Vector arrows showing two objects of equal mass moving in opposite directions, with momentum vectors pointing in opposite directions and equal lengths

Figure 1: Vector arrows showing two objects of equal mass moving in opposite directions, with momentum vectors pointing in opposite directions and equal lengths

Momentum and Impulse

Grade 12 Physical Sciences (DBE)

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1. Momentum

Definition of Momentum

Momentum is a measure of how difficult it is to stop a moving object.
It is defined as the product of an object's mass and velocity.

Formula for Momentum

The momentum (p) of an object is given by:

$$p = mv$$

where: - (m) is the mass of the object (in kg) - (v) is the velocity of the object (in m sˆ{-1})

Vector Nature of Momentum

Momentum is a **vector quantity**, meaning it has both magnitude and direction.
The direction of momentum is the same as the direction of motion.

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2. Change in Momentum

The change in momentum of an object is defined as:

$$\Delta p = p_f - p_i$$

Force versus time graph showing area under the curve representing impulse

Figure 2: Force versus time graph showing area under the curve representing impulse

3. Newton's Second Law in Terms of Momentum

Statement

The net force acting on an object is equal to the rate of change of momentum.

Mathematical Form

$$\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t}$$

7. Impulse

Definition of Impulse

Impulse is defined as:

$$J = F_{net}\Delta t$$

8. Impulse–Momentum Theorem

$$J = \Delta p$$

This relationship is known as the **impulse–momentum theorem**.

Suggested Diagram

9. Applications of Impulse in Everyday Life

Increasing the time over which momentum changes reduces the force experienced.

This principle is applied in: - Airbags - Seatbelts - Arrestor beds for aircraft

Suggested Diagram

Comparison of a passenger stopping suddenly without an airbag versus stopping over a longer time with an airbag deployed

Figure 3: Comparison of a passenger stopping suddenly without an airbag versus stopping over a longer time with an airbag deployed

Exam Tip

In momentum and impulse problems: 1. Define the system 2. Choose a positive direction 3. Apply conservation of momentum (if the system is isolated) 4. Use the impulse–momentum theorem where forces act over time