1. Physical Quantities and Units

1.4 Scalars and vectors

Paper 2

Question Paper

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

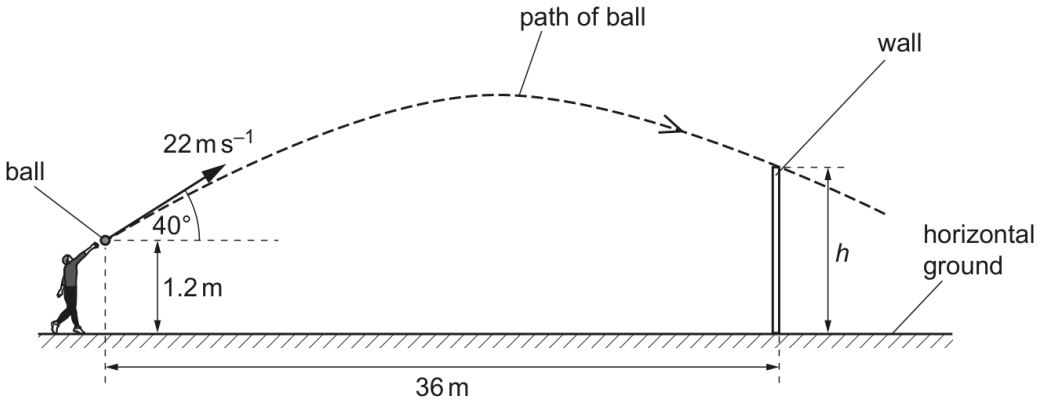


Fig. 2.1 (not to scale)

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.

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

u = ...m s^{-1} [1]

2 **(a)** State what is meant by a vector quantity.

.....

..... [1]

3 A rigid uniform beam of weight *W* is connected to a fixed support by a hinge, as shown in Fig. 2.1.

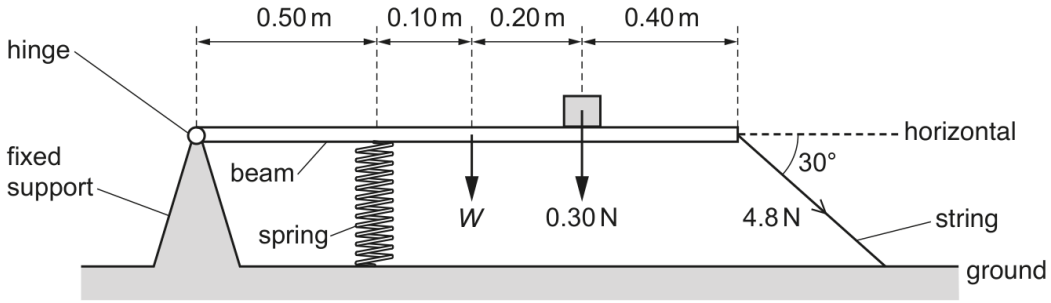


Fig. 2.1 (not to scale)

A compressed spring exerts a total force of 8.2 N vertically upwards on the horizontal beam. A block of weight 0.30 N rests on the beam. The right-hand end of the beam is connected to the ground by a string at an angle of 30° to the horizontal. The tension in the string is 4.8 N. The distances along the beam are shown in Fig. 2.1.

The beam is in equilibrium. Assume that the hinge is frictionless.

(a) **(i)** Show that the vertical component of the tension in the string is 2.4 N.

[1]

4 **(a)** Compare scalar and vector quantities.

.....

.....

..... [2]

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

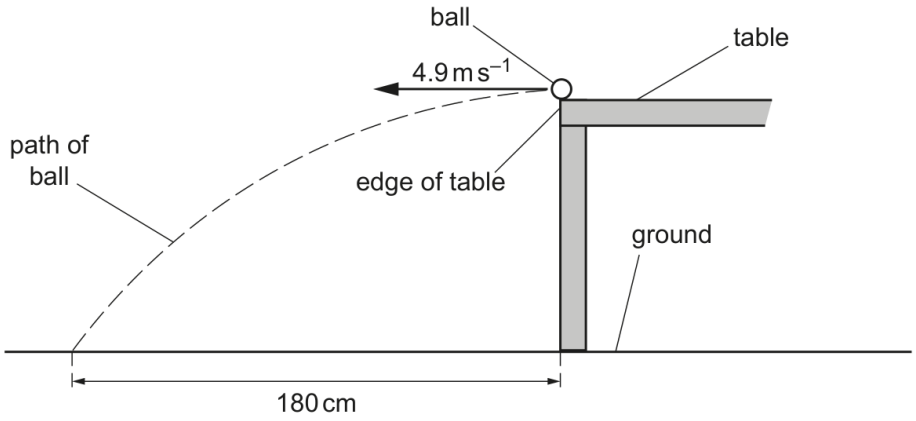


Fig. 2.1 (not to scale)

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

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

angle to the horizontal = ... °

[3]

6 **(c)** The lorry in **(b)** travels up a straight section of road that is inclined at an angle θ to the horizontal, as shown in Fig. 3.1.

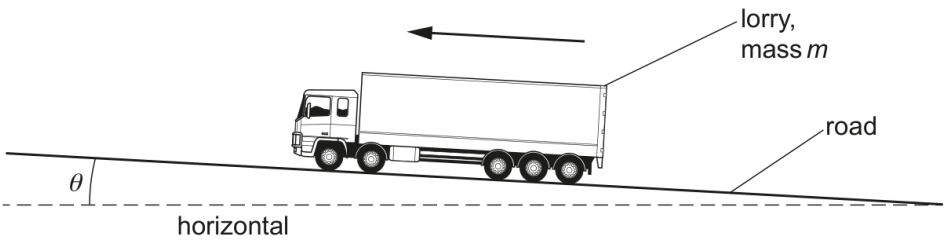


Fig. 3.1 (not to scale)

The lorry has mass m and the acceleration of free fall is g.

(i) Determine an expression, in terms of m, g and θ, for the component of the weight of the lorry that acts parallel to the surface of the road.

[1]

7 **(b)** A uniform beam AB is attached by a frictionless hinge to a vertical wall at end A. The beam is held so that it is horizontal by a metal wire CD, as shown in Fig. 3.1.

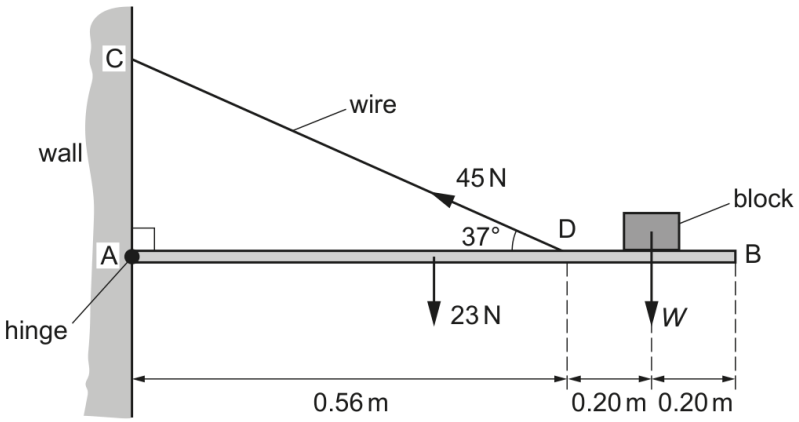


Fig. 3.1 (not to scale)

The beam is of length 0.96 m and weight 23 N. A block of weight *W* rests on the beam at a distance of 0.20 m from end B. The wire is attached to the beam at point D which is a distance of 0.40 m from end B. The wire exerts a force on the beam of 45 N at an angle of 37° to the horizontal. The beam is in equilibrium.

(i) Calculate the vertical component of the force exerted by the wire on the beam.

vertical component of the force = ... N [1]

8 A pendulum consists of a solid sphere suspended by a string from a fixed point P, as shown in Fig. 3.1.

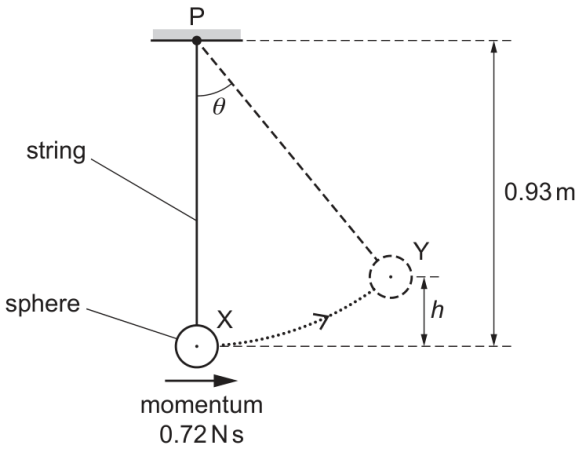


Fig. 3.1 (not to scale)

The sphere swings from side to side. At one instant the sphere is at its lowest position X, where it has kinetic energy 0.86 J and momentum 0.72 N s in a horizontal direction. A short time later the sphere is at position Y, where it is momentarily stationary at a maximum vertical height *h* above position X.

The string has a fixed length and negligible weight. Air resistance is also negligible.

(a) On Fig. 3.1, draw a solid line to represent the displacement of the centre of the sphere at position Y from position X. [1]

9 **(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	
electrical resistance	
momentum	

[2]

10 **(c)** The movement of the car in **(b)** from A to B causes its gravitational potential energy to increase by 4.8×10^4 J.

Calculate:

(ii) angle θ.

θ = ... ° [1]

11 (b) A ball is kicked with a velocity of $15\,m\,s^{-1}$ 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.

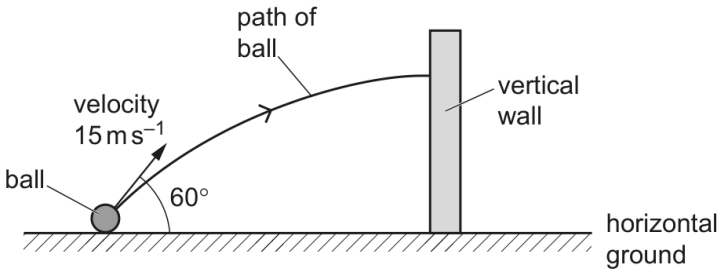


Fig. 2.2 (not to scale)

Assume that air resistance is negligible.

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

[1]

12 (c) A fishing rod AB, made from the rod in **(b)**, is shown in Fig. 1.2.

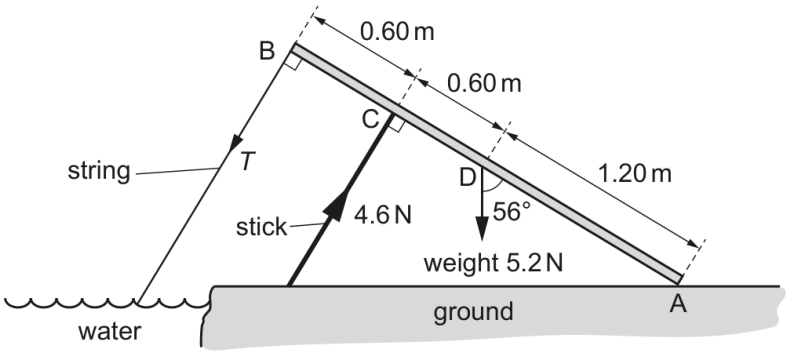


Fig. 1.2 (not to scale)

End A of the rod rests on the ground and a string is attached to the other end B. A support stick exerts a force perpendicular to the rod at point C. The weight of the rod acts at point D.

The tension *T* in the string is in a direction perpendicular to the rod. The rod is in equilibrium and inclined at an angle of 56° to the vertical.

The forces and the distances along the rod of points A, B, C and D are shown in Fig. 1.2.

(i) Show that the component of the weight that is perpendicular to the rod is 4.3 N.

[1]

13 **(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]

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

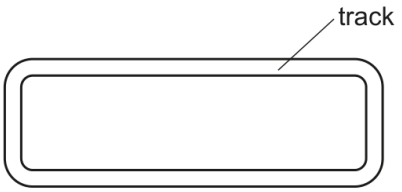


Fig. 1.2

The train completes exactly one lap of the loop.

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

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.....

..... [1]

14 A rigid plank is used to make a ramp between two different horizontal levels of ground, as shown in Fig. 4.1.

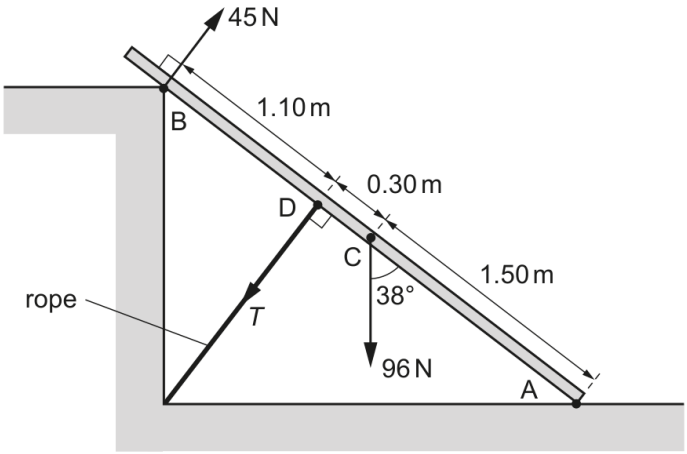


Fig. 4.1 (not to scale)

Point A at one end of the plank rests on the lower level of the ground. A force acts on, and is perpendicular to, the plank at point B. The plank is held in equilibrium by a rope that connects point D on the plank to the ground. The plank has a weight that may be considered to act from its centre of gravity C.

The rope is perpendicular to the plank and has tension *T*. The plank is at an angle of 38° to the vertical.

The forces and the distances along the plank of points A, B, C and D are shown in Fig. 4.1.

(a) Show that the component of the weight that is perpendicular to the plank is 59 N.

[1]

15 (b) A uniform square sign with sides of length 0.68 m is fixed at its corner points A and B to a wall. The sign is also supported by a wire CD, as shown in Fig. 3.1.

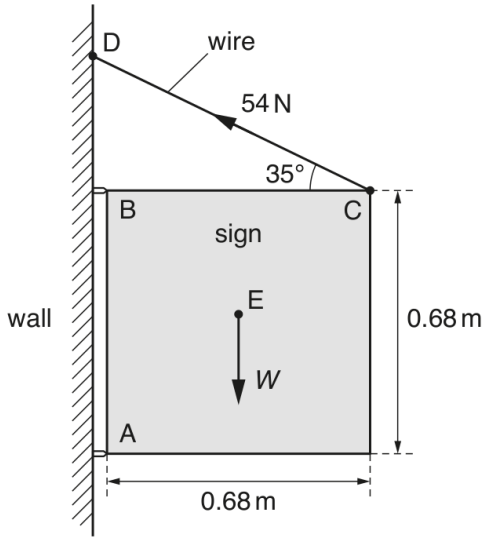


Fig. 3.1 (not to scale)

The sign has weight *W* and centre of gravity at point E. The sign is held in a vertical plane with side BC horizontal. The wire is at an angle of 35° to side BC. The tension in the wire is 54 N.

The force exerted on the sign at B is only in the vertical direction.

(i) Calculate the vertical component of the tension in the wire.

vertical component of tension = ... N [1]

16 A small charged glass bead of weight 5.4×10^{-5} N is initially at rest at point A in a vacuum. The bead then falls through a uniform horizontal electric field as it moves in a straight line to point B, as illustrated in Fig. 2.1.

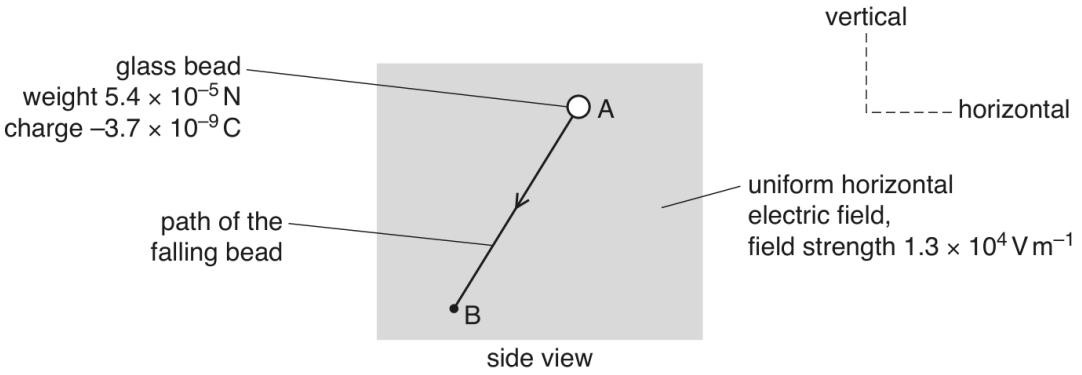


Fig. 2.1 (not to scale)

The electric field strength is 1.3×10^4 V m^{-1}. The charge on the bead is -3.7×10^{-9} C.

(b) Determine the magnitude of the electric force acting on the bead.

electric force = ... N [2]

(c) Use your answer in **(b)** and the weight of the bead to show that the resultant force acting on it is 7.2×10^{-5} N.

[1]

(d) Explain why the resultant force on the bead of 7.2×10^{-5} N is constant as the bead moves along path AB.

.....

.....

.....

..... [2]

17 (a) Distinguish between vector and scalar quantities.

.....

.....

..... [2]

18 **(a)** State what is meant by a *scalar* quantity and by a *vector* quantity.

scalar: .....

.....

vector: .....

.....

[2]

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

quantity	vector or scalar
power	
temperature	
momentum	

Fig. 1.1

[2]

(c) An aircraft is travelling in wind. Fig. 1.2 shows the velocities for the aircraft in still air and for the wind.

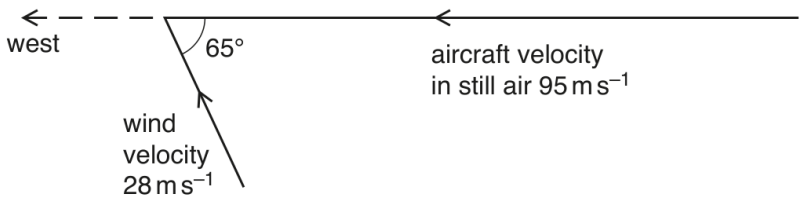


Fig. 1.2

The velocity of the aircraft in still air is 95 m s^{-1} to the west.
The velocity of the wind is 28 m s^{-1} from 65° south of east.

(i) On Fig. 1.2, draw an arrow, labelled R, in the direction of the resultant velocity of the aircraft. [1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

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

19 (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.

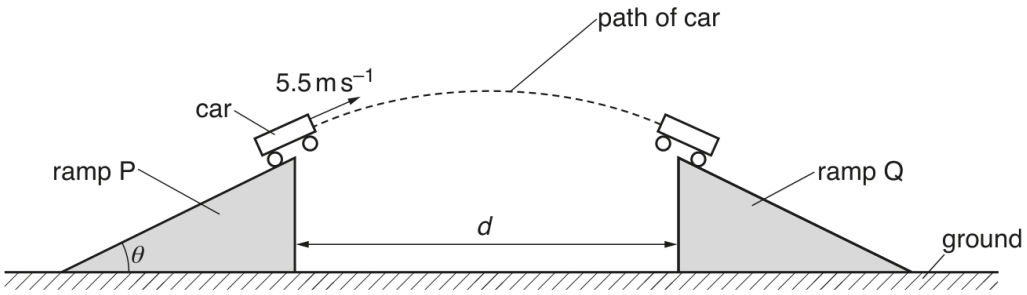


Fig. 1.1

The car leaves ramp P with a velocity of $5.5\,m\,s^{-1}$ at an angle θ to the horizontal. The horizontal component of the car's velocity as it leaves the ramp is $4.6\,m\,s^{-1}$. 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 $3.0\,m\,s^{-1}$.

[1]

20 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.

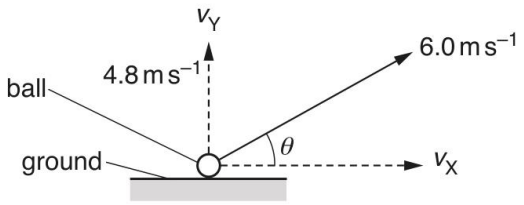


Fig. 1.1 (not to scale)

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]