

Momentum and Newton's laws of motion

ASHPHYS · REVISION CHEAT SHEET

AS Level

9702 AS Ch.6

Chapter 6: Momentum

Lesson 6.6

Sections 6.6

Goal: Use force = rate of change of momentum, including for collisions and streams of fluid.

01 The big picture

Newton's second law in its general form: the resultant force on an object equals its rate of change of momentum. For a constant mass, $\Delta p / \Delta t = m \Delta v / \Delta t = ma$.

Rearranged, $F \Delta t = \Delta p$: the same change in momentum over a longer time needs a smaller force. That is why crumple zones, airbags and bending your knees on landing protect you.

Force (Newton's second law) [paraphrase]

The resultant force on an object equals its rate of change of momentum.

02 Key equations

Newton's second law

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

Constant mass

$$F = ma$$

Rearranged

$$F \Delta t = \Delta p$$

Symbols and units

F resultant force N Δp change in momentum kg m s^{-1} Δt time taken s

03 Sample problems with solutions

Sample 1 · Hitting a ball

A 0.15 kg ball arrives at a bat at 20 m s^{-1} and leaves in the opposite direction at 30 m s^{-1} . Contact lasts 0.010 s. Calculate the average force on the ball.

Step 1. Return direction positive, so $u = -20 \text{ m s}^{-1}$:

$$\Delta p = 0.15 (30 - (-20)) = 7.5 \text{ kg m s}^{-1}$$

Step 2. Rate of change of momentum:

$$F = \frac{7.5}{0.010} = 750 \text{ N}$$

Answer: 750 N, in the direction the ball leaves

Unit check: $\frac{\text{kg m s}^{-1}}{\text{s}} = \text{kg m s}^{-2} = \text{N} \checkmark$

04 Practice problems

P1 A 1000 kg car goes from rest to 20 m s^{-1} in 8.0 s.

Find the average resultant force.

Answer: 2500 N

P2 A hose sends 2.0 kg of water per second at 15 m s^{-1}

onto a wall, where it stops. Find the force on the wall.

Answer: 30 N

P3 A momentum change of 12 kg m s^{-1} takes 0.040 s.

Find the average force.

Answer: 300 N

P4 Why do you bend your knees when you land from a jump?

Answer: Longer stopping time, so a smaller force for the same Δp

05 Other useful information

Common mistakes

- ✗ **Wrong:** Use $F = ma$ for a stream of fluid.
- ✓ **Right:** Use $F = \Delta p / \Delta t$: mass per second $\times$ change in velocity.

Exam tips

- Check units: kg m s^{-1} per second is kg m s^{-2} , which is N.

What the syllabus asks

- 9702 topic 3: define and use force as rate of change of momentum. Coursebook 6.6.

Explore: [Practice questions for this lesson](#)