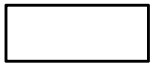
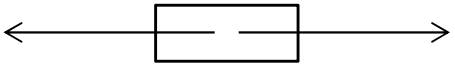
Newton's First, Second and Third Laws

First Law: For a **stationary** object, if the resultant force is zero the object will **stay stationary**.
Second Law: For a **moving** object, if the resultant force is zero it will carry on **moving** at the **same velocity**.



Stationary object, no force.
Object stays stationary



Moving object with balanced forces (no resultant force).
Object stays stationary

Third Law: When two objects interact, the forces they exert on each other are **equal** and **opposite**.

If you push on a wall, there is a **normal contact force** pushing back with the same force. This is an **equilibrium** situation – neither object moves.

If two people on roller-skates push against each other, they will both feel the **same size force** and so accelerate away from each other. If one person has a smaller mass they will accelerate away more quickly.

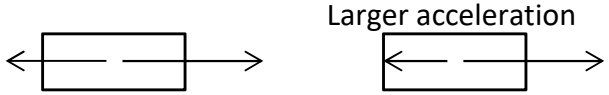
Inertia

Objects at rest, stay at rest and objects moving at a steady speed, keep moving until acted on by a force.
This tendency to remain in the **same state of motion** is called inertia.

Inertial mass is a ratio of force over acceleration: $m = F \div a$
($F = ma$ rearranged)

Acceleration and Resultant Force

The larger the resultant force, the larger the acceleration. Force and acceleration are directly proportional.



Acceleration is inversely proportional to mass – a larger mass will accelerate more slowly for a given force.

$F = ma$
Force (N) — Acceleration (m/s^2) — Mass (kg)

Investigating Motion

REQUIRED PRACTICAL
SEE PRACTICAL SHEET FOR DETAIL

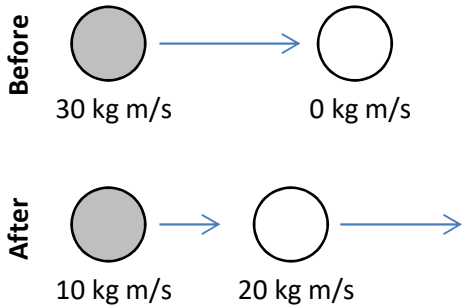
The acceleration of a trolley can be investigated as the mass is changed.

Momentum

All moving objects have momentum.
It is a vector quantity (has size and direction).

$p = mv$
Momentum (kg m/s) — Velocity (m/s) — Mass (kg)

The greater the mass, the greater an objects its momentum.
The greater the velocity, the greater an objects momentum.



A moving object crashes into a stationary object causing both objects to move.

The total **momentum before** the collision is **equal** to the **momentum after** the collision (30 kg m/s in this example).

If the two objects lock together and continue to move after a collision then the mass of the moving object will increase, therefore the velocity will decrease to maintain momentum.

Physics Only

Changes In Momentum

Car Safety Zones

- **Crumple zones:** these crumple on impact, increasing the time taken for the car to stop. This decreases the force of the impact.
- **Seat belts stretch:** this increases the time for the person to stop, decreasing the force on them.
- **Air bags:** these inflate before the person hits the dashboard. The air inside compresses as the person hits it, slowing them down more gradually, reducing the force of impact.

Bike Helmets

They have a layer of foam that is crushable. This increases the time taken to stop, therefore reducing the force of the impact on the riders head.

Crash mats/cushioned flooring

If a person falls onto them they compress. This increases the time taken to come to a stop, therefore reducing the force of impact.