

4.1 Linear Momentum

Name: _____ Class: _____ Date: _____

Total: 10 marks**KEY WORDS** total momentum 总动量 • linear momentum 线动量

Objective

Build the skills to answer exam questions on **linear momentum**.**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**

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ 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 $p = 6.0 \text{ kg m s}^{-1}$.

■ 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 $+3 \text{ kg m s}^{-1}$.

■ Mass and speed both matter

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

2 Practice

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

2.2 A 1200 kg car has momentum $18\,000 \text{ kg m s}^{-1}$. Find its speed. [2]

2.3 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. [2]

3 Exam-style questions

3.1 Momentum is a [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

3.2 Two objects have equal momentum. The one with the greater mass has the [1]

- **A** greater speed
- **B** smaller speed
- **C** same speed
- **D** greater kinetic energy

3.3 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. [1]

(b) Find its momentum after the bounce. [1]

(c) State the change in momentum. [1]

Solutions

2.1 $p = mv = 0.50 \times 8.0 = 4.0 \text{ kg m s}^{-1}$.

2.2 $v = \frac{p}{m} = \frac{18\,000}{1200} = 15 \text{ m s}^{-1}$.

2.3 $p = (3.0)(+2.0) + (1.0)(-4.0) = +6.0 - 4.0 = +2.0 \text{ kg m s}^{-1}$.

3.1 B.

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

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