eClassroom

Momentum and Impulse

Worked Solutions

Suitable for:

Pearson Edexcel International A-Level (iAL) — Mechanics 1

Question 1 — Worked Solution

Take the positive direction as the direction of A's initial motion.

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

$$4 \times 5 + 2 \times 0 = 4 \times 2 + 2v_B$$

$$20 = 8 + 2v_B \Rightarrow v_B = \frac{12}{2}$$

$$\therefore v_B = 6 \text{ m s}^{-1} \text{ (in same direction as A)}$$

Question 2 — Worked Solution

Both particles move in the same direction. After collision, total mass = 8 kg.

$$3 \times 8 + 5 \times 2 = 8v$$

$$24 + 10 = 8v \Rightarrow v = \frac{34}{8} = \frac{17}{4}$$

$$\therefore v = 4.25 \text{ m s}^{-1}$$

Question 3 — Worked Solution

Take the direction of A's motion as positive. B moves in the negative direction, so u_B = –3.

$$6 \times 4 + 2 \times (-3) = 6 \times 0 + 2v_B$$

$$24 - 6 = 2v_B \Rightarrow v_B = \frac{18}{2} = 9$$

$$\therefore v_B = 9 \text{ m s}^{-1} \text{ in the same direction as A's original motion}$$

Question 4 — Worked Solution

(a)

$$\text{Impulse} = Ft = 12 \times 5$$

$$\therefore = 60 \text{ N s}$$

(b)

$$I = mv - mu = m(v - 0) \Rightarrow 60 = 4v$$

$$\therefore v = 15 \text{ m s}^{-1}$$

Question 5 — Worked Solution

$$I = m(v - u) = 3 \times (8 - 2) = 3 \times 6$$

$$\therefore I = 18 \text{ N s}$$

Question 6 — Worked Solution

Take the direction toward the wall as positive.

Before: u = +6 m s^{-1}. After rebound: v = –4 m s^{-1}.

$$I = m(v - u) = 0.5 \times (-4 - 6) = 0.5 \times (-10) = -5 \text{ N s}$$

$$\therefore \text{Magnitude of impulse} = 5 \text{ N s}$$

Question 7 — Worked Solution

(a)

$$I = m(v-u) \Rightarrow 5 = 0.4(v-6) \Rightarrow v - 6 = \frac{5}{0.4} = 12.5$$

$$\therefore v = 18.5 \text{ m s}^{-1}$$

(b)

No resistance, so the particle continues at constant speed 18.5 m s^{-1}.

$$d = vt = 18.5 \times 3$$

$$\therefore d = 55.5 \text{ m}$$

Question 8 — Worked Solution

A and B coalesce, moving together at 2 m s^{-1}.

$$m \times 6 + 4 \times 0 = (m + 4) \times 2$$

$$6m = 2m + 8 \Rightarrow 4m = 8$$

$$\therefore m = 2 \text{ kg}$$

Question 9 — Worked Solution

(a)

Conservation of momentum for A-B collision. Take direction of A's motion as positive.

$$3 \times 4 + 2 \times 0 = 3 \times 1 + 2v_B$$

$$12 = 3 + 2v_B \Rightarrow v_B = \frac{9}{2}$$

$$\therefore v_B = 4.5 \text{ m s}^{-1}$$

(b)

B (2 kg) collides with C (4 kg) at rest and they coalesce.

$$2 \times 4.5 + 4 \times 0 = (2 + 4)\,v \Rightarrow 9 = 6v$$

$$\therefore v = 1.5 \text{ m s}^{-1}$$

(c)

$$I_C = m_C(v - u_C) = 4 \times (1.5 - 0) = 4 \times 1.5$$

$$\therefore I_C = 6 \text{ N s}$$

Question 10 — Worked Solution

(a)

$$1500 \times 6 + 2500 \times 0 = (1500 + 2500)\,v$$

$$9000 = 4000v \;\Rightarrow\; v = \frac{9}{4}$$

$$\therefore v = 2.25 \text{ m s}^{-1}$$

(b)

$$I_S = m_S(v - u_S) = 1500 \times (2.25 - 6) = 1500 \times (-3.75)$$

$$\therefore |I_S| = 5625 \text{ N s}$$

Question 11 — Worked Solution

Take direction of P's motion as positive. u_P = +2u, u_Q = –u (opposite direction). v_P = +u.

(a)

$$3m(2u) + m(-u) = 3m(u) + m\,v_Q$$

$$6mu - mu = 3mu + m\,v_Q$$

$$5mu - 3mu = m\,v_Q \Rightarrow v_Q = 2u$$

$$\therefore v_Q = 2u \text{ in P's original direction}$$

(b)

Impulse on P = change in momentum of P:

$$I_P = 3m(v_P - u_P) = 3m(u - 2u) = 3m(-u) = -3mu$$

$$\therefore |I_P| = 3mu$$

Question 12 — Worked Solution

(a) Show k = 5

Both particles move in the same direction. Conservation of momentum:

$$4m(3u) + m(u) = 4m(2u) + m(ku)$$

$$12mu + mu = 8mu + kmu$$

$$13mu = 8mu + kmu \Rightarrow 5mu = kmu$$

$$\therefore k = 5 \checkmark$$

(b)

$$I_B = m(ku - u) = m(5u - u) = m(4u)$$

$$\therefore |I_B| = 4mu$$

Question 13 — Worked Solution

(a)

Take the original direction of A as positive. After collision: A moves at –u (reversed), B moves at +3u.

$$3m(4u) + M(0) = 3m(-u) + M(3u)$$

$$12mu = -3mu + 3Mu$$

$$15mu = 3Mu \Rightarrow M = \frac{15m}{3}$$

$$\therefore M = 5m$$

(b)

After the collision, A moves in the negative direction at speed u, and B moves in the positive direction at speed 3u.

Since A and B are moving in opposite directions away from each other, B cannot catch A.

B cannot catch A. They move in opposite directions after the collision, so the distance between them increases.