

# 4 Momentum and impulse – Part 1

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English         | 中文 | Write it 3 times (English) |
|-----------------|----|----------------------------|
| Linear momentum | 动量 | _____                      |
| impulse         | 冲量 | _____                      |

## 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** 动量 is mass times velocity – a vector pointing the same way as the velocity:

$$p = mv.$$

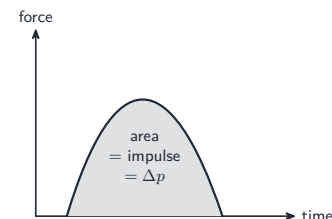
It measures how hard something is to stop. Its unit is kg m/s.

*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** 冲量 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]