

Exercise walk-through

Conservation of Linear Momentum ■ 4.3

eXercise

You must be able to

- state that total **momentum** 动量 is conserved when no net external force acts
- apply $p_{\text{before}} = p_{\text{after}}$ to collisions and explosions
- solve for an unknown velocity after an interaction
- use signs for direction in one dimension

Method — Total momentum is conserved

If no net external force acts, the total momentum before equals the total after:

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2.$$

Method — A collision

A 2 kg cart at 3 m s^{-1} hits a stationary 1 kg cart and they stick. Total before
 $= 2(3) + 1(0) = 6$. After, combined mass 3 kg at speed v :

$$6 = 3v \Rightarrow v = 2 \text{ m s}^{-1}.$$

Method — An explosion

A stationary object splits. Total momentum stays zero, so the pieces fly apart with equal and opposite momenta.

Practice 2.1 ■ 1 mark

State the condition for total momentum to be conserved.

Solution 2.1

Method: Total momentum is conserved

Worked steps

When no net external force acts on the system **B1**.

Practice 2.2 ■ 2 marks

A 4 kg cart at 2 m s^{-1} collides and sticks to a stationary 4 kg cart. Find their common speed.

Solution 2.2

Method: A collision

Worked steps

$$4(2) = 8 = 8v \Rightarrow v = 1 \text{ m s}^{-1} \quad \text{M1} \quad \text{A1}.$$

Practice 2.3 ■ 1 mark

A stationary object explodes into two pieces. State the total momentum afterward.

Solution 2.3

Method: An explosion

Worked steps

Zero (equal and opposite momenta) **B1**.

Practice 2.4 ■ 1 mark

Before a collision the total momentum is 30 kg m s^{-1} . State the total momentum after.

Solution 2.4

Method: A collision

Worked steps

30 kg m s^{-1} (conserved) **B1**.

Exam-style 3.1 ■ 1 mark

Momentum is conserved in a collision provided

- A** kinetic energy is conserved
- B** no net external force acts
- C** the objects stick together
- D** the objects are identical

Solution 3.1

Method: Total momentum is conserved

A kinetic energy is conserved

B no net external force acts 

C the objects stick together

D the objects are identical

Worked steps

B — momentum is conserved when no net external force acts.

Exam-style 3.2 ■ 1 mark

A 3 kg ball at 4 m s^{-1} strikes a stationary 1 kg ball and they stick. Their speed after is

A 1 m s^{-1}

B 3 m s^{-1}

C 4 m s^{-1}

D 12 m s^{-1}

Solution 3.2

Method: A collision

A 1 m s^{-1}

B 3 m s^{-1} 

C 4 m s^{-1}

D 12 m s^{-1}

Worked steps

B — $3(4) = 12 = 4v \Rightarrow v = 3 \text{ m s}^{-1}.$

Exam-style 3.3 ■ 1 mark

A 60 kg skater at rest throws a 2 kg ball at 10 m s^{-1} .

- (a) State the total momentum before the throw.
- (b) Find the skater's recoil speed.

Solution 3.3

Method: A collision

Worked steps

(a) Zero (both at rest) **B1**. (b) $0 = 60v + 2(10) \Rightarrow v = -0.33 \text{ m s}^{-1}$, i.e. 0.33 m s^{-1} backward **M1** **A1**.

Exam-style 3.4 ■ 1 mark

A 2 kg trolley at 5 m s^{-1} collides with a 3 kg trolley at rest; they couple together.

- (a) Find the total momentum before.
- (b) Find the speed of the coupled trolleys.

Solution 3.4

Method: A collision

Worked steps

(a) $2(5) = 10 \text{ kg m s}^{-1}$ **B1**. (b) $10 = 5v \Rightarrow v = 2 \text{ m s}^{-1}$ **M1** **A1**.