# Exercise walk-through

## Momentum ▪ 4.3

eXercise

## You must be able to

- calculate momentum (mass $\times$ velocity), treating direction with signs
- apply $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$
- handle "stick together" (coalesce) collisions

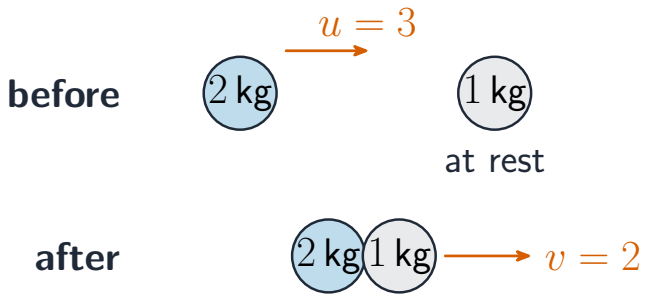
# Method — Conservation of momentum

**$2$ 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.

# Method — Conservation of momentum




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

*Two bodies before a collision and combined after it*

## Practice 2.1 ▪ 1 mark

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

# Solution 2.1

Method: Conservation of momentum

**Worked steps**

$p = mv = 0.5 \times 8 = 4$ kg m $s^{-1}$ B1.

## Practice 2.2 ▪ 1 mark

State what physical quantity is conserved in a collision with no external horizontal force.

# Solution 2.2

**Worked steps**

(linear) momentum B1.

## Exam-style 3.1 ▪ 1 mark

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

**A** $1.2$ m s$^{-1}$

**B** $2.0$ m s$^{-1}$

**C** $2.4$ m s$^{-1}$

**D** $4.0$ m s$^{-1}$

# Solution 3.1

Method: Conservation of momentum

**A** $1.2\ \text{m s}^{-1}$

**B** $2.0\ \text{m s}^{-1}$

**C** $2.4\ \text{m s}^{-1}$ ✓

**D** $4.0\ \text{m s}^{-1}$

## Worked steps

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

## Exam-style 3.2 ▪ 4 marks

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.

# Solution 3.2

Method: Conservation of momentum

**Worked steps**

take $A$'s direction positive: $0.4(5) + 0.6(-2) = (0.4 + 0.6)v$ M1 M1; $2 - 1.2 = 1.0\,v \Rightarrow v = 0.8$ M1; $0.8$ m s$^{-1}$ in $A$'s original direction A1.

## Exam-style 3.3 ▪ 3 marks

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.

# Solution 3.3

Method: Conservation of momentum

**Worked steps**

$2(6) + 4(0) = 2(1) + 4v$ M1; $12 = 2 + 4v \Rightarrow v = \dfrac{10}{4} = 2.5$ m s$^{-1}$ M1 A1.