13.1 Use the graph to determine the impulse of the ball.

13.2 At what velocity will the ball leave the hockey stick?

13.3 Venitha hits a softer ball (also 200 g). The ball leaves the hockey stick at the same velocity as in Question 13.2. How will the graph change?

1.5 The law of conservation of momentum

Two moving objects each have their own momentum.
This physical interaction/collision of objects is called the "system".
A closed system is a system on which no external forces, from outside the system, are exerted on the system.
When the two objects collide, they exert forces on each other – these forces are called internal forces.
External forces are for example air resistance, friction between wheels and road surface, brakes and the drive of an engine.

This means:
If the sum of the vectors of all the external forces on the system is zero, the external forces may be ignored and the system is closed or isolated.
A closed system excludes all the forces that are applied by objects outside the system.

Quick facts

A system is a small part of the complete scenario that is observed when a specific problem is solved. Everything outside the system is called the environment.

The law of conservation of linear movement is defined as follows:

In a closed system, the vector sum of the linear momentum before a collision or explosion is equal to the vector sum of the linear momentum after the collision or explosion.

OR

The total momentum of a closed system remains constant.

Symbol format:

$$\Sigma p_{\text{before collision}} = \Sigma p_{\text{after collision}}$$
$$\Sigma p_i = \Sigma p_f$$

Quick facts

Σ is the Greek symbol sigma. It is used to indicate "the sum of".
IT IS NOT AN "E"!

Although the total momentum stays constant, the distribution of the momentum can change. This means the momentum can be transferred from one object to another.

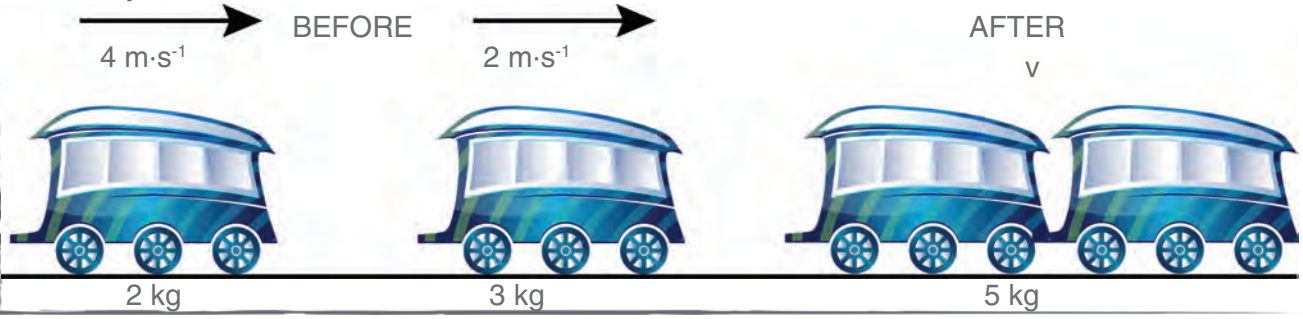
Quick facts

The velocities used in conservation of momentum problems are always the velocities **just before** and **just after** the collision.

The principle of the conservation of momentum is especially used in collision-type of problems, in other words sudden events.
Examples are collisions, explosions, gunshots, jumping on, etc.

Examples

Two trolleys, masses 2 kg and 3 kg respectively, move in the same straight line. The 2 kg trolley moves at 4 m·s^{-1} behind the 3 kg trolley, which is moving at 2 m·s^{-1} in the same direction. During the collision, the trolleys get stuck to each other and proceed to move as one. Calculate the velocity of the trolleys after the collision.



All motion is to the right, therefore right is chosen as positive.

$\Sigma p_{before} = \Sigma p_{after}$ and $p = mv$

$m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$

$(2 \times 4) + (3 \times 2) = (2 + 3)v$

$v_f = 2{,}8\ m{\cdot}s^{-1}$ to right

Quick facts

If there are two objects: always start with: $\Sigma p_{before} = \Sigma p_{after}$.

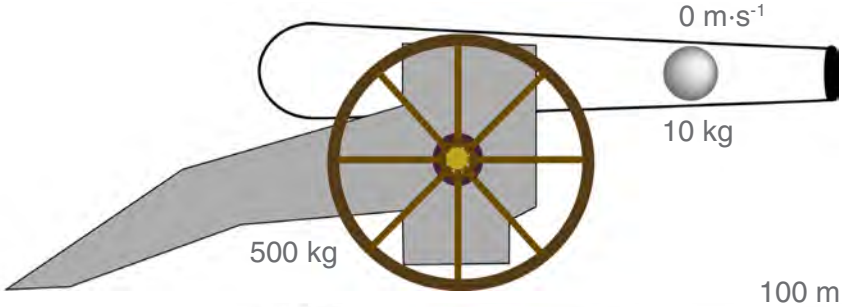
Quick facts

The word **linear** refers to motion in a straight line.

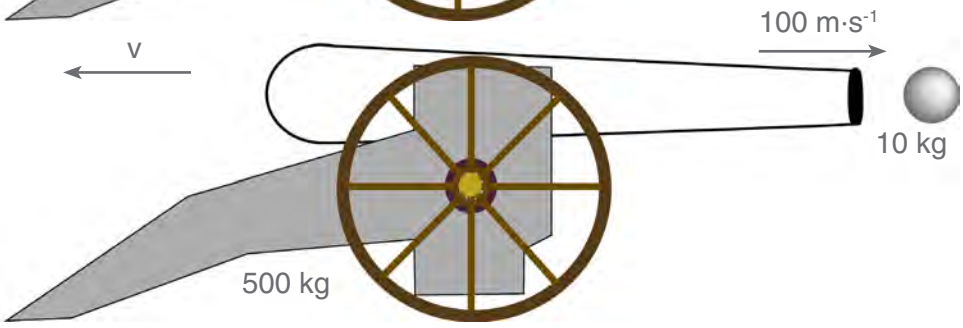
Examples

A cannon, mass 500 kg, shoots a cannon ball, mass 10 kg, horizontally. If the velocity of the cannon ball, after it has been shot, is 100 $m{\cdot}s^{-1}$ to the right, calculate the recoil velocity of the cannon.

BEFORE



AFTER



Choose motion to the right as positive and to the left as negative. Remember that there is no motion before the shot. Let v be the velocity of the cannon after the shot.

$\Sigma p_{before} = \Sigma p_{after}$ and $p = mv$ so

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

$0 = 10(100) + 500v_{2f}$

$v_{2f} = -2\ m{\cdot}s^{-1}$

$= 2\ m{\cdot}s^{-1}$ to the left