Edexcel GCE

Core Mathematics M1

Momentum

Materials required for examination
Mathematical Formulae (Green)

Items included with question papers
Nil

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

1. Two particles A and B have masses 4 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 5 m s^{-1} and the speed of B is 3 m s^{-1}. Immediately after the collision, the direction of motion of A is unchanged and the speed of A is 1 m s^{-1}.

(a) Find the magnitude of the impulse exerted on A in the collision.

(2)

Immediately after the collision, the speed of B is 2 m s^{-1}.

(b) Find the value of m.

(4)

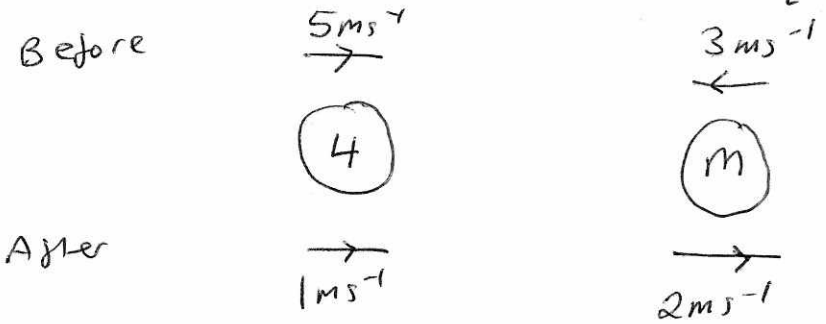
a) $I = mv - mu$

$= |4(1) - 4(5)|$

$= 16 \text{ kg ms}^{-1}$

b)

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$



$4(5) + m(-3) = 4(1) + m(2)$

$20 - 3m = 4 + 2m$

$16 = 5m$

$m = \frac{16}{5} \text{ kg}$

2. Two particles A and B, of mass 0.3 kg and m kg respectively, are moving in opposite directions along the same straight horizontal line so that the particles collide directly. Immediately before the collision, the speeds of A and B are 8 m s^{-1} and 4 m s^{-1} respectively. In the collision the direction of motion of each particle is reversed and, immediately after the collision, the speed of each particle is 2 m s^{-1}.

Find

(a) the magnitude of the impulse exerted by B on A in the collision,

(3)

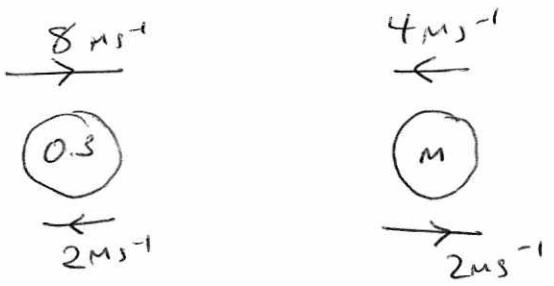
(b) the value of m.

(4)

$$I = mv - mu$$
$$= 0.3(8) - 0.3(-2)$$
$$= 3 \text{ kg ms}^{-1}$$

b/

Before



$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$
$$0.3(8) + m(-4) = 0.3(-2) + m(2)$$
$$2.4 - 4m = -0.6 + 2m$$
$$3 = 6m$$
$$M = 0.5\text{kg}$$

3. Two particles A and B, of mass 3 kg and 2 kg respectively, are moving in the same direction on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 4 m s^{-1} and the speed of B is 1.5 m s^{-1}. In the collision, the particles join to form a single particle C.

(a) Find the speed of C immediately after the collision.

(3)

Two particles P and Q have mass 3 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table. Each particle has speed 4 m s^{-1}, when they collide directly. In this collision, the direction of motion of each particle is reversed. The speed of P immediately after the collision is 2 m s^{-1} and the speed of Q is 1 m s^{-1}.

(b) Find

(i) the value of m,

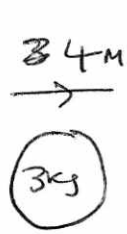
(3)

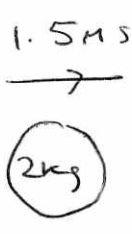
(ii) the magnitude of the impulse exerted on Q in the collision.

(2)

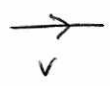
a)

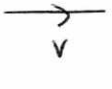
Before





After





$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

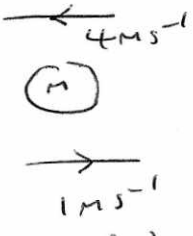
$$3(4) + 2(1.5) = 3v + 2v$$

$$15 = 5v$$

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

b)

Before



$$3(4) + m(-4) = 3(-2) + m(1)$$

$$12 - 4m = -6 + m$$

$$18 = 5m$$

$$m = \frac{18}{5} \quad 4$$

ii)

$$I = mv - mu$$

$$= 3.6(-24) - 3.6(-4)$$

$$= 18\text{ kg ms}^{-1}$$

4. Two particles A and B have mass 0.4 kg and 0.3 kg respectively. They are moving in opposite directions on a smooth horizontal table and collide directly. Immediately before the collision, the speed of A is 6 m s^{-1} and the speed of B is 2 m s^{-1}. As a result of the collision, the direction of motion of B is reversed and its speed immediately after the collision is 3 m s^{-1}. Find

(a) the speed of A immediately after the collision, stating clearly whether the direction of motion of A is changed by the collision,

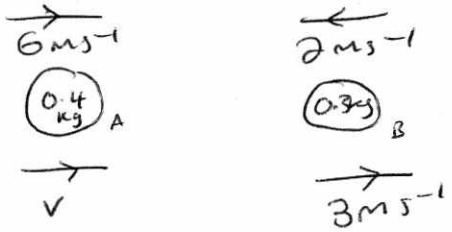
(4)

(b) the magnitude of the impulse exerted on B in the collision, stating clearly the units in which your answer is given.

(3)

a/

Before



$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0.4(6) + 0.3(-2) = 0.4v + 0.3(3)$

$2.4 - 0.6 = 0.4v + 0.9$

$0.9 = 0.4v$

$v = \frac{9}{4}$ ms^{-1} [direction is unchanged]

b/

$I = mv - mu$

$= 0.3(3) - 0.3(-2)$

$= 1.5$ kg ms^{-1}

5. A particle P of mass 0.3 kg is moving with speed u ms^{-1} in a straight line on a smooth horizontal table. The particle P collides directly with a particle Q of mass 0.6 kg, which is at rest on the table. Immediately after the particles collide, P has speed 2 m s^{-1} and Q has speed 5 m s^{-1}. The direction of motion of P is reversed by the collision. Find

(a) the value of u.

(4)

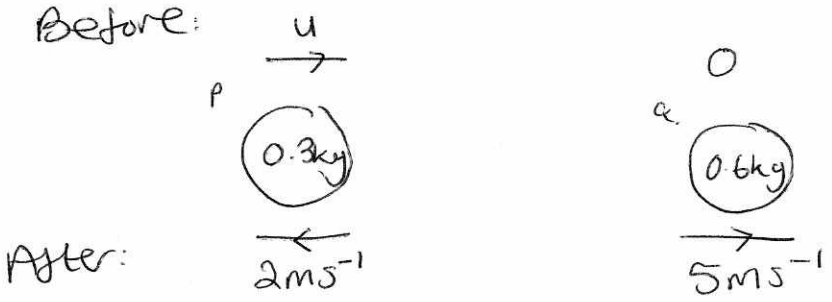
(b) the magnitude of the impulse exerted by P on Q.

(2)

Immediately after the collision, a constant force of magnitude R newtons is applied to Q in the direction directly opposite to the direction of motion of Q. As a result Q is brought to rest in 1.5 s.

(c) Find the value of R.

(4)



a) $M_1u_1 + M_2u_2 = M_1v_1 + M_2v_2$

$0.3u = 0.3(-2) + 0.6(5)$

$0.3u = -0.6 + 3$

$0.3u = 2.4$

$u = 8 \text{ ms}^{-1}$

b) $I = mv - mu$

$= 0.6(5) - 0$

$= 3 \text{ kg ms}^{-1}$

c) $s =$
$u = 5$
$v = 0$
$a = a$
$t = 1.5$

$v = u + at$

$0 = 5 + a(1.5)$

$a = -\frac{10}{3} \text{ ms}^{-1}$

$F = ma$

$R = 0.6\left(-\frac{10}{3}\right) = \frac{3}{5} \times \frac{10}{3}$

$= 2 \text{ N}$

6. Two particles A and B are moving on a smooth horizontal plane. The mass of A is $2m$ and the mass of B is m. The particles are moving along the same straight line but in opposite directions and they collide directly. Immediately before they collide the speed of A is $2u$ and the speed of B is $3u$. The magnitude of the impulse received by each particle in the collision is $\frac{7mu}{2}$.

Find

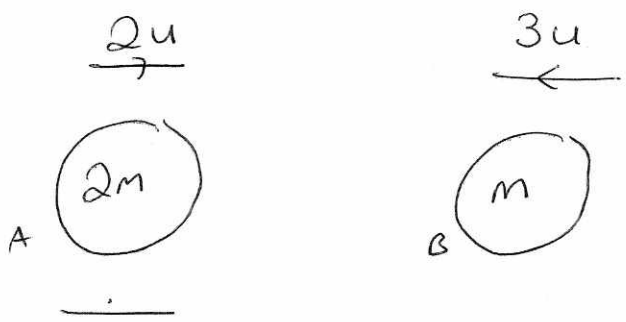
(a) the speed of A immediately after the collision,

(3)

(b) the speed of B immediately after the collision.

(3)

Before



a/ $I = mv - mu$

$\left|\frac{7mu}{2}\right| = 2mv - 2m(2u)$

$\left|\frac{7mu}{2}\right| = 2mv - 4mu$

$7u = 4v - 8u$ or $-7u = 4v - 8u$

$15u = 4v$ $u = 4v$

$v = \frac{15}{4}u$ $v = \frac{1}{4}u$

b/ $\left|\frac{7mu}{2}\right| = mv - m(-3u)$

$\left|\frac{7mu}{2}\right| = mv + 3mu$

$7u = 2v + 6u$

$u = 2v$

$v = \frac{1}{2}u$

7. Two particles A and B are moving on a smooth horizontal plane. The mass of A is km, where $2 < k < 3$, and the mass of B is m. The particles are moving along the same straight line, but in opposite directions, and they collide directly. Immediately before they collide the speed of A is $2u$ and the speed of B is $4u$. As a result of the collision the speed of A is halved and its direction of motion is reversed.

(*a*) Find, in terms of k and u, the speed of B immediately after the collision.

(3)

(*b*) State whether the direction of motion of B changes as a result of the collision, explaining your answer.

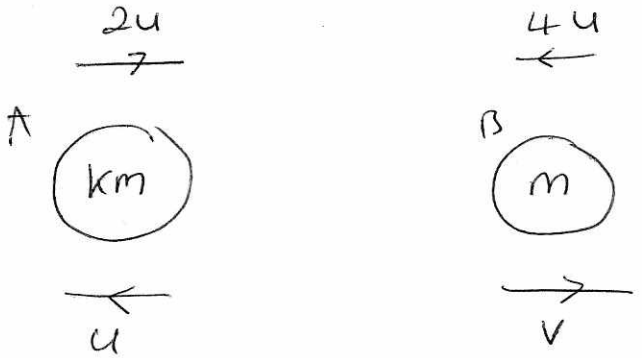
(3)

Given that $k = \frac{7}{3}$,

(*c*) find, in terms of m and u, the magnitude of the impulse that A exerts on B in the collision.

(3)

Before:



After.

a) $m_1u_1 + m_2u_2 = m_1v_1 + u_2v_2$

$km(2u) + m(4u) = km(-u) + m(v)$

$2kmu - 4mu = -kmu + mv$

$3ku - 4u = v$

b) The motion of B changes

$3ku - 4u$ is positive as $2 < k < 3$

Positive velocity represents a change of direction.

c) $v = 3\left(\frac{7}{3}\right)u - 4u$

$= 3u$

$I = mv - mu$

$= m(3u) - m(-4u)$

$= 7mu$ $\quad kgms^{-1}$

8. Two particles P and Q have mass 0.4 kg and 0.6 kg respectively. The particles are initially at rest on a smooth horizontal table. Particle P is given an impulse of magnitude 3 N s in the direction PQ.

(*a*) Find the speed of P immediately before it collides with Q.

(3)

Immediately after the collision between P and Q, the speed of Q is 5 m s^{-1}.

(*b*) Show that immediately after the collision P is at rest.

(3)

a)

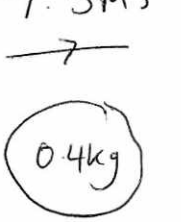
$I = mv - mu$

$3 = 0.4v$

$v = 7.5 \text{ ms}^{-1}$

b)

Before



After

$M_1U_1 + M_2U_2 = M_1V_1 + M_2V_2$

$0.4(7.5) + 0 = 0.4v + 0.6(5)$

$3 = 0.4v + 3$

$0 = 0.4v$

$v = 0$