AP PHYSICS C: MECHANICS • EXERCISE SHEET

4.2 Change in Momentum and Impulse

Name: _____ Class: _____ Date: _____ **Total: 16 marks**

KEY WORDS impulse 冲量 • kinetic energy 动能

Objective

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

You must be able to:

- calculate **impulse** 冲量: $J = F\,\Delta t$
- use the impulse-momentum theorem: $J = \Delta p$
- explain why a longer contact time reduces the force for a given change in momentum
- find force, time, or change in momentum given the other two

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Impulse equals change in momentum

$$J = F\,\Delta t = \Delta p = m\Delta v.$$

A 50 N force acting for 0.2 s delivers $J = 50 \times 0.2 = 10$ kg m s^{-1}, changing the momentum by 10 kg m s^{-1}.

■ Longer time, smaller force

For a fixed change in momentum, a longer contact time means a smaller force:

$$F = \frac{\Delta p}{\Delta t}.$$

This is why crumple zones and airbags help – they stretch Δt, cutting the force.

■ Finding the change in velocity

A 2 kg ball receives an impulse of 12 kg m s^{-1}: $\Delta v = J/m = 12/2 = 6$ m s^{-1}.

2 Practice

Now apply the methods above.

2.1 A 20 N force acts for 3 s. Find the impulse. [2]

2.2 State what impulse equals (the theorem). [1]

2.3 A 4 kg object receives an impulse of 16 kg m s^{-1}. Find its change in velocity. [2]

2.4 Explain why a longer collision time reduces the force. [2]

3 Exam-style questions

3.1 The impulse of a force equals the change in [1]

- **A** kinetic energy
- **B** momentum
- **C** mass
- **D** acceleration

3.2 For a fixed change in momentum, increasing the contact time [1]

- **A** increases the force
- **B** decreases the force
- **C** leaves the force unchanged
- **D** reverses the force

3.3 A 0.15 kg ball hits a wall at 10 m s^{-1} and bounces back at 8 m s^{-1} (opposite direction).

(a) Find the change in momentum. [2]

(b) If the contact lasts 0.02 s, find the average force. [2]

3.4 A 60 kg person jumps down and lands, changing momentum by 300 kg m s^{-1}.

(a) Find the force if they stop in 0.1 s (stiff legs). [1]

(b) Find the force if they stop in 0.5 s (bent knees). [2]

Solutions

2.1 $J = F\Delta t = 20 \times 3 = 60$ kg m s^{-1}.

2.2 The change in momentum, Δp.

2.3 $\Delta v = J/m = 16/4 = 4$ m s^{-1}.

2.4 For a fixed Δp, $F = \Delta p/\Delta t$; a larger Δt gives a smaller F.

3.1 B — impulse equals the change in momentum.

3.2 B — a longer time reduces the force.

3.3 (a) Taking the incoming direction positive: $\Delta p = m(v_f - v_i) = 0.15(-8 - 10) = -2.7$ kg m s^{-1} (magnitude 2.7). (b) $F = \Delta p/\Delta t = 2.7/0.02 = 135$ N.

3.4 (a) $F = 300/0.1 = 3000$ N. (b) $F = 300/0.5 = 600$ N.