AP PHYSICS 1 • EXERCISE SHEET

4.2 Change in Momentum and Impulse

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS impulse 冲量 • contact time 接触时间

Objective

Build the skills to answer exam questions on **change in momentum and impulse**.

You must be able to:

- define **impulse** 冲量 as $\vec{J} = \vec{F}_{net}\,\Delta t$
- state the **impulse-momentum theorem** 冲量-动量定理, $\vec{J} = \Delta\vec{p}$
- find the impulse from the **area** under a force-versus-time graph
- explain how a longer **contact time** 接触时间 reduces the average force

1 Worked examples

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

■ Impulse changes momentum

$\vec{J} = \vec{F}_{net}\,\Delta t = \Delta\vec{p}$, measured in N s (the same as kg m s^{-1}).

■ Longer time means smaller force

For a fixed change in momentum, a **longer** contact time gives a **smaller** average force. This is why airbags, crumple zones, and bending your knees on landing reduce injury.

■ Example

A 0.50 kg ball changes velocity from +4.0 to −2.0 m s^{-1}: $\Delta p = 0.50(-2.0 - 4.0) = -3.0$ N s.

2 Practice

2.1 A 2.0 kg object's velocity increases by +3.0 m s^{-1}. Find the impulse on it. [1]

2.2 A 6.0 N force acts for 0.50 s. Find the impulse. [1]

2.3 Explain why a longer stopping time reduces the force on a passenger in a car crash. [2]

2.4 A 0.10 kg ball hits a wall at 8.0 m s^{-1} and rebounds at 6.0 m s^{-1}. Taking "toward the wall" as positive, find the impulse on the ball. [2]

3 Exam-style questions

3.1 Impulse is equal to [1]

- **A** $F\,\Delta t$
- **B** ma
- **C** $\frac{1}{2}mv^2$
- **D** mgh

3.2 An airbag protects a passenger by increasing the [1]

- **A** momentum change
- **B** total impulse
- **C** contact time of the collision
- **D** kinetic energy

3.3 A 0.058 kg tennis ball leaves a racket at 50 m s^{-1} from rest, with a contact time of 5.0 ms.

(a) Find the impulse on the ball. [2]

(b) Find the average force during contact. [1]

Solutions

2.1 $J = \Delta p = m\,\Delta v = 2.0 \times 3.0 = 6.0$ N s.

2.2 $J = F\,\Delta t = 6.0 \times 0.50 = 3.0$ N s.

2.3 A longer time for the same momentum change means a smaller average force, since $F = \Delta p/\Delta t$; a smaller force means less injury.

2.4 $\Delta p = 0.10(-6.0) - 0.10(+8.0) = -1.4$ N s.

3.1 **A**.

3.2 **C**.

3.3 (a) $J = \Delta p = 0.058 \times 50 = 2.9$ N s. (b) $F = \dfrac{J}{\Delta t} = \dfrac{2.9}{5.0 \times 10^{-3}} = 580$ N.