

Exercise walk-through

Linear Momentum ■ 4.1

eXercise

You must be able to

- define **linear momentum** 线动量 as $\vec{p} = m\vec{v}$
- describe momentum as a **vector** pointing in the direction of the velocity
- calculate the **total momentum** 总动量 of a system as the vector sum of its parts
- explain how momentum depends on both **mass** and **speed**

Method — Momentum is mass times velocity

$\vec{p} = m\vec{v}$, measured in kg m s^{-1} , and points the same way as the velocity. A 2.0 kg ball at 3.0 m s^{-1} has $p = 6.0 \text{ kg m s}^{-1}$.

Method — Total momentum uses signs

Add momenta as vectors (with signs in 1-D). A $+4 \text{ kg m s}^{-1}$ and a -1 kg m s^{-1} object give a total of $+3 \text{ kg m s}^{-1}$.

Method — Mass and speed both matter

A heavy truck at low speed can carry the same momentum as a light car at high speed.

Practice 2.1 ■ 1 mark

Find the momentum of a 0.50 kg ball moving at 8.0 m s^{-1} .

Solution 2.1

Method: Momentum is mass times velocity

Worked steps

$$p = mv = 0.50 \times 8.0 = 4.0 \text{ kg m s}^{-1} \quad \text{B1}.$$

Practice 2.2 ■ 2 marks

A 1200 kg car has momentum $18\,000 \text{ kg m s}^{-1}$. Find its speed.

Solution 2.2

Worked steps

$$v = \frac{p}{m} = \frac{18\,000}{1200} = 15 \text{ m s}^{-1} \quad \text{M1} \quad \text{A1}.$$

Practice 2.3 ■ 2 marks

Two carts move along a line: 3.0 kg at $+2.0 \text{ m s}^{-1}$ and 1.0 kg at -4.0 m s^{-1} . Find the total momentum.

Solution 2.3

Method: Total momentum uses signs

Worked steps

$$p = (3.0)(+2.0) + (1.0)(-4.0) = +6.0 - 4.0 = +2.0 \text{ kg m s}^{-1} \quad \text{M1 A1}.$$

Exam-style 3.1 ■ 1 mark

Momentum is a

- A** scalar with the same direction as force
- B** vector in the direction of the velocity
- C** scalar equal to mv^2
- D** vector opposite to the velocity

Solution 3.1

A scalar with the same direction as force

B vector in the direction of the velocity



C scalar equal to mv^2

D vector opposite to the velocity

Worked steps

B.

Exam-style 3.2 ■ 1 mark

Two objects have equal momentum. The one with the greater mass has the

A greater speed

B smaller speed

C same speed

D greater kinetic energy

Solution 3.2

A greater speed

B smaller speed



C same speed

D greater kinetic energy

Worked steps

B — for equal mv , larger m means smaller v .

Exam-style 3.3 ■ 1 mark

A 0.16 kg ball moving at $+5.0 \text{ m s}^{-1}$ bounces straight back at -3.0 m s^{-1} .

- (a) Find its momentum before the bounce.
- (b) Find its momentum after the bounce.
- (c) State the change in momentum.

Solution 3.3

Method: Momentum is mass times velocity

Worked steps

$$\text{(a) } p_i = 0.16 \times (+5.0) = +0.80 \text{ kg m s}^{-1} \text{ (B1). (b) } p_f = 0.16 \times (-3.0) = -0.48 \text{ kg m s}^{-1} \text{ (B1). (c) } \Delta p = -0.48 - 0.80 = -1.28 \text{ kg m s}^{-1} \text{ (B1).}$$