A-LEVEL MATHEMATICS • EXERCISE SHEET

4.3 Momentum

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

Objective

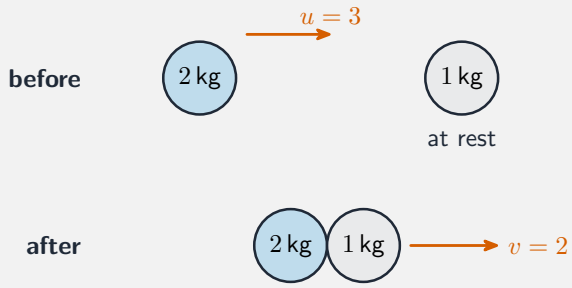
Build the skills to answer exam questions on **momentum** 动量—linear momentum and the **conservation of momentum** 动量守恒 in collisions. Take $g = 10$ m s^{-2}.

You must be able to:

- calculate momentum (mass × velocity), treating direction with signs
- apply $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
- handle "stick together" (coalesce) collisions

1 Worked examples

■ Conservation of momentum



$$2(3) + 1(0) = (2 + 1)\,v$$

Total momentum is the same before and after a collision

2 kg at 3 m s^{-1} hits a stationary 1 kg and they stick:

$$2(3) + 1(0) = (2 + 1)v \Rightarrow v = \tfrac{6}{3} = 2 \text{ m s}^{-1}.$$

Sign convention: choose a positive direction; a velocity the other way is negative.

2 Practice

2.1 Find the momentum of a 0.5 kg ball moving at 8 m s^{-1}. [1]

2.2 State what physical quantity is conserved in a collision with no external horizontal force. [1]

3 Exam-style questions

3.1 A 3 kg body at 4 m s^{-1} collides with a 2 kg body at rest and they coalesce. Their common speed is: [1]

- **A** 1.2 m s^{-1}
- **B** 2.0 m s^{-1}
- **C** 2.4 m s^{-1}
- **D** 4.0 m s^{-1}

3.2 A particle A of mass 0.4 kg moving at 5 m s^{-1} collides directly with particle B of mass 0.6 kg moving in the **opposite** direction at 2 m s^{-1}. After the collision they move together.

(a) Find their common velocity, stating its direction. [4]

3.3 A 2 kg ball moving at 6 m s^{-1} strikes a 4 kg ball at rest. After the collision the 2 kg ball continues in the same direction at 1 m s^{-1}. Find the speed of the 4 kg ball. [3]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **4.3 Momentum** past-paper sheet in the Library, or try these in **Practice mode**:

- 9709/41 N25 —Q2 (momentum)
- 9709/41 N25 —Q6 (collision)
- 9709/42 N25 —Q4 (conservation of momentum)

Solutions

2.1 $p = mv = 0.5 \times 8 = 4$ kg m s^{-1}.

2.2 (linear) momentum.

3.1 C. $3(4) = (3+2)v \Rightarrow v = \dfrac{12}{5} = 2.4$ m s^{-1}.

3.2 take A's direction positive: $0.4(5)+0.6(-2) = (0.4+0.6)v$; $2-1.2 = 1.0\,v \Rightarrow v = 0.8$; 0.8 m s^{-1} in A's original direction.

3.3 $2(6) + 4(0) = 2(1) + 4v$; $12 = 2 + 4v \Rightarrow v = \dfrac{10}{4} = 2.5$ m s^{-1}.