4.5 Momentum and impulse

Name: _____ Class: _____ Date: _____ **Total: 25 marks**

KEY WORDS impulse • momentum

Momentum and impulse

Objective

Use the impulse-momentum principle on one body at a time (including reversals of direction) and conservation of momentum for direct collisions (objectives 4.3).

1 Key knowledge and worked examples

Signs carry the physics. Momentum mv is signed along the line; impulse $I = mv - mu$ is the change. A rebound reverses a velocity, so $I = m(v+u)$ in magnitudes when the direction flips. In a collision the impulses on the two bodies are equal and opposite – use ONE of them. Conservation: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$, all velocities signed the same way.

Worked example – impulse on both bodies (WME01 June 2025 Q1). P (mass km, speed $5u$) strikes Q (mass $3m$, speed $2u$); afterwards P has $2u$ and Q has v, and the impulse on Q is $4.5mu$. For Q: $3m(v - 2u) = 4.5mu$, so $v = 3.5u$. The impulse on P is equal and opposite: $km(5u - 2u) = 4.5mu$, so $k = 1.5$.

2 Practice

2.1 A ball of mass 0.5 kg hits a wall perpendicular to it at 6 $\mathrm{m\,s^{-1}}$ and rebounds at 4 $\mathrm{m\,s^{-1}}$. Find the magnitude of the impulse the wall exerts on the ball. [3]

2.2 A 2 kg particle moving at 5 $\mathrm{m\,s^{-1}}$ collides with a 3 kg particle at rest and they move off together. (a) Find their common speed. (b) Find the impulse on the 3 kg particle. [4]

2.3 A ball of mass 0.4 kg is dropped and hits the floor at 5 $\mathrm{m\,s^{-1}}$, rebounding at 3 $\mathrm{m\,s^{-1}}$. Find the impulse exerted by the floor. [4]

2.4 A 1 kg particle moving right at 4 $\mathrm{m\,s^{-1}}$ collides with a 2 kg particle moving left at 1 $\mathrm{m\,s^{-1}}$. After the collision the 1 kg particle moves left at 0.5 $\mathrm{m\,s^{-1}}$. Find the velocity of the 2 kg particle. [4]

3 Exam-style questions

3.1 *(Edexcel IAL WME01 June 2025 Q1.)* Two particles P and Q move in the same direction along the same straight line on a smooth horizontal surface. The mass of P is km and the mass of Q is $3m$. They collide directly. Immediately before the collision, the speed of P is $5u$ and the speed of Q is $2u$. Immediately after, the speed of P is $2u$ with direction unchanged, and the speed of Q is v. The impulse exerted on Q by P has magnitude $4.5mu$. (a) Find v in terms of u. (b) Find k. [6]

3.2 *(Edexcel IAL WME01 June 2025 Q8d, condensed.)* A ball of mass 1.5 kg falls and hits the ground with speed $3.13\ \mathrm{m\,s^{-1}}$, rebounding with speed $0.4\ \mathrm{m\,s^{-1}}$. Find the magnitude of the impulse it receives. [4]

Solutions

2.1 Reversal: $I = 0.5(6 + 4) = 5$ N s.

2.2 (a) $2(5) = (5)v$, so $v = 2\ \mathrm{m\,s^{-1}}$. (b) Impulse on the 3 kg: $3(2 - 0) = 6$ N s.

2.3 Reversal: $I = 0.4(5 + 3) = 3.2$ N s.

2.4 Right positive: $1(4) + 2(-1) = 1(-0.5) + 2v$, so $2 = -0.5 + 2v$ and $v = 1.25\ \mathrm{m\,s^{-1}}$ to the right.

3.1 (a) Impulse-momentum on Q: $3m(v - 2u) = 4.5mu$, so $v - 2u = 1.5u$ and $v = 3.5u$. (b) The impulse on P is equal in magnitude and opposite in effect (it slows P): $km(5u - 2u) = 4.5mu$, so $3k = 4.5$ and $k = 1.5$.

3.2 $I = 1.5(3.13 + 0.4) = 5.3$ N s (5.30).

Local review guidance: impulse-momentum applied to ONE named body; momentum conserved with all velocities signed consistently; reversals handled as sums of speeds in magnitude-form or clean sign algebra. This is authored classroom guidance.