval during which the beam of light is broken by the ball.

.....

.....

.....

..... [2]

[Total: 8]

2 A dolphin is swimming under water at a constant speed of 4.50 m s^{-1} .

- (a) The dolphin emits a sound as it swims directly towards a stationary submerged diver. The frequency of the sound heard by the diver is 9560 Hz . The speed of sound in the water is 1510 m s^{-1} .

Determine the frequency, to three significant figures, of the sound emitted by the dolphin.

frequency = ... Hz [2]

- (b) The dolphin strikes the bottom of a floating ball so that the ball rises vertically upwards from the surface of the water, as illustrated in Fig. 2.1.

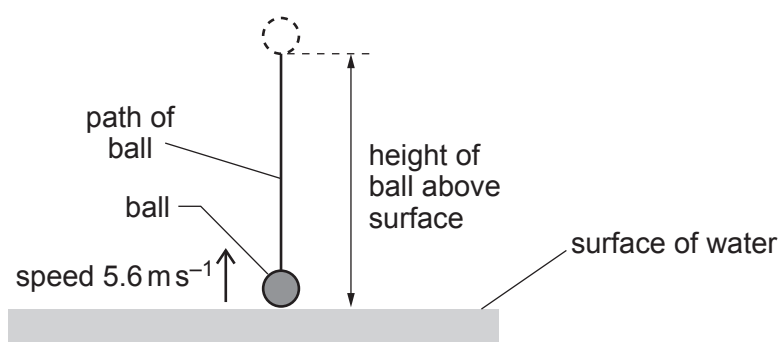


Fig. 2.1

The ball leaves the water surface with speed 5.6 m s^{-1} .

Assume that air resistance is negligible.

- (i) Calculate the maximum height reached by the ball above the surface of the water.

height = ... m [2]

(ii) The ball leaves the water at time $t = 0$ and reaches its maximum height at time $t = T$.

On Fig. 2.2, sketch a graph to show the variation of the speed of the ball with time t from $t = 0$ to $t = T$. Numerical values are **not** required.

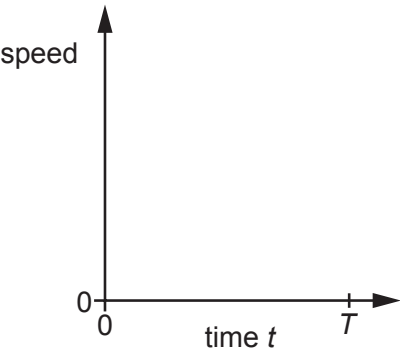


Fig. 2.2

[1]

(iii) The mass of the ball is 0.45 kg.

Use your answer in (b)(i) to calculate the change in gravitational potential energy of the ball as it rises from the surface of the water to its maximum height.

change in gravitational potential energy = ... J [2]

(iv) State and explain the variation in the magnitude of the acceleration of the ball as it falls back towards the surface of the water if air resistance is **not** negligible.

.....

.....

.....

.....

..... [2]

[Total: 9]

13. Question part 1/2 | 9702 May-June 2020 P2 V1 Q2

2 (a) State Newton’s second law of motion.

.....
..... [1]

(b) A delivery company suggests using a remote-controlled aircraft to drop a parcel into the garden of a customer. When the aircraft is vertically above point P on the ground, it releases the parcel with a velocity that is horizontal and of magnitude 5.4 ms^{-1} . The path of the parcel is shown in Fig. 2.1.

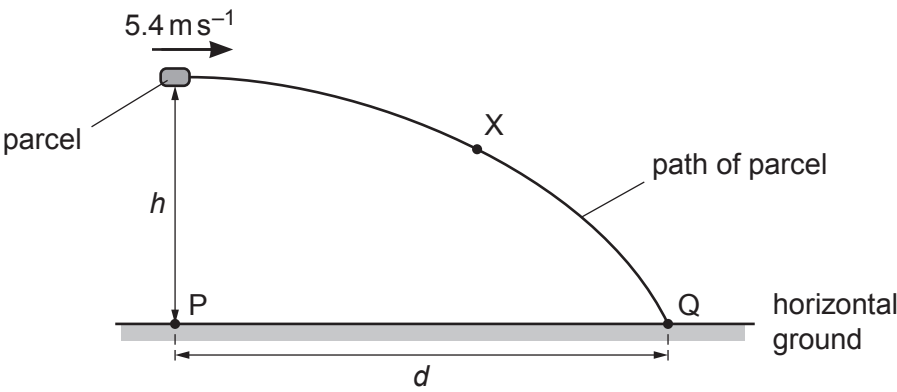


Fig. 2.1 (not to scale)

The parcel takes a time of 0.81 s after its release to reach point Q on the horizontal ground. Assume air resistance is negligible.

- (i) On Fig. 2.1, draw an arrow from point X to show the direction of the acceleration of the parcel when it is at that point. [1]
- (ii) Determine the height h of the parcel above the ground when it is released.

$h =$ m [2]

(iii) Calculate the horizontal distance d between points P and Q.

$d =$ m [1]

13. Question part 2/2 | 9702 May-June 2020 P2 V1 Q2

- (c) Another parcel is accidentally released from rest by a different aircraft when it is hovering at a great height above the ground. Air resistance is now significant.
- (i) On Fig. 2.2, draw arrows to show the directions of the forces acting on the parcel as it falls vertically downwards. Label each arrow with the name of the force.

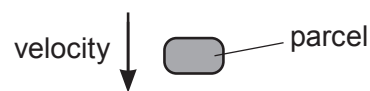


Fig. 2.2

[2]

- (ii) By considering the forces acting on the parcel, state and explain the variation, if any, of the acceleration of the parcel as it moves downwards before it reaches constant (terminal) speed.

.....

.....

.....

.....

.....

..... [3]

- (iii) Describe the energy conversion that occurs when the parcel is falling through the air at constant (terminal) speed.

.....

..... [1]

[Total: 11]

14. Question part 1/2 | 9702 May-June 2020 P2 V2 Q2

- 2 (a) Fig. 2.1 shows the velocity–time graph for an object moving in a straight line.

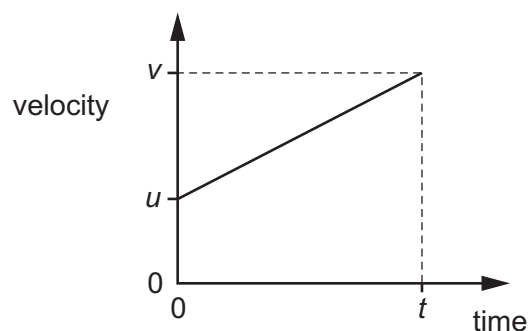


Fig. 2.1

- (i) Determine an expression, in terms of u , v and t , for the area under the graph.

area = ... [1]

- (ii) State the name of the quantity represented by the area under the graph.

..... [1]

- (b) A ball is kicked with a velocity of 15 ms^{-1} at an angle of 60° to horizontal ground. The ball then strikes a vertical wall at the instant when the path of the ball becomes horizontal, as shown in Fig. 2.2.

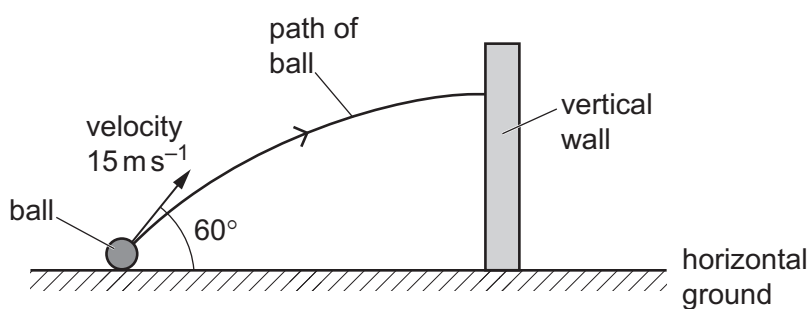


Fig. 2.2 (not to scale)

Assume that air resistance is negligible.

- (i) By considering the vertical motion of the ball, calculate the time it takes to reach the wall.

time = ... s [3]

- (ii) Explain why the horizontal component of the velocity of the ball remains constant as it moves to the wall.

.....

..... [1]

- (iii) Show that the ball strikes the wall with a horizontal velocity of 7.5 m s^{-1} .

[1]

- (c) The mass of the ball in (b) is 0.40 kg . It is in contact with the wall for a time of 0.12 s and rebounds horizontally with a speed of 4.3 m s^{-1} .

- (i) Use the information from (b)(iii) to calculate the change in momentum of the ball due to the collision.

change in momentum = ... kg m s^{-1} [2]

- (ii) Calculate the magnitude of the average force exerted on the ball by the wall.

average force = ... N [1]

[Total: 10]

- 2** A small block is lifted vertically upwards by a toy aircraft, as illustrated in Fig. 2.1.

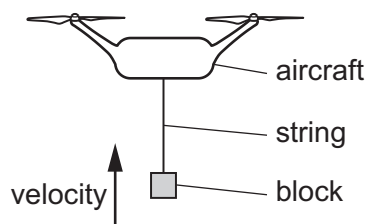


Fig. 2.1

As the block is moving upwards, the string breaks at time $t = 0$. The block initially continues moving upwards and then falls and hits the ground at time $t = 0.90$ s. The variation with time t of the velocity v of the block is shown in Fig. 2.2.

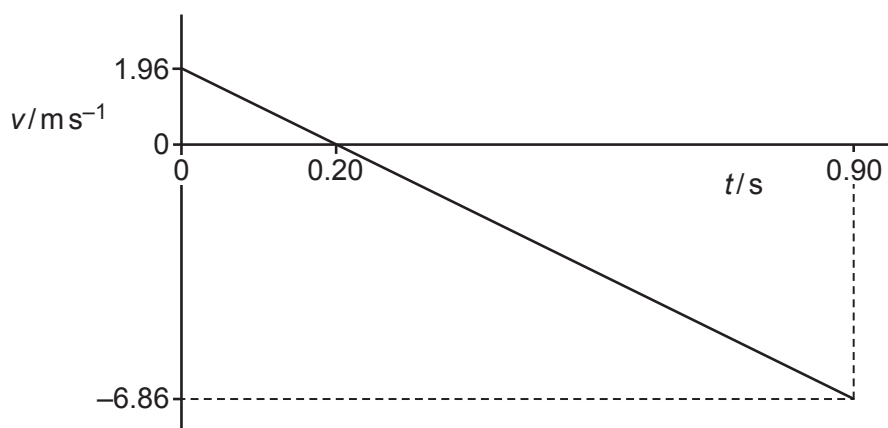


Fig. 2.2

Air resistance is negligible.

- (a)** State the feature of the graph in Fig. 2.2 that shows the block has a constant acceleration.

..... [1]

- (b)** Use Fig. 2.2 to determine the height of the block above the ground when the string breaks at time $t = 0$.

height = ... m [3]

15. Question part 2/2 | 9702 Oct-Nov 2020 P2 V1 Q2

(c) The block has a weight of 0.86 N.

Calculate the difference in gravitational potential energy of the block between time $t = 0$ and time $t = 0.90$ s.

difference in gravitational potential energy = ... J [2]

(d) On Fig. 2.3, sketch a line to show the variation of the distance moved by the block with time t from $t = 0$ to $t = 0.20$ s. Numerical values of distance are not required.

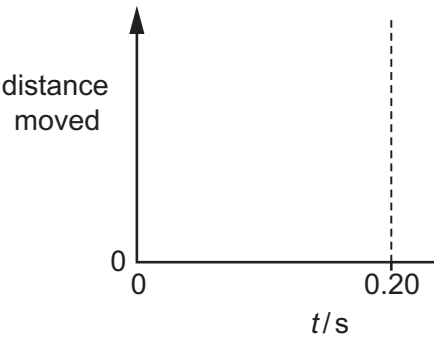


Fig. 2.3

[2]

(e) A block of greater mass is now released from the same height with the same upward velocity. Air resistance is still negligible.

State and explain the effect, if any, of the increased mass on the speed with which the block hits the ground.

.....
..... [1]

[Total: 9]

- 1 (a) Complete Table 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

Table 1.1

quantity	scalar	vector
acceleration		
density		
temperature		
momentum		

[2]

- (b) A toy train moves along a straight section of track. Fig. 1.1 shows the variation with time t of the distance d moved by the train.

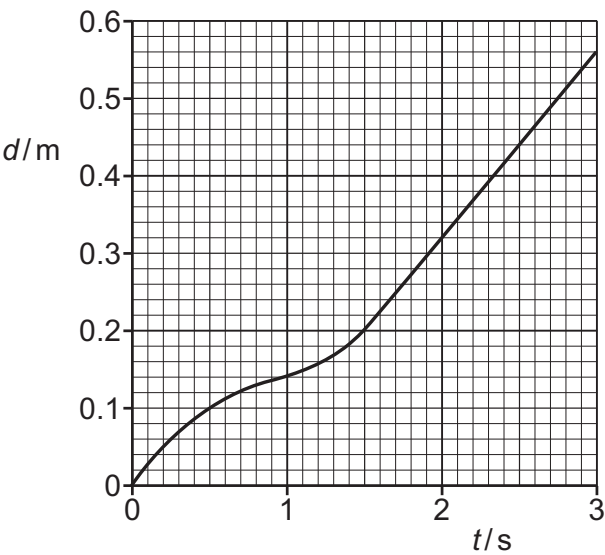


Fig. 1.1

- (i) Describe qualitatively the motion of the train between time $t = 0$ and time $t = 1.0$ s.

.....
..... [1]

(ii) Determine the speed of the train at time $t = 2.0\text{ s}$.

speed = ... ms^{-1} [2]

(c) The straight section of track in (b) is part of the loop of track shown in Fig. 1.2.

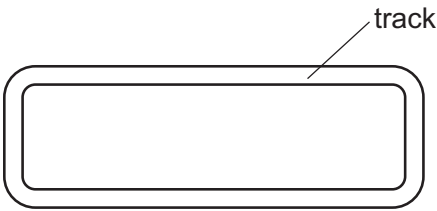


Fig. 1.2

The train completes exactly one lap of the loop.

State and explain the average velocity of the train over the one complete lap.

.....
.....
..... [1]

[Total: 6]

17. Question part 1/2 | 9702 Oct-Nov 2020 P2 V3 Q3

- 3 A ball is fired horizontally with a speed of 41.0 m s^{-1} from a stationary cannon at the top of a hill. The ball lands on horizontal ground that is a vertical distance of 57 m below the cannon, as shown in Fig. 3.1.

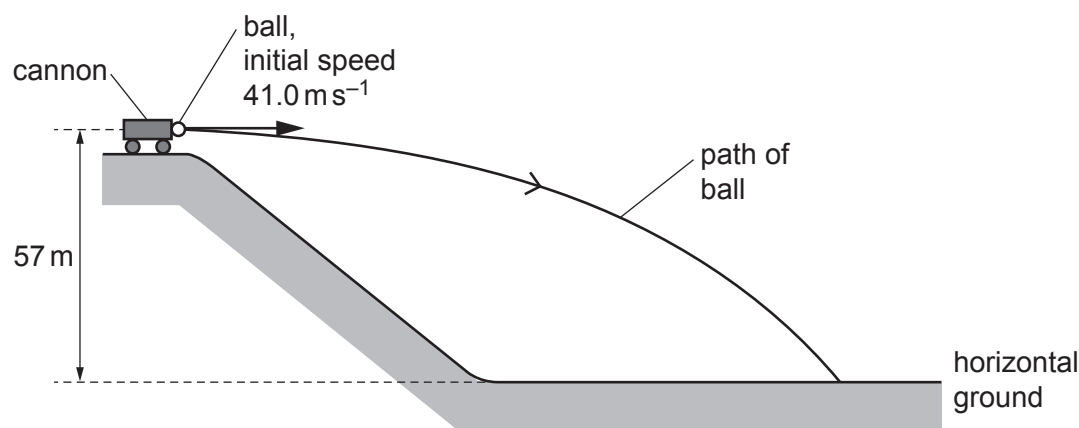


Fig. 3.1 (not to scale)

Assume air resistance is negligible.

- (a) Show that the time taken for the ball to reach the ground, after being fired, is 3.4 s.

[2]

- (b) Calculate the horizontal distance of the ball from the cannon at the point where the ball lands on the ground.

horizontal distance = ... m [1]

- (c) Determine the magnitude of the displacement of the ball from the cannon at the point where the ball lands on the ground.

displacement = ... m [2]

- (d) The ball leaves the cannon at time $t = 0$.

On Fig. 3.2, sketch a graph to show the variation of the magnitude v of the vertical component of the velocity of the ball with time t from $t = 0$ to $t = 3.4$ s. Numerical values are not required.

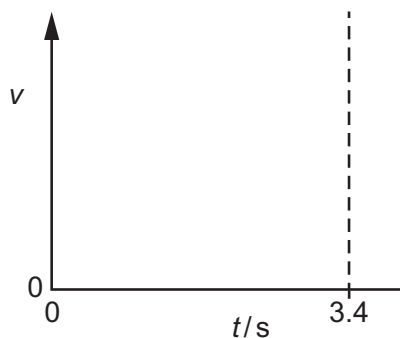


Fig. 3.2

[1]

- (e) The cannon recoils horizontally with a speed of 0.340 ms^{-1} when it fires the ball. The total mass of the ball and the cannon is 1480 kg . Assume that no external horizontal forces act on the ball-cannon system.

Determine, to three significant figures, the mass of the ball.

mass = ... kg [2]

- (f) The cannon now fires a ball of smaller mass. Assume that air resistance is still negligible.

State and explain the change, if any, to the graph in Fig. 3.2 due to the decreased mass of the ball.

.....

 [2]

[Total: 10]

18. Question part 1/2 | 9702 Feb-March 2021 P2 V2 Q1

1 (a) Complete Table 1.1 by stating whether each of the quantities is a vector or a scalar.

Table 1.1

quantity	vector or scalar
acceleration	
power	
work	

[2]

(b) The variation with time t of the velocity v of an object is shown in Fig. 1.1.

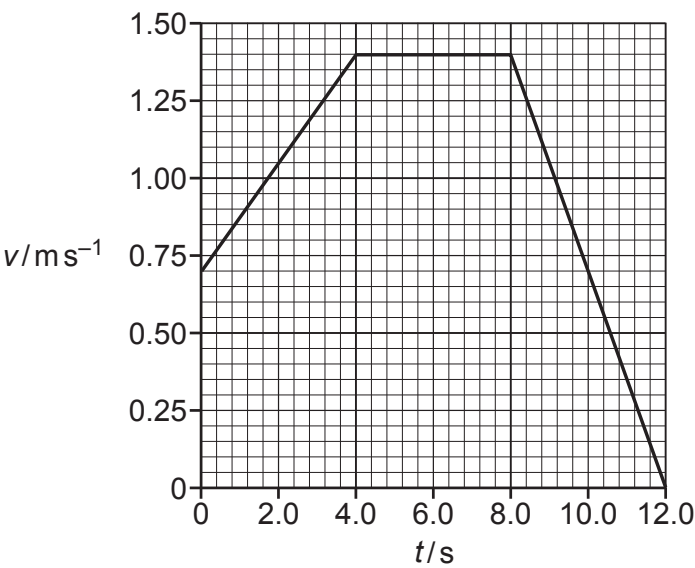


Fig. 1.1

(i) Determine the acceleration of the object from time $t = 0$ to time $t = 4.0$ s.

acceleration = ... ms^{-2} [2]

(ii) Determine the distance moved by the object from time $t = 0$ to time $t = 4.0\text{ s}$.

distance = ... m [2]

(c) (i) Define *force*.

.....
..... [1]

(ii) The motion represented in Fig. 1.1 is caused by a resultant force F acting on the object.

On Fig. 1.2, sketch the variation of F with time t from $t = 0$ to $t = 12.0\text{ s}$.
Numerical values of F are not required.

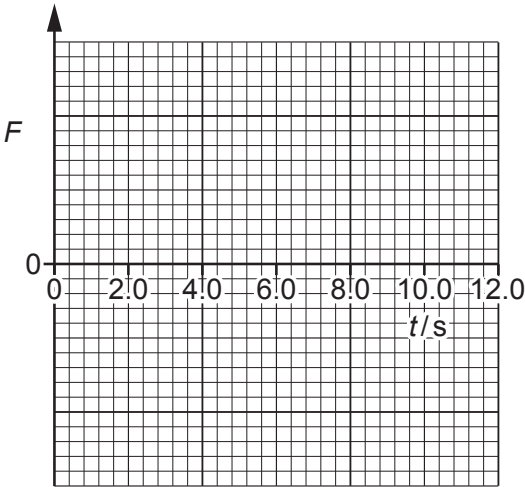


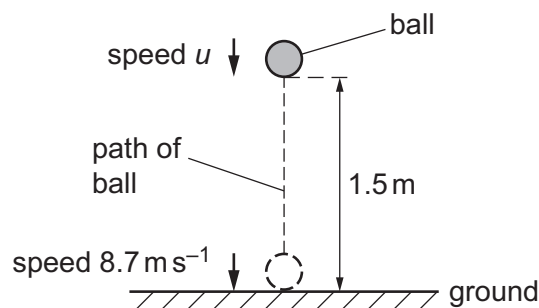
Fig. 1.2

[3]

[Total: 10]

19. Question part 1/2 | 9702 May-June 2021 P2 V2 Q2

- 2** A ball is thrown vertically downwards to the ground, as illustrated in Fig. 2.1.

**Fig. 2.1**

The ball is thrown with speed u from a height of 1.5 m. The ball then hits the ground with speed 8.7 m s^{-1} . Assume that air resistance is negligible.

- (a)** Calculate speed u .

$$u = \dots\dots\dots \text{ m s}^{-1} \quad [2]$$

- (b)** State how Newton's third law applies to the collision between the ball and the ground.

.....

 [2]

- (c)** The ball is in contact with the ground for a time of 0.091 s. The ball rebounds vertically and leaves the ground with speed 5.4 m s^{-1} . The mass of the ball is 0.059 kg.

- (i)** Calculate the magnitude of the change in momentum of the ball during the collision.

$$\text{change in momentum} = \dots\dots\dots \text{ N s} \quad [2]$$

19. Question part 2/2 | 9702 May-June 2021 P2 V2 Q2

(ii) Determine the magnitude of the average resultant force that acts on the ball during the collision.

average resultant force = ... N [1]

(iii) Use your answer in (c)(ii) to calculate the magnitude of the average force exerted by the ground on the ball during the collision.

average force = ... N [2]

(d) The ball was thrown downwards at time $t = 0$ and hits the ground at time $t = T$.

On Fig. 2.2, sketch a graph to show the variation of the speed of the ball with time t from $t = 0$ to $t = T$. Numerical values are not required.

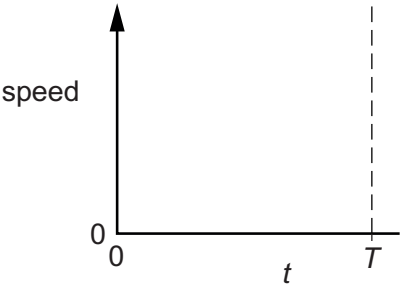


Fig. 2.2

[1]

(e) In practice, air resistance is not negligible.

State and explain the variation, if any, with time t of the gradient of the graph in (d) when air resistance is not negligible.

.....
.....
.....
..... [2]

[Total: 12]

2 (a) Define *acceleration*.

.....
..... [1]

(b) A stone falls vertically from the top of a cliff. Fig. 2.1 shows the variation with time t of the velocity v of the stone.

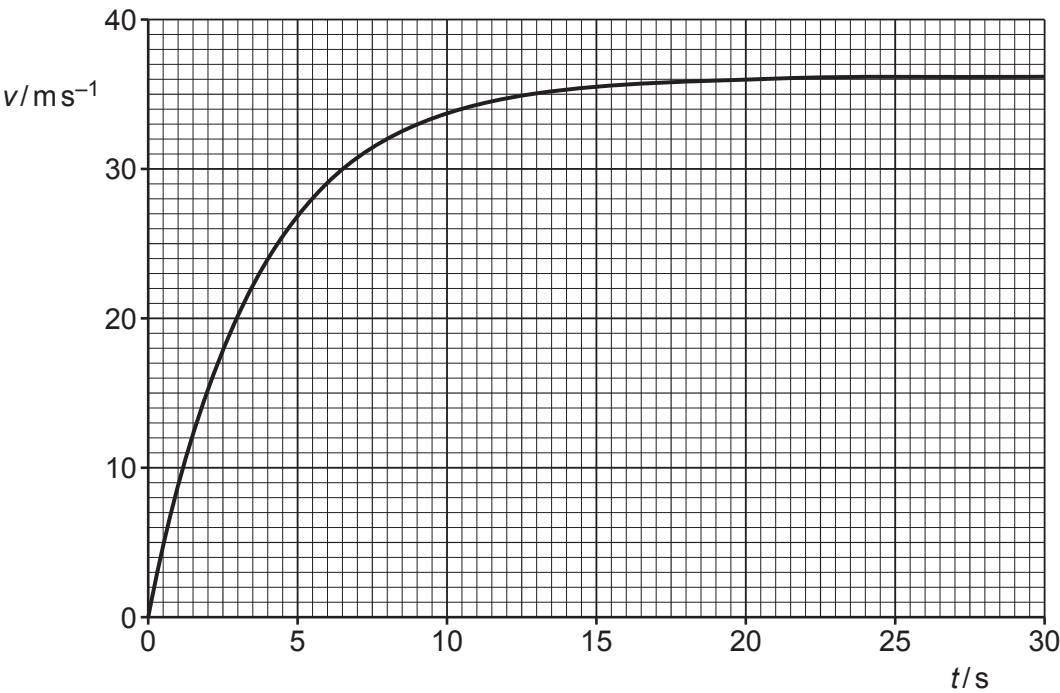


Fig. 2.1

(i) Explain, with reference to forces acting on the stone, the shape of the curve in Fig. 2.1.

.....
.....
.....
.....
..... [3]

(ii) Use Fig. 2.1 to determine the speed of the stone when the resultant force on it is zero.

speed = ... ms^{-1} [1]

- (iii) Use Fig. 2.1 to calculate the approximate height through which the stone falls between $t = 0$ and $t = 30\text{ s}$.

height = ... m [3]

- (iv) On Fig. 2.2, sketch the variation with t of the acceleration a of the stone between $t = 0$ and $t = 30\text{ s}$.

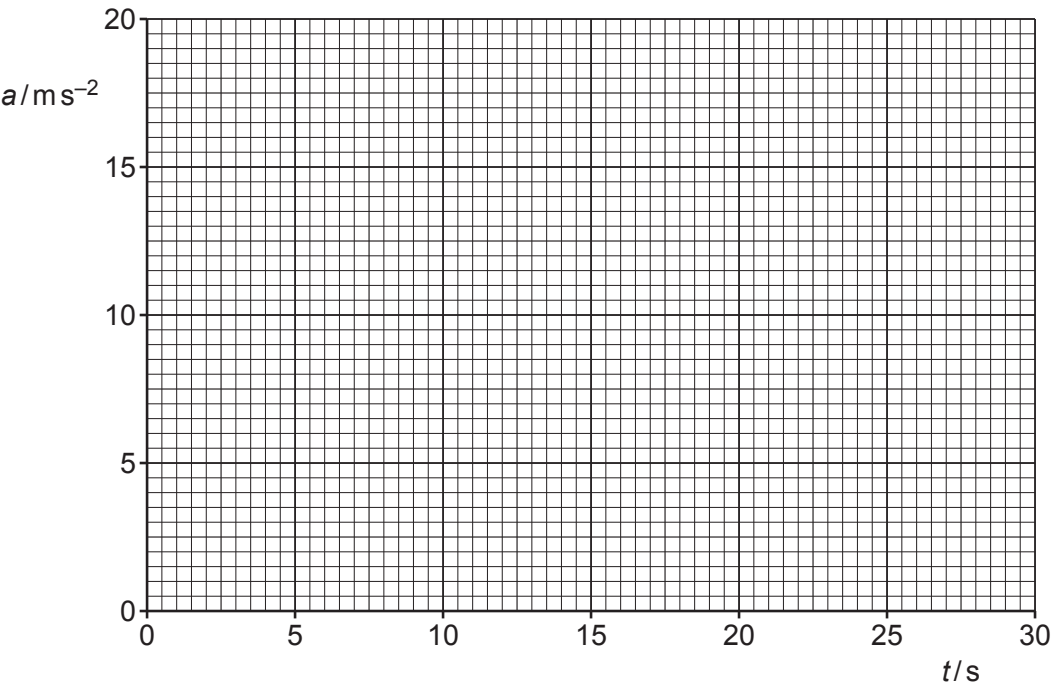


Fig. 2.2

[3]

[Total: 11]

3 (a) Define *velocity*.

.....
..... [1]

(b) A remote-controlled toy aircraft is flying horizontally in a wind. Fig. 3.1 shows the velocity vectors, to scale, of the wind and of the aircraft in still air.

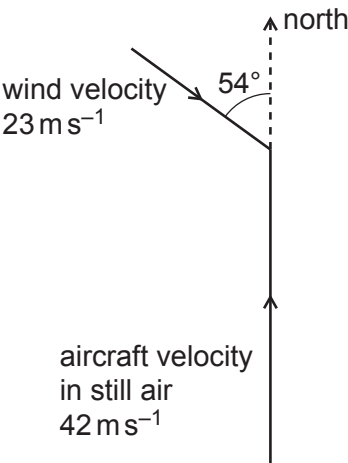


Fig. 3.1

The velocity of the aircraft in still air is 42 m s^{-1} to the north. The velocity of the wind is 23 m s^{-1} in a direction of 54° east of south.

Determine the magnitude of the resultant velocity of the aircraft.

magnitude of velocity = ... m s^{-1} [2]

- (c) The engine of the aircraft in (b) stops. The aircraft then glides towards the ground with a constant velocity at an angle θ to the horizontal, as illustrated in Fig. 3.2.

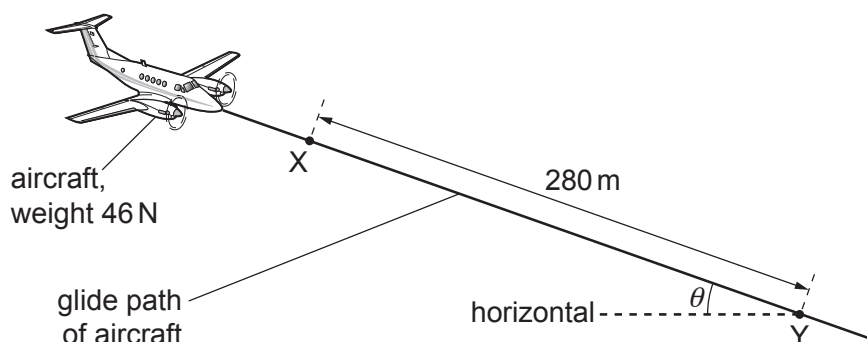


Fig. 3.2 (not to scale)

The aircraft has a weight of 46 N and travels a distance of 280 m from point X to point Y. The change in gravitational potential energy of the aircraft for its movement from X to Y is 6100 J.

Assume that there is now no wind.

- (i) Calculate angle θ .

$\theta = \dots\dots\dots^\circ$ [3]

- (ii) Calculate the magnitude of the force acting on the aircraft due to air resistance.

force = $\dots\dots\dots$ N [2]

- (d) The aircraft in (c) travels from X to Y in a time of 14 s. Fig. 3.3 shows that, as the aircraft travels from X to Y, it moves directly towards an observer who is standing on the ground.

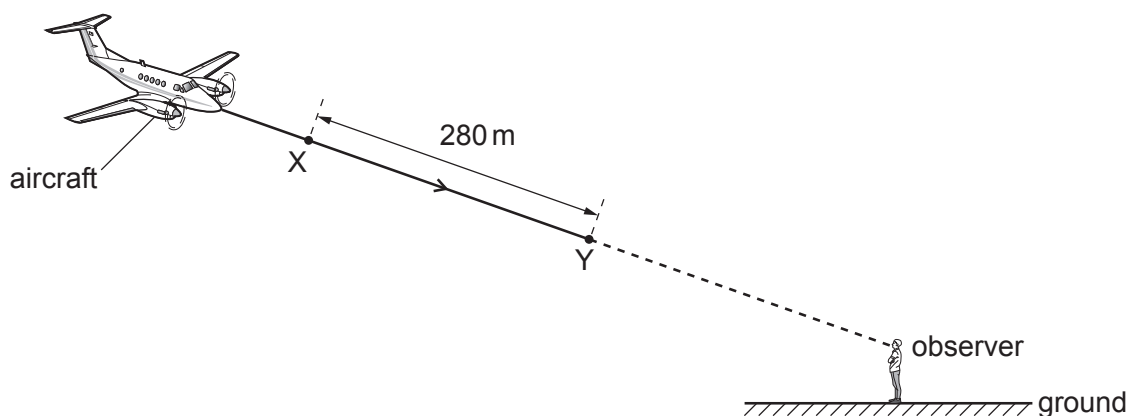


Fig. 3.3 (not to scale)

The aircraft emits sound as it travels from X to Y. The observer hears sound of frequency 450 Hz. The speed of the sound in the air is 340 m s^{-1} .

Calculate the frequency of the sound that is emitted by the aircraft.

frequency = ... Hz [3]

[Total: 11]

22. Question part 1/2 | 9702 Feb-March 2022 P2 V2 Q2

- 2
- Water leaves the end of a hose pipe at point P with a horizontal velocity of 6.6 ms^{-1} , as shown in Fig. 2.1.

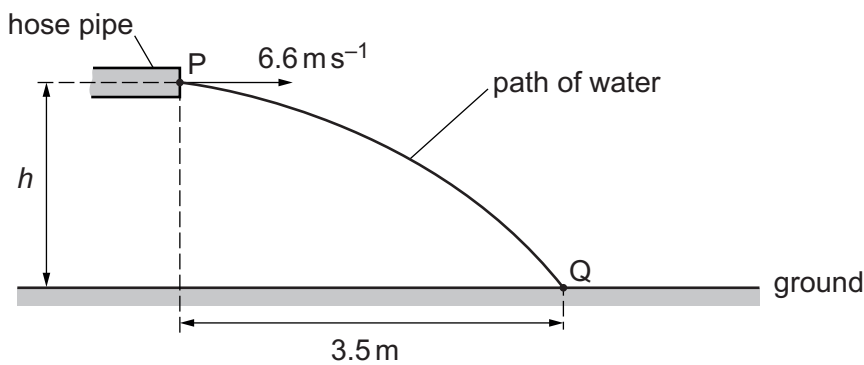


Fig. 2.1 (not to scale)

Point P is at height h above the ground. The water hits the ground at point Q. The horizontal distance from P to Q is 3.5m.

Air resistance is negligible. Assume that the water between P and Q consists of non-interacting droplets of water and that the only force acting on each droplet is its weight.

- (a)
- Explain, briefly, why the horizontal component of the velocity of a droplet of water remains constant as it moves from P to Q.

.....
..... [1]

- (b)
- Show that the time taken for a droplet of water to move from P to Q is 0.53 s.

[1]

- (c)
- Calculate height h .

$h =$ m [2]

(d) For the movement of a droplet of water from P to Q, state and explain whether the displacement of the droplet is less than, more than or the same as the distance along its path.

.....

.....

..... [1]

(e) Calculate the magnitude of the displacement of a droplet of water that moves from P to Q.

displacement = ...m [2]

[Total: 7]

1 (a) Define velocity.

.....
..... [1]

(b) A rock of mass 7.5 kg is projected vertically upwards from the surface of a planet. The rock leaves the surface of the planet with a speed of 4.0 m s^{-1} at time $t = 0$. The variation with time t of the velocity v of the rock is shown in Fig. 1.1.

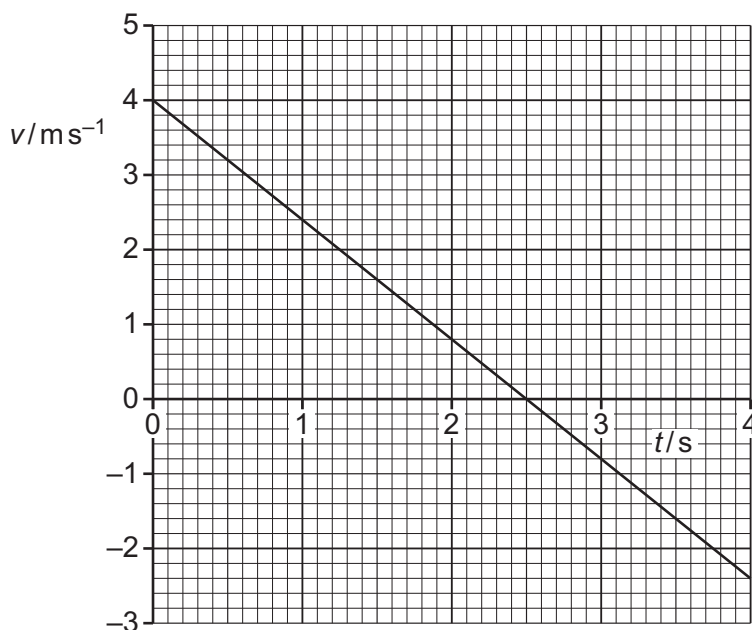


Fig. 1.1

Assume that the planet does not have an atmosphere and that the viscous force acting on the rock is always zero.

(i) Determine the height of the rock above the surface of the planet at time $t = 4.0\text{ s}$.

height = ... m [3]

(ii) Determine the change in the momentum of the rock from time $t = 0$ to time $t = 4.0\text{ s}$.

change in momentum = ... N s [2]

(iii) Determine the weight W of the rock on this planet.

$W =$ N [2]

(c) In practice, the planet in (b) does have an atmosphere that causes a viscous force to act on the moving rock.

State and explain the variation, if any, in the resultant force acting on the rock as it moves vertically upwards.

.....

.....

.....

..... [2]

[Total: 10]

24. Question part 1/2 | 9702 May-June 2022 P2 V2 Q3

- 3 A man standing on a wall throws a small ball vertically upwards with a velocity of 5.6 m s^{-1} . The ball leaves his hand when it is at a height of 3.1 m above the ground, as shown in Fig. 3.1.

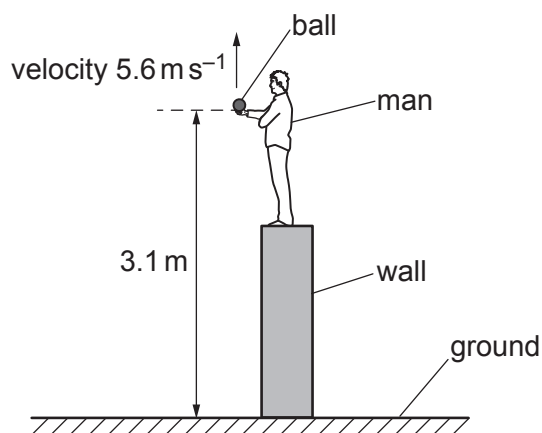


Fig. 3.1 (not to scale)

Assume that air resistance is negligible.

- (a) Show that the ball reaches a maximum height above the ground of 4.7 m .

[2]

- (b) The man does not catch the ball as it falls.

Calculate the time taken for the ball to fall from its maximum height to the ground.

time taken = ... s [2]

(c) The ball leaves the man’s hand at time $t = 0$ and hits the ground at time $t = T$.

On Fig. 3.2, sketch a graph to show the variation of the velocity v of the ball with time t from $t = 0$ to $t = T$. Numerical values of v and t are not required. Assume that v is positive in the upward direction.

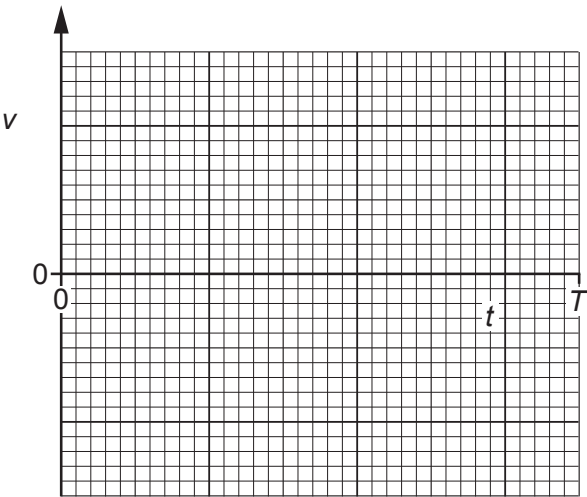


Fig. 3.2

[3]

(d) State what is represented by the gradient of the graph in (c).

..... [1]

(e) The man now throws a second ball with the same velocity and from the same height as the first ball. The mass of the second ball is greater than that of the first ball. Assume that air resistance is still negligible.

For the first and second balls, compare:

(i) the magnitudes of their accelerations

..... [1]

(ii) the speeds with which they hit the ground.

..... [1]

[Total: 10]

25. Question part 1/2 | 9702 May-June 2022 P2 V3 Q2

- 2 An archer releases an arrow towards a target at a velocity of 65.0 m s^{-1} at an angle of 4.30° above the horizontal, as shown in Fig. 2.1.

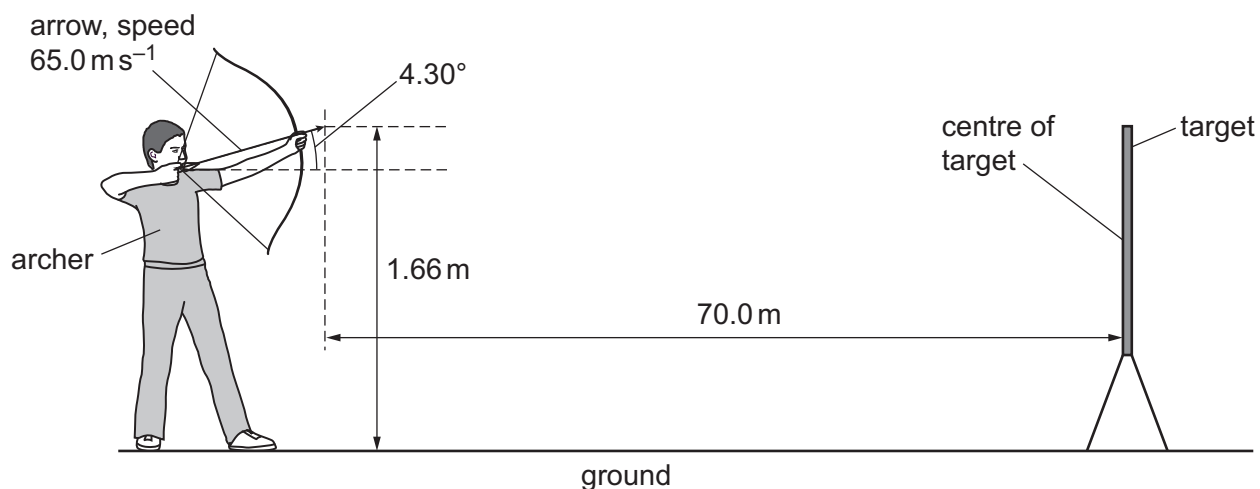


Fig. 2.1 (not to scale)

When released, the tip of the arrow is a horizontal distance of 70.0 m from the target and 1.66 m above the horizontal ground.

The arrow hits the centre of the target.

Assume that air resistance is negligible and that all the mass of the arrow is at its tip.

- (a) Show that the time taken for the arrow to reach the target is 1.08 s.

[2]

- (b) Calculate the height of the centre of the target above the ground.

height above ground = ... m [3]

(c) By considering energy changes, state and explain how the final kinetic energy of the arrow as it hits the target compares with its initial kinetic energy immediately after release. A numerical calculation is not required.

.....

.....

.....

..... [2]

[Total: 7]

- 2 A steel ball is projected horizontally from the top of a table, as shown in Fig. 2.1.

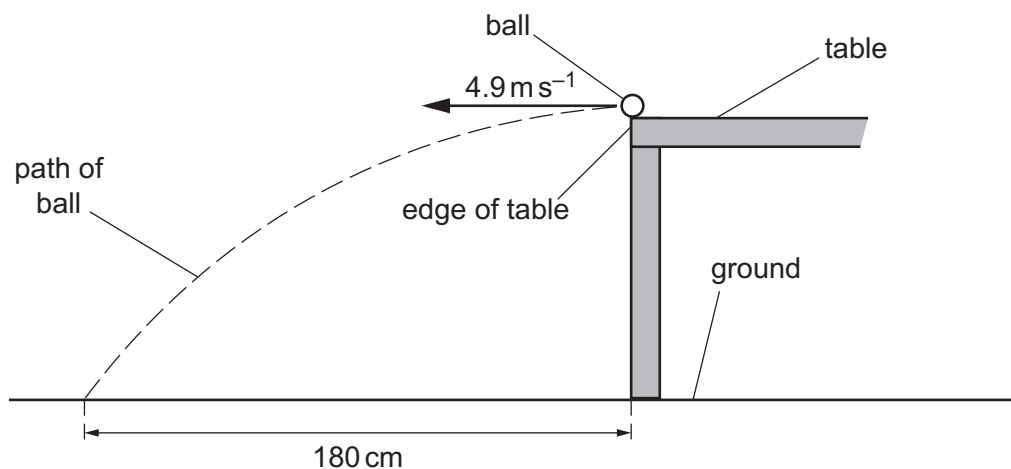


Fig. 2.1 (not to scale)

The ball is projected horizontally at a speed of 4.9 m s^{-1} . The ball lands on the ground a horizontal distance of 180 cm from the edge of the table.

Assume that air resistance is negligible.

- (a) (i) Calculate the time taken for the ball to reach the ground.

time = ... s [1]

- (ii) Calculate the vertical component of the velocity of the ball as it hits the ground.

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

- (iii) Determine the magnitude and the angle to the horizontal of the velocity of the ball as it hits the ground.

magnitude of velocity = ... ms^{-1}

angle to the horizontal = ... $^{\circ}$
[3]

- (b) The ball is projected by means of a compressed spring which is attached to a fixed block as shown in Fig. 2.2.

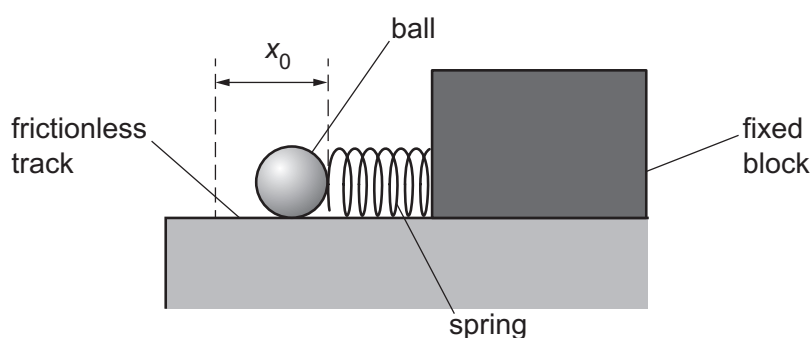


Fig. 2.2

The ball is placed on a frictionless track in front of the spring. The ball is then pulled back so that the spring has compression x_0 .

When the spring is released, the ball is projected horizontally as shown in Fig. 2.3.

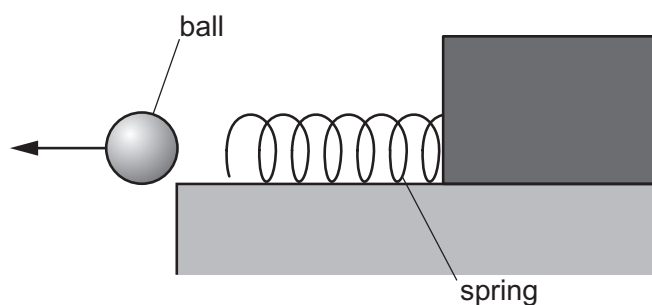


Fig. 2.3

The variation with compression x of the applied force F for the spring is shown in Fig. 2.4.

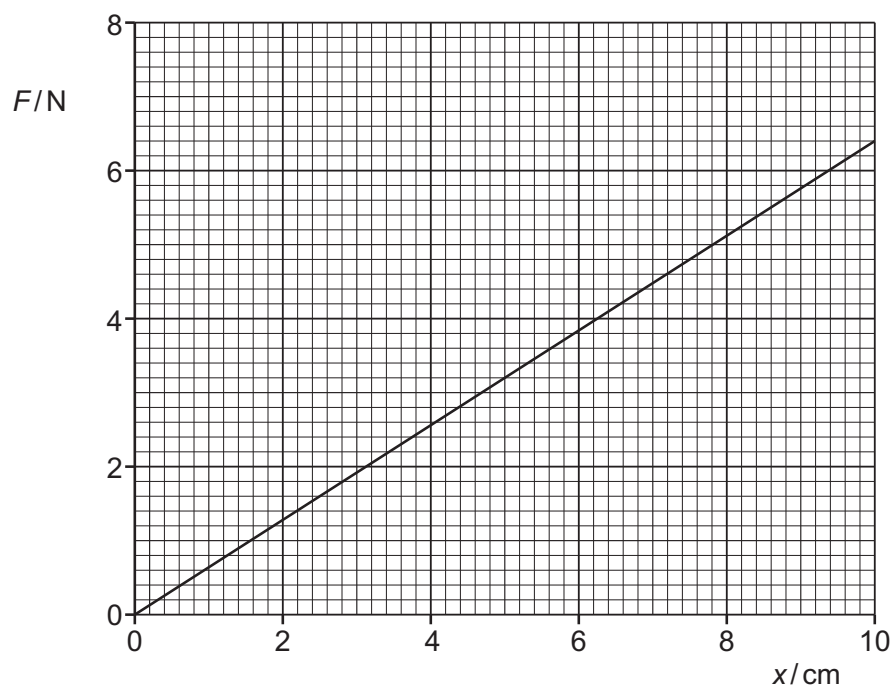


Fig. 2.4

The ball is a uniform sphere of steel of diameter 0.016 m and mass 0.017 kg.

- (i) Calculate the density of the steel.

density = ... kg m^{-3} [3]

- (ii) All of the elastic potential energy in the spring is converted into kinetic energy of the ball. The speed of the ball as it leaves the spring is 4.9 m s^{-1} .

Show that the maximum elastic potential energy of the spring is 0.20 J.

(iii) Use Fig. 2.4 to determine the spring constant k of the spring.

$$k = \dots\dots\dots \text{N m}^{-1} \quad [2]$$

(iv) Use your answer in (b)(iii) and the value of energy given in (b)(ii) to determine the compression x_0 of the spring.

$$x_0 = \dots\dots\dots \text{m} \quad [2]$$

(c) The steel ball is replaced by a polystyrene ball of the same diameter but of much lower mass. The spring is given compression x_0 and is then released.

Air resistance on this ball is **not** negligible after it leaves the spring.

Explain:

(i) why this ball leaves the spring with a greater speed than that of the steel ball

.....
.....
..... [1]

(ii) why this ball takes a longer time to reach the ground than the steel ball.

.....
.....
..... [1]

[Total: 17]

- 2** The engine of a toy rocket pushes gases vertically downwards and this results in the rocket accelerating vertically upwards from the ground.

The rocket starts to move from rest at time $t = 0$. The variation with time t of the vertical velocity v of the rocket for the first 0.30 s of the flight is shown in Fig. 2.1.

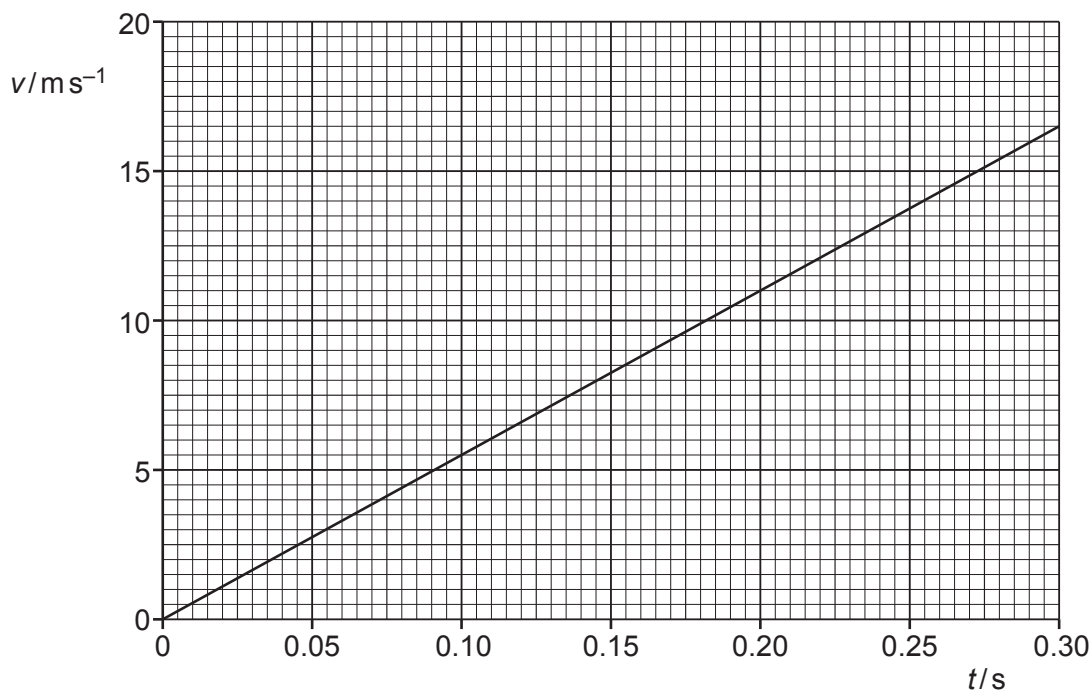


Fig. 2.1

As the rocket moves, the thrust force T provided by the rocket engine is 16 N. Assume that the mass of the rocket is constant for this part of its flight.

Assume that air resistance is negligible.

(a) For this part of the rocket's flight:

- (i)** show that the acceleration of the rocket is 55 m s^{-2}

[1]

- (ii)** state an expression for the resultant force F experienced by the rocket in terms of the thrust force T and the weight W of the rocket

[1]

9702 Physics Paper 2 - Kinematics

Topical questions | 38 questions

27. Question part 2/2 | 9702 Oct-Nov 2022 P2 V3 Q2

(iii) calculate the mass of the rocket.

mass = ... kg [2]

(b) At time $t = 0.30$ s, a small piece of metal separates from the rocket.

Calculate:

(i) the height of the rocket above the ground at $t = 0.30$ s

height = ... m [2]

(ii) the speed at which the piece of metal strikes the ground.

speed = ... ms^{-1} [3]

[Total: 9]

2 (a) Define acceleration.

.....
..... [1]

(b) A ball is kicked from horizontal ground towards a vertical wall, as shown in Fig. 2.1.

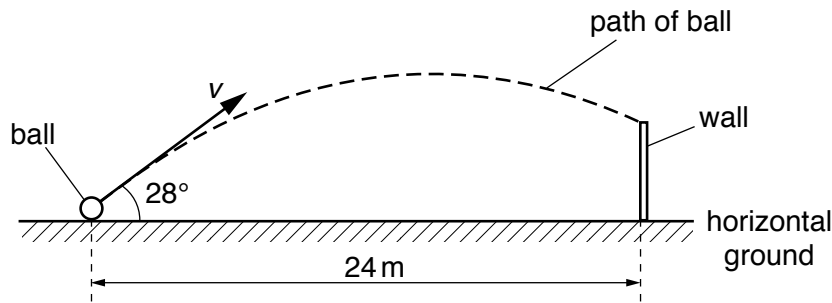


Fig. 2.1 (not to scale)

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball hits the top of the wall after a time of 1.5 s. Air resistance is negligible.

(i) Calculate the initial horizontal component v_x of the velocity of the ball.

$v_x = \dots\dots\dots \text{ m s}^{-1}$ [1]

(ii) Show that the initial vertical component v_y of the velocity of the ball is 8.5 m s^{-1} .

[2]

(iii) Calculate the time taken for the ball to reach its maximum height above the ground.

time = $\dots\dots\dots \text{ s}$ [2]

- (iv) The ball is kicked at time $t = 0$. Assume that the vertical component v_y of the velocity of the ball is positive in the upwards direction. On Fig. 2.2, sketch the variation with time t of v_y for the time until the ball hits the wall.

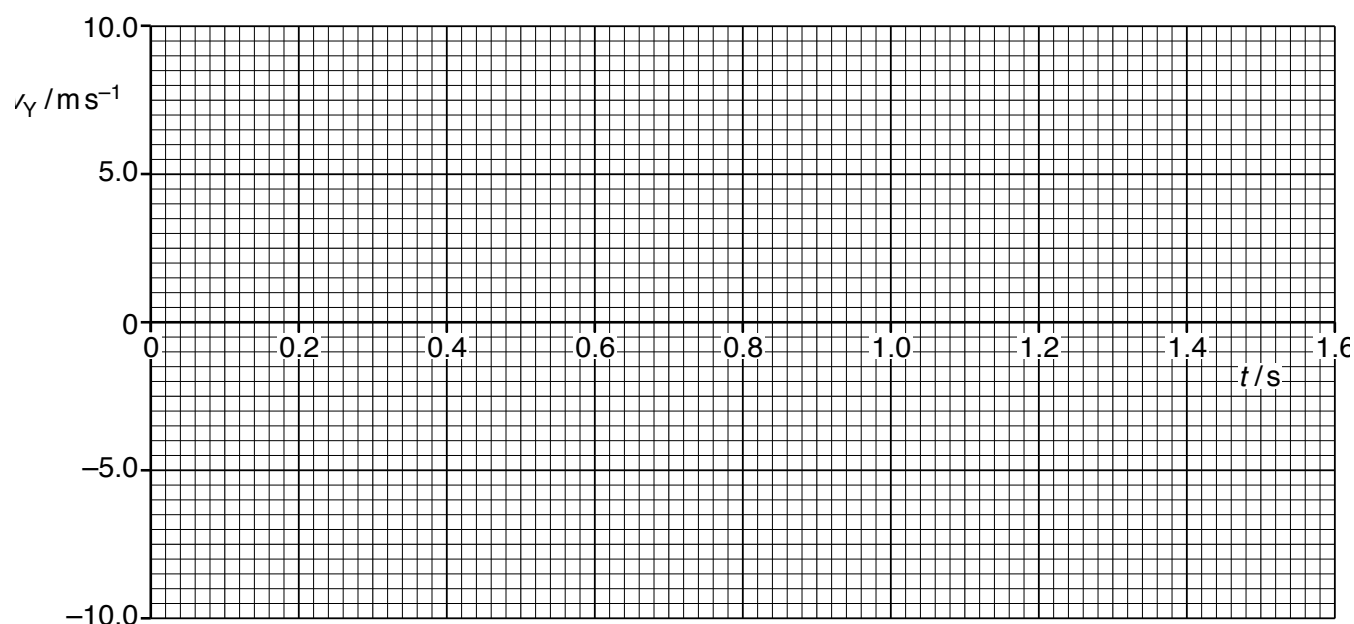


Fig. 2.2

[2]

- (c) (i) Calculate the maximum height above the ground of the ball in (b).

maximum height = ... m [2]

- (ii) The maximum gravitational potential energy of the ball above the ground is 22 J.

Calculate the mass of the ball.

mass = ... kg [2]

- (d) A ball of greater mass is kicked with the same velocity as the ball in (b).
Air resistance is still negligible.

State and explain the effect, if any, of the increased mass on the time taken by the ball to reach its maximum height.

.....
..... [1]

[Total: 13]

29. Question part 1/2 | 9702 May-June 2023 P2 V3 Q1

- 1 A well has a depth of 36 m from ground level to the surface of the water in the well, as shown in Fig. 1.1.

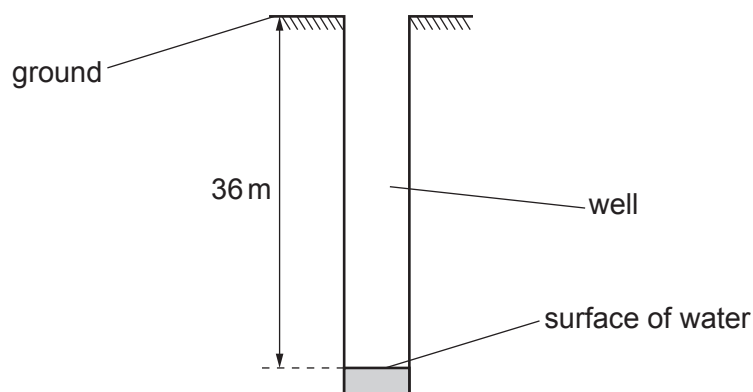


Fig. 1.1 (not to scale)

A student wishes to find the depth of the well. The student plans to drop a stone down the well and record the time taken from releasing the stone to hearing the splash made by the stone as it enters the water.

- (a) Assume that air resistance is negligible and that the stone is released from rest.

Calculate the time taken for the stone to fall from ground level to the surface of the water.

time = ... s [2]

- (b) The time recorded by the student using a stop-watch is not equal to the time in (a).
Suggest **three** possible reasons, other than the effect of air resistance, for this difference.
- 1
- 2
- 3
- [3]

- (c) The student repeats the experiment three times and uses the results to calculate the depth of the well. The values are shown in Table 1.1.

Table 1.1

	1st experiment	2nd experiment	3rd experiment
depth/m	54.4	53.9	54.1

The true depth of the well is 36.0 m. Explain why these results may be described as precise but not accurate.

.....

.....

.....

..... [2]

[Total: 7]

30. Question part 1/2 | 9702 Oct-Nov 2023 P2 V2 Q1

- 1 (a) In the following list, underline **all** quantities that are SI base quantities.

charge electric current force time [1]

- (b) Under certain conditions, the distance s moved in a straight line by an object in time t is given by

$$s = \frac{1}{2}at^2$$

where a is the acceleration of the object.

State **two** conditions under which the above expression applies to the motion of the object.

1

2

[2]

- (c) The variation with time t of the velocity v of a car that is moving in a straight line is shown in Fig. 1.1.

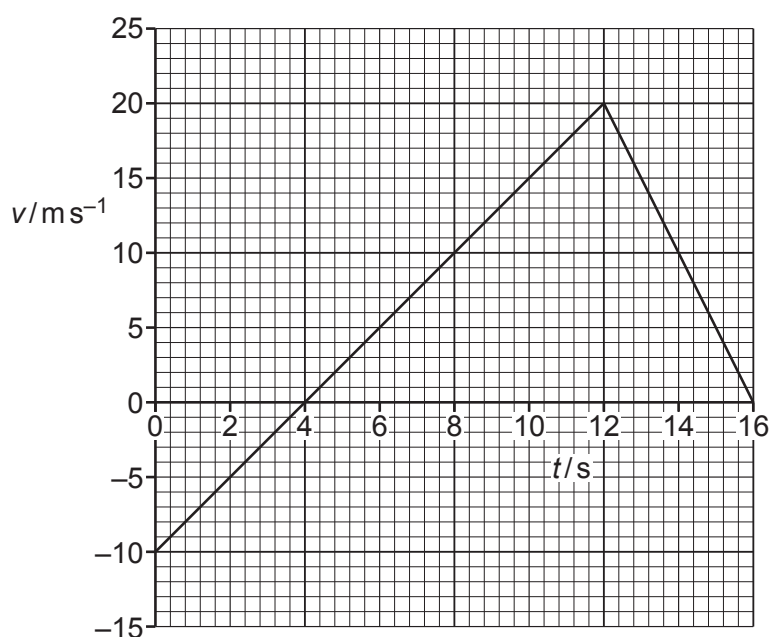


Fig. 1.1

30. Question part 2/2 | 9702 Oct-Nov 2023 P2 V2 Q1

(i) Compare, qualitatively, the acceleration of the car at time $t = 8.0\text{ s}$ and at time $t = 14.0\text{ s}$ in terms of:

- magnitude

.....

.....

- direction.

.....

.....

[2]

(ii) Determine the magnitude of the acceleration of the car at time $t = 4.0\text{ s}$.

acceleration = ... ms^{-2} [2]

(iii) The car is at point X at time $t = 0$.

Determine the magnitude of the displacement of the car from X at time $t = 12.0\text{ s}$.

displacement = ... m [2]

[Total: 9]

- 2 A ball on horizontal ground is kicked towards a vertical wall. Fig. 2.1 shows the path of the ball.

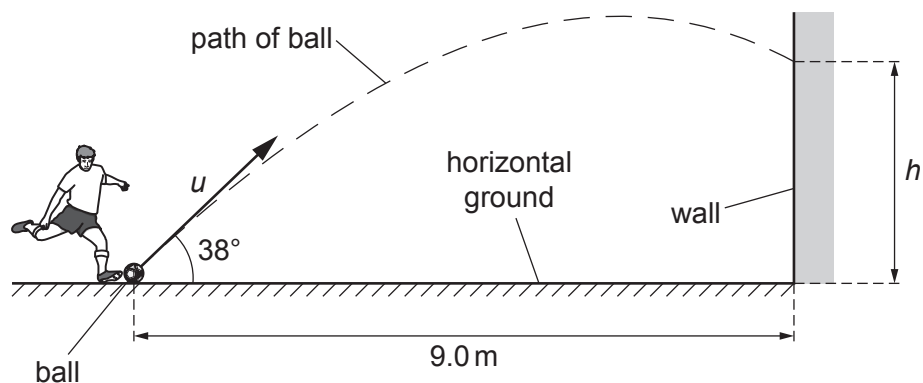


Fig. 2.1 (not to scale)

The ball has an initial velocity u at an angle of 38° to the ground. The ball travels a horizontal distance of 9.0 m before striking the wall at a height h above the ground. The horizontal component u_H of the initial velocity of the ball is 9.5 m s^{-1} .

Air resistance is negligible.

- (a) (i) Show that the time t for the ball to reach the wall is 0.95 s .

[1]

- (ii) Calculate the vertical component u_V of the initial velocity of the ball.

$$u_V = \dots\dots\dots \text{ m s}^{-1} \quad [2]$$

- (iii) Determine h .

$$h = \dots\dots\dots \text{ m} \quad [2]$$

31. Question part 2/2 | 9702 Oct-Nov 2023 P2 V3 Q2

(b) The speed of the ball just after striking the wall is less than its speed just before striking the wall.

State what this indicates about the nature of the collision of the ball with the wall.

.....
..... [1]

[Total: 6]

2 (a) Define velocity.

.....

..... [1]

(b) A student throws a ball over a vertical wall of height h , as shown in Fig. 2.1.

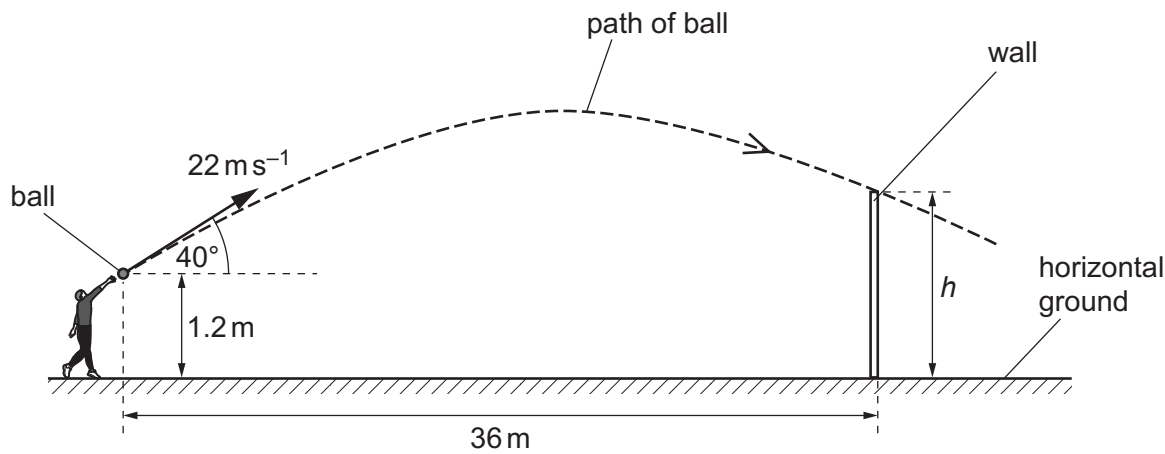


Fig. 2.1 (not to scale)

The ball leaves the hand of the student at a height of 1.2 m above the horizontal ground.
The ball has an initial velocity of 22 m s^{-1} at an angle of 40° to the horizontal.
The wall is a horizontal distance of 36 m from where the student releases the ball.

Air resistance is negligible.

(i) Determine the time taken for the ball to reach the wall.

time taken = ... s [2]

9702 Physics Paper 2 - Kinematics

Topical questions | 38 questions

32. Question part 2/2 | 9702 May-June 2024 P2 V1 Q2

(ii) Calculate the vertical component u of the initial velocity of the ball.

$u = \dots\dots\dots \text{ms}^{-1}$ [1]

(iii) The ball just goes over the wall.

Calculate the height h of the wall.

$h = \dots\dots\dots \text{m}$ [3]

[Total: 7]

2 (a) Define displacement from a point.

.....
..... [1]

(b) An object is projected horizontally at a speed of 6.0 m s^{-1} from a slope, as shown in Fig. 2.1.

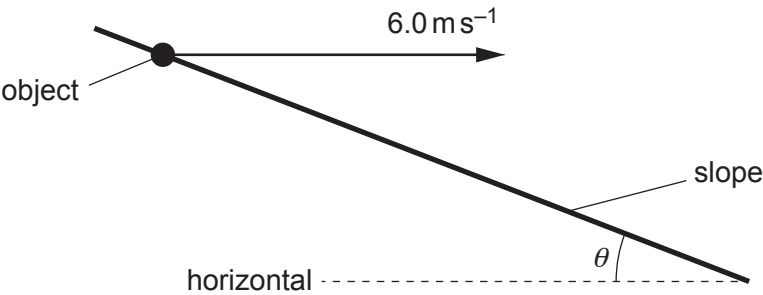


Fig. 2.1 (not to scale)

The slope is at an angle θ to the horizontal. Air resistance is negligible.
The object lands on the slope a time of 0.71 s later and stops without rolling or bouncing.

(i) Determine the horizontal distance travelled by the object.

distance = ... m [1]

(ii) Determine the vertical distance travelled by the object.

distance = ... m [2]

9702 Physics Paper 2 - Kinematics

Topical questions | 38 questions

33. Question part 2/2 | 9702 May-June 2024 P2 V3 Q2

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to calculate θ .

$$\theta = \dots\dots\dots^\circ \quad [2]$$

(iv) Determine the magnitude of the displacement of the object from its original position.

$$\text{displacement} = \dots\dots\dots \text{ m} \quad [2]$$

(v) By considering energy, calculate the speed of the object just before it lands.

$$\text{speed} = \dots\dots\dots \text{ ms}^{-1} \quad [3]$$

[Total: 11]

34. Question part 1/2 | 9702 Oct-Nov 2024 P2 V3 Q1

1 (a) Define acceleration.

.....

..... [1]

(b) A small aircraft is flying horizontally at a speed of 42 m s^{-1} at a height of 63 m above horizontal ground, as shown in Fig. 1.1.

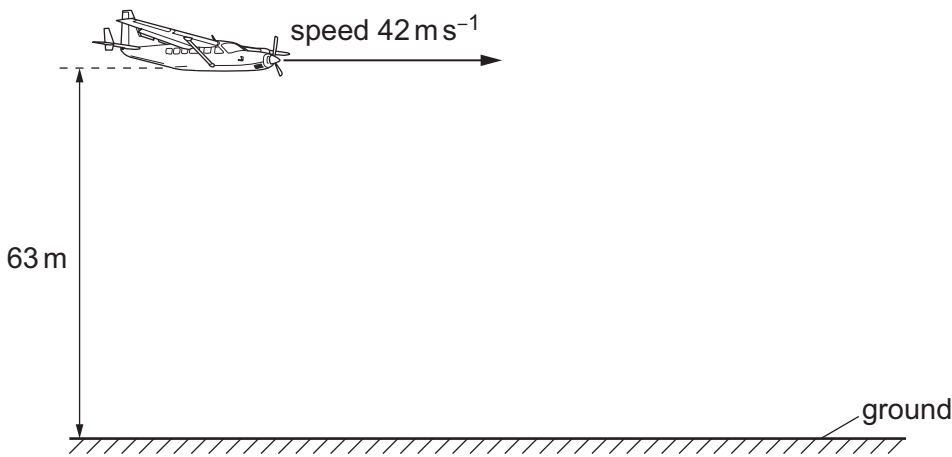


Fig. 1.1

The aircraft drops a small parcel. The parcel is released from the aircraft at the instant shown in Fig. 1.1. Air resistance is negligible.

- (i) On Fig. 1.1, draw a line to show the path of the parcel as it falls from the aircraft to the ground. [1]
- (ii) Calculate the time taken from the instant of release to the instant the parcel reaches the ground.

time = ... s [2]

34. Question part 2/2 | 9702 Oct-Nov 2024 P2 V3 Q1



(iii) Calculate the vertical component of the velocity of the parcel immediately before it reaches the ground.

vertical component of velocity = ... ms^{-1} [1]

(iv) Determine the speed at which the parcel reaches the ground.

speed = ... ms^{-1} [2]

[Total: 7]

35. Question part 1/2 | 9702 May-June 2025 P2 V1 Q1

1 (a) Define acceleration.

.....
..... [1]

(b) In an experiment, two objects A and B are released from the side of a building, as shown in Fig. 1.1.

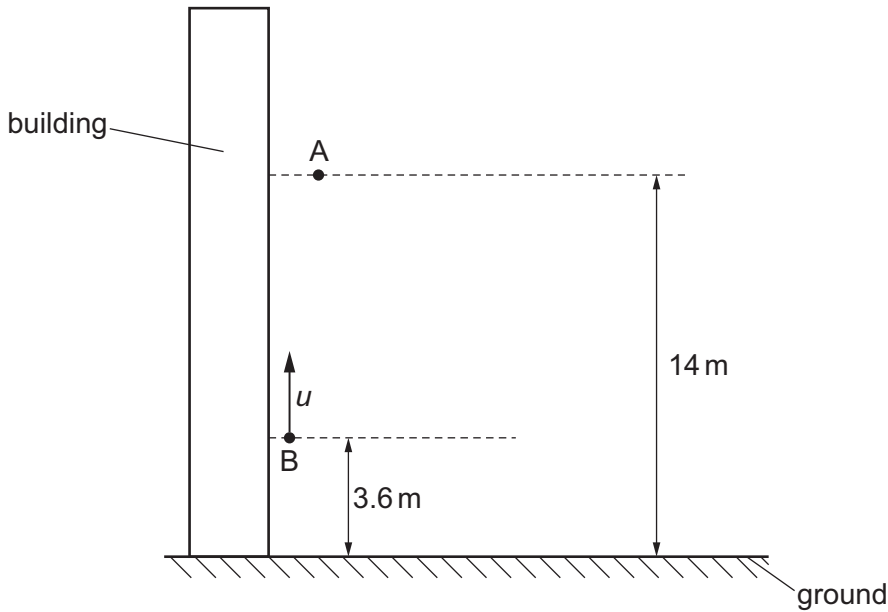


Fig. 1.1 (not to scale)

Object A is released from rest at a height of 14 m above the horizontal ground.
Object B is released with an initial upwards vertical velocity u at a height of 3.6 m above the ground.
Both objects take the same time to reach the ground and they do not collide with each other.
Air resistance is negligible.

(i) Calculate the time taken for object A to reach the ground.

time = ... s [2]

(ii) Use your answer in (b)(i) to calculate u .

u = ... ms^{-1} [2]

35. Question part 2/2 | 9702 May-June 2025 P2 V1 Q1



(c) In a second experiment, object B is released from the same height and given the same initial speed as in (b) but at a release angle θ to the vertical, as shown in Fig. 1.2.

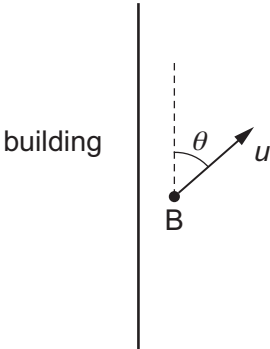


Fig. 1.2

(i) State and explain whether the time taken for object B to reach the ground is less than, the same as or greater than the time in (b)(i).

.....

.....

..... [2]

(ii) By considering energy, state and explain the effect of the change in release angle on the speed at which B reaches the ground.

.....

.....

..... [2]

[Total: 9]

36. Question part 1/2 | 9702 May-June 2025 P2 V3 Q1

1 (a) Define velocity.

.....
..... [1]

(b) In an experiment, two objects A and B are released from the side of a building, as shown in Fig. 1.1.

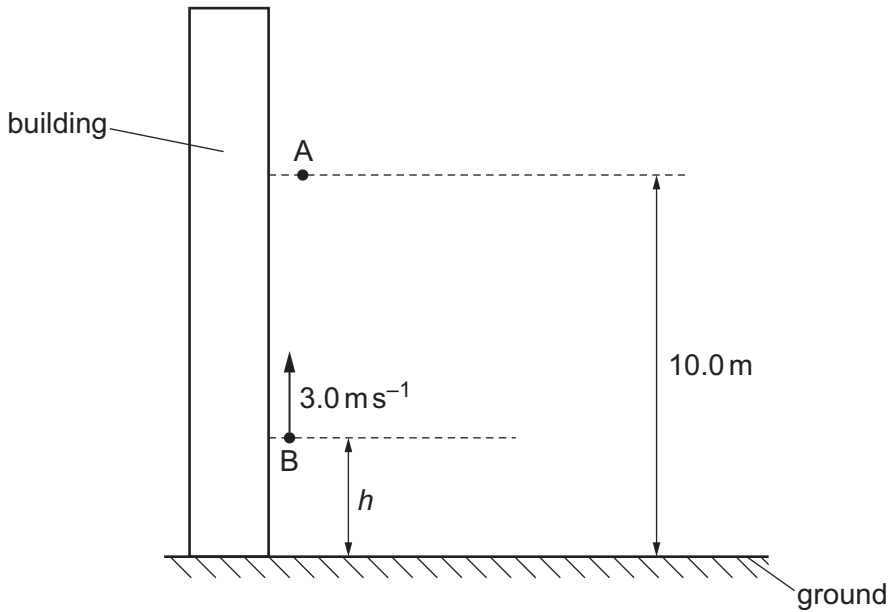


Fig. 1.1 (not to scale)

Object A is released from rest at a height of 10.0 m above horizontal ground.
Object B is released with an initial upward velocity of 3.0 ms⁻¹ at a height h above the ground.
Both objects take the same time to reach the ground and they do not collide with each other.
Air resistance is negligible.

Calculate h.

h = ... m [3]

36. Question part 2/2 | 9702 May-June 2025 P2 V3 Q1



(c) In a second experiment, object B is released from the same height as in (b) but with a speed of 6.0 m s^{-1} at an angle of 60° to the vertical, as shown in Fig. 1.2.

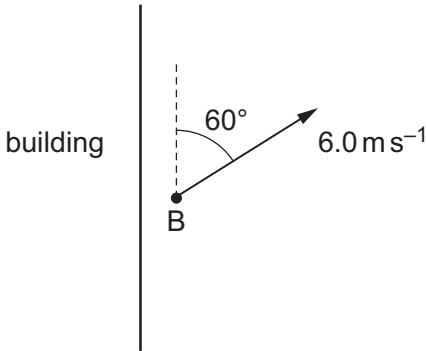


Fig. 1.2

(i) State and explain whether the time taken for object B to reach the ground is less than, the same as, or greater than the time taken in the first experiment.

.....

.....

..... [2]

(ii) By considering energy, state and explain whether the speed at which object B reaches the ground is less than, the same as, or greater than in the first experiment.

.....

.....

..... [2]

[Total: 8]

37. Question part 1/2 | 9702 Oct-Nov 2025 P2 V3 Q1

1 (a) Define acceleration.

.....

..... [1]

(b) A rocket is launched vertically from the surface of the Earth.

Fig. 1.1 shows the variation of the velocity of the rocket with time for the first 20 s after its launch.

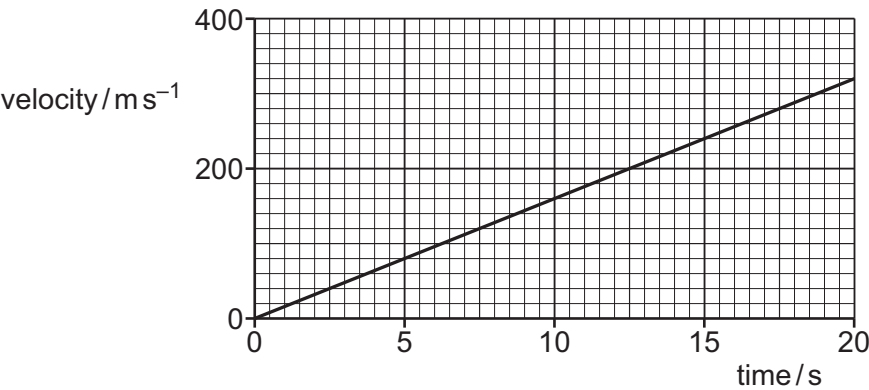


Fig. 1.1

(i) Determine the acceleration of the rocket.

acceleration = ... ms⁻² [1]

(ii) Show that the height of the rocket above the surface of the Earth at a time of 20 s after launch is 3.2 km.

37. Question part 2/2 | 9702 Oct-Nov 2025 P2 V3 Q1



(c) The mass of the rocket in (b) is $2.9 \times 10^6 \text{ kg}$. Assume that this mass remains constant.

For this rocket, from launch to its height at a time of 20 s after launch:

(i) calculate the gain in gravitational potential energy ΔE_p

$\Delta E_p = \dots\dots\dots \text{ J [2]}$

(ii) calculate the gain in kinetic energy ΔE_k

$\Delta E_k = \dots\dots\dots \text{ J [2]}$

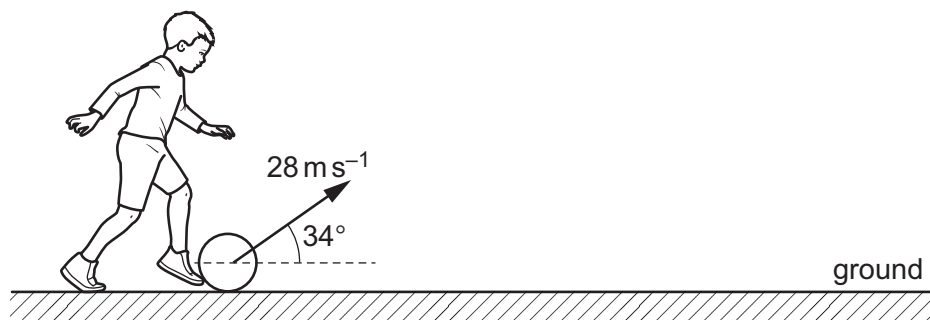
(iii) determine the average power output of the rocket engines. Assume that resistive forces are negligible.

power = $\dots\dots\dots \text{ W [2]}$

[Total: 10]

38. Question part 1/2 | 9702 Oct-Nov 2025 P2 V4 Q1

- 1 A child kicks a ball so that it leaves horizontal ground with a velocity of 28 m s^{-1} at an angle of 34° to the horizontal, as shown in Fig. 1.1.

**Fig. 1.1**

Air resistance is negligible. The ball leaves the ground at time $t = 0$.

- (a) (i) Calculate the horizontal component v_H and the vertical component v_V of the velocity of the ball immediately after it has left the ground.

$$v_H = \dots\dots\dots \text{ m s}^{-1}$$

$$v_V = \dots\dots\dots \text{ m s}^{-1}$$

[2]

- (ii) Show that the ball reaches its maximum height at time $t = 1.6 \text{ s}$.

[1]

38. Question part 2/2 | 9702 Oct-Nov 2025 P2 V4 Q1



(iii) On Fig. 1.2, sketch the variation of v_H with time t between $t = 0$ and $t = 3.2$ s. Label your line H.

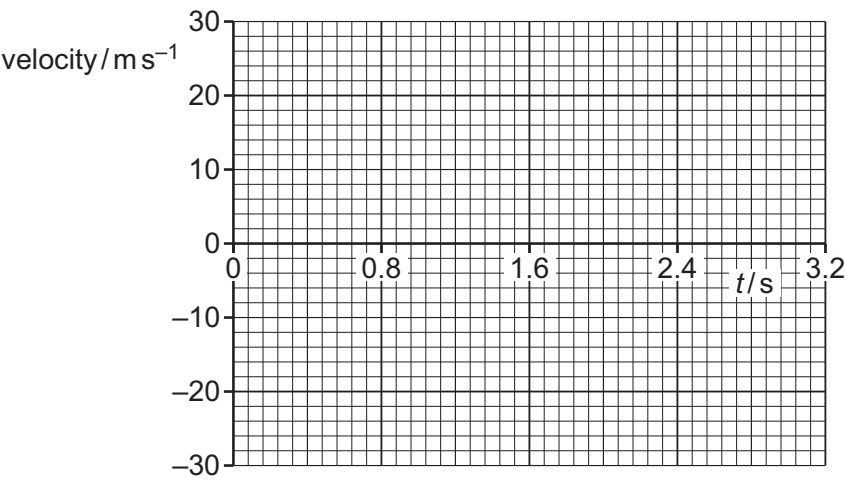


Fig. 1.2

[1]

(iv) On Fig. 1.2, sketch the variation of v_V with time t between $t = 0$ and $t = 3.2$ s. Assume that velocity in the upward direction is positive. Label your line V. [3]

(b) The total change in momentum of the ball between leaving the ground at $t = 0$ and landing on the ground at $t = 3.2$ s is 13 kg ms^{-1} .

(i) Define momentum.

.....
..... [1]

(ii) Calculate the force that acts on the ball while it is in the air.

force = ... N [2]

(iii) Determine the mass of the ball.

mass = ... kg [1]

[Total: 11]