

4 Momentum and impulse – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English

Write it 3 times (English)

Linear momentum

impulse

Recall

You already have a feel for momentum, even without the word:

- A heavy truck is harder to stop than a bicycle at the same speed.
- A fast ball hurts more than a slow one when you catch it.
- Catching a ball gently (moving your hands back) hurts less. This sheet explains why, exactly.

Each idea has a worked example before the Practice.

New ideas

■ 1 Momentum

Linear momentum is mass times velocity – a vector pointing the same way as the velocity:

$$p = mv.$$

It measures how hard something is to stop. Its unit is kg m/s.

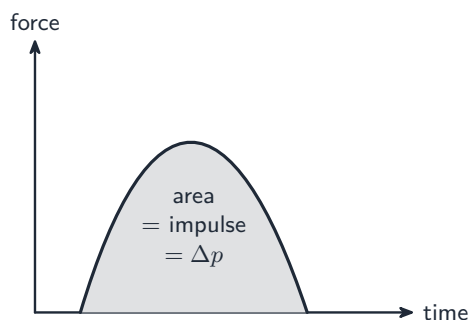
Worked example. A 0.40 kg ball moving at 5.0 m/s has momentum $p = mv = 0.40 \times 5.0 = 2.0$ kg m/s.

■ 2 Impulse

A force acting for a time changes the momentum. The **impulse** is

$$J = F \Delta t,$$

and it equals the change in momentum: $J = \Delta p$. This is the **impulse–momentum theorem**.



Worked example. A 12 N force pushes a trolley for 3.0 s: impulse = $F\Delta t = 12 \times 3.0 = 36$ kg m/s, so the momentum increases by 36 kg m/s.

■ 3 Why time matters

Because $F = \frac{\Delta p}{\Delta t}$, spreading the same momentum change over a **longer time** makes the force **smaller**. That is exactly how airbags, crash mats and bending your knees on landing protect you.

Worked example. A 0.15 kg ball hits a wall at 20 m/s and bounces back at 15 m/s; contact lasts 0.020 s. Taking the rebound direction as positive, $\Delta p = m(v - u) = 0.15(15 - (-20)) = 5.25$ kg m/s, so $F = \frac{\Delta p}{\Delta t} = \frac{5.25}{0.020} = 260$ N.

Watch out: when a ball **bounces back**, its velocity **reverses sign**, so the change in momentum is large. Forgetting the sign flip is the most common mistake here.

Practice

Try these in order. The methods are all above.

2.1 Find the momentum of a 2.0 kg ball moving at 6.0 m/s.

[2]

2.2 A 5.0 N force acts on a cart for 4.0 s. Find the impulse. [2]

2.3 The cart in 2.2 started at rest with mass 2.0 kg. Find its final speed. [2]

2.4 Explain, using impulse, why bending your knees when landing from a jump reduces the force on your legs. [2]

2.5 A 0.20 kg ball moving at 8.0 m/s is caught and stopped in 0.50 s. Find the average force on it. [3]

2.6 A ball hits a wall at 10 m/s and rebounds at 10 m/s. Its mass is 0.25 kg. Find the size of the change in momentum. [2]