

1.6 Momentum

Name: _____ Class: _____ Date: _____

Total: 15 marks

KEY WORDS momentum • impulse • conservation of momentum • force
• mass

Objective

Build the skills to answer exam questions on **momentum** — $p = mv$, $F = \frac{\Delta p}{\Delta t}$,
and the **conservation of momentum** .

You must be able to:

- calculate momentum $p = mv$ (a vector — mind the direction)
- use $F = \frac{\Delta p}{\Delta t}$ (impulse)
- apply conservation of momentum to a collision

1 Key knowledge and worked examples

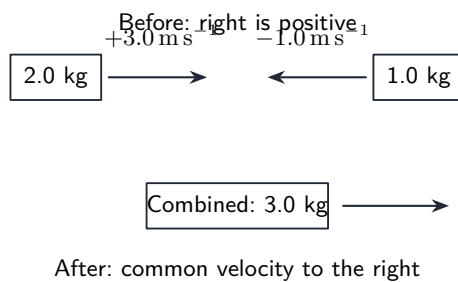
■ Conservation of momentum

Momentum is a vector; keep the velocity directions in a collision calculation.

2.0 kg at $3.0 \frac{\text{m}}{\text{s}}$ hits stationary 1.0 kg, they stick: $(2.0 \times 3.0) + (1.0 \times 0) = (3.0)v \Rightarrow v = 2.0 \frac{\text{m}}{\text{s}}$.

■ Worked application: Use signed momentum before solving a collision

Take right as positive. A 2.0 kg trolley moving at $+3.0 \text{ m s}^{-1}$ collides with a 1.0 kg trolley moving at -1.0 m s^{-1} . They stick and external impulse is negligible. Total momentum is $p = m_1 u_1 + m_2 u_2 = 2(3) + 1(-1) = 5.0 \text{ kg m s}^{-1}$. Therefore $(m_1 + m_2)v = p$ gives $v = 5/3 = +1.67 \text{ m s}^{-1}$, to the right. Adding speed magnitudes instead would give the wrong momentum. Momentum conservation does not imply kinetic-energy conservation in this sticking collision.



2 Practice

2.1 Find the momentum of a 0.40 kg ball moving at $5.0 \frac{\text{m}}{\text{s}}$. [2]

2.2 State the principle of conservation of momentum. [1]

3 Exam-style questions

3.1 The momentum of an object is its mass multiplied by its: [1]

- ☐ **A** acceleration
☐ **B** velocity
☐ **C** weight
☐ **D** density

3.2 A 3.0 kg trolley moving at $4.0 \frac{\text{m}}{\text{s}}$ collides with a stationary 1.0 kg trolley and they move off together.

(a) Find the total momentum before the collision. [2]

(b) Find their common velocity after the collision. [2]

3.3 A force acts on a 2.0 kg ball for 0.10 s and changes its velocity from 0 to $6.0 \frac{\text{m}}{\text{s}}$. Find the force. [3]

3.4 Take right as positive. A 3.0 kg trolley at $+2.0 \text{ m s}^{-1}$ sticks to a 1.0 kg trolley at -2.0 m s^{-1} . External impulse is negligible. Find the combined velocity and explain why the signs must be kept. [4]

Solutions

Each answer shows the steps, then the **result**.

2.1

- $p = mv$

$$p = mv = (0.40 \text{ kg})(5.0 \frac{\text{m}}{\text{s}}) = \mathbf{2.0 \text{ kg m/s}}$$

2.2

- when no external force acts, the total momentum before a collision equals the total momentum after

3.1 B

- momentum = mass $\times$ velocity

3.2

(a) total momentum before

$$p = m_1 u_1 + m_2 u_2 = (3.0 \text{ kg})(4.0 \frac{\text{m}}{\text{s}}) + (1.0 \text{ kg})(0) = \mathbf{12 \text{ kg m/s}}$$

(b) conservation of momentum, $p = (m_1 + m_2)v$: $12 \text{ kg m/s} = (3.0 \text{ kg} + 1.0 \text{ kg})v$

$$v = \frac{p}{m_1 + m_2} = \frac{12 \text{ kg m/s}}{4.0 \text{ kg}} = \mathbf{3.0 \frac{\text{m}}{\text{s}}}$$

3.3

- $F = \Delta p / \Delta t$

$$\Delta p = m \Delta v = (2.0 \text{ kg})(6.0 \frac{\text{m}}{\text{s}}) = 12 \text{ kg m/s}$$

$$F = \frac{\Delta p}{t} = \frac{12 \text{ kg m/s}}{0.10 \text{ s}} = \mathbf{120 \text{ N}}$$

3.4

$p = m_1 u_1 + m_2 u_2 = 3(2) + 1(-2) = 4.0 \text{ kg m s}^{-1}$; $v = p / (m_1 + m_2) = 1.0 \text{ m s}^{-1}$, right; opposite velocities have opposite momenta, so adding speed magnitudes loses direction.