

4.3 Conservation of Linear Momentum

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS collisions 碰撞 • conserved 守恒 • recoil 反冲 • isolated system 孤立系统
• explosions 爆炸

Objective

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

You must be able to:

- state that the total momentum of an **isolated system** 孤立系统 is constant
- identify an isolated system as one with **zero net external force**
- explain that **internal forces** 内力 cannot change a system's total momentum
- apply conservation of momentum to **collisions** 碰撞 and **explosions** 爆炸 in one dimension

1 Worked examples

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

■ Conservation of momentum

When the net external force is zero, $\sum p_{\text{before}} = \sum p_{\text{after}}$.

■ Explosions

An object at rest has zero total momentum, so after it bursts apart the fragments carry **equal and opposite** momenta that still sum to zero.

■ Example (collision)

A 2.0 kg cart at 3.0 m s⁻¹ strikes a stationary 1.0 kg cart and they stick:

$$2.0(3.0) = (2.0 + 1.0)v \Rightarrow v = 2.0 \text{ m s}^{-1}.$$

2 Practice

2.1 State the condition for the total momentum of a system to be conserved. [1]

2.2 A 3.0 kg cart at 4.0 m s^{-1} hits a stationary 1.0 kg cart and they couple together. Find their common speed. [2]

2.3 A stationary 5.0 kg object explodes into two pieces; a 2.0 kg piece flies off at $+6.0 \text{ m s}^{-1}$. Find the velocity of the 3.0 kg piece. [2]

3 Exam-style questions

3.1 The total momentum of a system is conserved when [1]

A	B
C	D

- A** kinetic energy is conserved
- B** the net external force is zero
- C** there is no friction anywhere
- D** the velocity is constant

3.2 A 2.0 kg rifle fires a 0.010 kg bullet at 400 m s^{-1} . The rifle recoils at [1]

A	B
C	D

- A** 2.0 m s^{-1}
- B** 4.0 m s^{-1}
- C** 0.5 m s^{-1}
- D** 8.0 m s^{-1}

3.3 A 60 kg astronaut, initially at rest in space, throws a 2.0 kg tool at 5.0 m s^{-1} .

(a) Find the astronaut's recoil speed. [2]

(b) State the direction of the recoil relative to the tool. [1]