0 1 . 1

State the equation for the momentum of an object.

Momentum (p) = mass (m) × velocity (v)

0 1 . 2

A speedboat of mass 2000 kg has a momentum of 52,000 kg m/s. Calculate its velocity.

v = p ÷ m = 52,000 ÷ 2000 = **26 m/s**

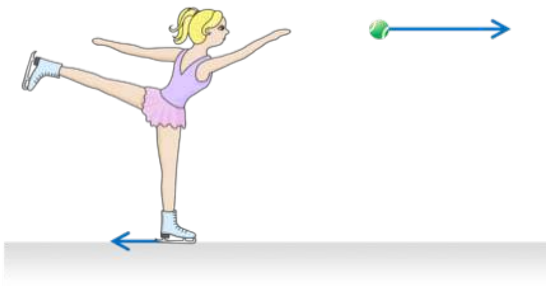
0 1 . 3

You read in a textbook that the electron in the hydrogen atom orbits the nucleus at approximately 2,200 kilometres per second, and that the mass of the electron is 9.11×10^{-31} kg. Calculate the momentum of one of these electrons.

v = 2,200 km/s = 2,200,000 m/s
p = m v = $(9.11 \times 10^{-31}) \times (2{,}200{,}000)$ = **2.0×10^{-24} kg m/s** (1 d.p.)

0 2

An ice skater is balancing at rest on an ice rink. She then throws a tennis ball forwards and starts to move backwards, as shown below.



0 2 . 1

State the Principle of Conservation of Momentum.

In a closed system [1] the total momentum before an event is equal [1] to the momentum after the event [1].

0 2 . 2

Explain why the ice skater moves as shown in the above diagram.

Before the ice skater throws the ball, she is at rest, so the total momentum of the system (of the ice skater and ball) is zero [1]. After she throws the ball forwards, its momentum increases [1]. By the Principle of Conservation of Momentum, she gains an equal amount of momentum in the opposite direction [1].

Remember that momentum is a vector quantity. The momentum of forwards-moving tennis ball is equal and opposite to the momentum of the ice skater as she moves backwards.

0 3 A car of mass 1500 kg is about to crash into the back of a lorry of mass 6000 kg, as shown below.

0 3 . 1 Show that the combined momentum of both vehicles before the collision is 90,000 kg m/s.

Car: $p_1 = m\ v = 1500 \times 20 = 30{,}000$ kg m/s
Truck: $p_2 = m\ v = 6000 \times 10 = 60{,}000$ kg m/s
Total momentum before collision = $p_1 + p_2$ = **90,000 kg m/s**

0 3 . 2 After the collision the car and lorry stick together and travel with a common velocity of 10 m/s. Calculate their combined momentum after the collision.

Total mass = 1500 + 6000 = 7500 kg
Momentum after = m v = 7500 × 10 = **75,000 kg m/s**

0 3 . 3 Compare and comment on the previous two answers.

The total momentum of the car and truck before the collision (90,000 kg m/s) is more than their total momentum after the collision (75,000 kg m/s) [1]. This tells us that this was not a closed system [1], in other words that there must have been external forces acting on the car and truck (such as friction and air resistance) [1].

(Remember that a closed system is one in which no external forces act, so there must have been forces acting on the two vehicles other than those which they exerted on each other when they collided.)