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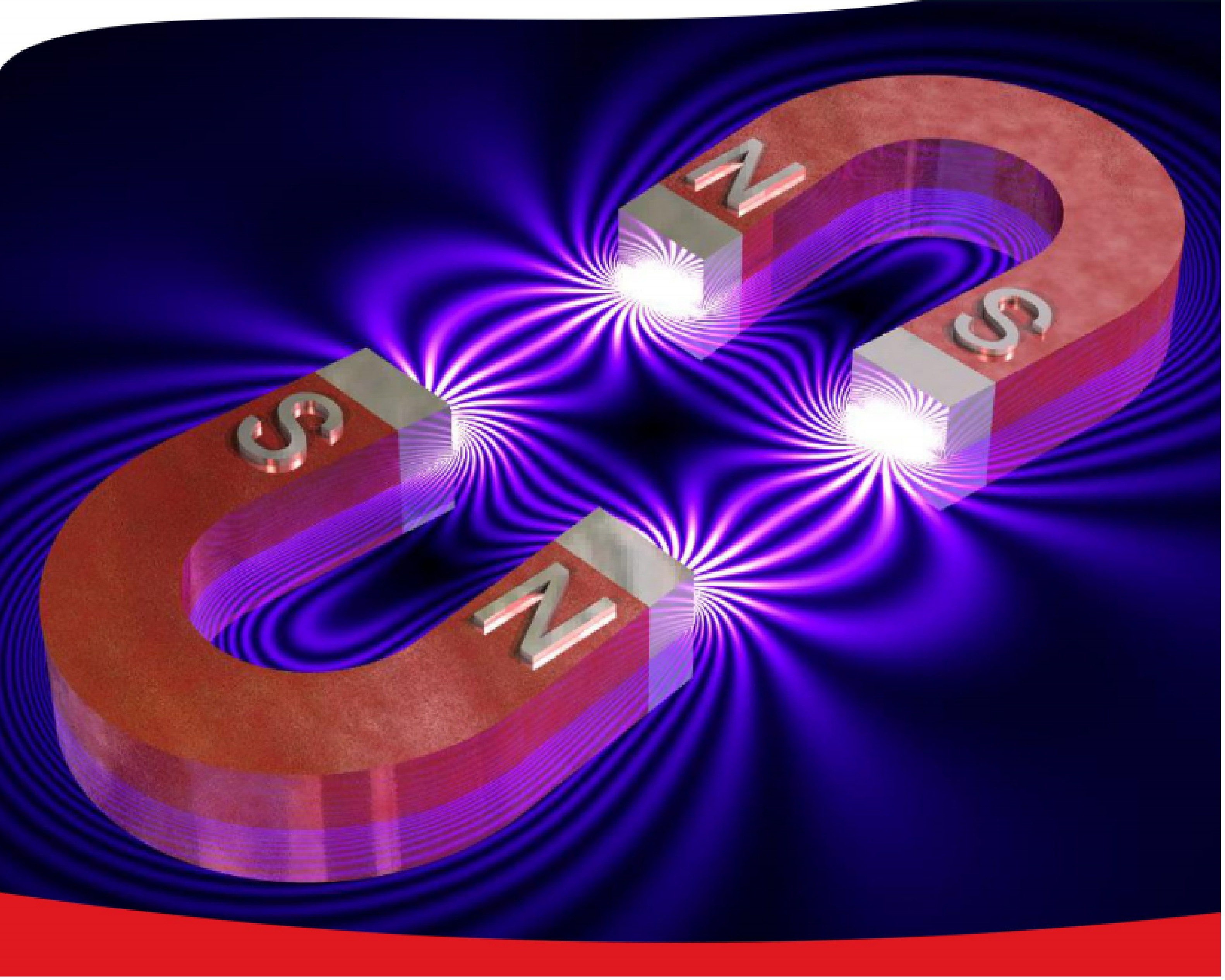
PHYSICS (9702) P2

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



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Chapter 4

Dynamics

4.1 Momentum and Newton's laws of motion

33. 9702_w20_qp_21 Q: 3

(a) Define *force*.

....

.... [1]

(b) A ball falls vertically downwards towards a horizontal floor and then rebounds along its original path, as illustrated in Fig. 3.1.

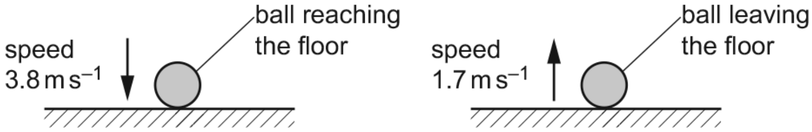


Fig. 3.1

The ball reaches the floor with speed 3.8 m s^{-1}. The ball is then in contact with the floor for a time of 0.081 s before leaving it with speed 1.7 m s^{-1}. The mass of the ball is 0.062 kg.

(i) Calculate the loss of kinetic energy of the ball during the collision.

loss of kinetic energy = ... J [2]

(ii) Determine the magnitude of the change in momentum of the ball during the collision.

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

(iii) Show that the magnitude of the average resultant force acting on the ball during the collision is 4.2 N.

[1]

(iv) Use the information in **(iii)** to calculate the magnitude of:

1. the average force of the floor on the ball during the collision

average force = ... N

2. the average force of the ball on the floor during the collision.

average force = ... N
[2]

[Total: 8]

34. 9702_s19_qp_21 Q: 2

A block X slides along a horizontal frictionless surface towards a stationary block Y, as illustrated in Fig. 2.1.

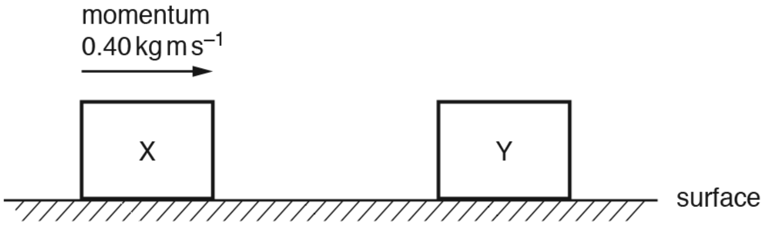


Fig. 2.1

There are no resistive forces acting on block X as it moves towards block Y. At time $t = 0$, block X has momentum $0.40\,\text{kg m s}^{-1}$. A short time later, the blocks collide and then separate.

The variation with time t of the momentum of block Y is shown in Fig. 2.2.

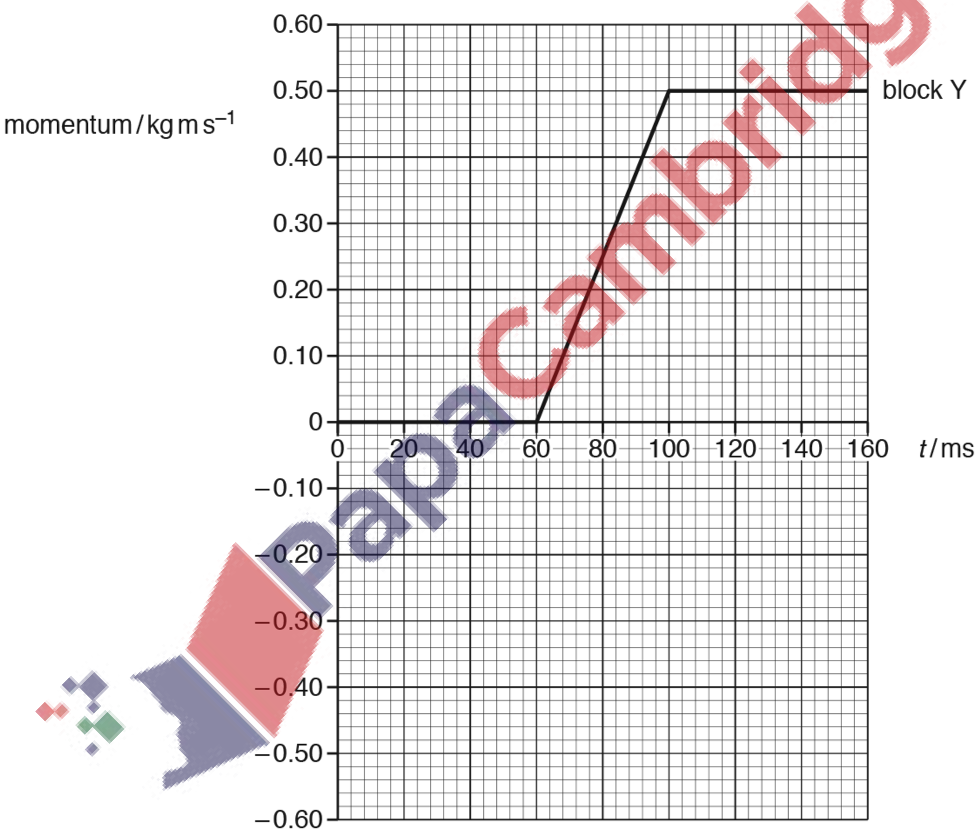


Fig. 2.2

(a) Define *linear momentum*.

....[1]

(b) Use Fig. 2.2 to:

(i) determine the time interval over which the blocks are in contact with each other

time interval = ... ms [1]

(ii) describe, without calculation, the magnitude of the acceleration of block Y from:

1. time $t = 80\,\text{ms}$ to $t = 100\,\text{ms}$

....

2. time $t = 100\,\text{ms}$ to $t = 120\,\text{ms}$.

....
[2]

(c) Use Fig. 2.2 to determine the magnitude of the force exerted by block X on block Y.

force = ... N [2]

(d) On Fig. 2.2, sketch the variation of the momentum of block X with time t from $t = 0$ to $t = 160\,\text{ms}$. [3]

[Total: 9]

35. 9702_w17_qp_21 Q: 1

(a) The drag force F_D acting on a sphere moving through a fluid is given by the expression

$$F_D = K\rho v^2$$

where K is a constant,
ρ is the density of the fluid
and v is the speed of the sphere.

Determine the SI base units of K.

base units ....[3]

(b) A ball of weight 1.5 N falls vertically from rest in air. The drag force F_D acting on the ball is given by the expression in **(a)**. The ball reaches a constant (terminal) speed of 33 m s^{-1}.

Assume that the upthrust acting on the ball is negligible and that the density of the air is uniform.

For the instant when the ball is travelling at a speed of 25 m s^{-1}, determine

(i) the drag force F_D on the ball,

F_D = ... N [2]

(ii) the acceleration of the ball.

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

(c) Describe the acceleration of the ball in **(b)** as its speed changes from zero to 33 m s^{-1}.

....

....

....

....[3]

[Total: 10]

4.2 Linear momentum and its conservation

36. 9702_s20_qp_22 Q: 2

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

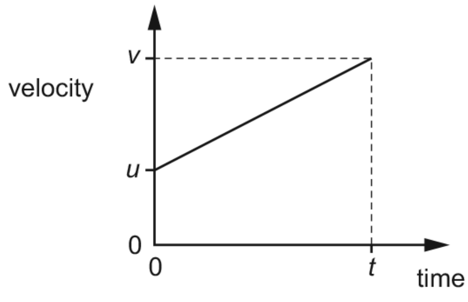


Fig. 2.1

(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 $15\,\text{m}\,\text{s}^{-1}$ 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.

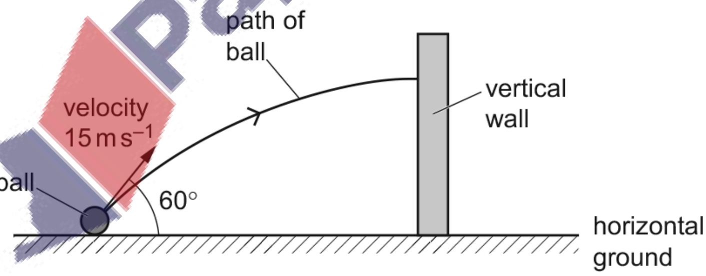


Fig. 2.2 (not to scale)

Assume that air resistance is negligible.

(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]

37. 9702_w20_qp_23 Q: 3

A ball is fired horizontally with a speed of $41.0\,\text{m}\,\text{s}^{-1}$ 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.

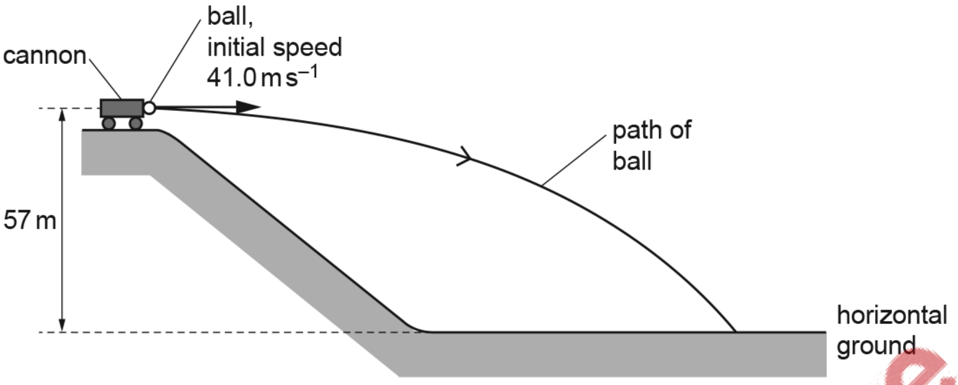


Fig. 3.1 (not to scale)

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.

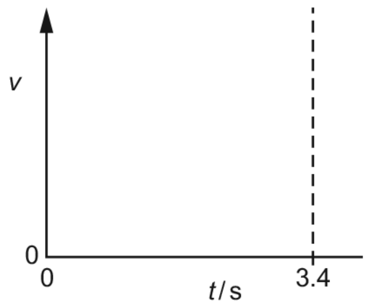


Fig. 3.2

[1]

(e) The cannon recoils horizontally with a speed of $0.340\,\text{m}\,\text{s}^{-1}$ 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]

38. 9702_w18_qp_21 Q: 2

A wooden block moves along a horizontal frictionless surface, as shown in Fig. 2.1.

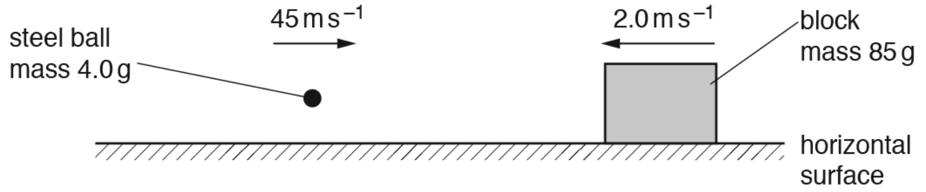


Fig. 2.1

The block has mass 85 g and moves to the left with a velocity of $2.0\,m\,s^{-1}$. A steel ball of mass 4.0 g is fired to the right. The steel ball, moving horizontally with a speed of $45\,m\,s^{-1}$, collides with the block and remains embedded in it. After the collision the block and steel ball both have speed *v*.

(a) Calculate *v*.

v = ... $m\,s^{-1}$ [2]

(b) **(i)** For the block and ball, state

1. the relative speed of approach before collision,

relative speed of approach = ... $m\,s^{-1}$

2. the relative speed of separation after collision.

relative speed of separation = ... $m\,s^{-1}$ [1]

(ii) Use your answers in **(i)** to state and explain whether the collision is elastic or inelastic.

....

.... [1]

(c) Use Newton's third law to explain the relationship between the rate of change of momentum of the ball and the rate of change of momentum of the block during the collision.

....

....

....

.... [2]

[Total: 6]

39. 9702_s17_qp_23 Q: 2

(a) State Newton's second law of motion.

....

....[1]

(b) A constant resultant force *F* acts on an object A. The variation with time *t* of the velocity *v* for the motion of A is shown in Fig. 2.1.

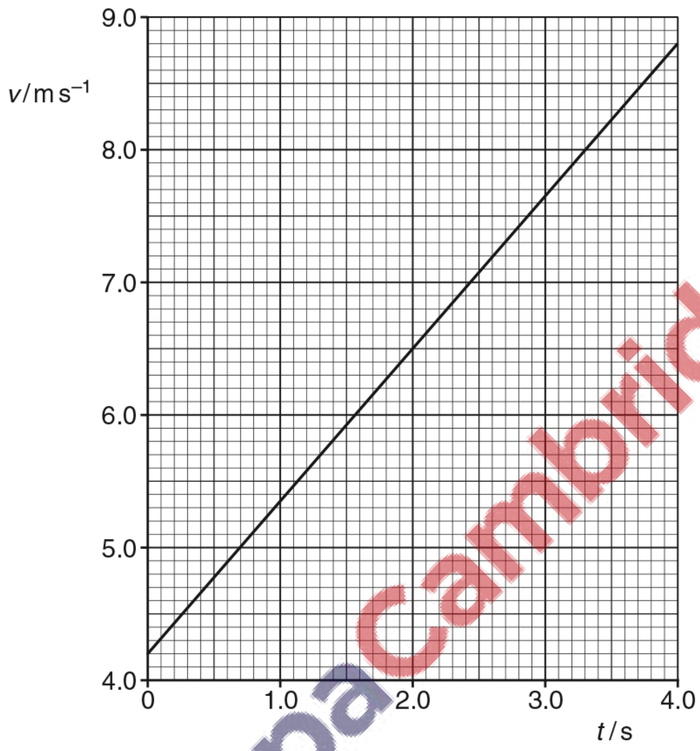


Fig. 2.1

The mass of A is 840 g.

Calculate, for the time $t = 0$ to $t = 4.0$ s,

(i) the change in momentum of A,

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

(ii) the force *F*.

F = ... N [1]

(c) The force F is removed at t = 4.0 s. Object A continues at constant velocity before colliding with an object B, as illustrated in Fig. 2.2.

Fig. 2.2

Object B is initially at rest. The mass of B is 730 g.
The objects A and B join together and have a velocity of 4.7 m s^{-1}.

(i) By calculation, show that the changes in momentum of A and of B during the collision are equal and opposite.

[2]

(ii) Explain how the answers obtained in **(i)** support Newton's third law.

....

....

....

....[2]

(iii) By reference to the speeds of A and B, explain whether the collision is elastic.

....

....[1]

[Total: 9]

40. 9702_w17_qp_23 Q: 3

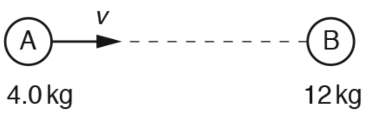
(a) State the principle of conservation of momentum.

....

....

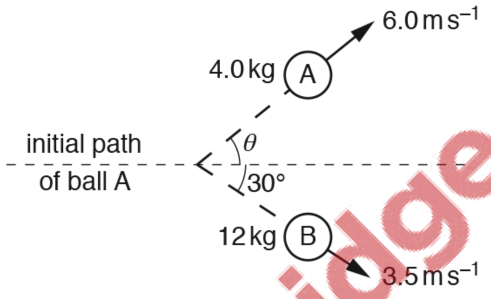
....[2]

(b) Ball A moves with speed v along a horizontal frictionless surface towards a stationary ball B, as shown in Fig. 3.1.



before collision

Fig. 3.1



after collision

Fig. 3.2 (not to scale)

Ball A has mass 4.0 kg and ball B has mass 12 kg.
The balls collide and then move apart as shown in Fig. 3.2.
Ball A has velocity $6.0\,\text{m}\,\text{s}^{-1}$ at an angle of θ to the direction of its initial path.
Ball B has velocity $3.5\,\text{m}\,\text{s}^{-1}$ at an angle of 30° to the direction of the initial path of ball A.

(i) By considering the components of momentum at right-angles to the direction of the initial path of ball A, calculate θ.

θ = ... ° [3]

(ii) Use your answer in **(i)** to show that the initial speed v of ball A is $12\,\mathrm{m\,s^{-1}}$.
Explain your working.

[2]

(iii) By calculation of kinetic energies, state and explain whether the collision is elastic or inelastic.

....

....[3]

[Total: 10]

41. 9702_s16_qp_23 Q: 5

(a) State the law of conservation of momentum.

....

....

.... [2]

(b) Two particles A and B collide elastically, as illustrated in Fig. 5.1.

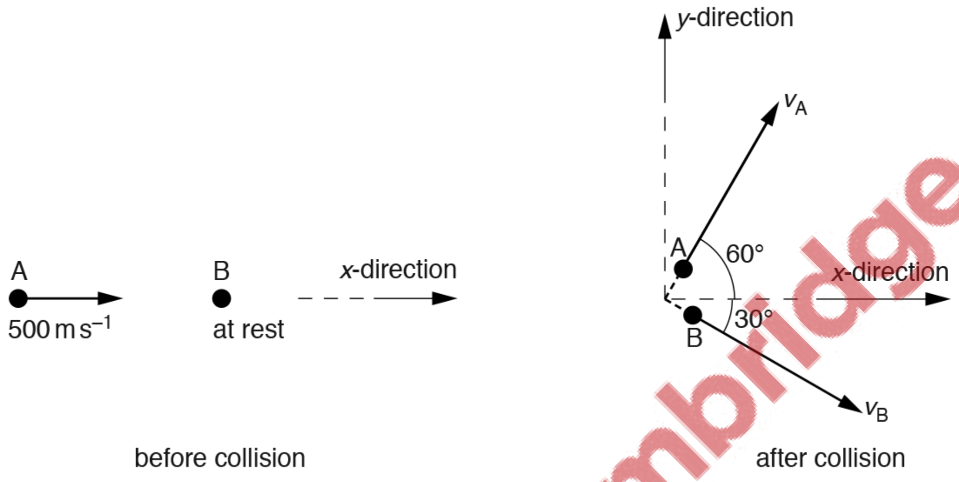


Fig. 5.1

The initial velocity of A is 500 m s^{-1} in the *x*-direction and B is at rest.

The velocity of A after the collision is v_A at 60° to the *x*-direction. The velocity of B after the collision is v_B at 30° to the *x*-direction.

The mass *m* of each particle is 1.67×10^{-27} kg.

(i) Explain what is meant by the particles colliding *elastically*.

.... [1]

(ii) Calculate the total initial momentum of A and B.

momentum = ... N s [1]

(iii) State an expression in terms of m, v_A and v_B for the total momentum of A and B after the collision

1. in the *x*-direction,

....

2. in the *y*-direction.

....
[2]

(iv) Calculate the magnitudes of the velocities v_A and v_B after the collision.

v_A = ... m s^{-1}

v_B = ... m s^{-1}
[3]

[Total: 9]

42. 9702_s15_qp_21 Q: 3

Two balls X and Y are supported by long strings, as shown in Fig. 3.1.

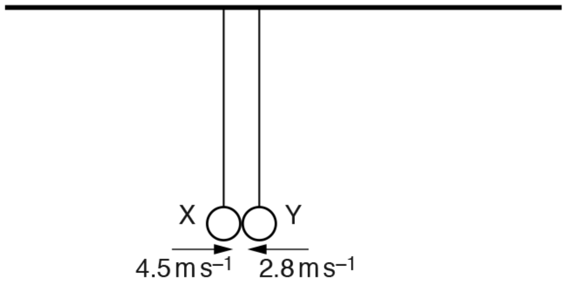


Fig. 3.1

The balls are each pulled back and pushed towards each other. When the balls collide at the position shown in Fig. 3.1, the strings are vertical. The balls rebound in opposite directions.

Fig. 3.2 shows data for X and Y during this collision.

ball	mass	velocity just before collision / $m s^{-1}$	velocity just after collision / $m s^{-1}$
X	50 g	+4.5	–1.8
Y	*M*	–2.8	+1.4

Fig. 3.2

The positive direction is horizontal and to the right.

(a) Use the conservation of linear momentum to determine the mass *M* of Y.

M = ... g [3]

(b) State and explain whether the collision is elastic.

....

....

....[1]

(c) Use Newton's second and third laws to explain why the magnitude of the change in momentum of each ball is the same.

....

....

....

....

....[3]