AP PHYSICS 1 • EXERCISE SHEET

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 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** 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** 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]

Solutions

2.1 the net external force on the system must be zero.

2.2 $3.0(4.0) = (3.0 + 1.0)v \Rightarrow v = \dfrac{12}{4.0} = 3.0 \text{ m s}^{-1}$.

2.3 $0 = 2.0(+6.0) + 3.0\,v \Rightarrow v = \dfrac{-12}{3.0} = -4.0 \text{ m s}^{-1}$.

3.1 B.

3.2 A — $0 = 0.010(400) + 2.0\,v \Rightarrow v = -2.0 \text{ m s}^{-1}$.

3.3 (a) $0 = 2.0(5.0) + 60\,v \Rightarrow v = \dfrac{-10}{60} = -0.17 \text{ m s}^{-1}$, i.e. 0.17 m s^{-1}. (b) opposite to the tool's direction.