background sheet

Newton explained

Misconceptions in science

Students have their own ideas about how the world works, and they often differ from accepted scientific understandings. This document identifies more common misconceptions amongst students, explains why they're incorrect, and provides physical explanations of forces and motion.

Some common misconceptions about forces and motion are:

1. If an object isn't moving, there's no force acting on it.
2. If an object is moving, a force must be acting in the direction of motion.
3. If you want to keep an object moving in a straight line, at a constant speed, you have to keep pushing or it will run out of force and stop.
4. When falling freely in a vacuum, heavy objects fall faster.

Before addressing these misconceptions let's recap Newton's laws of motion.

Newton's first law of motion (the law of inertia)

Objects remain at rest or in uniform straight-line motion unless an external unbalanced force acts on them.

Essentially this law tells us that objects tend to keep doing what they're doing (inertia).

- An object at rest stays at rest, unless a force acts on it.
- A moving object continues moving at the same speed and in the same direction, unless a force acts on it.

What is an external unbalanced force?

An external force is applied outside the object, such as pushing against a trolley. An unbalanced force doesn't have a force of equal strength in the opposite direction to counteract it.

Examples of Newton's first law

1. A book remains at rest on a desk unless an external force is applied to move it.
2. When a car suddenly slows down, passengers keep moving forward at their original speed until the seat belt applies a force to stop them.
3. When a lift accelerates upwards we feel heavier because we tend to remain at rest.

Newton's second law of motion

When an unbalanced force acts on an object, the object will accelerate in the direction of the force. The acceleration is directly proportional to the unbalanced force ($a \propto F$) and indirectly proportional to the mass of the object ($a \propto 1/m$).

This leads to the mathematical relationship:

$a = F/m$ or $F = ma$

Newton's second law tells us that unbalanced forces change the motion of objects. They can move stationary objects, accelerate or decelerate moving objects, or stop them altogether.

The law explains why objects with more mass need bigger forces to change their motion.

Uses of Newton's second law

Newton's second law enables us to quantify forces and the acceleration they produce.

1. It takes more force to push a heavy truck than to push a small car.
2. The same amount of force applied to a car and a truck makes the car accelerate more than the truck.
3. More force is needed to stop a truck travelling at 30 km h^{-1} than to stop a car moving at the same speed.

Examples

1. If a force of 1000 N is applied to a car of mass 800 kg, its acceleration will be:

   force F = 1000 N

   mass m = 800 kg

   $F = ma$

   1000 = 800.a

   acceleration a = 1000/800 = 1.25 m s^{-2}

2. If the same force (1000 N) is applied to a truck of mass 1600 kg, its acceleration will be:

   force F = 1000 N

   mass m = 1600 kg

   $F = ma$

   1000 = 1600.a

   acceleration a = 1000/1600 = 0.625 m s^{-2}